שיטה חדשנית לזיהוי הזדקרות מדחס באמצעות חתימת רעידות

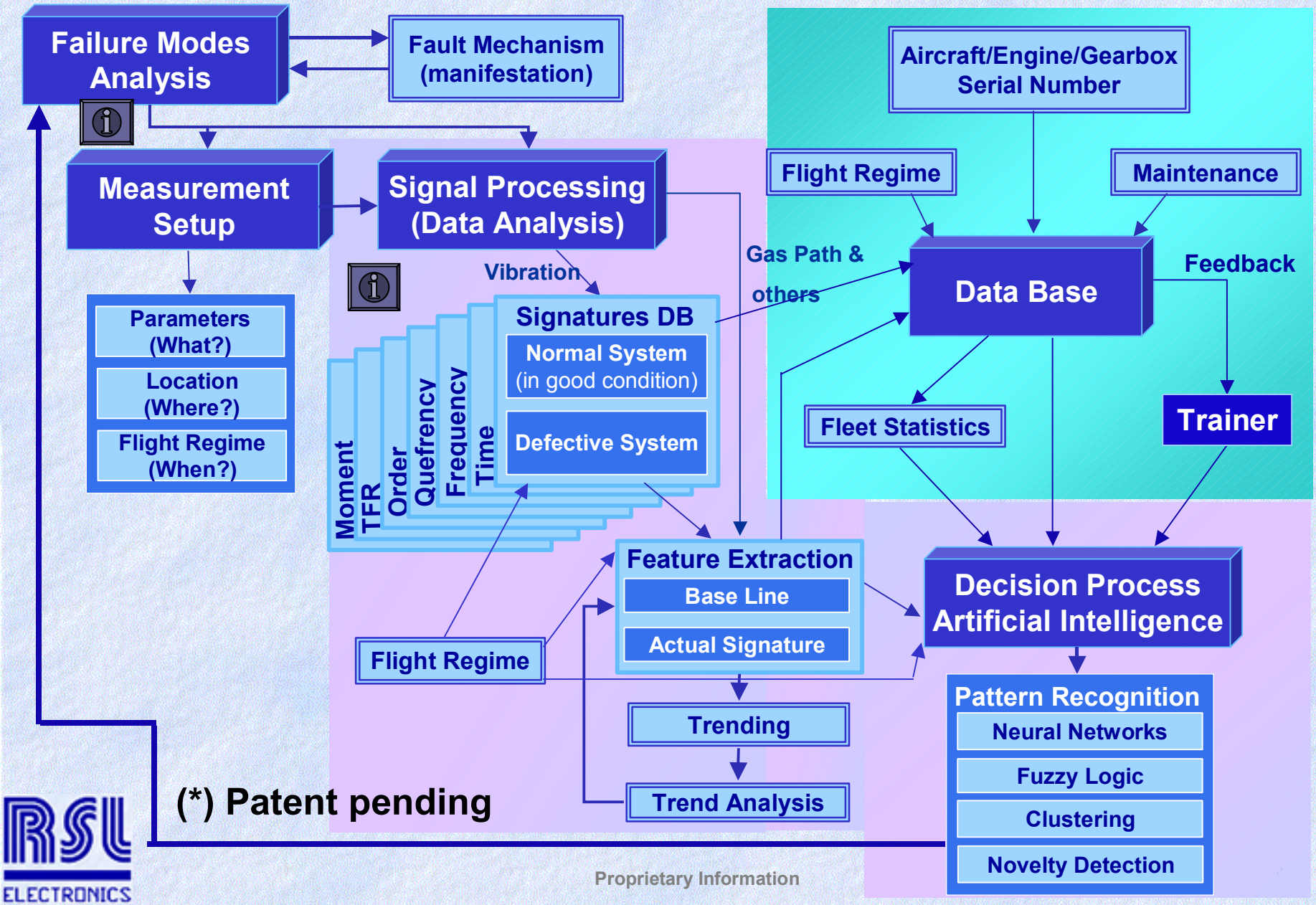
RSL ELECTRONICS

נובמבר 2003

Vib-RAY Dictionary

- Focused on analysis of SPECIFIC vibration patterns reflecting the respective component behavior
- Vibration patterns are analyzed in different DOMAINS (time, frequency, quefrency, order, envelope, phase average, …, moments and joint time-frequency and their derivatives)
- The analysis is focused in predefined regions in the multi-domain space corresponding to a specific component / failure mode hereafter designated as POINTER
- Up to 9 DIAGNOSTIC INDEXES are derived for each POINTER
- A DIAGNOSTIC INDEX is a mathematical operator that compares current to baseline patterns and quantifies a specific change in the vibration pattern
- The value of a DIAGNOSTIC INDEX at a specific POINTER is hereafter designated as FEATURE

