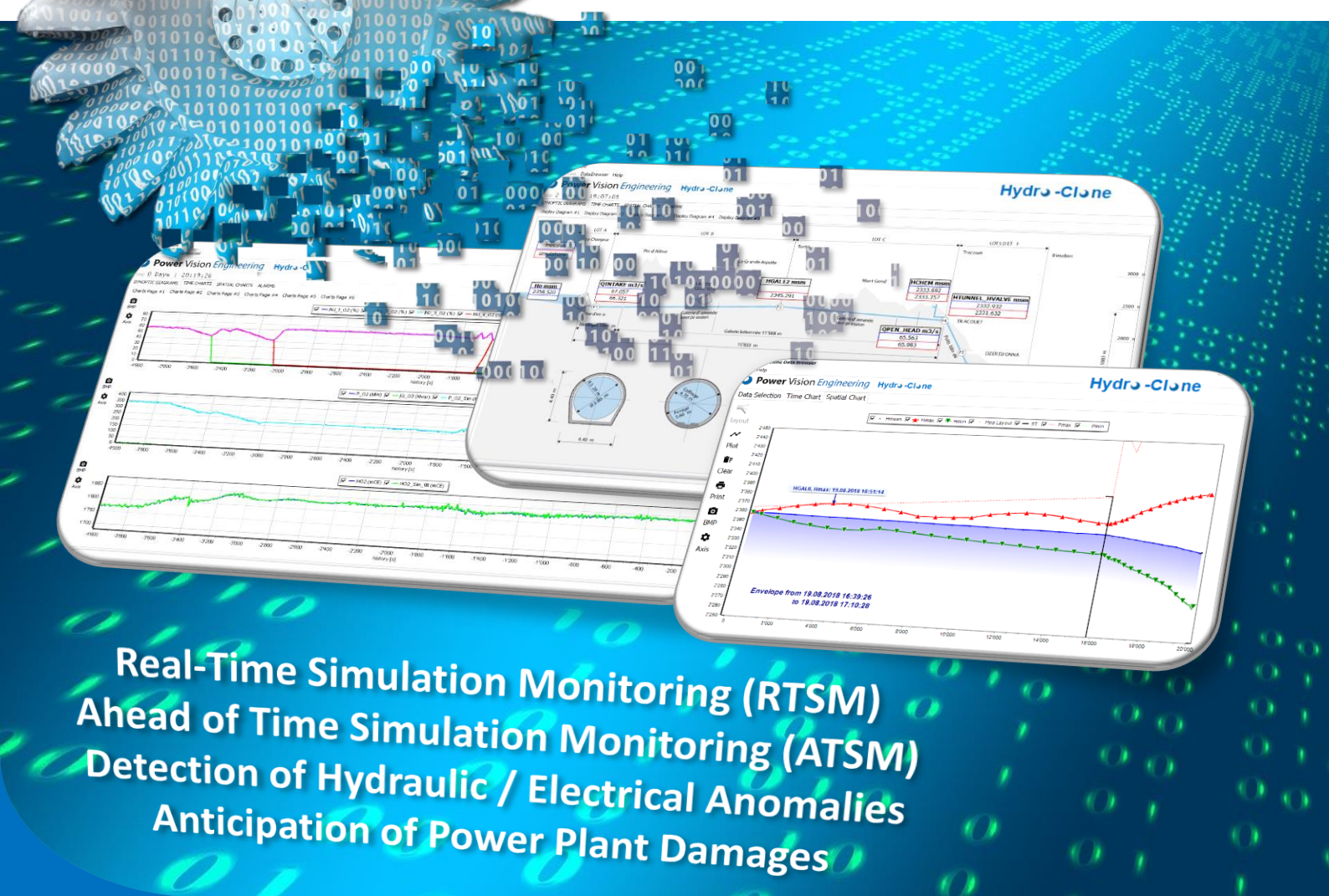
Hydro-Clone

Innovative Real-Time Simulation Monitoring System for Hydro Power Plant Transient Survey



Real-Time Simulation Monitoring (RTSM)
Ahead of Time Simulation Monitoring (ATSM)
Detection of Hydraulic / Electrical Anomalies
Anticipation of Power Plant Damages

