



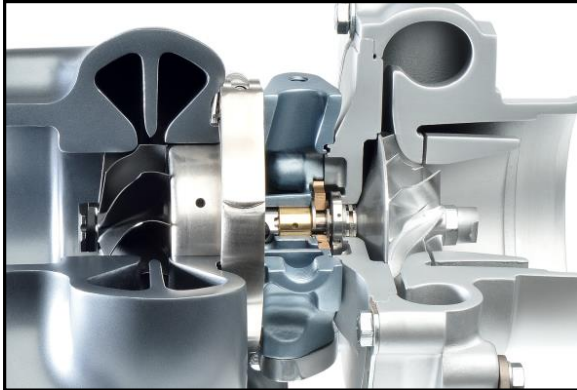
June 4th, 2019 | Garrett Eng COEs - Vibratrac

Hybrid Approach for “Turbocharger-Vehicle” Vibration Management

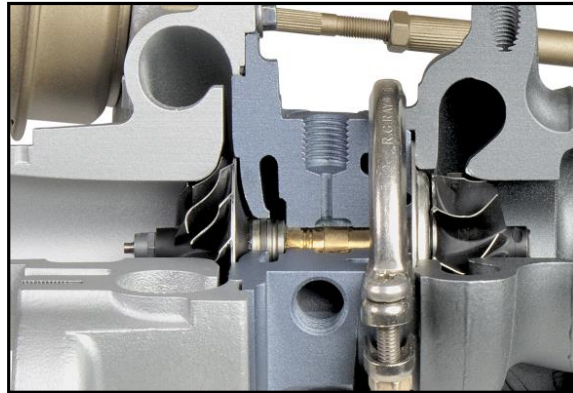
Garrett
ADVANCING MOTION

CMT-AFM 2019 Annual Meeting, Garrett Advancing Motion

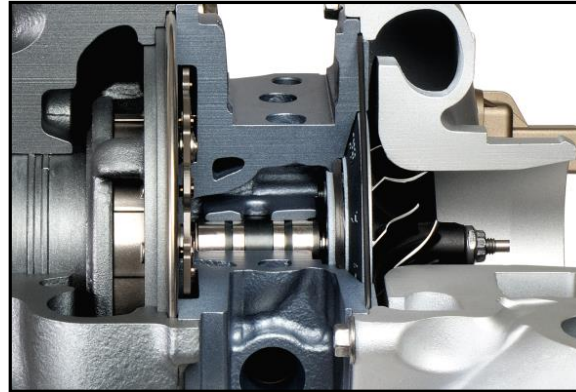
Garrett's Automotive Turbochargers



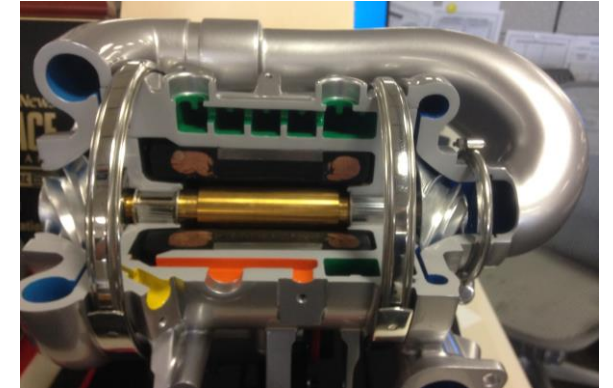
