



Integrated Operations – Knut Hovda – UiO, May 20th 2011

ABB – Industry Examples

Calculations and engineering software

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 - ErosionInsight – Erosion Modelling in Critical Components
- **Experiences from other companies**
 - SPT Group – Multiphase Simulations
 - PTI AS – Stochastic Permeability Modeling
- **An ideal future employee should...**

About the speaker

- **Knut Hovda (44)**



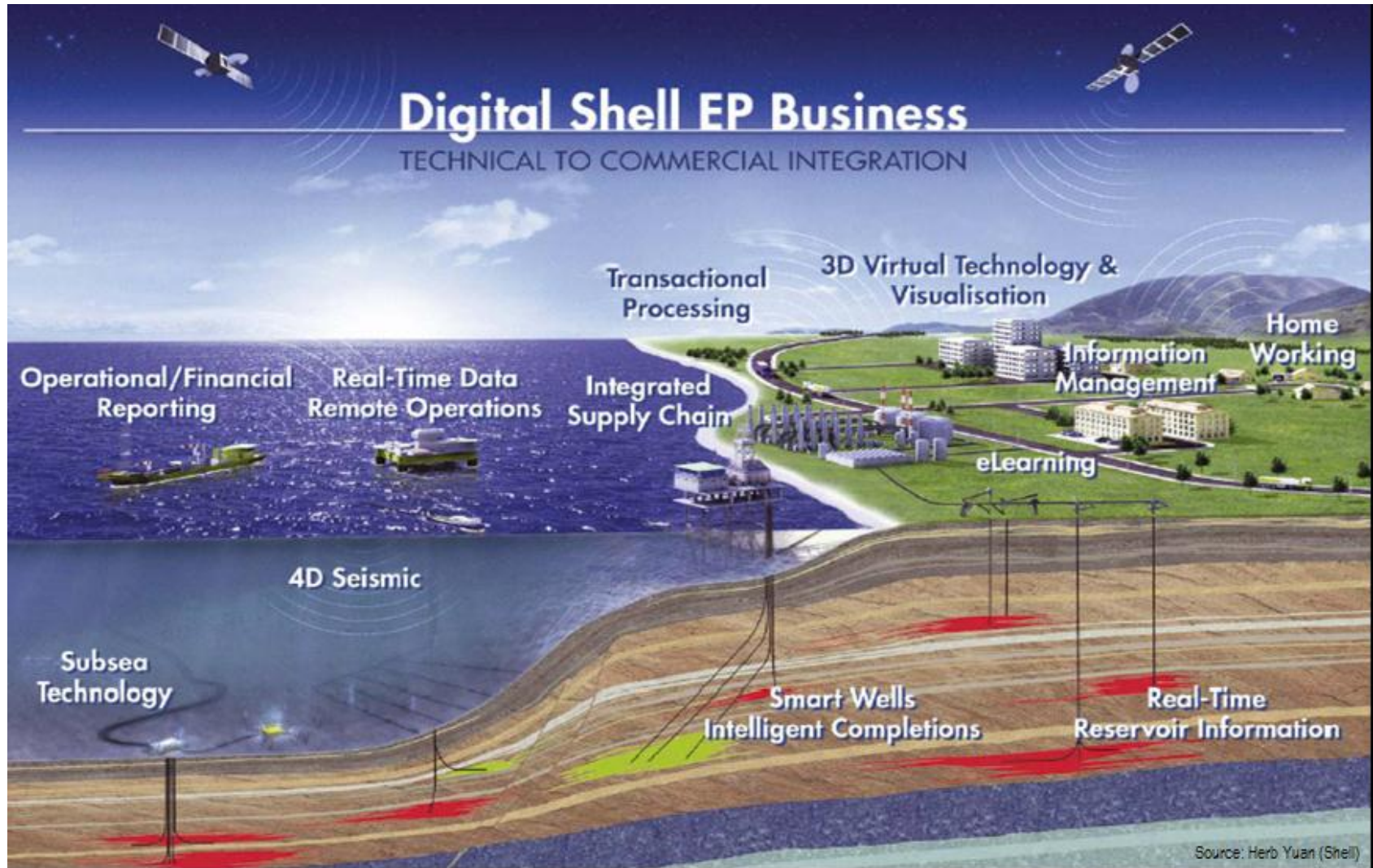
- **Team Manager in ABB Oil & Gas** – Integrated Operations
- **Cand Scient from Ifi in 1994** – Mathematical modeling / image proc.
- **Experience from** Hewlett-Packard, Forsvarets Forskningsinstitut, Scandpower Petroleum Technology, Production Technology Integrated, ABB
- Responsible for software development activities in ABB IO
- Special interest in calculation-centric software – analysis tools

ABB Oil, Gas & Petrochemicals - IO

Domains: Offshore and Onshore Operation Centres



Integrated Operations in practice



Is there anything to calculate?



Enhanced Operations and Production offers a broad spectrum of solutions for gaining critical reservoir and process data, and for using this information to provide optimal production and process control.



Multi-discipline environment

- **ABB Integrated operations team**
 - 70 engineers based in Oslo with M.Sc or Ph.D in i.e.
 - Cybernetics – Process control
 - Fluid mechanics
 - Physics
 - Chemistry
 - Geology
 - Mathematics
 - Statistics
 - Computer Science
- **Common need: Software calculations**



