SHIPMECHS

How Mechatronic solutions can help to improve overall performance

16 June 2009

Teus van Beek
Leo de Vries

WÄRTSILÄ

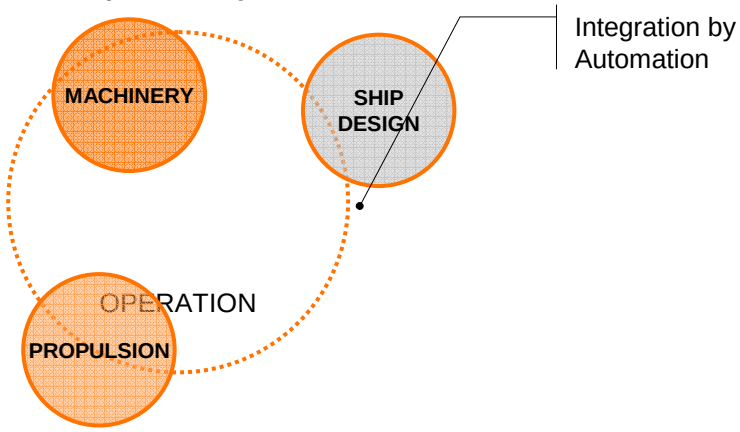
Content

- Background of Wärtsilä Energy Core
- SHIPMECHS project proposal
- Examples of applications
- Conclusions

WÄRTSILÄ

Definition of Wärtsilä Energy Core

Evolution of ship efficiency

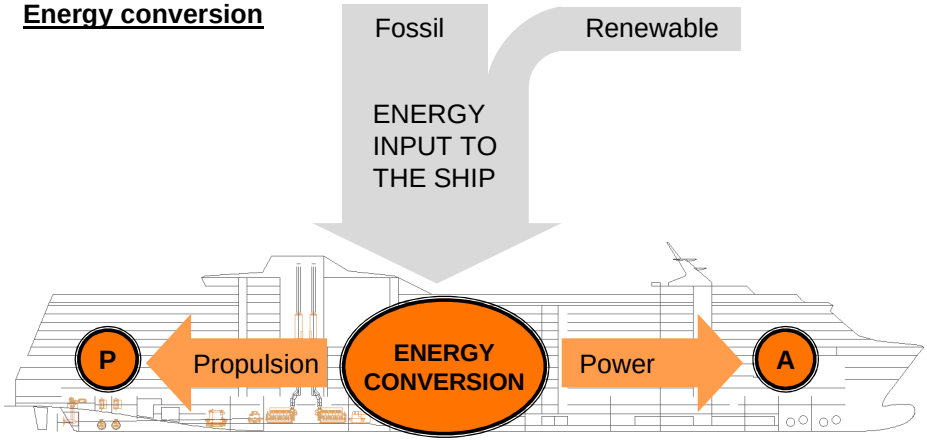


- **By combining these areas and treating them together as an integrated solution, a truly efficient ship operation can be achieved.**