The Diagnostic Concept*



(*) Patent pending

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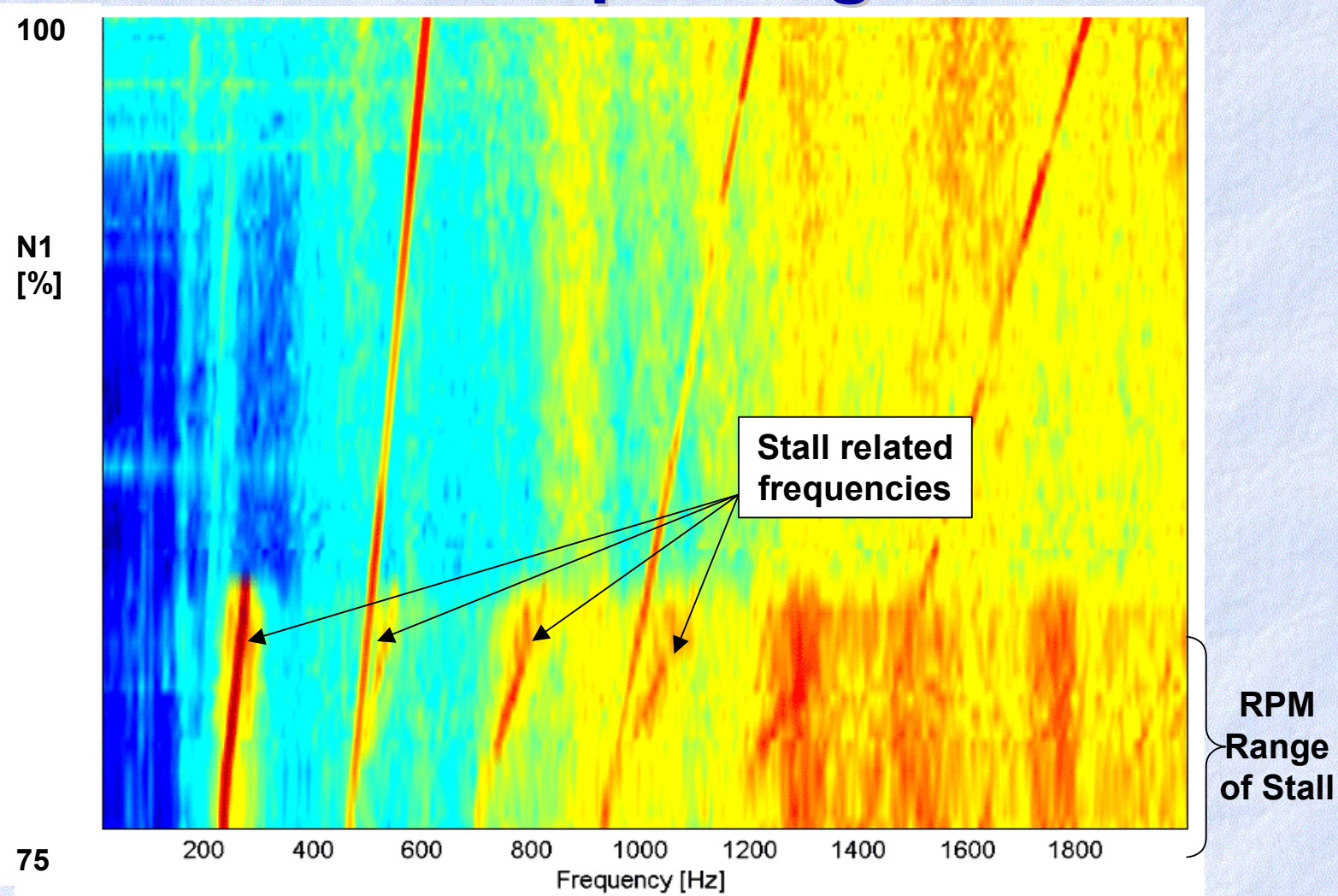
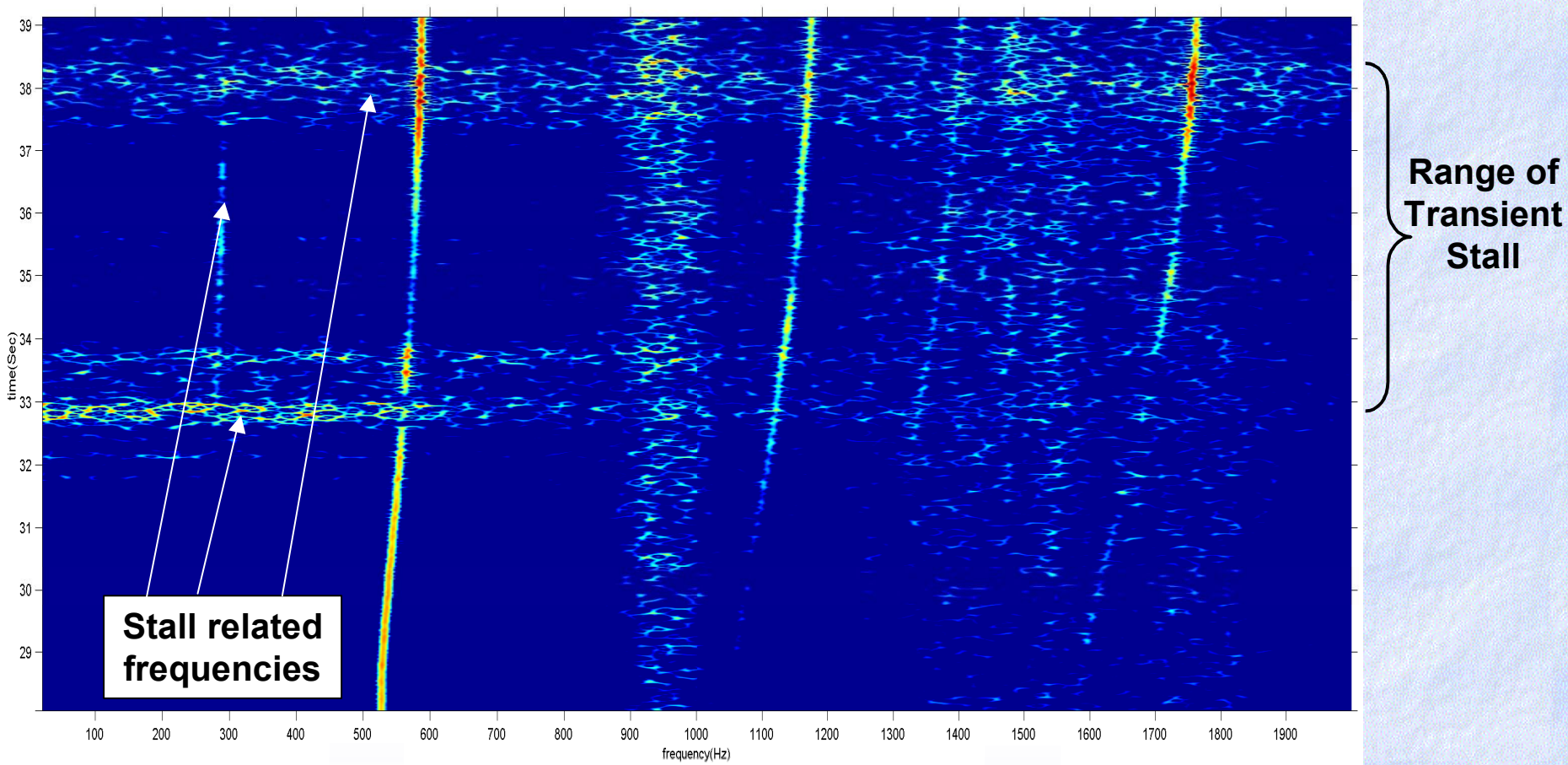
Proprietary Information

