# TAPPI Paper Con 2011

## DCS Embedded Condition Monitoring

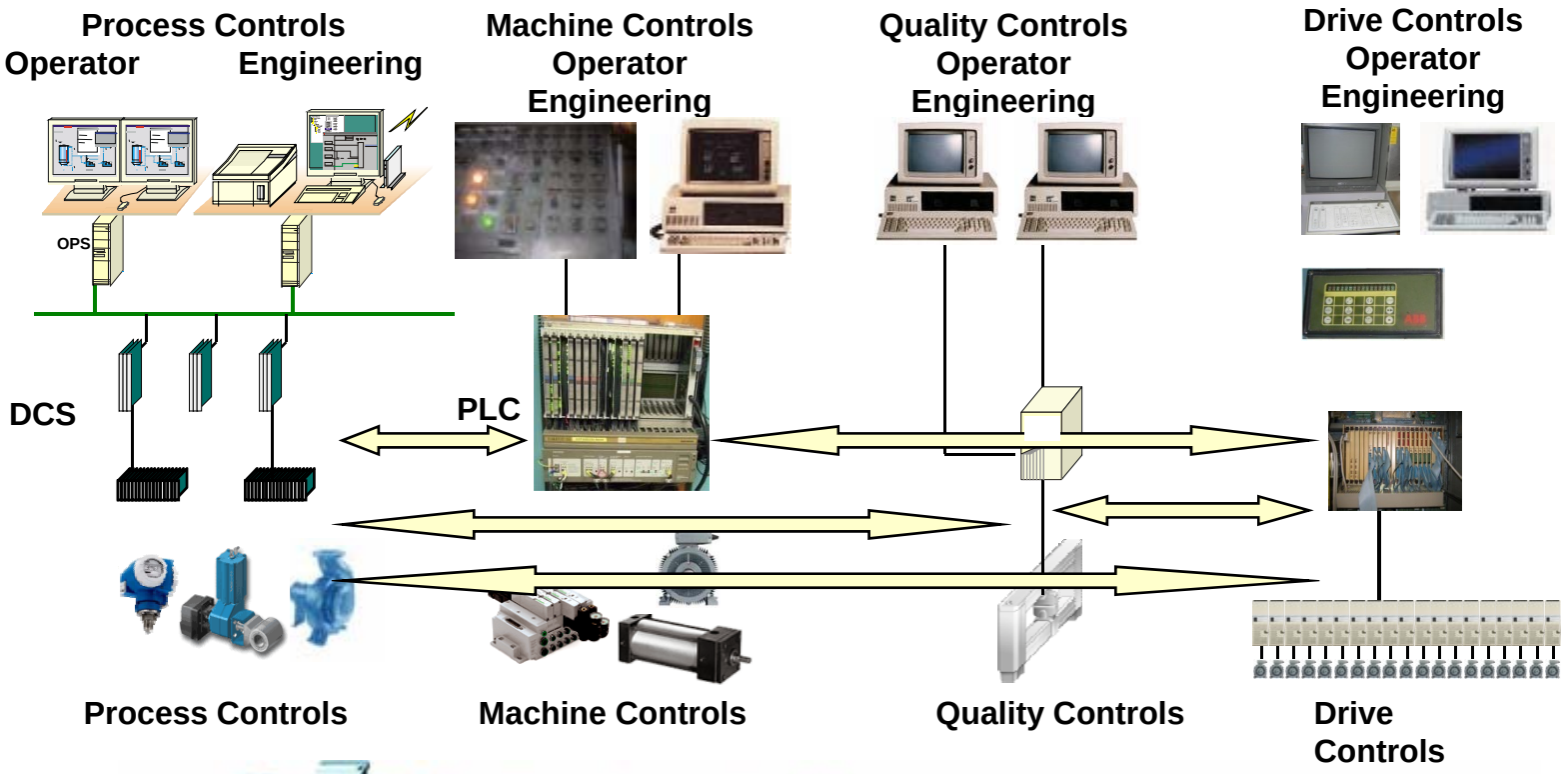
Erkki Jaatinen, Metso

# DCS embedded condition monitoring

- Content:
  - How DCS functionality has developed and how its role has evolved over the years
    - Metso´s approach with metsoDNA, from an ”only DCS” into  a true ”Distributed Network of Applications
  - Condition Monitoring System (CMS) integration and embedding into DCS
    - Motivation to do this and Metso´s approach with Sensodec 6S system and the new metsoDNA MachineMonitoring solution
      - First integrate
      - Then embedd
  - The embedded solution
    - Functionality and objectives
    - User interface for different users
    - Experience so far
  - Summary

# ”Conventional” concept for a paper machine

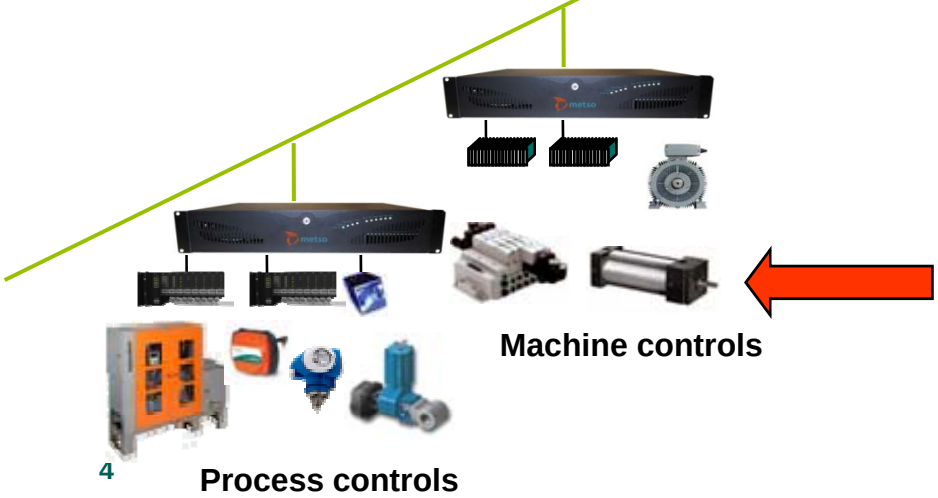
## Several separate systems with many links



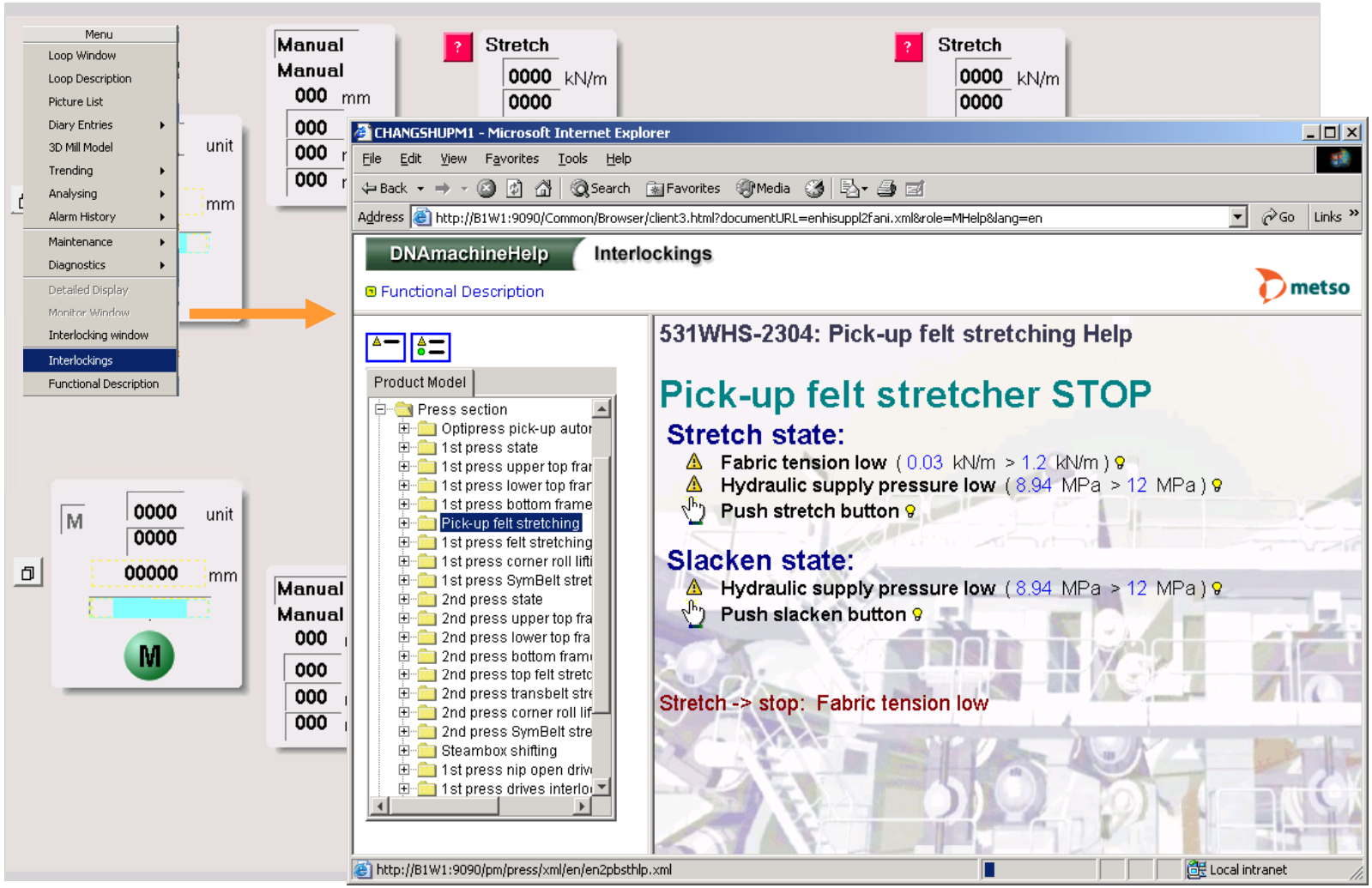

# Machine controls integration, 1990

**Targets and achievements:**

- Have the machine controls inside DCS instead of a PLC
- Controls applications and interlock diagnostics up to todays technology level
  - Interlock diagnostics  can be done by operators without help from instrument specialists
- Uniform operator interface with process and machine controls
- Implement common data management tools



