

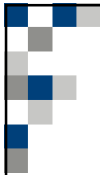


# Risk management for Mining Industry

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Control Engineering  
University of Oulu

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Oulu 8 September 2015

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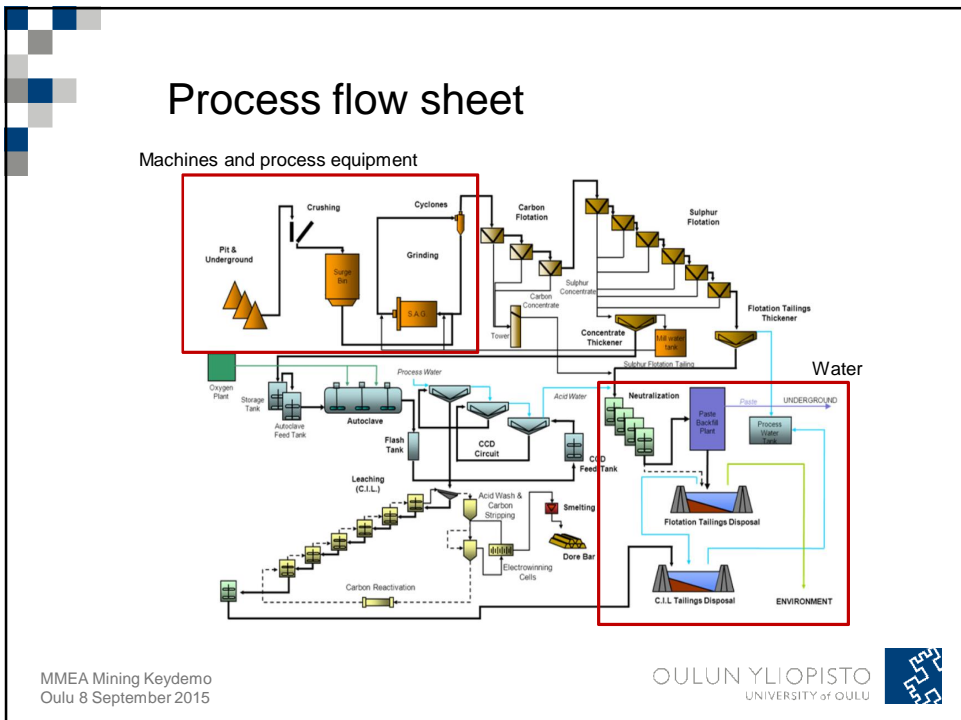
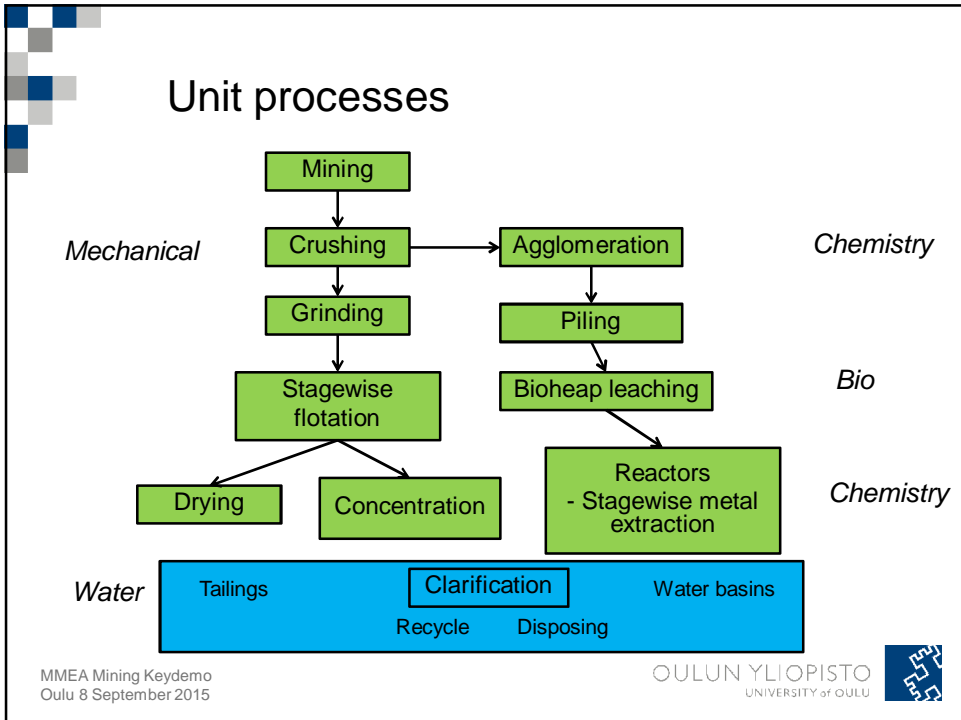



