8.2

The Technical Experts in Wind Turbine Engineering

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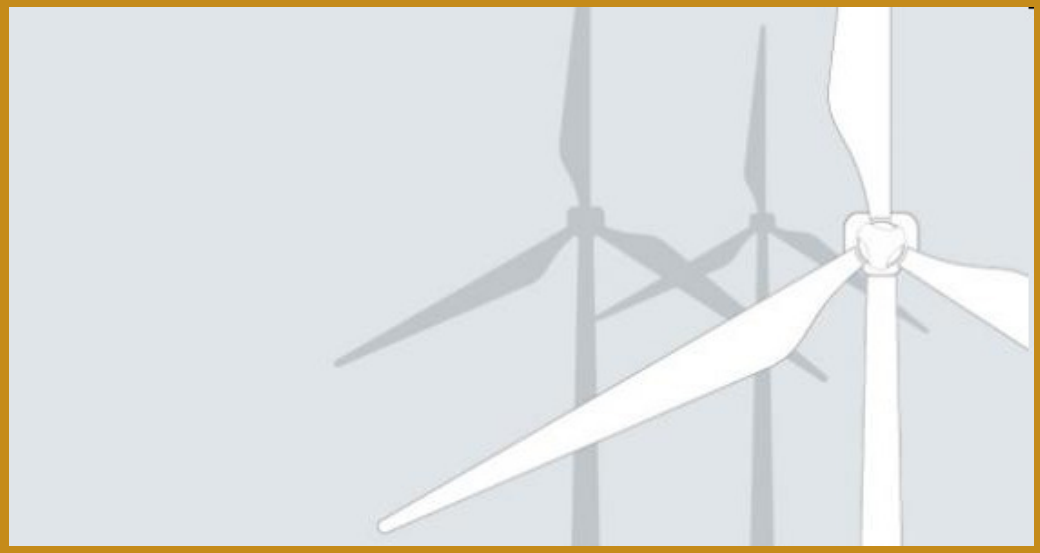
Condition Based Monitoring For Performance Improvements



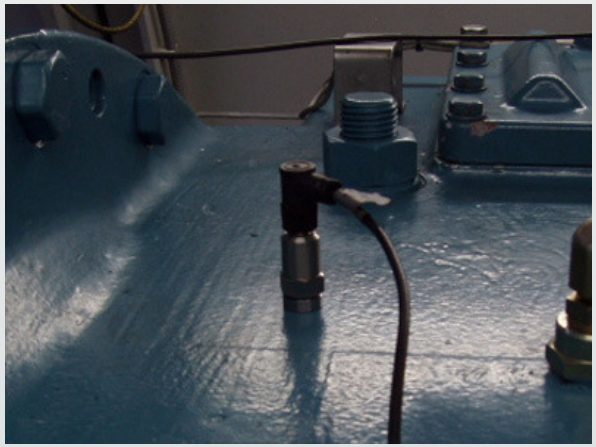
Jochen Ziehmann, 8.2 Consulting AG

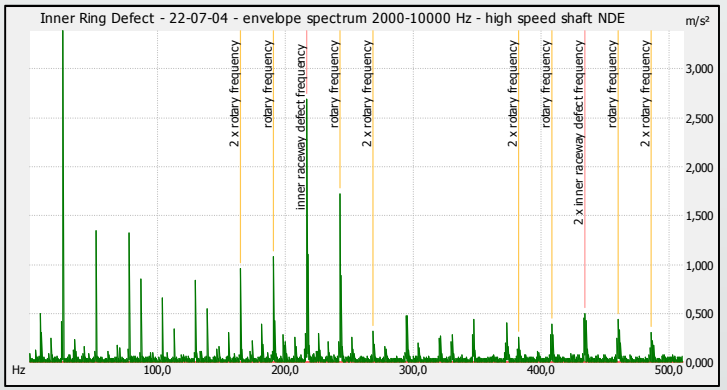
1. Existing condition monitoring methods
2. Short introduction to vibration analysis
3. Current status of the technology
4. What should operators take into consideration when buying a condition monitoring system
5. Future prospects

Visual Inspection

- Cheap
- Easy to perform
- Can see only some of the gears

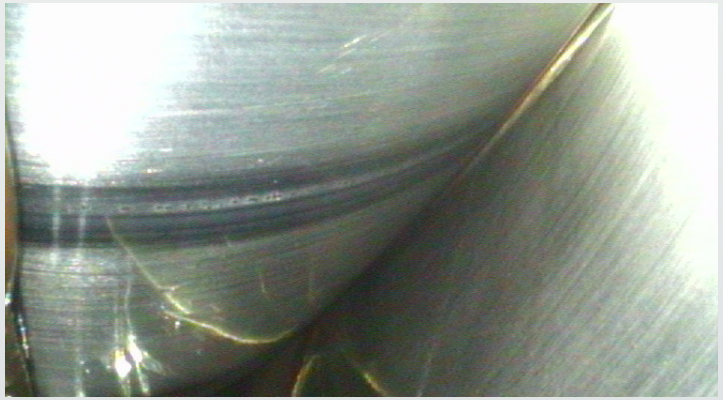
Vibration Analysis





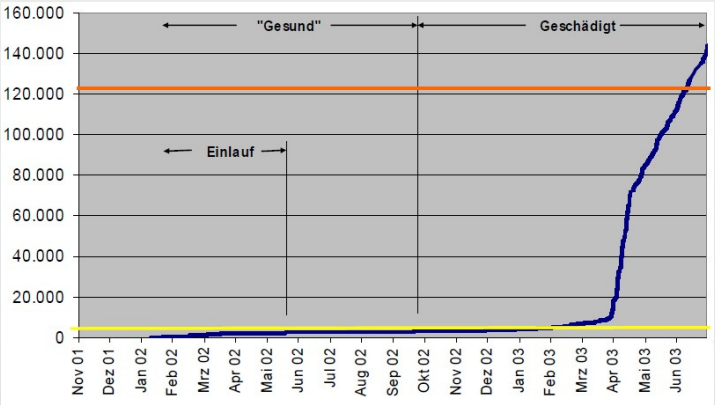
- "Offline" or "Online" possible
- Main method for Condition Monitoring
- Can see most of the defects
- Problems with slow speed parts
- Not possible to see planetary bearing defects