WÄRTSILÄ

Definition of Wärtsilä Energy Core

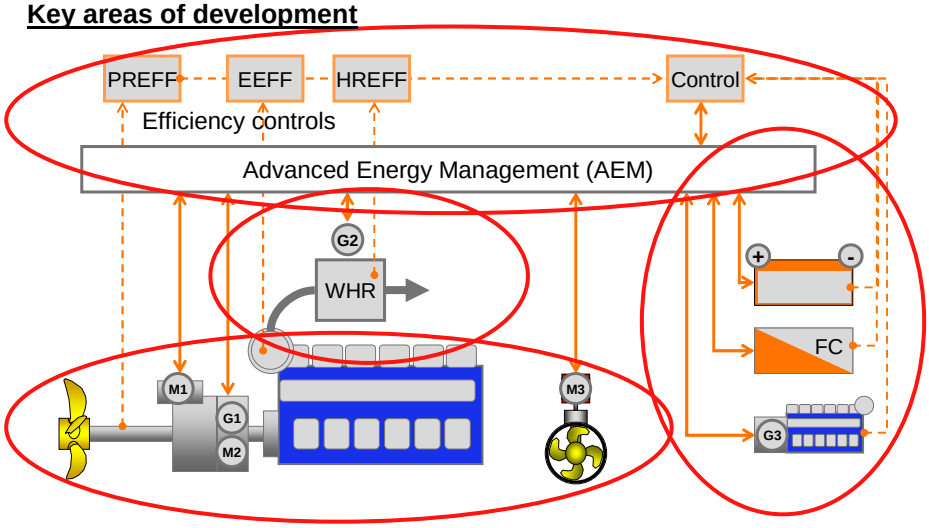
Energy conversion



- Economical
- Environmentally sound

Definition of Wärtsilä Energy Core

Key areas of development



Ship design is playing a key role in defining
And facilitating our solutions

WÄRTSILÄ

SHIPMECHS

National co-operation project

"SHIP MECHATRONICS"
Mechatronics = combination of '**Mecha**nics' and 'Elec**tronics**'
1.3 MEuro, 24 months (July 2009 – June 2011)

Operators:
- *Koninklijke Wagenborg B.V.*
- *Heerema Marine Contractors Nederland B.V.*

Industrial partners:
- *Wärtsilä Netherlands B.V.*
- *VAF Instruments B.V.*

Knowledge providers:
- *Eindhoven University of Technology*
- *Avans Hogeschool*

WÄRTSILÄ

SHIPMECHS

Objective

Main objective is to provide a solution for better ship management

capable of providing the required information and advisory for enabling a better ship management, in terms:

- Improved safety & reliability
- fuel saving & emission reductions
- predictive operating costs

WÄRTSILÄ

SHIPMECHS

project results

- Innovative solution for ship management;
- New sensors and control solutions;
- Real-time advisory system for onboard and onshore support;
- A mock-up training simulator for operating crew and office support.

WÄRTSILÄ

SHIPMECHS

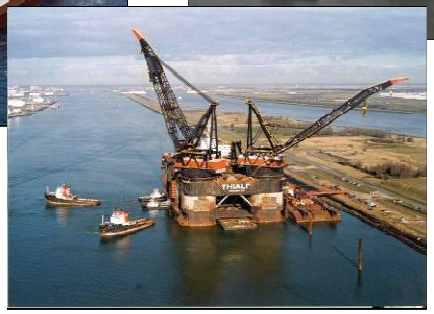
Challenge

- *How to provide real-time advice on ship manoeuvring, ship operation and ship maintenance that enables better ship management?*
- a combination of mechatronics and intelligence can be the answer

WÄRTSILÄ

1. Introduction: Applications Large Offshore & Heavy lift

Dockwise Heavy Lift 2 x 5,5 MW



Thialf
6 x 5,5 MW
Retractable

Covered by Lips Modular Thruster

WÄRTSILÄ

1. Introduction: Steerable thrusters power range

- Lips Compact Thrusters
- Lips Modular Thrusters
  - Can mounted
  - Underwater mounting
  - Retractable
  - Containerized

WÄRTSILÄ

1. Introduction Health thruster

What can effect a thruster?

- Seal damage: water content in lub.oil reduces the life time of bearings and gears
- Inadequate lubrication: due to late filter / oil change
- Overloading of the thruster
- External impacts

- Eventually this leads to early wear of gears and bearings
- Wear particles spread through the unit and affect other "healthy" components

THE HEALTH OF THE THRUSTER SLOWLY BUT STEADILY DETERIORATES EVENTUALLY THE CONSEQUENCES WILL LEAD TO

- Unplanned maintenance / repairs
- Replacement parts
- Loss of redundancy (Class)
- Docking

WÄRTSILÄ

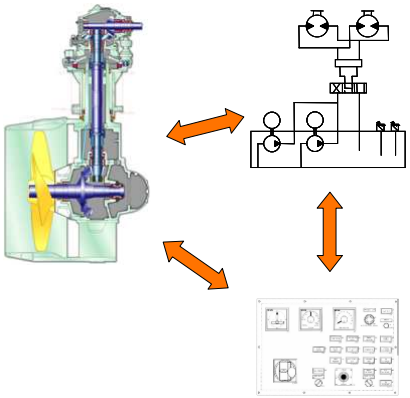
1. Introduction: Operators interest

Uninterrupted reliable operations, so no:

