



Measurements

Basis for mine water risk management

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IX ENVIRONMENTAL MONITORING DAYS
Kajaani 27-28 March 2014

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Outline

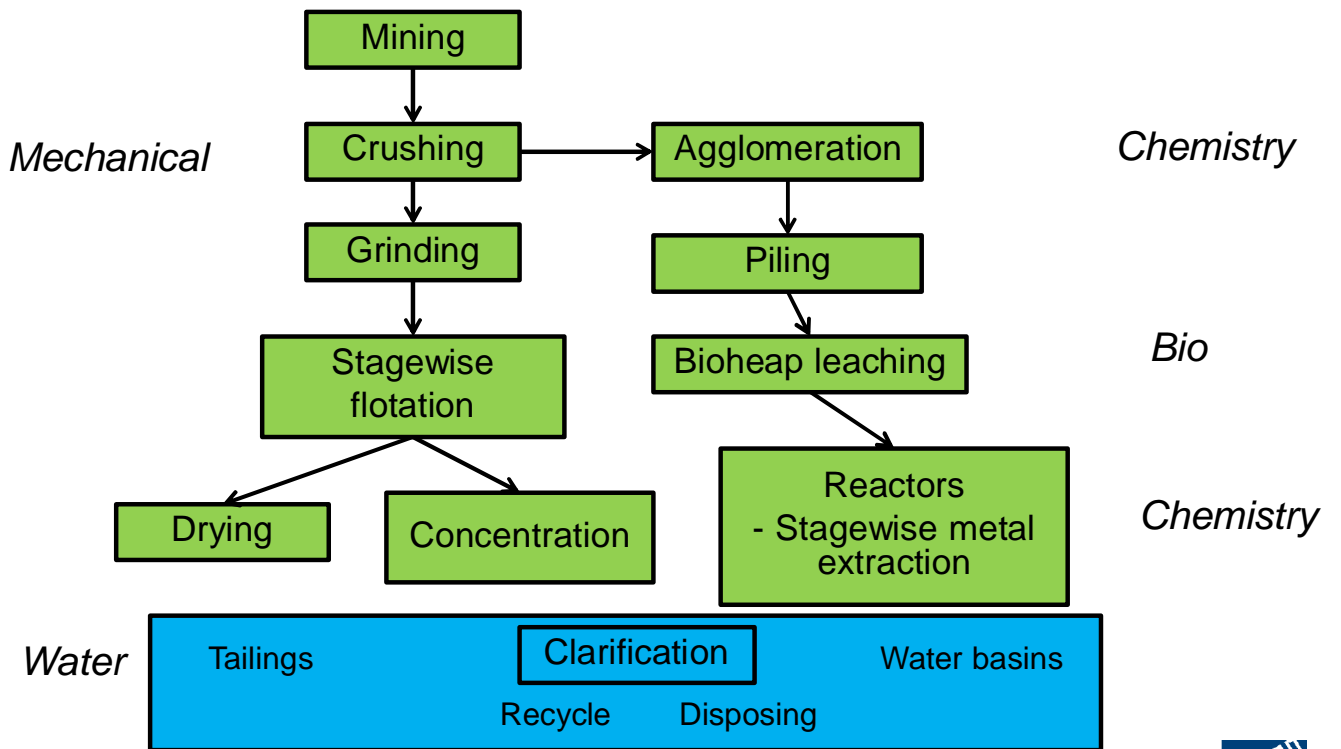
- Mine processes and water
- Measurements
 - Process & environment
 - Laboratory & online
- Water balance
 - weather, rainfall, snow
 - Hydrological forecasts, 3D
- Automation & monitoring concept
 - Combined measurements, trend analysis
- Risk management
- Conclusions

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Unit processes

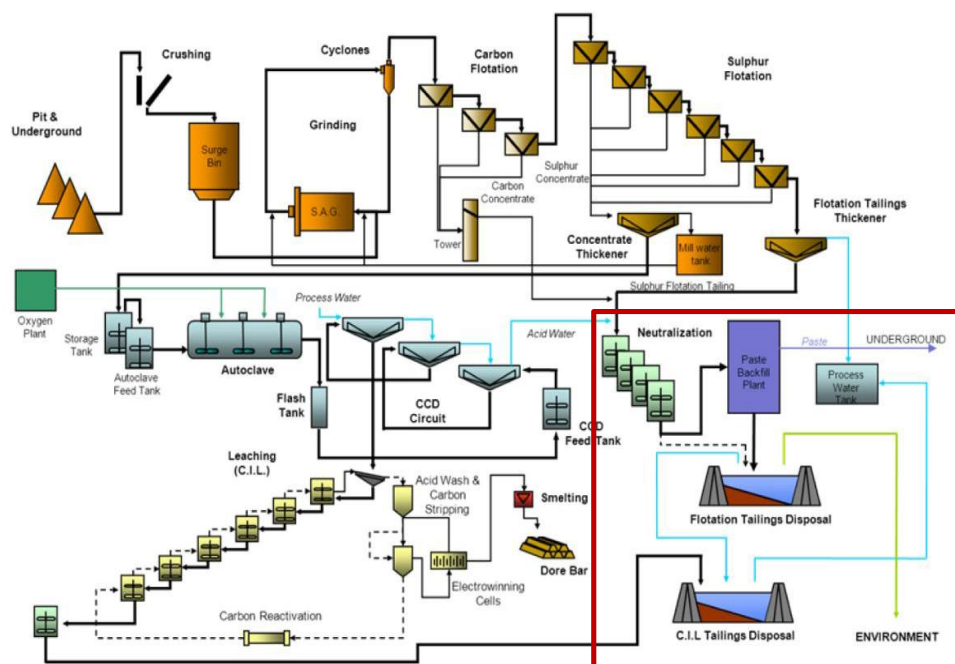


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Process flow sheet



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Water handling

Mine water

- Water supply
- Process water
 - Mining & mineral processing
 - Metallurgical extraction
- Wastewater (disposed)
 - Contamination
 - Waste → drainage, leakage
- Ground/Surface water
 - Rainfall
 - Melting of snow