Video Endoscope



- Can see defects in detail
- Accepted method for proving defects
- Only parts of the gearbox are inspected
- Some parts are not accessible

Metal Particle Sensor



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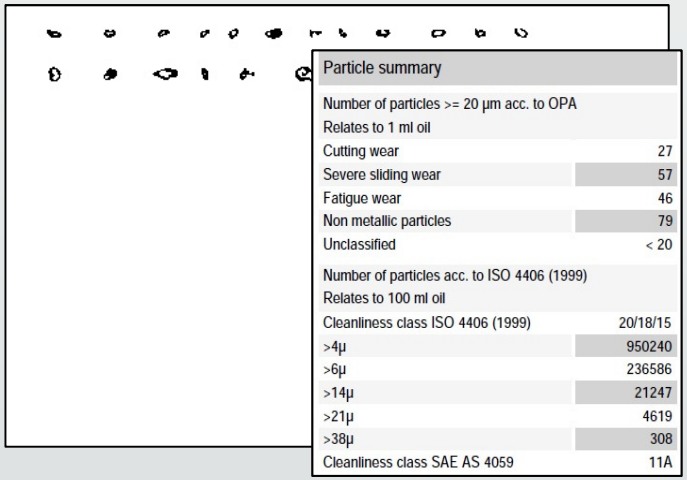
- General indication for defects
- Not possible to tell which part is defective
- Still quite expensive

Oil Analysis

Source: OELCHECK GmbH

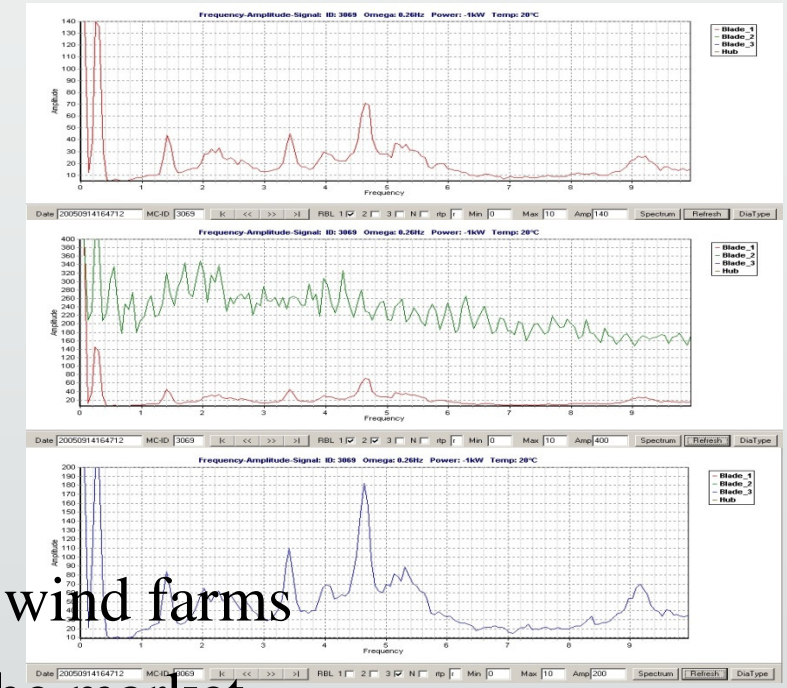


Particle summary	
Number of particles >= 20 µm acc. to OPA	
Relates to 1 ml oil	
Cutting wear	27
Severe sliding wear	57
Fatigue wear	46
Non metallic particles	79
Unclassified	< 20
Number of particles acc. to ISO 4406 (1999)	
Relates to 100 ml oil	
Cleanliness class ISO 4406 (1999)	20/18/15
>4µ	950240
>6µ	236586
>14µ	21247
>21µ	4619
>38µ	308
Cleanliness class SAE AS 4059	11A

- Analysis of the oil in the lab
- General indication for defects
- Not possible to tell which part is defective

Rotor Blade Monitoring

© IGUS - Innovative Technische Systeme GmbH



- Mandatory for offshore wind farms
- Not many products on the market
- Still in early product stage
- Promising results