- Loss of hire > 150.000 USD / Day
- Docking > 1 Milj USD
- Replacement parts
- Mounting / De-mounting
- Loss of redundancy (Class)
- Loss of Confidence

WÄRTSILÄ

1. Introduction from alarming…



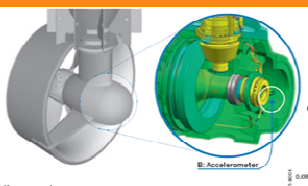
- Rely on expertise on board, Wärtsilä's service
- Alarm: (too?) late, not source related

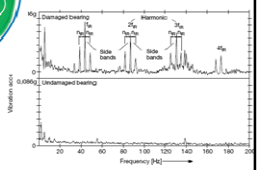
- Temperature alarms
  - lubrication
  - steering
- Pressure alarms
  - pumps
  - steering motors
  - filters
- Level alarms
  - gearboxes
  - header tanks

WÄRTSILÄ

1. Introduction … to monitoring…

- Detect early changes in behavior
- Establish trend lines
- Optimize usage of equipment

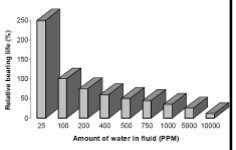




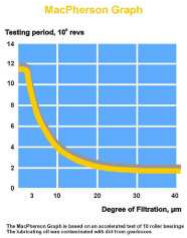
Source: FAG

By adding sensors to system:

- Accelerometers-> vibrations gears/bearings
  - damage raceway / roller element of bearing
- Saturation sensors-> moisture in oil
  - Expectation is that (sea) water leakage can be early detected
  - Water has mayor influence on the lifetime of gears/bearings and on the characteristics of oil



- Contamination sensors-> particles in oil
  - Keep track on the cleanliness of the oil
  - Particles have major influence on the lifetime of thruster components



Source: C.C. Jensen A/S

WÄRTSILÄ

1. Introduction: Definitions

Condition Monitoring System (CMS):

is a real-time machinery parameter measurement & signal processing system.

Offline:

Measurements and data collection are manual performed (not automatically) by an engineer on regularly basis with a hand held measurement device

Online:

Measurements and data collection are performed automatically on a continuous basis without human intervention. The systems are connected with a local network.

Online with remote access:

Thruster and operational parameters can be monitored and analyzed by experts on different locations.

WÄRTSILÄ

1. Introduction: Definitions

Condition Based Maintenance (CBM):

constitutes a set of maintenance processes and capabilities derived from real-time assessment of the machinery condition obtained from embedded sensors and on-line signal processing.

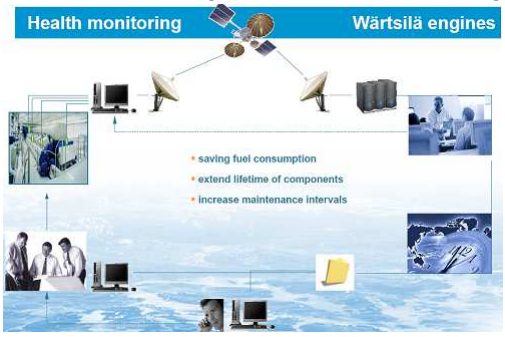
Prognostics:

is an automated CBM system, which predicts the remaining machinery service life under defined operational conditions.

WÄRTSILÄ

1. Introduction: CBM Engines

Condition Based Maintenance (CBM) and related services are well established offerings for Wärtsilä diesel engines.



For the propulsion systems Wärtsilä has now introduced a Condition Monitoring System (CMS) for steerable thrusters that supports its CBM Services.