## Outline

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

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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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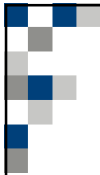


## Laboratory measurements

- 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

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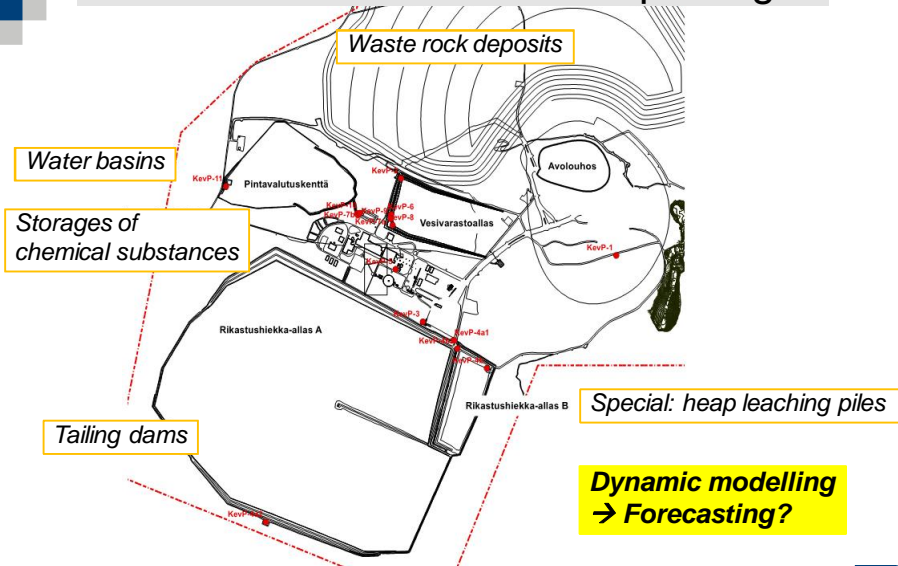
## Online measurements

- 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

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## Waste areas → measurement placing?



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## 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

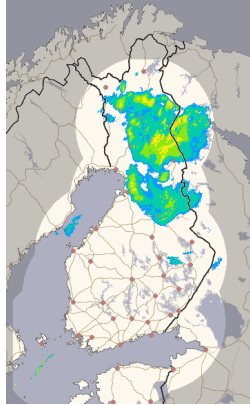


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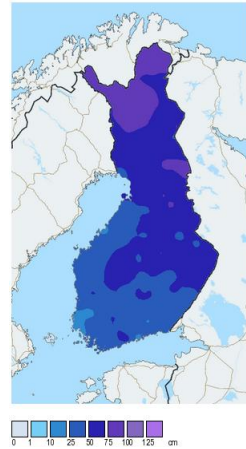
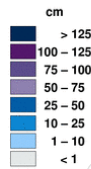
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## Weather forecasts