Examples – calculations in software products

- **ProcessInsight**

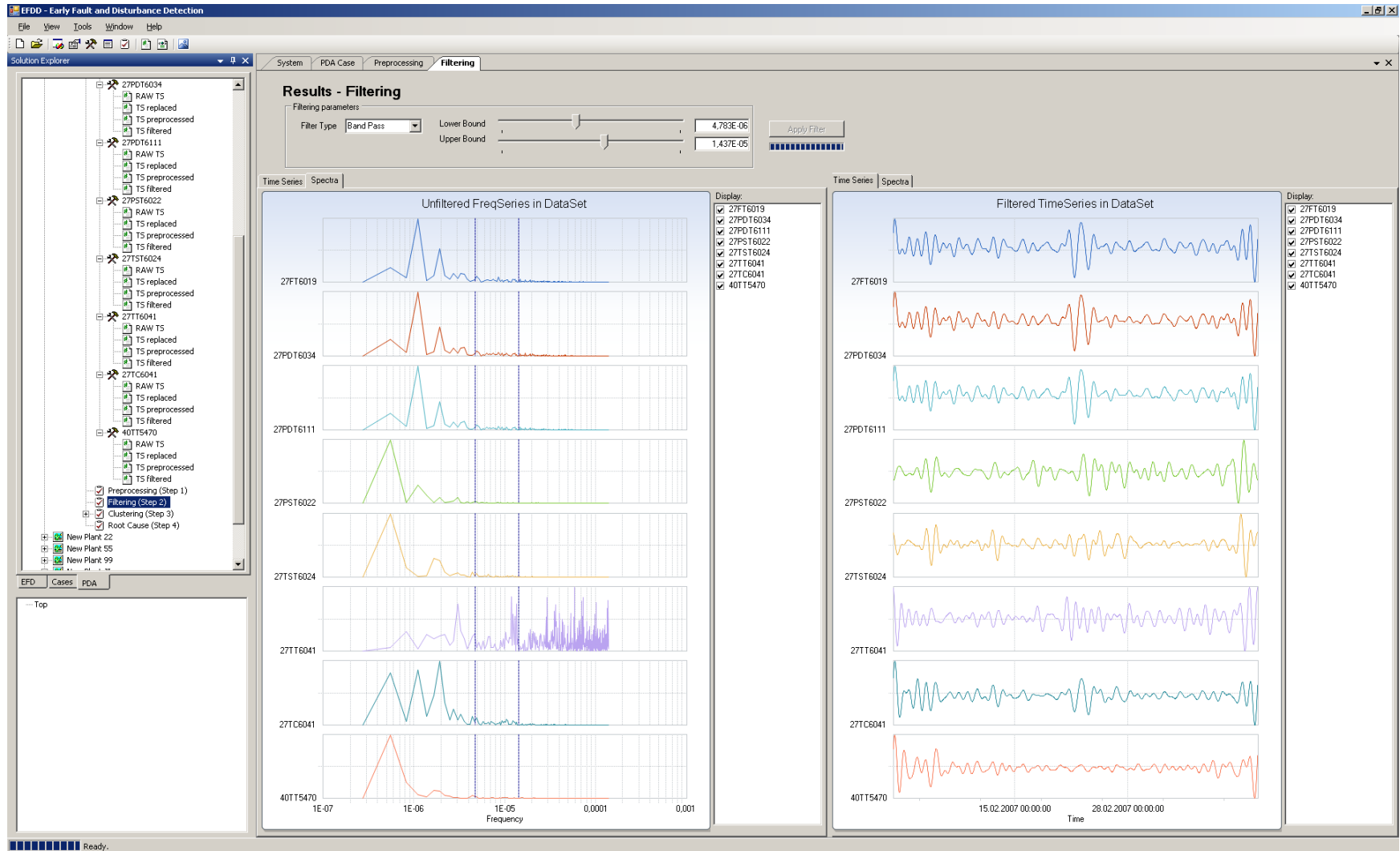
- Early Fault and Disturbance Detection
- Detect faults and problems before they become critical
- Reduces downtime
- Increases safety

- **ErosionInsight**

- Erosion Modeling in critical components
- Increased production, reduced maintenance costs
- Cooperation with DNV on erosion models

ProcessInsight – Early Fault and Disturbance Detection

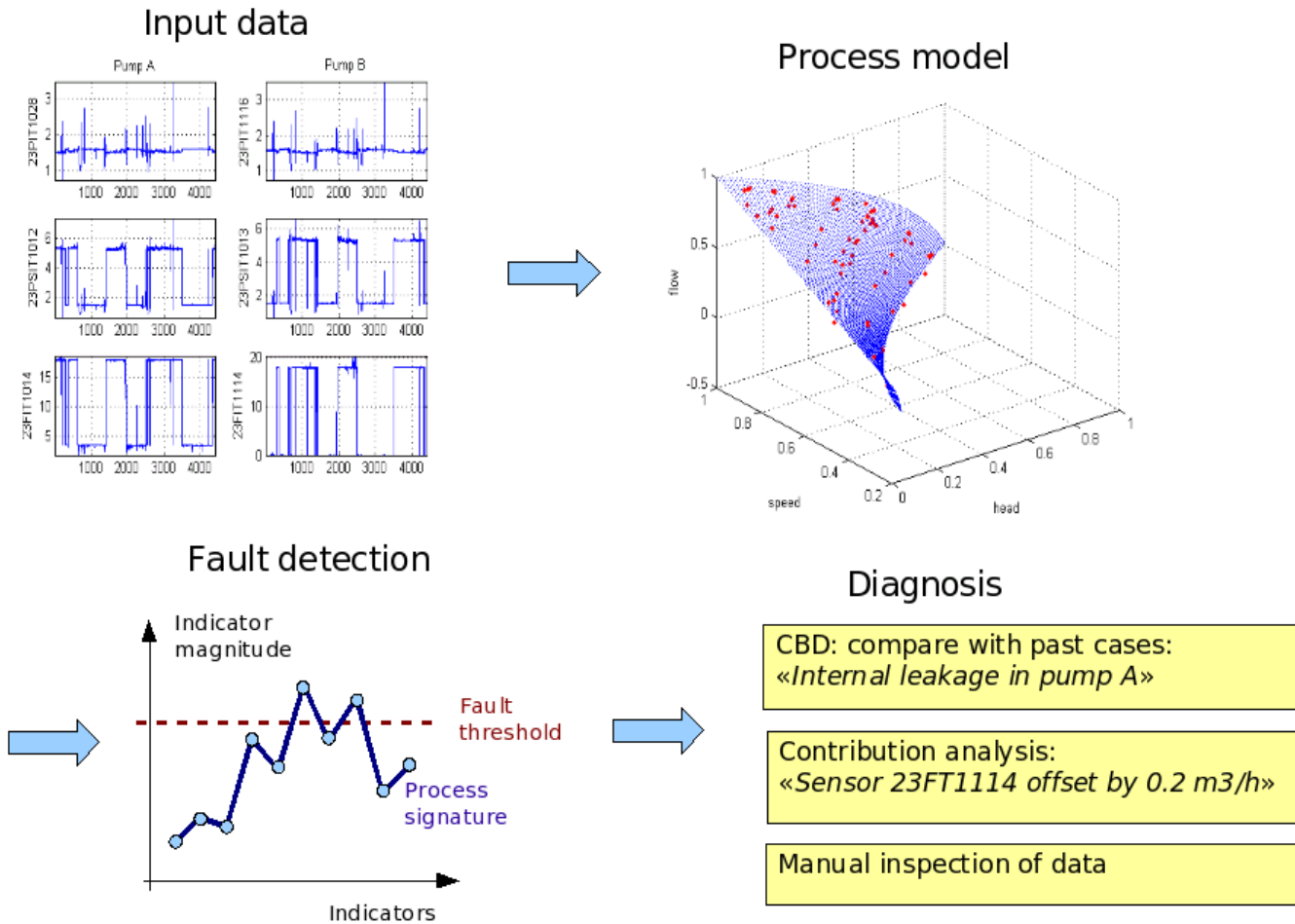
- Software product from ABB, developed in cooperation with Statoil.



