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New Sensor- and Software Concepts for Reliable Operation of Real-Time Water Quality Monitoring Systems (part 1)

Real-Time Water Quality Monitoring Workshop
St. John's, June 16th and 17th, 2009

Part 1:
New Sensor- and Software Concepts for Reliable Operation of Real-Time Water Quality Monitoring Systems (Part 1)
- About s::can
- Sensors and stations
- Soft- and hardware for sensor management and data validation
- Software for event detection

Part 2:
Real-Time Water Quality Monitoring Systems: The Vienna Experience (Part 2)
- About UV-Vis Spectrometry: Principle, Advantages
- Perspective of sensor networks based on UV spectrometry
- Water monitoring applications in Vienna, Austria
- From Source to Drink, from Drink to Waste, back to the River and into the Groundwater

Who is s::can ?

Designer and manufacturer of optical online instrumentation in Vienna, Austria, since 1999

:

established OnLine Spectrometry as an accepted method for many parameters in many countries

:

World leader in online UV spectrometry with > 2300 Systems sold

:

Today, provider of a full range of plug-and-measure water quality sensors

:

Focus on low maintenance sensors and innovative sensor management software, that make possible the old dream of highly-reliable, high-resolution, multi-sensor monitoring networks

The s::can sensor philosophy

1. On-Line Only
2. Plug & Measure
3. Can be operated by uneducated staff
4. Lowest Maintenance
5. Long-Term-Stable
6. Multi-Parametric
7. Works-Calibrated
8. Lowest cost in > 3 years of operation

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The Full Range Online

	„Maximum number of parameters"	Pressure	Hydrocarbon alarm	Contaminant alarm	Fingerprints	AOC	H2S	O3	O2	Temperature	Conductivity	ORP	pH	Colour	Turbidity	TSS	F	Free chlorine	K	NH4	NO2	NO3	UV254	DOC	TOC	BTX	COD	BOD	Parameter	Platinum electrode	Inductive	Glass electrode	Optical	Fluorescent	ISE	Spectral UV-Vis	Spectral UV	Probe type
spectro::lyser™	8*	X	X	X	X	X	X	X		X				X	X	X						X	X	X	X	X	X	X								X		
spectro::lyser™	8*	X	X	X	X	X				X											X	X	X	X	X	X	X	X									X	
carbo::lyser™	4*	X								X					X	X							X	X	X		X	X								X		
nitro::lyser™	4*	X								X					X	X						X														X		
color::lyser™	4*	X								X				X	X	X																				X		
multi::lyser™	5*	X								X					X	X						X	X	X	X		X	X								X		
ammo::lyser™	4*									X			X						X	X															X			
oxi::lyser™	2*								X	X																								X				
uv::lyser™	4*	X								X					X	X							X													X		
ozo::lyser™	4*	X						X		X					X	X																				X		
fluoro::lyser™	1																X																		X			
chloro::lyser™	1																	X																	X			
condu::lyser™	2*									X	X																				X							
redo::lyser™	2*									X		X																		X								
pH::lyser™	2*									X			X																			X						
soli::lyser™	1															X																	X					
turbi::lyser™	1														X																		X					

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0.5-5mm (waste water)

+ waste water: ppm to g/l

+ sewer system

+ processes / industries

- paper
- vine
- beer
- juices
- oils
- petrochemical
- biotech
- ……..

35 mm (sensitive)

+ general water monitoring: ppb to ppm

- river water, bank filtrate
- sea water
- groundwater, -recharge
- drinking waters
- compliance of WWTP
- treatment processes

+ alarm / early warning systems

100 mm (ultra sensitive)

+ water monitoring: low ppb

- low turbidity drinking waters: alarm + protection / security / distribution system monitoring
- ground waters (organic contamination)
- sea water
- ultra pure waters

+ processes / industries

- cooling waters
- pharma
- electronics industries

The Sensors: digital, intelligent, almost zero maintenance

chlori::lyser: Total or Free Chlorine:

_pro: pH-compensated; no zero calibration necessary
_eco: next generation: solid state, not compensated, no maintenance, just exchange head.

condu::lyser_pro

digital sensor, either toroidal or direct, today's highest possible level of accuracy and quality

NEW 2009 condu::lyser_eco

digital sensor; direct measurement; high accuracy for price sensitive applications

pH::lyser_diff

digital sensor; differential - former GLI – sensor; world wide best acknowledged pH sensor on the market

NEW 2009 pH::lyser_pro

non-porous, "solid-state", slow-ageing Refex electrode for most difficult and lowest maintenance applications; will replace differential pH.

NEW! ammo::lyser – plug&measure NH4 measurement

- Fully integrated via RS485/modbusRTU
- no additional terminal
- ammo::lyser IV: 4 parameters: NH4, K, pH & Temp.
- Potassium-, pH- & Temperature compensated
- „Ionophore“ (ion selective liquid membrane)
- Long term stability outstanding for ion selective sensor
- 2-Weekly check of calibration recommended; typical re-calibration monthly in environmental, several months in waste water
- Auto cleaning (compressed air)
- Simple membrane replacement all 6 – 12 months (or even longer)
- Running costs a fraction of other brands, because membranes can be replaced separately
- Many other ions possible (i.e. Fluoride)
- close to 1.000 of predecessor version running word wide today

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NEW: chlori::lyser: pH- independent free chlorine

- "plug & measure"
- monitoring of free chlorine (Cl2 + HOCl + OCl-), or total chlorine, or chlorine dioxide
- measuring principle: Amperometric (membrane covered), potentiostatic 3-electrode system
- internally compensates fluctuations of pH between 6.5 and 9
- stable at fluctuations of flow
- long term stable, lowest maintenance possible today
- operation via s::can terminals and s::can software
- range: 0 to 2 mg/l or 0 to 20 mg/l
- resolution: 0,001 mg/l
- response time: 90 % in 2 minutes
- operating range: 4 – 10 pH (can be increased to 12)
- typical performance with pH changes: < 5 % per pH unit between 6 and 9 pH; < 1 % at < 6 pH
- dimensions: 25 mm x 210 mm
- max. pressure: 1 bar (higher on request)
- operating temperature: 0 – 50 °C

The oxi::lyser – plug&measure Dissolved Oxygen

- Fully integrated via RS485 Bus, no extra terminal
- optical DO & Temperature
- Pre-calibration ex works
- No flow required
- Long term stable (drift< 1% per year)
- Only yearly check of calibration recommended
- No replacement of membrane, no consumables
- Warranty: 3 (5) years
- Self cleaning, integrated in compressed air system

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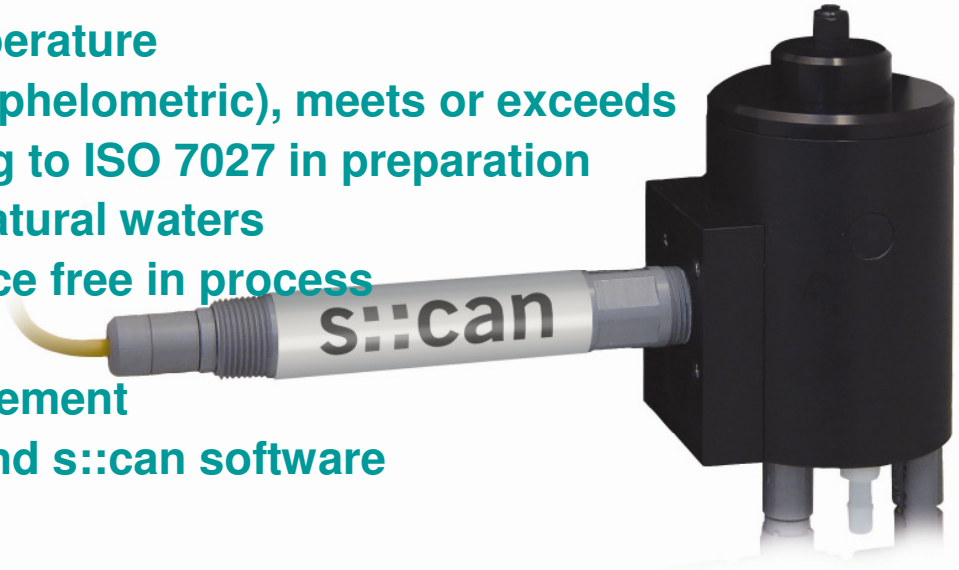
NEW: turbi::lyser: Turbidity according to USEPA method 180.1

- mounted submersed or in measuring cell
- s::can plug & measure
- monitoring of turbidity and temperature
- measuring principle: Optical (nephelometric), meets or exceeds USEPA 180.1 / version according to ISO 7027 in preparation
- perfect for drinking water and natural waters
- long term stable and maintenance free in process
- pre-calibrated ex works
- by-pass installation and measurement
- operation via s::can terminals and s::can software
- range: 0 to 100 NTU
- resolution: 0.001 NTU
- accuracy below 40 NTU: +/-2 % of reading or +/-0.02 NTU
- response time: 90 % in 2 minutes
- light source: Tungsten white light
- sample chamber material: ABS



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NEW: soli::lyser: TS (MLSS) for Waste Water

- s::can plug & measure
- measuring principle: Optical (infrared absorbance)
- perfect for waste water applications
- long term stable and maintenance free in process
- auto compensation of temperature
- auto cleaning via compressed air or water, fully integrated into s::can cleaning system
- pre-calibrated ex-works
- automatic self diagnostics
- operation via s::can terminals and s::can software
- range: 0 to 30.000 mg/l
- resolution: 10 mg/l (1.000 mg/l to 9.999 mg/l) resp. 100 mg/l (above 10.000 mg/l)
- accuracy: +/- 3 % of reading or +/- 20 mg/l (whichever is greater)
- response time: 90 % in 1 minute
- sensor drift less than 1 % per year

The „compact“ s::can-Station

- TOC
- DOC
- NO3
- Turbidity
- pH
- spec. conductance
- free Chlorine
- DO
- div. ISE, i.e. NH4, Fluoride, Chloride
- spectral alarms
- event detection