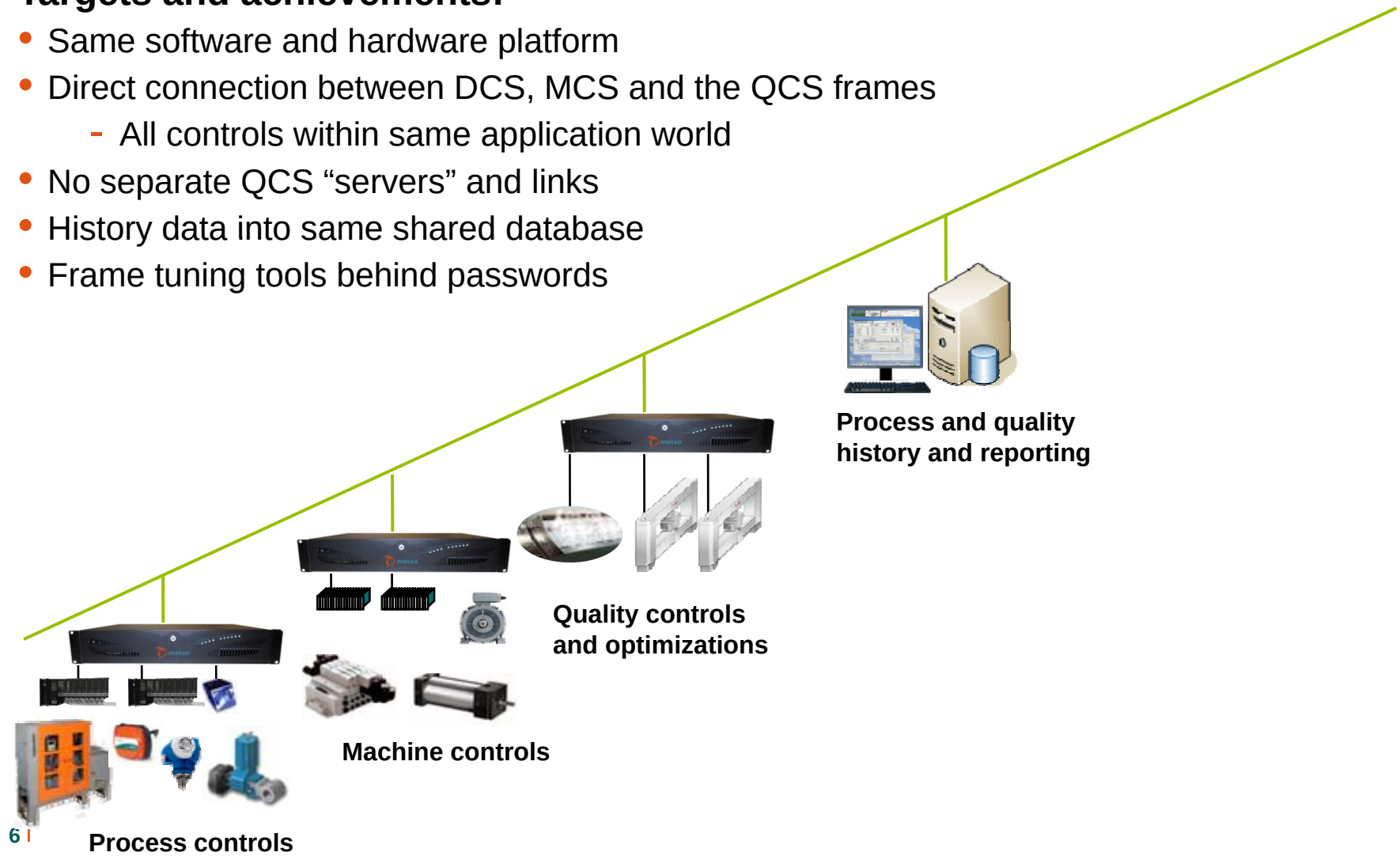

# Interlocks diagnostics



# Paper quality measurements integration, 1995

**Targets and achievements:**

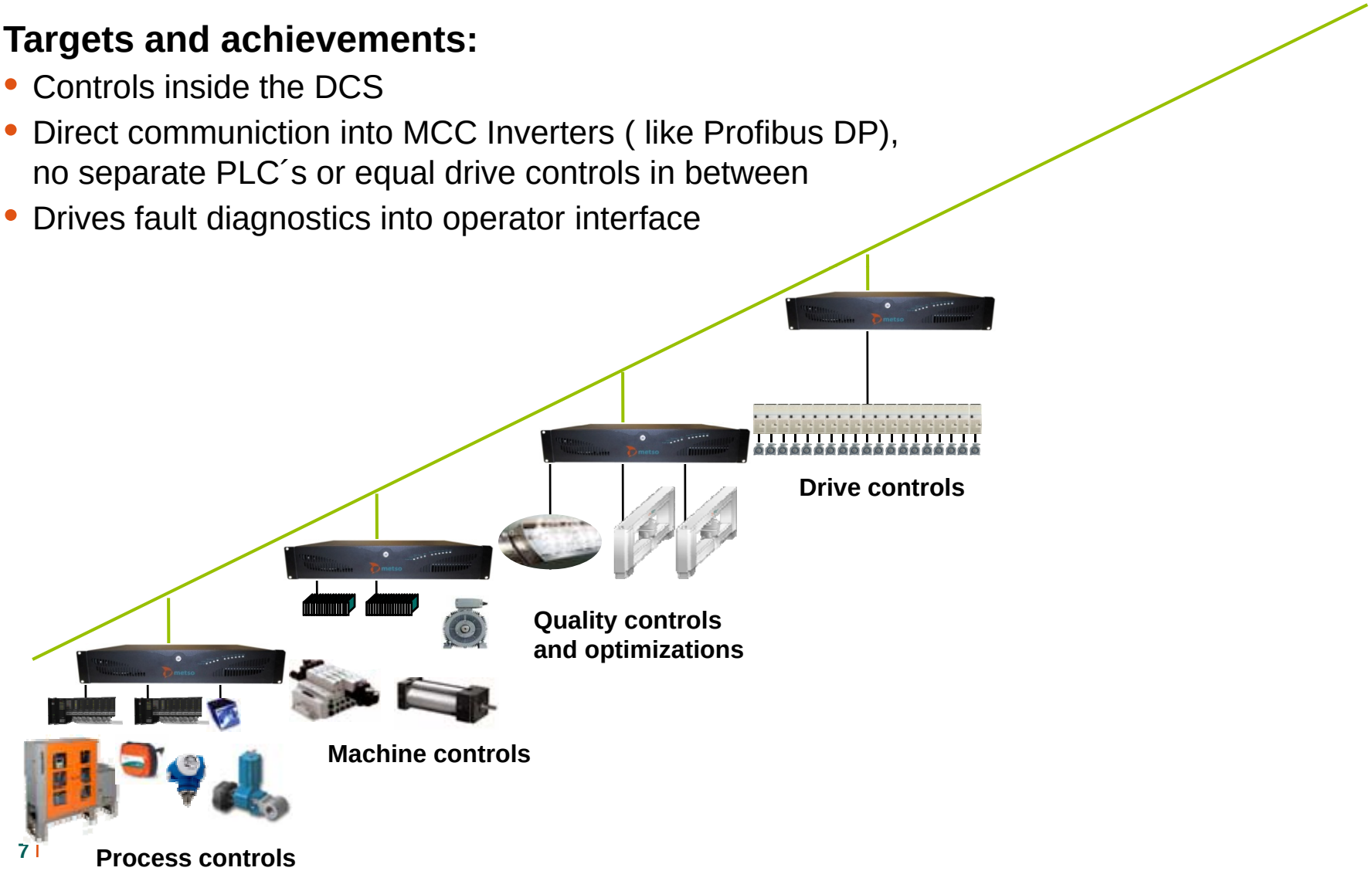
- Same software and hardware platform
- Direct connection between DCS, MCS and the QCS frames
  - All controls within same application world
- No separate QCS “servers” and links
- History data into same shared database
- Frame tuning tools behind passwords



# Drive motor controls, 2000

**Targets and achievements:**

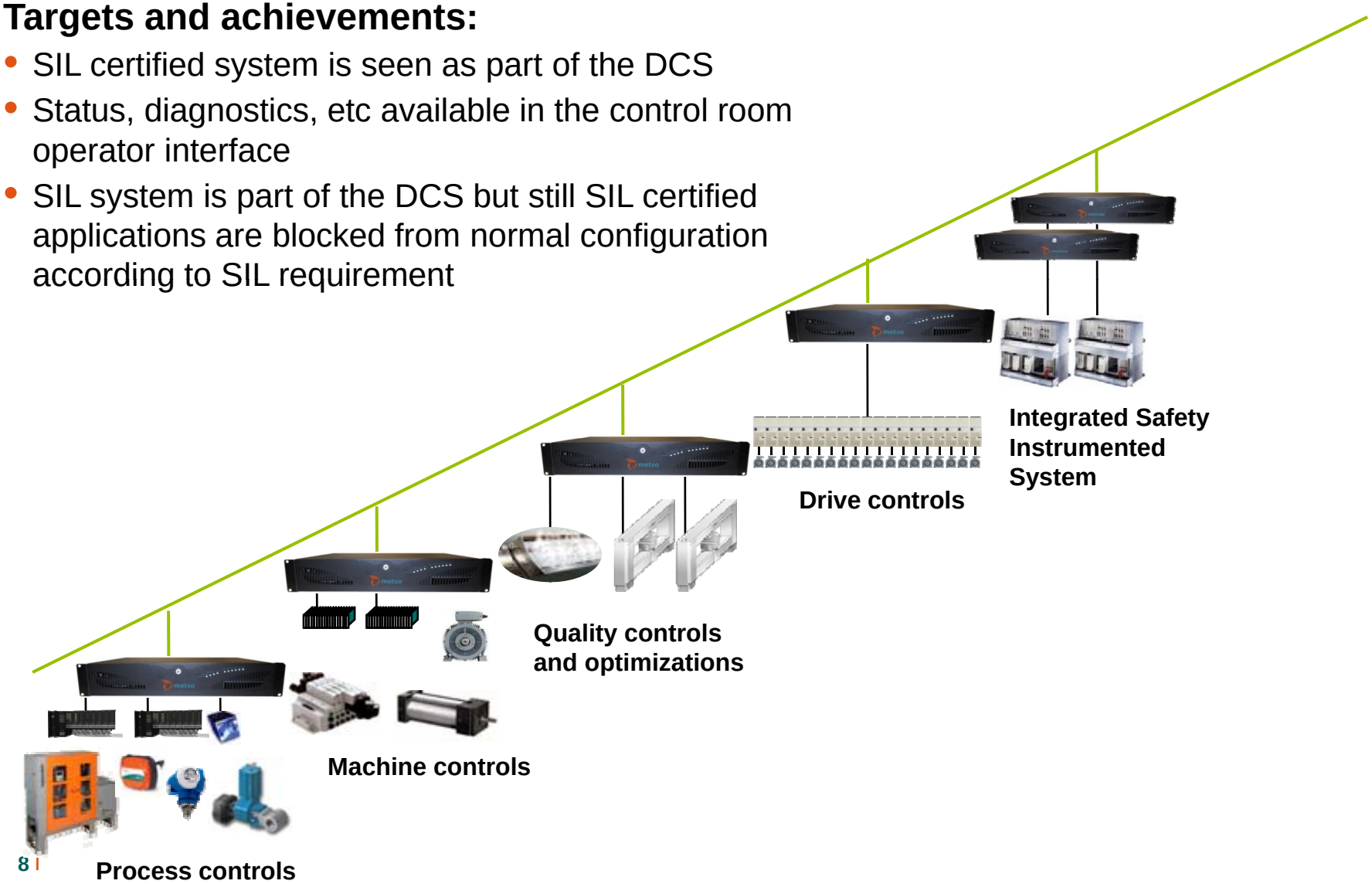
- Controls inside the DCS
- Direct communiction into MCC Inverters ( like Profibus DP), no separate PLC´s or equal drive controls in between
- Drives fault diagnostics into operator interface



