Fiber optical sensing

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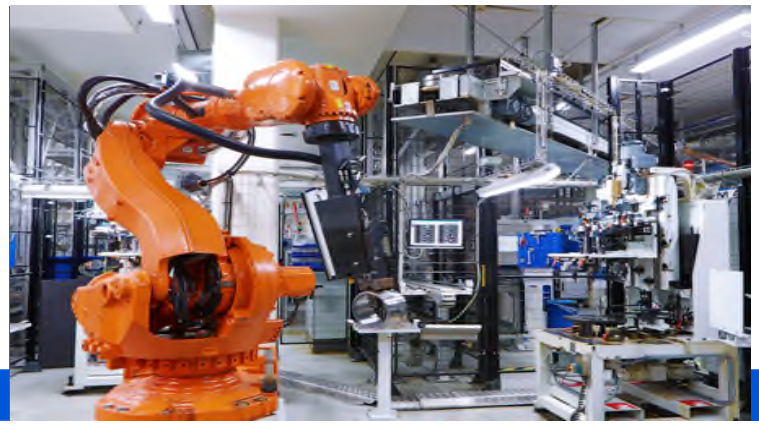
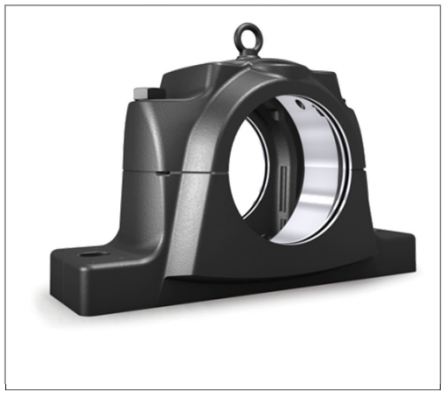
SKF – a truly global company

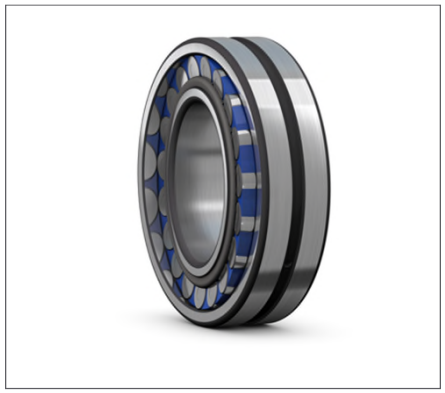
• Established	1907
• Sales 2015	Euro 8,287 Million
• Employees	46,635
• Production sites	around 115 in 29 countries
• SKF presence	in over 130 countries
• Distributors/dealers	17,000 locations

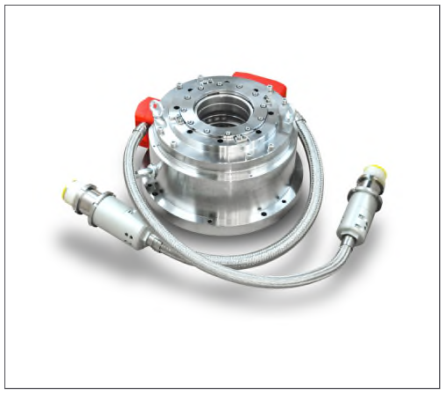
Our solutions are everywhere



SKF technology







Technologies around the rotating shaft

Changing business reality

Globalization

- More competitive landscape across the value chain
- Asian companies going global
- Overcapacity in heavy and investment- driven industries

Technology

- Automation, electrification and digitalization drive the change
- New technology requirements for new applications
- Technology for cost competitiveness

Competitors

- New, emerging competitors gaining ground
- Chinese competitors strengthen position fueled by local market

Customers

- More transparent supplier market gives stronger buying power
- Strong price/cost focus
- Tougher competition and SKF traditional customer base under competitive pressure

Two value propositions in focus

1. Rotating equipment performance

Customer need:

"I want your products and my assets to reach technical end of life with trouble-free operation"

2. Product

Customer need:

"I want on-time delivery, quality and field performance, flawless launches of new products, technology and price"