23.3. 8:00



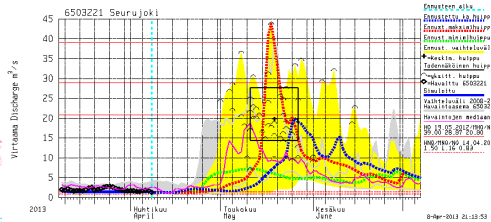
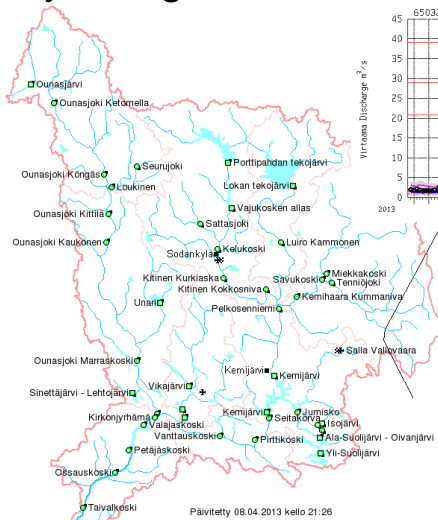
Finnish meteorological institute (FMI) provides information about air quality, wind, temperature, climate, rain, snow depth, etc.

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## Hydrological forecasts



[www.environment.fi](http://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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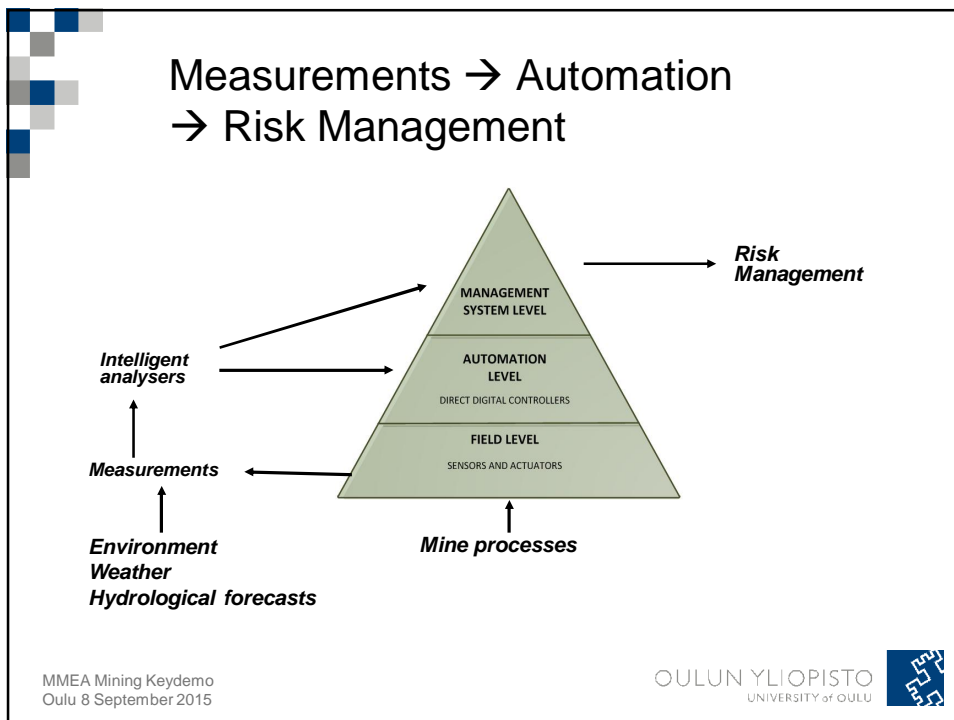
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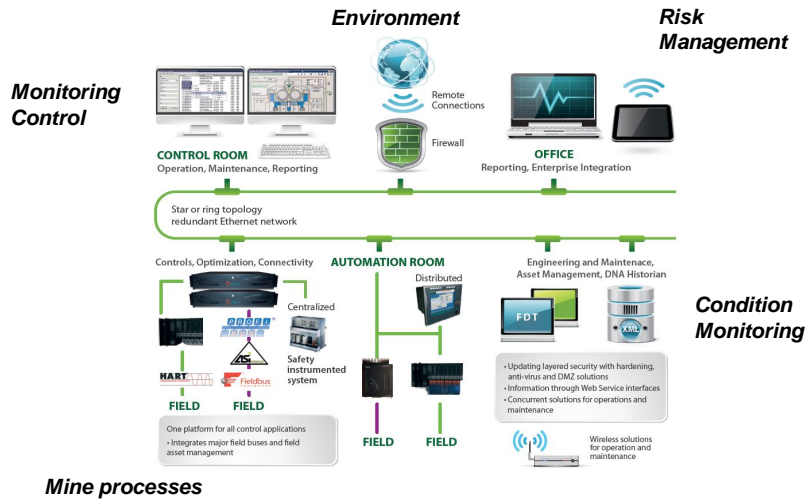
The screenshot shows the mmea.fi website interface. At the top, there is a navigation bar with 'HOME', 'NEWS', and 'MMEA RESEARCH PROGRAM'. The main content area is divided into several sections:

- NEWS:** A list of recent news items with dates and brief descriptions, such as 'Invitation to seminar: Monitoring and Risk Management in Mining Industry'.
- MMEA RESEARCH PROGRAM:** A section describing the program's goals and the availability of monitoring technologies, tools, and services.
- MEASUREMENT & MONITORING:** A section with a 'We all' sub-section and a list of tools including 'INDOORS ENERGY EFFICIENCY', 'PARTICIPATORY WATER QUALITY MEASURING', and 'MMEA PLATFORM'.
- DATA PROCESSING:** A section with a 'Developers' sub-section and a list of tools including 'COMPLEX EVENT PROCESSING' and 'MMEA PLATFORM'.
- APPS & LIVE DATA:** A section with a 'Consumers' sub-section and a list of tools including 'ALGAL BLOOMS' and 'WEATHER RADAR'.

At the bottom of the page, there is a footer with the text 'MMEA Mining Keydemo Oulu 8 September 2015' and the 'OULUN YLIOPISTO UNIVERSITY of OULU' logo.



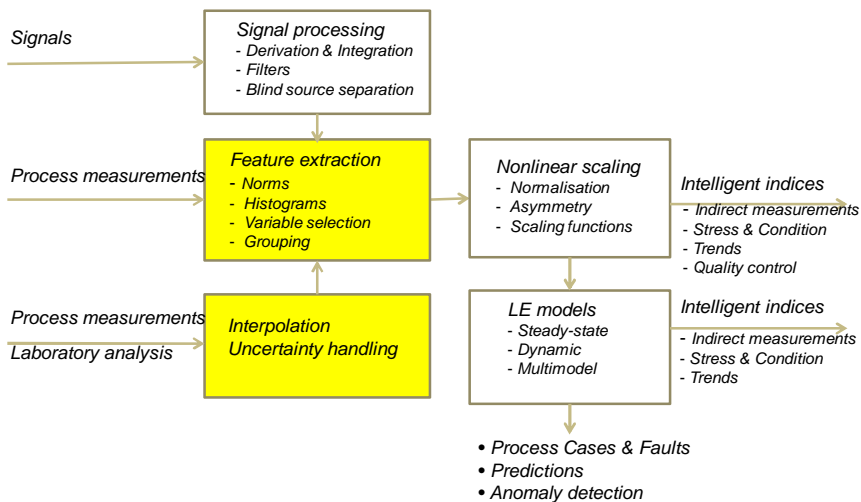
# Automation → Integration



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# Measurements → Intelligent analysers