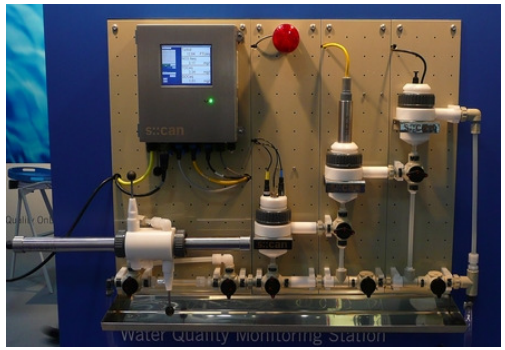
100 x 80 x 30 cm

size comparision

conventional station Endress+Hauser

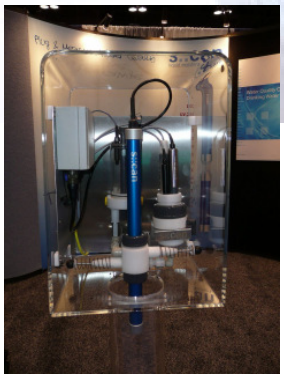
220 x 200 x 80 cm

compact modular station



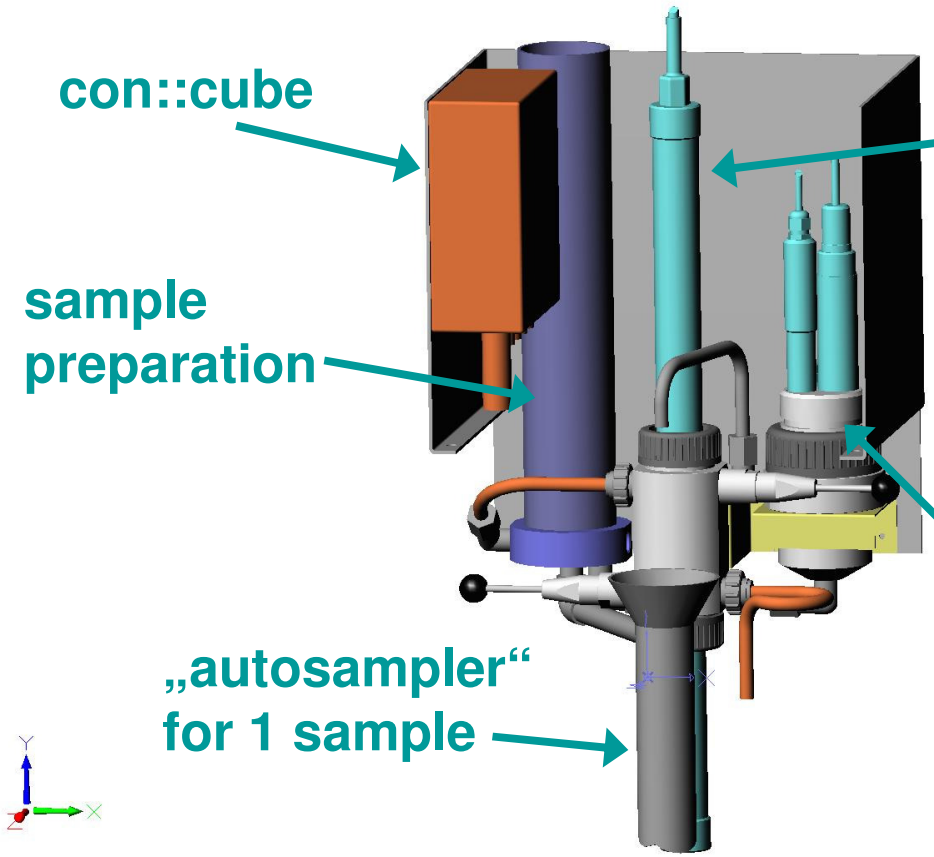
100 x 80 x 30 cm

micro-station



55 x 35 x 35 cm

The s::can microstation



con::cube

sample preparation

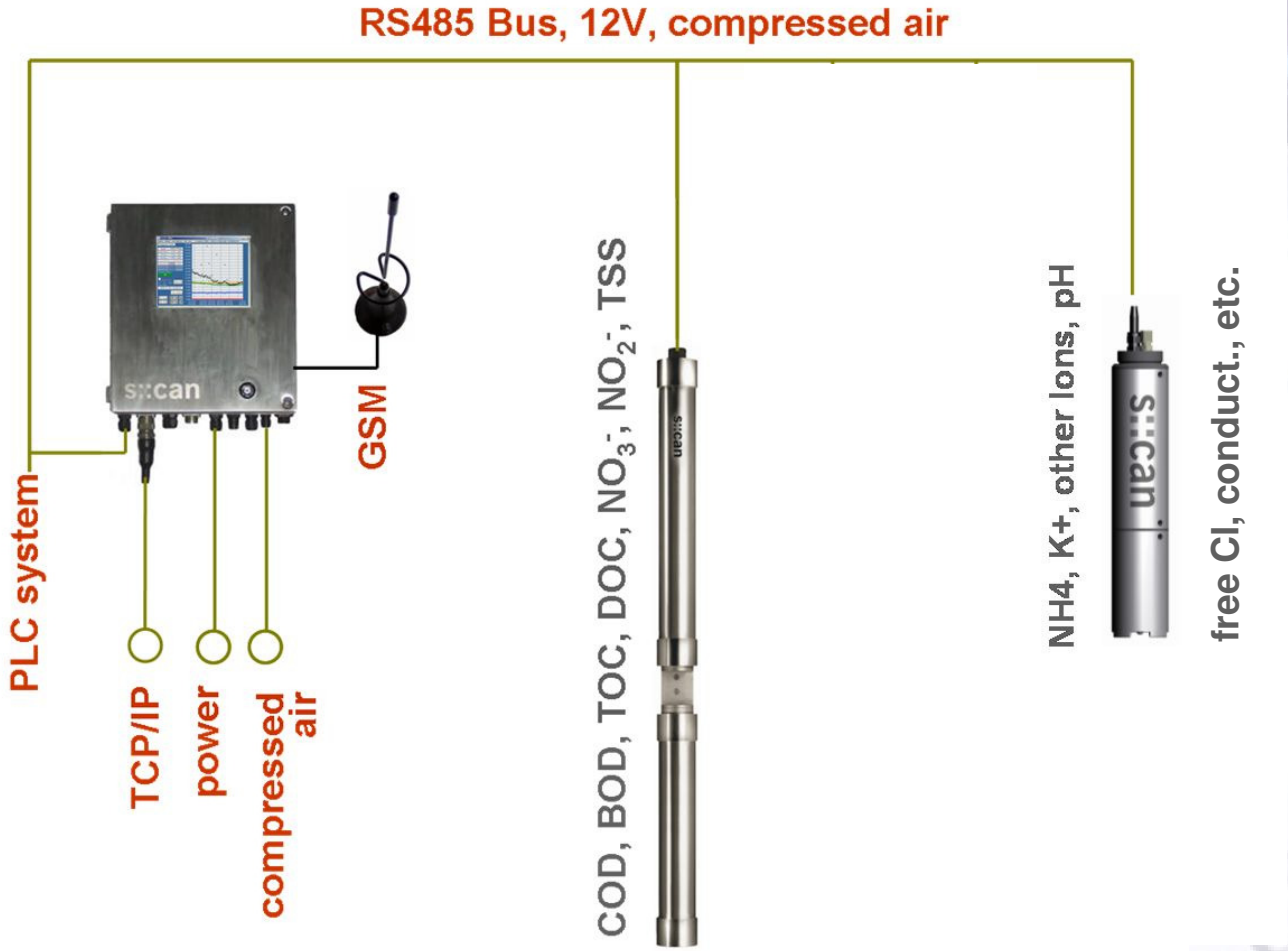
„autosampler“ for 1 sample

- TOC
- DOC
- NO3
- Turbidity
- spectral alarms
- event detection

- pH
- spec. conductance
- free Chlorine
- ISE: NH4, Fluoride, etc.

55 x 35 x 35 cm (!)

Submersed Operation



Complex Monitoring Systems Will Not Work Without:

1. **TRANSPARENT SENSOR AND STATION MANAGEMENT**: Clear and transparent management of all sensors and stations, synchronised both on a local and on a central level.

Sensor identity, and any occurrences like any manual change of settings, sensors or components, calibration, and any other activities, plus all messages from sensors must be logged.

all details are logged and stored in central data base so any non-event-related deviating data can be identified.

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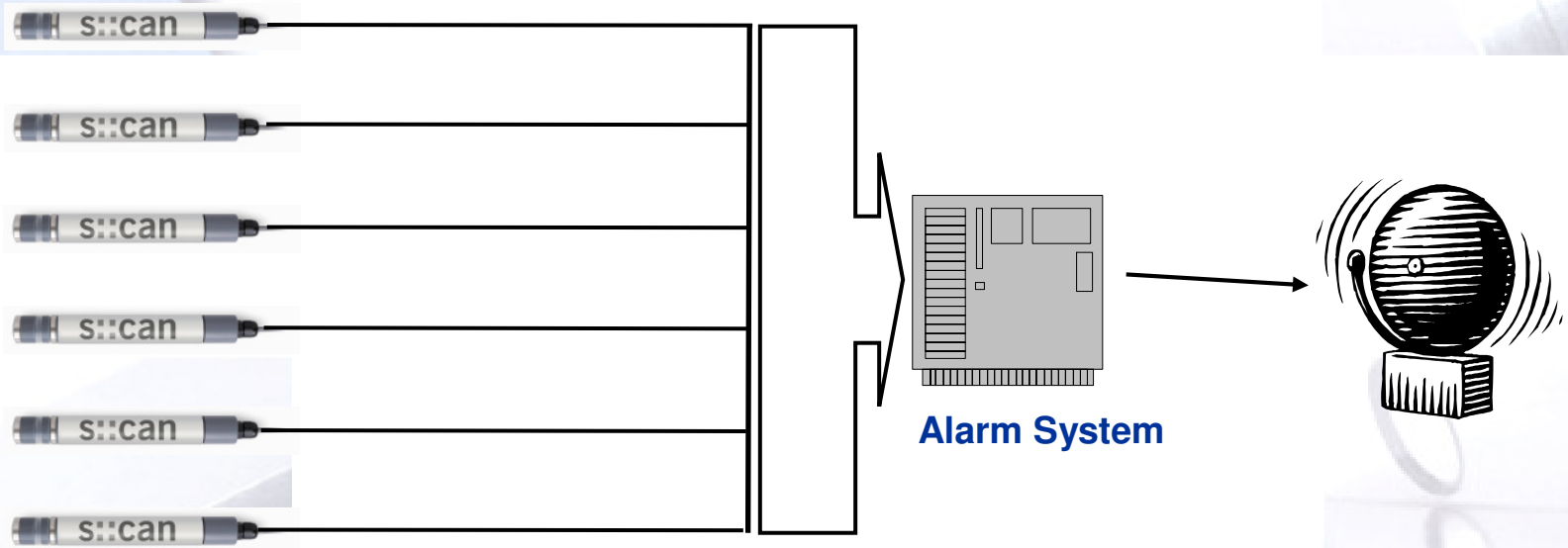
Complex Monitoring Systems Will Not Work Without:

Avoid that alarms are being trained on unvalidated data or false alarms will result.

2. **DATA VALIDATION: Automatic data validation provides that only "clean data" are used for further analysis, training and alarms.**

Monitoring / Alarm Systems in an Ideal World

…. perfect sensors would directly feed clean data one-way into real-time data analysis / alarm system.



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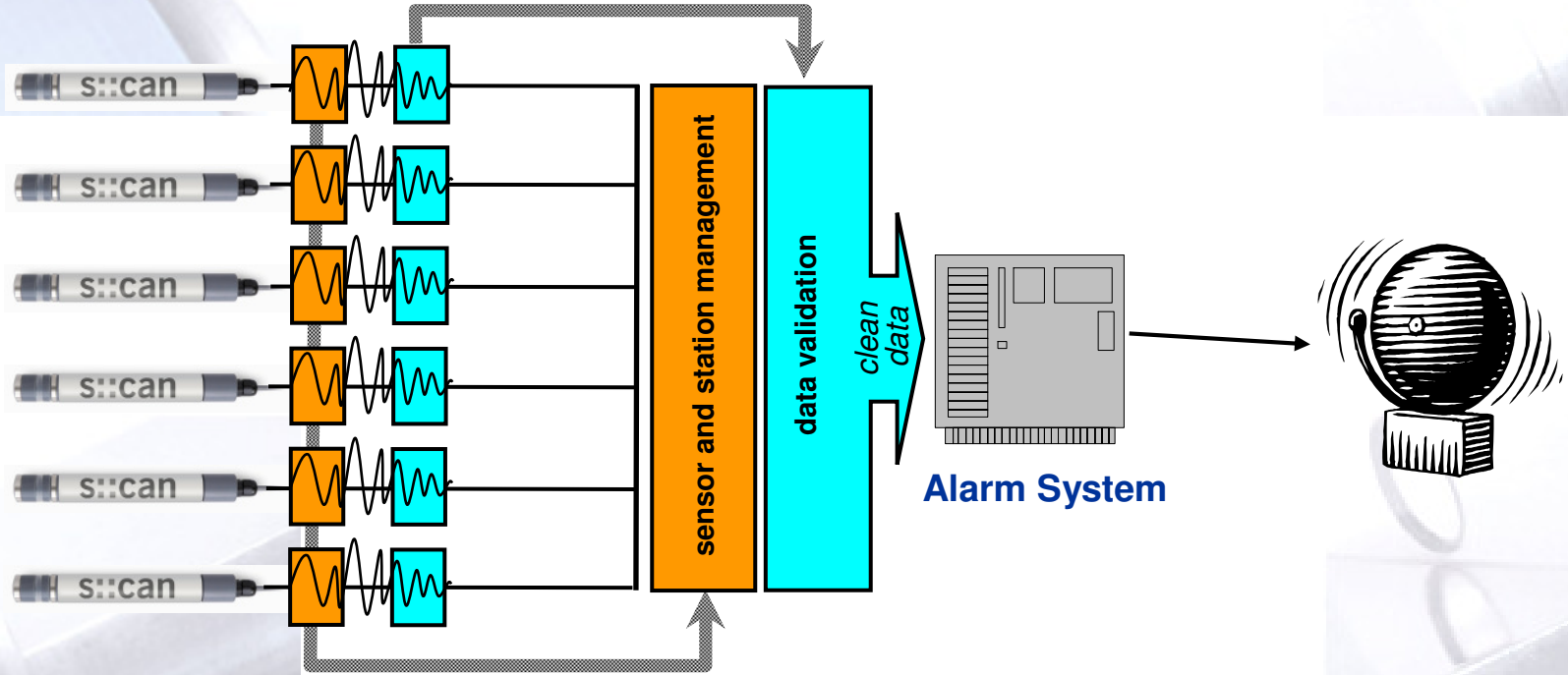
Monitoring / Alarm Systems in a Real World

.... best sensors still produce noisy data → need to be transparently managed → feed into sensor validation system → feed into data validation system → feed into further data analysis / alarm system



Local Data Validation = Precondition for any Alarm System

Very subjective lesson learned in 10 years of field experience, with hundreds of online water monitoring systems world wide, from small to very large (up to 130 stations / 500 parameters all 2 minutes in the largest one):

Multi-station water quality monitoring systems without real-time data validation will lead to

- non-interpretable data
- missed / ignored events
- unreliable / false alarms
- expensive field trips
- immense manual data cleaning work
- system overload
- low acceptance by operators as well as managers

and just will not work sustainably.

