Transition from stationary CMS to Industry 4.0

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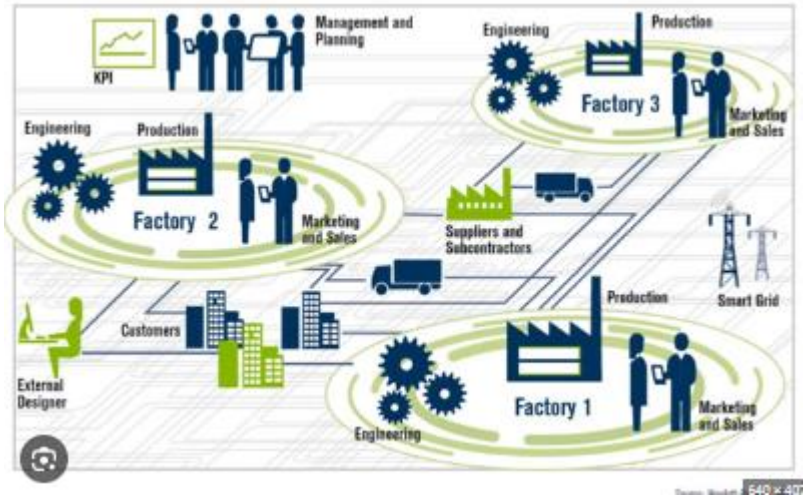
Agenda

- Motivation
- Types of systems
- Vibration essentials
- Thresholds settings
- Order analysis
- Handling large data
- New concept of data analysis automatization

Motivation

The main practical feature to be achieved withing the transformation is the **scalability**



- Cost of sensors
- Interfaces/protocols
- Data integration
- Analysis **automatization**

„It just takes the digital clock of the microvawe oven to illustrate how simple things are hard to use, if not necessary”

