



Control and optimization of wastewater treatment plants

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MMEA Wastewater Keydemo
Helsinki 17 September 2015



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Measurement, Monitoring and Environmental Assessment

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Measurements → Applications



- Basis: Measurements
 - Microwave, image processing, LED, ...
 - Sampling, dilution, cleaning, uncertainty
 - Towards on-line and process
- Methodology: Data analysis → pipelined
- Intelligent analysers (soft sensors)
- Decision support & operating conditions
- Modelling with specific submodels
- Integration to automation
- Risk analysis
- Services

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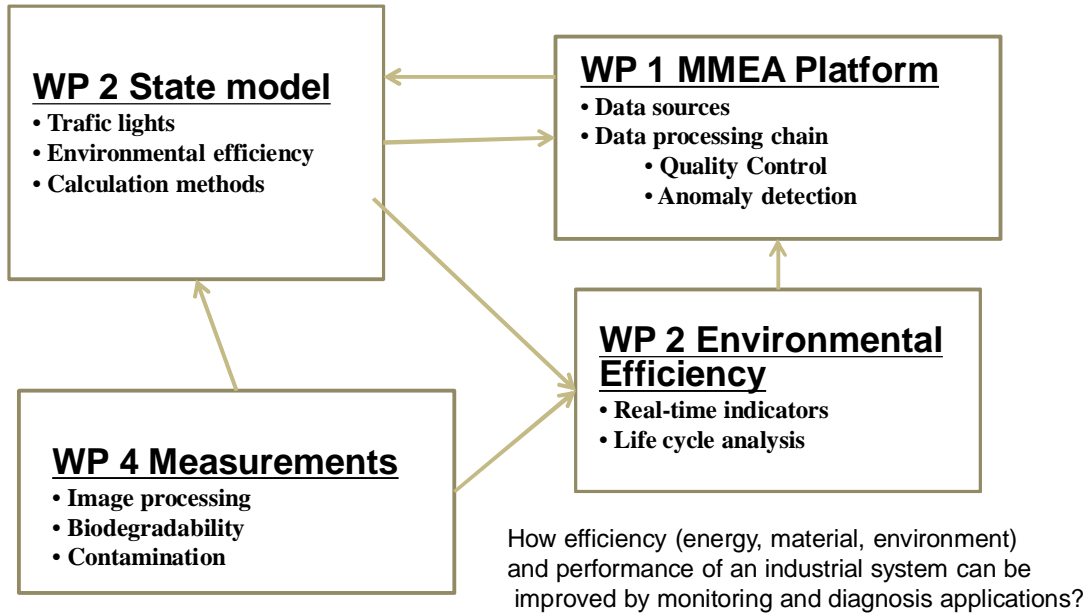
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How industrial applications can utilize MMEA platform and vice versa?



Monitoring and control

- Data analysis: nonlinear scaling → indices, limits
- Intelligent indicators
 - Scaled values [-2, 2]
 - Trend indices
 - Plant performance: long windows
 - Control + DSS: short windows
- Traffic lights
 - Levels & Trends
- Cases: wastewater treatment (WWT) plants
 - Pulp mill WWT (Stora Enso, Oulu)
 - Municipal WWT (HSY),
- Automation systems → Online (Valmet)