# Safety Instrumented system, 2005

**Targets and achievements:**

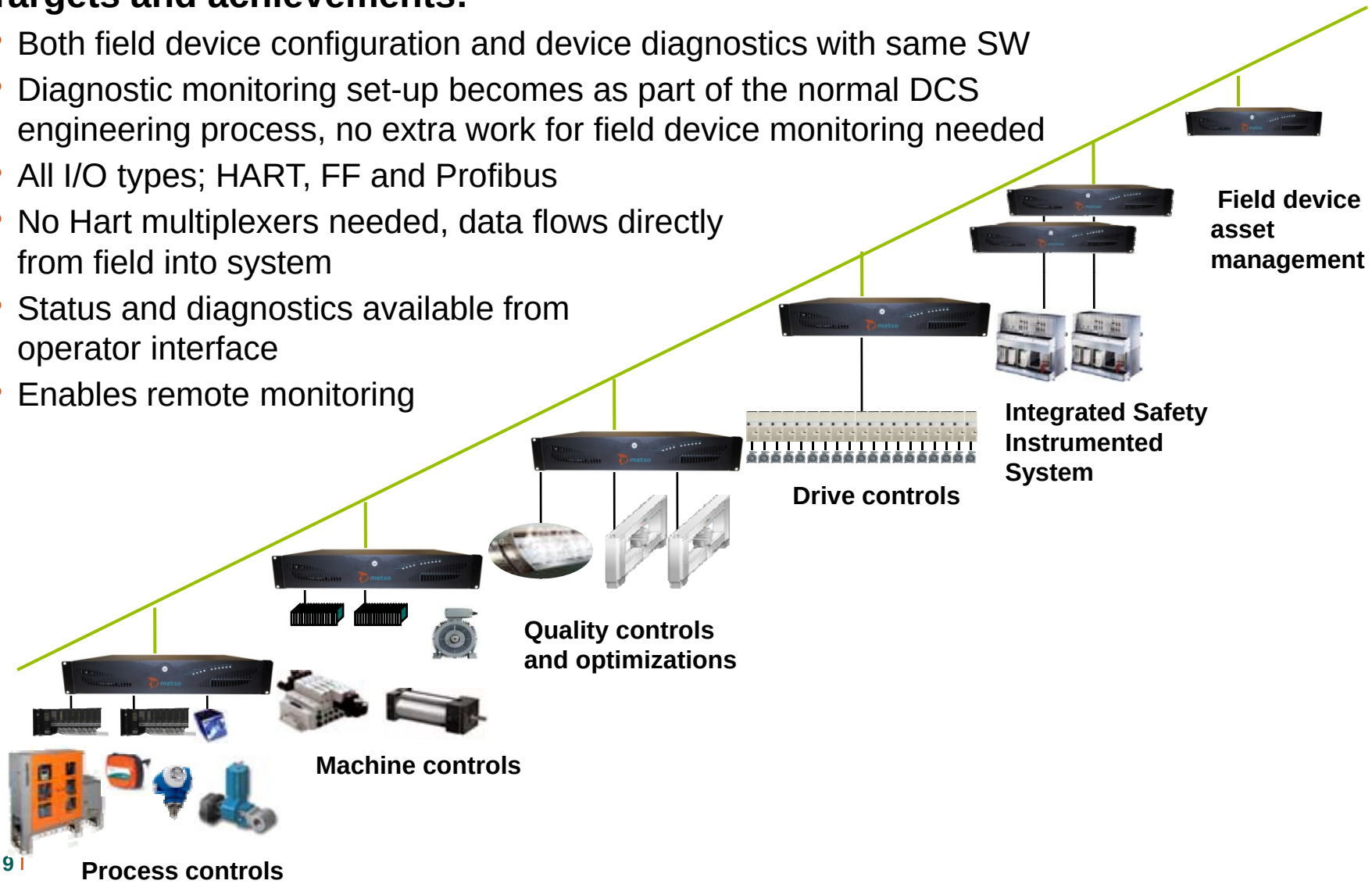
- SIL certified system is seen as part of the DCS
- Status, diagnostics, etc available in the control room operator interface
- SIL system is part of the DCS but still SIL certified applications are blocked from normal configuration according to SIL requirement



# Field devices, 2007

**Targets and achievements:**

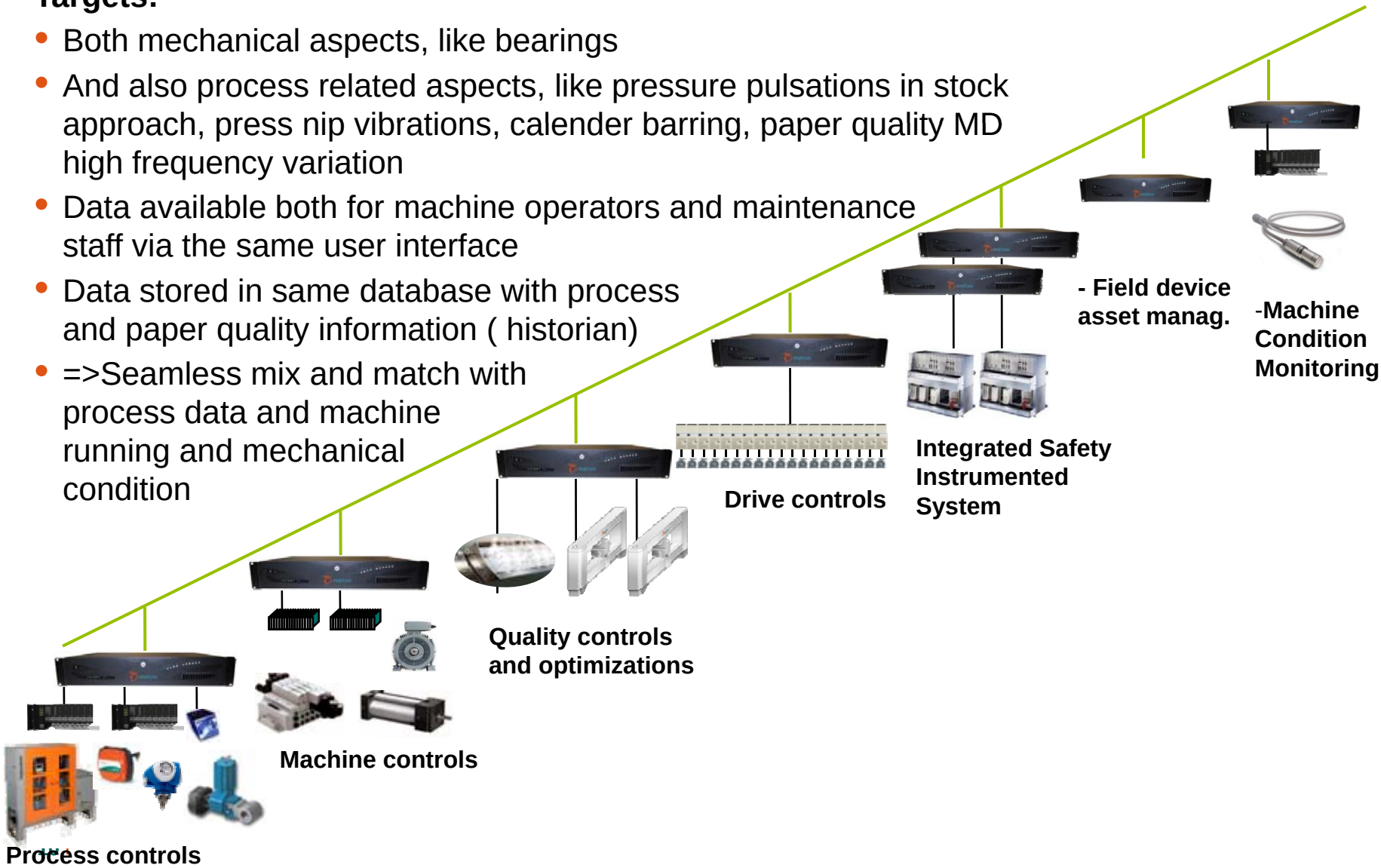
- Both field device configuration and device diagnostics with same SW
- Diagnostic monitoring set-up becomes as part of the normal DCS engineering process, no extra work for field device monitoring needed
- All I/O types; HART, FF and Profibus
- No Hart multiplexers needed, data flows directly from field into system
- Status and diagnostics available from operator interface
- Enables remote monitoring



# Machine (vibration) monitoring, 2009

**Targets:**

- Both mechanical aspects, like bearings
- And also process related aspects, like pressure pulsations in stock approach, press nip vibrations, calender barring, paper quality MD high frequency variation
- Data available both for machine operators and maintenance staff via the same user interface
- Data stored in same database with process and paper quality information ( historian)
- =>Seamless mix and match with process data and machine running and mechanical condition