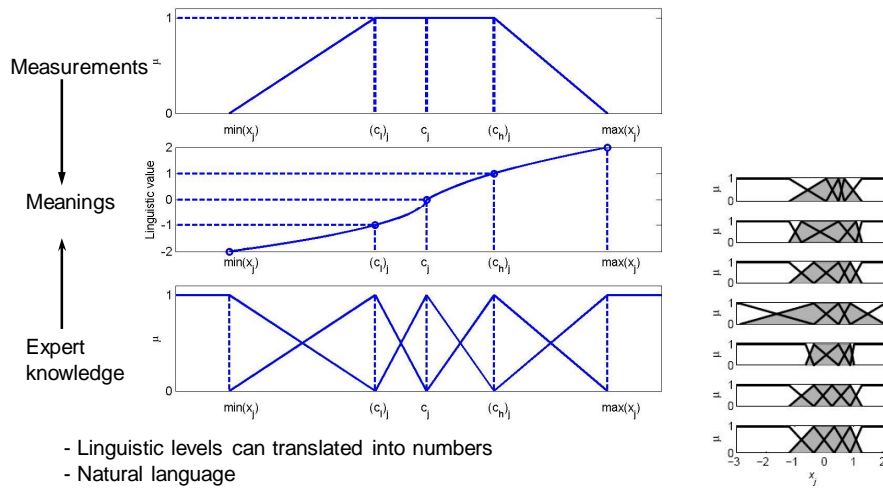


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## Nonlinear scaling

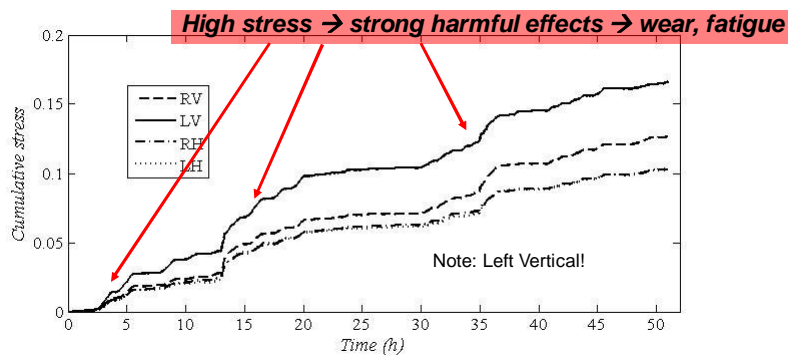


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## Machines: cumulative stress

$$24 \cdot 60 \cdot 12 = 17280$$



Low stress  $\rightarrow$  negligible effect

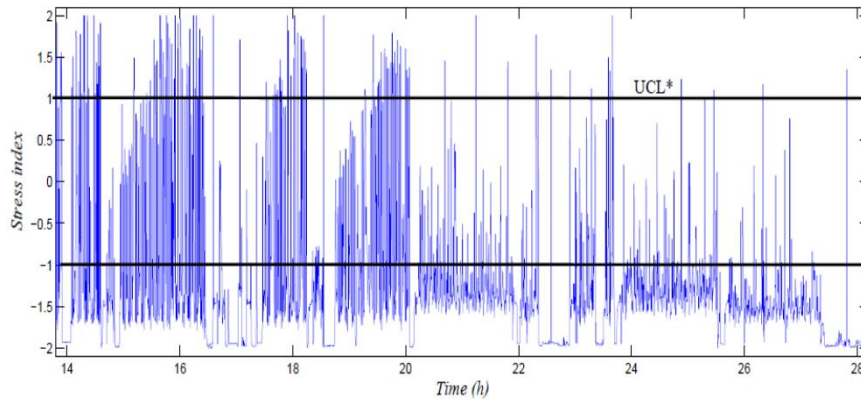
Normal stress  $\rightarrow$  moderate effect

$\rightarrow$  Very long smooth operation

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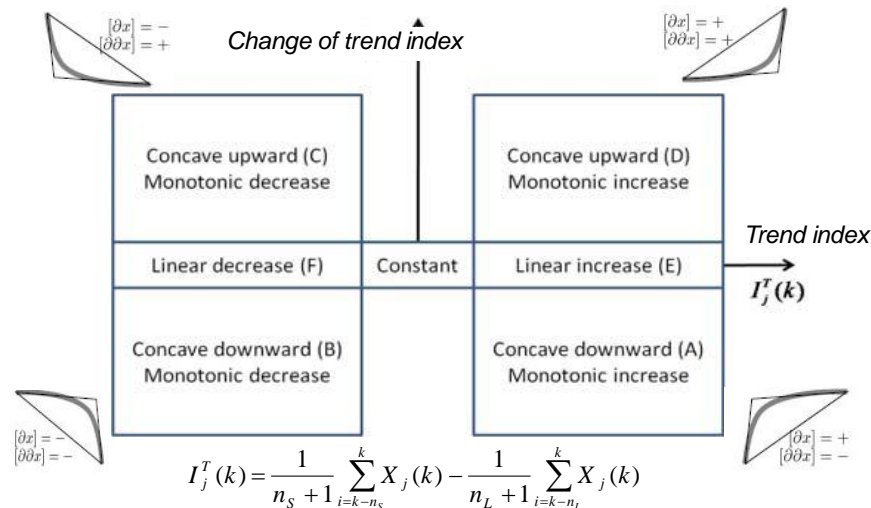
# Generalised SPC