WÄRTSILÄ

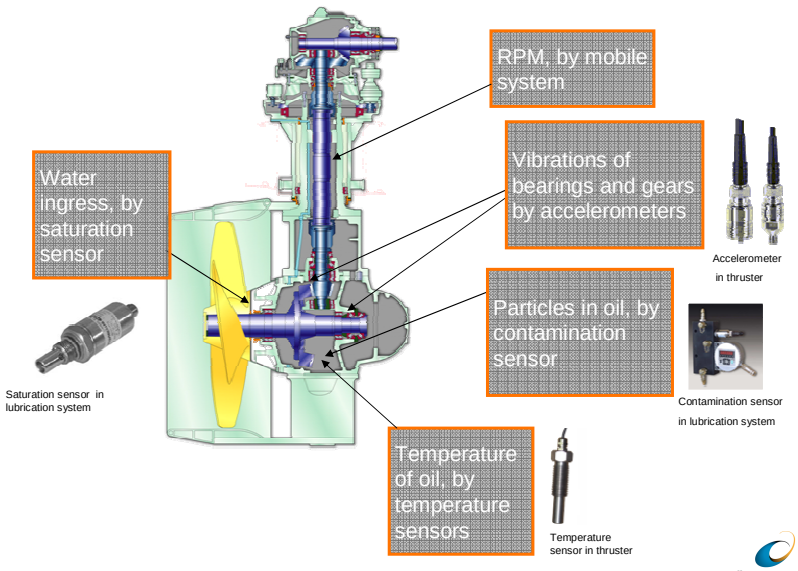
1. Introduction: Benefits CMS

Current situation and solutions:

- Classification societies/owners cope with failing machinery, by demanding and applying redundancy in propulsion devices
  ->CMS can detect deteriorating components
- Inspected via regular checks 2.5-5 years by Class
  – During the periodic dry-docking the main focus of the Classification Societies is on the inspection of machinery elements. These regular checks carried out **may** visualize a changing condition. During these checks a preventive maintenance will be executed
  ->CMS can continuously show the condition
- Protect machinery with the aid of alarms
  – The alarm will only indicate if the condition has reached an unacceptable level. In this case the system must be stopped for repair.
  -> CMS will indicate a changing condition and shall give an early warning
- If something fails, we have to rely on service reports from Wärtsilä service engineers or expertise on board
  -> CMS experts will perform an analysis and diagnosis which will contribute the service department

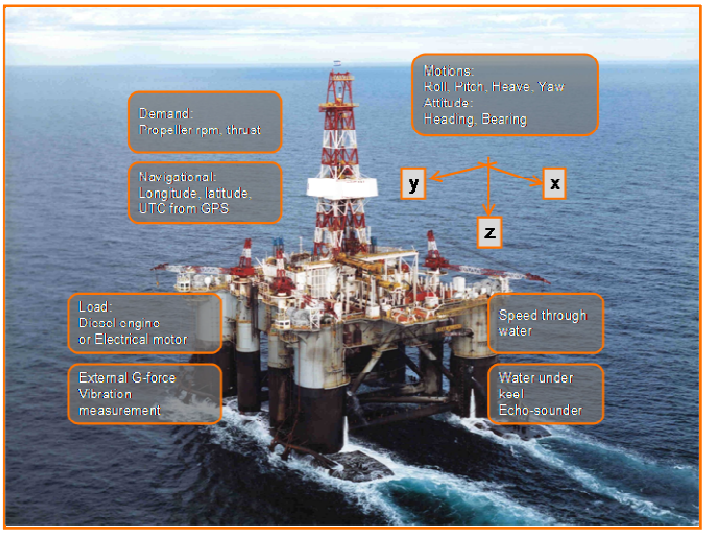
WÄRTSILÄ

3. CMS Thruster parameters



WÄRTSILÄ

3. CMS — Operational parameters



WÄRTSILÄ

3. CMS — Development

Past

Alarms

- pressure
- oil
- temperature
- level

Today

Monitoring/Diagnosis

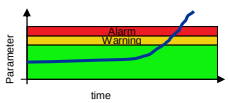
Early detection of deteriorating components:

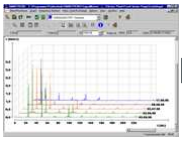
- vibrations
  - damage raceway / roller element of bearing
- moisture
  - water affects gears/bearings
- particles
  - keep track on contamination/oil quality

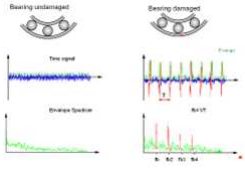
Tomorrow

Prognostics

- combine signals, remaining lifetime
- historical/statistical database
- usage







WÄRTSILÄ

3. CMS — Trending

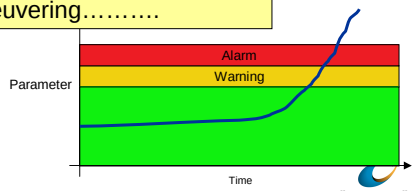
Periodical measurement of thruster parameters
under comparable thruster demands and stationary operational conditions
in order to be able to do trending.

Thruster parameters:
Vibrations, saturation, particles

Thruster demands:

Steering angle, RPM and pitch bands: 0-25%, 25-50%, 50-75%, 75-100%

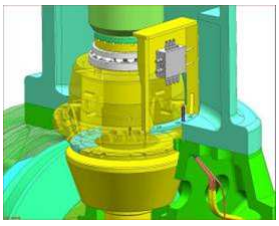
Operational conditions:
Same load, wind, yaw, no maneuvering…….

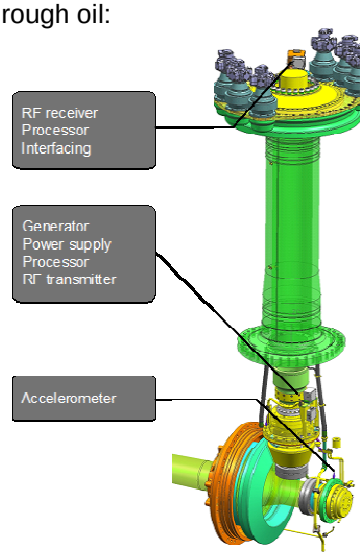


WÄRTSILÄ

3. CMS — Configuration

Transmission of accelerometer and temperature sensor signals via (patented) wireless transmission through oil:





WÄRTSILÄ

3. CMS — Features

Accelerometer to be as close as possible at gear or bearing location in order to:
- Avoid loss of signal due to attenuation
- Earlier detection of vibrations
- Locate the problem

Smart power generator:
- Permanent magnets
- No batteries

Mobile system:
- Dedicated reliable electronics
- Software can be uploaded wireless (when thruster is running)

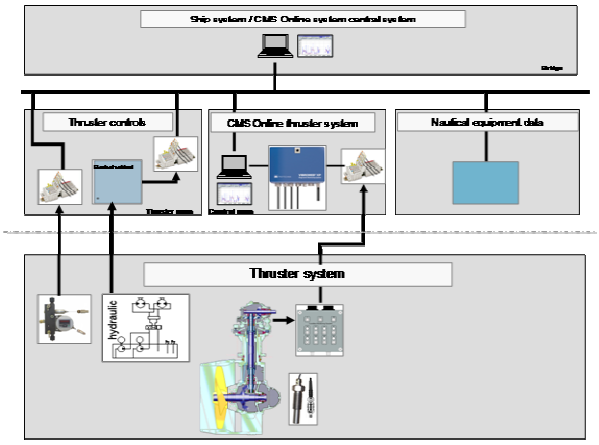
Wireless:
- Avoid cabling and connectors
- No slip rings

Stationary system:
- Dedicated reliable electronics
- Convert digital information into signals: vibrations, rpm, temperatures

WÄRTSILÄ

3. CMS — Online system overview

Measurements and data collection are performed automatically on a continuous basis without human intervention. The systems are connected with a local area network. The online system for automatic trending is developed as follows:



WÄRTSILÄ

3. CMS — Offline system components

Wireless Transmission System:

- 6 Accelerometers:
  - Current line drive 3.5mA closed current range 0.3Hz – 10kHz , 5.35µA/ms^-²
- 2 Temperature Sensors:
  - Passive 4-20mA , -5˚C..100˚C, tolerance +-2.2%
- RPM:
  - TTL pulse on rotary speed frequency

Oil Sensors:

- Contamination Sensor:
  - Number of particles per 100ml (ISO Class) for four indicated sizes (ISO 4,6,14 and 21) Sequential active 4-20mA signal
- Saturation Sensor:
  - Saturation of water in Oil 0%..100% Active 4-20mA signal

WÄRTSILÄ

3. CMS — Online system components

Online Thruster System per thruster

Vibroweb-XP:

- Performing specified vibration measuring tasks
  - FFT in Flat File (ODX)
  - RMS values (Modbus/TCP)
  - Alarms/warnings (Modbus/TCP)

WAGO Programmable Controller:

- Necessary for interface between Vibroweb-XP and Stationary System
- I/O and conversion to physical values of analogue signals
  - Oil sensors
  - Temperature sensors
  - Other analogue signals
- Serial Communication (optional)
  - Controls
    - RPM (demanded) • Pitch (demanded)
    - Steering angle (demanded) • Load • Direction of Rotation
- Publish Physical Values
  - Parameter values (Modbus/TCP)
- Alarms and Warning
  - Reading set points from IPC (Modbus/TCP)
  - Publish Alarms & Warnings (Modbus/TCP)

WÄRTSILÄ

3. CMS — Online System Central Overview

Online Central System

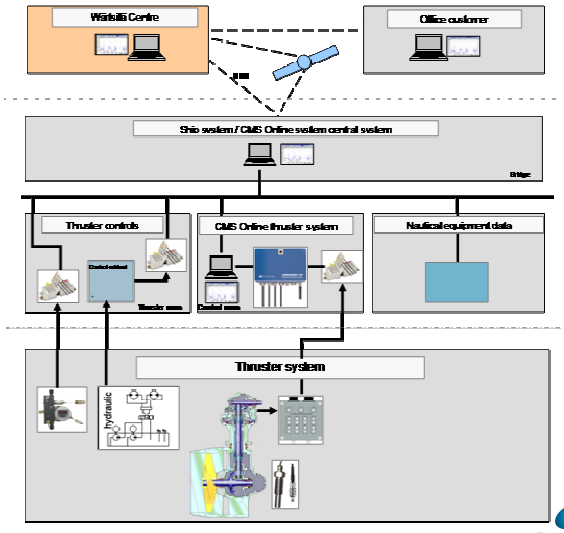
IPC:

- Gathering per Thruster
  - Parameter Values (Modbus/TCP)
  - Alarms/Warnings (Modbus/TCP)
  - Vibration Data (FTP)
- Gathering Nautical Equipment Data
  - GPS • Echo • Heading • Motions
- Publish Data
  - Parameter Values (OPC)
  - Alarms/Warnings (OPC)
  - Vibration Data (Flat Files)
- Data Storage
  - All data for 2 years
- Human Machine Interface
  - Client level (restricted possibilities)
    - Manual Input of events (maintenance)
  - Several Wärtsilä levels
    - Change set points
    - Analyzing stored data

WÄRTSILÄ

3. CMS — Online system with remote access

Thruster and operational parameters can be monitored and analyzed by experts on different locations. Remote access and automatic trending is developed as follows:



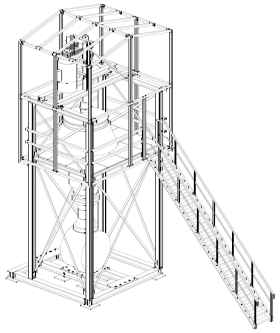
WÄRTSILÄ

4. Validation Trial — Demonstrator/Thialf

A real steerable thruster is mounted in a test rig, which is called a demonstrator, and equipped with the wireless transmission system in order to:

1. Validate the wireless transmission for sensors within thruster.
2. Measure attenuation to find best location of accelerometers.
3. Get a zero reference measurement for vibrations
4. Get performance data for the lubrication system, and validate the condition monitoring oil sensors.
5. Learn from online monitoring (remote access, automatic trending)

The steerable thruster o/b of the Thialf is tested on functionality.