Smartifying industry

Mobility becomes the window

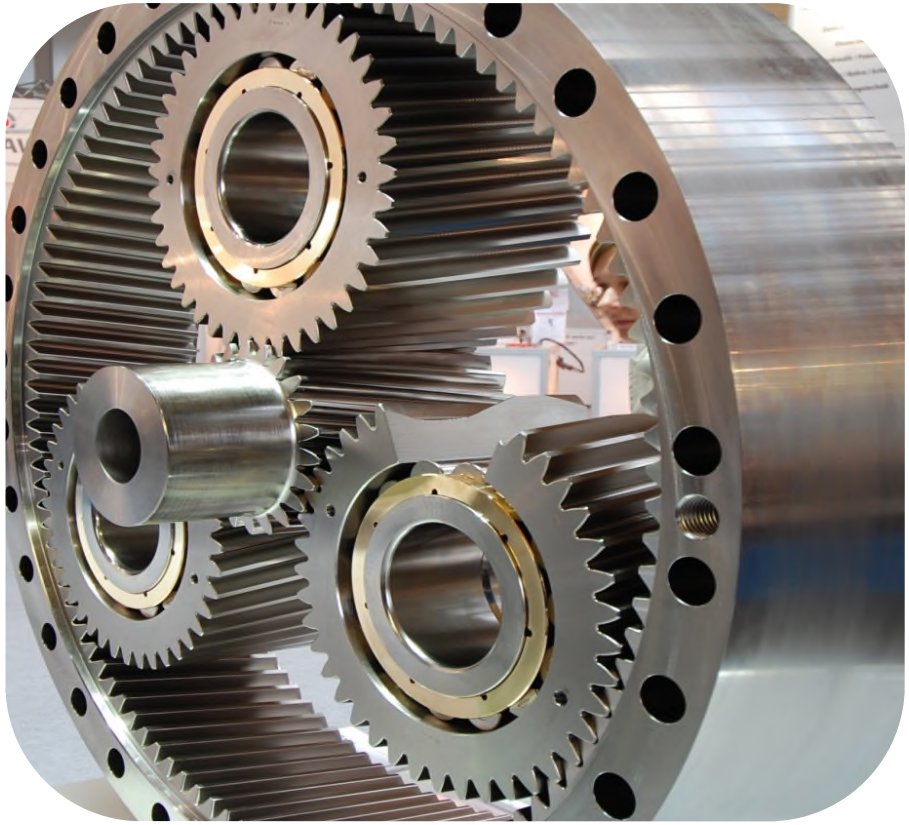
the Cloud becomes the infrastructure

(Big) Data management becomes the intelligence

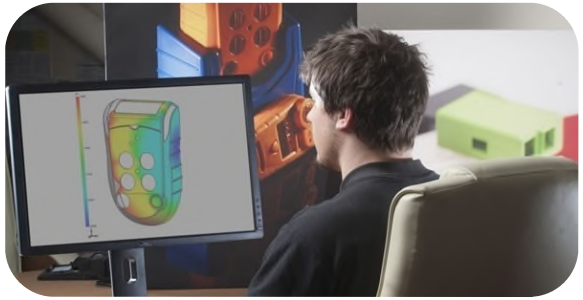
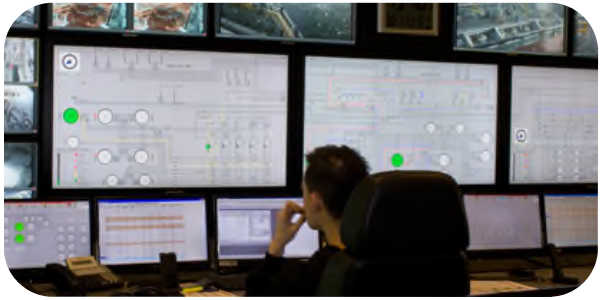
Connected sensors/systems become the data feed

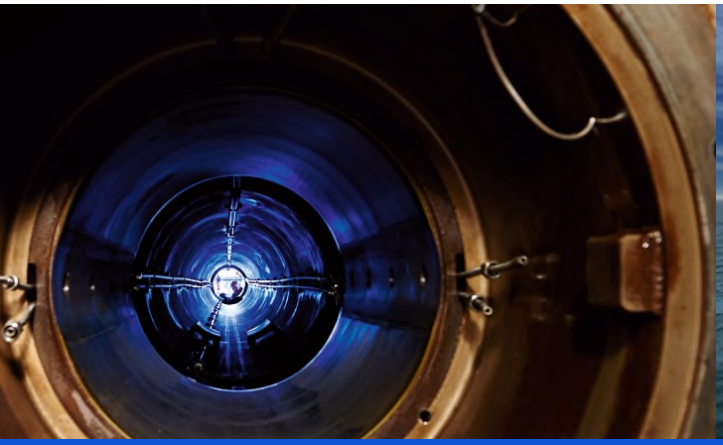
Monitoring the heart of your application

“Bearing unique control point of the application”



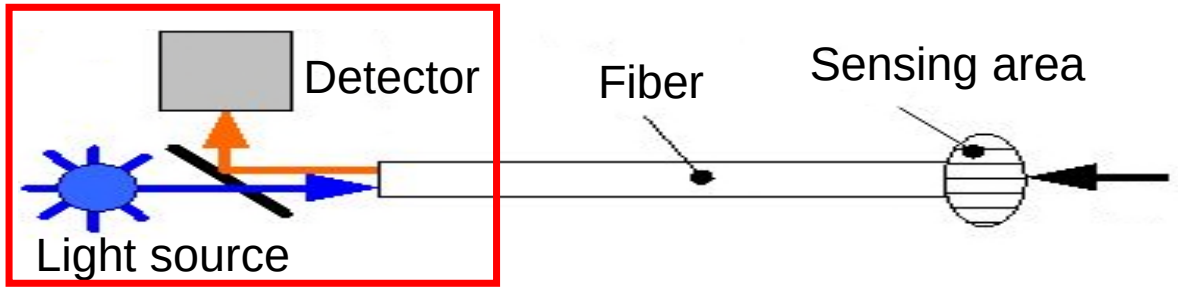
What to monitor in that heart

	Service	“Product & service”
Operation: Load	Design verification and support tool 	Process control 
Condition: Vibration	 Trouble shooting	 Condition monitoring & prognostics