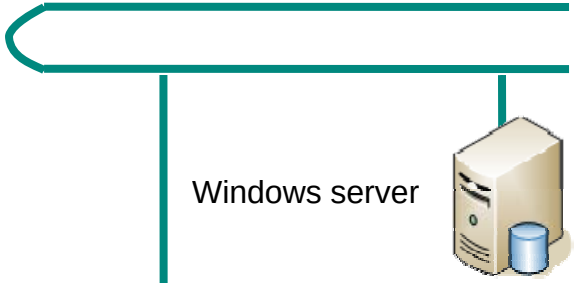
# Two step approach

## Development steps during 2007..2010

Embedding of the CMS into DCS took place in two steps

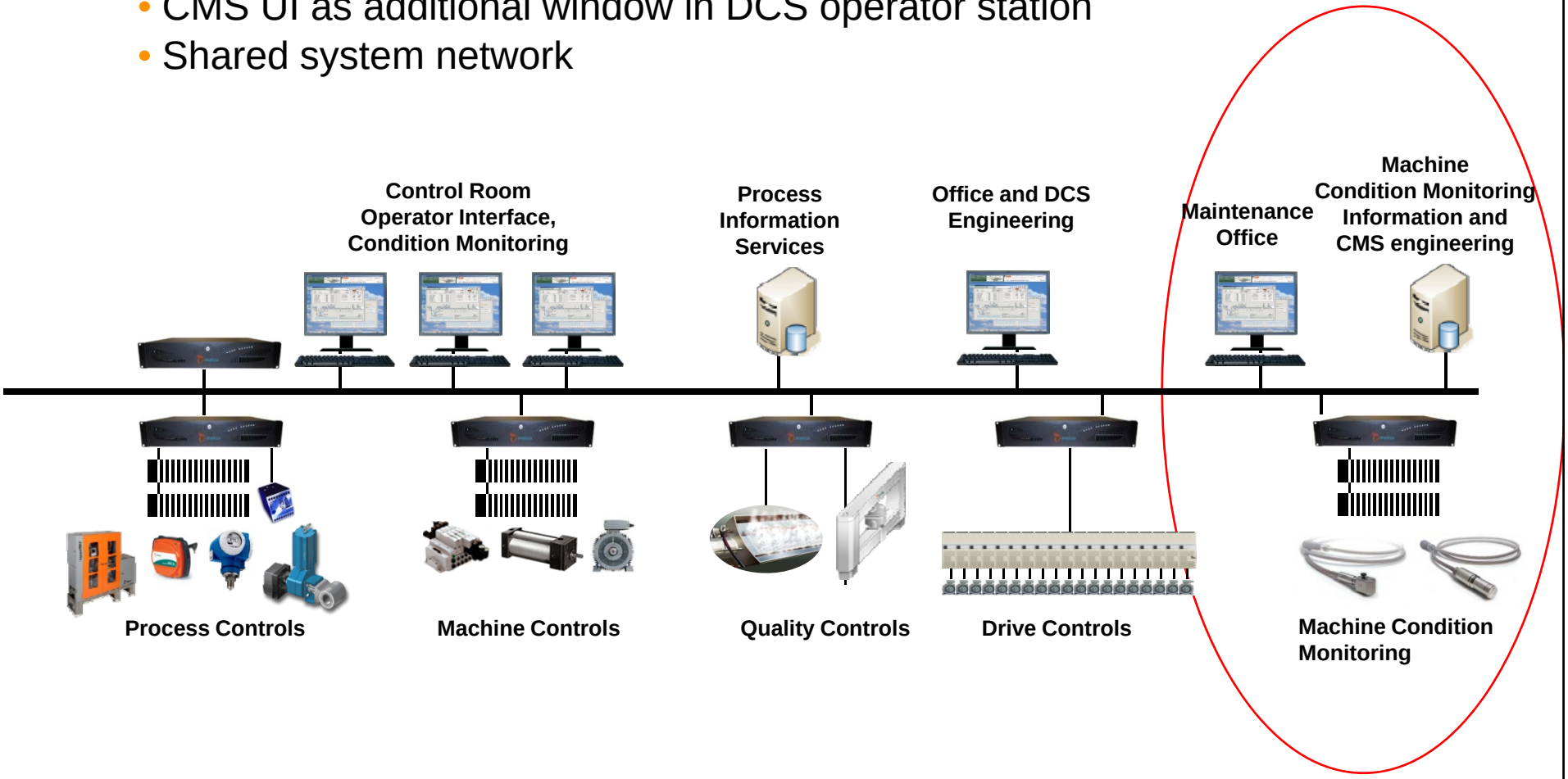
- Step1; integrate the existing CMS system into DCS environment
  - HW development for uniform HW platform
  - Capability to operate CMS from DCS operator stations (”single window”)
  - Data exchange gateway between Metso DCS and Metso CMS

# Step1 Common HW structure for CMS and DCS

| CMS system SW | System HW | DCS system SW |
|---|---|---|
| Sensodec GUI |  Windows PC | DNAuse |
| Sensodec 6S server |  Windows server | metsoDNA IA |
| Sensodec analysis substation SW |  MetsoACN  MIO | metsoDNA Process controller SW |

# Common HW platform for DCS and CMS

- CMS UI as additional window in DCS operator station
- Shared system network



# Two step approach

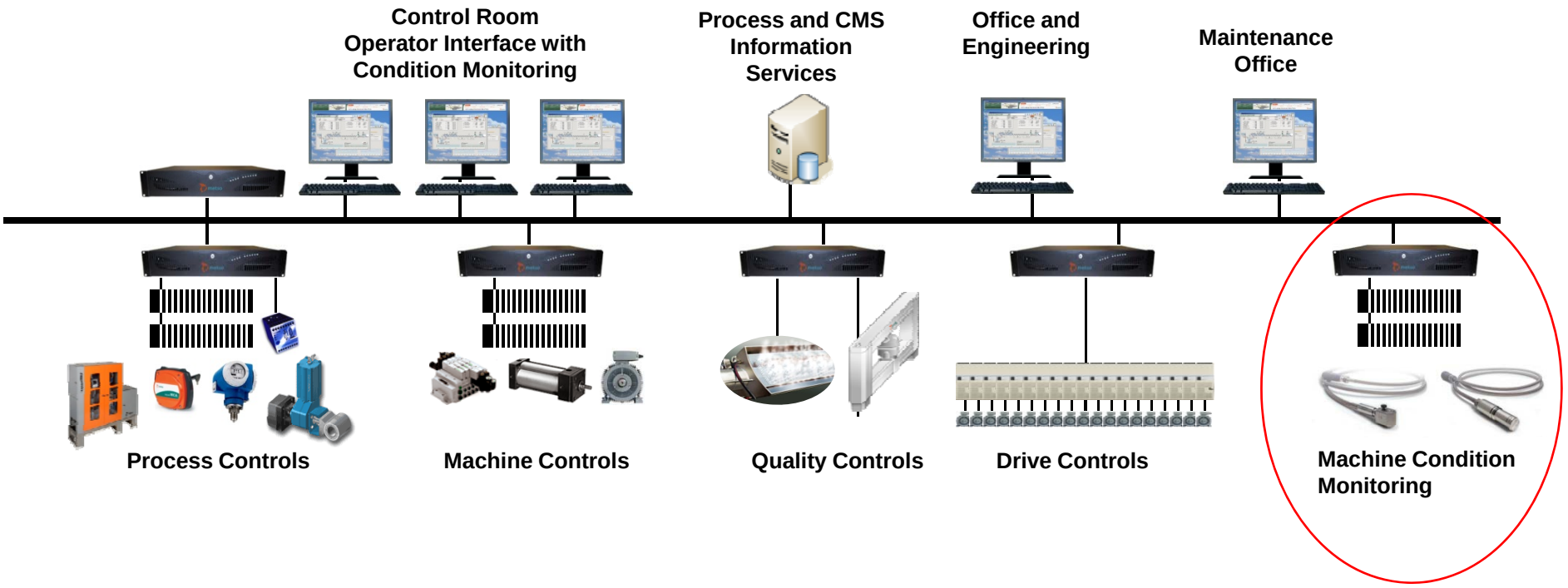
## Development steps during 2007..2010

Embedding of the CMS into DCS took place in two steps

- Step2; embedd the functionality into DCS
  - Uniform HW  and now also SW platform
    - Vibration monitoring calculations done in DCS language, ”Function Blocks”
  - Same engineering tools
  - Same database for history
  - Add vibration results into DCS Operator Interface
    - Both scalar results and also vector type results like signal samples and spectrums

# Common HW platform for DCS and CMS

- CMS is one part of DCS functions



# Motivators to embedd CMS into DCS

## What does the customer benefit

- Lower use barrier (operators, maintenance, management)
  - One tool to operate, common history and alarm handling
  - Same data in same format for both operators and maintenance staff
- Machine management 24/7
  - Important especially for non-office hours when predictive maintenance people are off-site
- Common history database for all data for reports and analysis
  - Efficient to analyze
- Common controllers and I/Os (DCS and CMS)
  - Easy and cost efficient to implement and expand
  - Simplier infrastructure
  - Easy to serve and upkeep
  - Common spare parts
- One set of engineering and operation training
  - Cost efficient, easy to allocate into training sessions

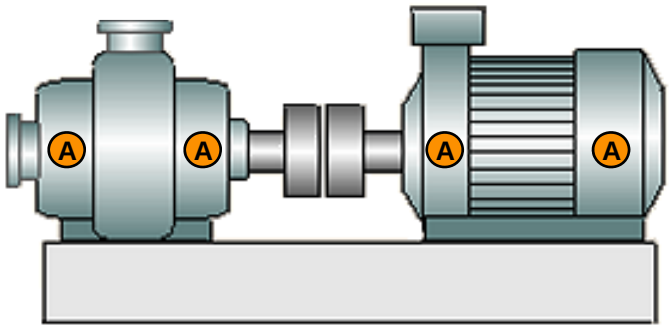
# Development objectives

- When embedding CMS into DCS there were some aspects to consider
  - Operators are NOT vibration analysts, so data format for their use has to be easy to read and has to suit into their role in the plant
    - Observe, notice, react, call for assistance if needed
    - Above especially for mechanical failure modes like bearings and gears and equal
    - On the other hand, aspects like felt corrugation analysis or roll cover condition follow-up are part of operator´s tasks
  - Data available for predictive maintenance specialists has to be up to level for their needs
    - You have to have good signal, spectrum and equal user interface elements for mechanical diagnostic work
  - All operators should not change alarm limits, frequency bands or equal parameters, but this should still be possible without logging in into DCS engineering tools
  - Monitoring has to be sensitive to detect different kind of faults
    - NOT only overall levels used, but also fault type tunable narrow band levels

# Examples of machines with sensor locations

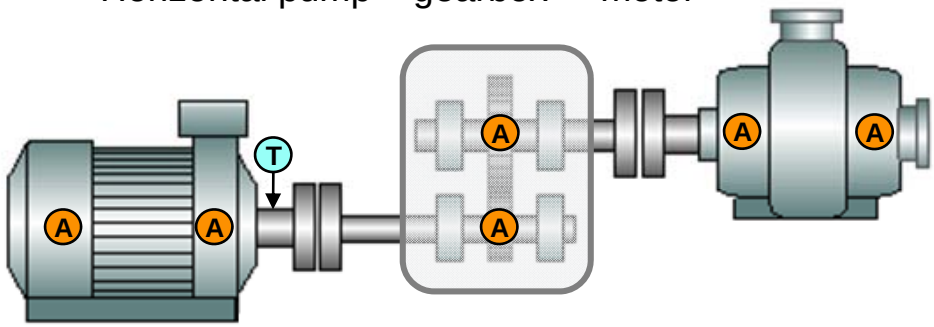
## Machines can be fixed speed or variable speed

Horizontal pump + motor

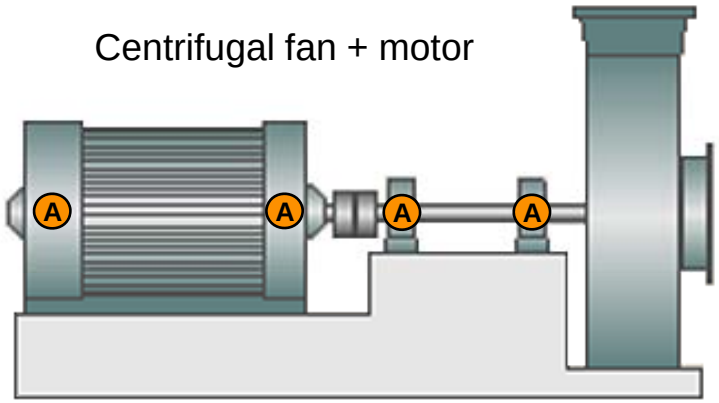



Monitoring has to be detailed anough to pick up different fault modes
Still simple & efficient to execute
=> Machinery templates used, variation via parameters in the template

Horizontal pump + gearbox + motor




Centrifugal fan + motor




A = acceleration sensor (vibrations)

T = speed trigger sensor (rotational frequency)