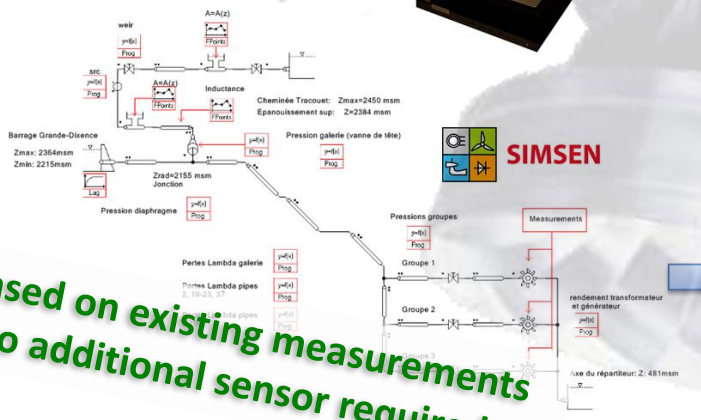
Hydro-Clone

Hydro-Clone PC
Simulation,
Acquisition,
Data processing

Data (Modbus)

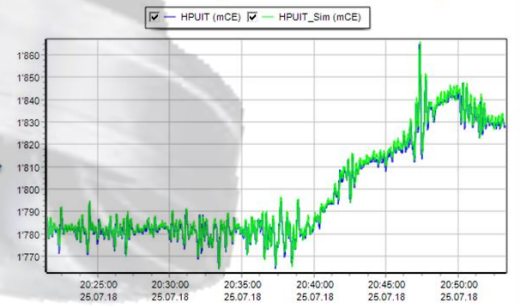
f_{sample}=10Hz

Power plant PLC

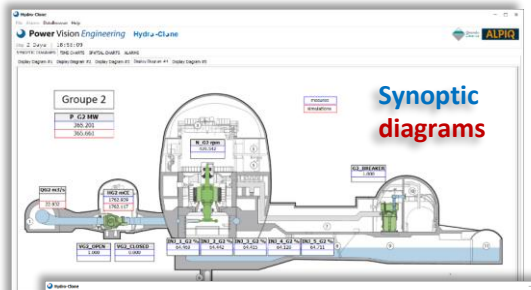


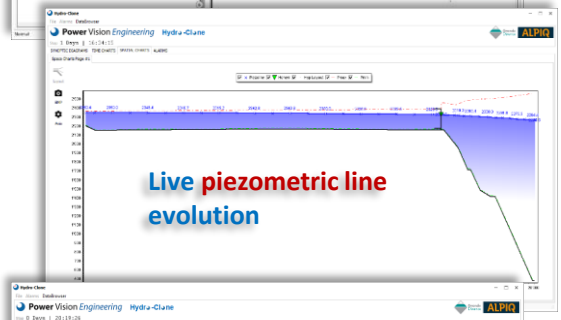
based on existing measurements
- no additional sensor required -