Compressor Stall Detected Via Vibration Spectrogram

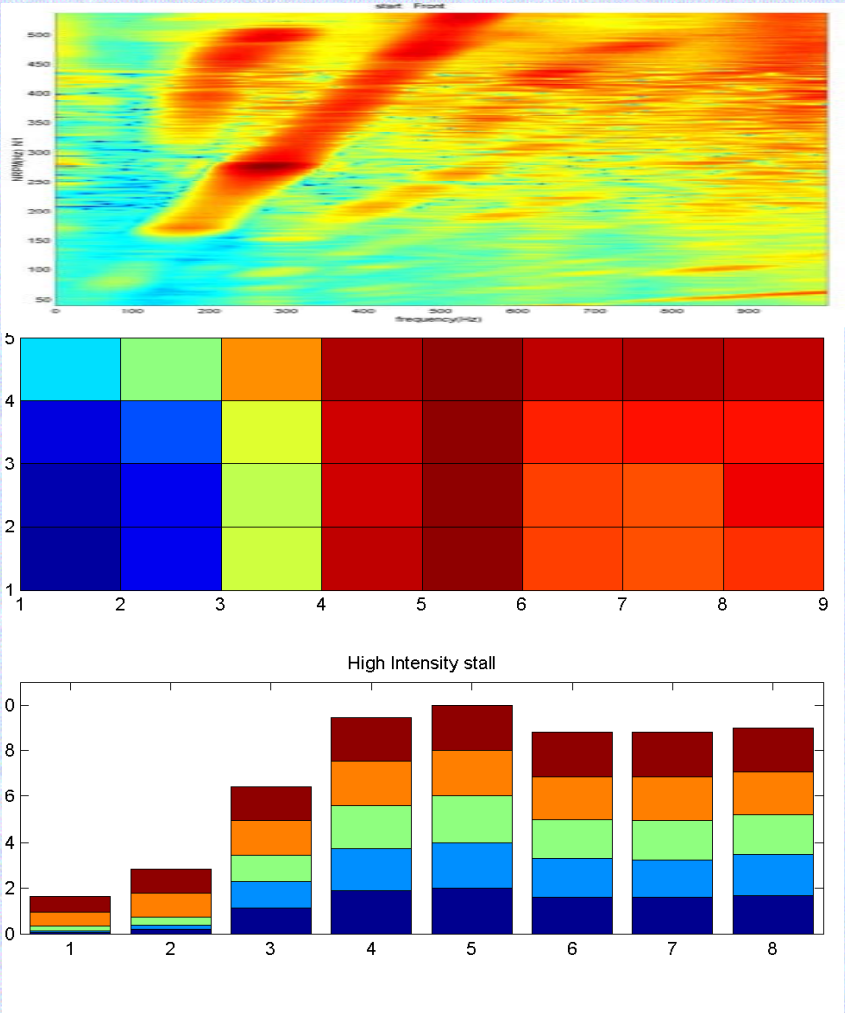


Marginal Compressor Stall
Wigner-Ville TFR

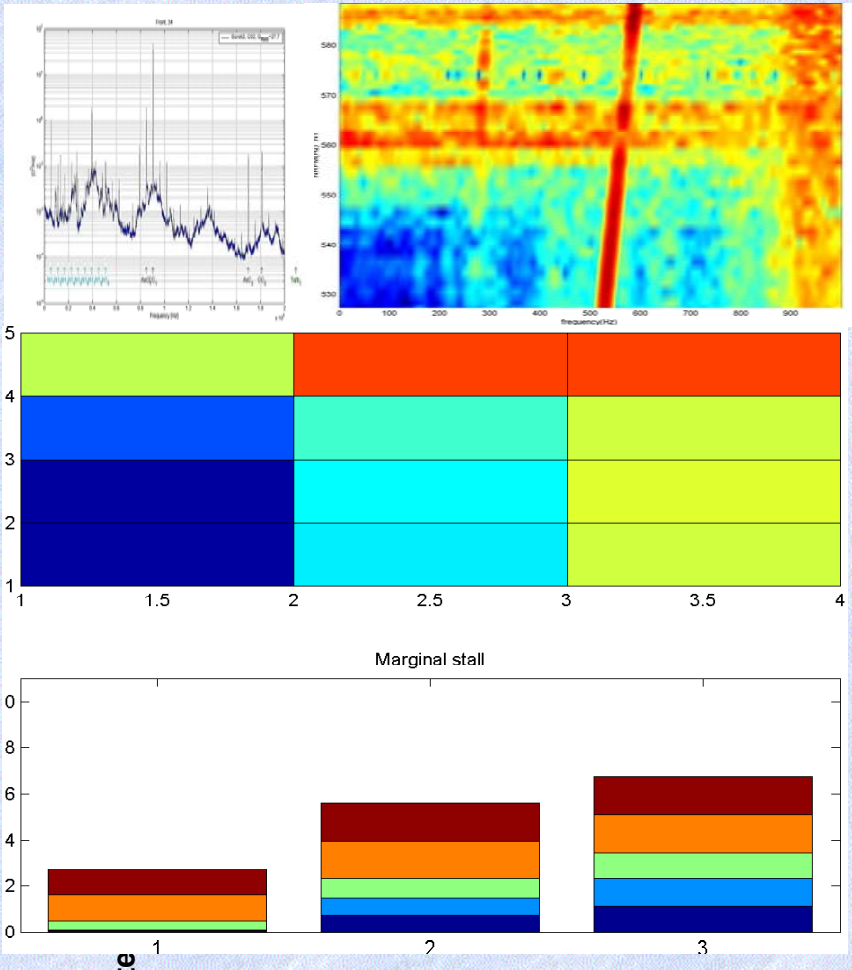


Compressor Stall – automatic detection

High intensity stall



Transient stall



Steady state 93%

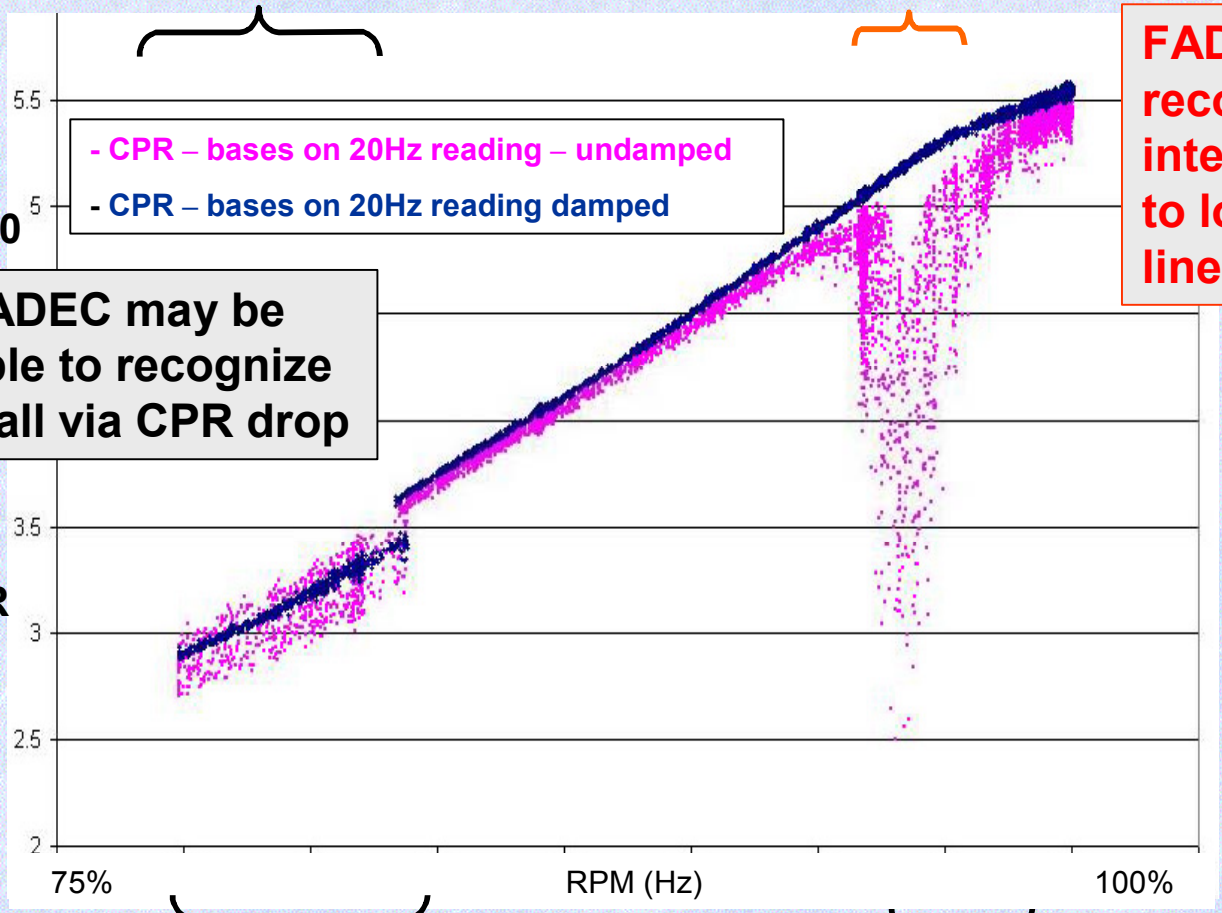
Fast acc 93%

Fast acc 96%

Marginal Compressor Stall – Gas Path

Working line / CPR dropped during stall

Working line / CPR hardly affected during marginal stall



FADEC unable to recognize low intensity stall due to long feeding lines of P2 sensor