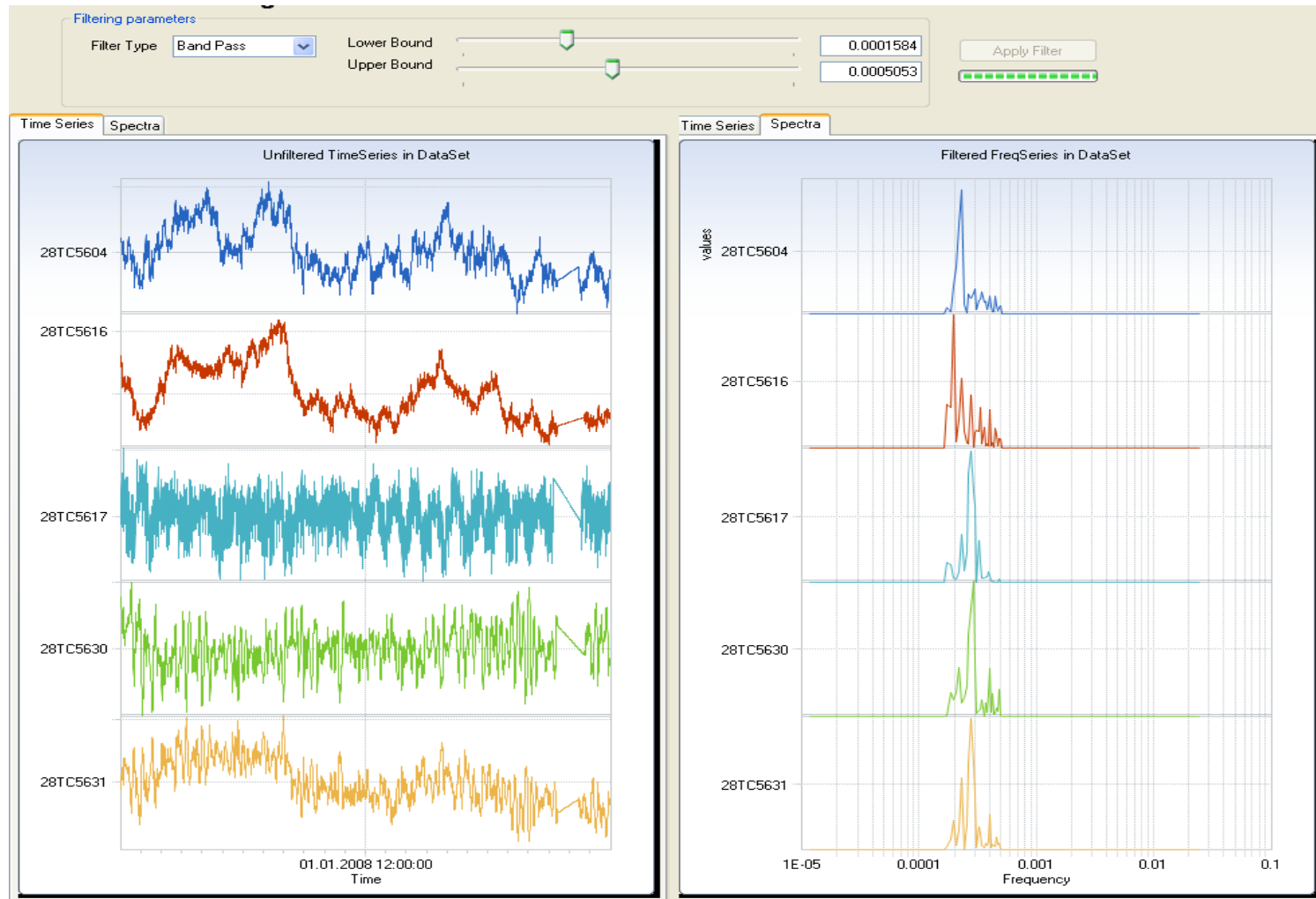
Main product features

- **Online or offline analysis - fully automated monitoring**
- **Using advanced and complementary algorithms:**
 - EFD (Early Fault Detection)
 - Configures a set of statistical models for different operating conditions, and uses them for fault detection.
 - PDA (Plant-wide Disturbance Analysis)
 - Detects system disturbances (e.g. oscillations) and performs a root-cause analysis to identify the source/problem.
- **Diagnosis and health conditions**
 - Health conditions for any part of the system is reported.
- **Status and decision support**
 - View status history for any part of the system
 - Consider the recommended system actions