Types of systems: hardware

Portable devices

Stationary systms

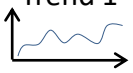
Wiereless solutions

Types of systems: data

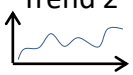
Hardware → data characteristics

Single scalar His (RMS, PP, VRMS): 1g, 3mm/s

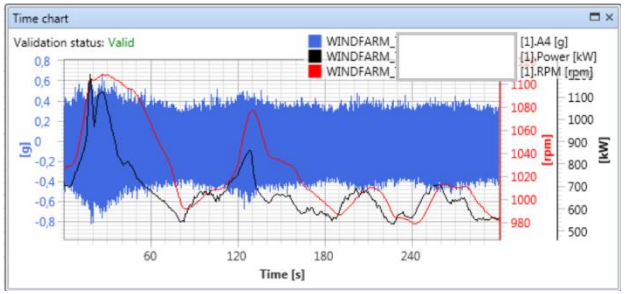
Trend 1

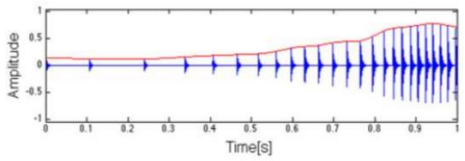


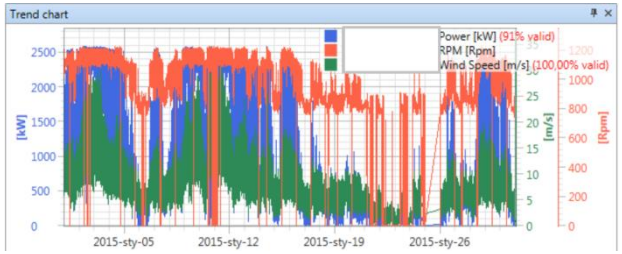
Trend 2



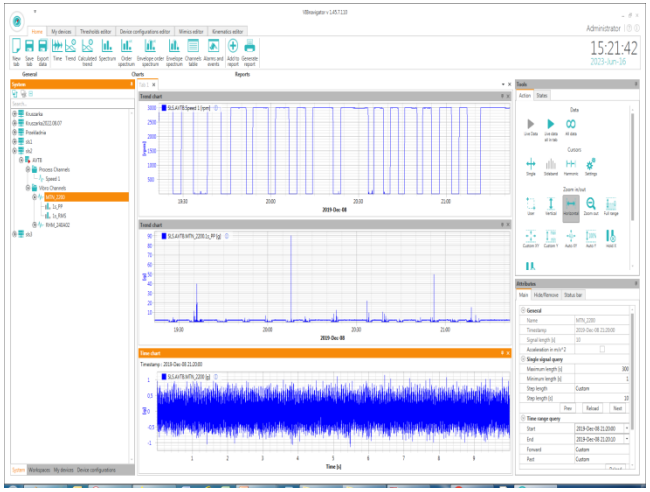
Very short,no PM



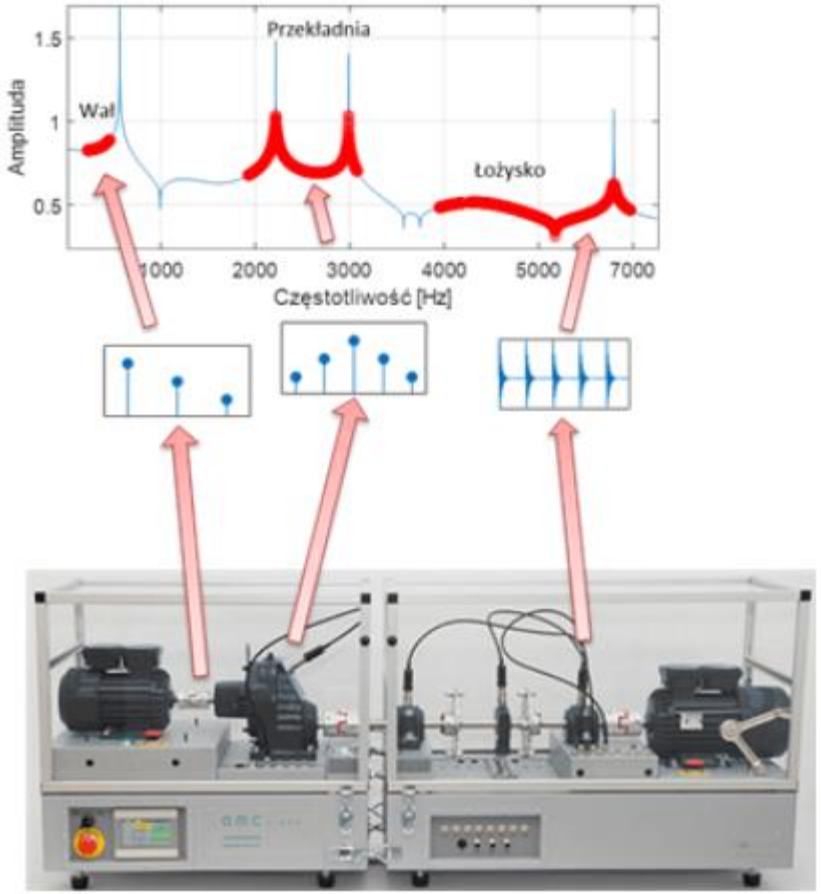




Types of systems: software



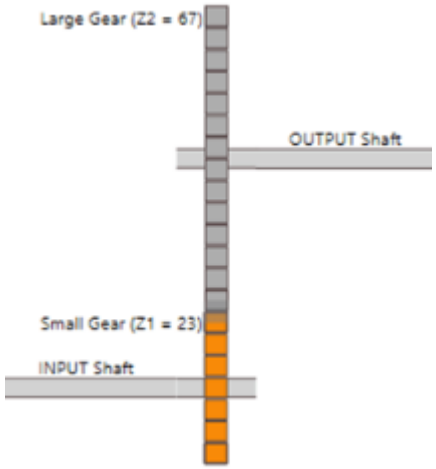
Vibration essentials

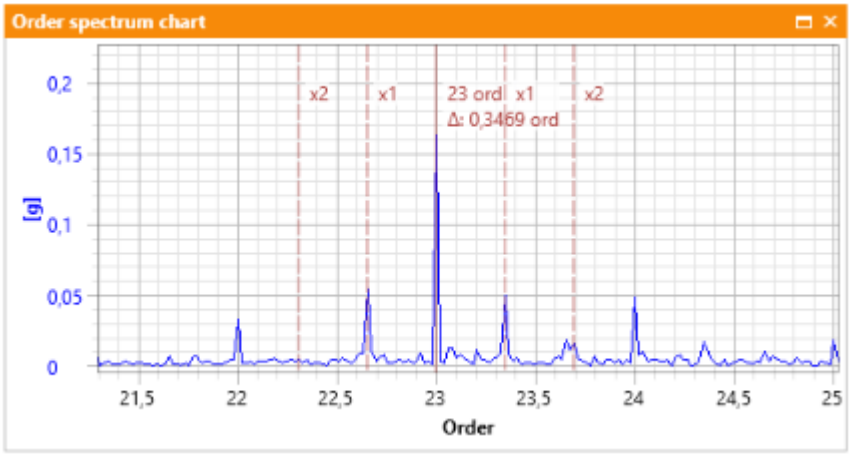


If possible, characteristic components are defined for individual machine parts – they generate **trend plots**

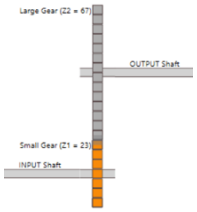
Vibration essentials

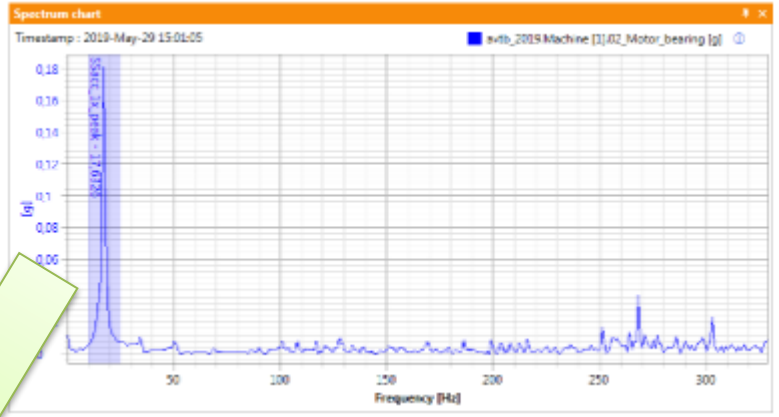
Kinetostatic models are used to calcualte **characteristic orders**