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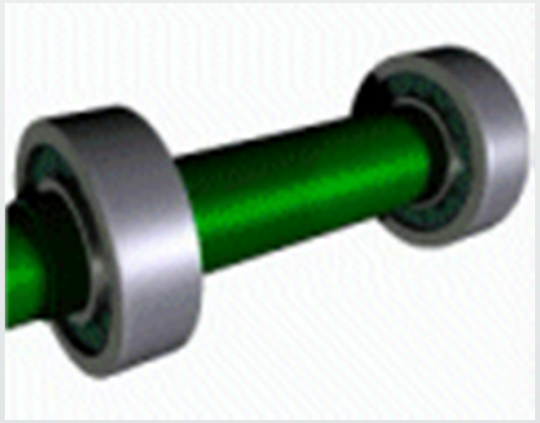
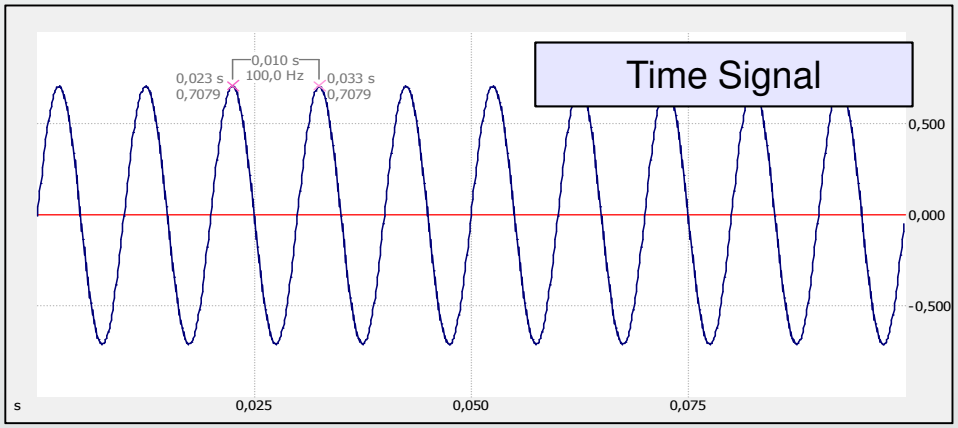
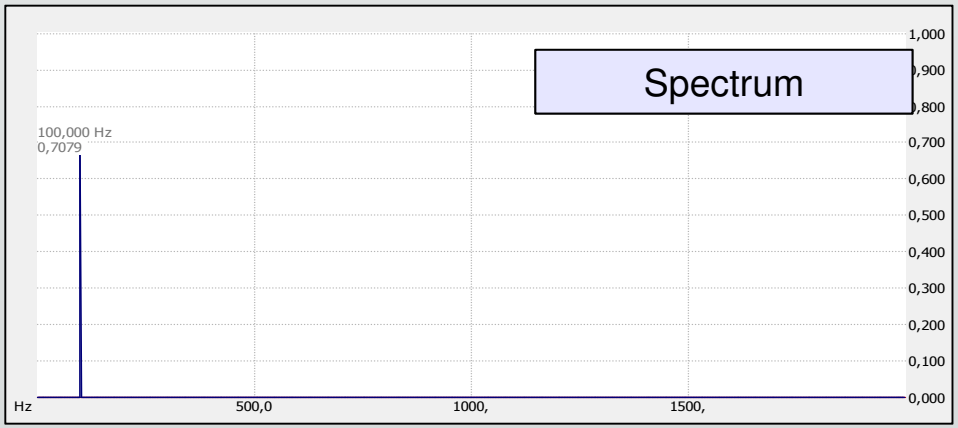
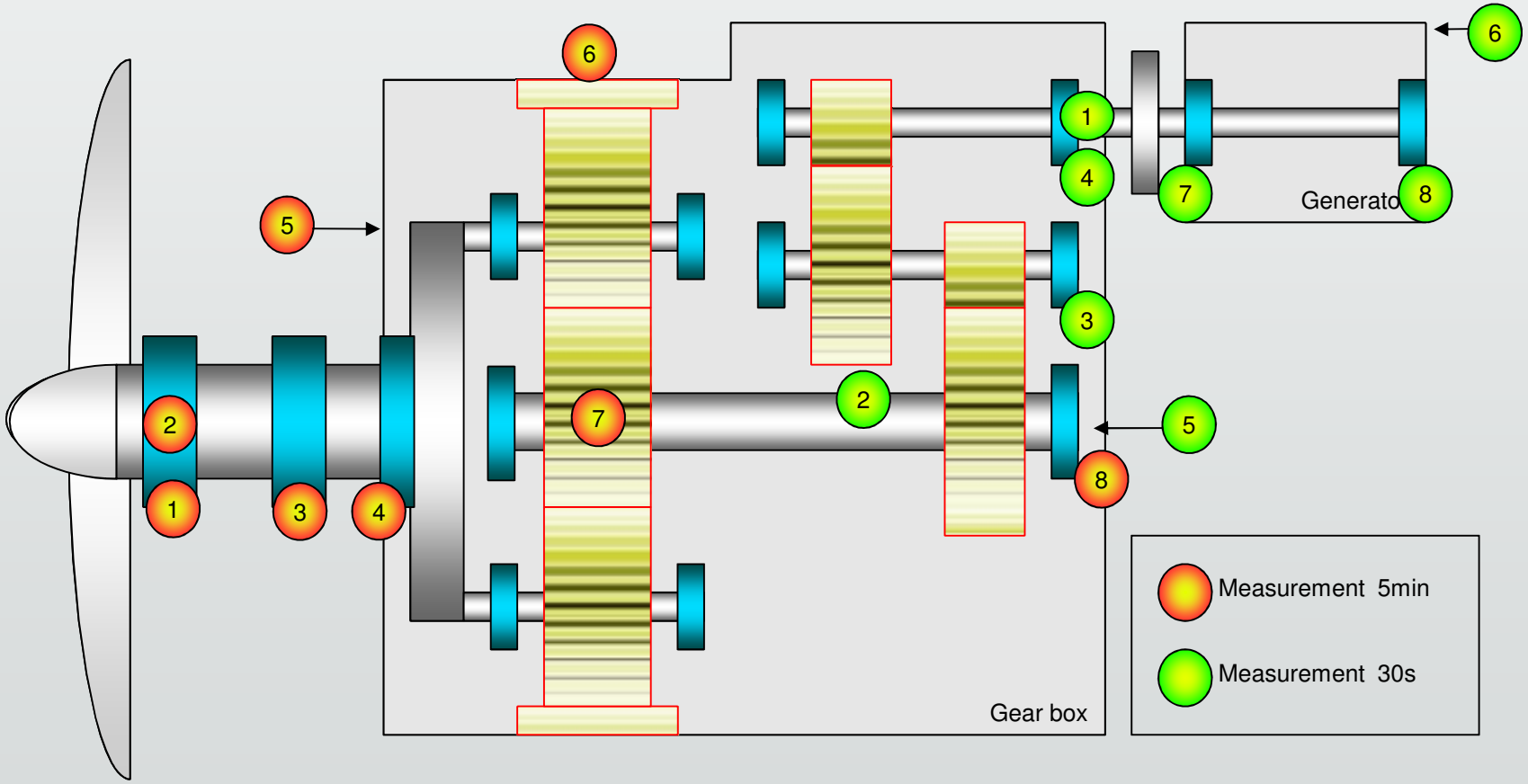
Example: Shaft Unbalance