Treatment and recycle

- Remove harmful chemicals
 - for processes
 - for environment
- Explosives → nitrogen + suspended solids
- Settling ponds
- Tailing dams (=crushed stones + chemicals) & other solid materials

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Measurements

Process

- flow (water, sludge & chemicals),
- pH, density, redox, volume, mass, temperature,
- level, dosage, air, pressure, gas flow, location, speed and conductivity,
- metal concentrations,
- suspended solids

Environment

- basin levels, suspended solids, flow, temperature, metal concentrations, air quality, pH, electrical conductivity
- dust, particle measurements
- moss analysis

***Note! Processes are mine specific,
i.e. developed for specific ores and metals.***

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Laboratory measurements

- Highly accurate in principle
- Time-consuming & tedious → Expensive
- Sampling in large areas
- Infrequent → hazards if leakages
 - Even small concentrations of heavy metals can be very harmful
- Environmental measurements:
 - Regular monitoring of wastewater required
 - Measurement locations
 - Sampling frequency: weekly, monthly, yearly



Online measurements

- Continuous & real-time
- Problems
 - Reliability & accuracy (malfunctioning periods)
 - applicability
 - speed
 - Cost
 - Cleaning requirements
 - Maintenance
- Rough and varying operating conditions
 - Process and weather
- Process measurements
- Condition monitoring (machines and process equipment)
- Environment
- Approval from environmental authorities?
- Environmental regulations



Environment

Measured Variable	Talvivaara Sotkamo	Sotkamo Silver	FQM Kevitsa Mining	Agnico-Eagle Kittilä	Yara Finland Siilinjärvi
Ni	x		x	x	
Cu	x		x		
Zn	x	x			
Co	x				
Pb		x			
Sb	x	x	x	x	
As				x	
Al				x	
Mn			x	x	
Fe	x		x	x	x
sulphate	x	x	x	x	x
CN				x	
thiocyanate				x	
chloride			x	x	
pH	x	x	x	x	x
conductivity	x	x	x	x	x
flow	x	x	x	x	x
solids	x	x	x	x	x
N	x		x		x
temperature	x	x	x	x	x
redox	x	x	x	x	x
P					x
F					x
ground water surface	x	x	x	x	x