Local Data Validation = Precondition for any Alarm System

- *For any time-critical system (alarm systems; process control) it is too late to validate + correct data in a central data base !*
- *To reduce complexity of your QAQC system, ensure good data quality as close to the source as possible. Let the sensor / controller do the job for you.*

Q1: System integrity ?

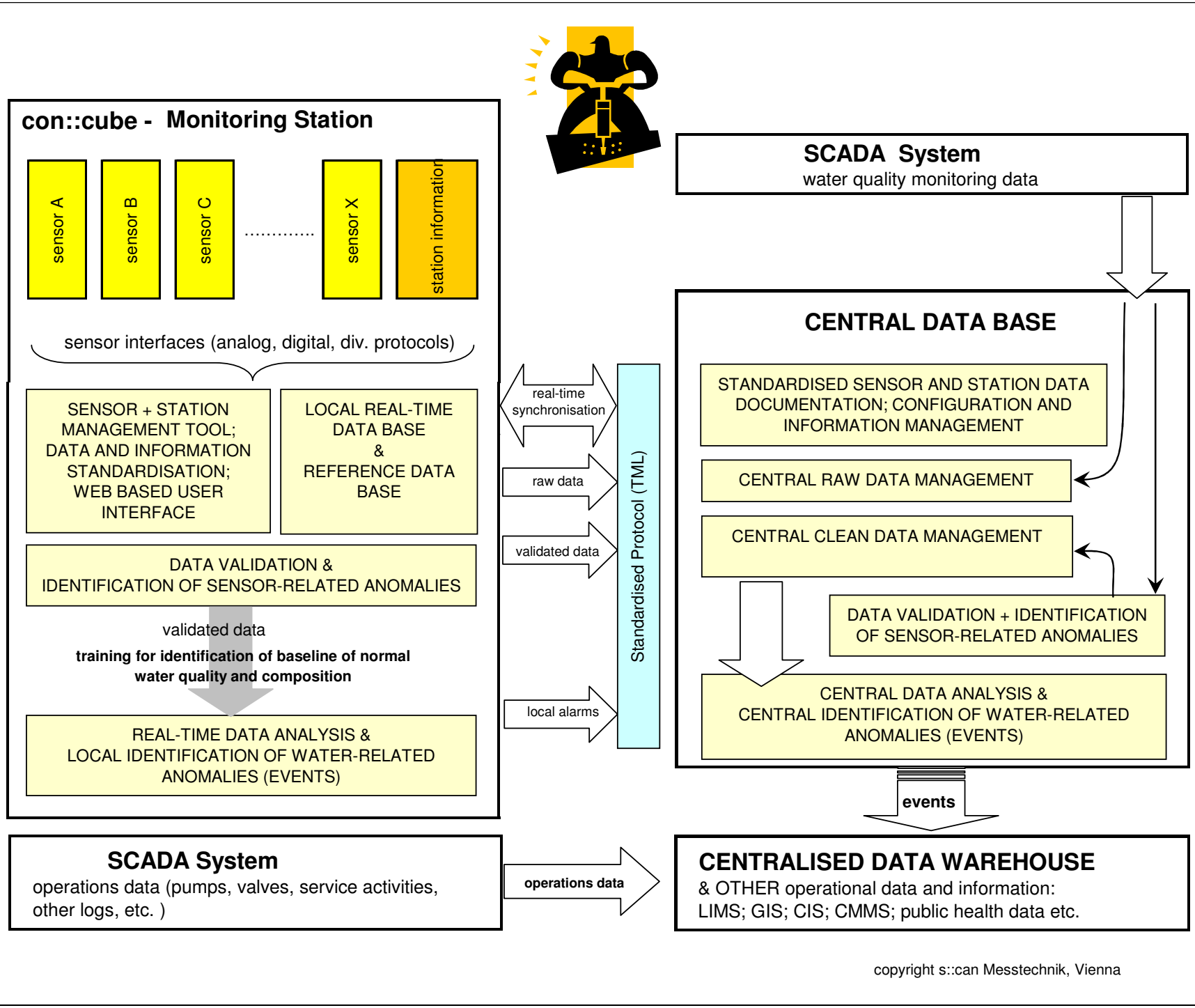
Q2: Installation integrity ?

Q3: Sensor integrity ?

Answers are calculated from

1. Provided sensor information (intelligent sensor protocol, digital outputs)
2. Station information (sample flow + pressure, camera pictures)
3. Enforced inputs during station visits via Web-based user interface
4. Real-Time data validation (and correction)

…. then stored in a local real-time data base, and synchronized to the outside world via diverse interfaces and protocols.



Quality Management

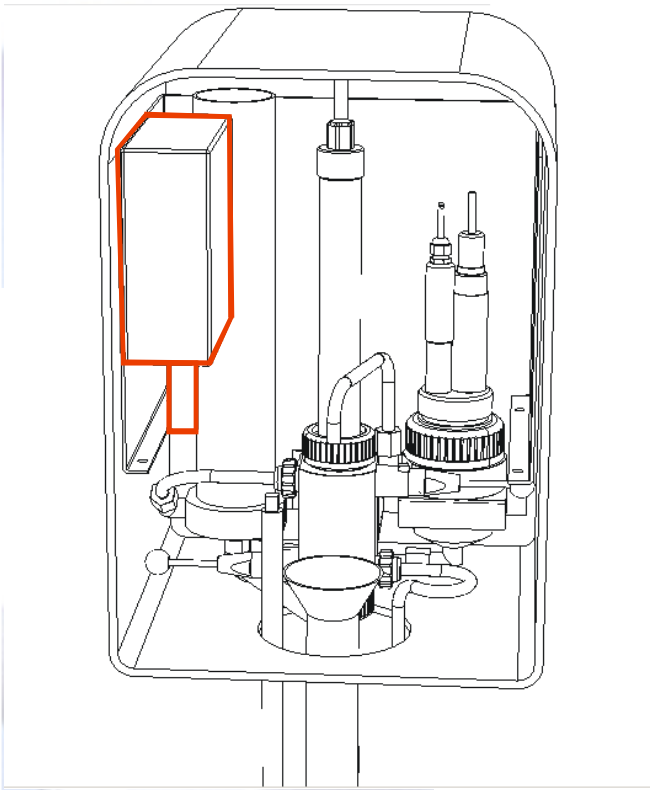
- **Design Quality.** All system components should be built upon a QM approach, and not QM set up later on top of an existing technical approach.
- **Make it Simple.** Reduce the complexity of the system to the greatest extent possible by using the simplest and most reliable technology only.
- **Make it Intelligent.** Use intelligent software and automated, enforced, and transparent procedures, so only few procedures and decisions left to be Q-controlled.

Quality Management

The Quality Management Concept:

1. **Transparency** of system and all procedures.
2. **Traceability & enforced documentation** - every maintenance activity to be documented, documentation according to customized standards; no way to by-pass documentation otherwise systems will alarm.
3. **Feedback** given by software to all field activities, stored both locally and in central data system.
4. **Q-controlled (lab)-environment** used for any delicate work; no complex decisions and no delicate work in the field.
5. **Certification** - s::can can help with partners to certify and audit the system and procedures.

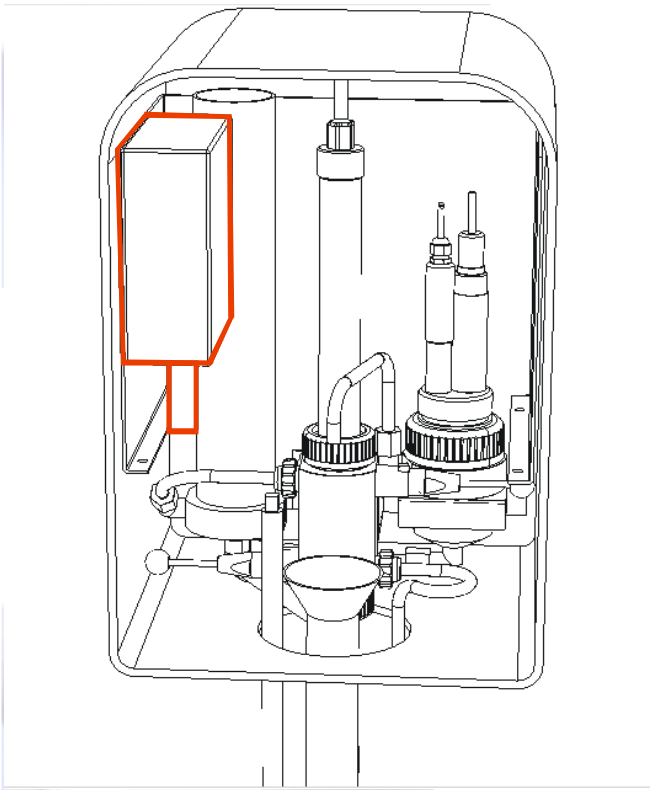
con::cube - The Brain of the Micro-Station



(6) The Station Controller – con::cube

- s::can industrial micro-PC
- smaller clone of well proven s::can con::stat
- for robustness no moving parts (runs on flash disk), solid state cooling, no display, minimum number of interfaces, “bullet proof” hermetical housing
- moni::tool software with comprehensive options for sensor and station management
- synchronization w SCADA / central data base provided (TML protocol), or other telemetry and protocol possible
- local access for configuration, calibration etc. via wired or wireless I/O module like PDA, or laptop, or mobile TouchScreen device, depending on preference.
- web based secure remote interface

moni::tool - the Micro-Station Software



(7) moni::tool - The station software

- open for any third party sensors / protocols / meta data
- Currently 4 modules, can be licensed independently:
  1. **moni::tool** sensor and station management
  2. **vali::tool** real-time data validation:
  3. **ana::larm + ana::tool** real-time local event detection:
  4. **repo::tool** reporting – generate your own format reports
- all data logged in Postgress data base: **measured values, spectra, sensor identities, and any occurrences like any changes of settings, sensors or components, calibration, and any other activities, plus all messages from sensors.**
- synchronized via XML w central data base (open); **any other protocols possible, i.e. Modbus RTU, STI12 / only for simple applications**