FADEC may be able to recognize stall via CPR drop

RPM Ranges of Stall

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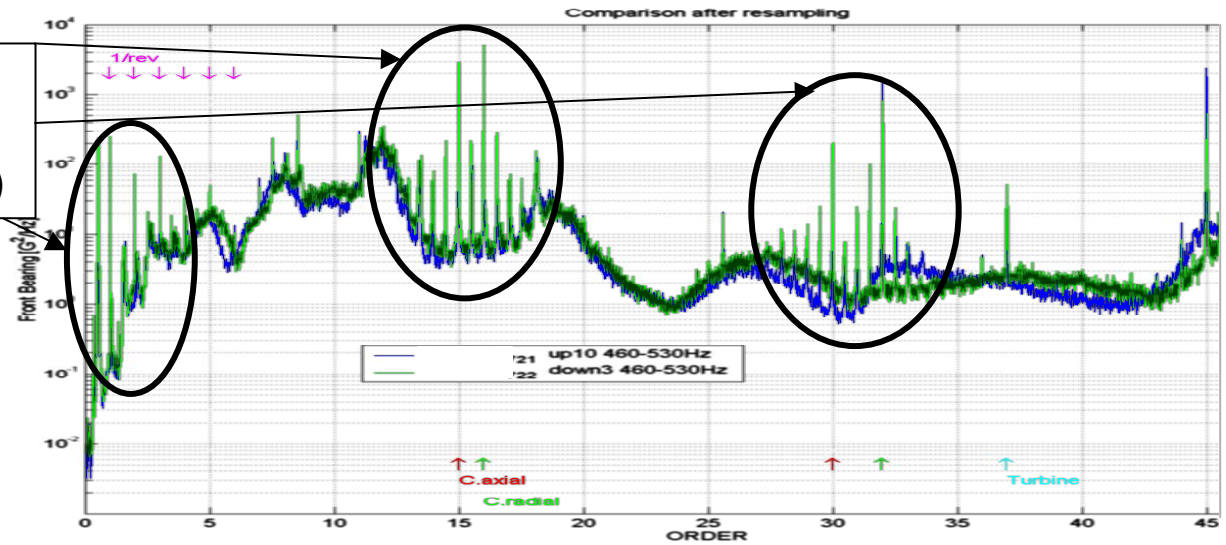
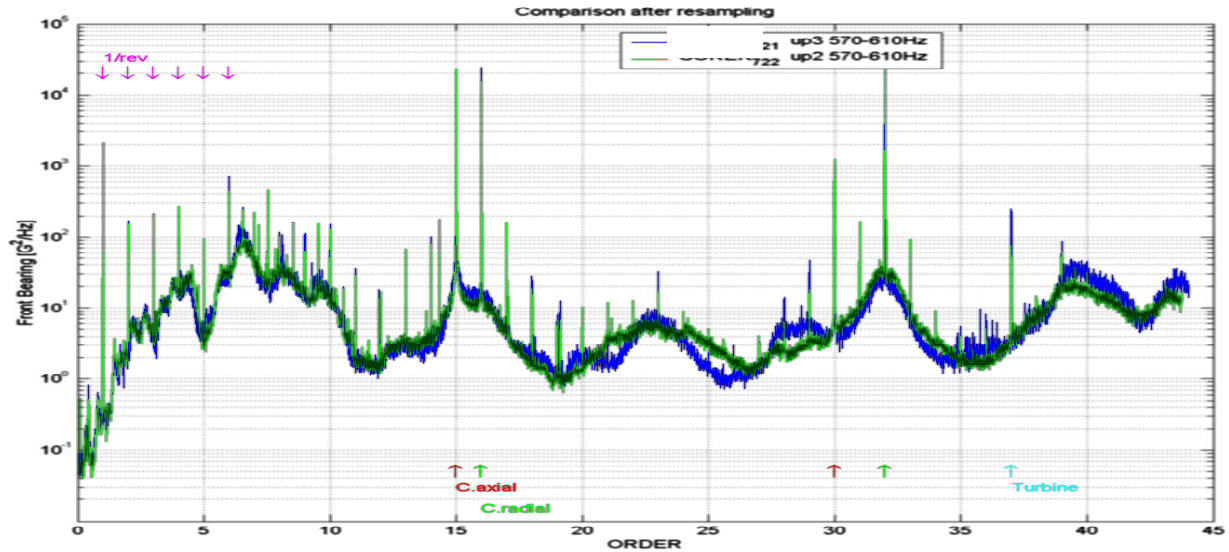
Compressor Stall Detected Via Order Tracking

Stall related frequencies (modulation)