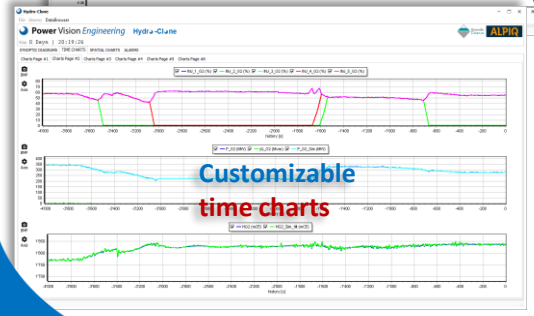
Real-time measure/simulation comparison



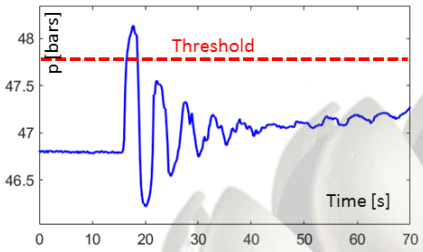
User-friendly interface







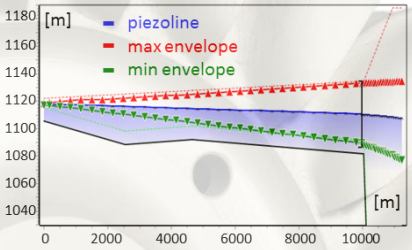
Alarm system



Type 1: Exceedance of the admissible limit of a measured quantity

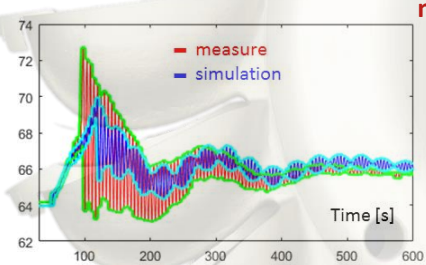
Type 2: Exceedance of the admissible limit of a non-measurable quantity:

- Minimum or maximum pressure throughout the penstock or the headrace/tailrace tunnels
- Discharge throughout the system
- Extreme torque in the coupling shaft
- Extreme current or voltage in electrical system



Type 3: Divergence measurements/simulations:

- Unexpected gate or valve closures
- Unexpected air admission from air-valves
- Flow obstruction by external body
- Head loss increase
- Water column separation
- Conduit breakdown
- Surge tank sediment deposit
- Electrical fault



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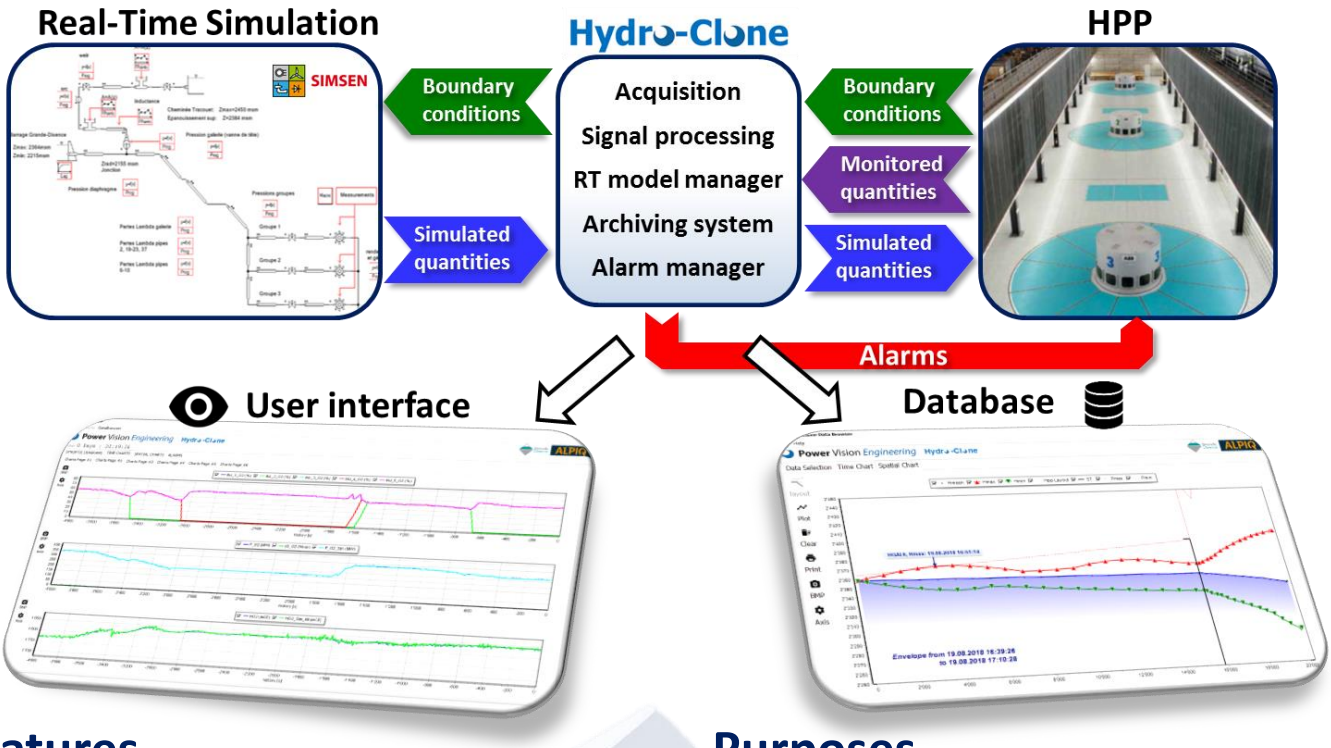
Hydro-Clone – Real Time Simulation Monitoring System