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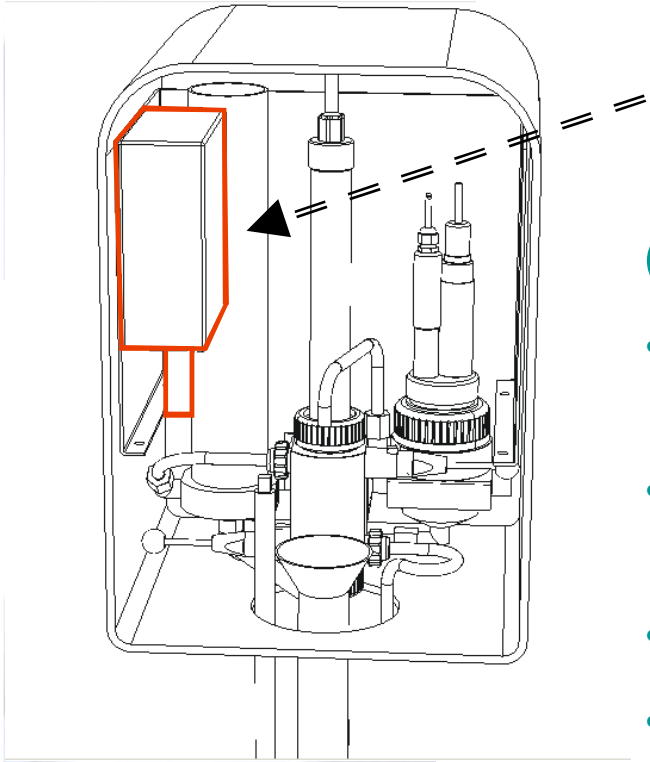
moni::tool - the Micro-Station Software

1. **moni::tool: Sensor / Station control and management tool**
   - easy and transparant sensor and station configuration, driven by a graphical user interface
   - tracking of all activities and status information (this type of data is essential in an EDS system to explain signal changes i.e. due to maintenance)
   - interfacing options for heterogeneous sensors via analogue and digital protocols, manufacturer independent
2. **vali::tool: Data validation tool**
   - real-time analysis of incoming data from any source
   - ensures only clean data is fed into the EDS
   - plausibility, outliers, sudden jumps, drift, noise, both recognition and -correction possible
   - avoid training of alarm systems on invalid data = false alarms
3. **ana::tool: Event detection tool**
   - combines spectral alarms with additional parameter alarm tools
   - static-, dynamic-, spectral-, pattern-, composite events
   - allows alarming & response locally on the station (i.e. switching of autosamplers, pumps etc)

The User Interface

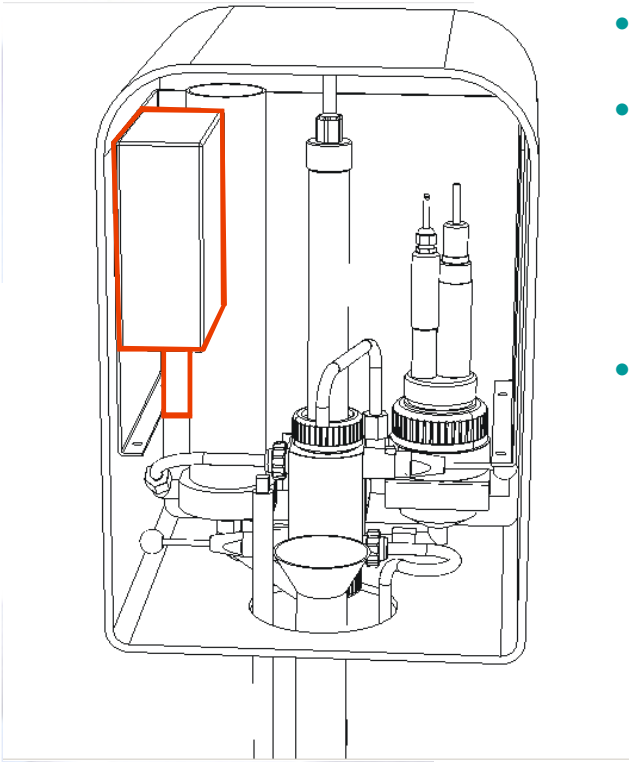


(7) The User Interface / Hardware

- PDA, laptop, or mobile TouchScreen device, any device that can run web applications is possible
- can be connected to con::cube via network cable or wireless, from any location in the world
- GUI is a web application running on any PC
- secure connection to con::cube, including ID check and secure password (see “Security Features”)

The User Interface

(8) The User Interface / Software



- ensures traceability of any local and remote activities
- physical access recognition enforces visitor to identify + register by connecting the Interface Device to station. Only ownership of Interface Device + secure code will allow registration.
- electronic log-book: visitor is enforced to log all activities during the physical visit (sensor and station maintenance, calibrations, cleaning, repairs, exchanges, etc.)

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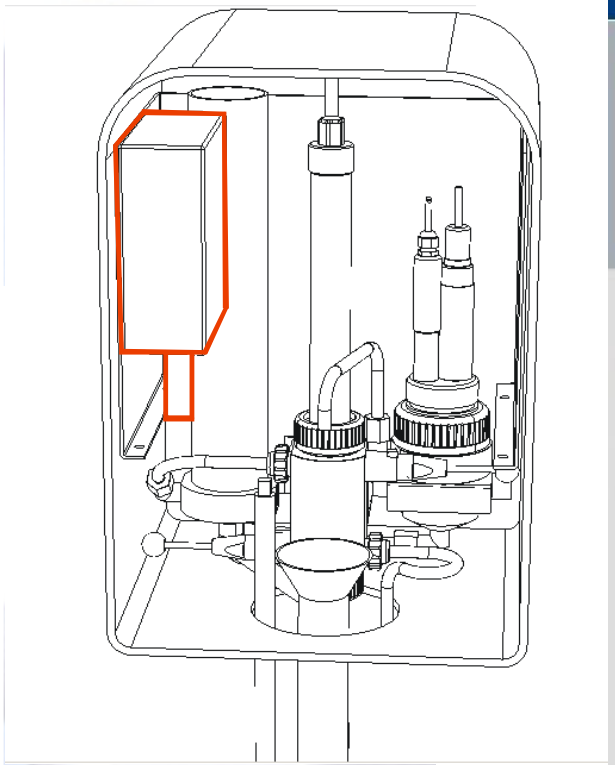
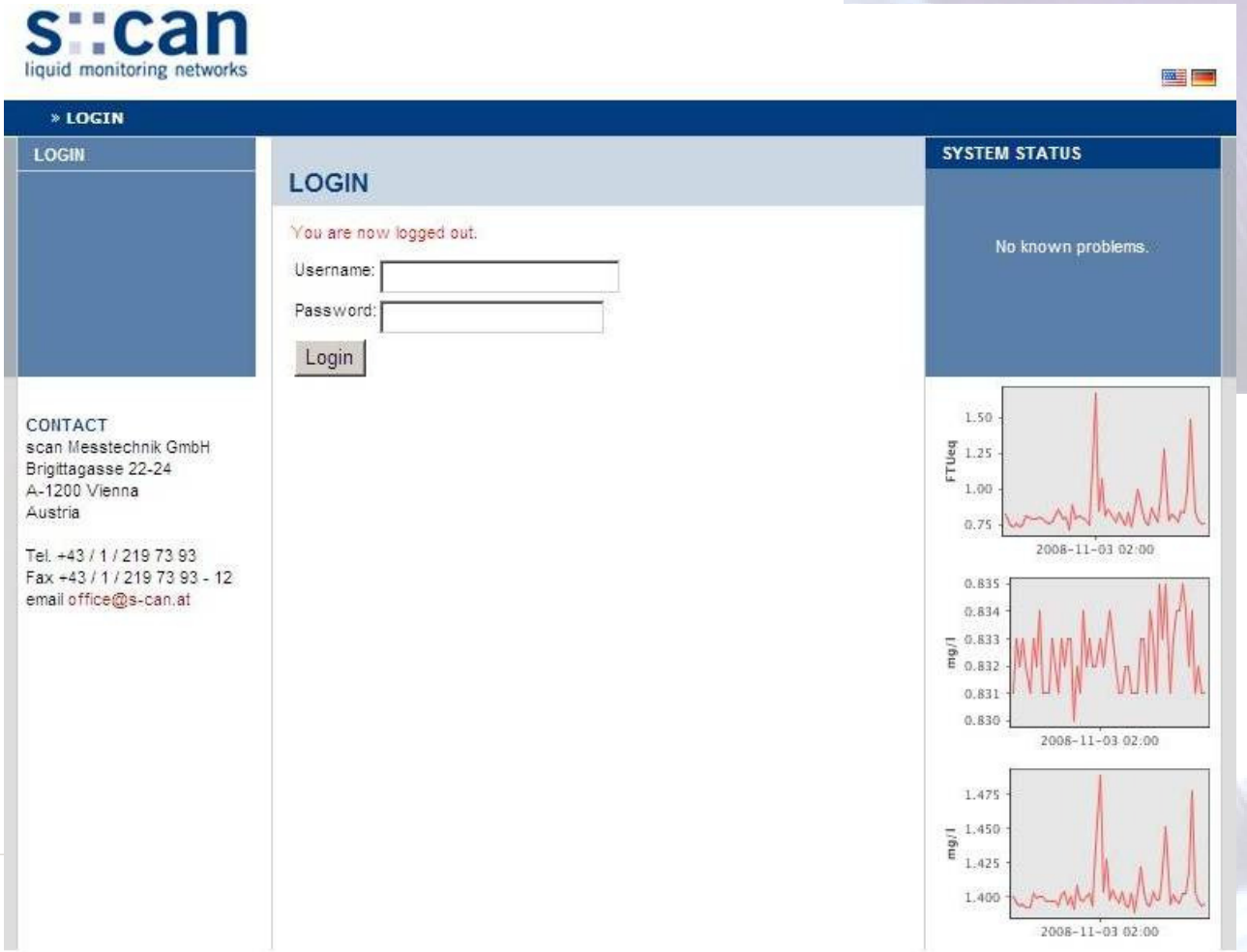
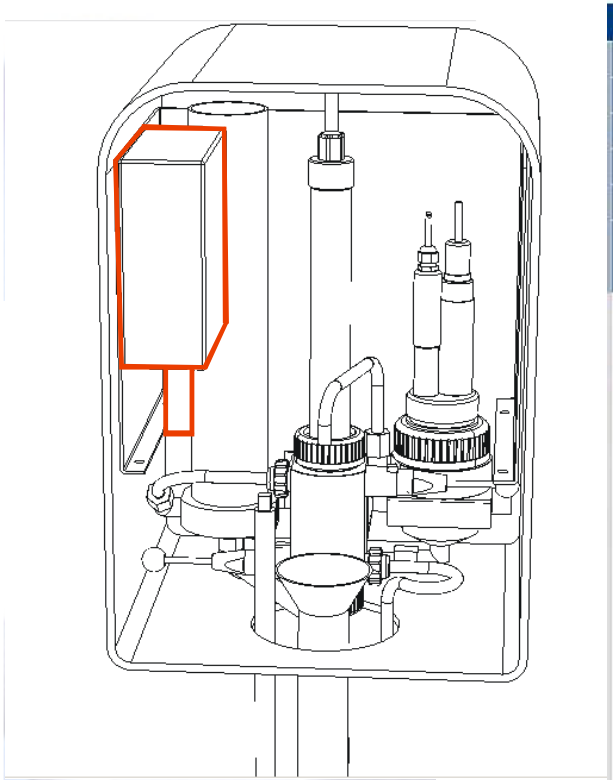
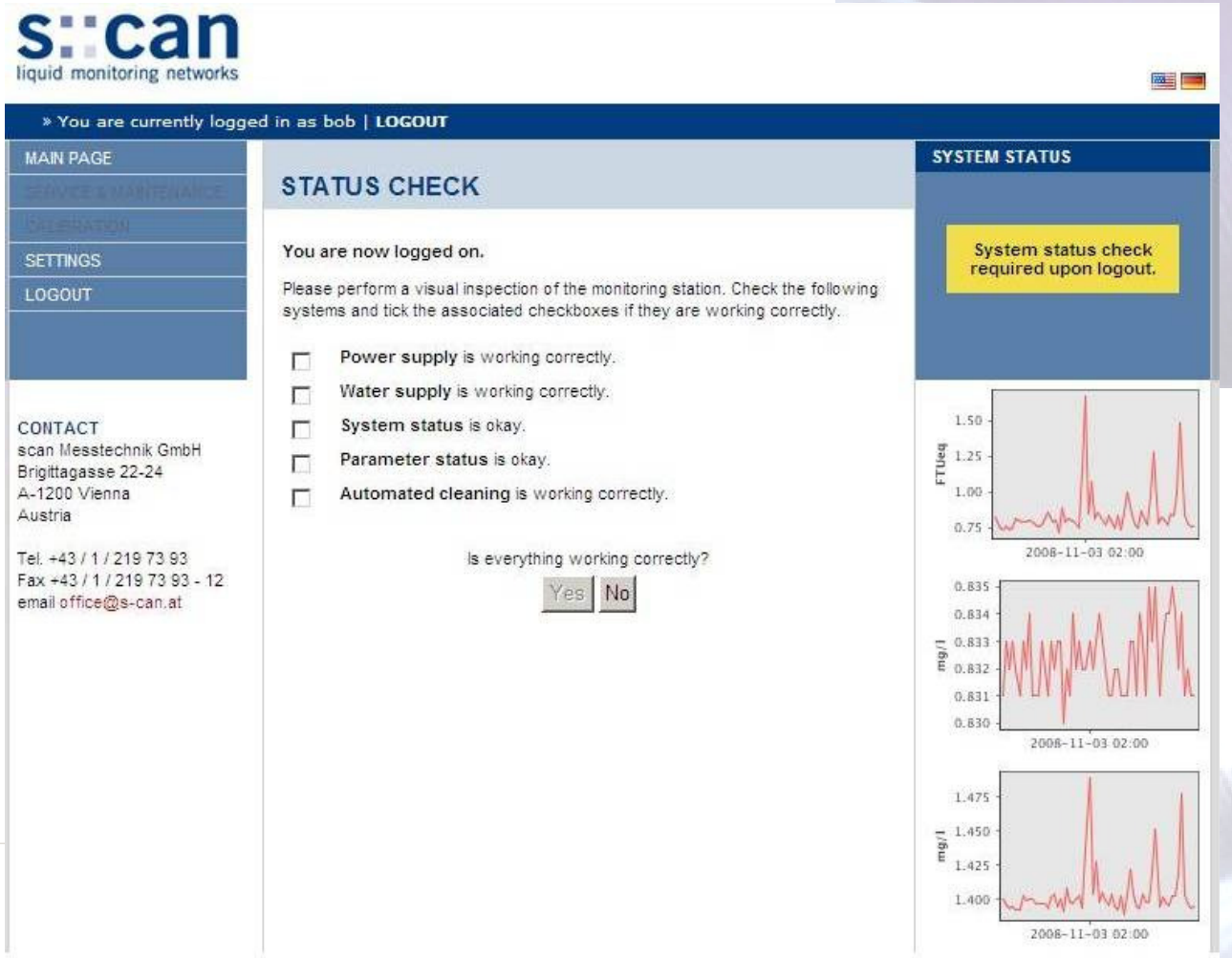
moni::tool - the microstation software