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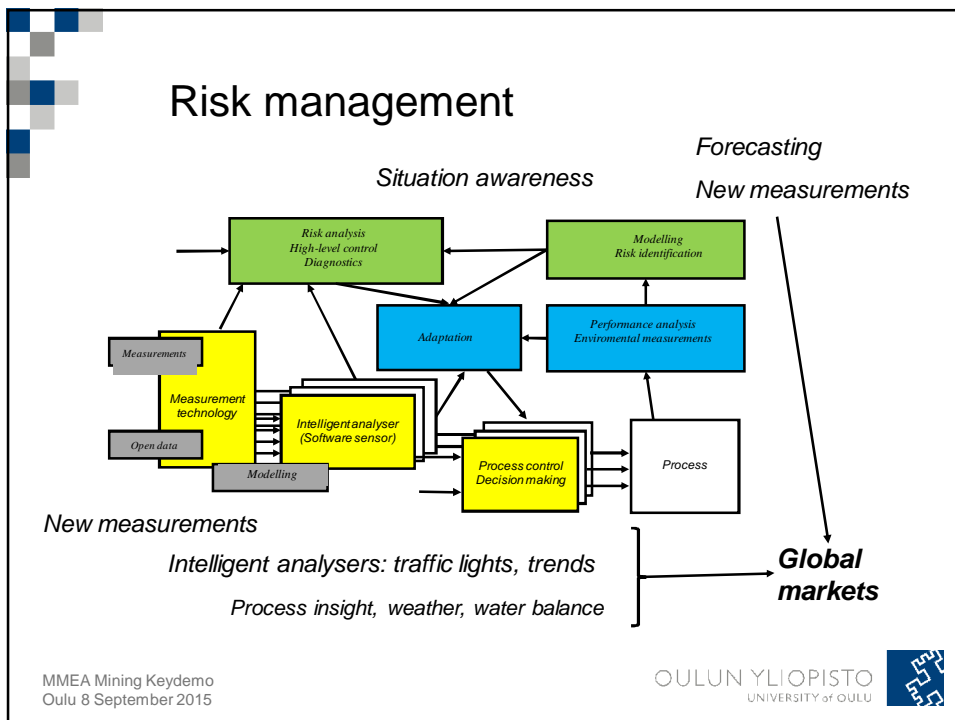
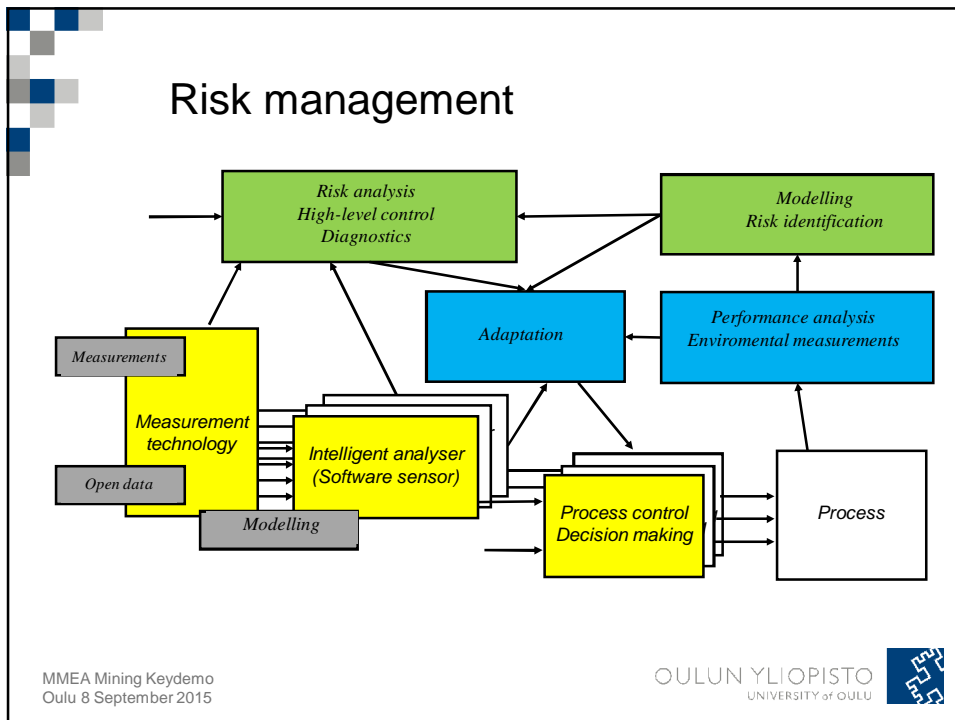
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# Trend analysis