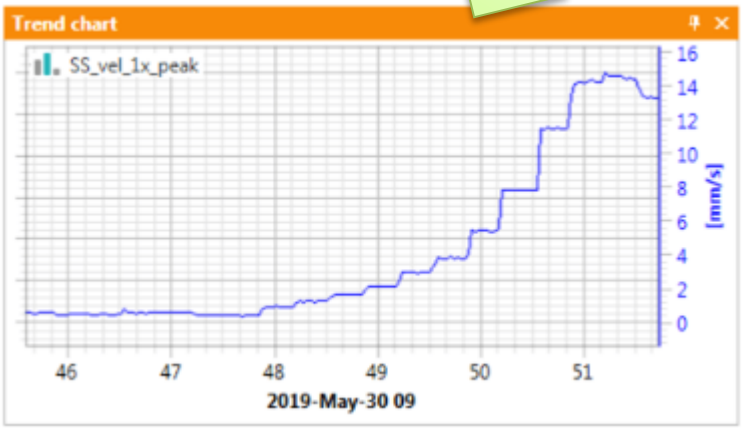




Vibration essentials

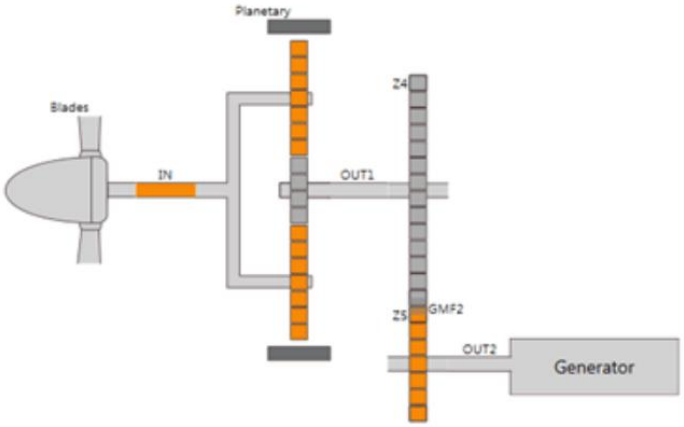




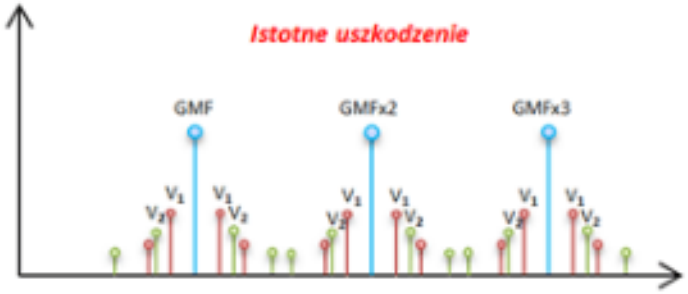


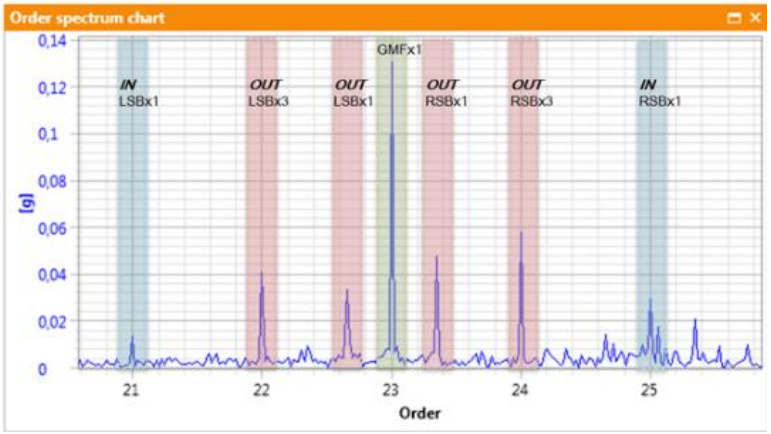
Individual characteristic orders generate **trends**

Vibration essentials



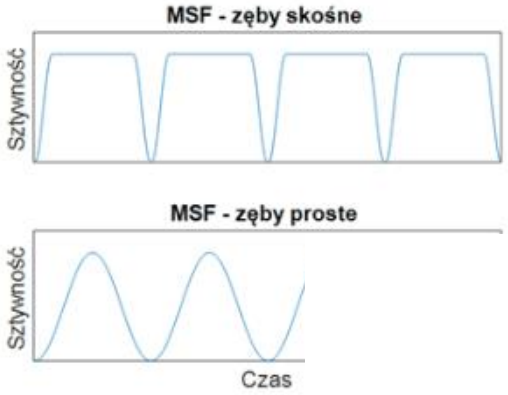
	Order	Minim...	Maximum	Bandw...
T				
	OUT2.3x	11,8200	12,1800	3,0000
	Planetary.GMFx1	23,6400	24,3600	3,0000
	Planetary.GMFx2	47,2800	48,7200	3,0000
	Planetary.GMFx3	70,9200	73,0800	3,0000
	Planetary.GMFx4	94,5600	97,4400	3,0000
	Planetary.HTF_PlanetRingx1	0,9850	1,0150	3,0000
	Planetary.HTF_PlanetRingx2	1,9700	2,0300	3,0000
	Planetary.HTF_PlanetRingx3	2,9550	3,0450	3,0000
	Planetary.HTF_PlanetRingx4	3,9400	4,0600	3,0000
	Planetary.HTF_PlanetSunx1	2,9550	3,0450	3,0000
	Planetary.HTF_PlanetSunx2	5,9100	6,0900	3,0000
	Planetary.HTF_PlanetSunx3	8,8650	9,1350	3,0000
	Planetary.HTF_PlanetSunx4	11,8200	12,1800	3,0000
	Planetary.PlanetSpeedx1	2,9550	3,0450	3,0000
	Planetary.PlanetSpeedx2	5,9100	6,0900	3,0000