moni::tool - the microstation software





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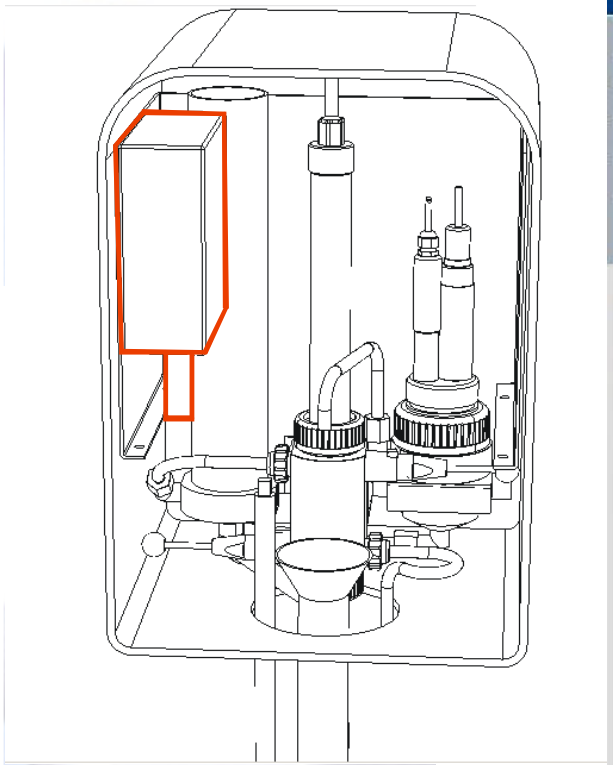

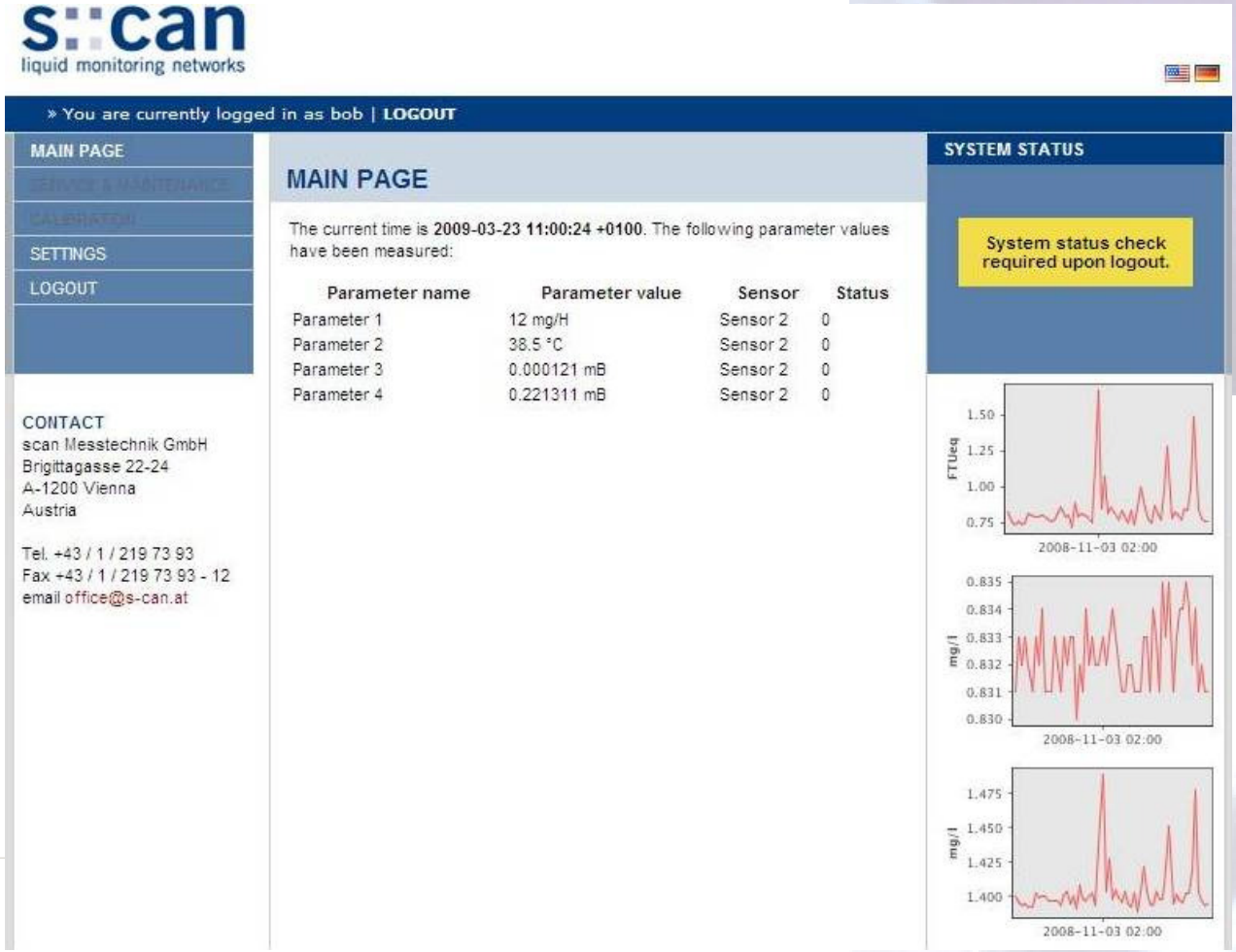

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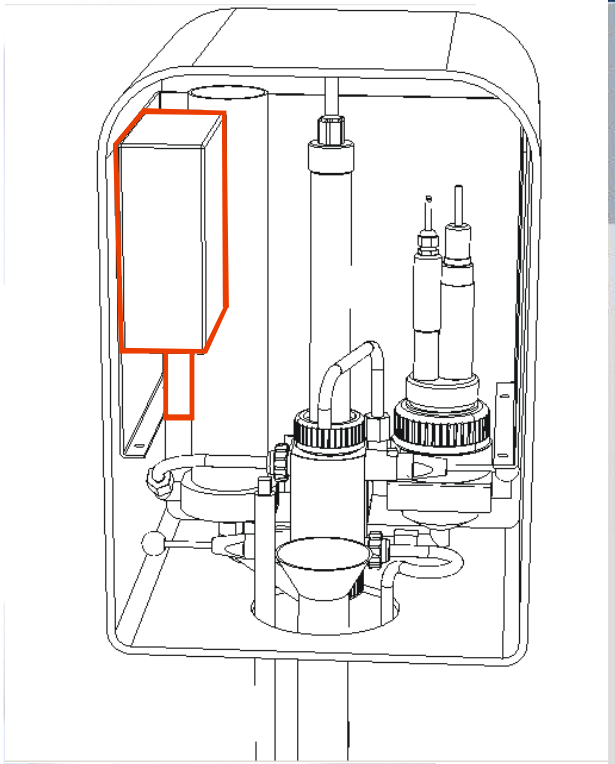

s::can liquid monitoring networks

» You are currently logged in as bob | LOGOUT

MAIN PAGE
SERVICE & MAINTENANCE
CALIBRATION
SETTINGS
Station Configuration
Sensor Configuration
Parameter Configuration
System time
LOGOUT

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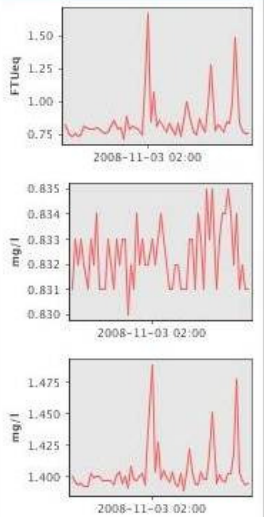
STATION CONFIGURATION

Name of station:	Local Station
Username:	Administrator
Location:	Original
Description:	This describes the local station.
IP Address:	
Subnet mask:	
Gateway:	
Nameserver 1:	
Nameserver 2:	
DHCP:	Use DHCP
Host name:	ipc1
Target URL for notifications:	https://user:password@sub.server.tld
Target port for notifications:	443
Measurement interval (seconds):	60
Measurement cycles between updates:	0
TTL of local database (days):	60
Hardware version:	0.1a
Software version:	0.1a
Access control list:	

Save

SYSTEM STATUS

System status check required upon logout.