Fully Floating Bearing



Semi Floating Bearing



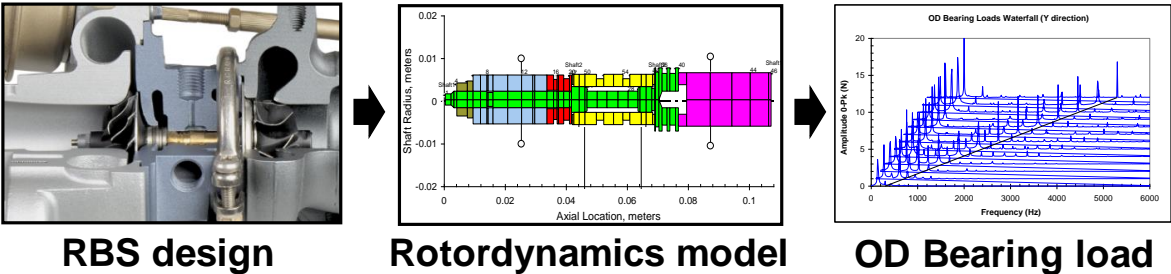
Ball Bearing



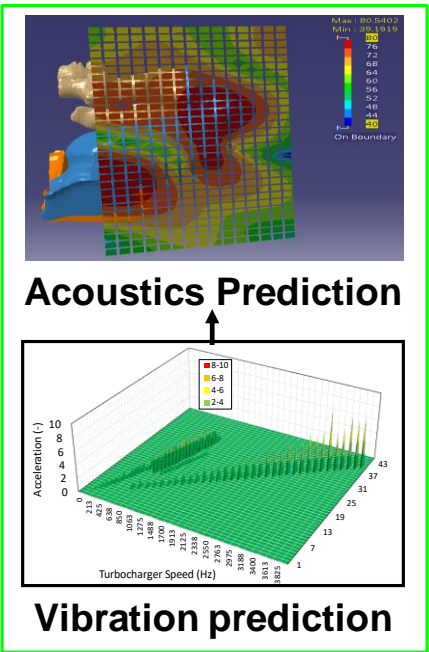
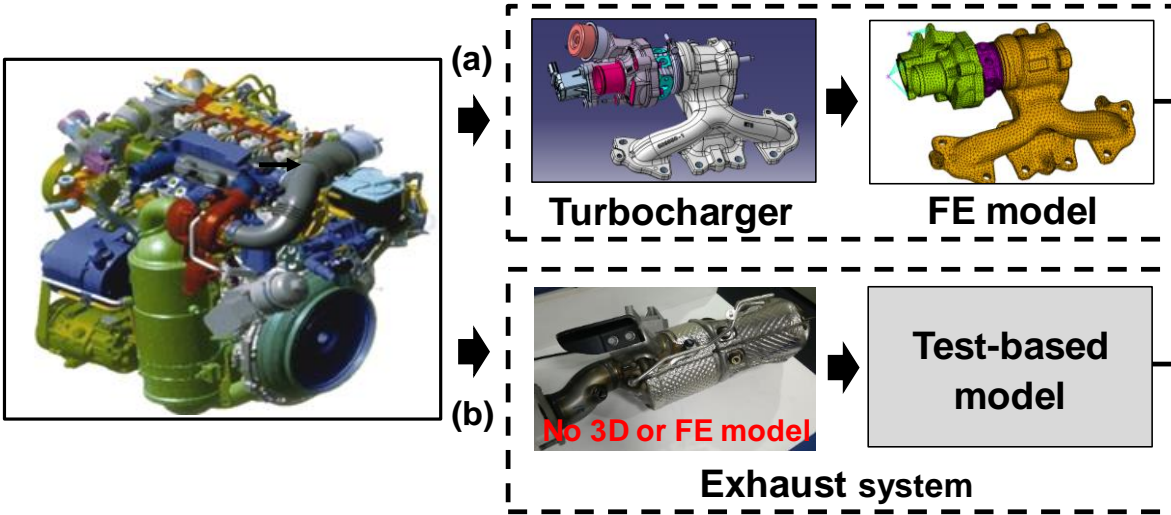
Air Foil Bearing

Hybrid Modelling Flow Chart

(1) Vibration excitation



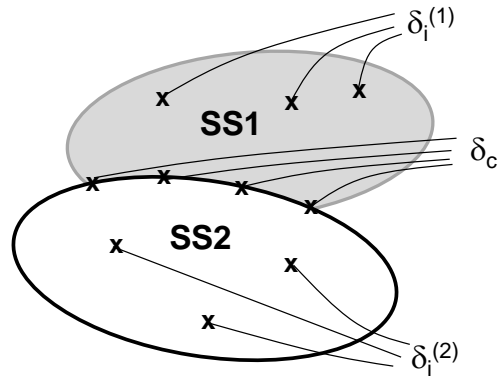
(2) “Turbocharger-Exhaust system” Structural Dynamics