Features

- **A calibrated SIMSEN model of the HPP, operated in Real-Time and using *in-situ* measured boundary conditions including:**
  - Hydraulic circuit: galleries, surge tanks, valves, pressure shaft, **pumps and turbines (Pelton, Francis, Pump-Turbine, Kaplan)**
  - Mechanical inertia and coupling shaft
  - Electrical system: motor-generator, transformer, circuit breakers, transmission lines
- **A real-time monitoring system performing the following tasks:**
  - Real-Time acquisition and transfer **of *in-situ* measured boundary conditions** and quantities to the digital clone
  - Data processing and diagnosis of the power plant health
  - Provide pre-defined appropriate alarms based on both real-time (RTSM) and ahead-of-time (ATSM) analysis
  - Communication with archival storage system
- **A tailor-made archival storage and related database system enabling:**
  - To archive simulated and measured quantities
  - To display and analyse previous results
  - To log alarms
  - To update and enhance the clone functioning

Purposes

- **Real-time Water Hammer/Surge Tank/Unit transient Survey**
- **Detection of abnormal pressure transients prior to reach admissible limit:**
  - Significant deviation between measurement and simulation
  - Identification of unappropriated sequence settings
  - Identification of possible hydroacoustic resonances
- **Detection of anomalies:**
  - Air admission
  - Unexpected valve closure
  - Flow obstruction by external body
  - Water column separation
  - Transducer failure/dysfunction
- **Monitoring of non-measurable quantities:**
  - Pressure and discharge in headrace/tailrace tunnels
  - Pressure and discharge along the penstock
  - Torque, current and voltages
- **Deviation of hydropower physical characteristics:**
  - Head losses increase
  - Turbine/generator efficiency drop
  - Closing law drift
- **Ahead-of-time projections** of the state of the system (Decision Support tool, Alert Awareness, what-if…?)
- **Anticipation of potential power plant damage:**
  - Fatigue evaluation
  - Buckling risk

***European Patent application EP 2 801 879 B1**, "Hydroelectric power plant real-time monitoring system and method"*

Hydro-Clone

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HYDRO-CLONE Services

Fitness Check (included in the license)

- Annual Report: summary of, alerts, remarkable facts, recommendations for future HPP operation
- Maintenance of HydroClone (hardware + software)

Specific Check (On Demand)

- Analysis of selected specific events and search for solutions/adaptations
- Definition of possible framework of agreement

Full Health Check (On Demand)

- Analysis and evolution of HPP model (corrections, upgrades)
- Definition of possible framework of agreement

Add-ons (On Demand)

- Specific modules (fatigue, buckling risk, ahead-of-time)

Training (On Demand)

Simulation of a hydro plant by '**cloning**' makes it possible to detect undesirable phenomena, such as penstock or gallery overpressures, head loss increases, decreases in efficiency, surge tank limits, start-up and shut-down issues, unexpected cavitation and possible water column separations, air intake, and unwanted valve closures. Furthermore, a digital clone is able to minimize the risk of potential imminent harmful behaviour of the plant, by generating so-called **'ahead of-time simulation monitoring' (ATSM) alarms**, based on a series of instantaneous simulations of any potential near-future behaviour of the plant. By combining RTSM and ATSM in real-time the Hydro-Clone system constitutes indubitably a valuable numerical asset for hydro plant owners to improve powerplant safety.

Power Vision *Engineering*

Power Vision Engineering Sàrl
Chemin des Champs-Courbes 1
CH – 1024 Ecublens
Switzerland
info@powervision-eng.ch
Phone: +41 21 691 45 13
Fax: +41 21 691 45 13
www.powervision-eng.ch