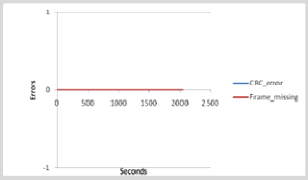
WÄRTSILÄ

4. Validation Trial — Transmission

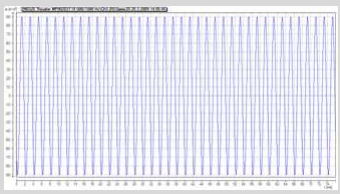
To validate the wireless transmission within the thruster the next tests are performed:

- Checked the signal on errors in communication at different conditions
- Programmed a known frequency in the mobile system inside the thruster and sent this wireless to the stationary system
- Measured acceleration time signals

The tests were successful. The quality of communication is good.



System A



500 Hz timesignal

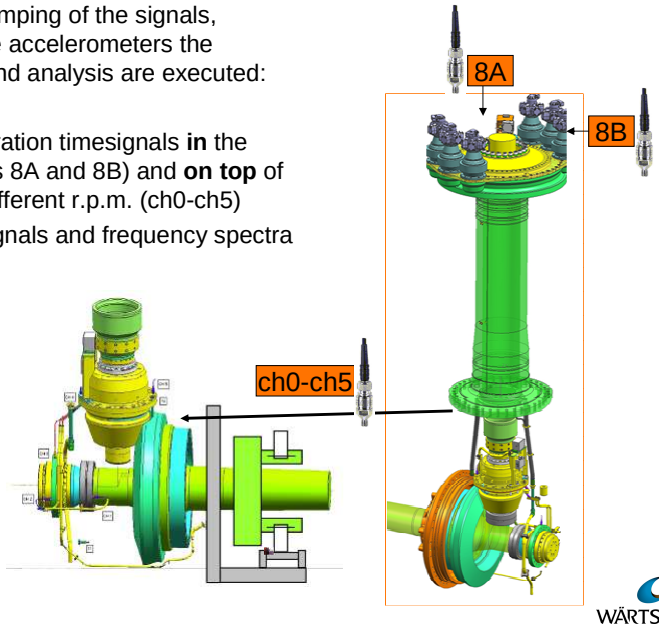
FFT of 500 Hz timesignal

WÄRTSILÄ

4. Validation Trial — Attenuation

To measure the damping of the signals, measured by the accelerometers the following tests and analysis are executed:

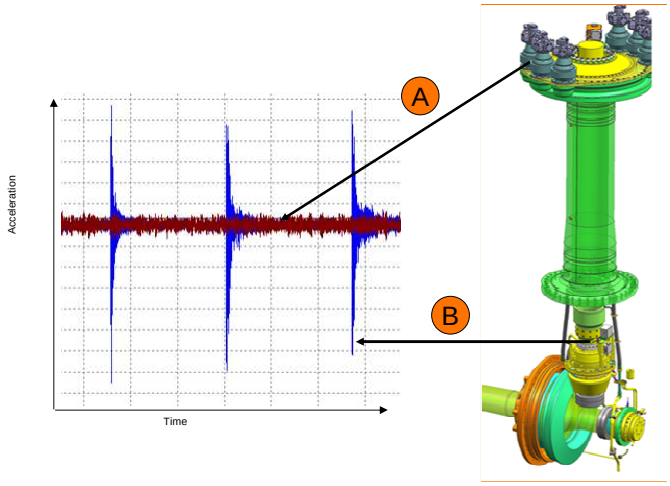
- Measure acceleration timesignals **in** the thruster (sensors 8A and 8B) and **on top** of the thruster at different r.p.m. (ch0-ch5)
- Compare timesignals and frequency spectra



WÄRTSILÄ

4. Validation Trial — Attenuation

Conclusion: Attenuation is clearly visible in the timesignal. Measuring as close as possible at element level results in the lowest possible attenuation of acceleration through metal and joints (peek from signal B is much higher than the peek from signal A).