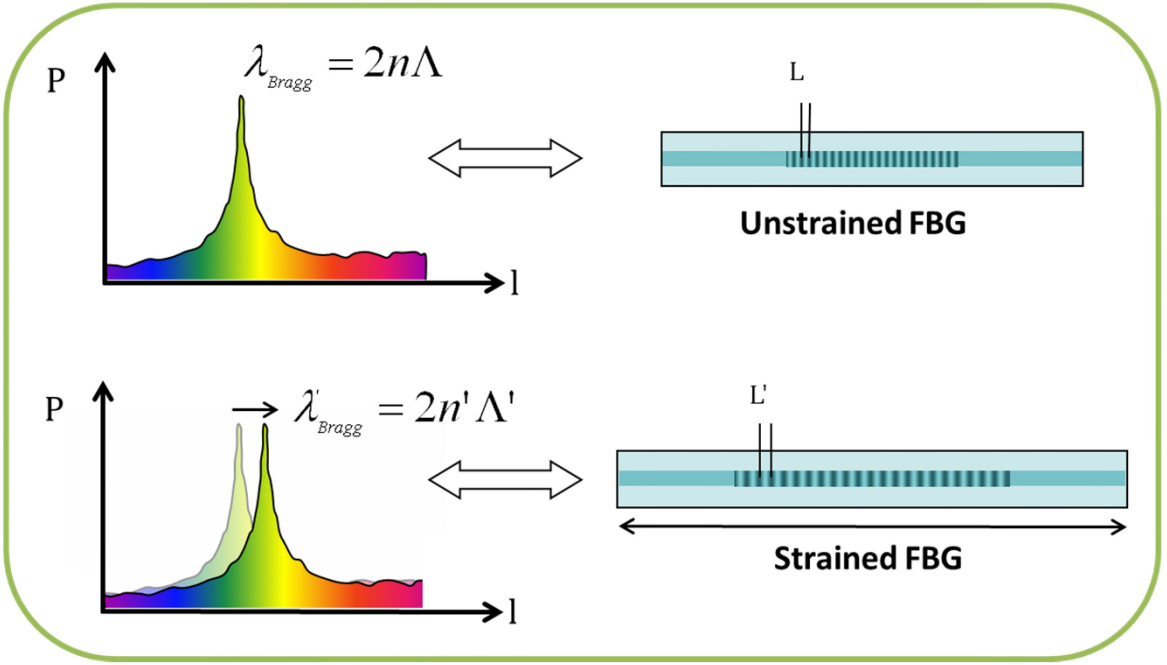


Fiber optical sensing

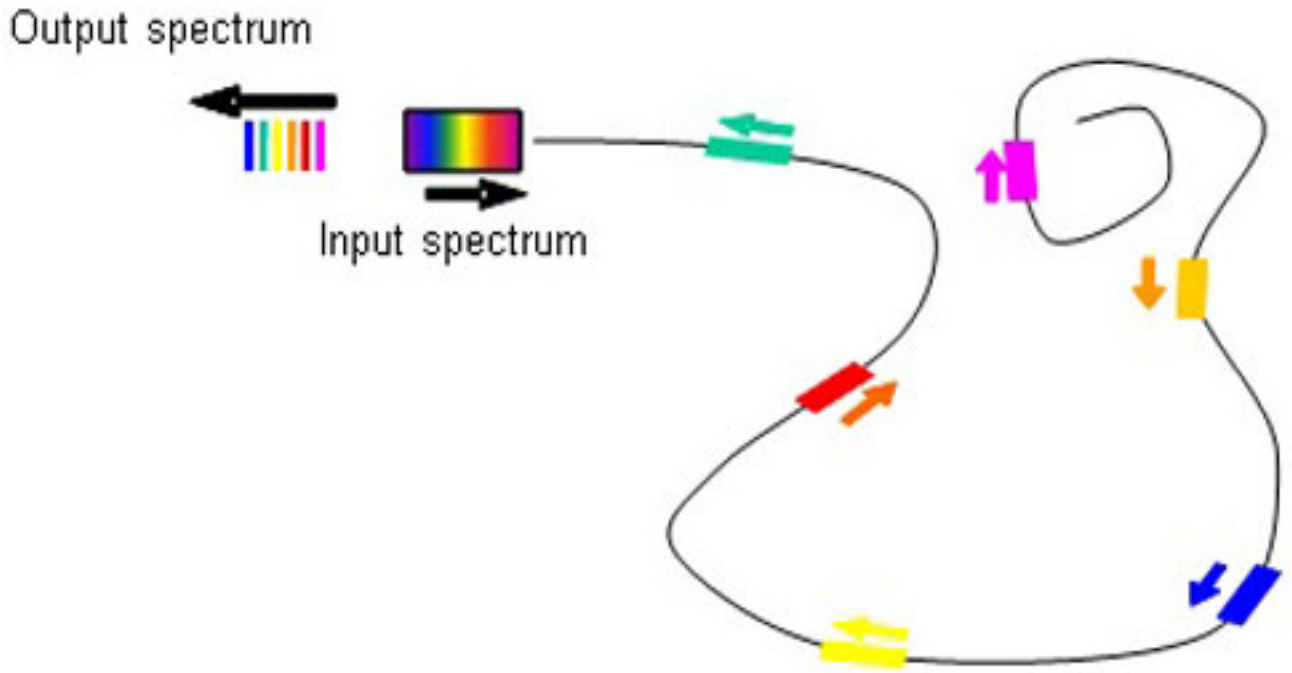
Fiber Bragg Sensing – principle



Interrogator

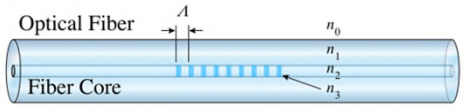


Multiplex sensing

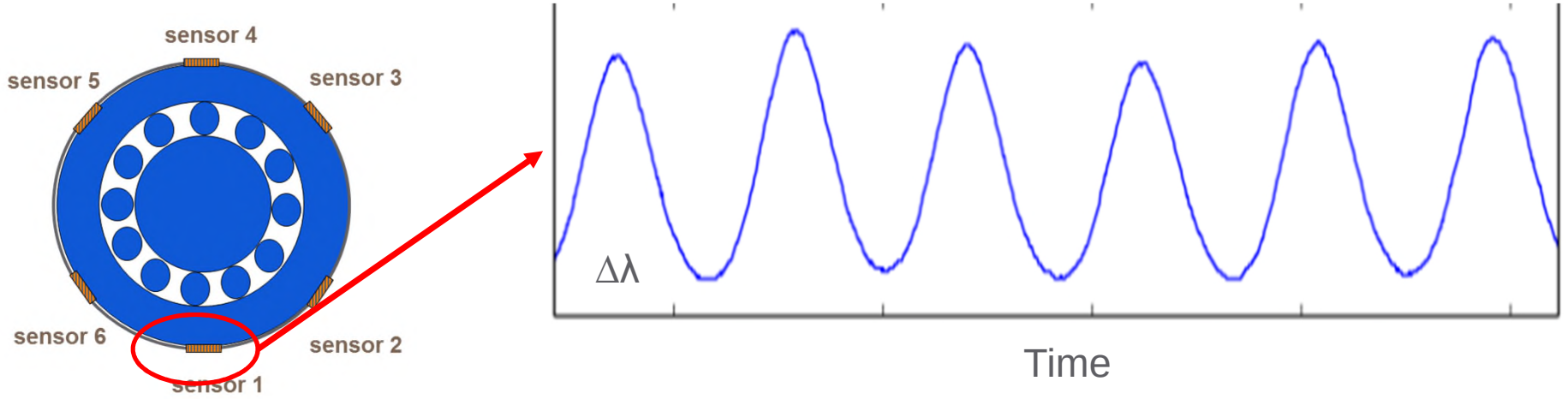


Up to 25 sensors per fiber

Technology integration



How do you measure



Parameter	Process parameter
Amplitude	**Load**
# peak / min	Speed
Response shape	Defects
Temperature	Offset
Amplitude different sensors	Loaded zone

Main sensing functionality in thrusters

Bearing loads

$$L_{10} = \frac{1}{\left[1 + \frac{a_u^m L_{10}^{(m-e)} I_s}{\ln(1/0.9)} \left(\frac{C}{P}\right)^{ep} (a_u)^e\right]^{1/e}} a_1 \left(\frac{C}{P}\right)^p$$

Load is the largest influence on bearing lifetime

Real application loads are often unknown, monitoring enables:

- Design optimization
- Bearing life – Condition based maintenance
- Optimal operating regime's
- Full control – lower cost/longer insurance period
- Fleet management – best practice optimization
- ….