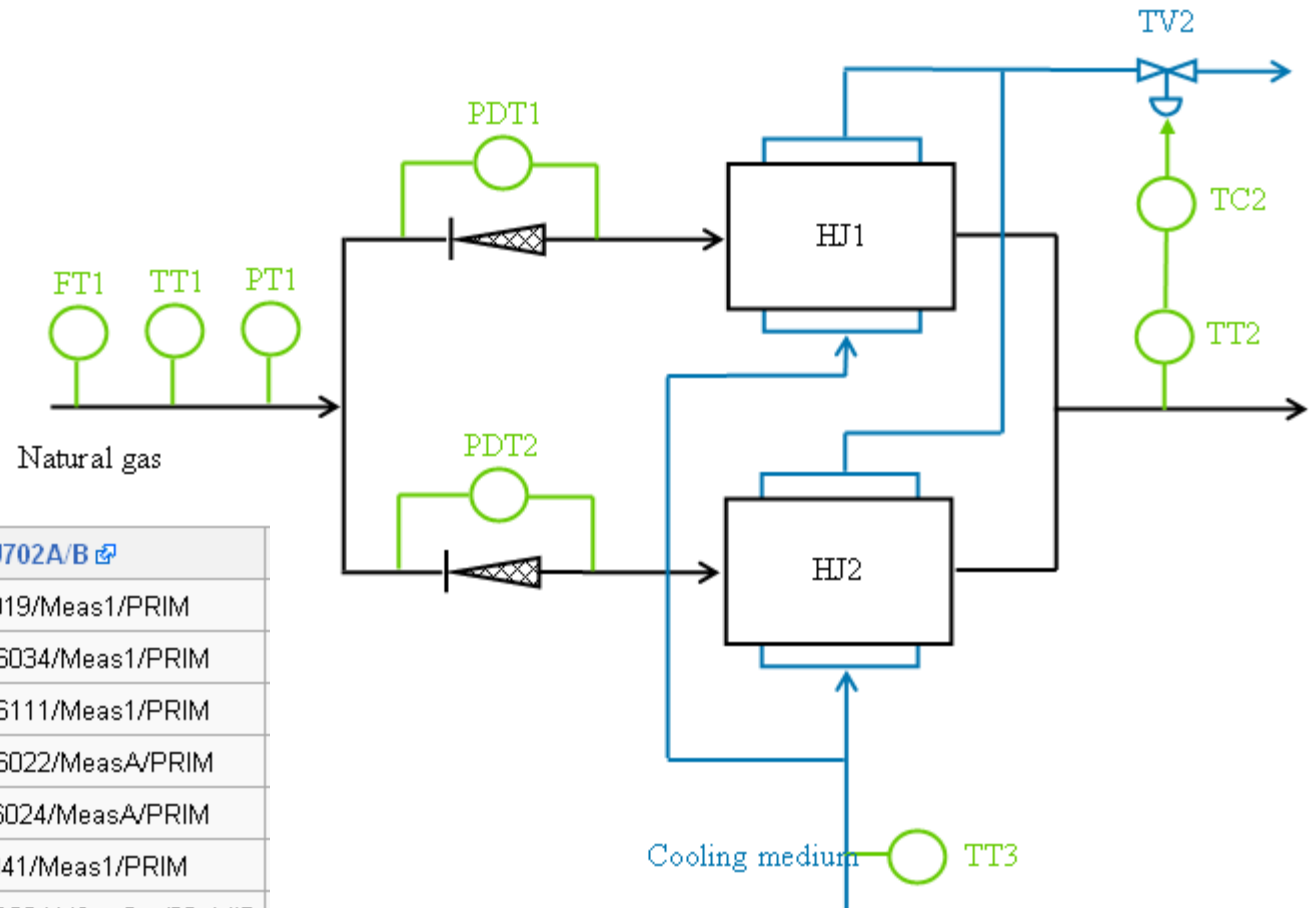
Early Fault Detection



Plant-wide Disturbance Analysis



Monitoring example I – Heat Exchanger



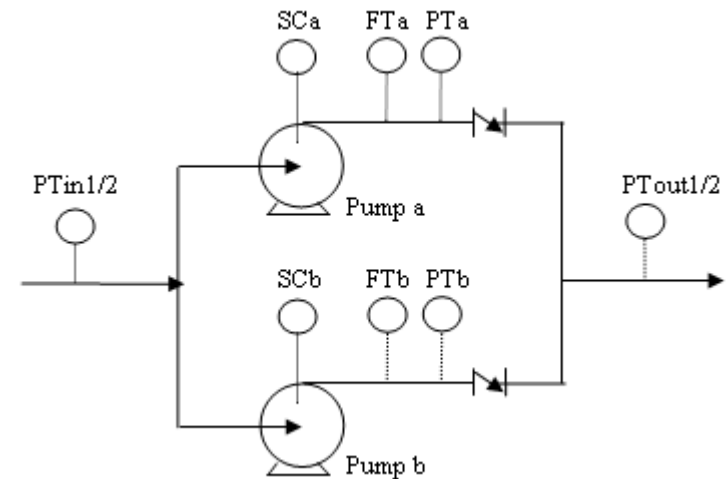
Tag	1st stage, 27HJ702A/B 🔗
FT1	ASGB.HS>PSPRIM:27FT6019/Meas1/PRIM
PDT1	ASGB.HS>PSPRIM:27PDT6034/Meas1/PRIM
PDT2	ASGB.HS>PSPRIM:27PDT6111/Meas1/PRIM
PT1	ASGB.HS>PSPRIM:27PST6022/MeasA/PRIM
TT1	ASGB.HS>PSPRIM:27TST6024/MeasA/PRIM
TT2	ASGB.HS>PSPRIM:27TT6041/Meas1/PRIM
TC2	ASGB.HS>PSSEC60s:27TC6041/ConOut/20sMID
TT3	ASGB.HS>PSSEC60s:40TT5470/Meas1/20sMID

Monitoring example II - Pump

Goal:

- Use EFDD to monitor the performance of two condensate export pumps.
- Demonstrate EFDD functionality
- Two parallel centrifugal pumps
- One running at the time

PT _{in1/2}	Inlet pressure, common manifold (2 sensors)
SC _{a/b}	Output from the pump's speed controller (assumed to be equal to the actual speed).
FT _{a/b}	The volumetric flow through the pump.
PT _{a/b}	The pump's discharge pressure.
PT _{out1/2}	Common down stream manifold pressure (2 sensors)



Top

Diagnosis

Plant 1

Cases

System 21

21HB101/201

21PA001

Tags

Datasets

Fault Detection

Tags

Datasets

Raw 20.12.2008 12:00

Raw 29.10.2009 18:19

Preprocessing

Clustering

Normal operation pump A

Datasets

Pump A curve

Datasets

Normal operation pump B

Disturbance Analysis

System 27

System 28

System 40/50

Coolant Temperatures

Flows

EFDD

— Top

Model Results

Plant 1 / System 21 / 21PA001 / Normal operation pump A / Pump A curve

Model details

Name: Pump A curve Created: 11.08.2009 14:51:07 Updated: 27.08.2009 13:54:29

Description: Model the pump curve as the relationship between the flow through, the diff pressure across, and the speed of the pump.

Configuration

Configuration

Reg 20.12.2008 12:00 Visualize

Model Type: ☒ PCA ☐ TM

Num Samples Build: 1000

Num Samples Test: 120

☐ Use Scaling

Build model: Build Model Model status: Model OK

Number of PCs: 2

Test Confidence: 0.95

Percent Explained (PCA only): 0.95

NPC Offset (PCA only): 0

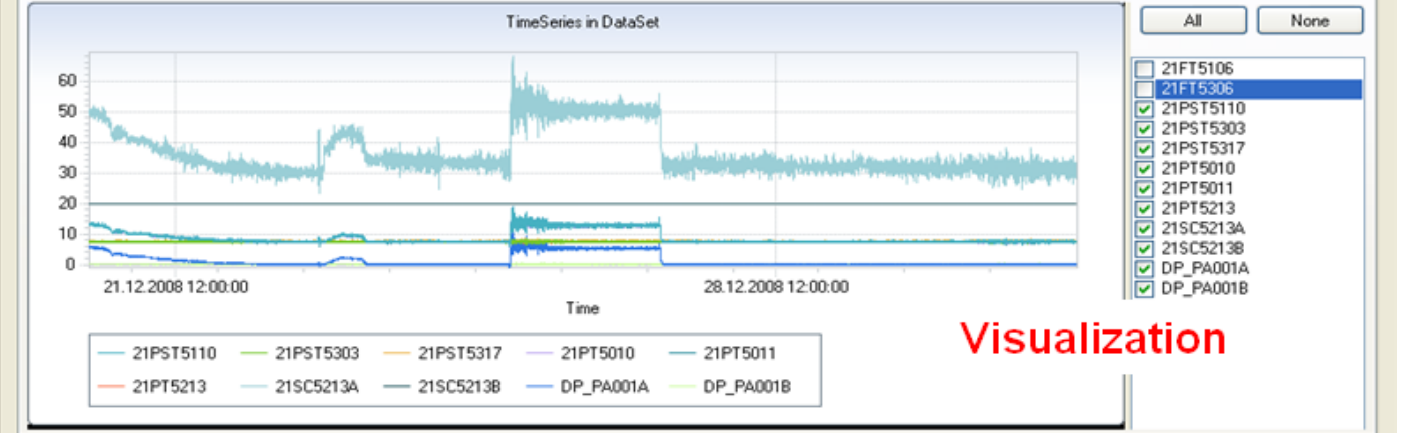
Num Faults (Default for Auto): 1

Status Weight: 1

Status Averaging: 0.5

DataSet results

Plant 1 / System 21 / 21PA001 / Raw 20.12.2008 12:00



Visualization

- All None
- ☐ 21FT5106
 - ☐ 21FT5306
 - ☒ 21PST5110
 - ☒ 21PST5303
 - ☒ 21PST5317
 - ☒ 21PT5010
 - ☒ 21PT5011
 - ☒ 21PT5213
 - ☒ 21SC5213A
 - ☒ 21SC5213B
 - ☒ DP_PA001A
 - ☒ DP_PA001B

Dataset

- Data can be imported from the process historian (database)
- Data are represented by datasets.
- All tags are sampled simultaneously and with a fixed sample interval.

% Dataset output from EFDD										
DateTime	FTa	FTb	PTb	PTin1	PTb	PTout1	PTout2	PTin2	SCa	SCb
19.11.2009 04:00:00	0	406.31	8.23	8.04	11.07	11.01	10.98	8.02	20.00	40.30
19.11.2009 04:01:00	0	402.14	8.14	7.961	10.94	10.89	10.86	7.94	20.00	40.01
19.11.2009 04:02:00	0	397.00	8.10	7.943	10.67	10.61	10.58	7.88	20.00	38.96

Virtual tags

- EFDD algorithms are basically linear
- Processes are normally nonlinear
- Virtual tags help us exploit a priori knowledge:
- Use virtual tags to establish new tags that are better suited to explain process behavior.
 - The pump curve can be approximated by a 2nd order curve, therefore include a virtual tag
 $FT_{sqr} = FT * FT$
 - Head is approximated by the pressure increase across the pump: the virtual tag $DP = PT_{out} - PT_{in}$
- We assume that the choice of tags:
{ DP, FT, FT_{sqr} , SC}
is sufficient to model the nonlinear pump curve.