(3)
Hybrid Model

Hybrid Modeling Technics

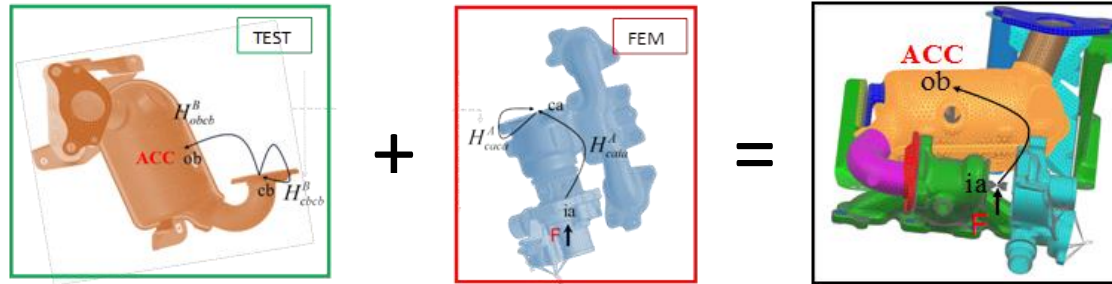
- *A sub-structuring method for complex systems*



- *Coupling techniques*
 - **“Modal coupling”**: Not appropriate for “Turbocharger structure-Exhaust line system” due to very high modal density on the frequency range 100-4500 Hz (> 250 modes)
 - **“FRF based sub-structuring (FBS)”**: Measured and/or predicted FRFs can be coupled

Application on “Turbocharger-Vehicle” Vibration Identification

- *Fundamentals*



$$H_{obia}^S = H_{obcb}^B \cdot (H_{caca}^A + H_{cbcb}^B)^{-1} \cdot H_{caia}^A$$

- *How FRFs are collected:*

- 1) By **test** on separated sub-structures: turbocharger and vehicle exhaust system
- 2) By **prediction** (FEA) on the turbocharger and by **test** on exhaust system, separated from each other
- 3) By **test** on the “turbocharger-vehicle exhaust system” assembly (so-called FRF reference)

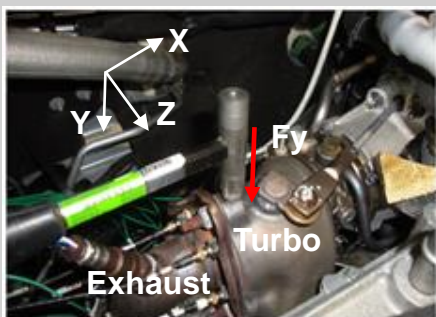
Note: same excitation & response points are used on (1), (2) & (3)

- *Coupling process:*

- FBS technique is used for coupling FRFs from (1) or (2)
- For validation purpose the FBS prediction is compared with test data from (3)

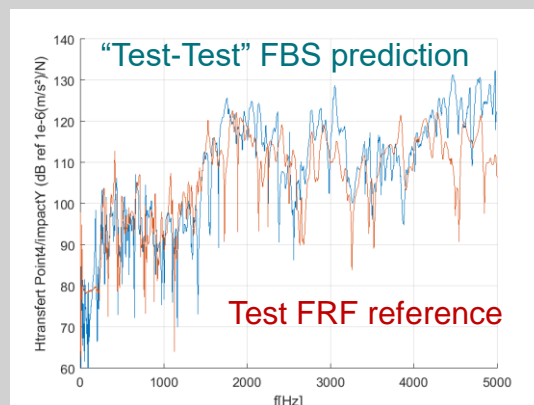
FRFs: Hybrid (FBS) vs Test (Reference)