Fiber Optical load Sensing

Measurement performance

- High signal-to-noise ratio
- Multiple variables: Load, temperature, pressure, vibration…
- Multiple sensors in one fiber

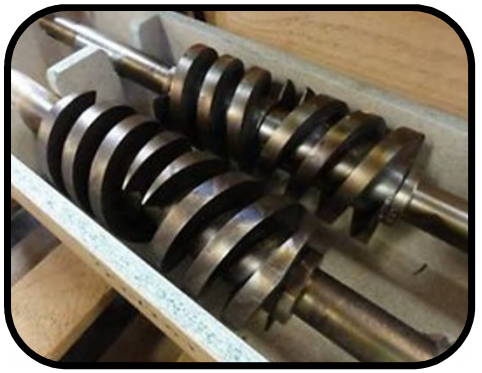
Harsh /hard accessible environments

- Intrinsic explosion safe
- Sub-water resistant
  - no corrosion
  - no signal issues from under water
- High chemical resistance
- Wide temperature range
- Robust against EM-interference


NO SMOKING

Pumps & Compressors

- One fiber for multi operating parameter sensing
- Large distances - submerged
- New type of pumps development

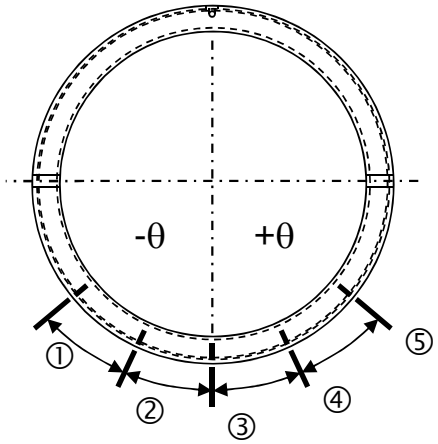


Value:

- No electro magnetic interference
- integrated into the bearing – small integration footprint
- large amounts of data
- One cable for Load, temperature, pressure and CoMo – One ingress
- No monitoring solution currently available – compressors
- Optimized operation/process control

Strain and speed measurement

- Able to identify roller speed.
  - Possible to identify bearing slip.
- The size of the loaded zone can be determined.
- Individual rollers can be identified by their signal strength.



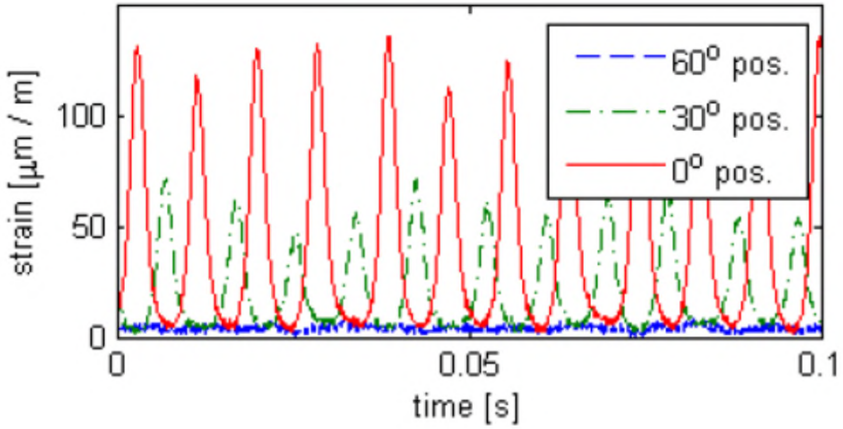
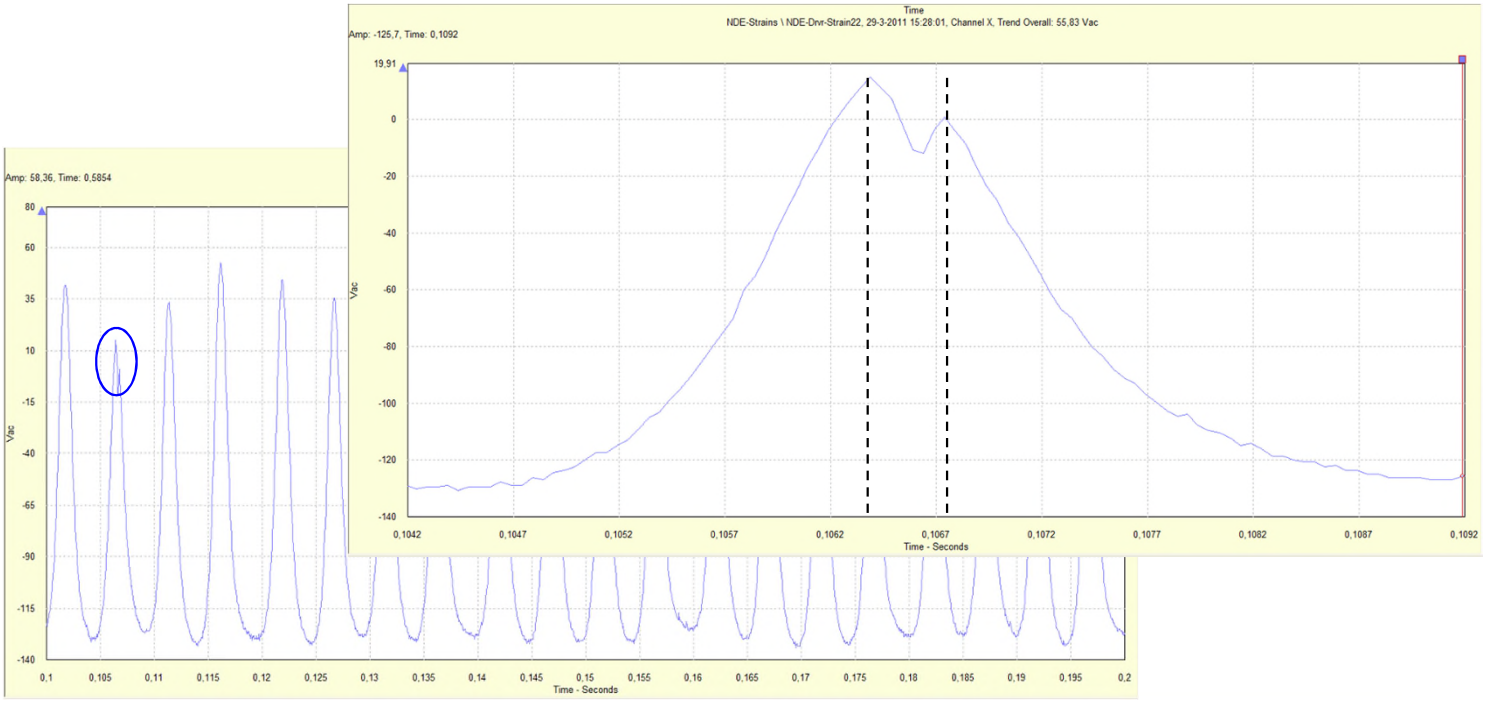


Figure 5 Example of strain signals

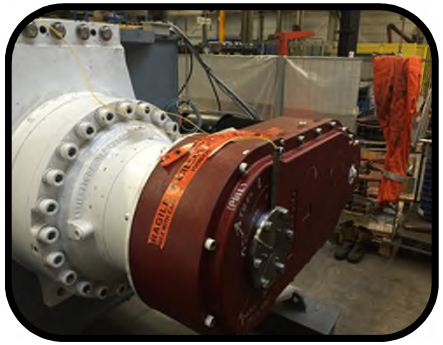
Condition monitoring

- High frequency content imposed on roller pass.
- Small pressure reduction visible.
- Calculated length of defect = ~2 μm