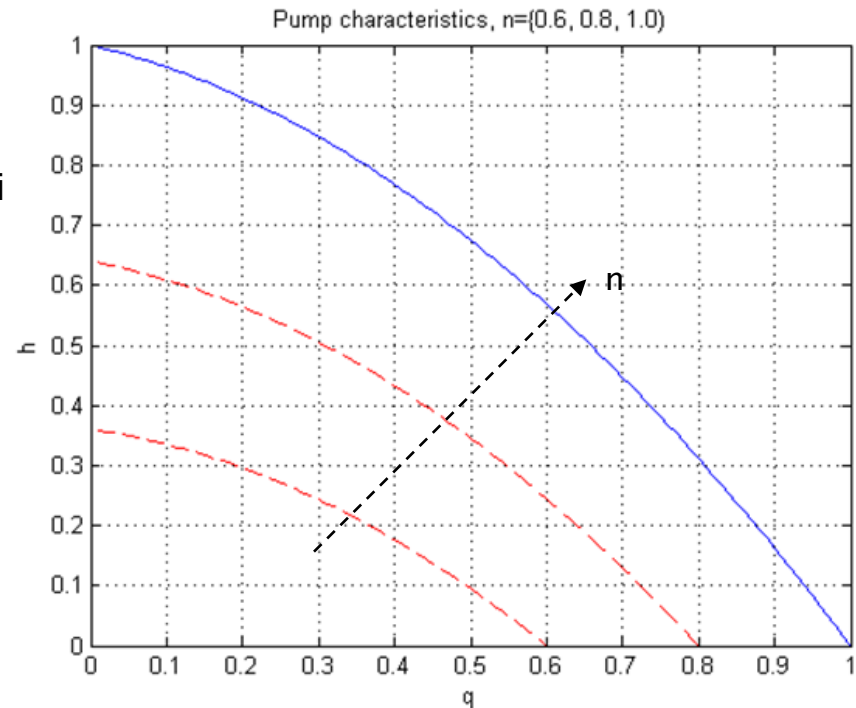


Figure 10 Pump curves; flow (q) vs. head (h) and motor speed (n)

Regimes

- Limit data to include samples inside boundaries defining the current operating region.
- For the pump case, choose a wide regime checking if the pump is in regular operation, i.e., the flow value has to be larger than a small threshold value.

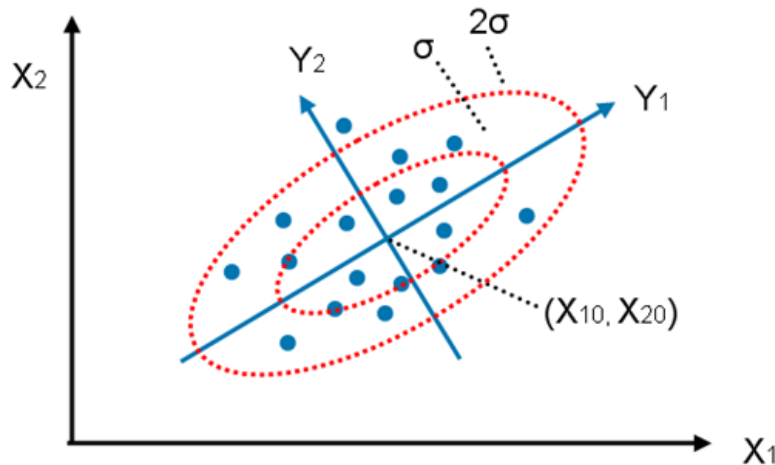
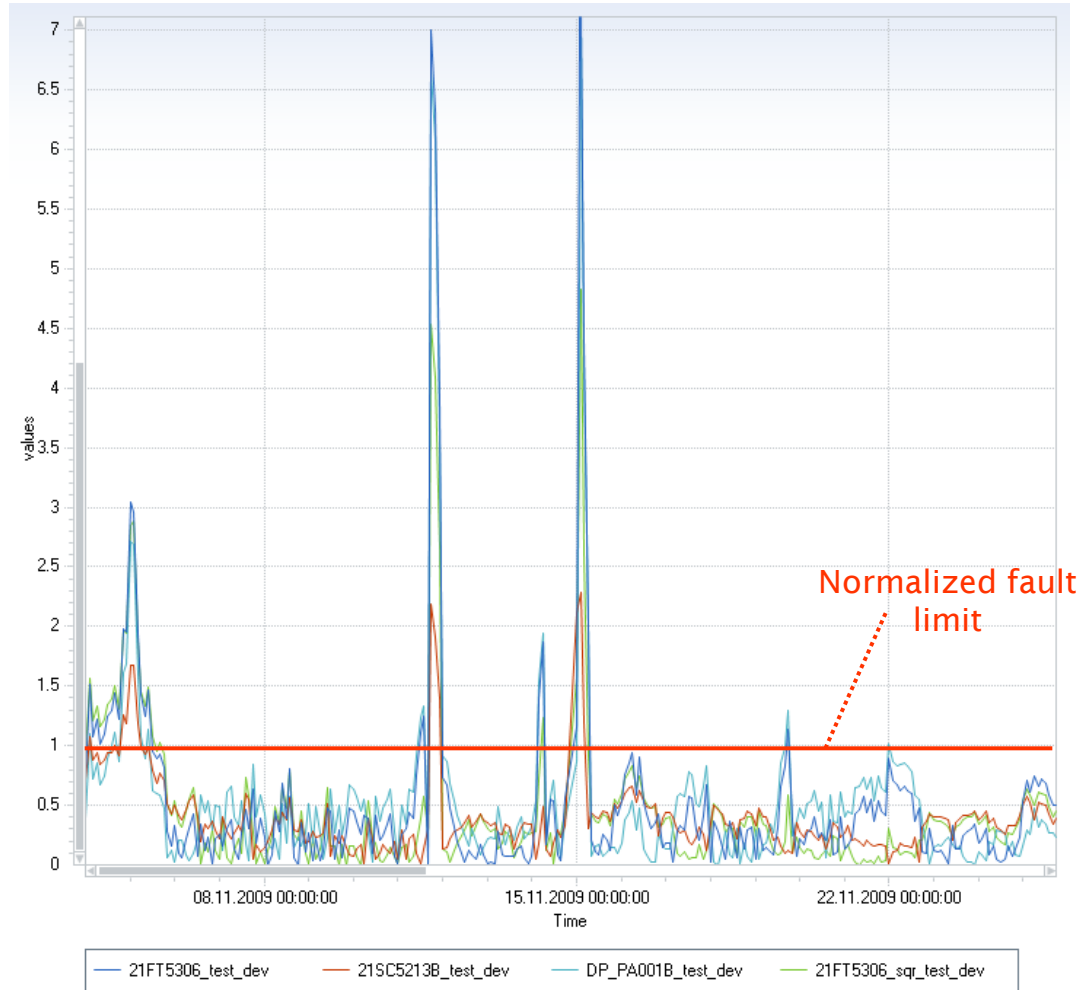


Figure 3: Regime boundaries (red, dotted) for simple 2D example, choosing the regime range as 1 or 2 times the standard deviation.