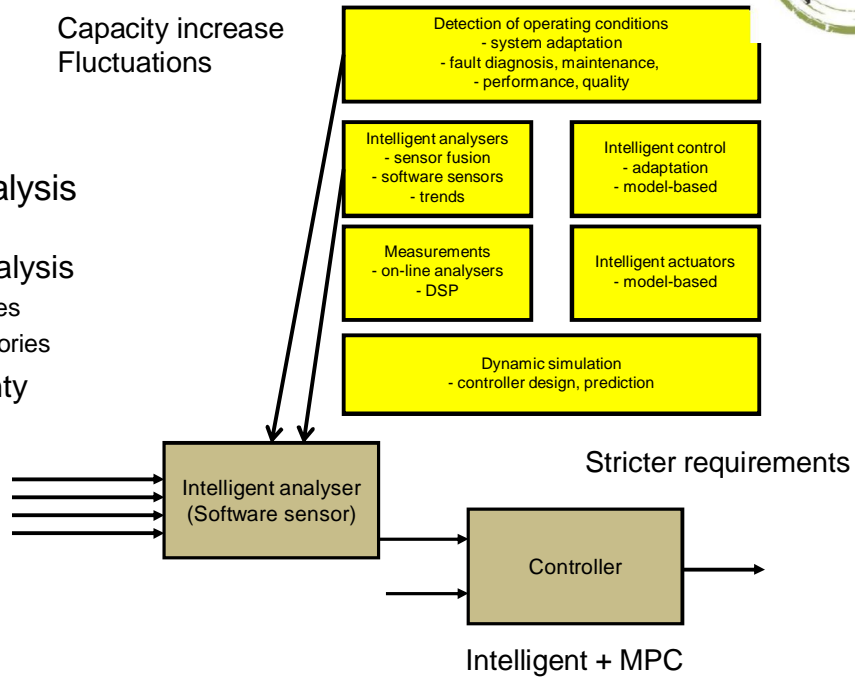


Measurements → Control

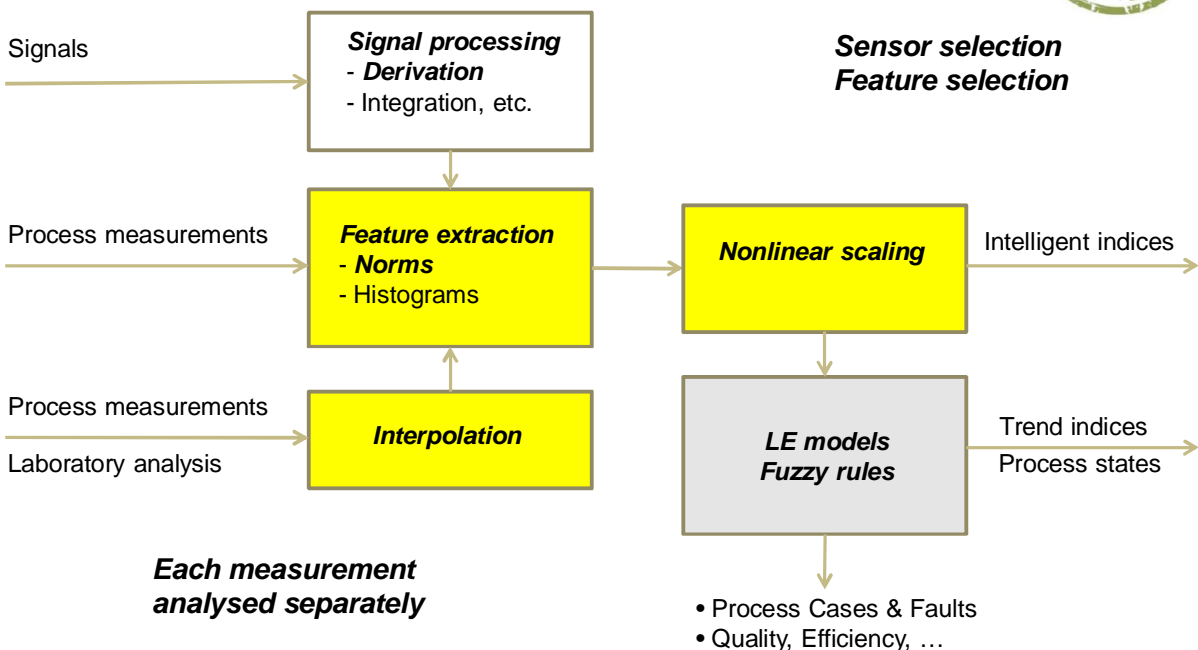


Capacity increase
Fluctuations

- Data analysis
 - Limits
- Trend analysis
 - Changes
 - Trajectories
- Uncertainty



Measurements → Features → Indices





Data analysis: generalised norms



- A generalised norm

$$\|{}^{\tau} M_j^p\|_p = ({}^{\tau} M_j^p)^{1/p} = \left[\frac{1}{N} \sum_{i=1}^N (x_j)_i^p \right]^{1/p}$$

Separately for each variable x_j

p is a real number

- Special cases. Min ... Max
 - Arithmetic mean
 - Standard deviation, rms value
- Variable specific