Sensor Positions



"Kinematics" Data

E.2 Planetary Stage

Planets	3
Teeth hollow wheel	112
Teeth planetary wheels	44
Teeth sun wheel	23
Ratio	5,87
Tooth mesh frequency	31,92 Hz
Rotary frequency planet carrier	17,10 rpm
Rotary frequency planets	26,42 rpm
Rotary frequency sun wheel	100,36 rpm
Defect frequency hollow wheel	0,85 Hz
Defect frequency planet wheels	0,88 Hz
Defect frequency sun wheel	4,16 Hz

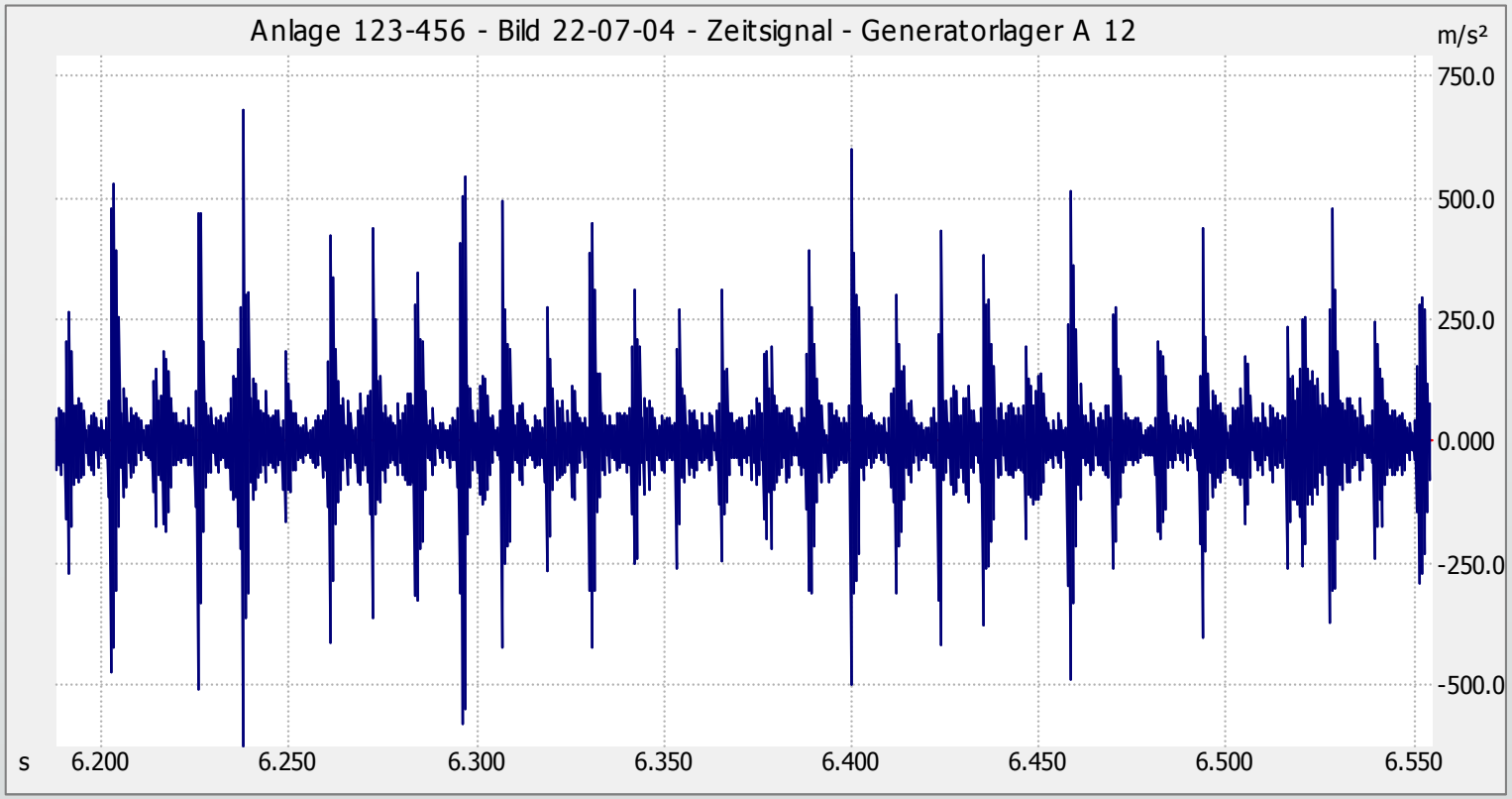
E.3 Spur Gear Stages

	Spur gear stage 1	*Spur gear stage 2*
Teeth wheel	91	112
Teeth pinion	21	27
Ratio	4,33	4,15
Tooth mesh frequency	152,21 Hz	811,80 Hz