- If the pump is stopped, no data will be let through and no further analysis will be performed.

PCA models

- In *principal component analysis* we get a linear model on the form $X_e = X \cdot M$, projecting inputs X onto estimates X_e .
- Whenever $E = X - X_e$ is small, we assume that everything is ok.
- If E grows large, we have an indication that something may be wrong, or will go wrong.
- When one or more fault indicators are above the fault limit, we generate a fault status.

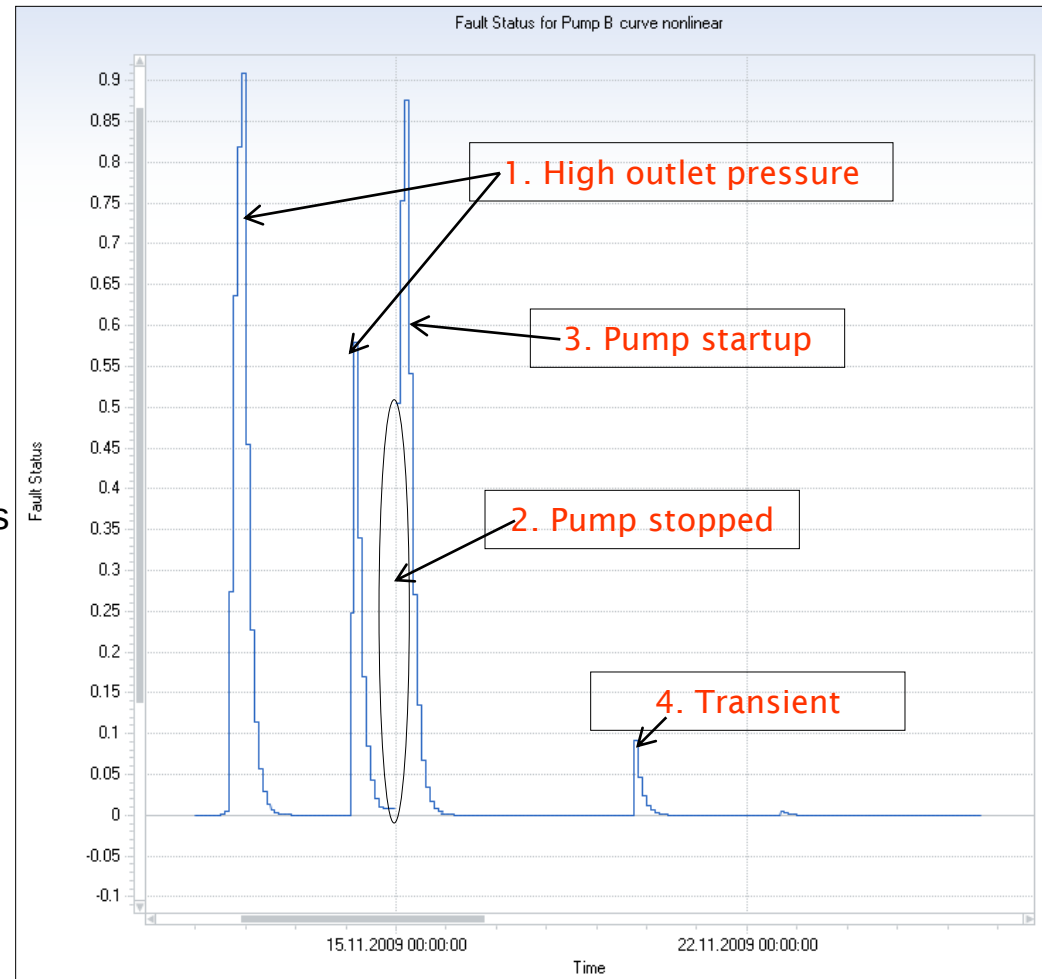


Pump status and history

The pump normally runs ok, the figure shows some fault modes:

1. Two peaks are caused by the outlet pressure occasionally going higher than what the model was trained for.
2. The missing data is for an interval where the pump was stopped.
3. After the stop, there was a transient phase, possibly packing the export line.
4. Short transient, probably due to a export line disturbance.

The fault status varies between 0 (ok) and 1 (fault).



Diagnoses

- Case Based Diagnosis
- Fuzzy classification
- Configured from analysis results

Diagnosis Configuration

Configure Diagnosis

Message:

Description:

Severity: ☒ Alarm ☐ Warning ☐ Info

Valid for Source Types:

- ☐ SubSystem
- ☐ Regime
- ☒ Model
- ☐ Tag

Valid for Equipment Types:

- ☐ Instrument
- ☐ Controller
- ☐ Scrubber
- ☐ Separator
- ☐ Turbine
- ☐ Valve
- ☐ Heat Exchanger

Filtering

Message: Description: Severity: Source Types: Equipment Types:

	Message	Description	Severity	Source Types	Equipment Types
	Operational condition 1	Normal operation 29.09.2009	Warning	[Regime]	[Heat Exchanger]
	Operational condition 2	Normal condition 19.10.2009	Warning	[Model]	[Heat Exchanger]
	Operational condition 3	Normal condition 20.10.2009	Info	[Model]	[Heat Exchanger]
▶	Pump Bump	High outlet pressure. Caused by downstream event.	Alarm	[Model]	[Pump]
	Pump Bump 2	High outlet pressure. Different signature from "Pump...	Alarm	[Model]	[Pump]

Health condition

Health Conditions				
	StartTime	EndTime	Reliability	Test Signature Exists
	11.11.2009 20:00:00	11.11.2009 21:59:00	0.405	Yes
▶	11.11.2009 22:00:00	11.11.2009 23:59:00	0.515	Yes
	12.11.2009 00:00:00	12.11.2009 01:59:00	0.096	Yes

Diagnosis Matching			
Match			
Diagnosis Match			
	Diagnosis	Description	HitRate
▶	Pump Bump	High outlet pressure. Caused by downstream event.	0.515
	Pump Bump 2	High outlet pressure. Different signature from "Pump Bump".	0.007

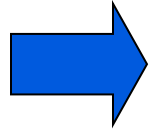
- If we have defined and configured any diagnoses for the model, we will get an assessment of its health condition (for each batch).
- The most reliable diagnosis is the source for the health condition.
- Diagnoses may overlap, if so, consider if they should be merged.

Early fault detection – What can be achieved?

- **Detection of gradually or instantaneous development of fault modes, changed performance or other operating conditions:**
 - Sensor-/transmitter faults: Drift, offset, noise
 - Component-/process faults: Functional faults, leaks, ..
 - Changed performance: Wear, tear, scaling...
 - Regulator performance: Following set point, oscillations
 - Process state: Flow, composition, temperature, ...
 - Legal / illegal process state
 - New process state
 - Oscillations and upsets: Which tags, what kind of disturbance
- **For more details, see paper SPE 128558.**

ErosionInsight – Main challenge

Sand can cause severe damage, and lead to reduced production, high maintenance costs and safety risks.



Therefore, tools for Erosion Management is a natural part of any Sand Management Strategy.

Example: Critical choke erosion due to sand production!