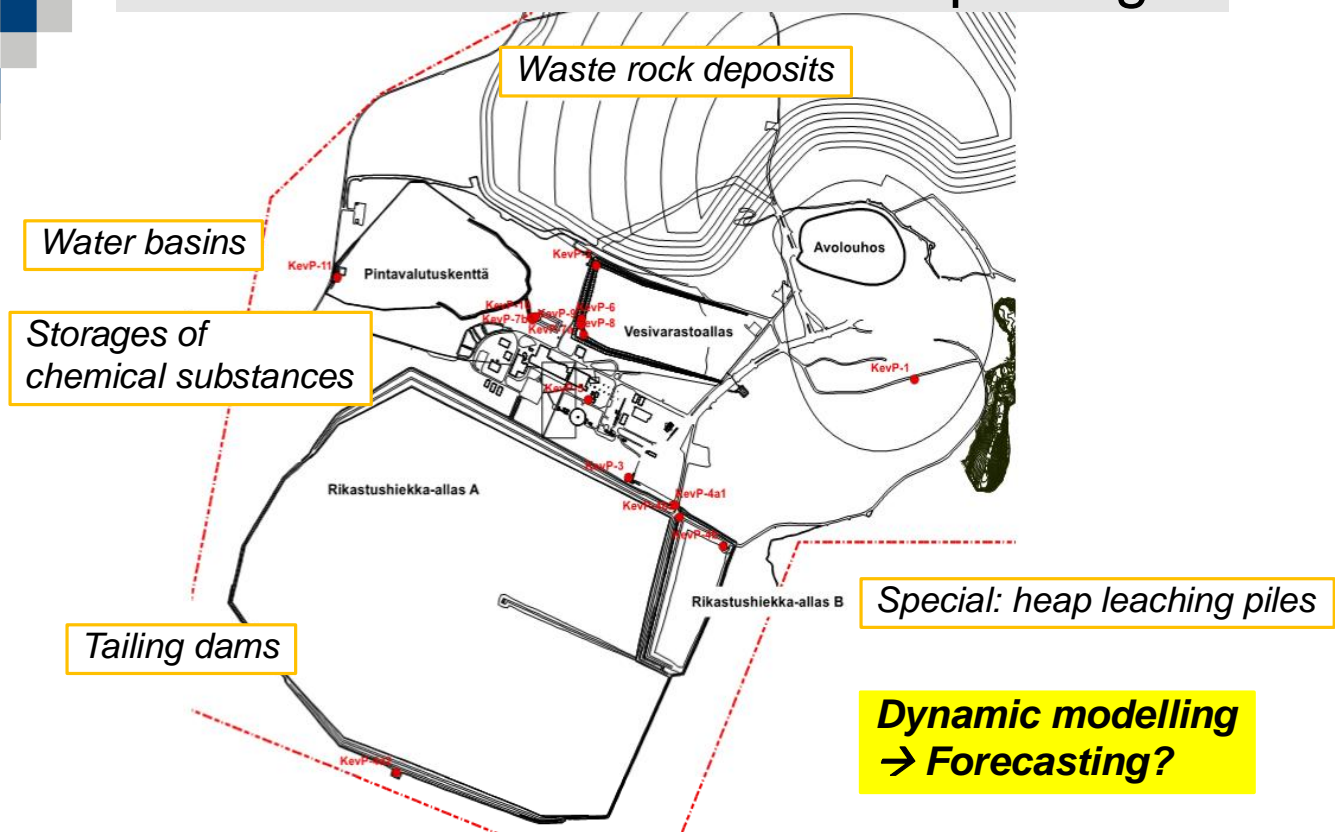
Online needs

Online available

Heavy metals are important, BUT matrix inference and very low concentrations!



Wast areas → measurement placing?

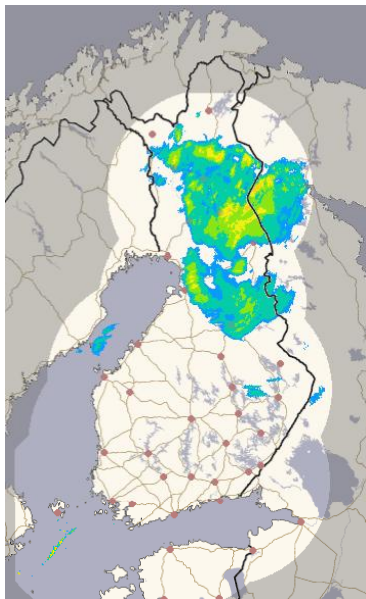


Geographical data

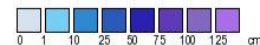
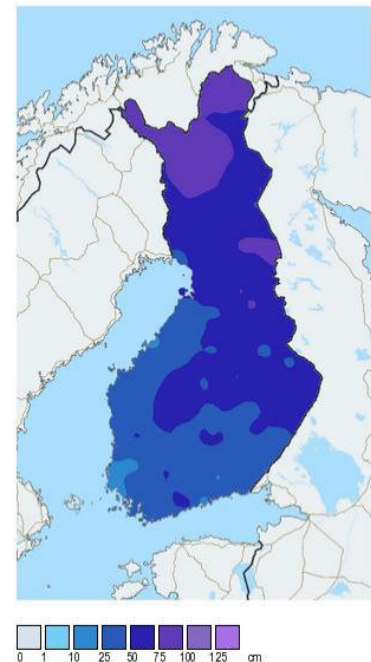
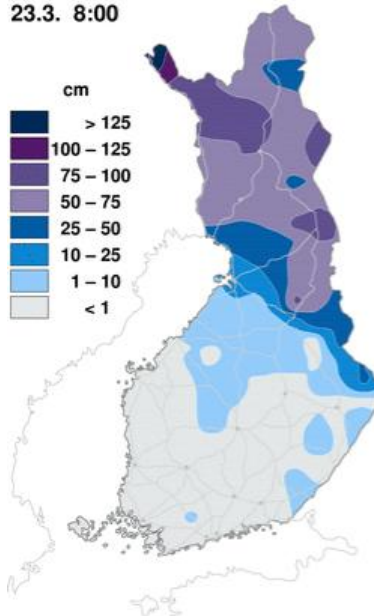
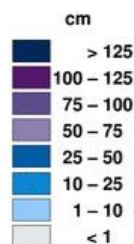
- Laser scanning → 3D data
 - airborne, terrestrial, mobile
 - unmanned airborne vehicles (UAV)
 - hyperspectral lidar system
- Digital terrain models (DTM)
- Digital surface model (DSM)
 - sensor quality
 - imaging system
 - atmospheric, illumination, and wind conditions during the data collection
- Detect environmental problems