Jacking systems

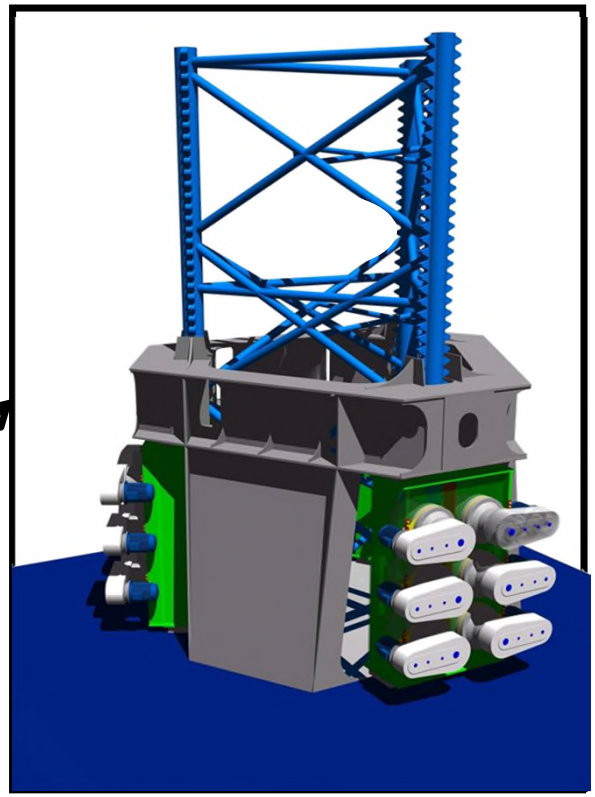
- Load measurement during stand-still
- Absolute static load measuring without prior dynamic load information
- Absolute load as operating parameter



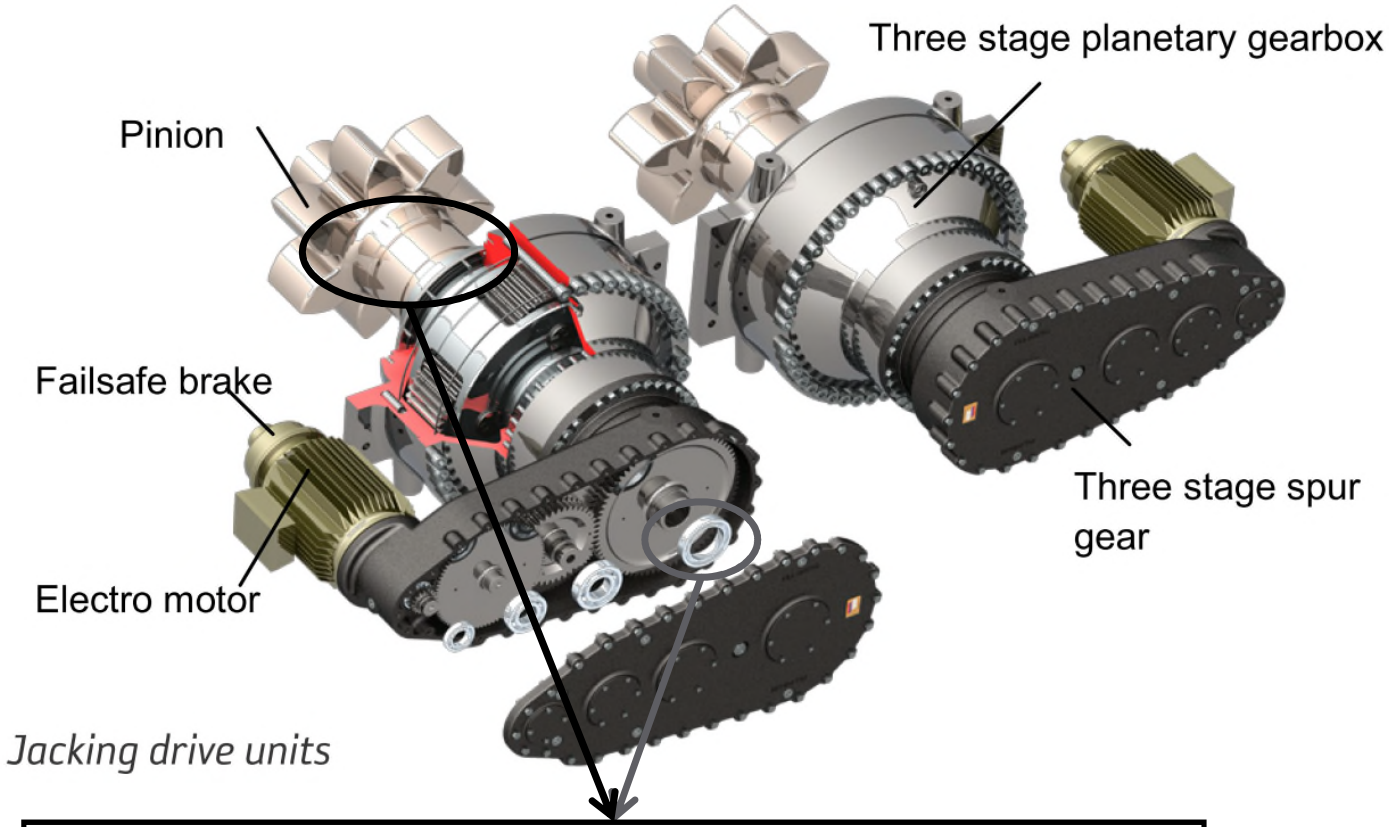
Value:

- Small footprint; integrated into the bearing
- Large amounts of data
- Direct measurement of load and load angle at the pinion
- **Static load measuring possible due to sensor integration density (~2.5 mm)**
- **Harsh environment (salt water corrosion)**