E.4 Bearings

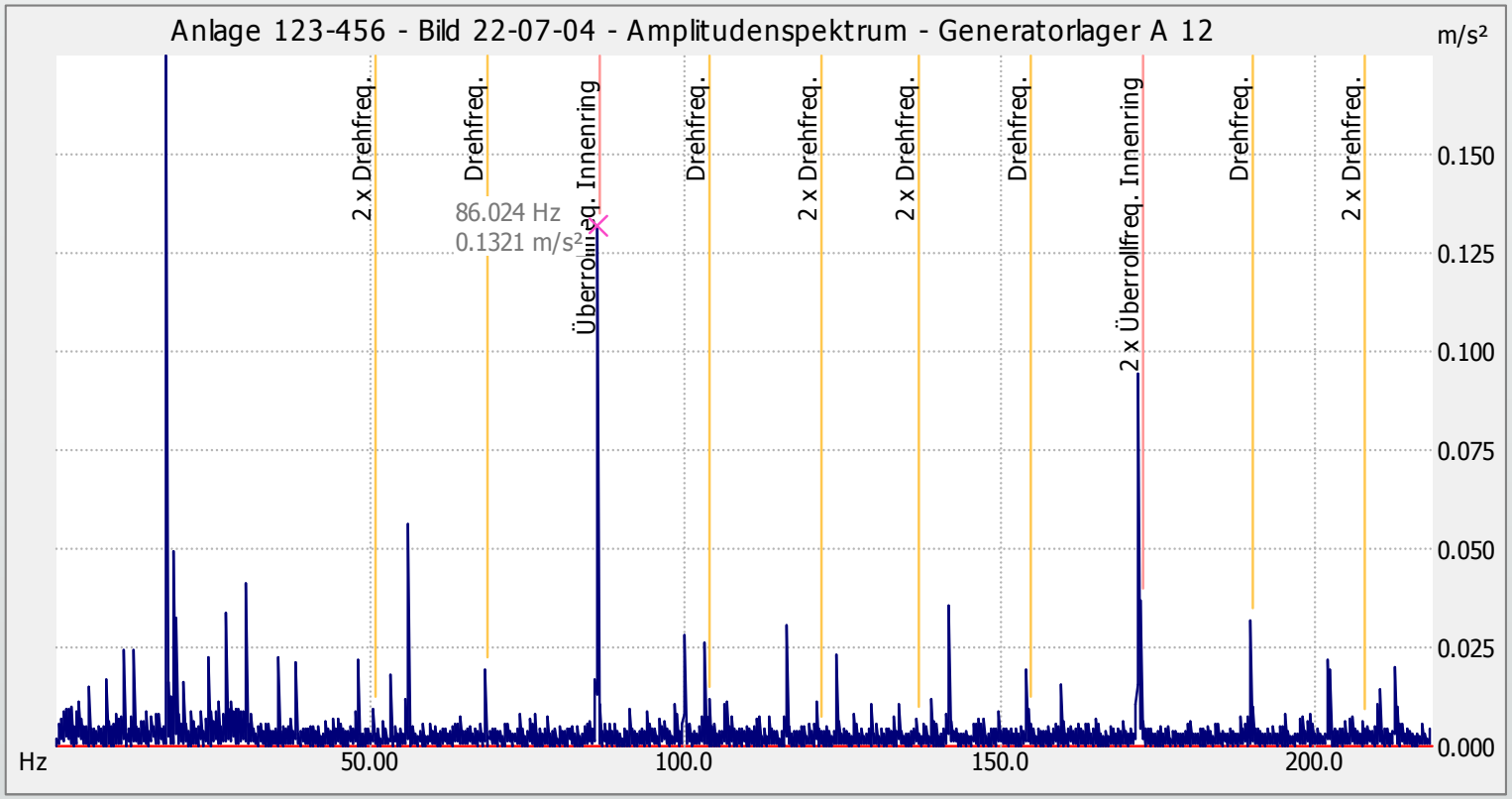
	Manuf.	*Type*	*Outer race*	*Inner race*	*Cage*	*Rollers*
Main bearing	SKF	240/630	3,63 Hz	4,35 Hz	0,13 Hz	3,05 Hz
Planet carrier bearing 1	INA	SL18 28/750	8,39 Hz	9,28 Hz		11,23 Hz
Planet carrier bearing 2	INA	SL18 18/630	7,82 Hz	8,71 Hz		10,51 Hz
Planet bearings	INA	SL18 5050	7,93 Hz	10,20 Hz		11,41 Hz
Low speed shaft bearing 1	INA	SL18 28/530	56,76 Hz	62,00 Hz		75,59 Hz
Low speed shaft bearing 2	INA	SL18 28/630	45,64 Hz	50,57 Hz		30,72 Hz
Rotary feedthrough bearing	SKF	6026-2RS1	10,97 Hz	14,12 Hz	0,73 Hz	13,16 Hz
Intermediate shaft bearing 1	SKF	NU2236ECMA	55,43 Hz	75,03 Hz	3,08 Hz	47,17 Hz
Intermediate shaft bearing 2	NSK	NU2338 EXM1/C3	41,11 Hz	60,37 Hz		73,61 Hz
High speed shaft bearing 1	SKF	NU2328ECMA	170,78 Hz	250,15 Hz	12,18 Hz	153,34 Hz
High speed shaft bearing 2	SKF	NU234ECMA	230,61 Hz	309,69 Hz	12,81 Hz	198,44 Hz
High speed shaft bearing 3	SKF	QJ332	147,57 Hz	213,23 Hz	12,30 Hz	130,79 Hz
Generator bearing DE	SKF	6330M/C3	107,94 Hz	162,66 Hz	12,00 Hz	142,22 Hz
Generator bearing NDE	SKF	6330M/C3	107,94 Hz	162,66 Hz	12,00 Hz	142,22 Hz

How do the signals look like?



Time signal of a defective inner race of a generator bearing

How do we see defects?



Time signal of a defective inner race of a generator bearing

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Current Status of Vibration Analysis

1. It is possible to detect defects in the high speed and intermediate speed stages
2. No reliable detection of problems in the planetary bearings
3. Some operators don't have access to the measurement data
4. Some operators don't get any reports
5. Some systems are installed but not running or not collecting data

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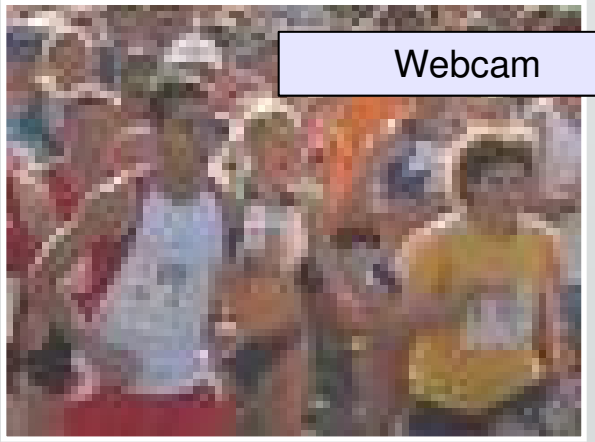
Resolution