Weather forecasts



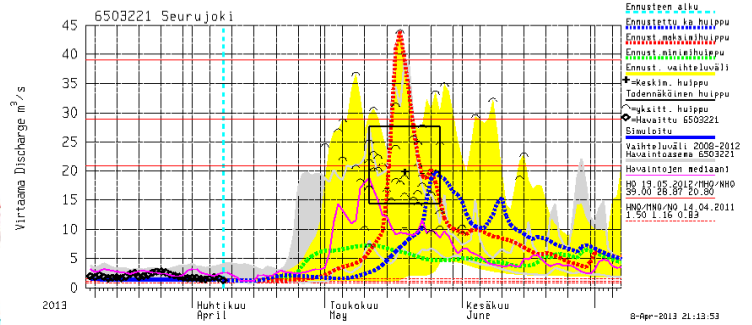
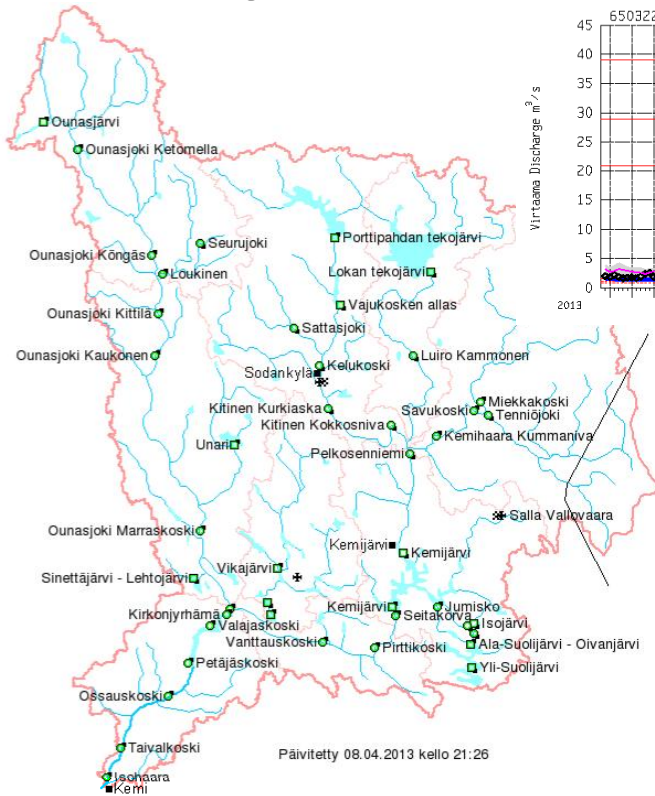
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Finnish meteorological institute (FMI) provides information about air quality, wind, temperature, climate, rain, snow depth, etc.



Hydrological forecasts



www.environment.fi

Finland's environmental administration (SYKE) provides

- Hydrological maps for water level, daily precipitation, water equivalent of snow, etc.
- Warnings for flood and water level, precipitation, snow load

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See testbed.mmea.fi

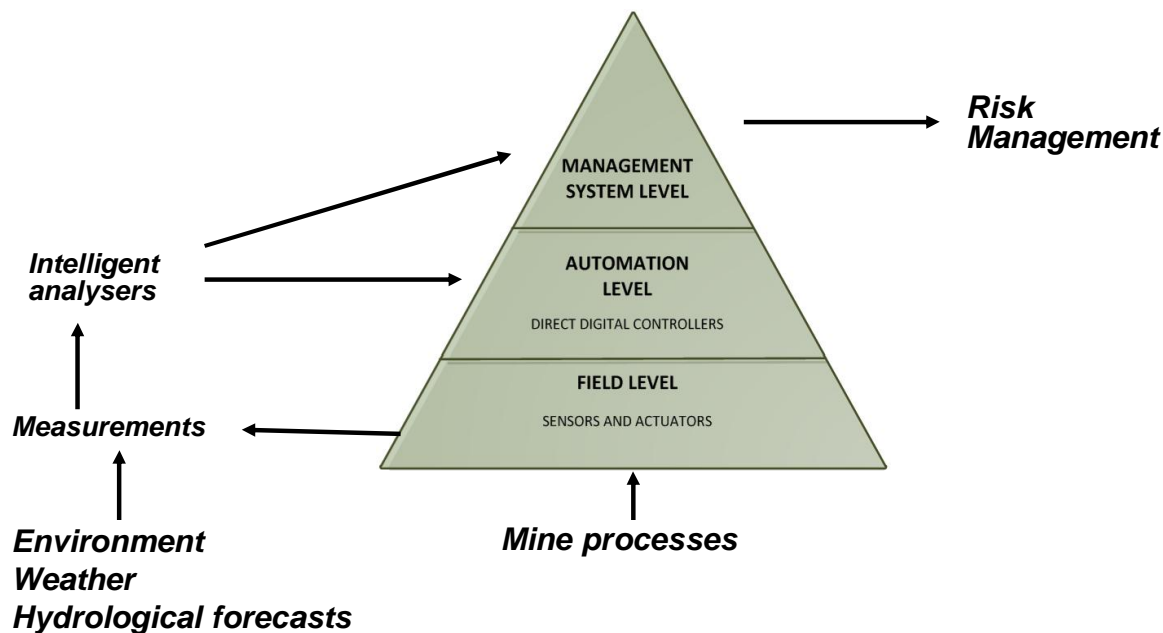
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Measurements → Automation → Risk Management