Excitation/Response Points

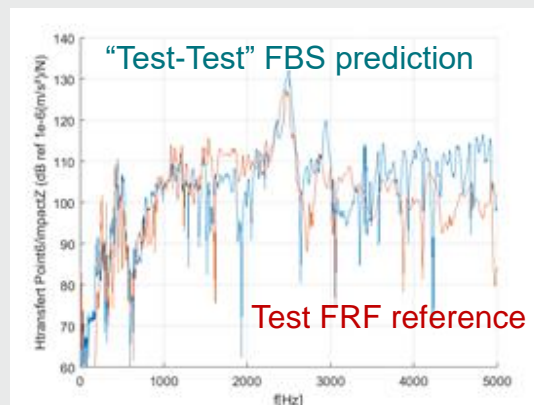


FRF: "Test-Test" coupling vs Reference

Response/Excitation: 4y/Fy

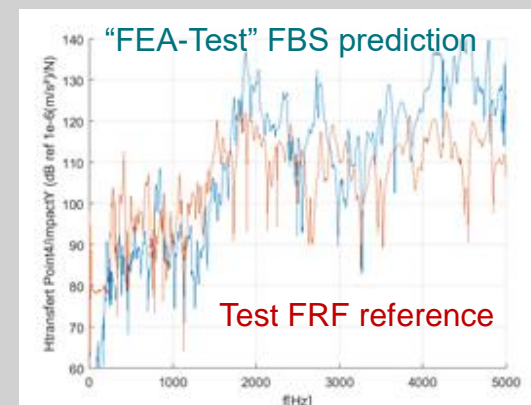


Response/Excitation: 6y/Fz

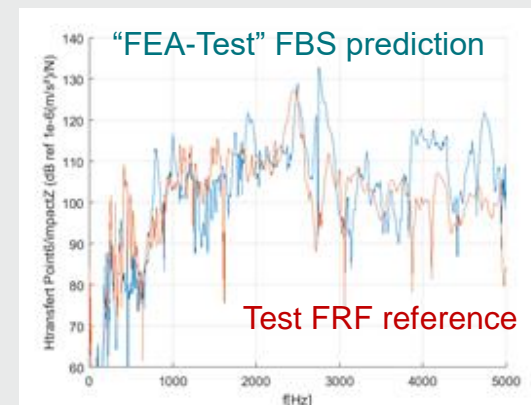


FRF: "Prediction-Test" coupling vs Reference