Application - Jacking systems



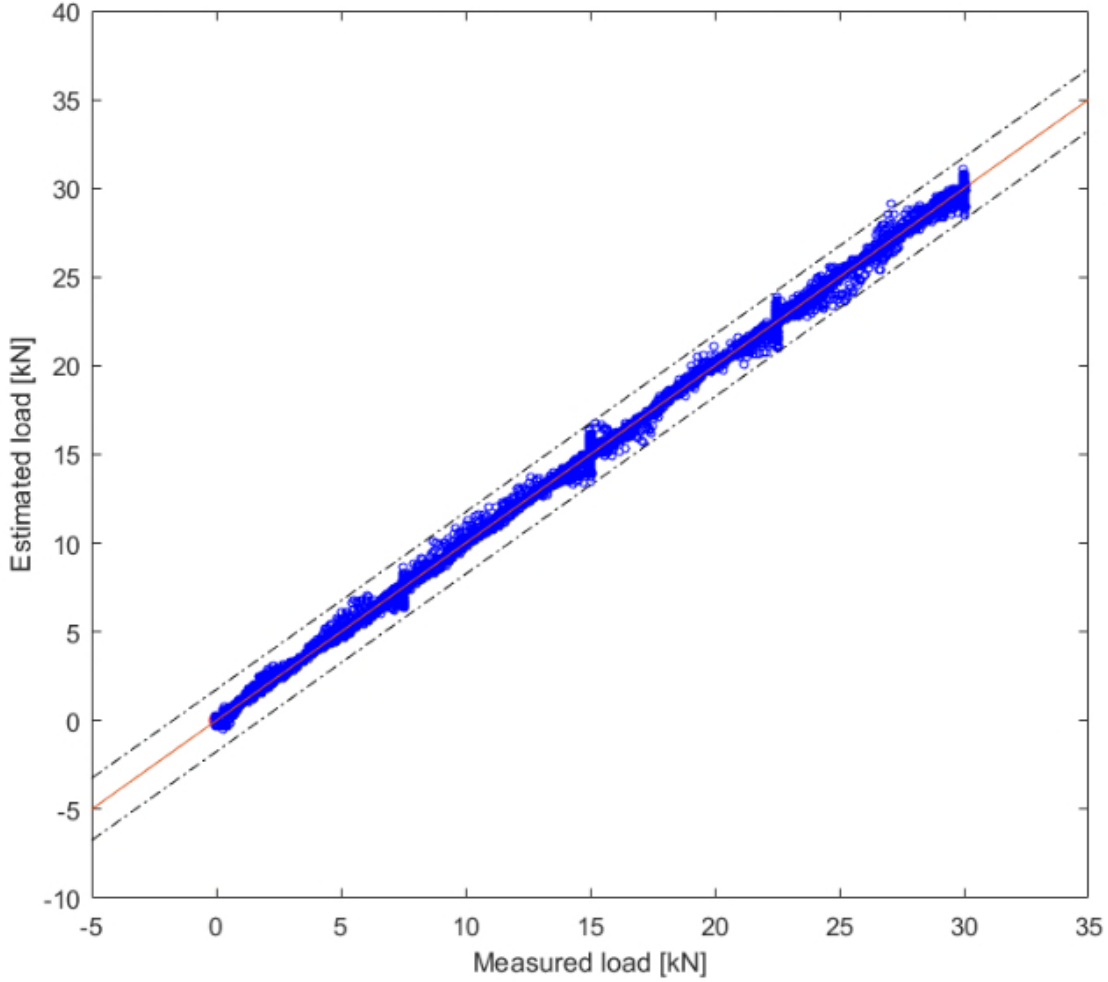
Application - Jacking systems



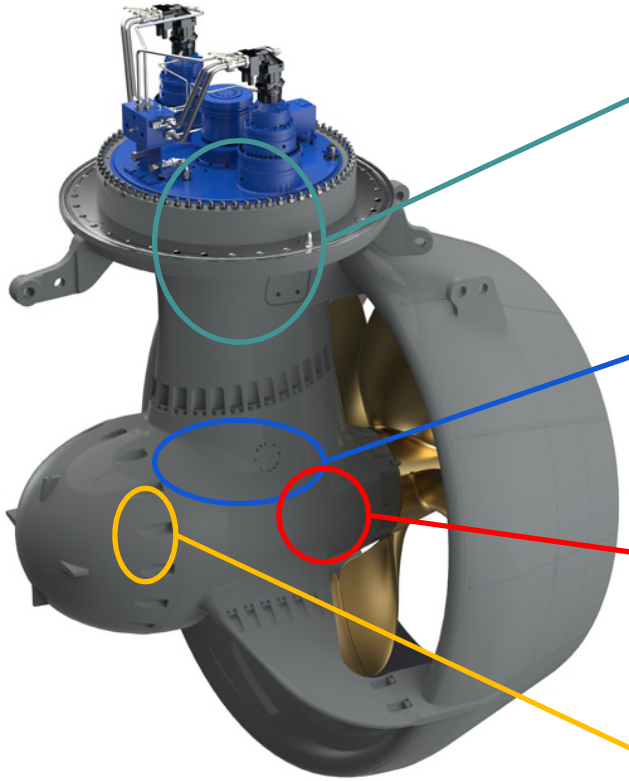
Two bearing position to measure **static and dynamic** load:

- Three stage spur gearbox
- At the pinion

Load estimate – guides are +/- 5%



Thruster pods monitoring



Vertical shaft
- Temperature
- Shock loads
- **Load direction**

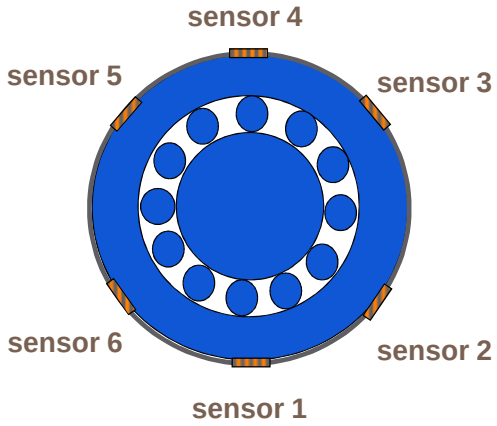
Pinion shaft
- Temperature
- Shock loads
- Load direction
- **CoMo**

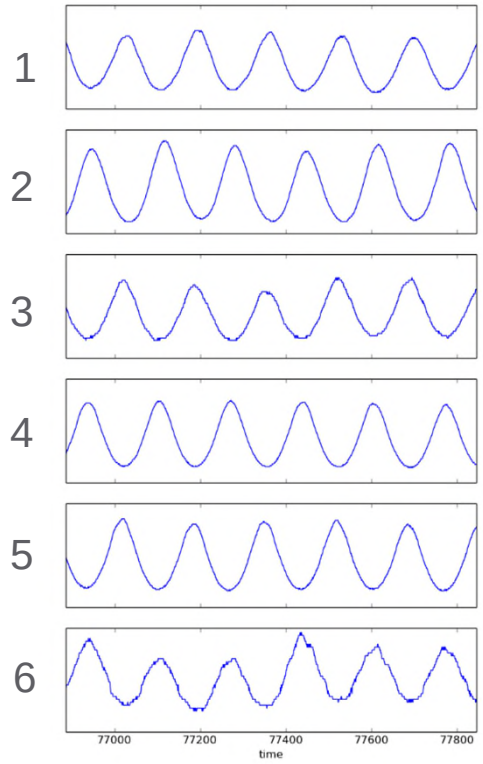
Propeller shaft
- Temperature
- **Shock loads**
- Load direction