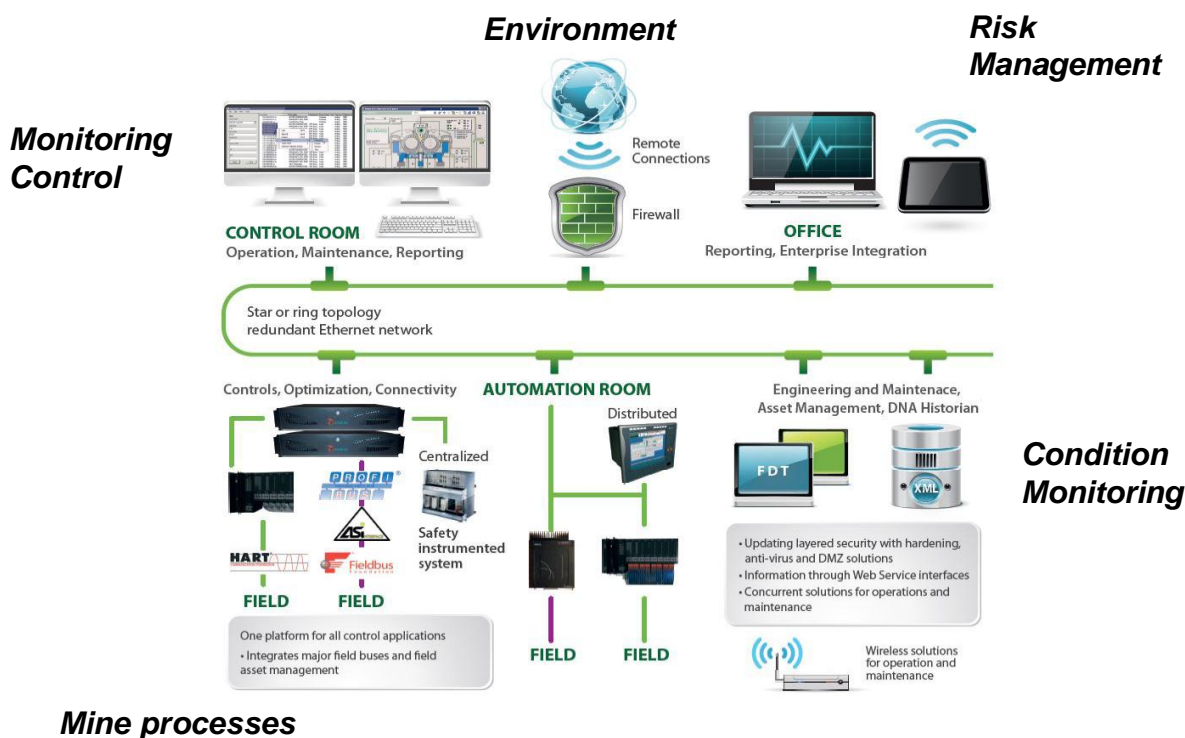


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Automation → Integration

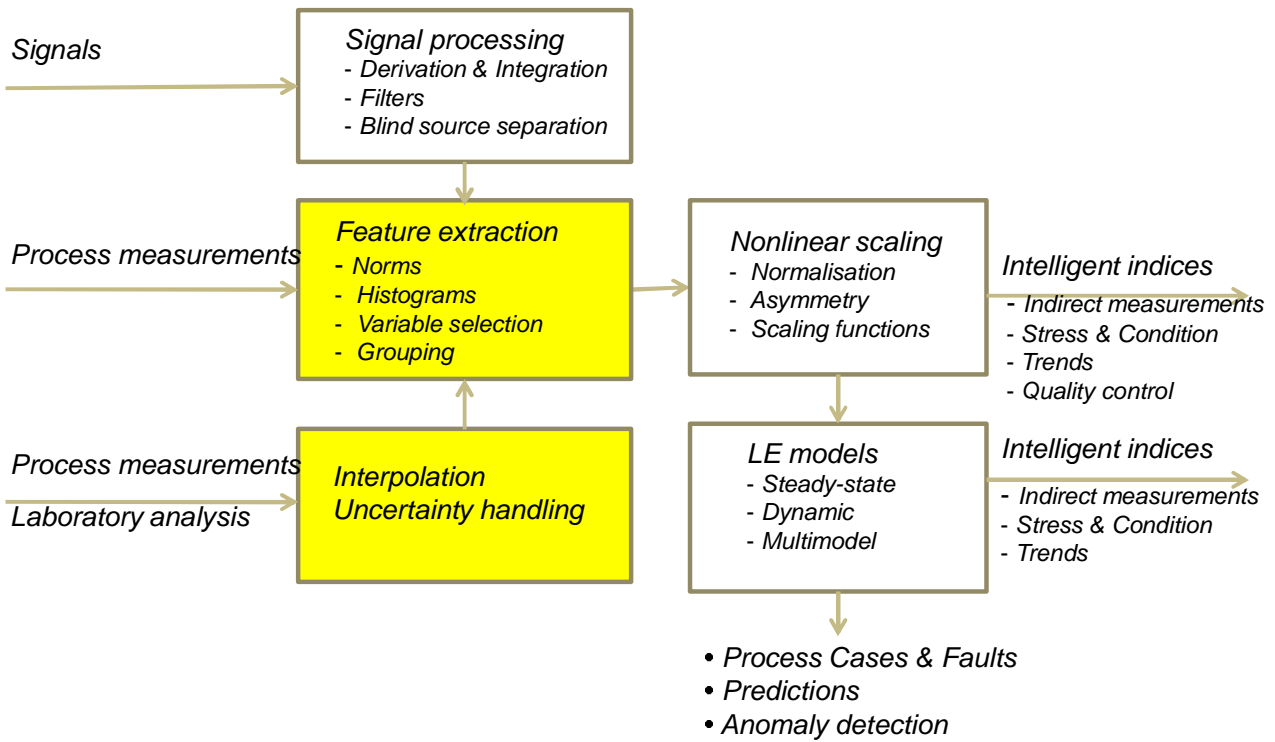