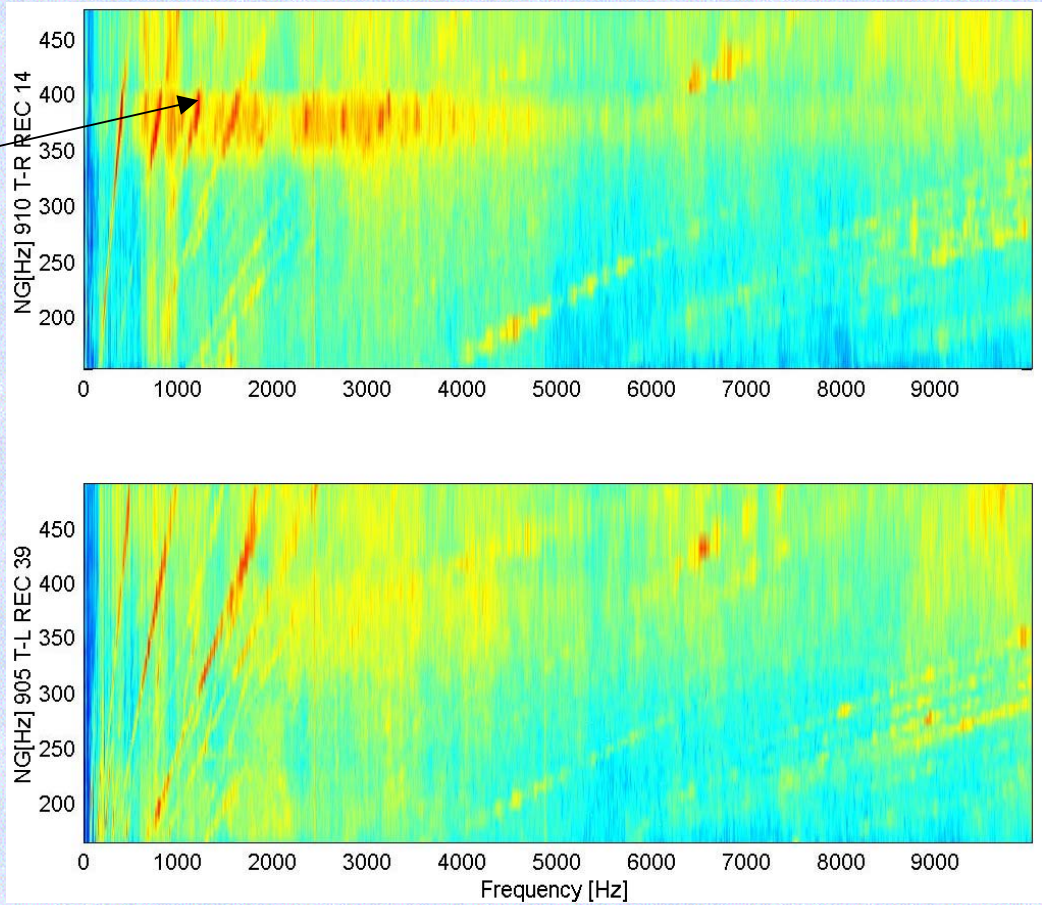




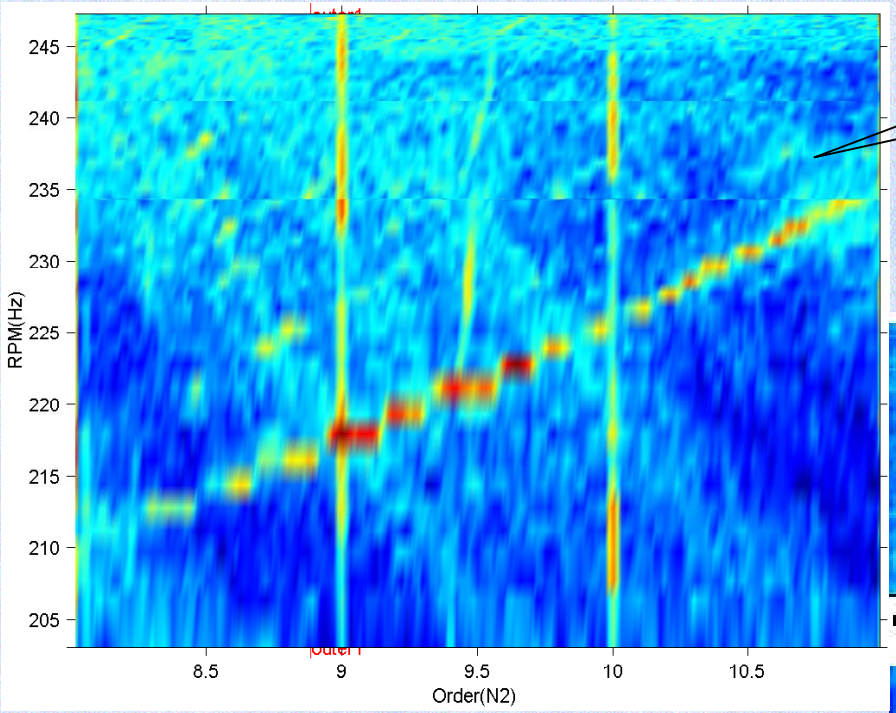
Engine Rumble

- Engine signature during acceleration showed sensitivity to rumble
- Verified by field report