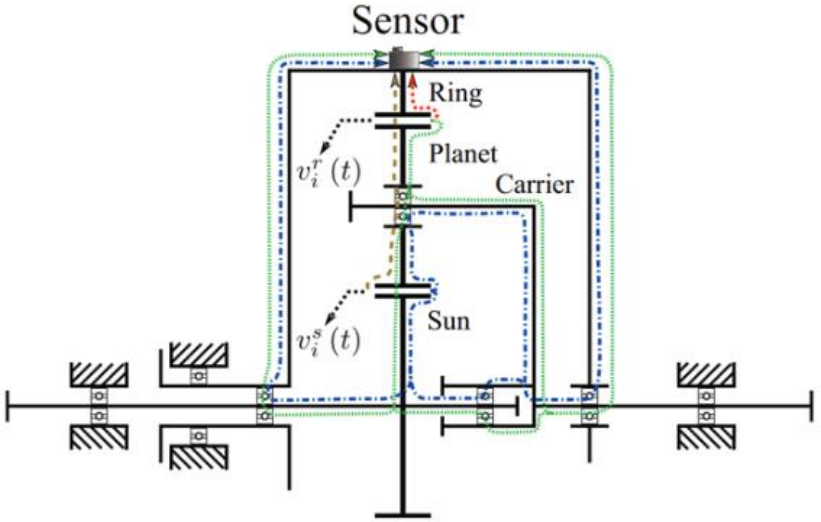




Gearboxes / drive trains could generate **hundereds of trends**

Vibration essentials



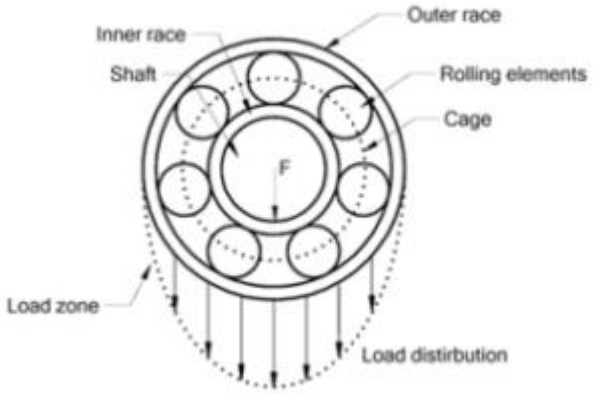


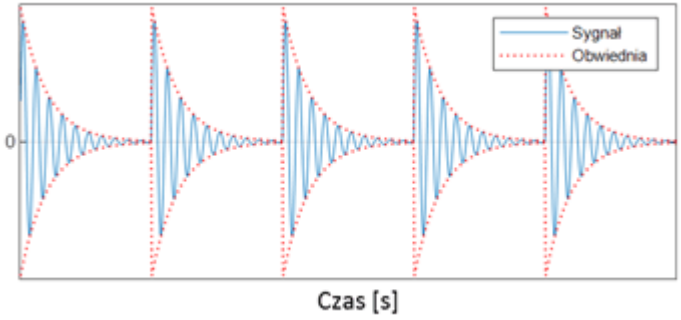
NATIONAL GEOGRAPHIC

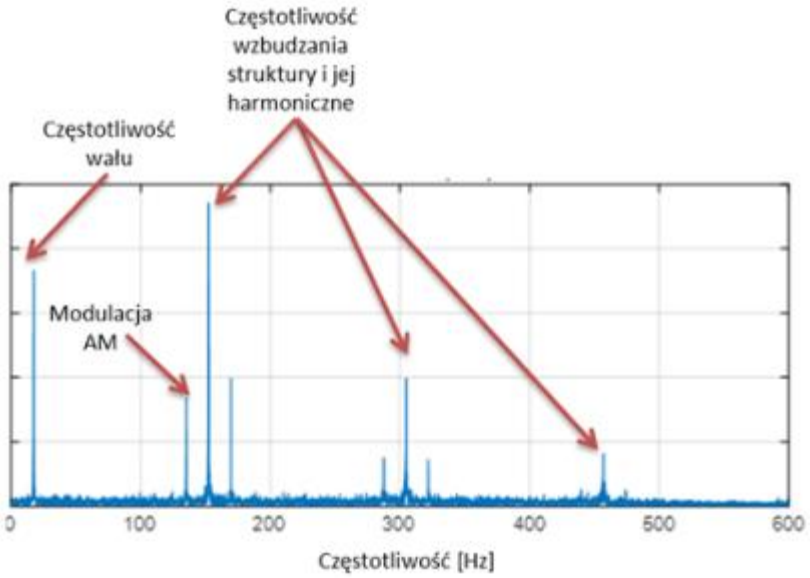
A close-up of the planthopper's gears.
PHOTOGRAPH BY MALCOLM BURROWS

Design of gearbox influences **vibration signature**

Vibration essentials

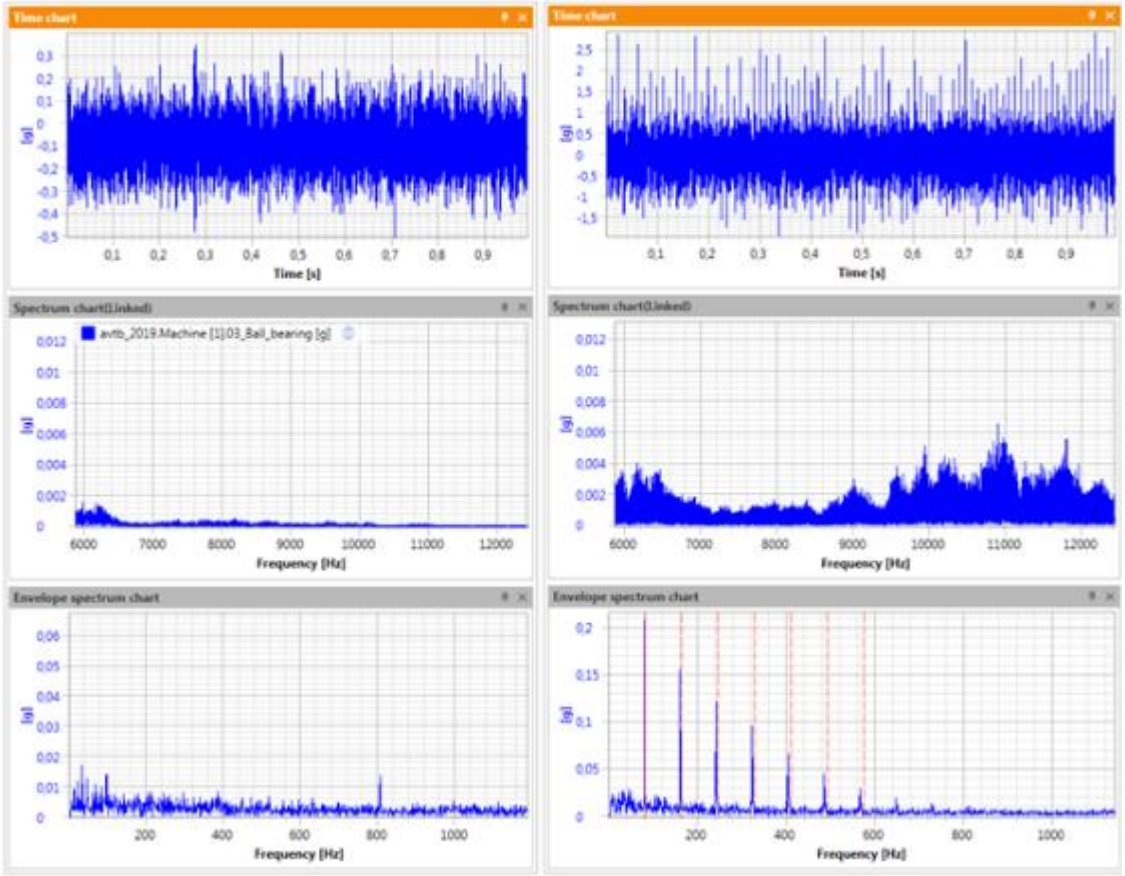






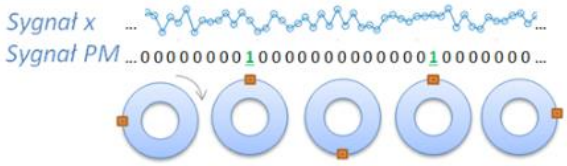
Bearings are monitored using **envelope** techniques