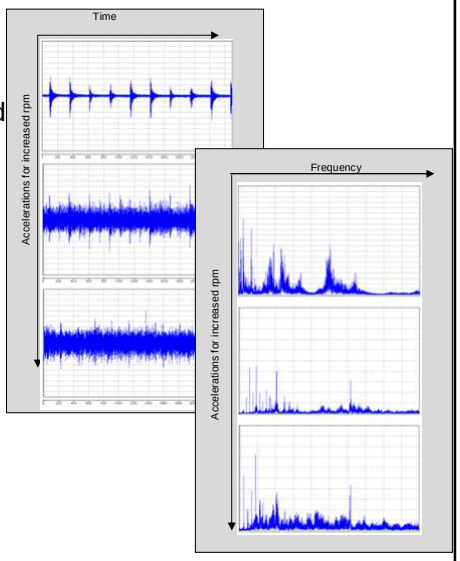


WÄRTSILÄ

4. Validation Trial — Zero reference measurement

To perform a zero reference test the following test are executed:

- Measure acceleration timesignals and generate frequency spectra at different r.p.m. (20%...100%)
- Measure velocity timesignals and generate frequency spectra at different r.p.m. (20%...100%)



In future a zero reference test must be executed for each thruster.

WÄRTSILÄ

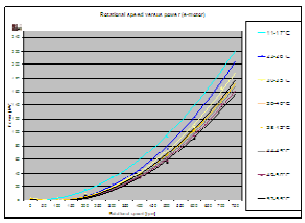
4. Validation Trial — Lubrication and cooling

To generate performance data and to validate the function of the oil sensors for lubrication the following tests are performed:

- Validation of the function of the sensors
- Measure the trend of the particle counter and saturation sensor
- Measure the delivered power at different r.p.m. for different oil temperatures
- Infrared pictures

Conclusion:

- The validation of the sensors is almost finished.
- Sensors of two companies gave different values. The accuracy is limited.
- The oil sample which has been sent to laboratory differed one till two classes in particles.
  - The oil sensor can be used to keep track on the oil quality on board.
  - Further research is needed.
- The delivered power at different r.p.m. is at the moment known for the different mean temperatures:



WÄRTSILÄ

4. Validation Trial — Remote access

To learn from on-line trending, the thruster is regularly running at different r.p.m. and different oil temperatures in order to test automatic trending and remote access.

Conclusion:

Automatic trending and remote access is working

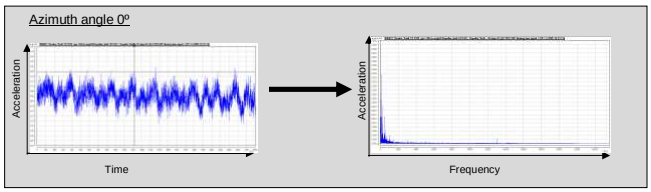
WÄRTSILÄ

4. Validation Trial — o/b measurements Thialf

One steerable thruster o/b of the Semi Submersible Crane Vessel Thialf is equipped with CMS.
It is running for on year and functional tested 1st May.

Conclusion:

- Wireless transmission works for azimuth angles (0,90,180 and 270º)
- Temperature sensors and accelerometers are functioning.



WÄRTSILÄ

5. Conclusions — From CMS to CBM

From Condition Monitoring to Condition Based Maintenance:

- **Asses the condition of components or system**
- **Dedicated electronics for wireless transmission system works**
- **Measure as close as possible to bearings as demonstrated is needed because of to much noise**
- **Online thruster system and remote access works**
- **Experience is gained for thruster under *no load* (demonstrator); the system o/b of the Thialf functions *with load***
- **Results give a fundamental basis for the definitive product specification**

Eventually this approach allows to perform *condition based maintenance*

WÄRTSILÄ

7. Questions

Questions?

WÄRTSILÄ