Erosion Management System Functionality

Analysis

Online help

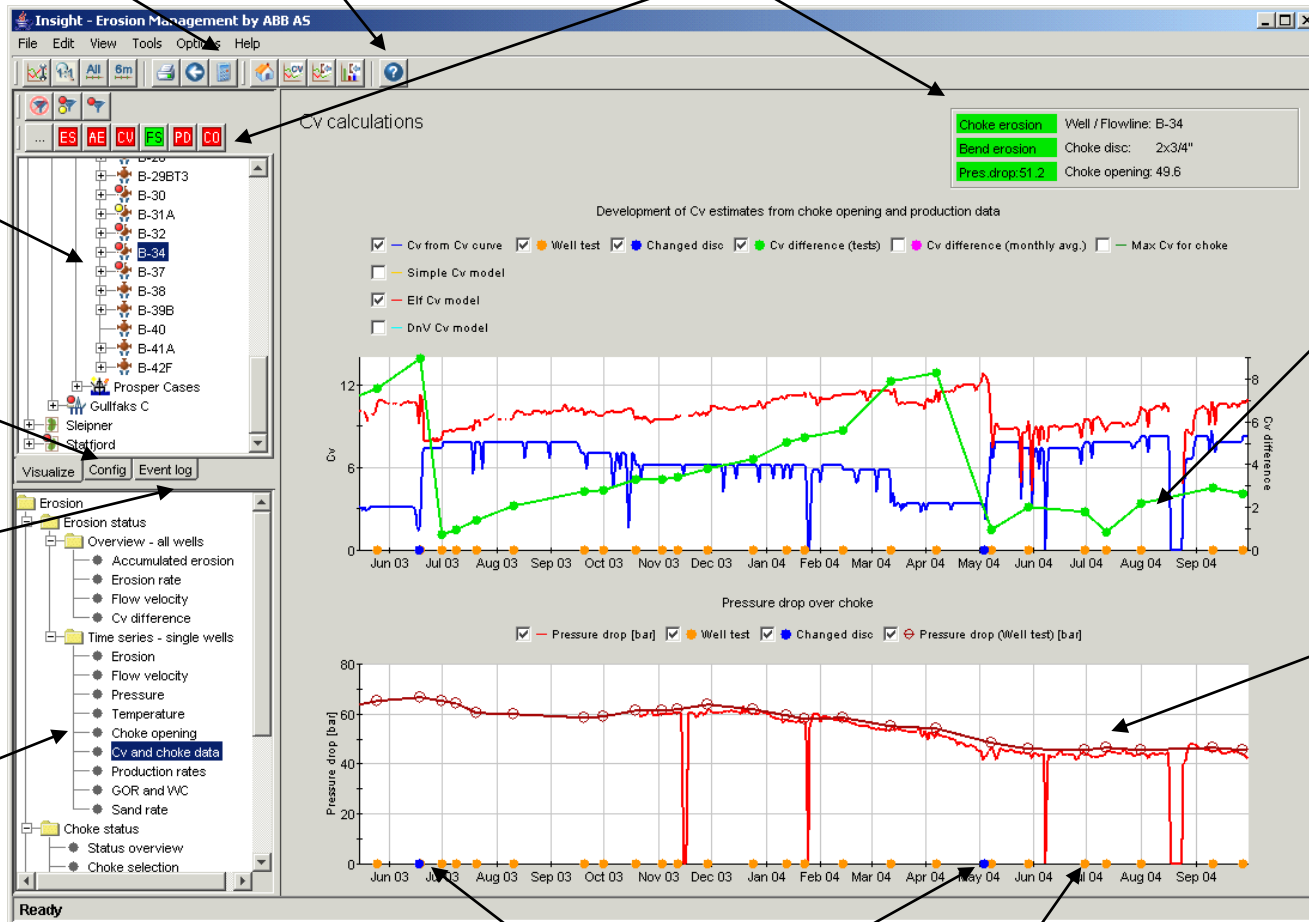
Status and alarms

Data tree
(wells etc.)

Configuration

Event log

Panel
selection
tree



Trending
(Increasing Cv
difference
shows erosion)

QA of
welltest data/
allocation

Choke changes

Well tests

Case Study: Statfjord Well SFC-39 (topside)

The system can detect erosion in three **independent** ways:

1. Choke erosion model (DNV)

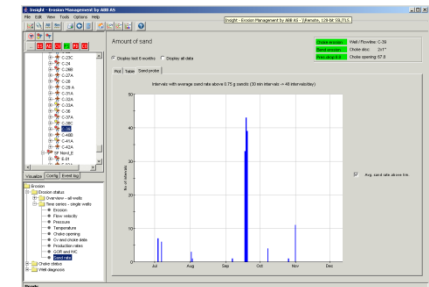
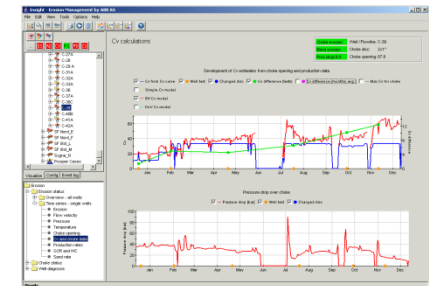
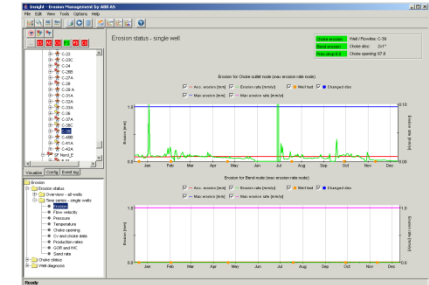
- Using fixed sand rate input (assumed worst case)
- Calculates choke outlet erosion

2. Cv calculation (*Cv - flow through the choke*)

- Trend analysis of actual Cv difference
- Monitors choke disk erosion

3. Sand rate measurements

- Intervals above sand limit



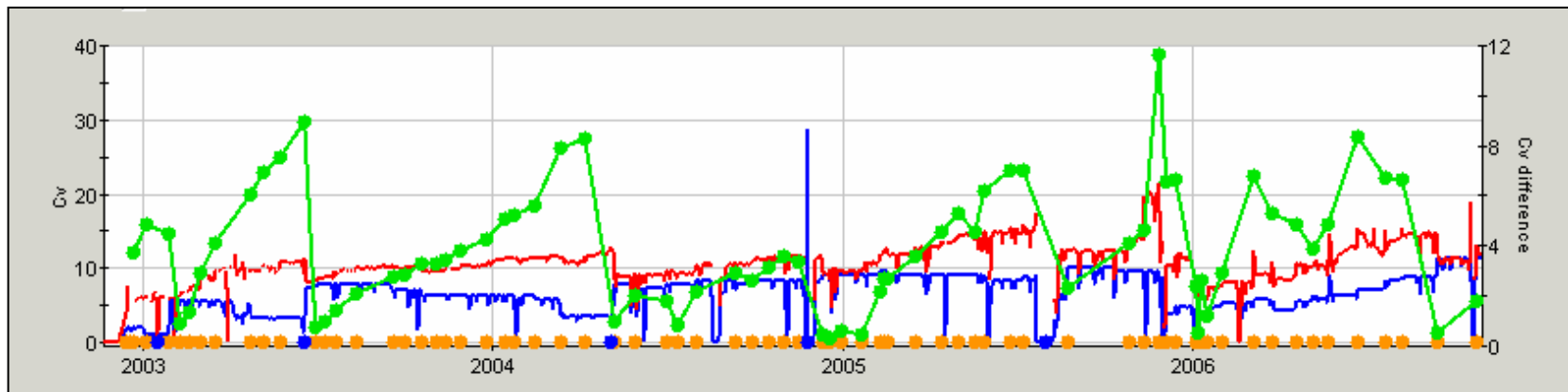
Case study – Gullfaks: Controlled choke erosion