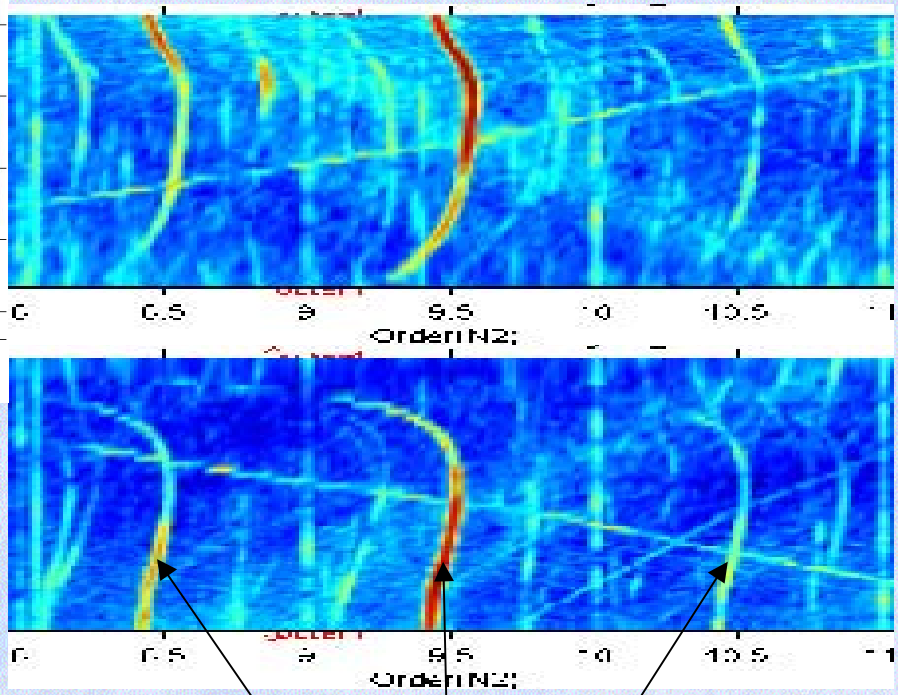
Rumble sensitivity



HPC Bearing - Outer Race 1st Harmony



Normal

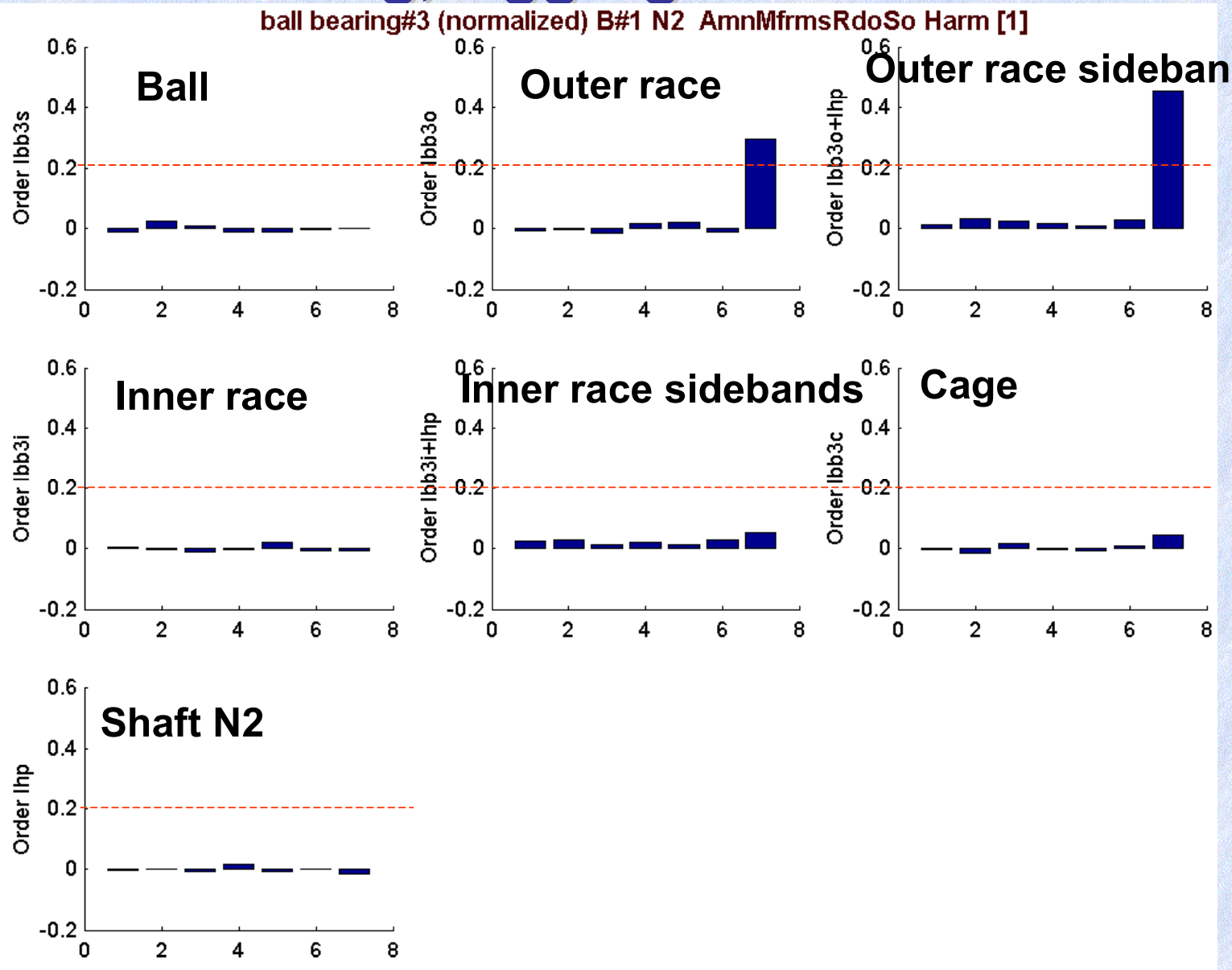


Sideband

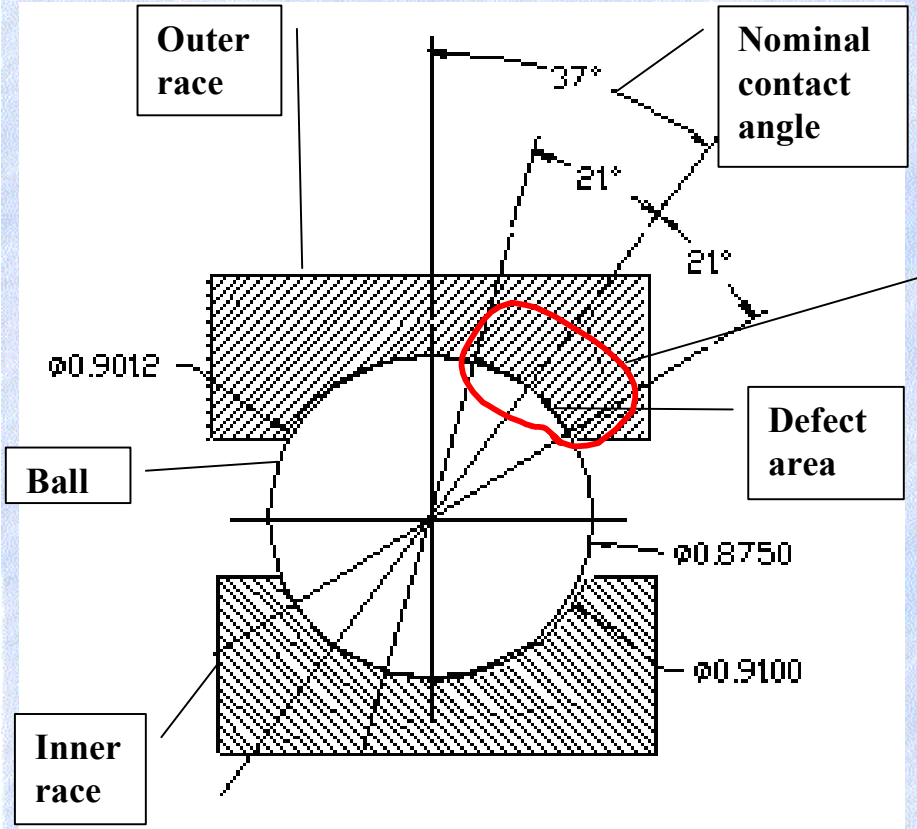
Outer race

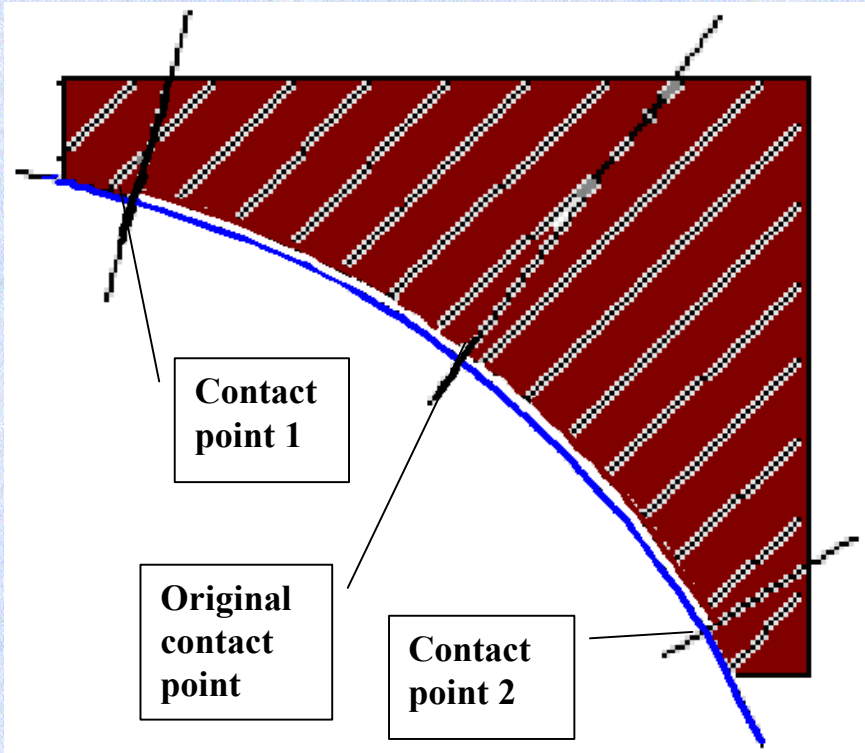
Sideband

Ball Bearing, Aggregated Features

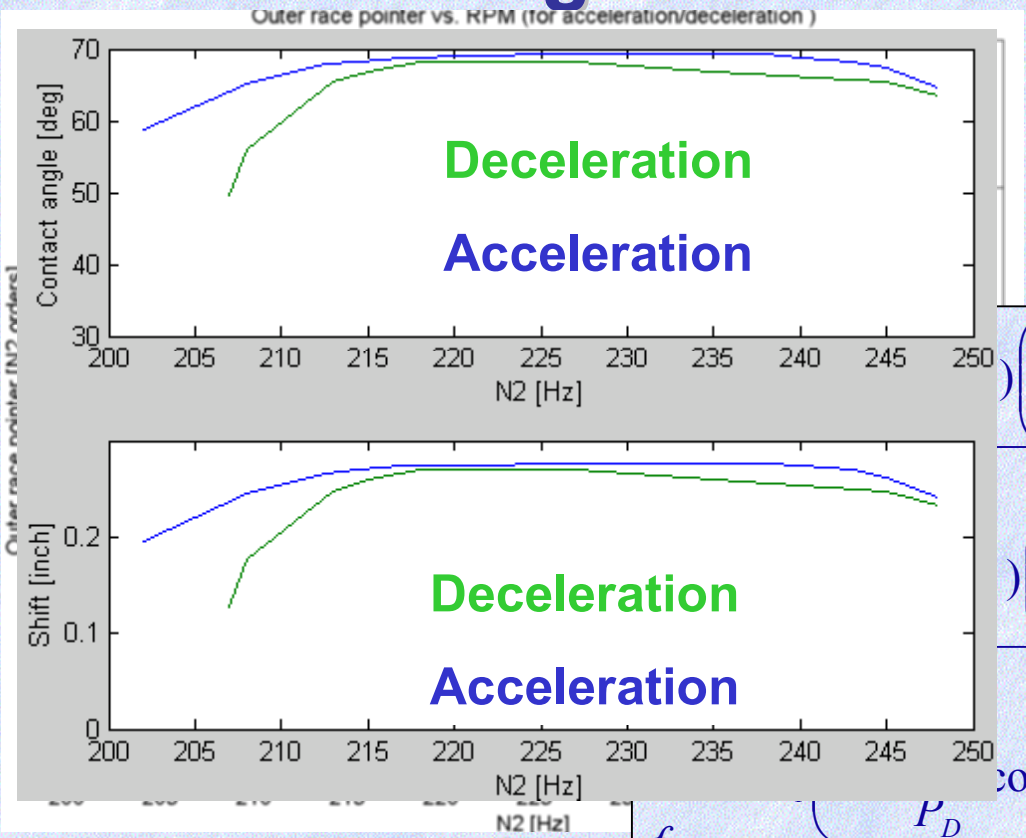


Contact angle change due to defect





Outer Race Pointer Variation with RPM
Contact Angle / Axial Load Hysteresis



$$\frac{\left(1+\frac{B_D}{P_D}\cos(\alpha)\right)}{2}$$

$$\frac{\left(1-\frac{B_D}{P_D}\cos(\alpha)\right)}{2}$$

$$f_c = \frac{\left(\quad P_D \quad \cos(\alpha)\right)}{2} + \frac{N_2\left(1+\frac{B_D}{P_D}\cos(\alpha)\right)}{2}$$