Response/Excitation: 4y/Fy



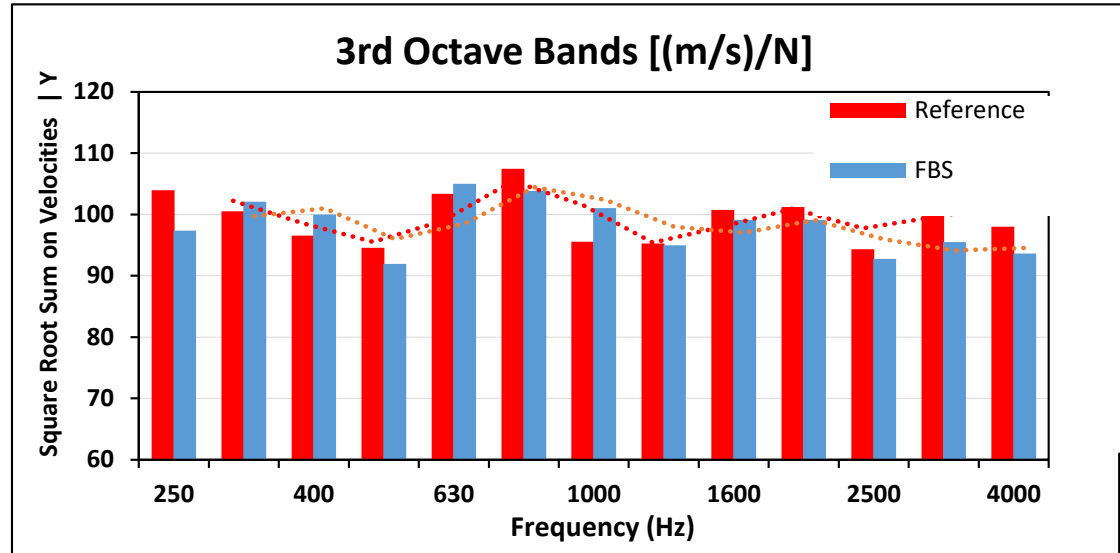
Response/Excitation: 6y/Fz



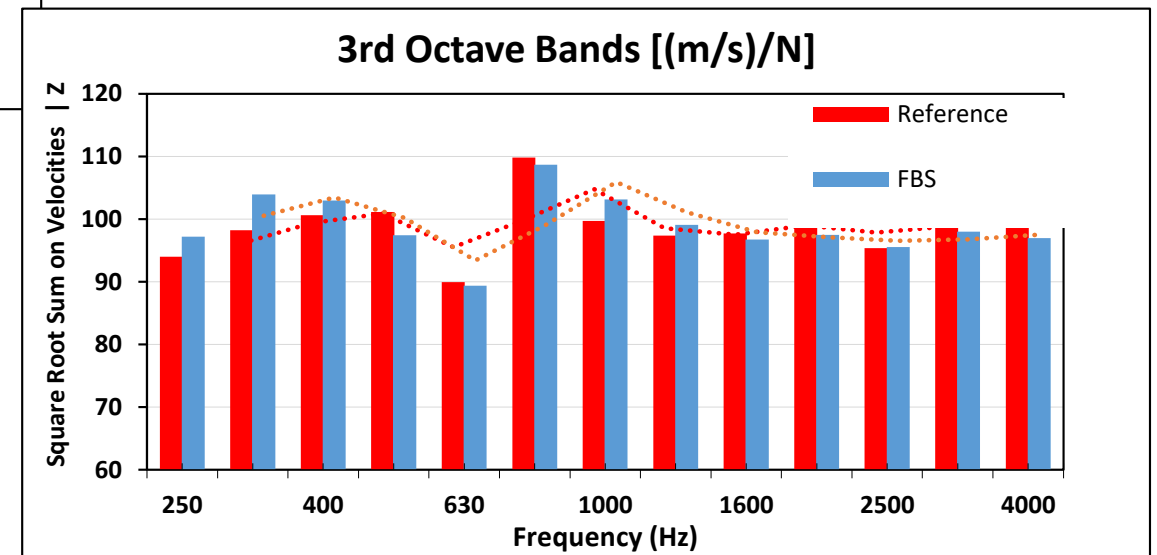
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More than 410 Test & Prediction FRFs Have Been Collected | Good Test/Prediction Correlation