# Typical analysis content in one template

## Monitoring Parameters vs. Faults

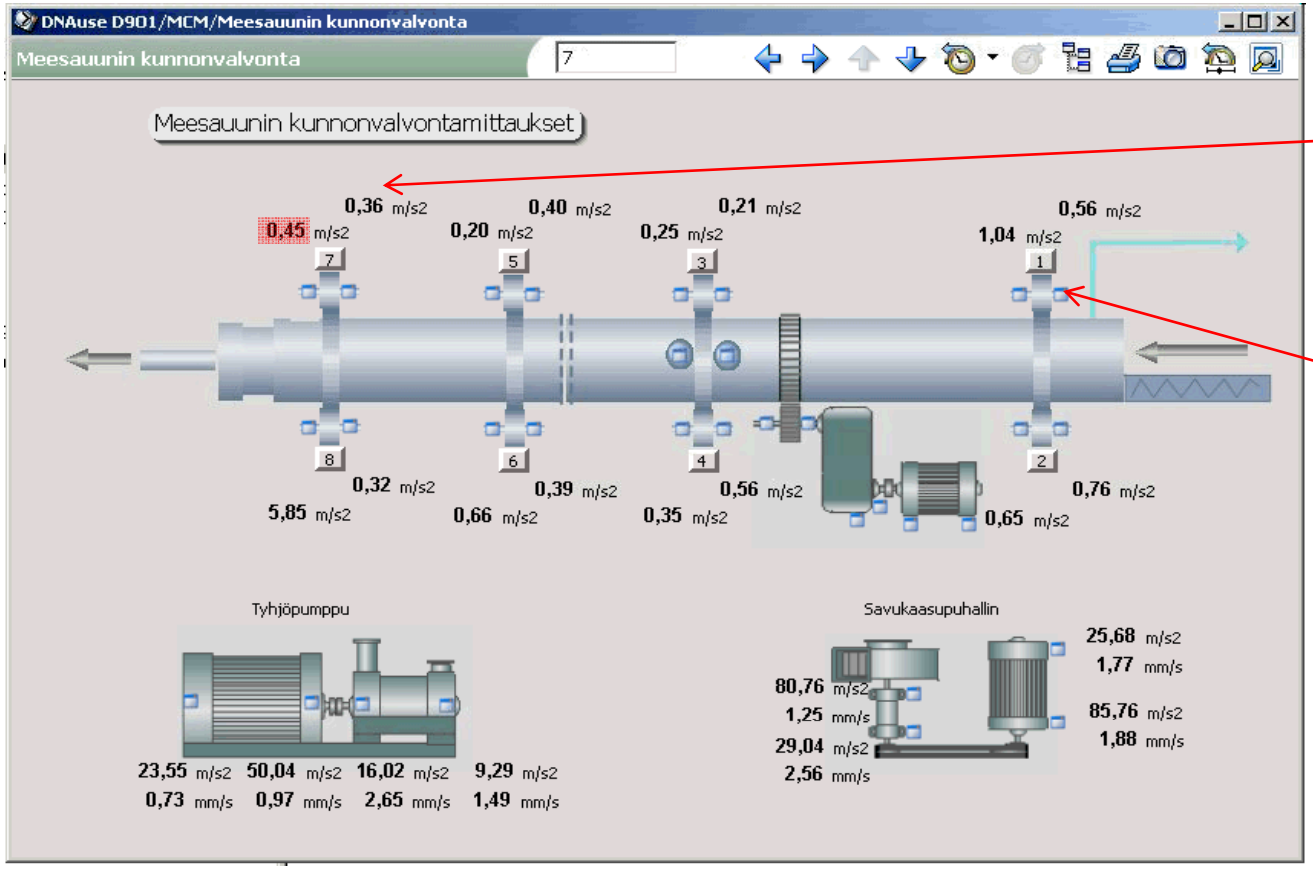
| Monitored phenomena | Character |
|---|---|
| ISO/DIN machine vibration severity (load, stress) | Vibration velocity rms, from frequency range 10 Hz – 1 kHz |
| Faults creating high frequency vibration , like;<br>Rolling element bearing fault<br>Lack of lubrication<br>Cavitation | Vibration acceleration peak<br>Vibration acceleration rms high frequency range 1 kHz -10 kHz<br>Enveloped acceleration level |
| Coupling fault<br>Rolling element bearing fault impulses | Vibration velocity rms<br>Frequency range 5-20xrpm (rotation frequency) |
| Unbalance and alignment | Vibration velocity rms<br>1xrpm + 2xrpm |
| Gearbox faults | Vibration velocity in gear mesh frequency |
| Detailed analysis | Signal, FFT, enveloped signal & FFT |

# Use case 1, mechanical failures

- Most mechanical failures develop over a longer period of time
  - Thus typically noticed by predictive maintenence staff before operators notice them
  - Repair actions are allocated into shutdown maintence schedules, thus may even go ”unnoticed” by operatos
- But there may be cases which develop fast
  - Dirt build-up on fans, cracking in fan blades, etc
    - Here ”operator driven maintenance” approach is needed to ensure no production losses occur if predictive maintenance is not at site ( night times, weekends)
- And also operators can take some of the workload away from predictive maintenance
  - Reacting into alarms and equal responsibilites
  - Visual walk-arounds, simple data collection, overall development follow-up
- For this to happen in mechanical fault monitoring, like said in previous slide
  - Base user inteface has to be easy to read for operators
  - Still for predictive maintenance you have to have tools to make detailed diagnostics