$$f_{rs} = \frac{(N_2 - N_1)P_D\left(1-\left(\frac{B_D}{P_D}\cos(\alpha)\right)^2\right)}{2B_D}$$

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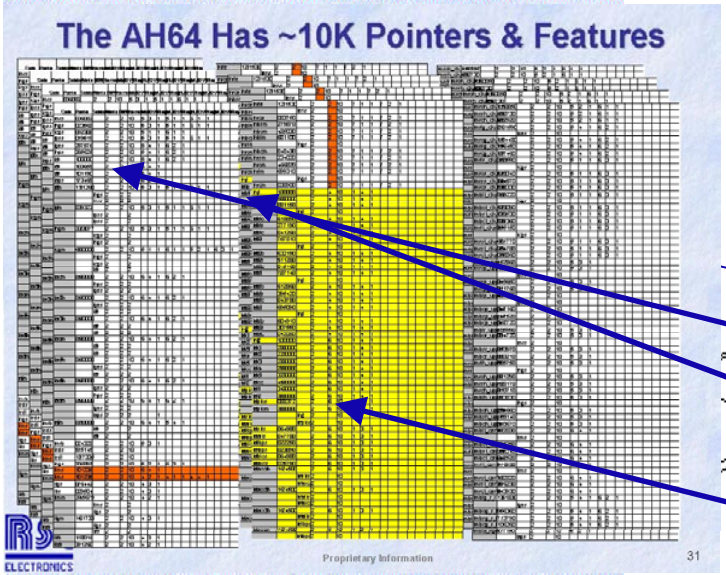
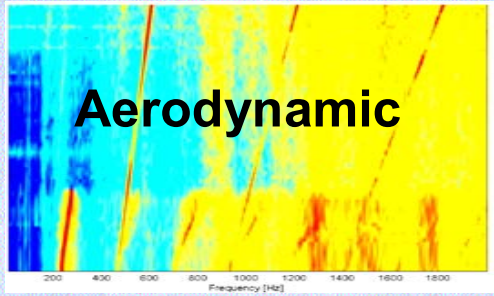
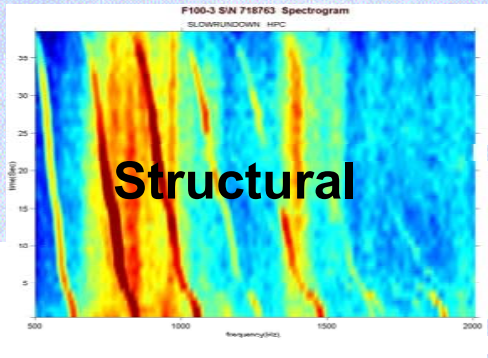
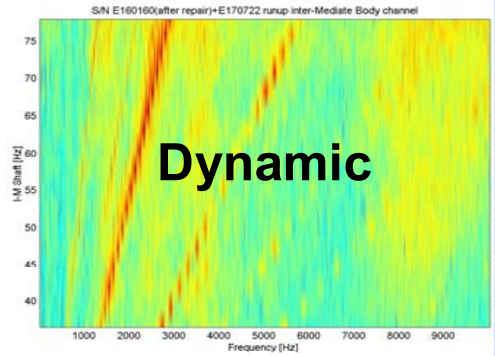
Initial Process

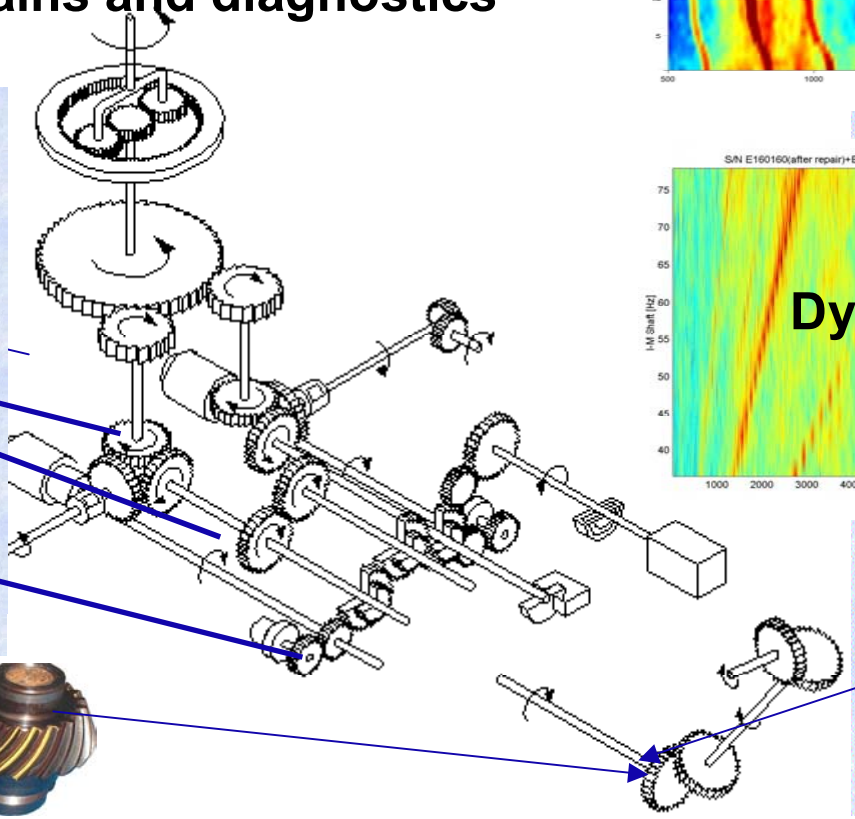
- The aircraft/ plant and its assemblies are analyzed
- Pointers are identified
- Failure modes are evaluated and their related phenomena are defined
- Relevant analysis domains and diagnostics indexes are selected