- **Acceptable Sand Rate strategy:**

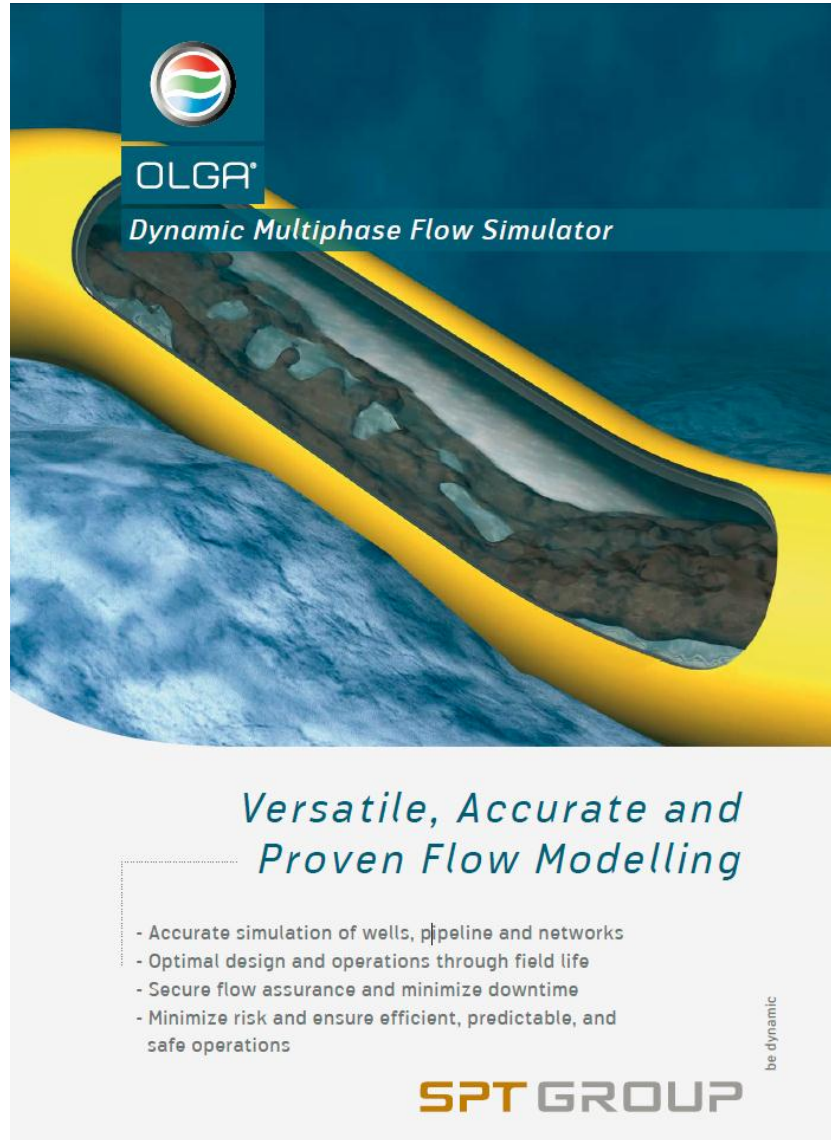
- Allows some sand production, and *allows* controlled erosion of chokes.
- Trade-off: Production increase vs maintenance costs

- **Example: Gullfaks well in the period 2003 – 2007:**

- Cv-difference "sawtooth" pattern (green curve) matching choke change dates (blue dots).



SPT Group – OLGA, world-leading simulator



The advertisement features a central 3D cutaway illustration of a yellow pipeline. Inside the pipeline, a complex mixture of dark brown, light blue, and white substances is shown flowing, representing a multiphase flow simulation. The background is a deep blue gradient. In the top left corner, there is a circular logo with red, green, and blue segments. Below the logo, the text 'OLGA' is displayed in a bold, white, sans-serif font, followed by 'Dynamic Multiphase Flow Simulator' in a smaller, italicized, white font. At the bottom, the text 'Versatile, Accurate and Proven Flow Modelling' is written in a large, italicized, dark blue font. Below this, a list of four bullet points is presented in a smaller, dark blue font. The SPT GROUP logo is at the bottom center, with 'SPT' in orange and 'GROUP' in grey. On the right side, the text 'be dynamic' is written vertically in a small, dark blue font.


OLGA
Dynamic Multiphase Flow Simulator

*Versatile, Accurate and
Proven Flow Modelling*

- Accurate simulation of wells, pipeline and networks
- Optimal design and operations through field life
- Secure flow assurance and minimize downtime
- Minimize risk and ensure efficient, predictable, and safe operations

SPT GROUP

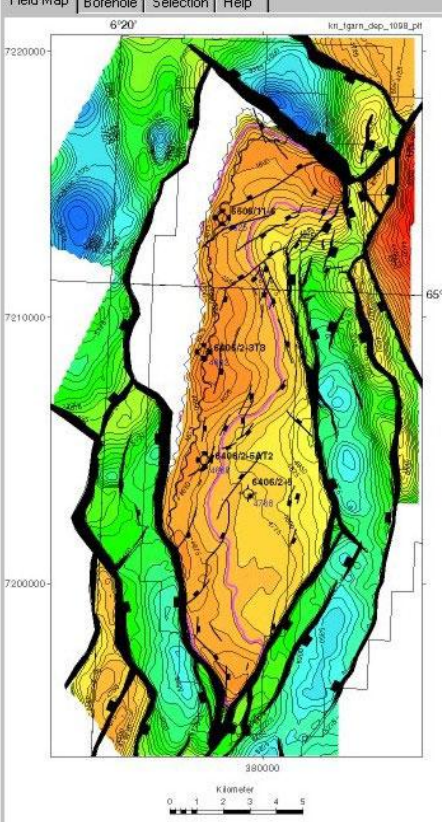
be dynamic

Production Technology Integrated AS Well Performance Modeling

Insight - Data Integration Through Stochastic Well Performance Modeling - [Define or Select Project]

File View Database Help

Field Map | Borehole | Selection | Help



Define or Select Project

Open Project Define New Project

Project DBLocation: D:\Data\Product\Database\test305.mdb

Project Name : test305

Unit system: SI system

Binary File Location

D:\Data\Bin Files\ Set Directory

Field Map Graphics

D:\Data\Product\Database\kri_tgarn_dep_1098_plt.bmp Import

UTM Coordinates for Field Map

Define coordinates

Point 1

Mouse coordinates: UTM coordinates:

x: 0 East: 0

y: 0 North: 0

Point 2

Mouse coordinates: UTM coordinates:

x: 0 East: 0

y: 0 North: 0



Conclusion: An ideal future employee should... (... at least at ABB IO...)

- Have a strong theoretical background in the main field
- Have experience using computers for calculations
- Software development experience:
 - Understanding the importance of code design
 - Experience with various tools (Matlab / Java / C# etc.)
- Experience from practical project work with real-life problems

Power and productivity
for a better world™