# Process picture with numers and links

## In this case a separate page created for CMS only (over 20 vib points)



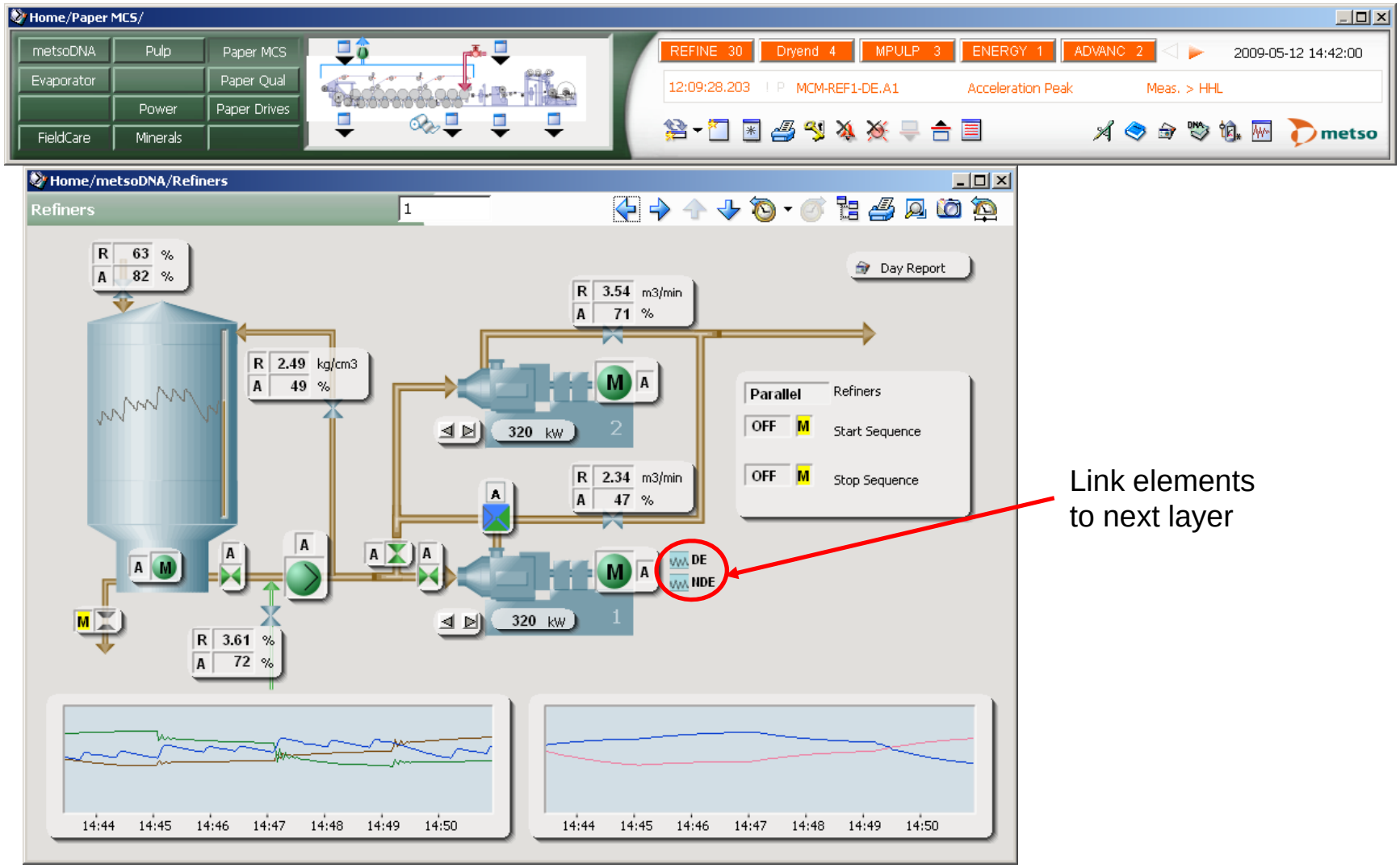

Main values with numbers

Alarms with colours

Link boxes to next layer of data

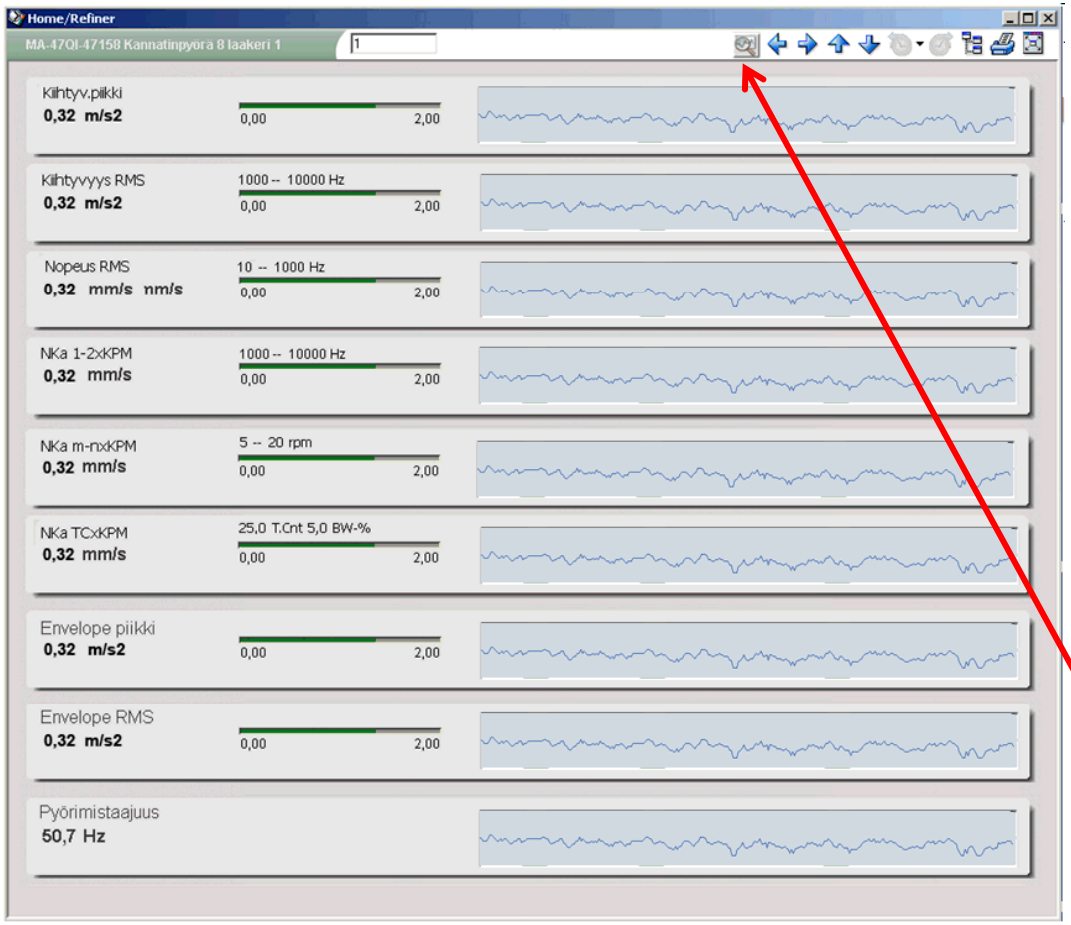
# Process picture

## In this case CMS links embedded into control page ( a few points only)




Link elements to next layer

# 2nd layer, easy to use for operators



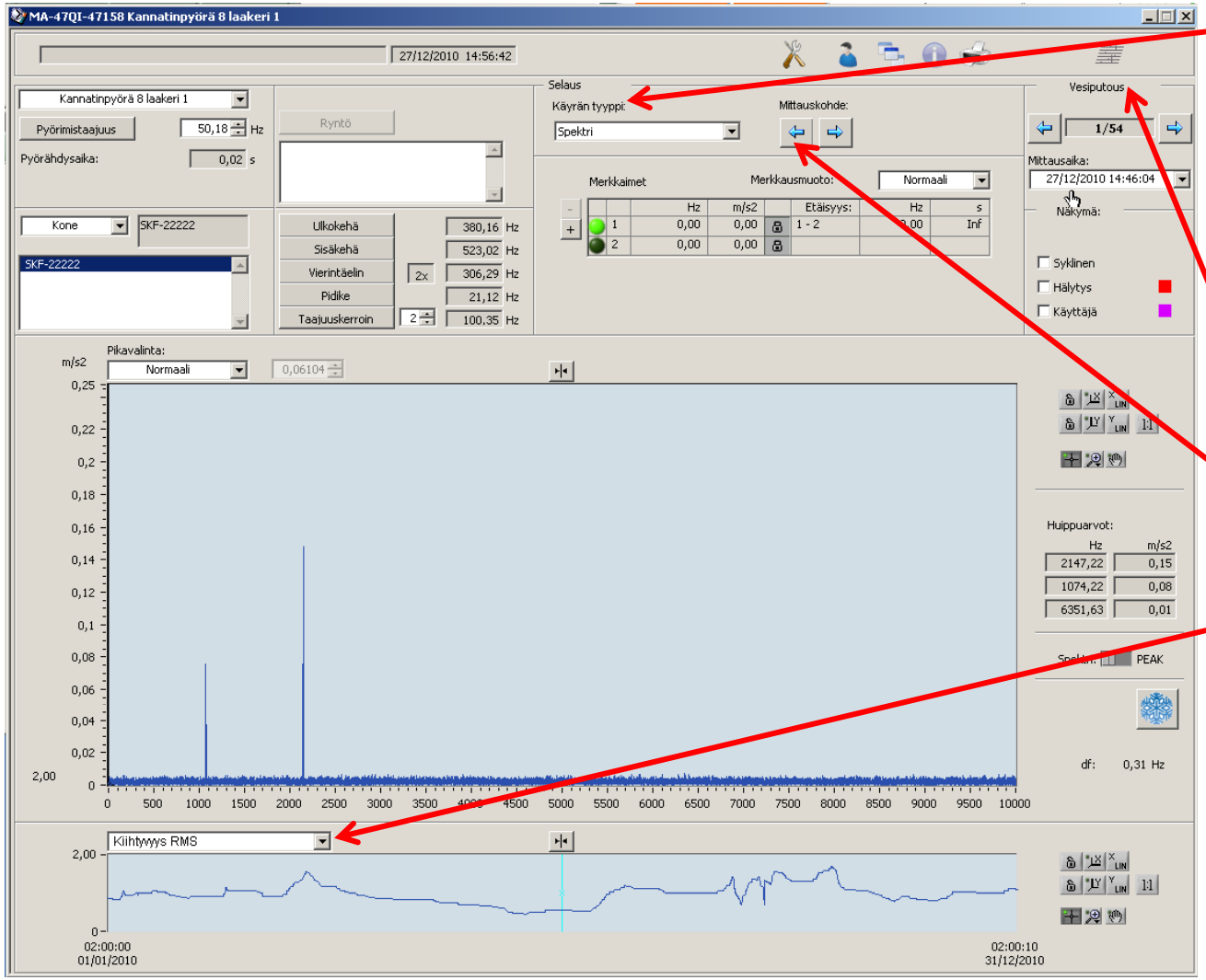

The next layer is a simplified overview to the status of each monitoring point

- Scalars with bar graphs
- Bar graphs are with alarm limits and alarm indication (colour)
- Trends of each scalar

More information is available from magnifying glass (opens analysis tools)

# Analysis display

## “all the bells and whistles for predictive maintenance”, FFT tool




Curve type selectable:

- signal sample
- acceleration spectrum
- intergated spectrum
- enveloped acceleration signal
- enveloped acceleration spectrum

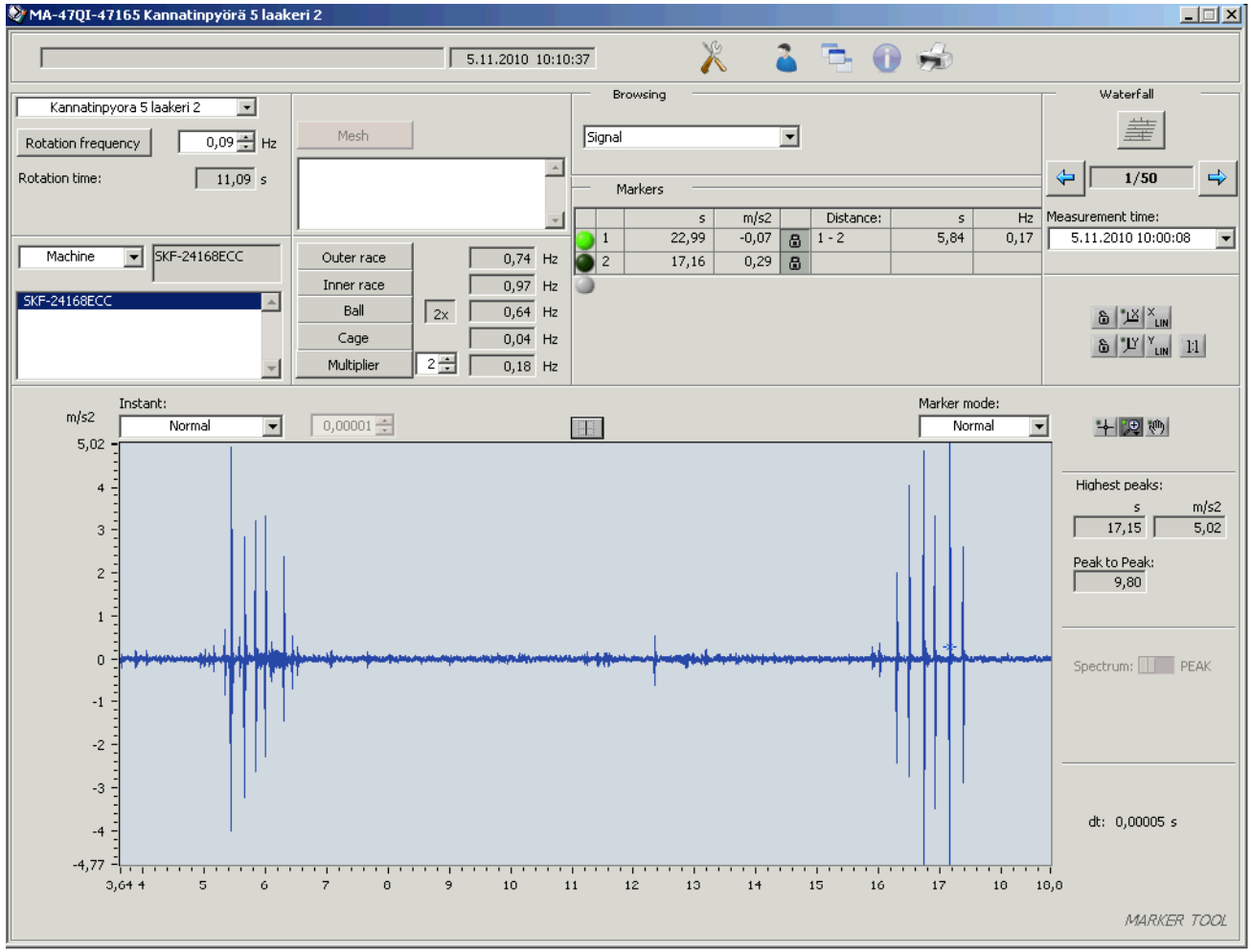
Waterfall history available for selected point and result

Analyzed point selectable within machine group

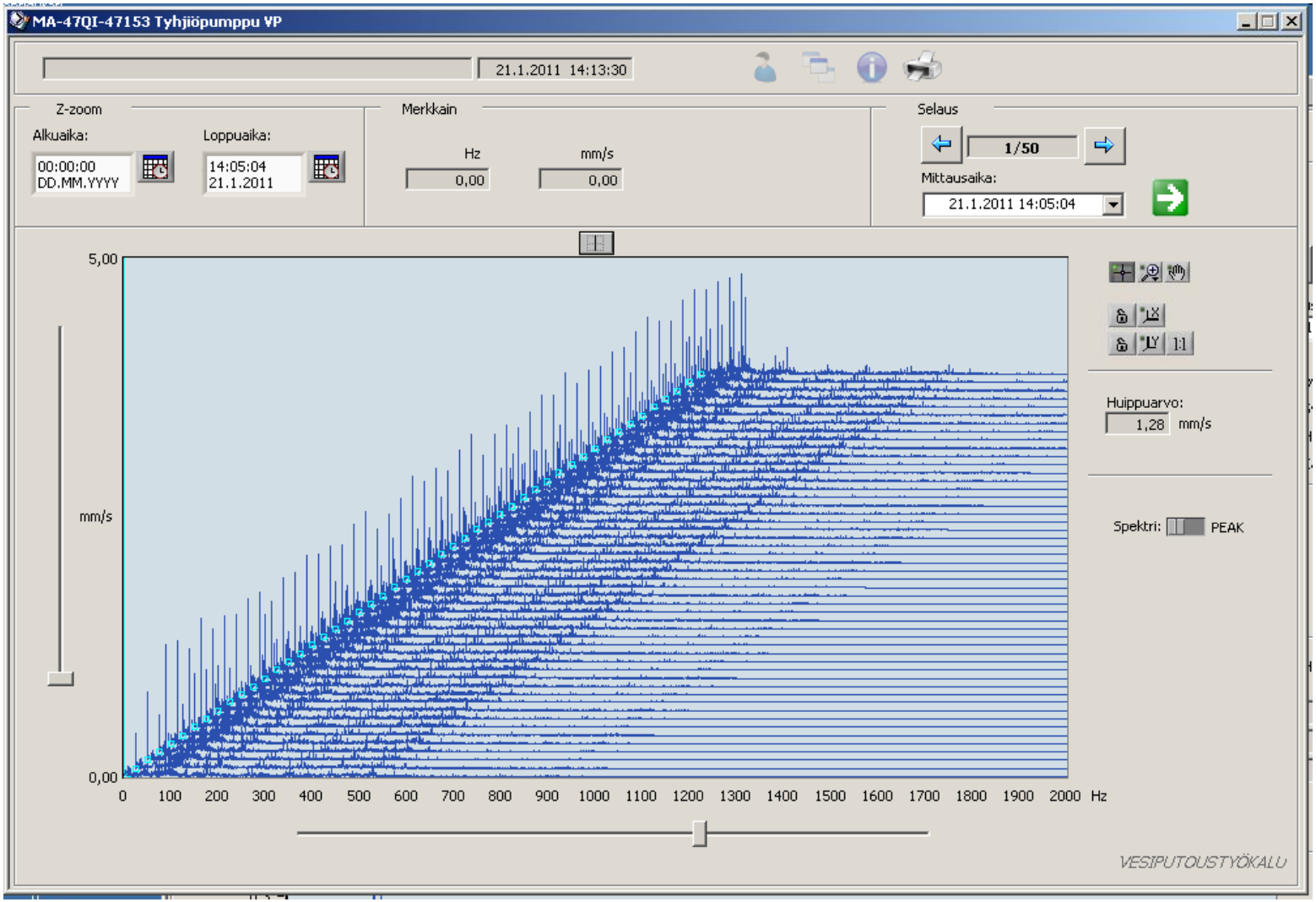
Scalar history trend in the bottom for background info, scalar to be shown is selectable