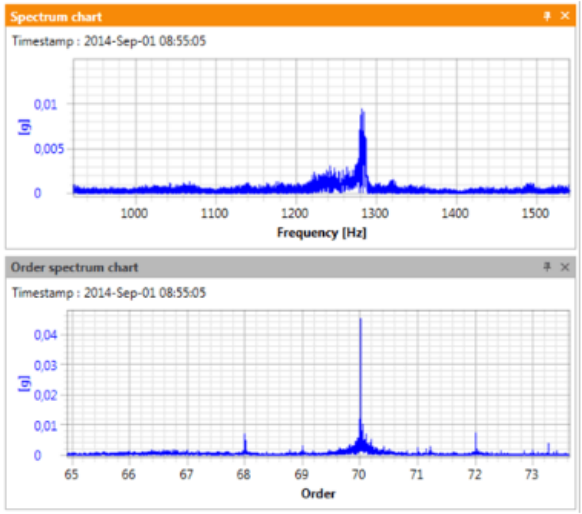
Vibration essentials

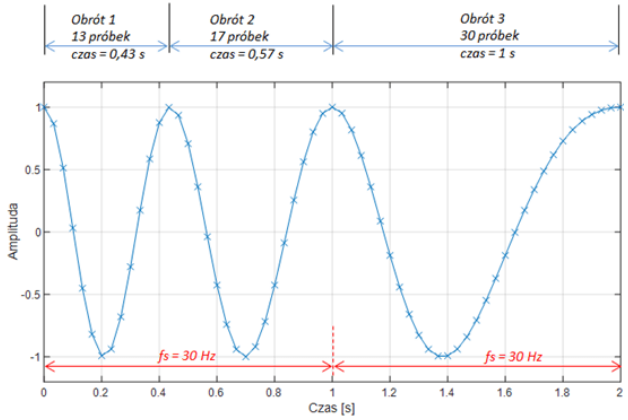


Comparison of healthy vs. faulty bering

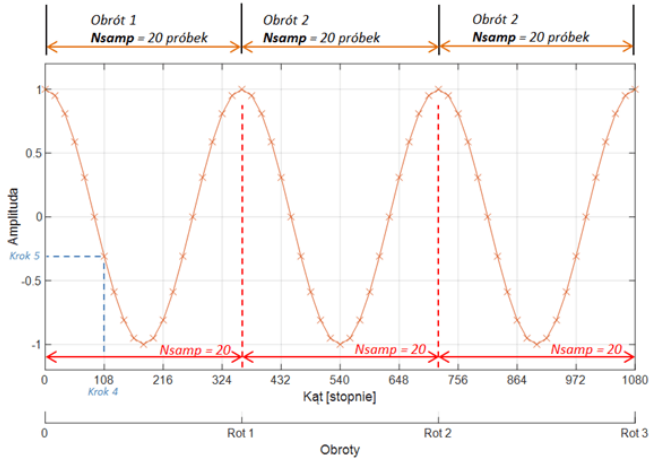
Order analysis





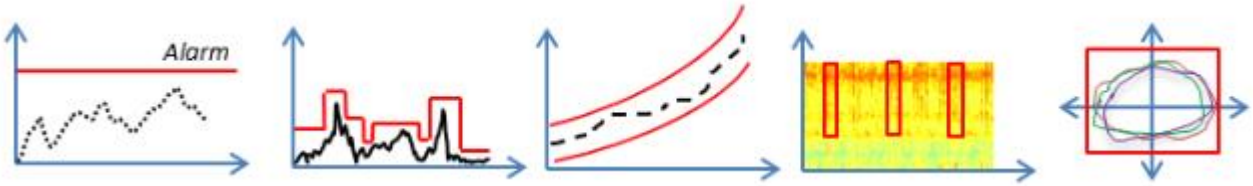


Rys. 2 Sygnał ze stałą ilością próbek w jednostce czasu



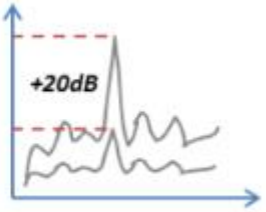
Order analysis minimized smearing effects

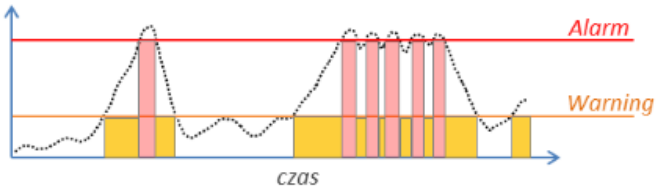
Threshold settings

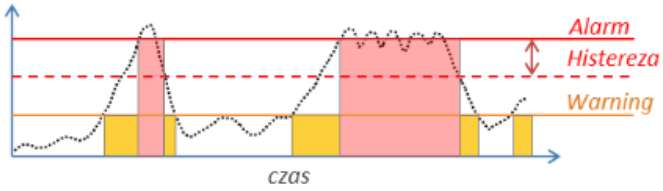


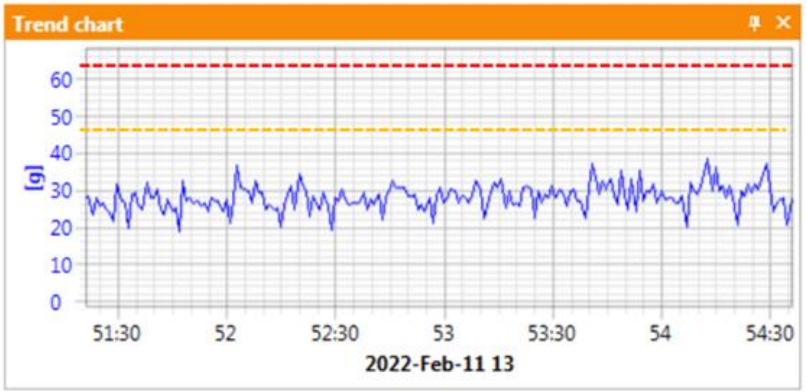
$$v_{\mathrm{rms}} = \sqrt{\frac{1}{T}\int_0^T v^2(t)\,\mathrm{d}t}$$