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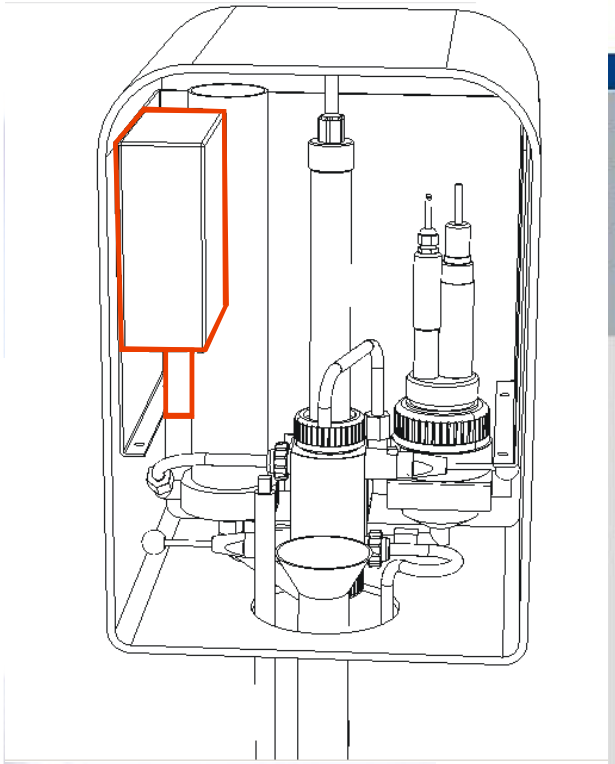
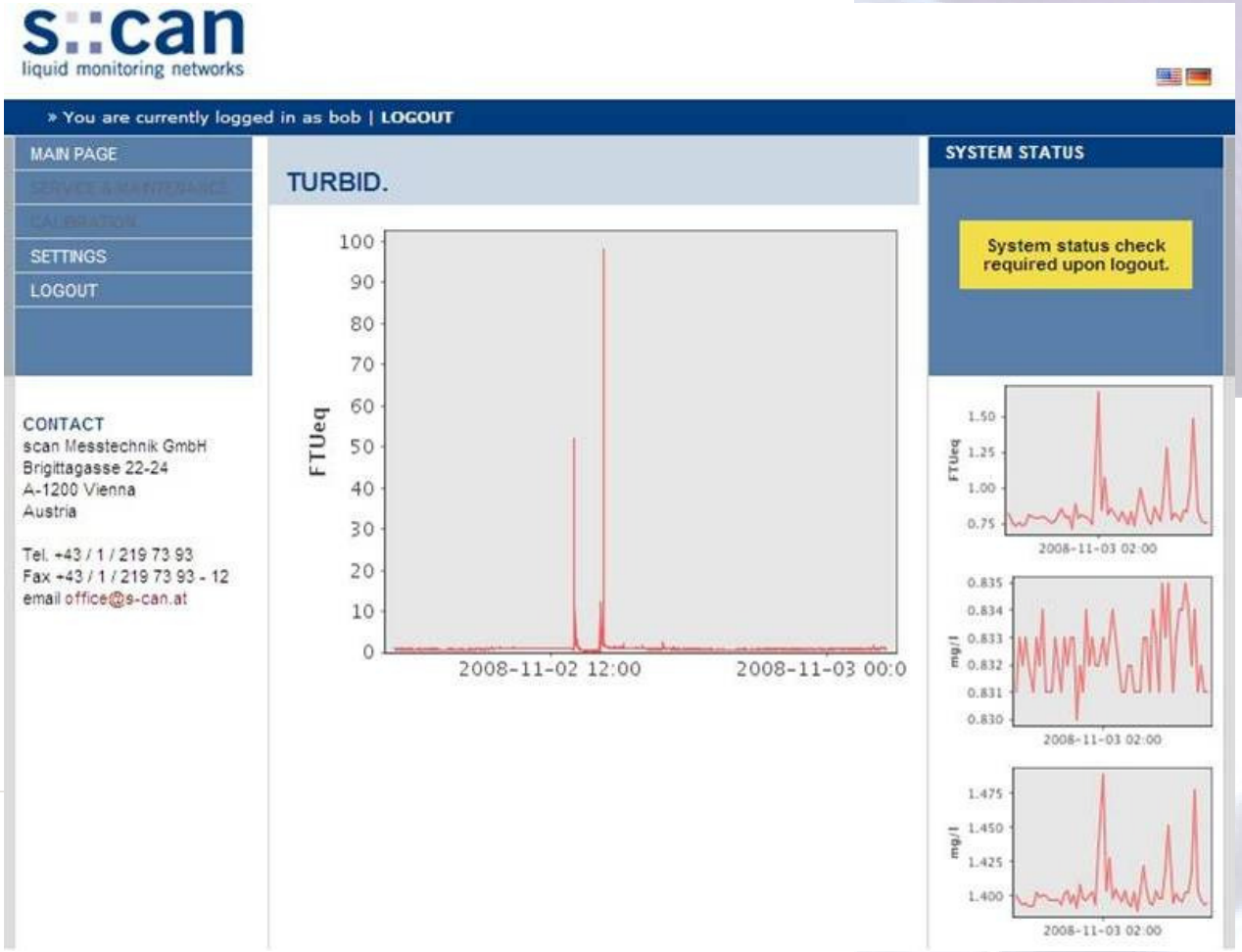
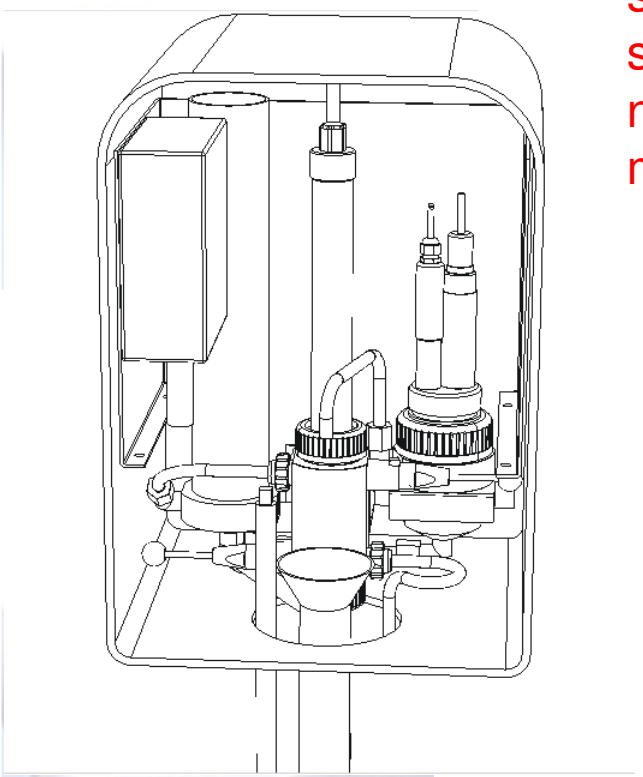


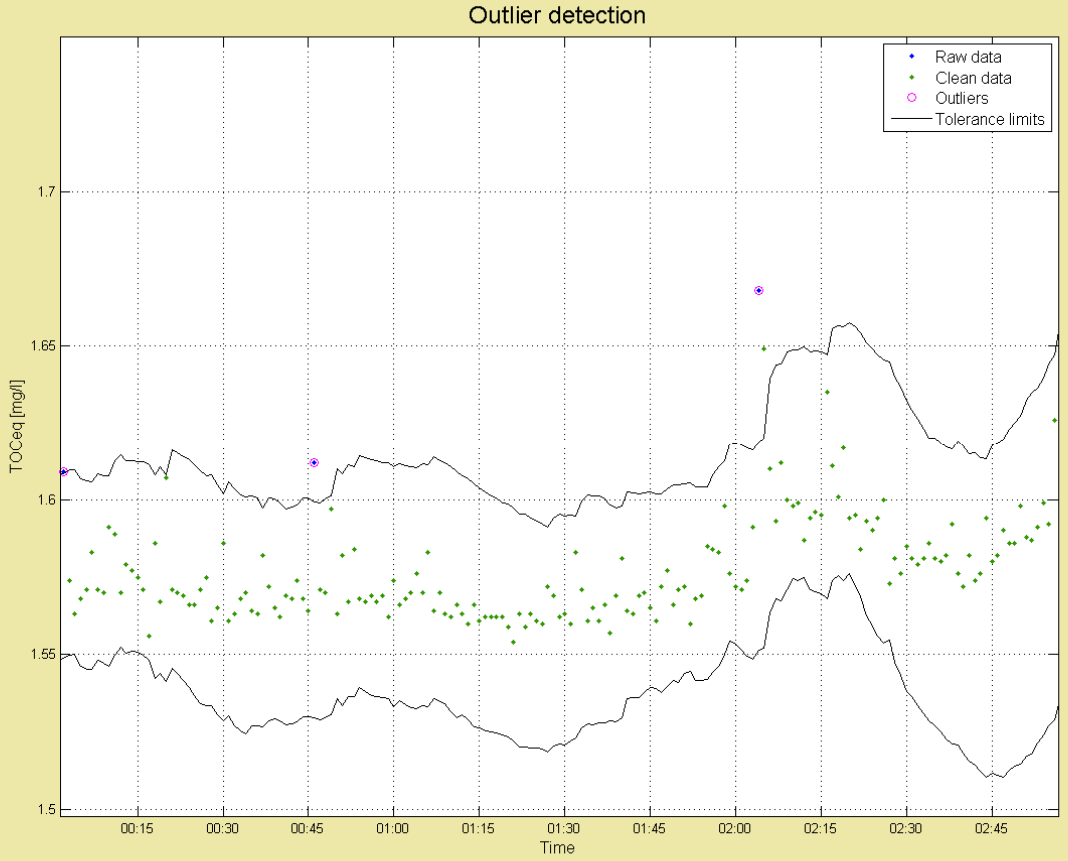


Operation, Service and Maintenance

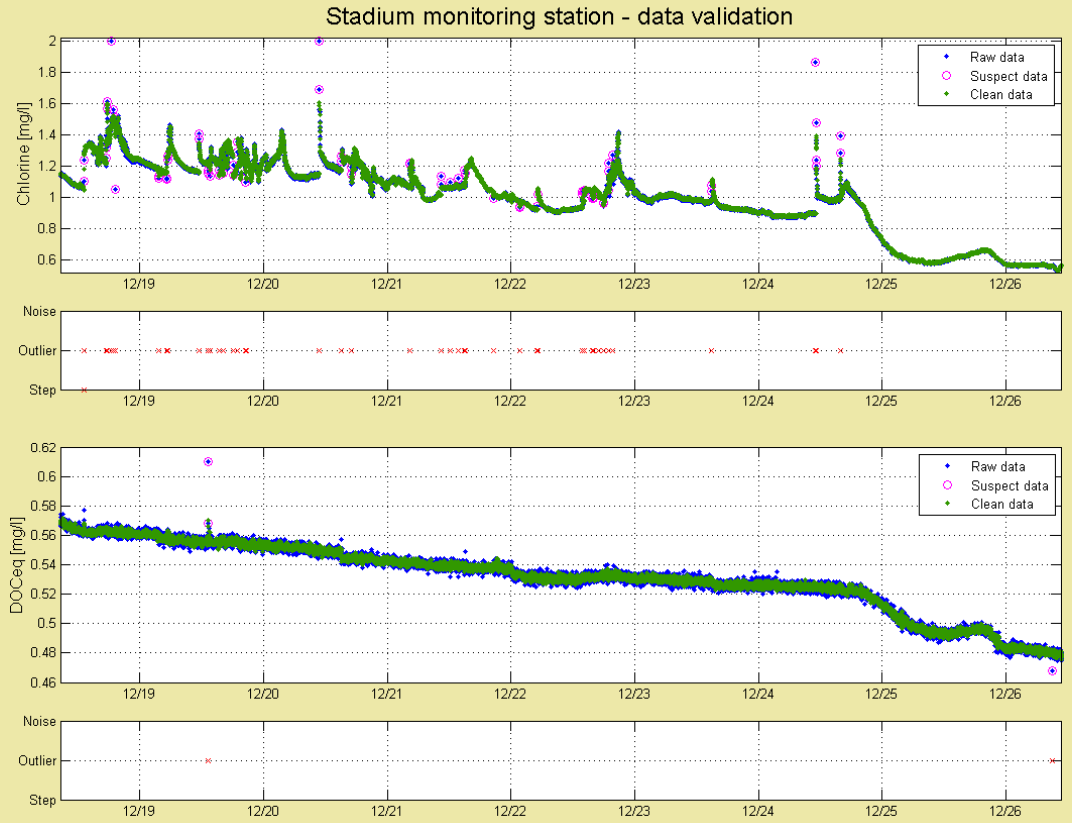
- Can be run and maintained by non-scientific, non-expert staff because of robust and reliable sensors, intelligent software that clearly explains about any deviations from normality, and because there is just no delicate maintenance work foreseen at site.