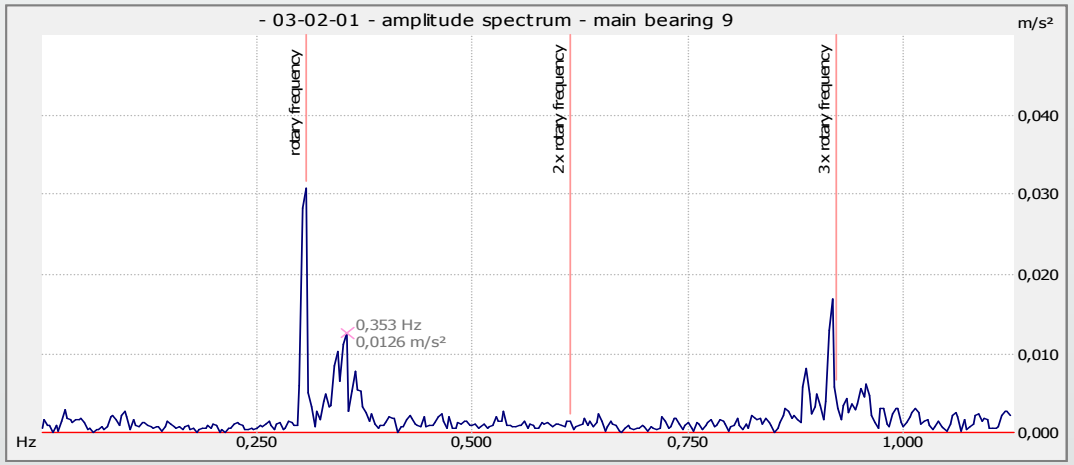
10 Megapixel

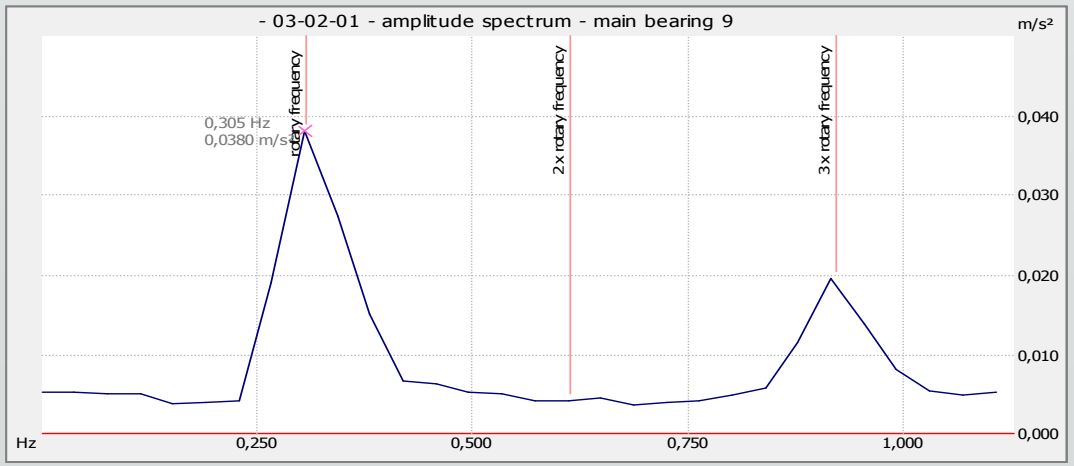


Webcam

Frequency Resolution

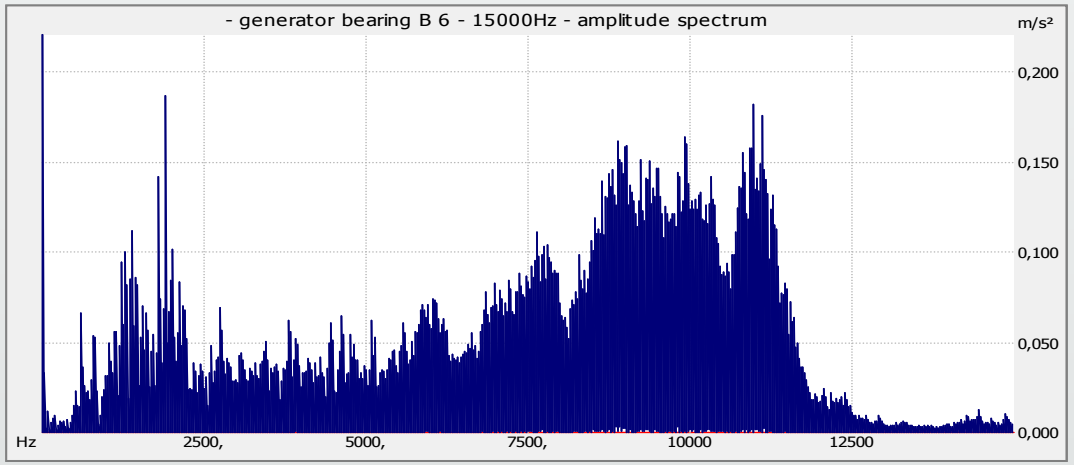
- Depends only on recording time
- Recommended: More than 30s recording time