VS

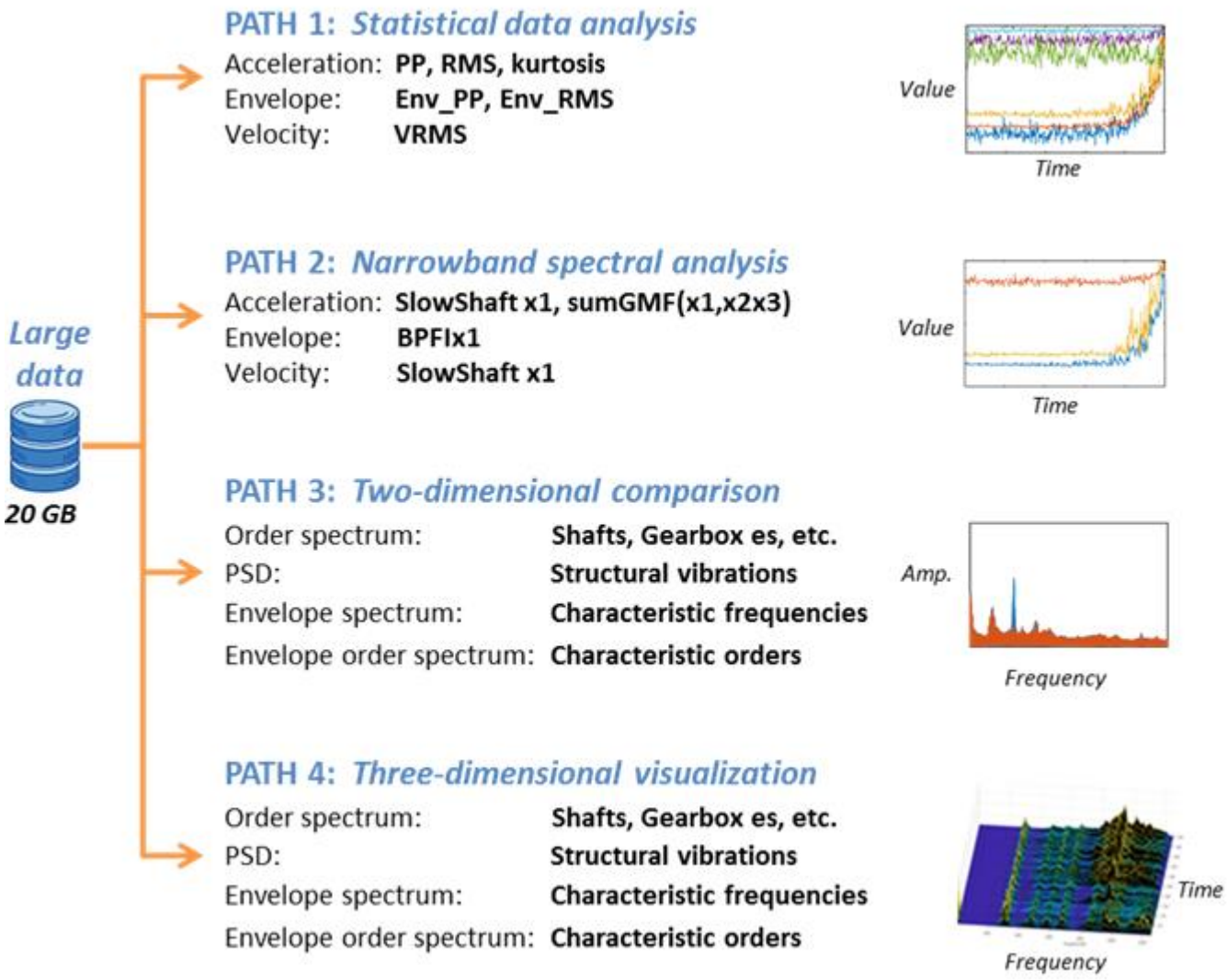




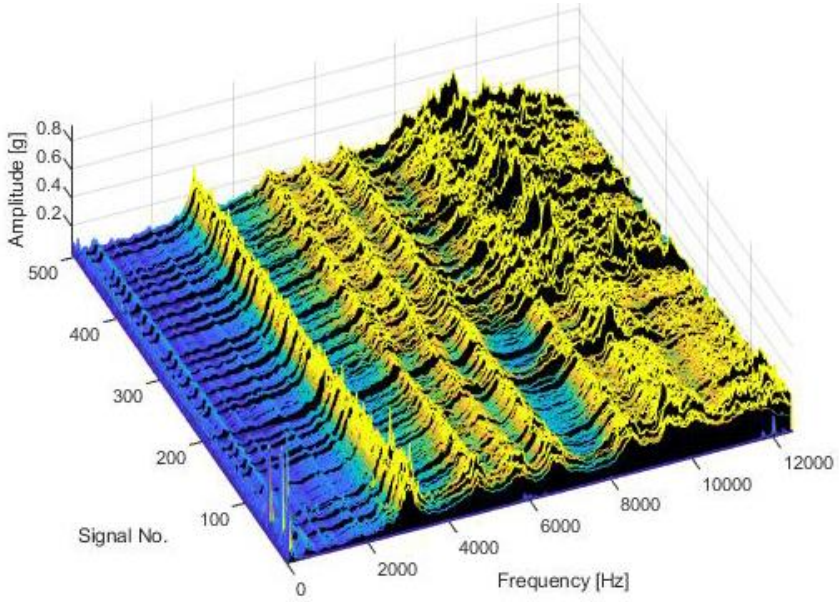


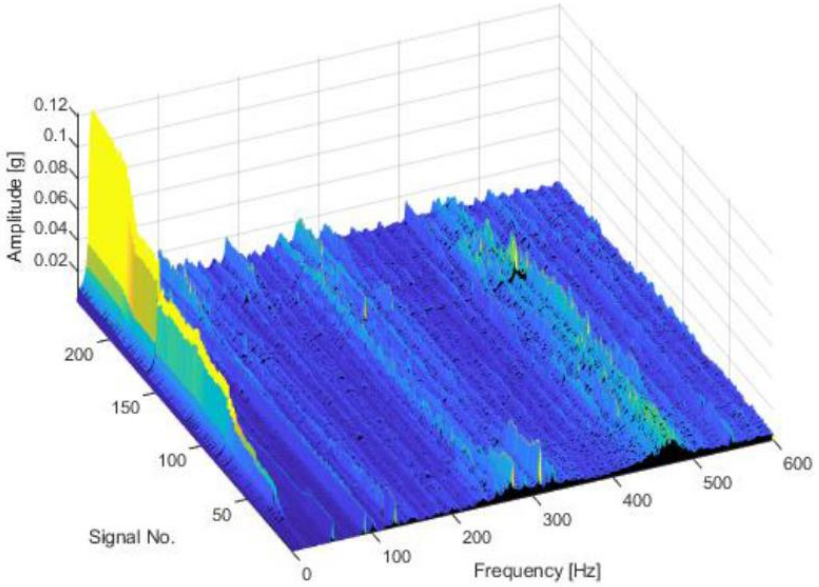


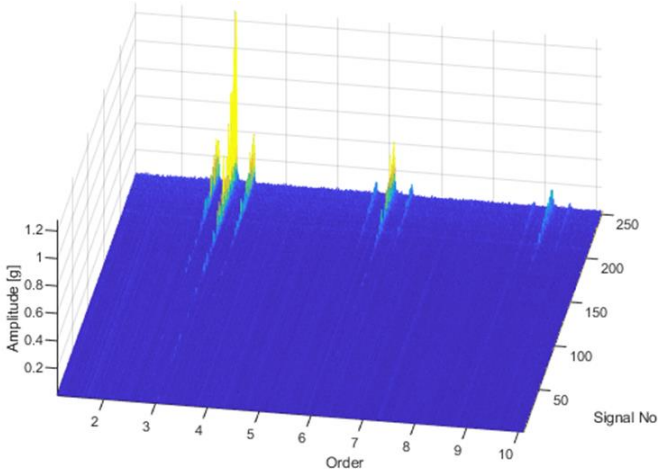
Handling large data