Generalised moments → Limits



- Normalised moments

$$\gamma_k = \frac{E[(X - E(X))^k]}{\sigma_X^k}$$

$k = 3$ Skewness

$k = 4$ Kurtosis

- Skewness

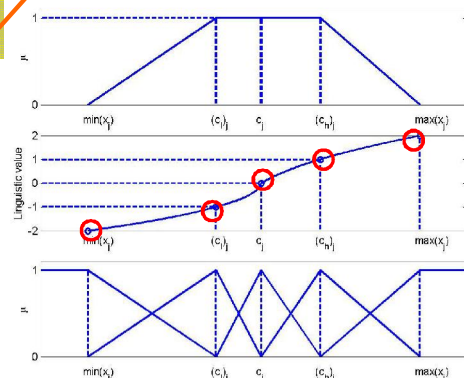
- Positive $\gamma_3 > 0$
- Symmetric $\gamma_3 = 0$
- Negative $\gamma_3 < 0$

$\gamma_3 = 0$

Central value

- Generalised moment

$$\gamma_k = \frac{E\left[\left(X^{(\alpha)} - \|{}^{\tau} M_{\alpha}^p\|_p\right)^k\right]}{\sigma_X^k}$$

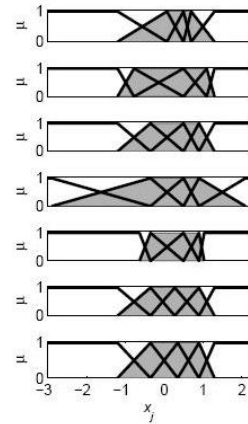
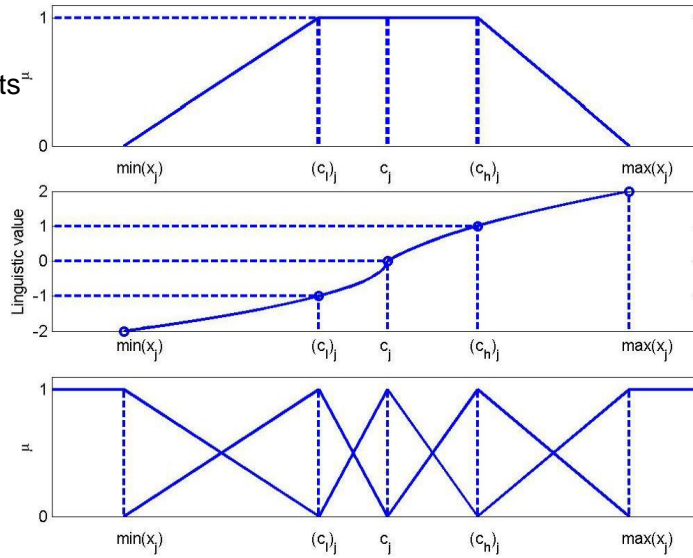




Nonlinear scaling



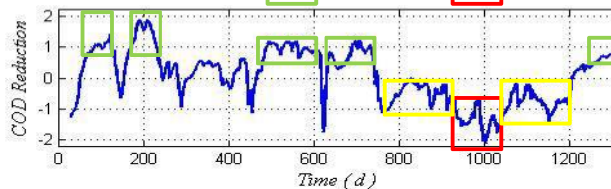
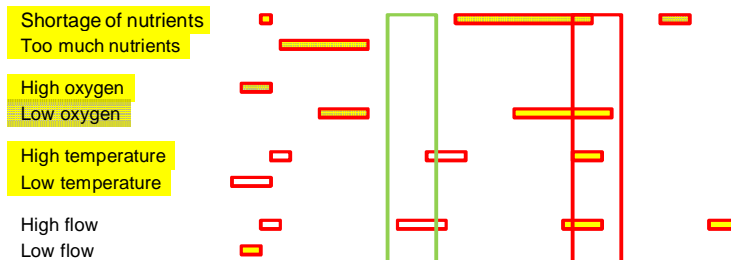
Measurements μ
 ↓
 Meanings
 ↑
 Expert knowledge