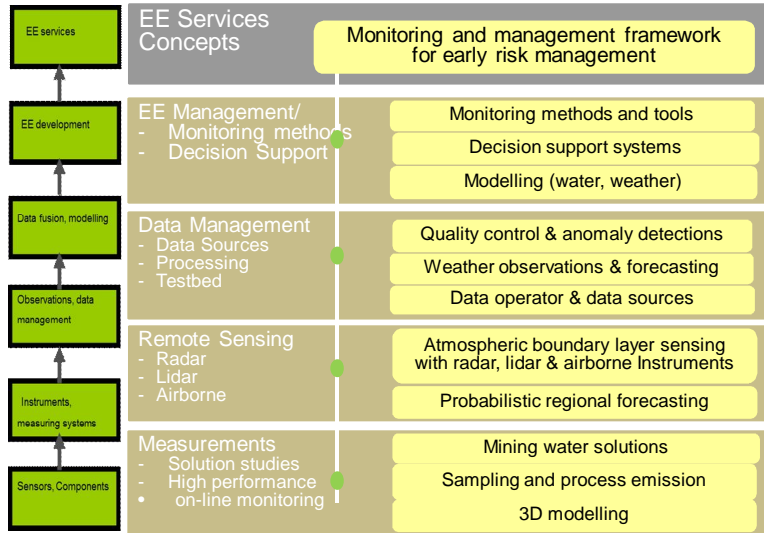


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## MMEA Mining Key Demonstration

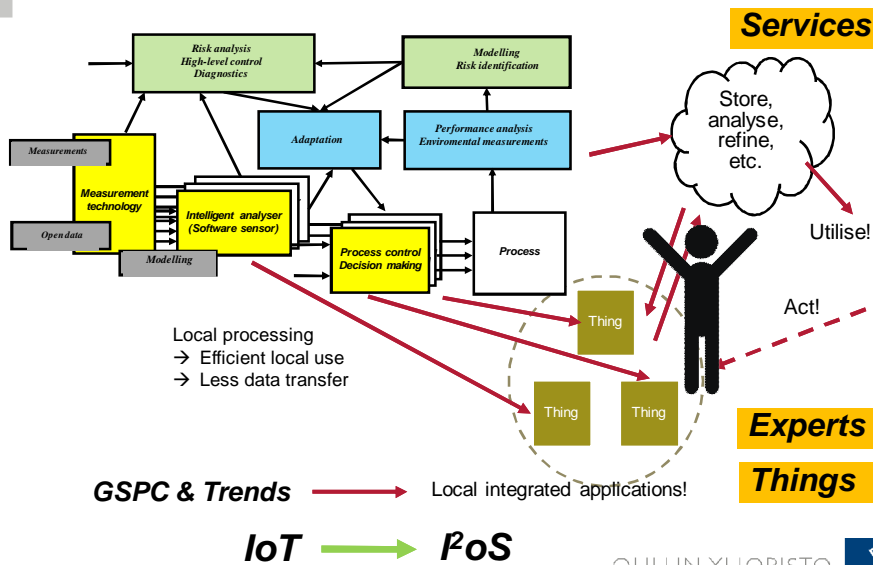


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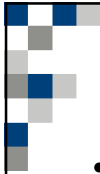


## Smart Applications in Industrial Internet



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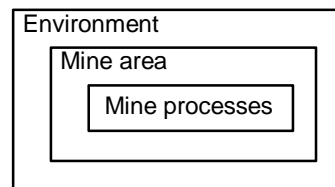


## Conclusions

- 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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