Examples of array representations



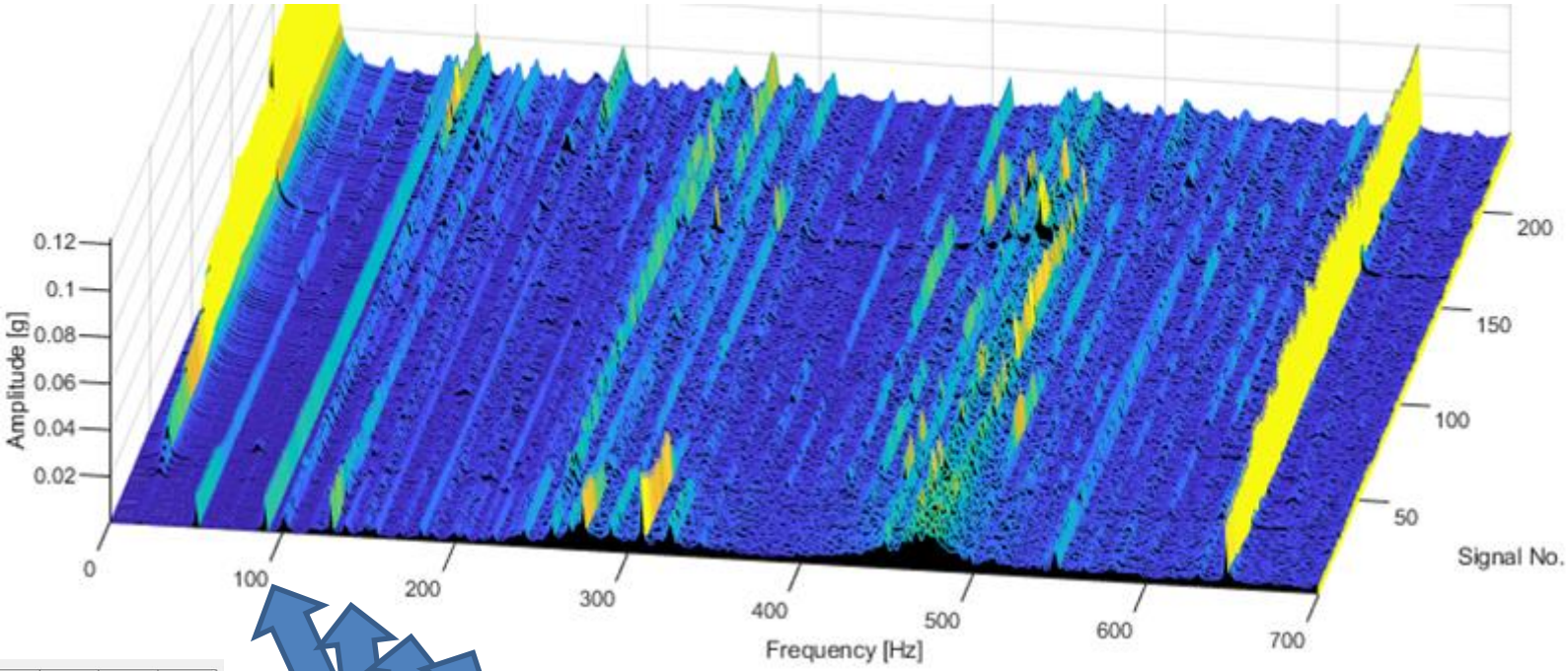


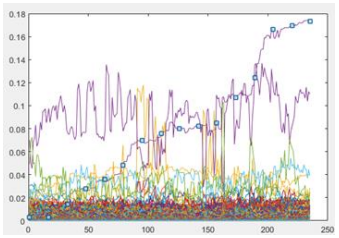


Problems:

- Large amont of calcualtions
- Unknown optimum resolution
- Unknown optimum **spectrum type**