- Linguistic levels can translated into numbers
- Natural language

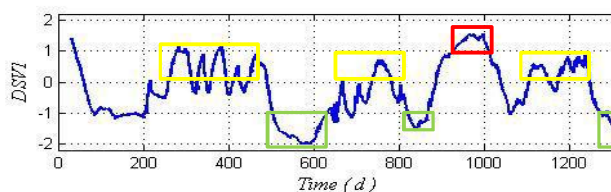


Process states & Limits ↔ Traffic lights



Very good
 Low reduction

Warnings

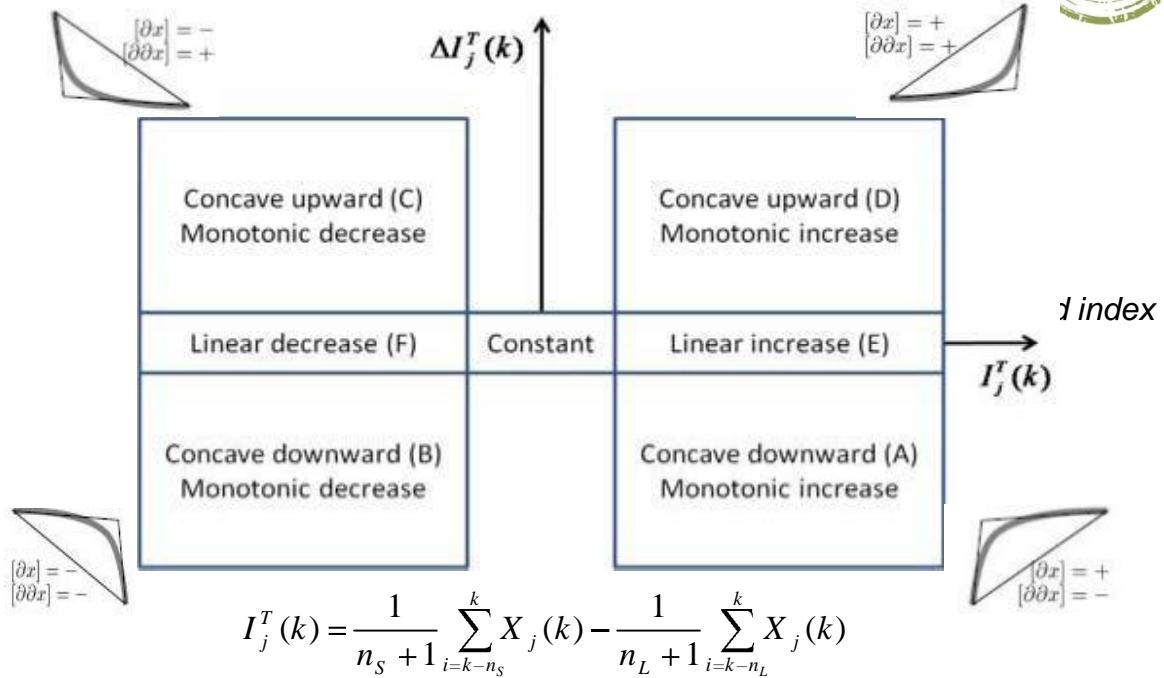


Settling problems
 Very good

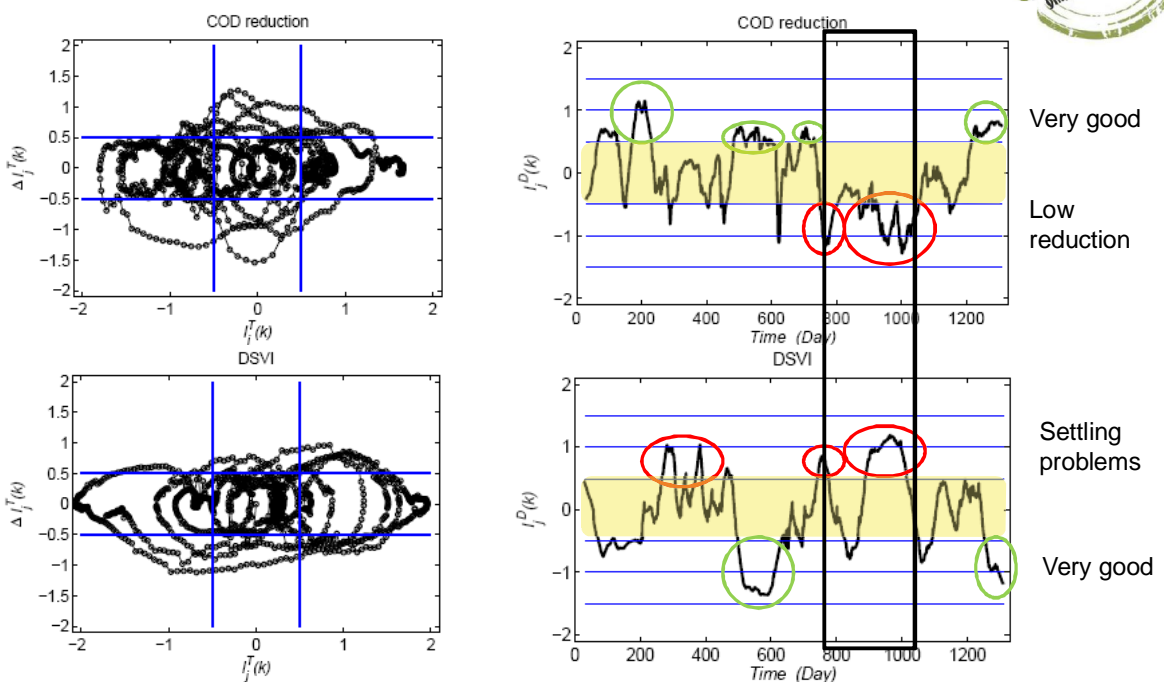




Trend analysis



Treatment results