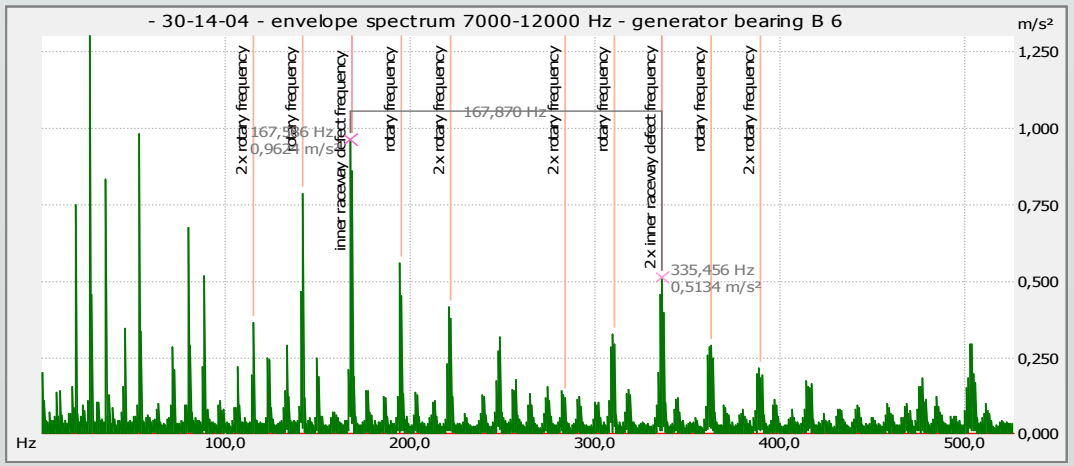




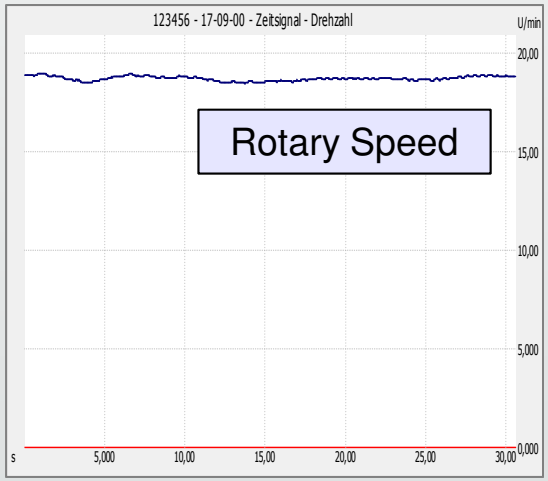
Sampling Rate

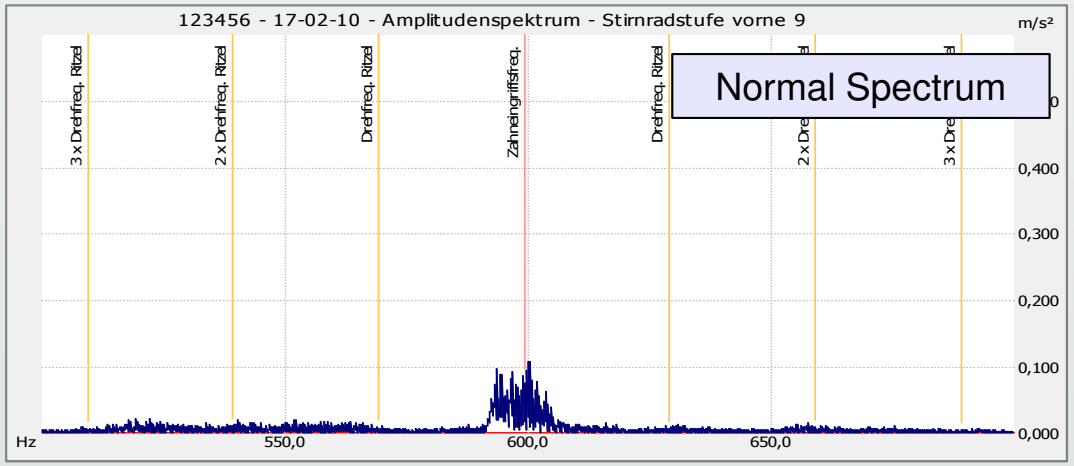
- Depends on highest frequency
- Recommended: More than 30 kHz

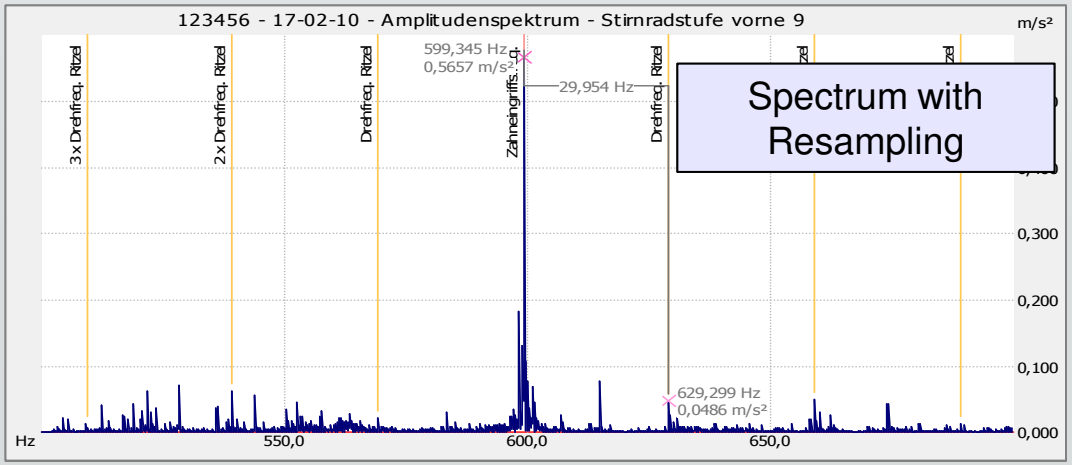




Resampling


123456 - 17-09-00 - Zeitsignal - Drehzahl
U/min
20,00
15,00
10,00
5,000
0,000
s
5,000
10,00
15,00
20,00
25,00
30,00
Rotary Speed

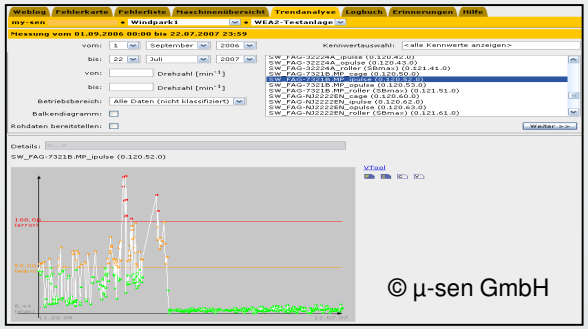

123456 - 17-02-10 - Amplitudenspektrum - Stirnradstufe vorne 9
m/s²
3 x Drehfreq. Ritzel
2 x Drehfreq. Ritzel
Drehfreq. Ritzel
Zahneingriffsfreq.
Drehfreq. Ritzel
Normal Spectrum
0,400
0,300
0,200
0,100
0,000
Hz
550,0
600,0
650,0