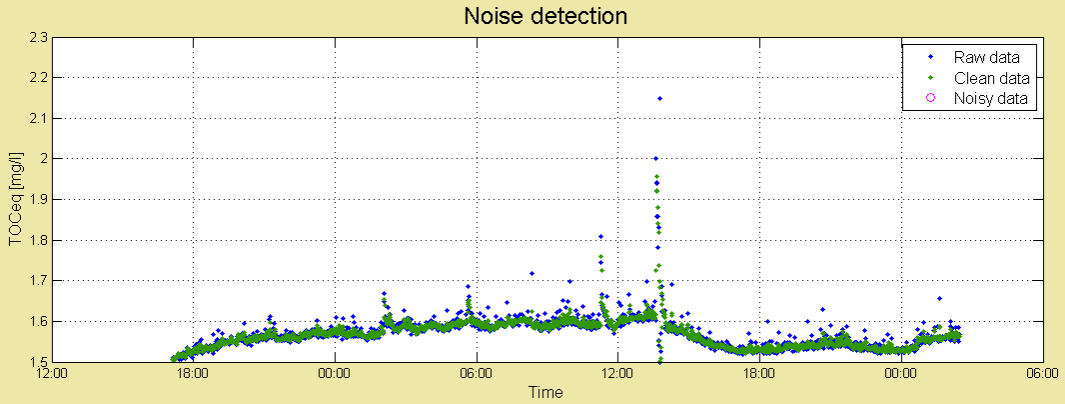
vali::tool – Real-Time Data Validation

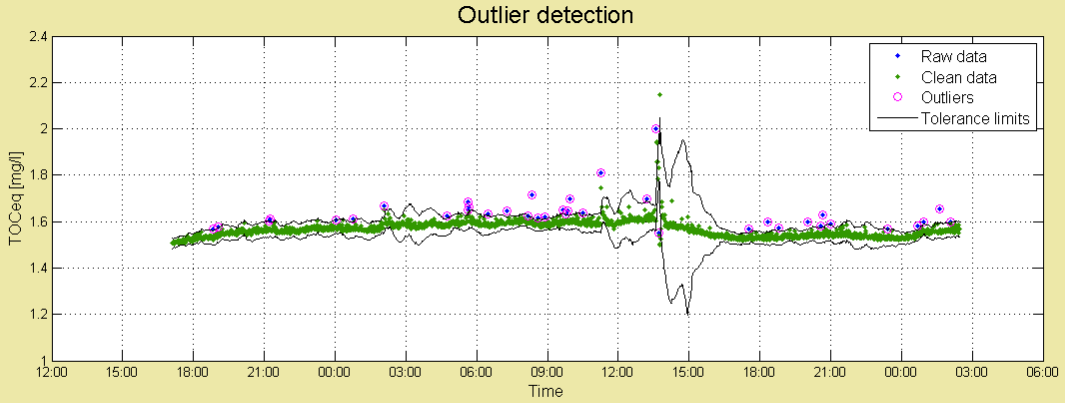


vali::tool – Real-Time Data Validation

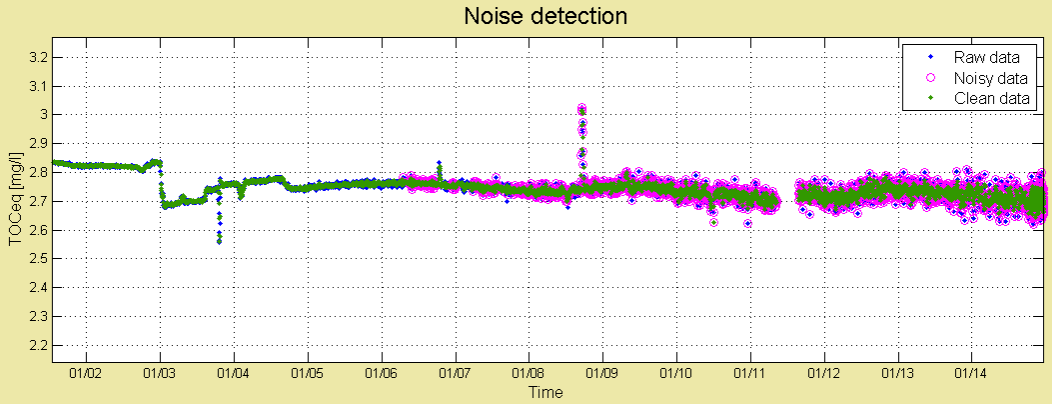


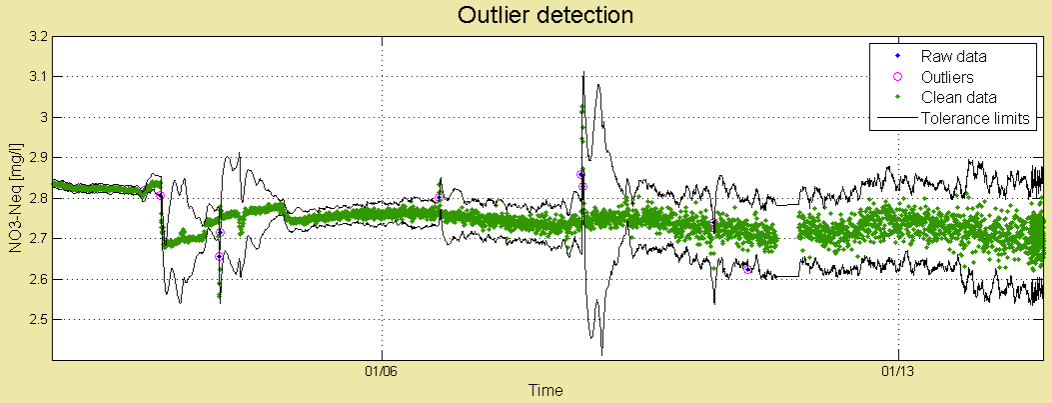
vali::tool – Real-Time Data Validation





vali::tool – Real-Time Data Validation





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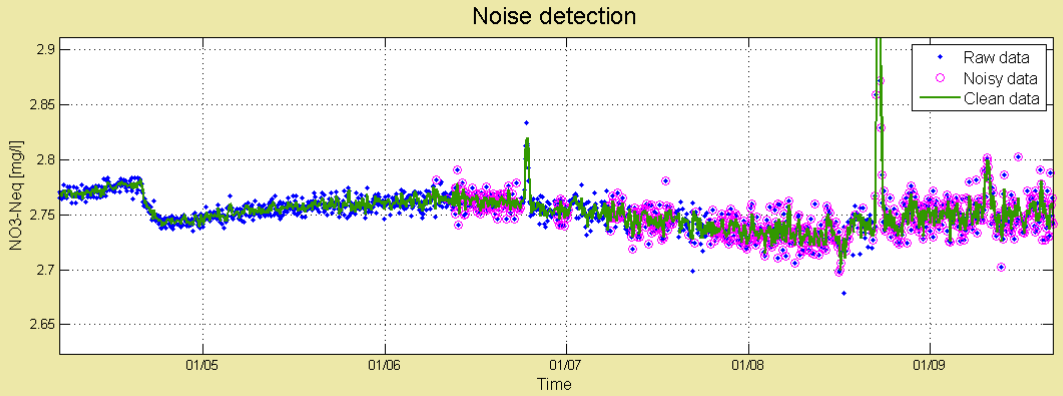

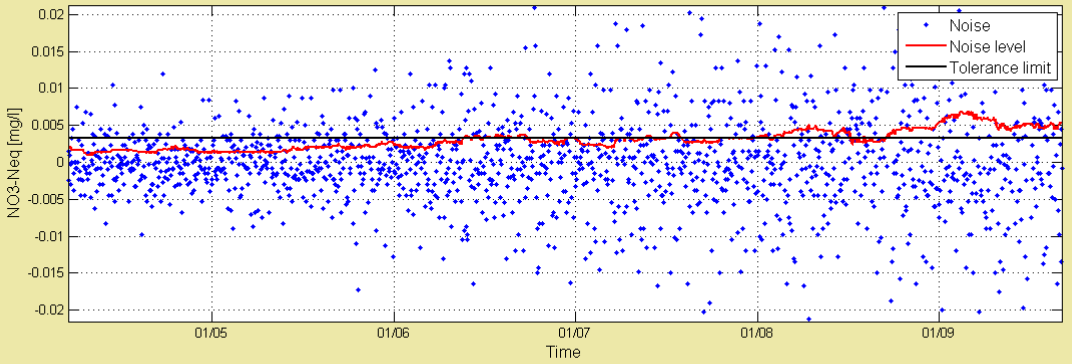

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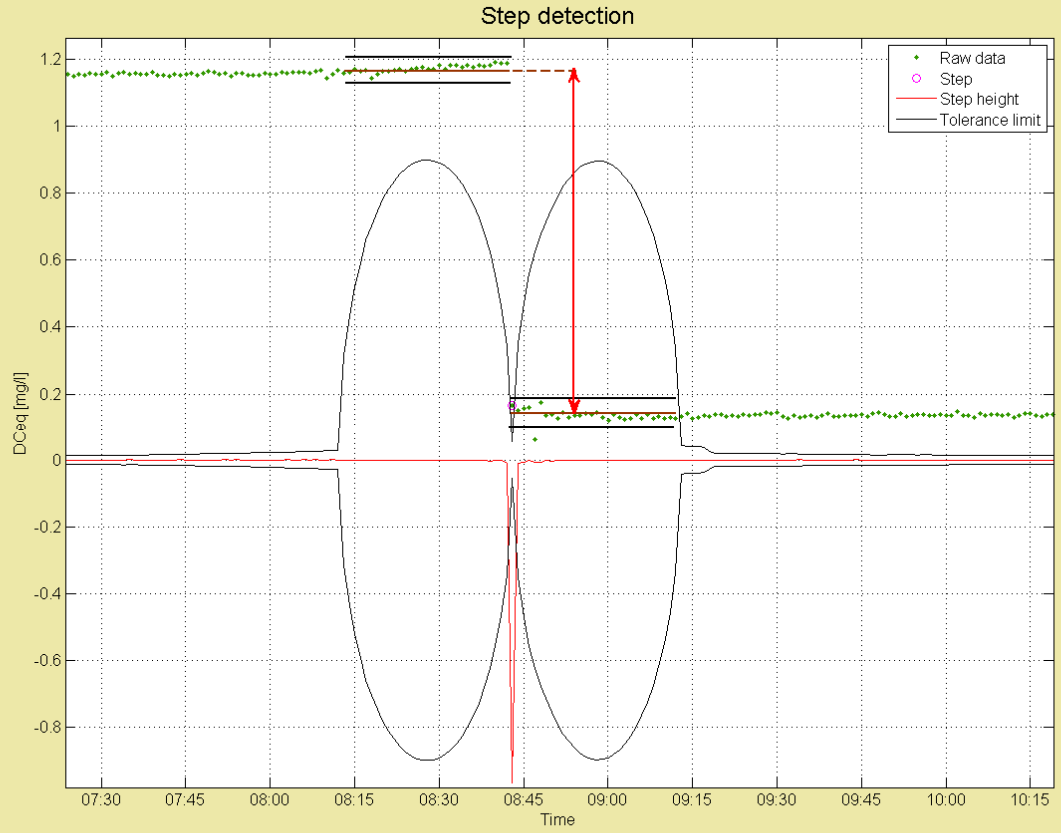