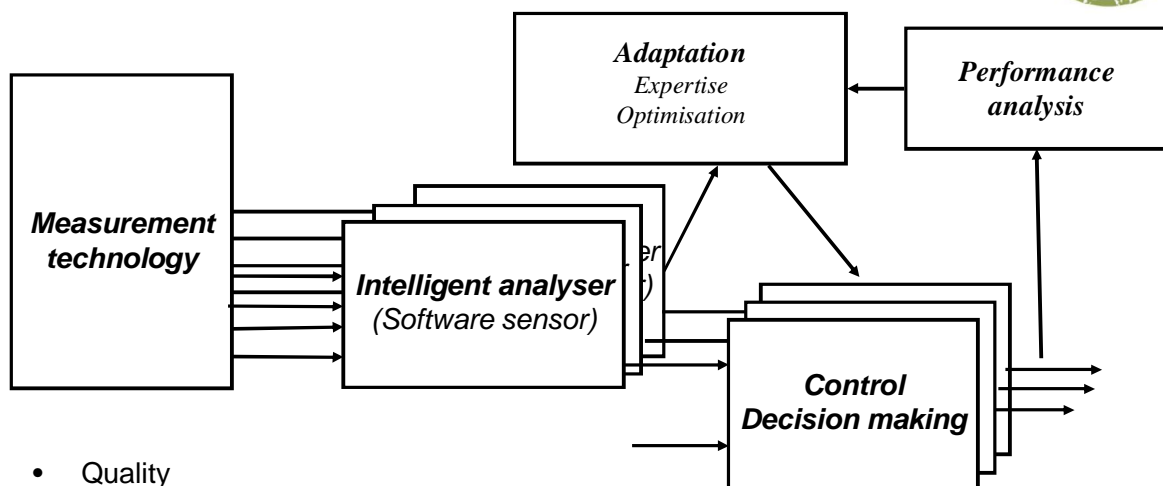


Decision support systems

- DSS system architecture
- Data visualization
 - Traffic lights
 - Trends
- Diagnosis tools
 - Variable specific
 - Combined
- Modelling
- “What if” simulations
- Detected problems
- Advisory tools for operator support
 - Process control
- Connectivity of industrial information systems with MMEA platform