# Analysis display

## “all the bells and whistles for predictive maintenance”, signal tool and real sample from troublesome lime kiln bearing assembly

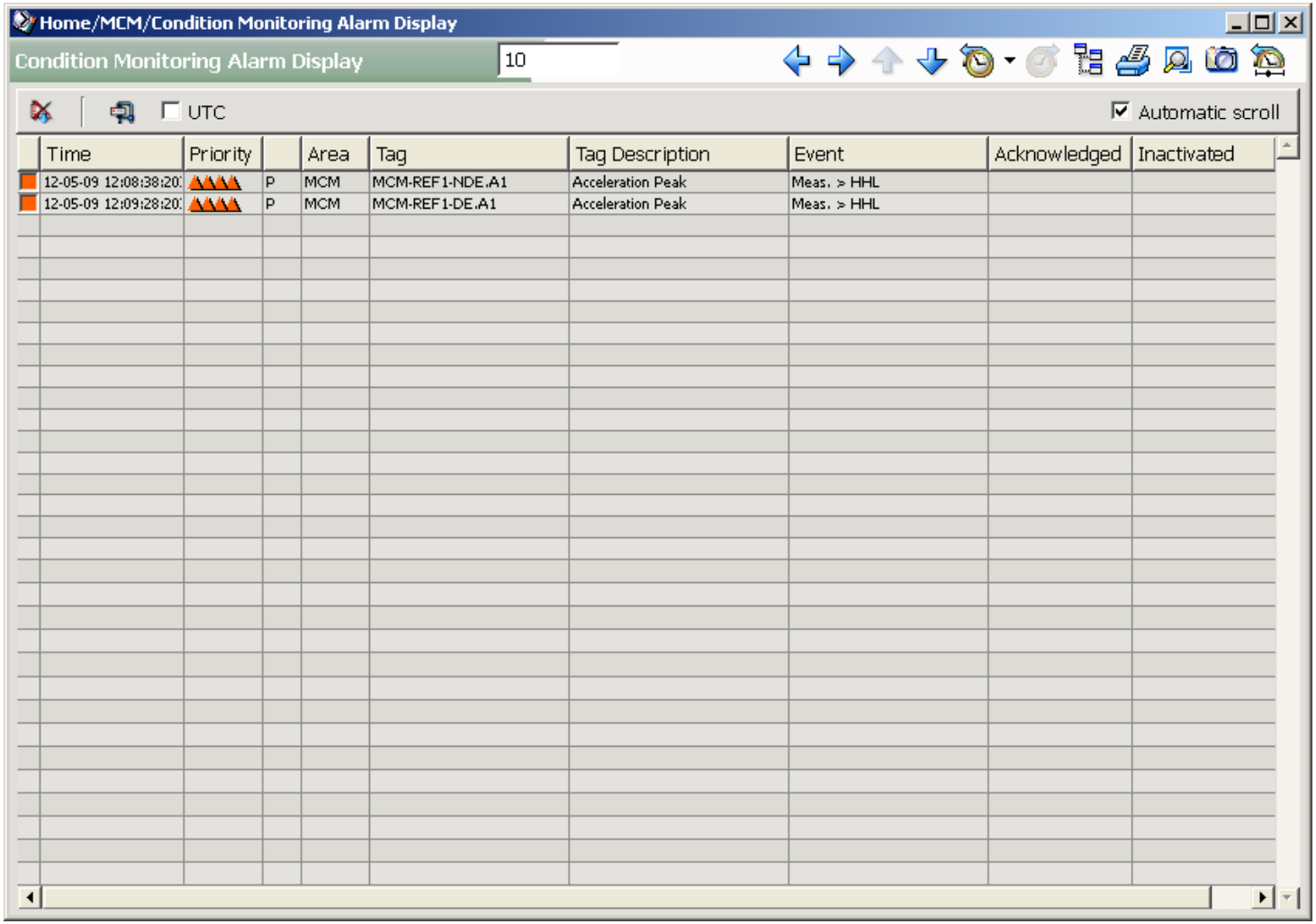


# Waterfall display (3-d spectrum history)



# Vibration alarm hadling

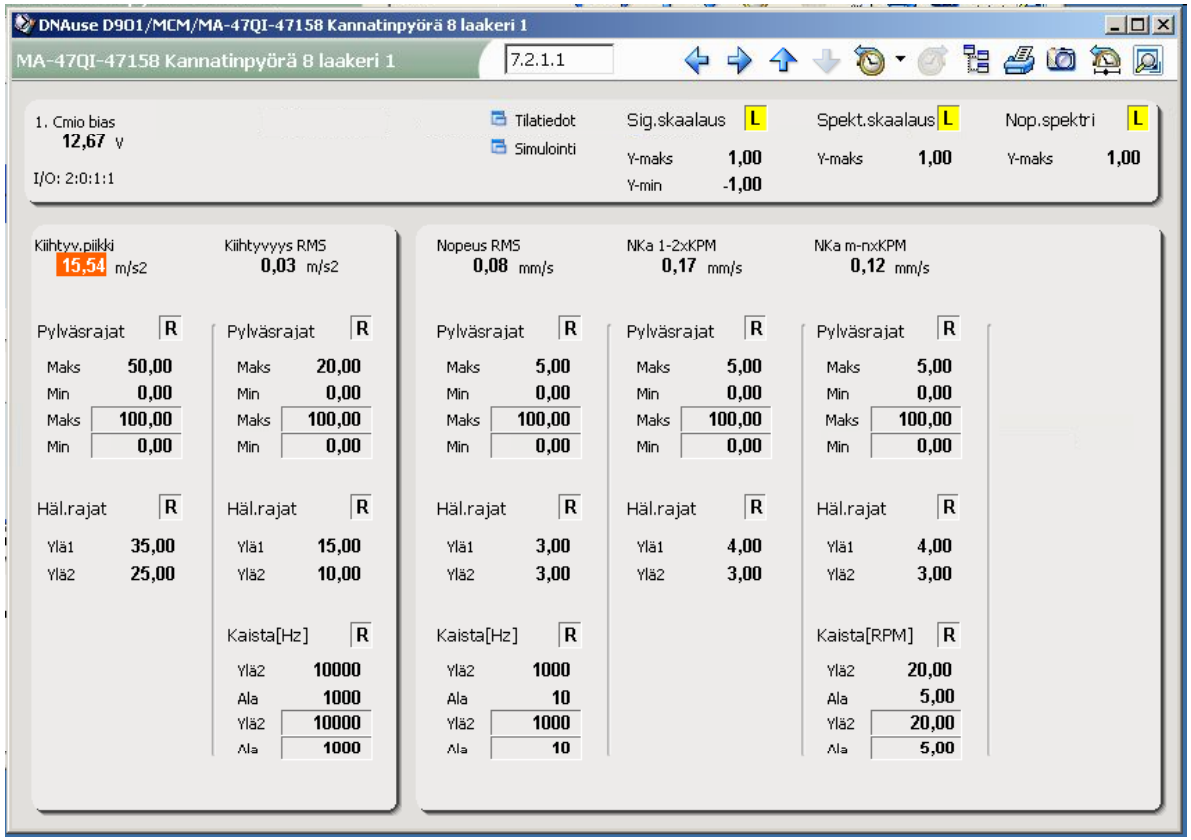
## Alarms are shown in the normal DSC alarm list



# Feedback

- Operator were happy to look at alarms and trends
- When things look ”dangerous”, they will contact to maintenance technician on call and ask him to start further analysis
- If the DCS is linked into the CMMS ( like DNA Diary –> SAP/Maximo link), maintenance work orders can be activated directly from DCS UI and its monitoring tools
- Predictive maintenance seem to be happy with analyzing tools available, these tools seem to fulfill their needs for detailed mechanical fault analysis
- Alarm limit adjustment and analysis tuning is available via so called ”tuning displays”, typically managed by predictive maintenance staff

# Tuning display for one measurement point




Analysis tuning can be done;
-for a goup of similar machines or monitoring points, ”remote” status controlled from a group tuning display
-when you want to tune parameters individually to certain point =>you change this parameter into ”Local” (yellow colour in respective box)