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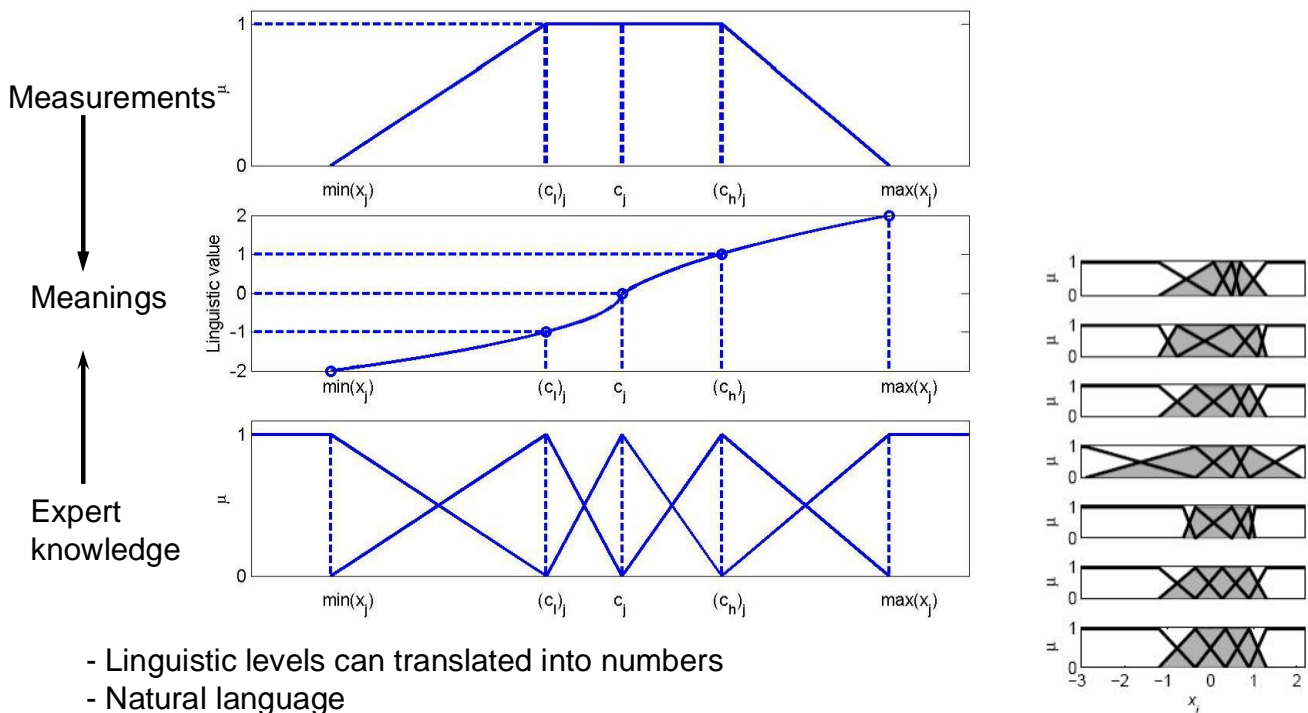
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Measurements → Intelligent analysers