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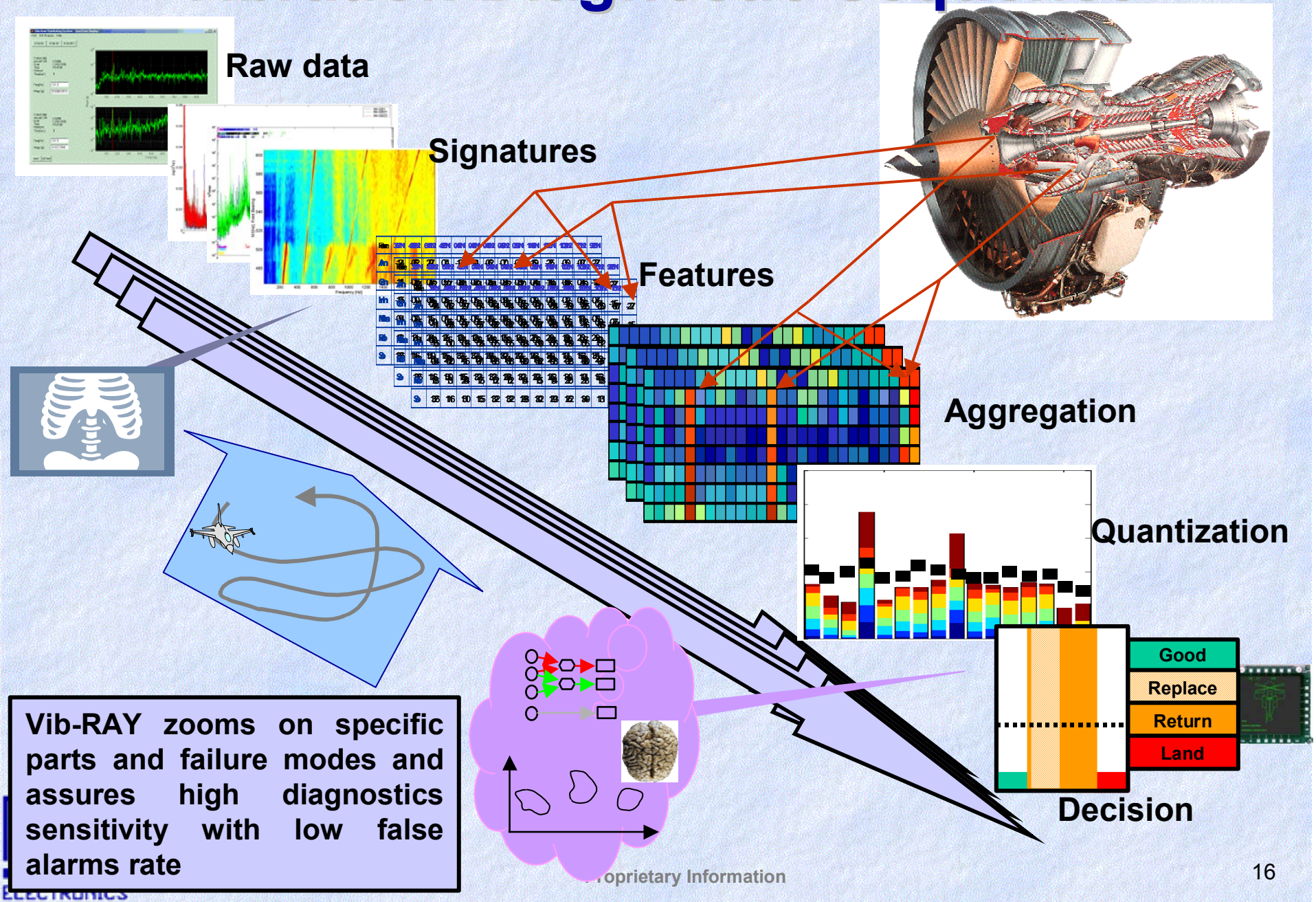
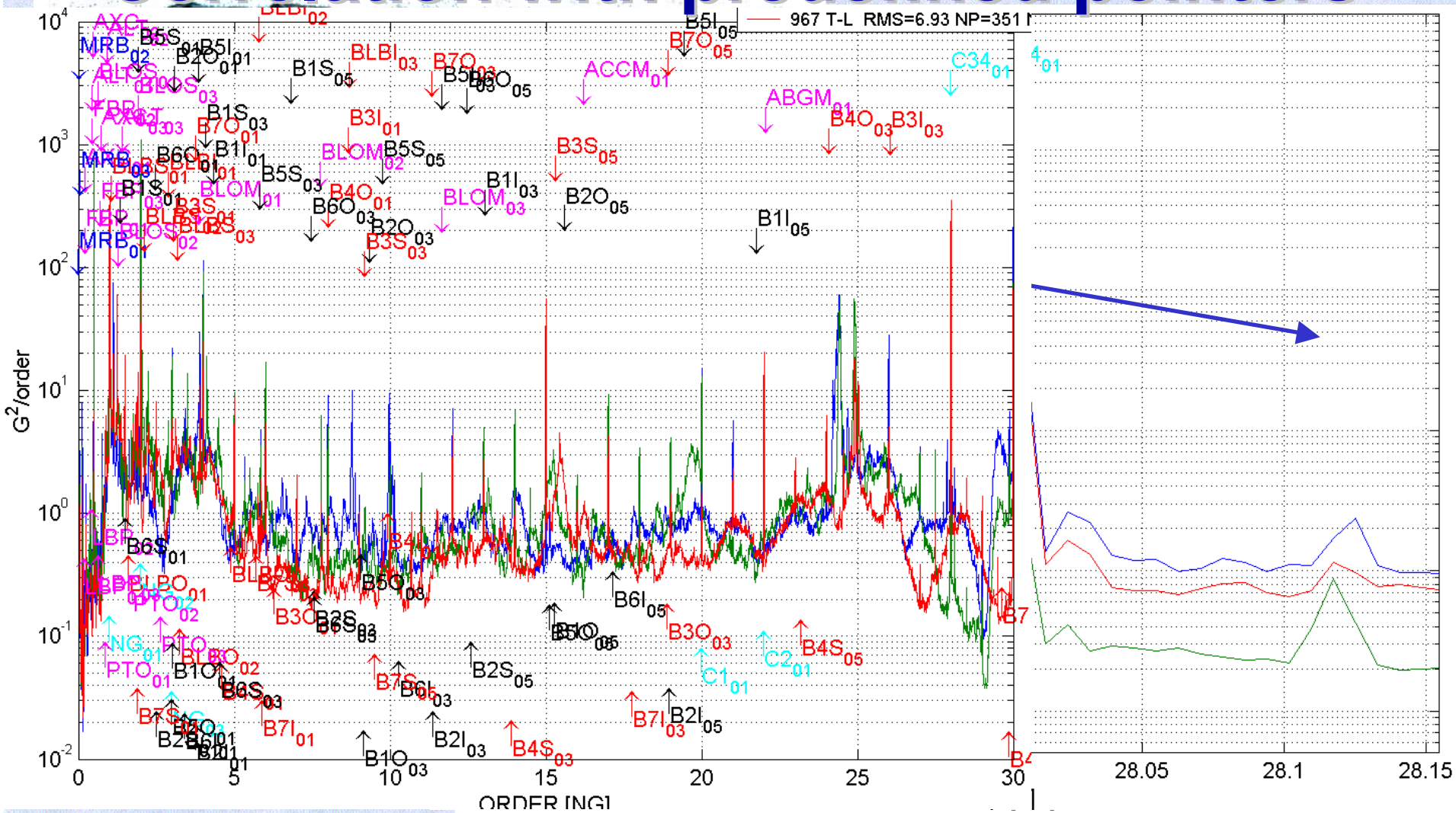
Vibration Diagnostic Sequence



Vib-RAY zooms on specific parts and failure modes and assures high diagnostics sensitivity with low false alarms rate

Correlation with predefined pointers



RSL approach

Provides effective utilization of the vibration data

Predefined pointers correlate with actual signature pattern