New concept

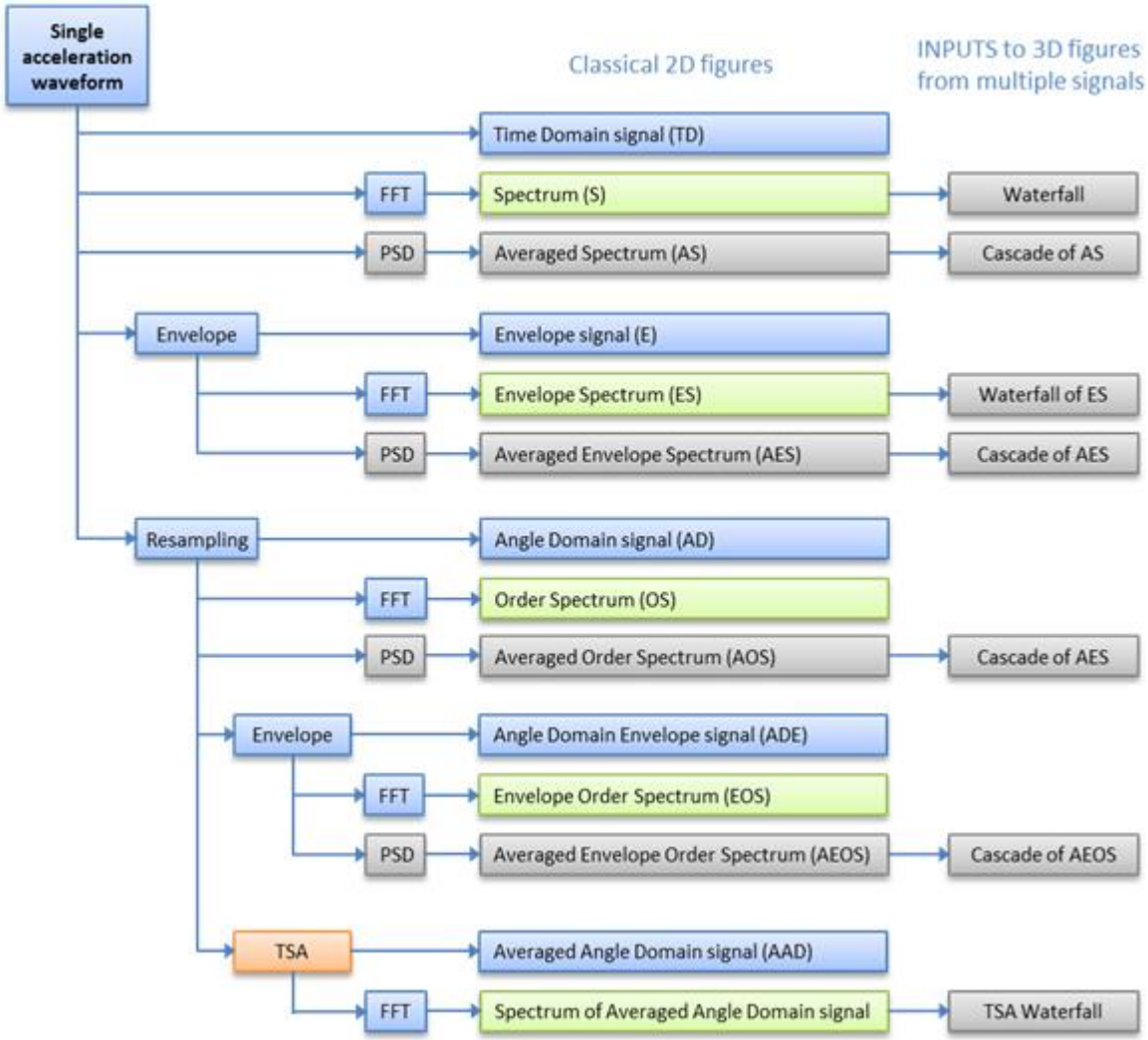




10k+ datesets

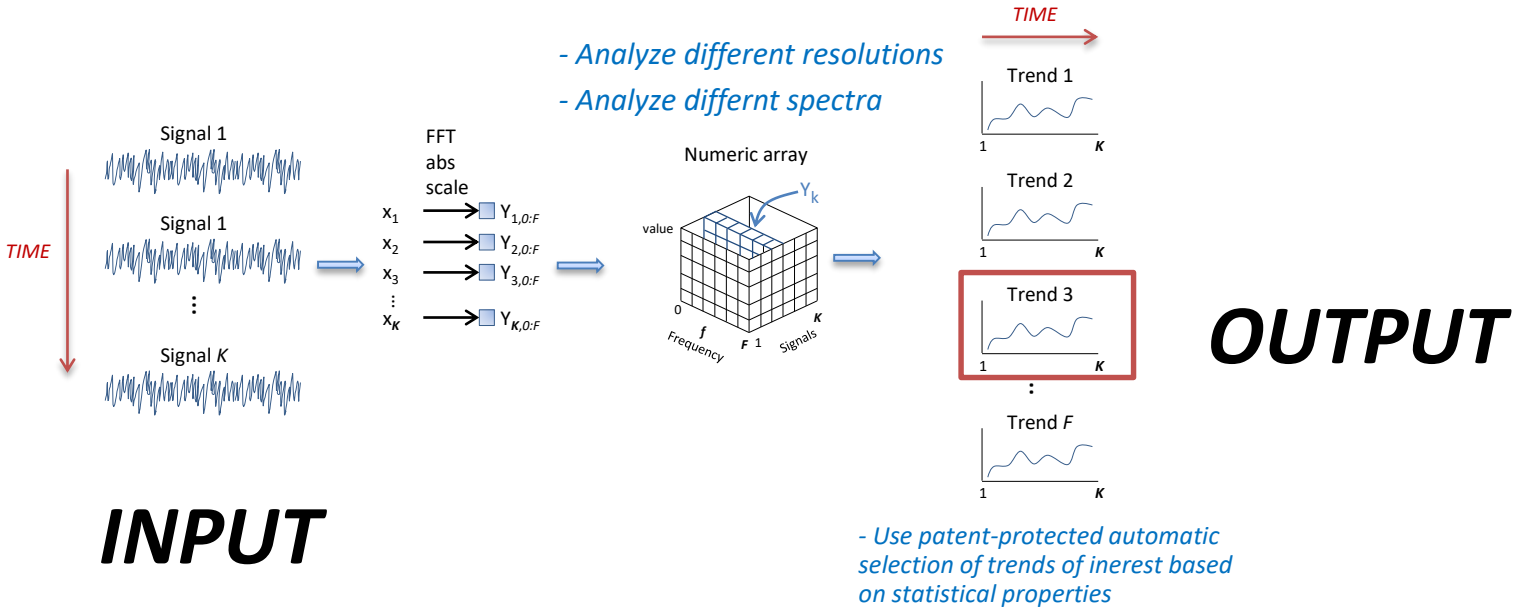
The idea of the new syste is to compare statistical behaviour of **independent trends** calcualted from 5 used spectral types

New concept



+ velocity
+ power

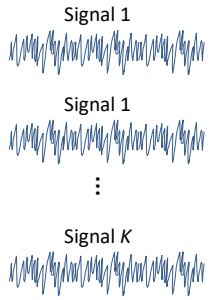
Advanced ND hidden

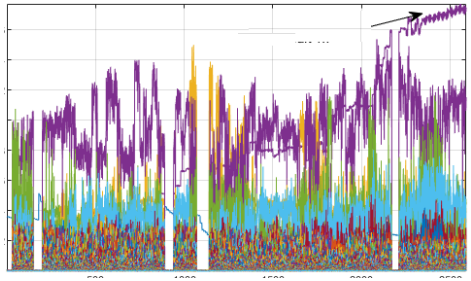


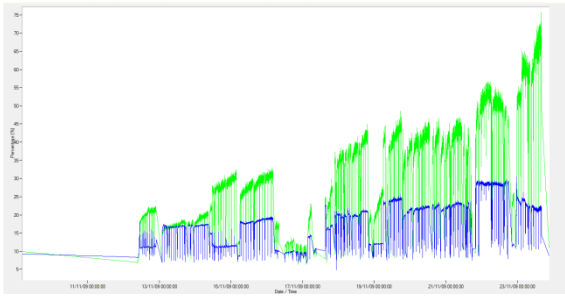
The metod accepts a large number of raw vibration signals and points (sorted) list of parametrs for display of trend (trend data available)

```
chanel_Name,PATH_Name,unit,method_Name,amp_Name,bin_Start,bin_Stop,resolution,PA,CA,is_Short_Term,score_Name,classification_Rule,bin_Method,value
channel 1,Spectrum,Hz,RR,Regular[g],15.5,18.5,1,1,0,NO,a,hist_Break,fd,0.00572515746314191
channel 1,Spectrum,Hz,RR,Regular[g],15.5,18.5,1,1,0,NO,a-score,hist_Break,fd,0.174906556355837
channel 1,Spectrum,Hz,RR,Regular[g],5074.5,5075.5,1,1,0,NO,a-score,hist_Break,fd,0.0164155904959713
channel 1,Spectrum,Hz,RR,Regular[g],15.5,18.5,1,1,0,NO,pHigh/pLow,hist_Break,fd,3.67004785277712
channel 1,Spectrum,Hz,RR,Regular[g],15.5,18.5,1,1,0,NO,pHigh-pLow,hist_Break,fd,0.0403156014910759
```

Summary







INPUT ***-inter-*** ***OUTPUT***

Because the program, which implements new concept iterates over machines, channels, singals, resolutions, ND methods, and statistical scores, it enables CMS **scalability**, even for different data sources (different systems and sensors).