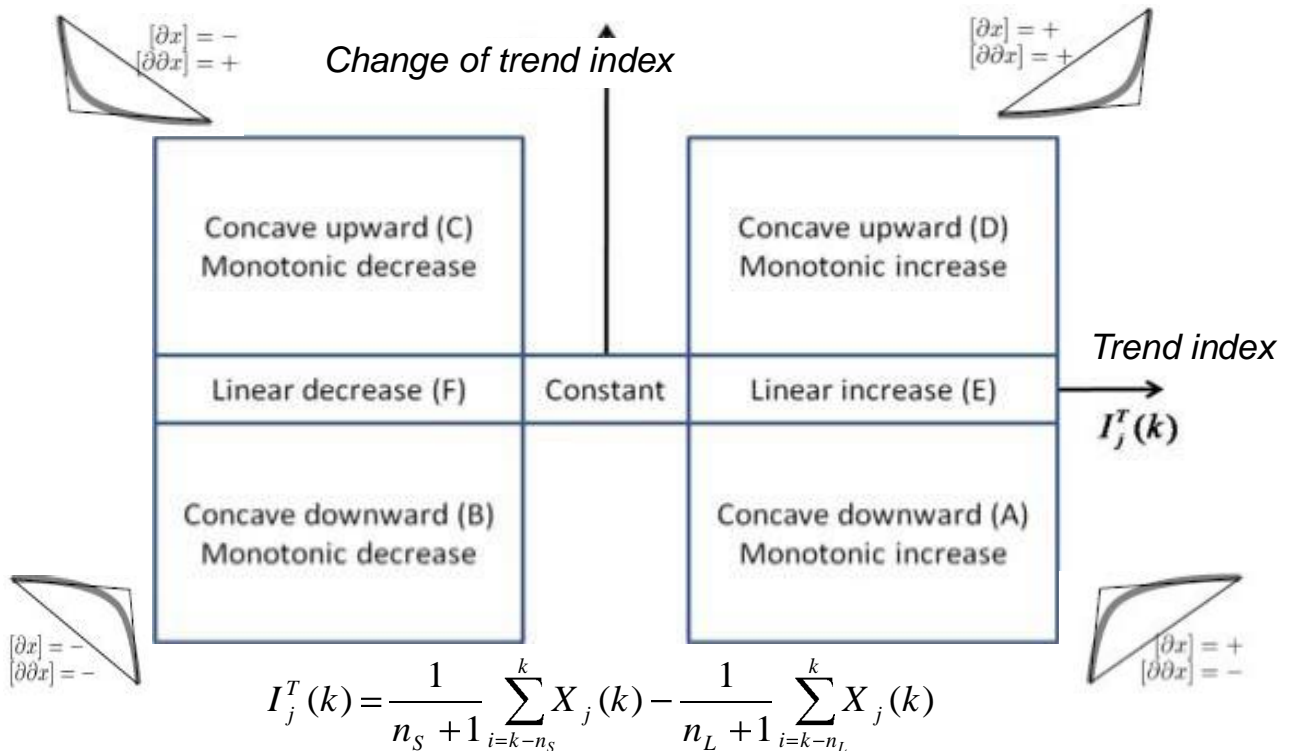
Nonlinear scaling



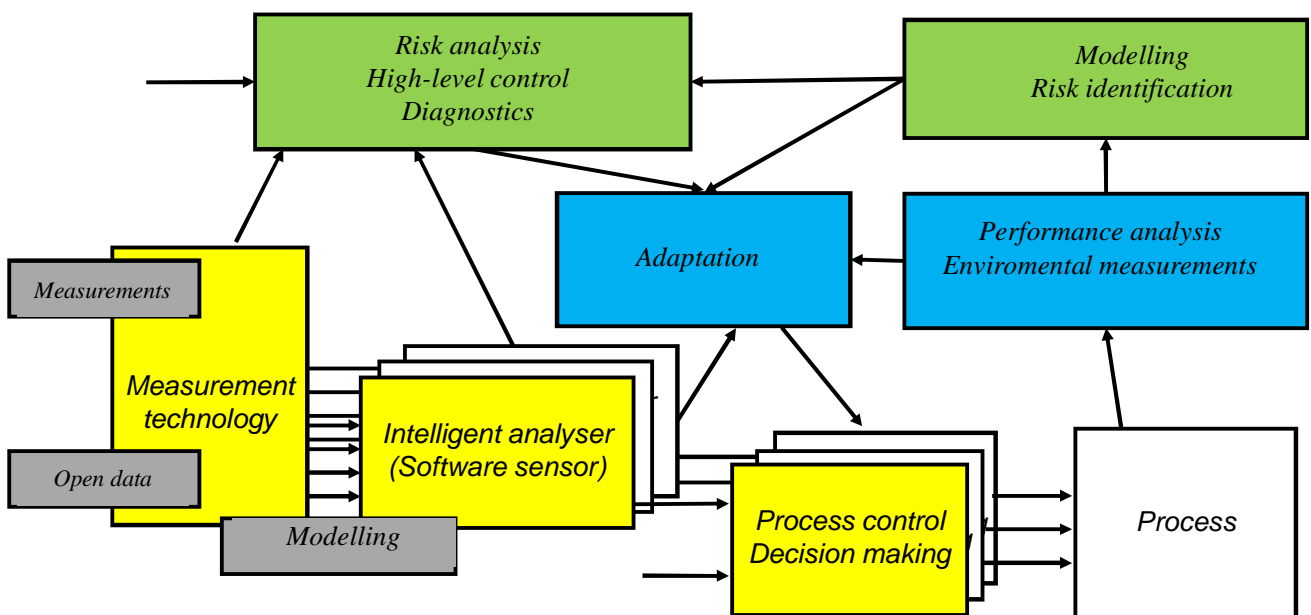
- Linguistic levels can translated into numbers
- Natural language