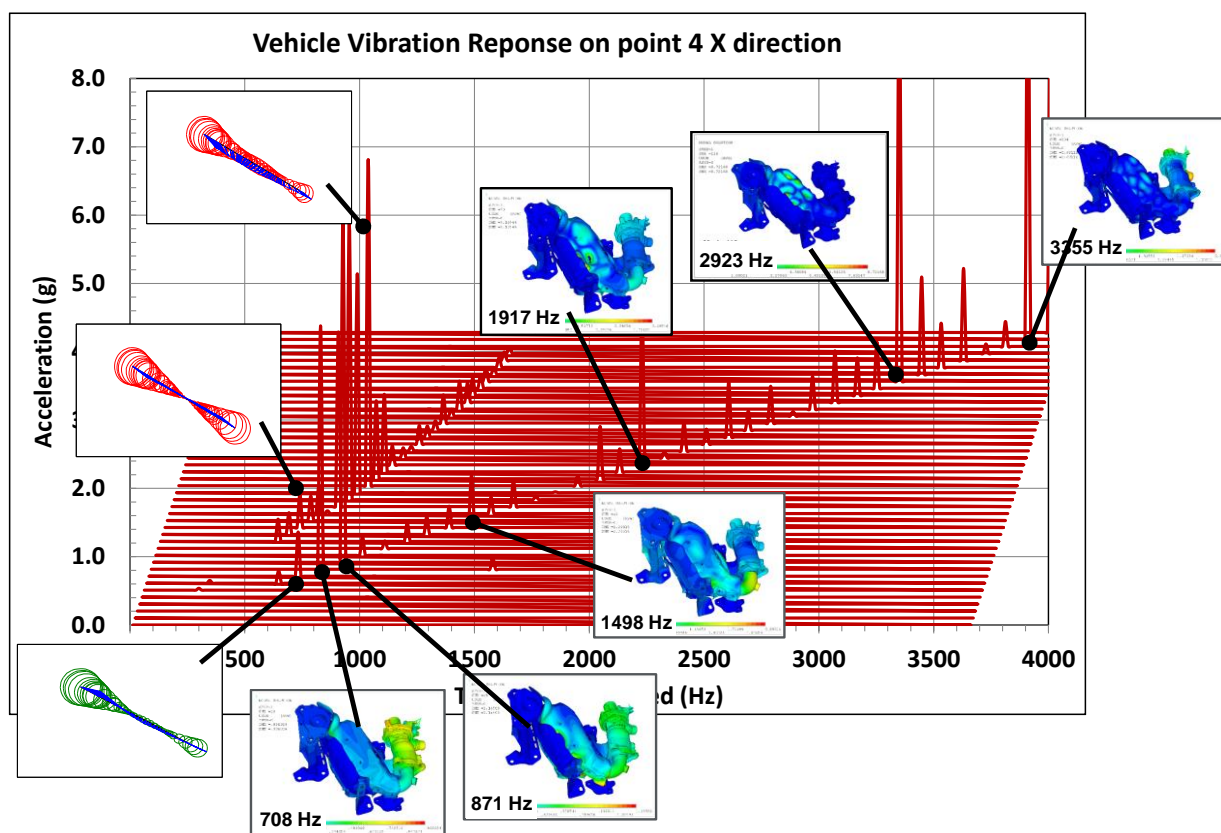
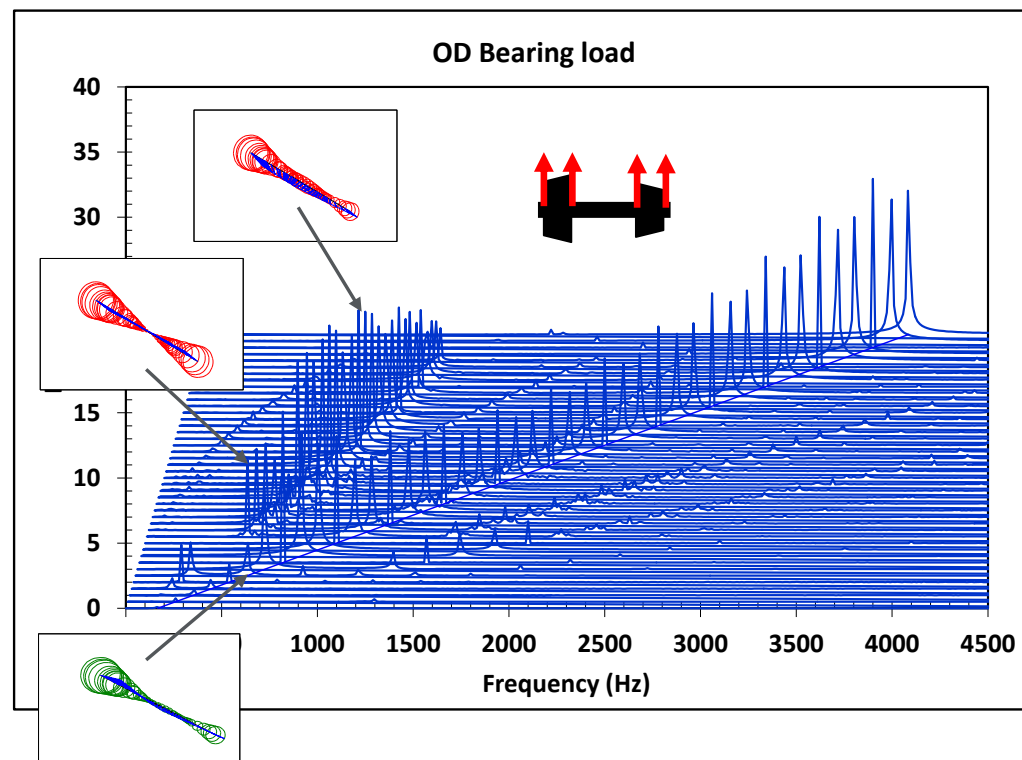
FBS vs Test Correlation (cont.)



- Summation of surface vibration velocity at all response points on exhaust.
- Represents potential acoustic power radiated by surface.
- Can be used to compare noise radiation potential of different components in turbo + exhaust assembly.



“Turbocharger-Vehicle” Nonlinear Vibration Analysis



4 Pillars of Garrett's Turbocharger RBS Development

- **Differentiated Strategy:** “Product-Process-Vehicle” performance optimization
- **Operating System:** “Get It Right the First Time”
 - Dynamic stability
 - Balanceability performance
 - “Turbocharger-Vehicle” Vibro-Acoustics management
- **Superior Financials**
 - Fast, Optimized and Cost saving solution
- **People Development**
 - A global and cross functional user team will be trained