Monitoring → Decision support

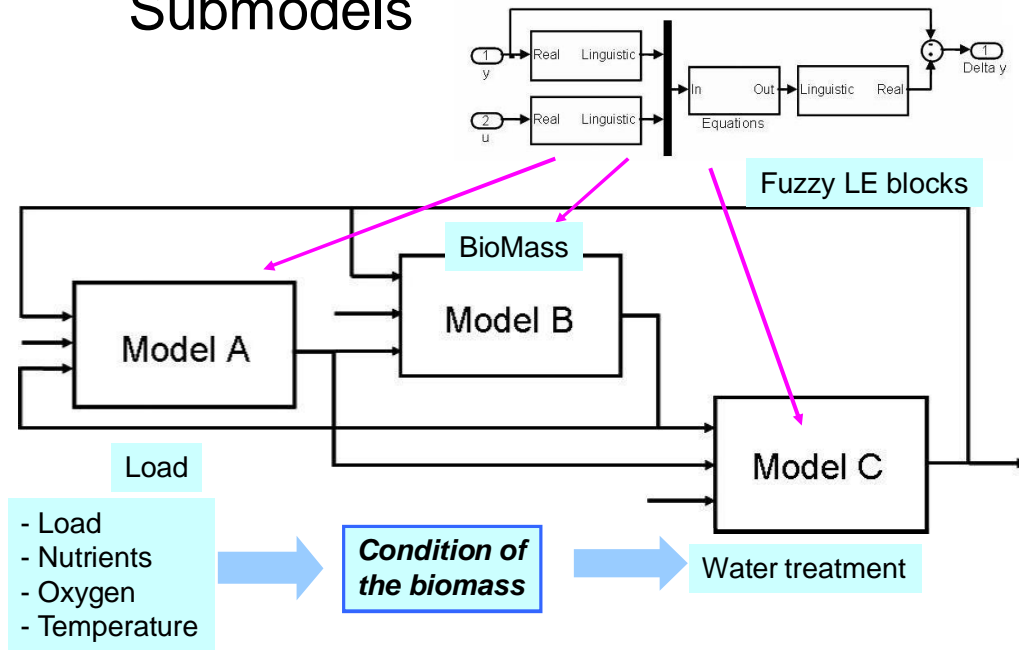


- Quality
- Uncertainty handling
- Online analysers and laboratory measurements
- Open data (weather)