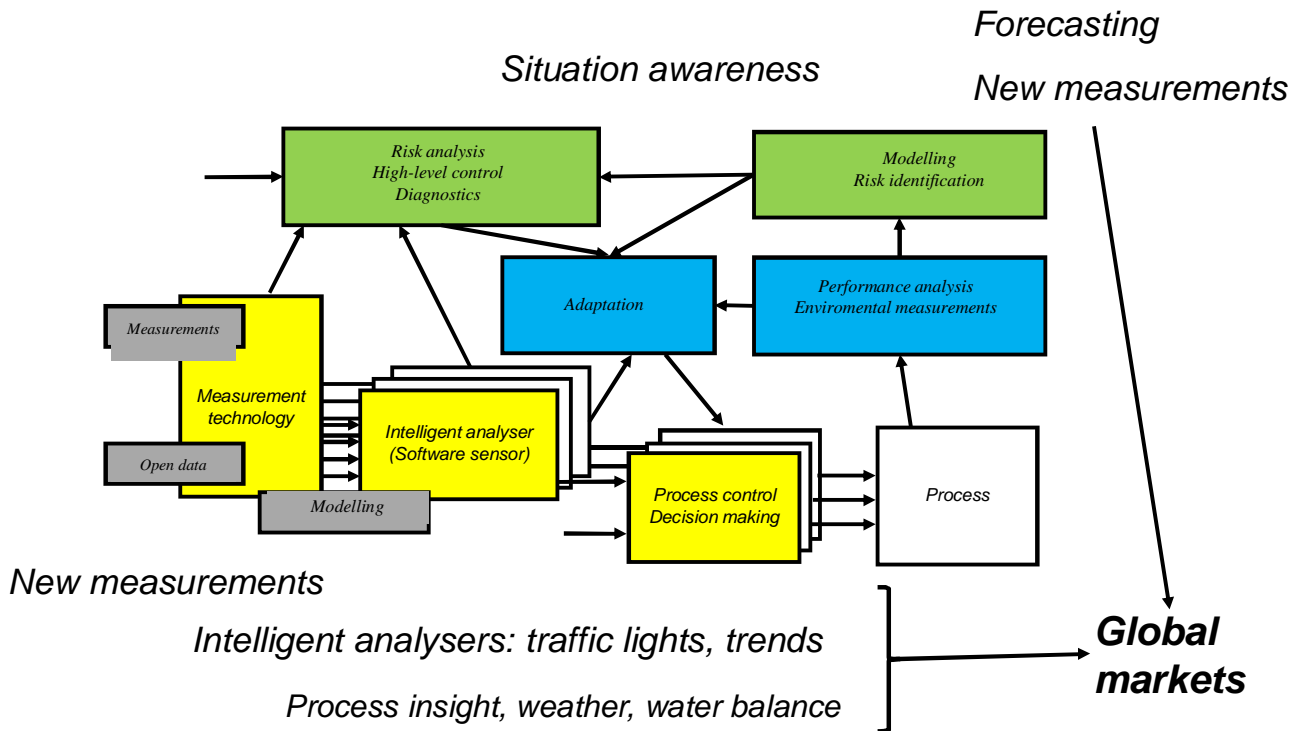
Trend analysis



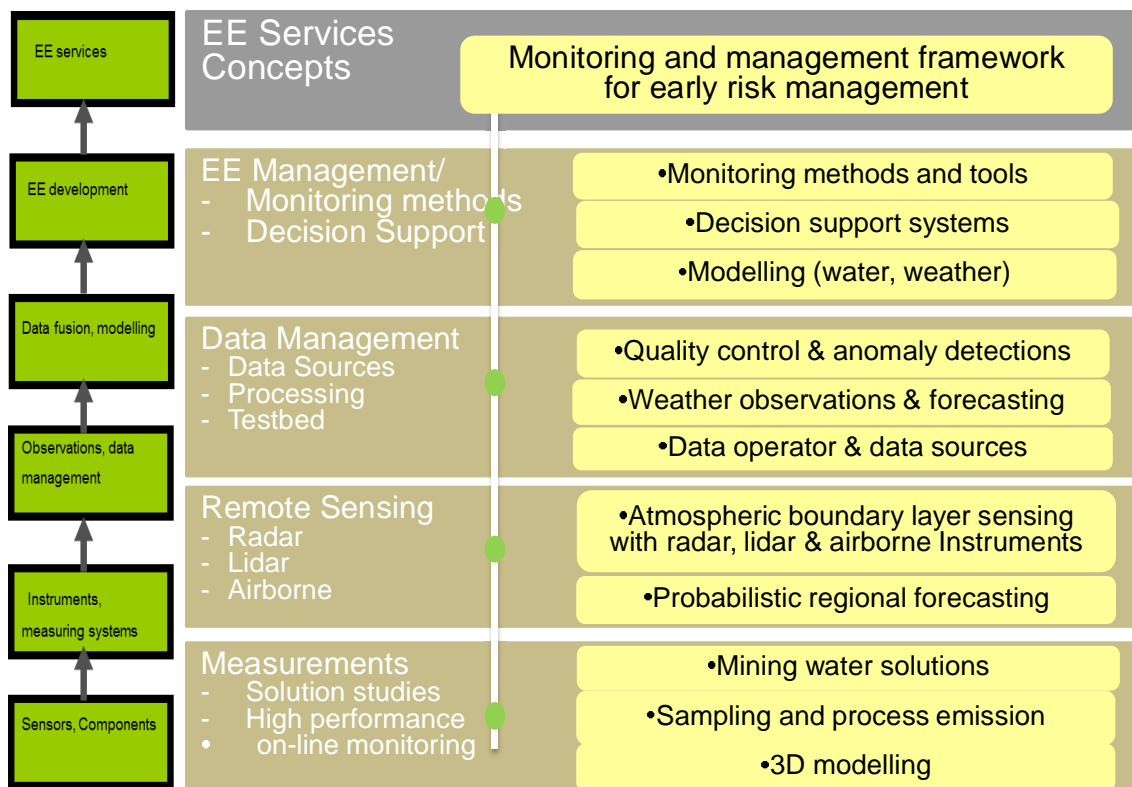
Risk management



Risk management



MMEA Mining Key Demonstration



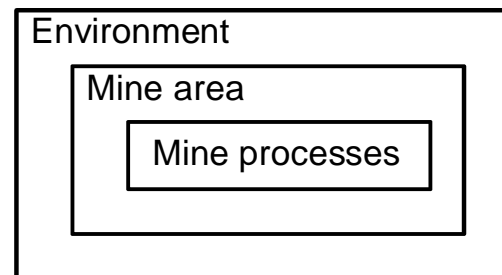


Conclusions

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

Open data

*Participatory
observations*



Publications

- Keskimölä A., Koistinen A. & Juuso E. (eds.), Mining monitoring concept, MMEA WP5.2.7 Report, University of Oulu, Control Engineering Laboratory, 2013, 80 pp.
- Juuso E. (2013) Integration of intelligent systems in development of smart adaptive systems: linguistic equation approach, Acta Universitatis Ouluensis. Series C, Technica 476, 258 pp., <http://urn.fi/urn:isbn:9789526202891>
- Juuso E. K. (2011) Intelligent trend indices in detecting changes of operating conditions. In: 2011 UKSim 13th International Conference on Modelling and Simulation, IEEE Computer Society: 162-167. DOI: 10.1109/UKSIM.2011.39.