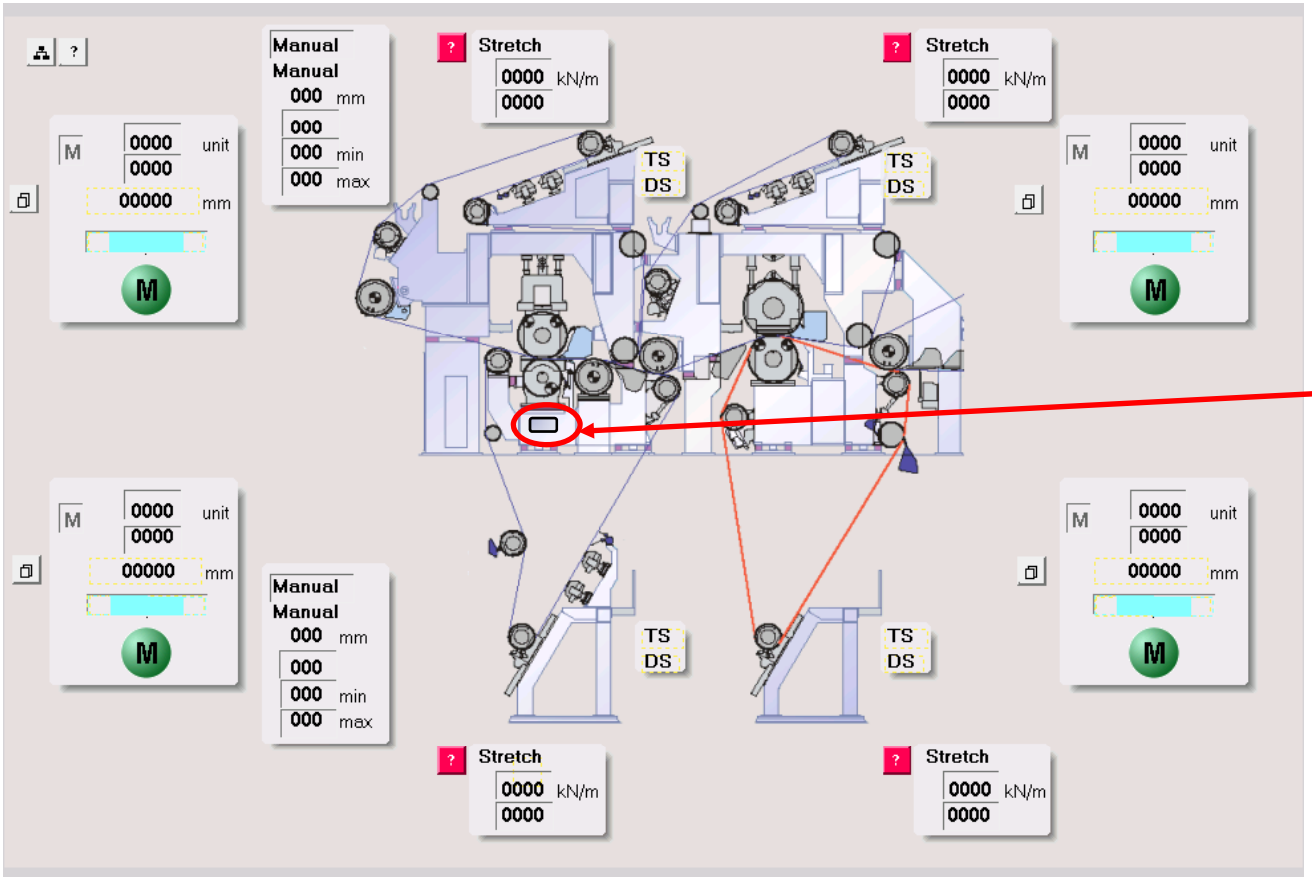
Tuning includes;
-bar graph scales
-alarm limits
-frequency band limits (narrow and broad band scalars)
-analysis execution cycle

# Use case 2, ”Runnability” monitoring

- With this ”Runnability” monitoring we mean measurements that are related to
  - Machine runnability, like felt vibrations and roll cover related vibrations
  - Stock approach pulsations
  - Paper quality MD variations ( due to am type machine behaviour)

- UI principles used
  - Slightly different principle here , since these results are primarily looked by operators
  - Operators are quite well aware of these phenomena, thus are not ”afraid” to see roll corrugation related ”detailed” results, like circular plots

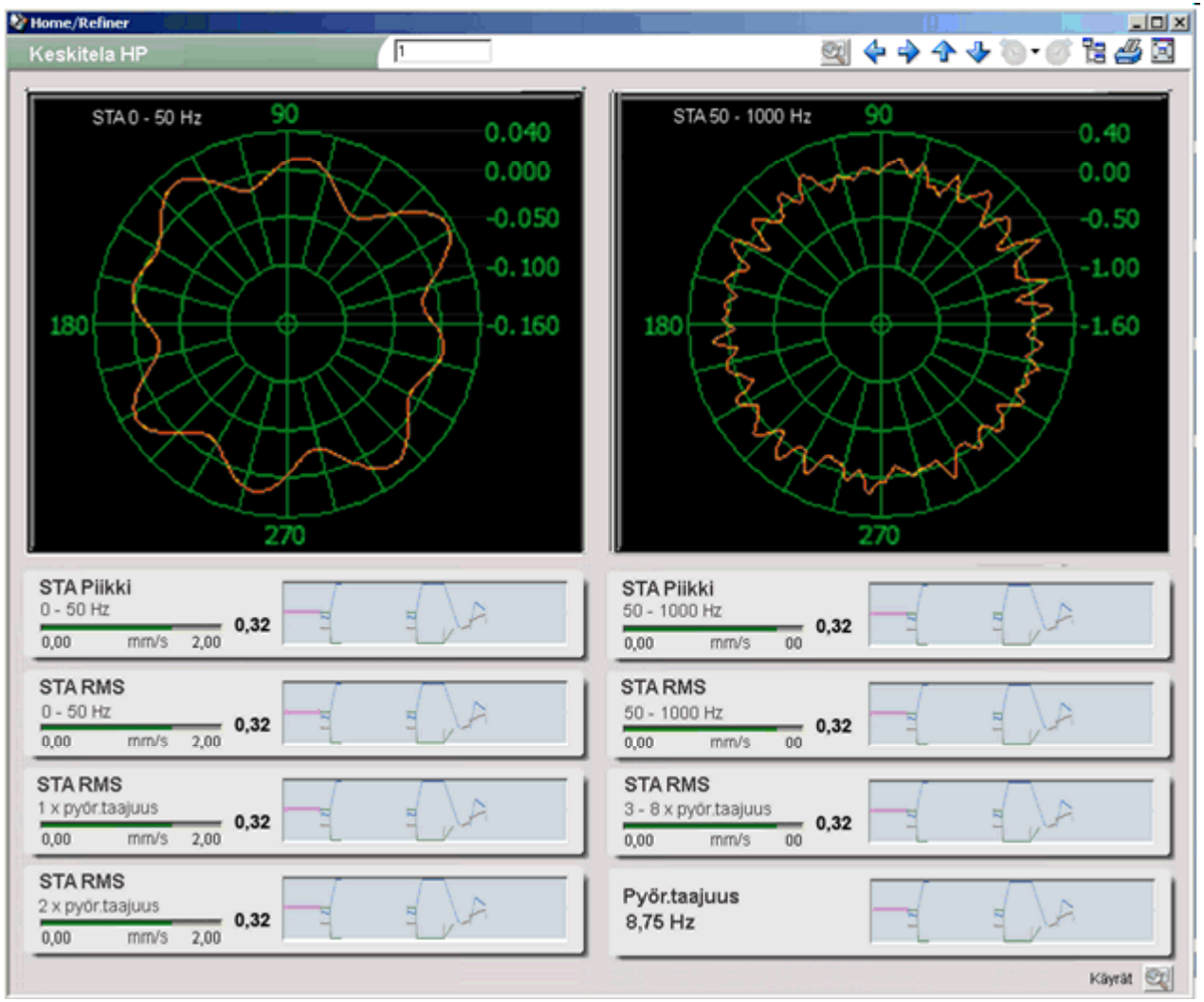
# Press Runnability monitoring




Link elements to next layer for the most important vibration results can be added into press section control picture

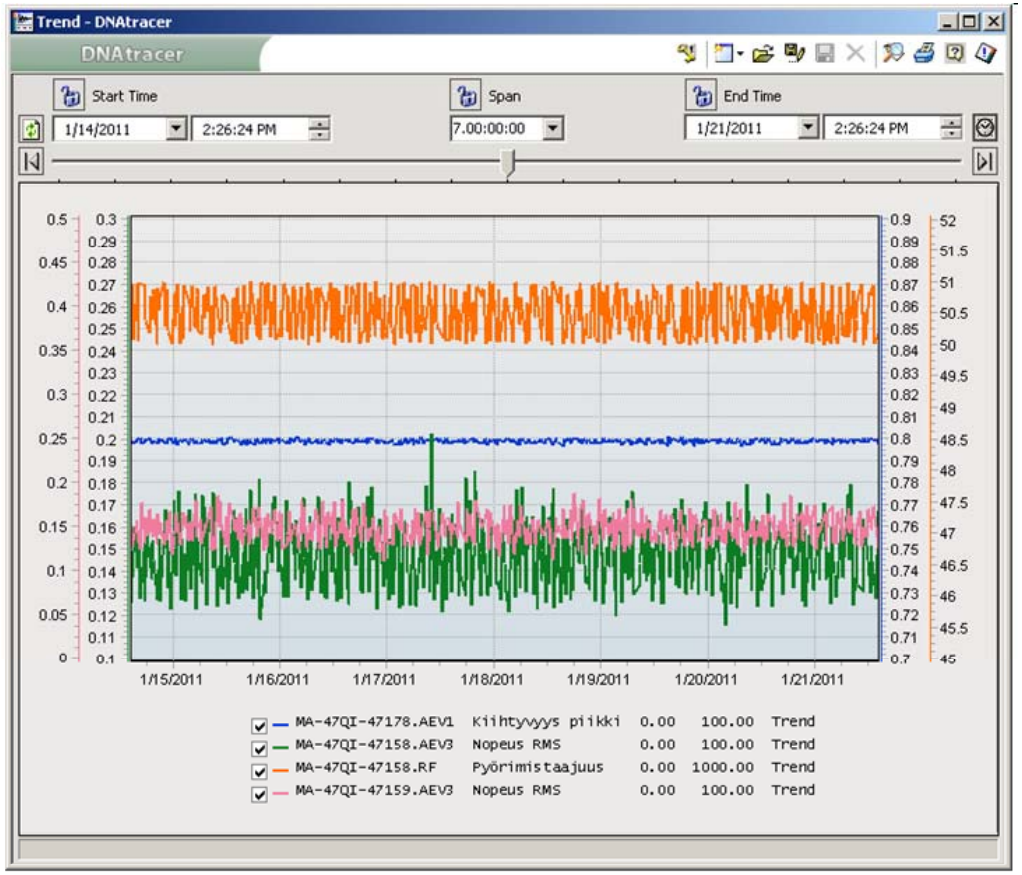
# Runnability monitoring

## Press roll vibration (STA result)



# Some general thoughts

## CM results and process data can be viewed and compared in same trends using DCS history tools, “drag and drop”




- With this you have the possibility to compare process values and vibrations in same trends (”drag and drop”).
- This can be very valuable to optimize machine operation, think about cases like;
  - Yankee crepe blade ”chatter” versus Yankee surface chemicals feed
  - Felt corrucation vs felt cocking vs felt water removal vs nip pressures
  - Headbox pressure pulsation vs overflow valve set-up
  - And equal set-ups where process parameters and machine dynamics are linked to each other

# Summary

- In the words of Mr Christer Idhammar of Idcon;
  - ”To include operators in essential care of equipment including preventive maintenance inspections is one of the relaibility and maintenance improvement initiatives that can yield the best return on investment”
- Why to do this
  - There is a need to increase competitiveness and productivity
  - Predictive maintenance programs will be much more cost effective
  - The partnership between operations and maintenance will improve
  - Operators are always there 24/7
- But naturally you have to provide proper tools for them to do this
- Embedding CMS into DCS brings machine condition information into the daily tools of the operators, and this can lead to the same kind of availability improvement like bringing machine interlock information into opertor interface