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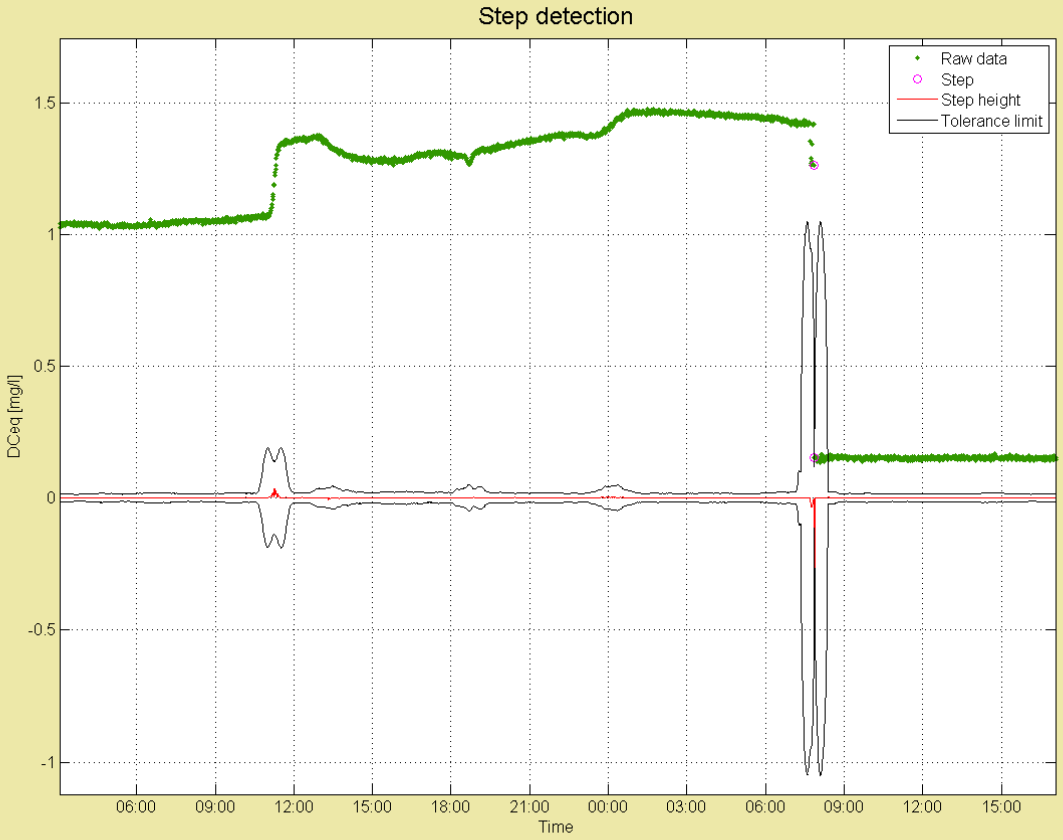

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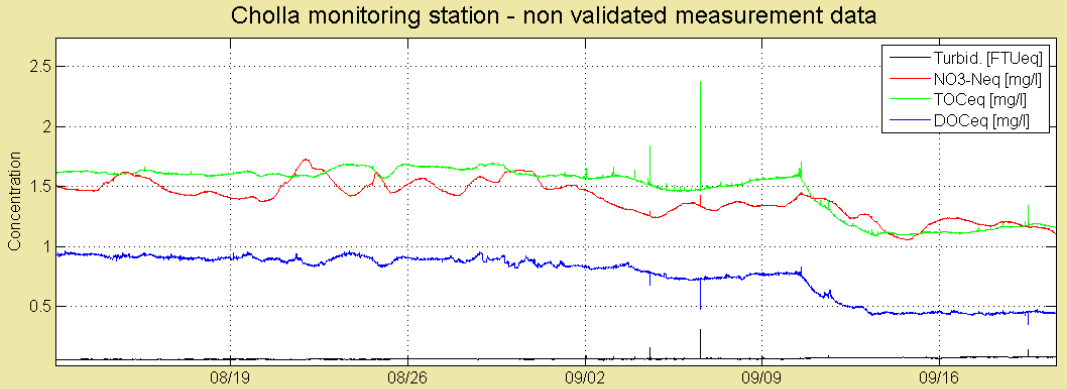
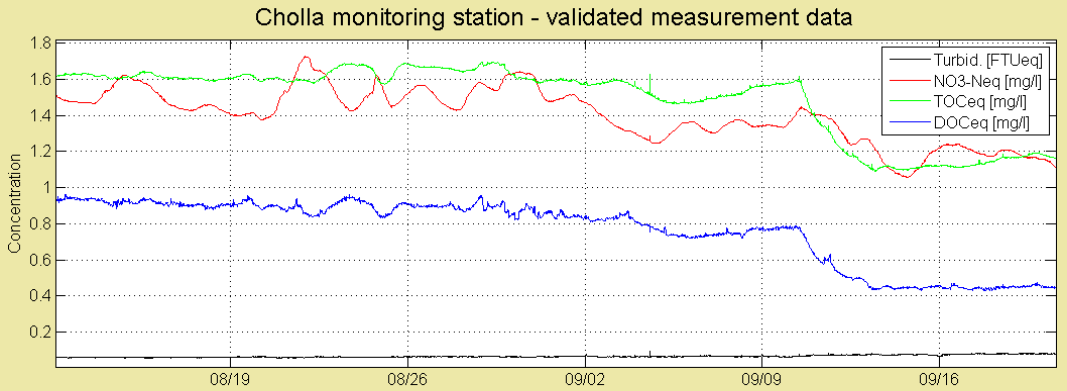
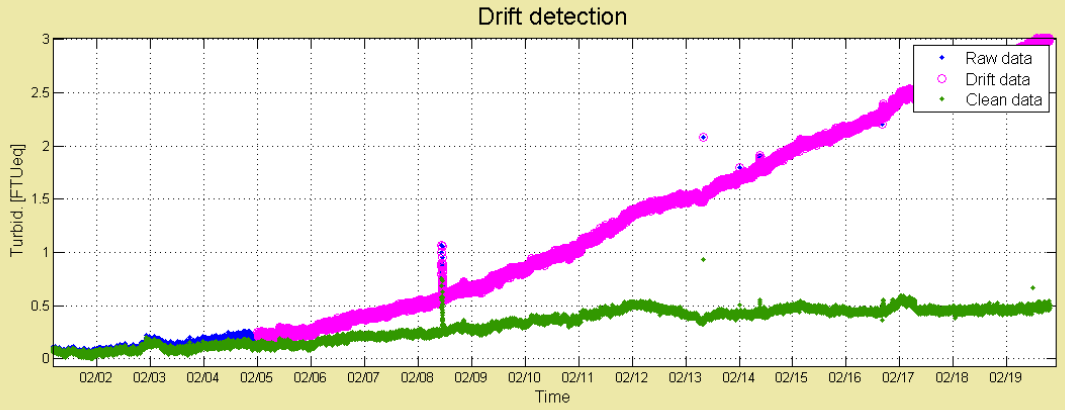
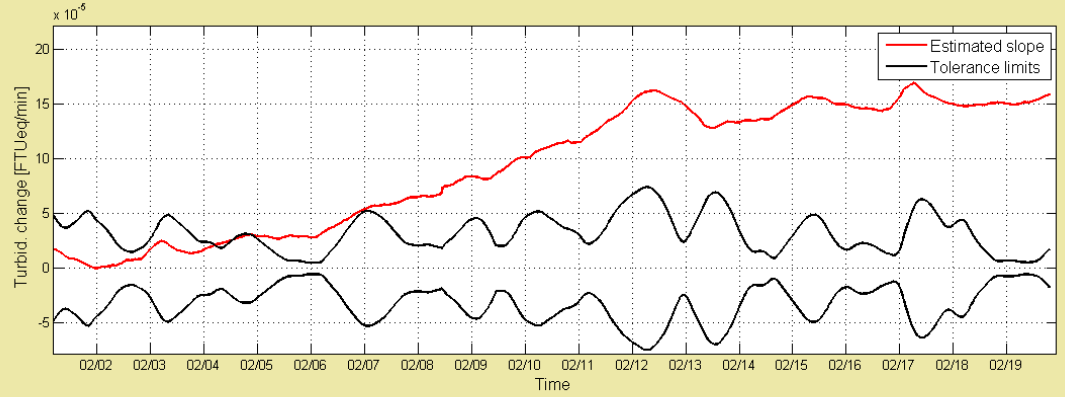




vali::tool – Real-Time Data Validation





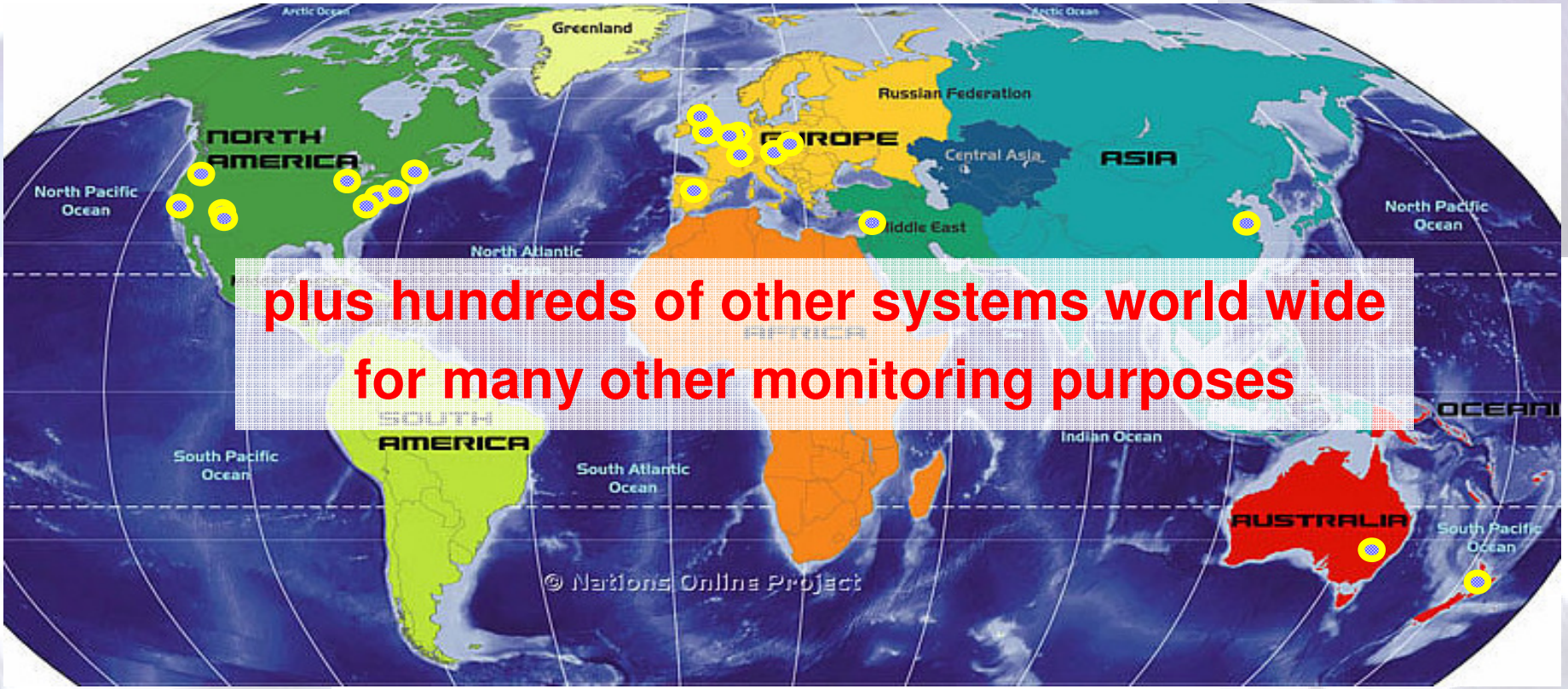
ana::tool – Event Detection Parameters

Possible inputs into ana::tool are:

- UV-Spectra (spectral features/“fingerprinting“, absorption, derivatives)
- parameters derived from spectra (TOC, DOC, NO3, FTU, etc.)
- non-spectral parameters (pH, conductivity, chlorine, temperature, bio-sensors, etc.)
- combination of all …. pattern learning and recognition algorithms

Experience

s::can spectral alarm systems in place or being installed:



Thank you!

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