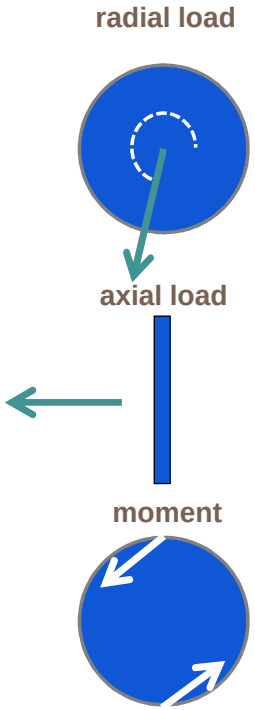
Propeller shaft
- Temperature
- **Shock loads**

Load Measurement: Strain to Load

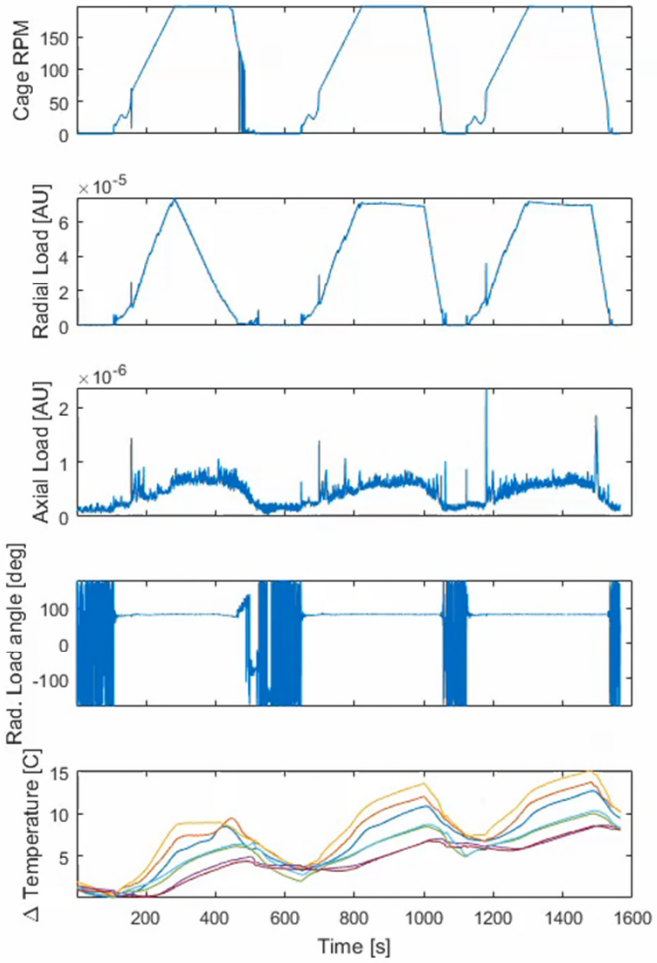
rotating axis → sensor signals → load measurement

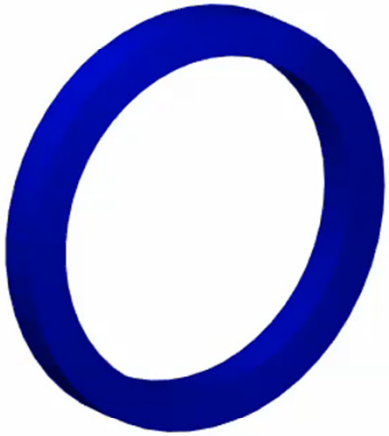


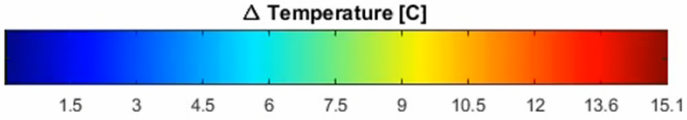




Measurements



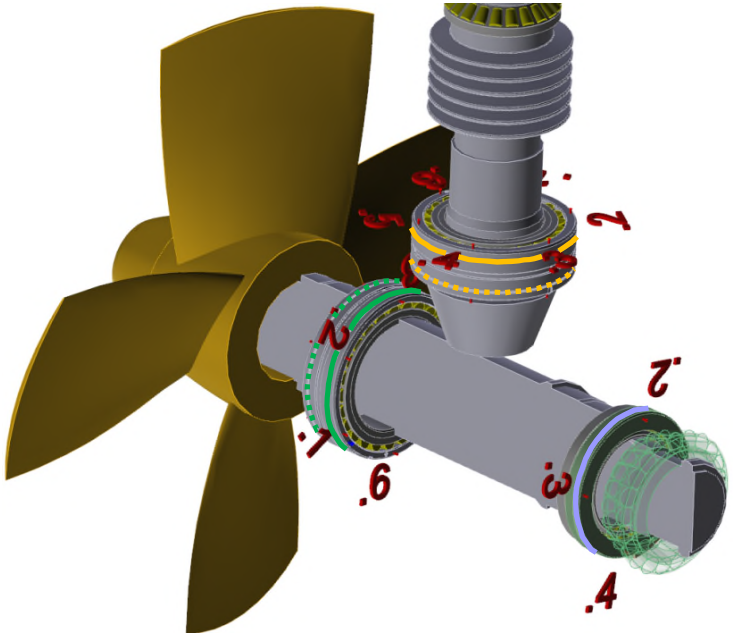


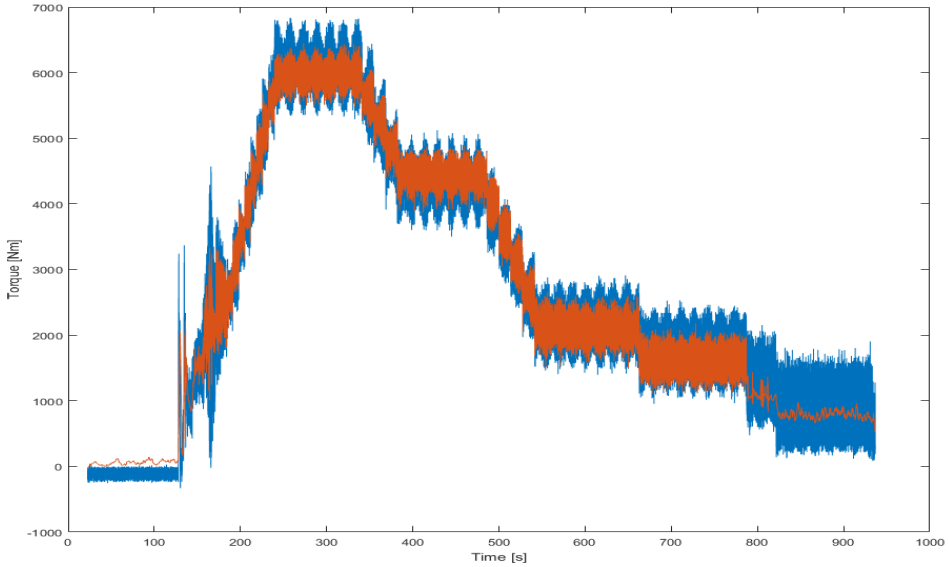


Dis-balance in propeller shaft

Naming:

- 23138_0 – Channel 0 pinion SRB
- 23138_1 – Channel 1 pinion SRB
- 23044_0 – Channel 0 Propeller SRB
- 23044_1 – Channel 1 Propeller SRB
- 29336E – SRTB





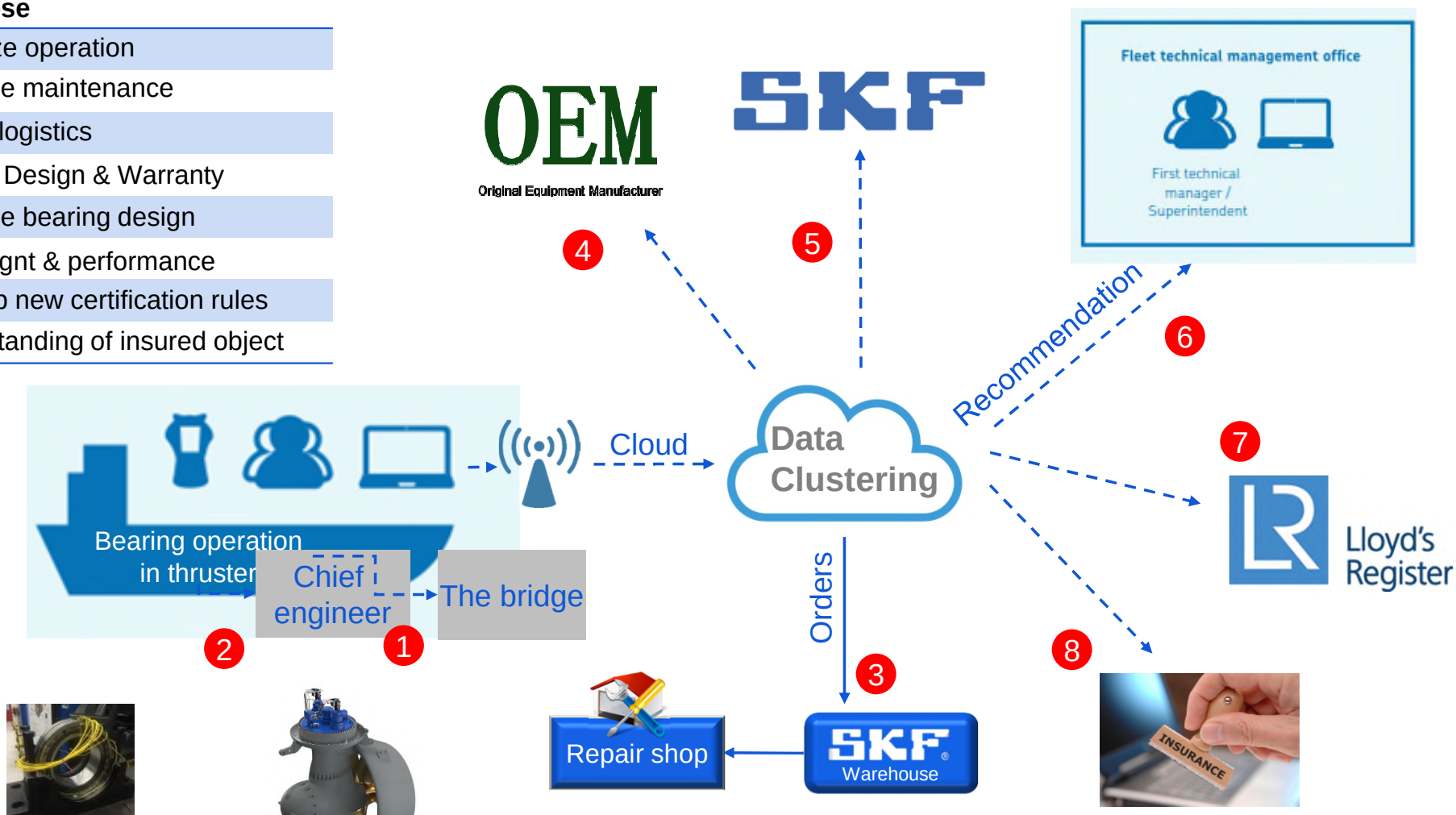
Sensing value

Via a sensor bearing we can sense multiple operating parameters in thrusters;

- Load (Axial/Radial)
- Direction of loaded zone
- Torque
- Bearing temperature & OR temperature distribution
- Speed & direction of rotation

What can be done with this operating information?

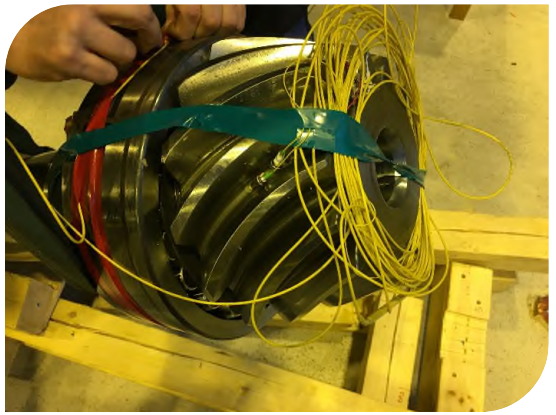
#	Purpose
1	Optimize operation
2	Optimize maintenance
3	Repair logistics
4	OEM – Design & Warranty
5	Optimize bearing design
6	Fleet mgnt & performance
7	Develop new certification rules
8	Understanding of insured object



Summary – Fibre optical sensing in Marine

An unique tool to monitor “unknown” thruster loads:

- Measuring “How your application is operated”
- Sensing is one, making sense of it is the complex part
- Multiple sensing; “You can get more then you expect”
- Sensors have to work:
  - At “impossible” situations
  - After extreme handling
- Internet-of-bearings

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