123456 - 17-02-10 - Amplitudenspektrum - Stirnradstufe vorne 9
m/s²
3 x Drehfreq. Ritzel
2 x Drehfreq. Ritzel
Drehfreq. Ritzel
599,345 Hz
0,5657 m/s²
29,954 Hz
Zahneingriffs. fr
Drehfreq. Ritzel
Spectrum with Resampling
629,299 Hz
0,0486 m/s²
0,300
0,200
0,100
0,000
Hz
550,0
600,0
650,0

Operator Access to Data

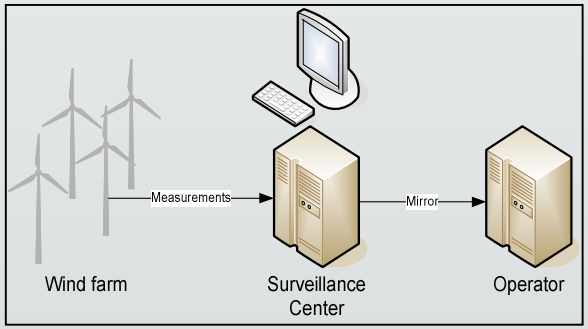
Web-Interface

Operator can download data



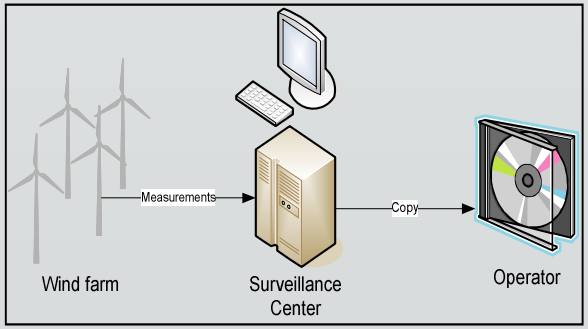
Mirror-Server

Operator has a copy of the server in the surveillance center



Copy by DVD

Operator gets a DVD with data in regular intervals



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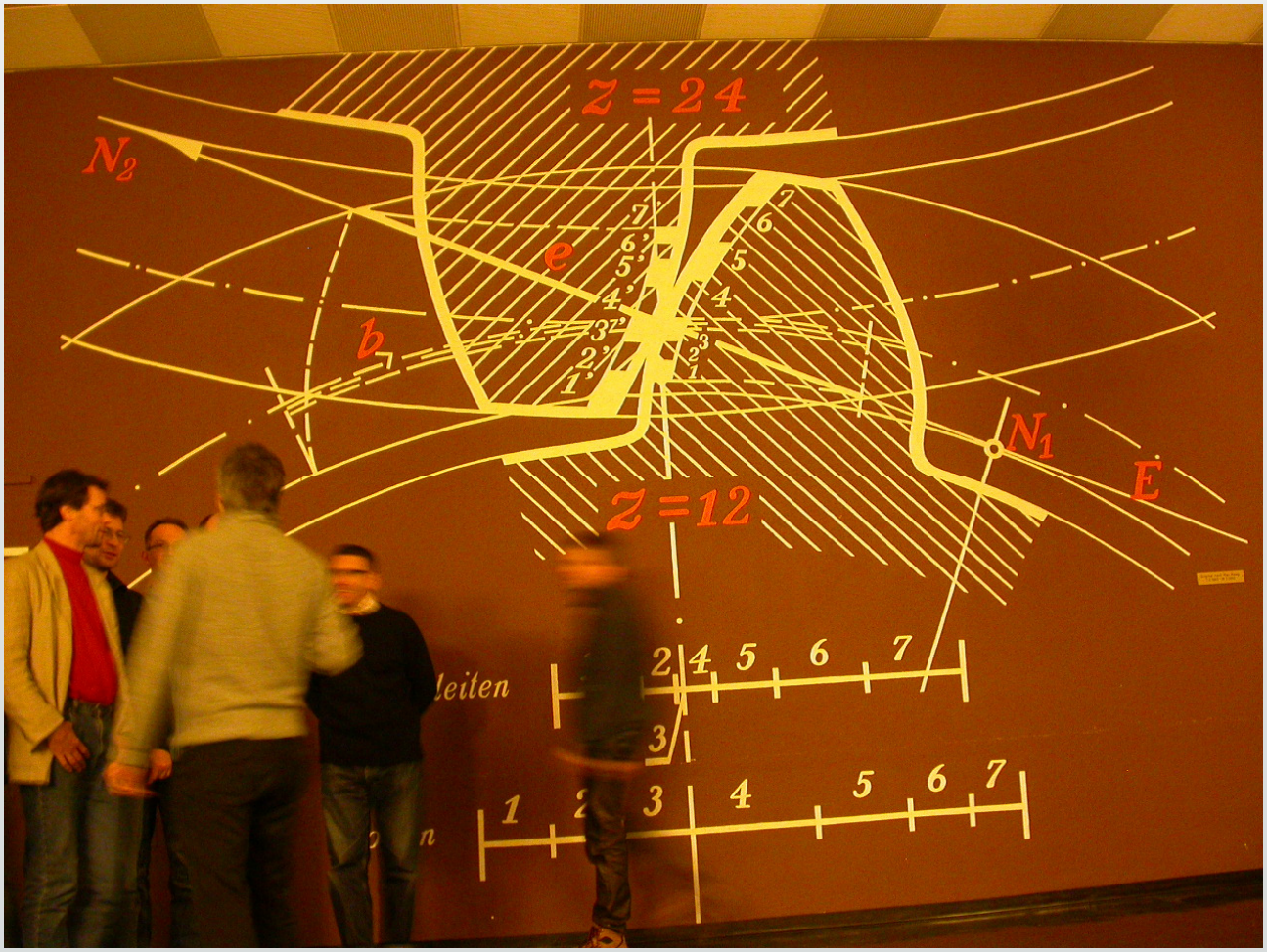
Future Prospects

1. Better algorithms
2. Detection of planetary bearing defects
3. More reliable detection with more feedback
4. Prediction of remaining life span

Thank you