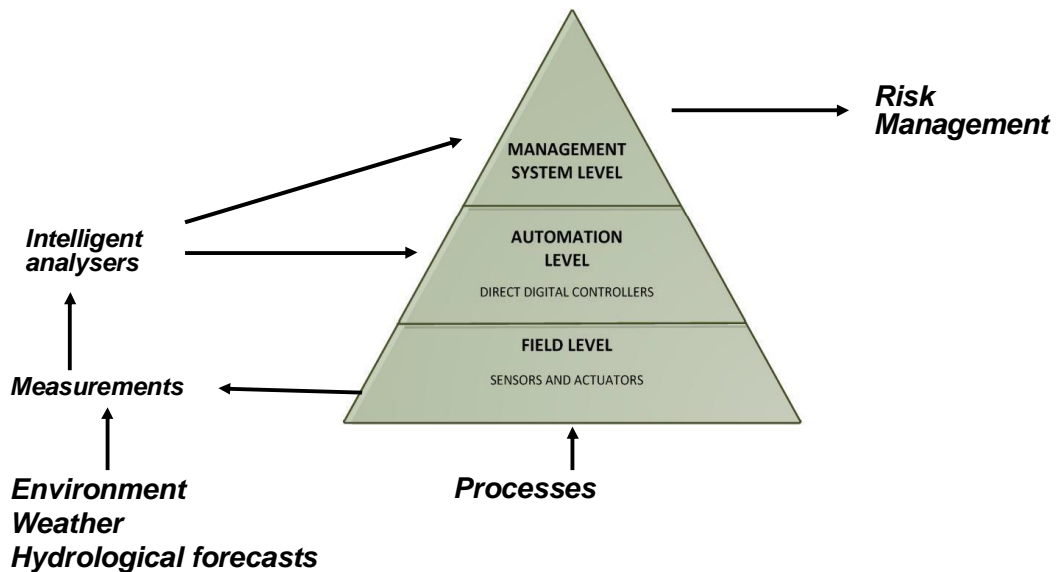




Submodels

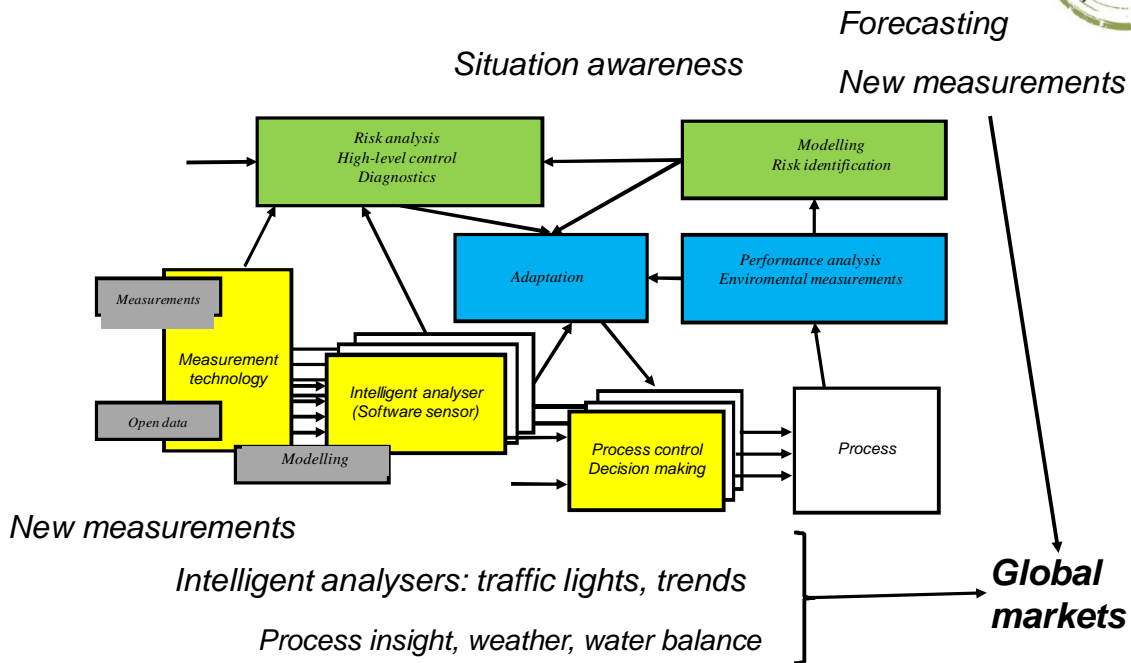


Measurements → Automation → Risk Management





Risk management

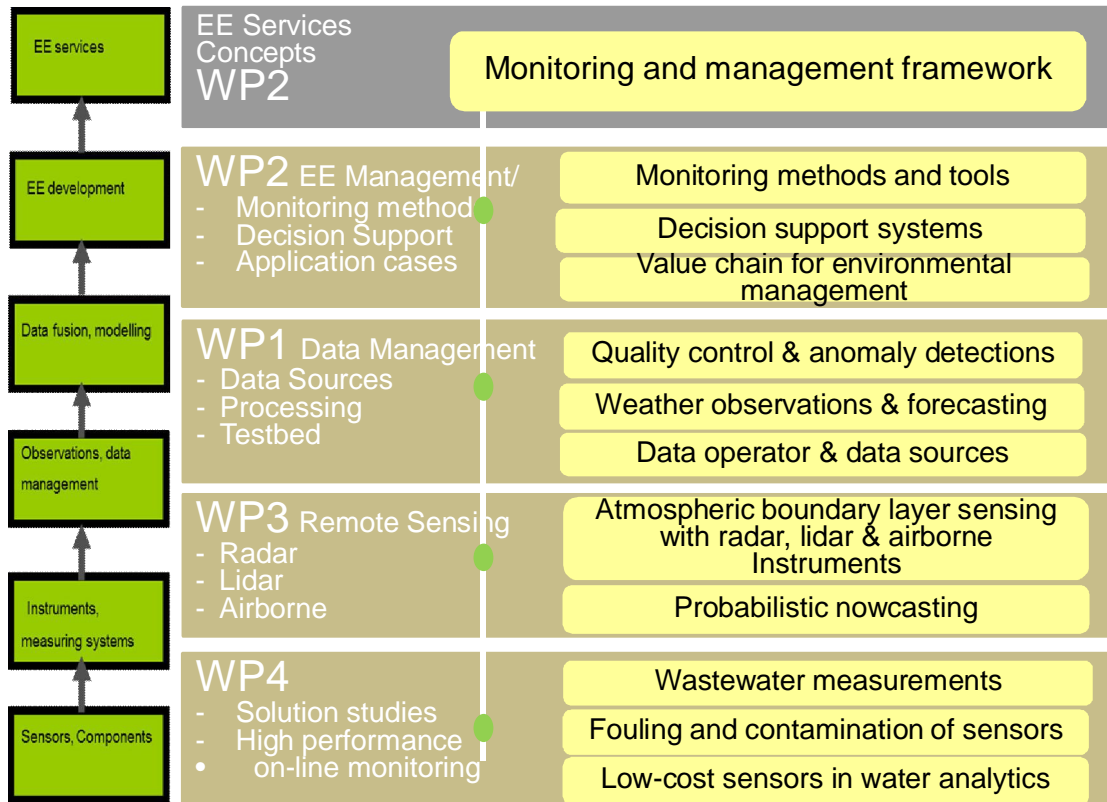


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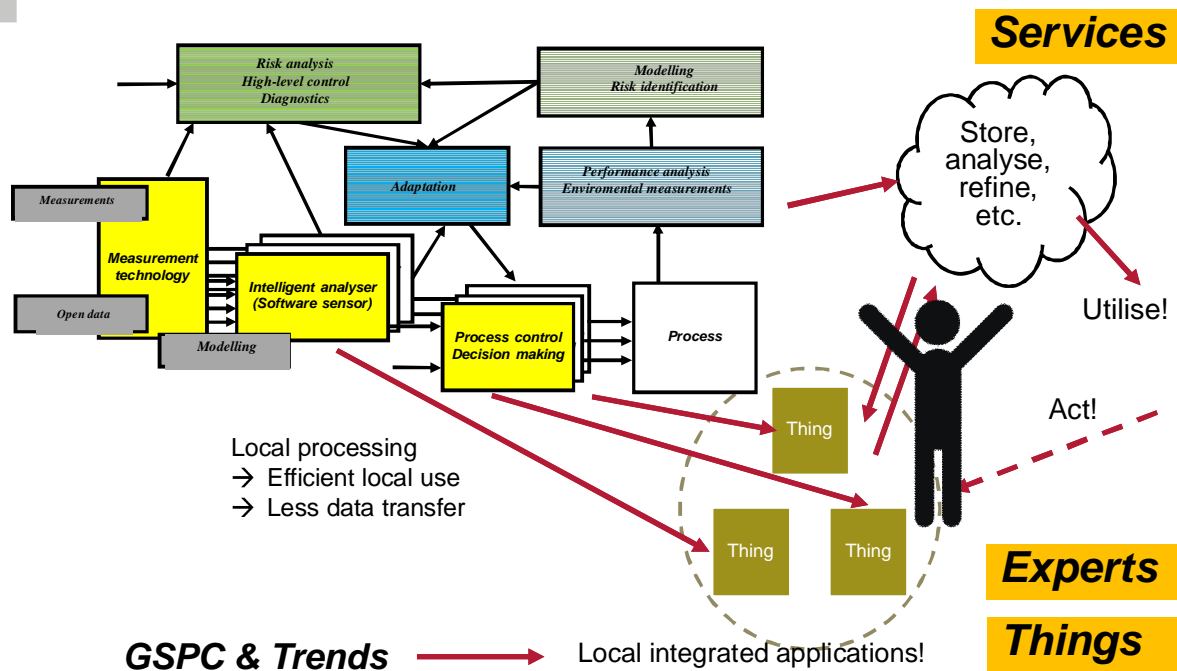


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Smart Applications in Industrial Internet



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IoT → **PoS**

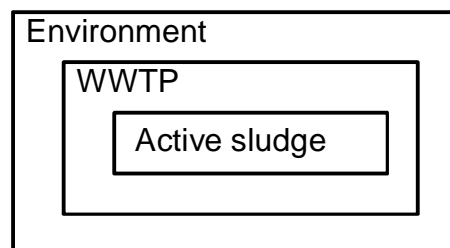
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Conclusions

- Process measurements → real-time
- Sampling → Laboratory analysis
- More real-time measurements
- Combine measurements + trend analysis + GSPC
- Monitoring → Control & Optimization
- Forecasting + Risk identification
- Situation awareness
- Services

Open data
Participatory observations



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