

# Correlating Spectral Measurements

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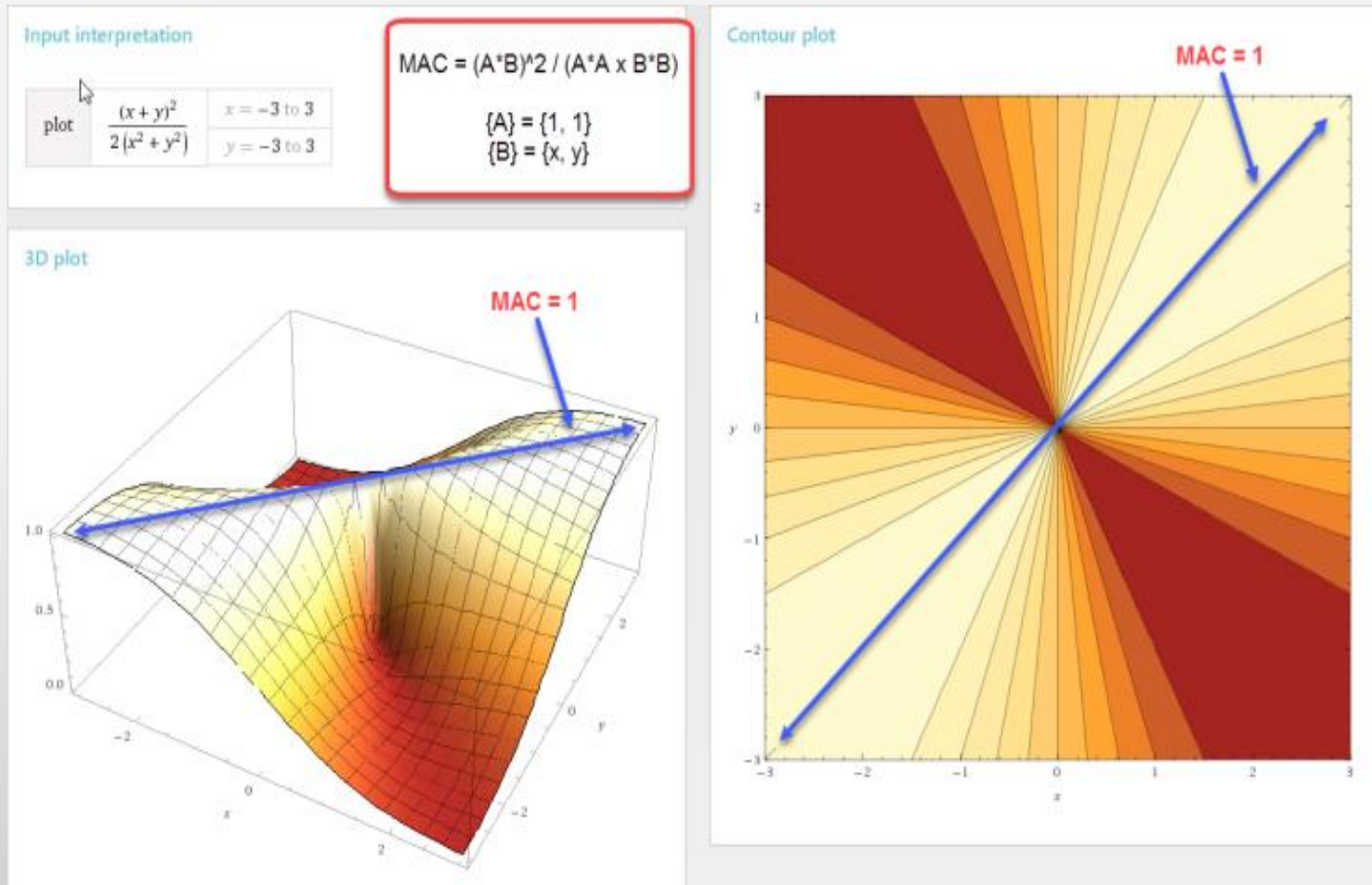
IMAC XXXVI, February 2018

# What is MAC?

MAC is a **correlation coefficient** that measures the **co-linearity** of two shapes

If two shapes lie on the **same straight line**, **MAC=1**.

If two shapes are **linearly independent**, **MAC<1**

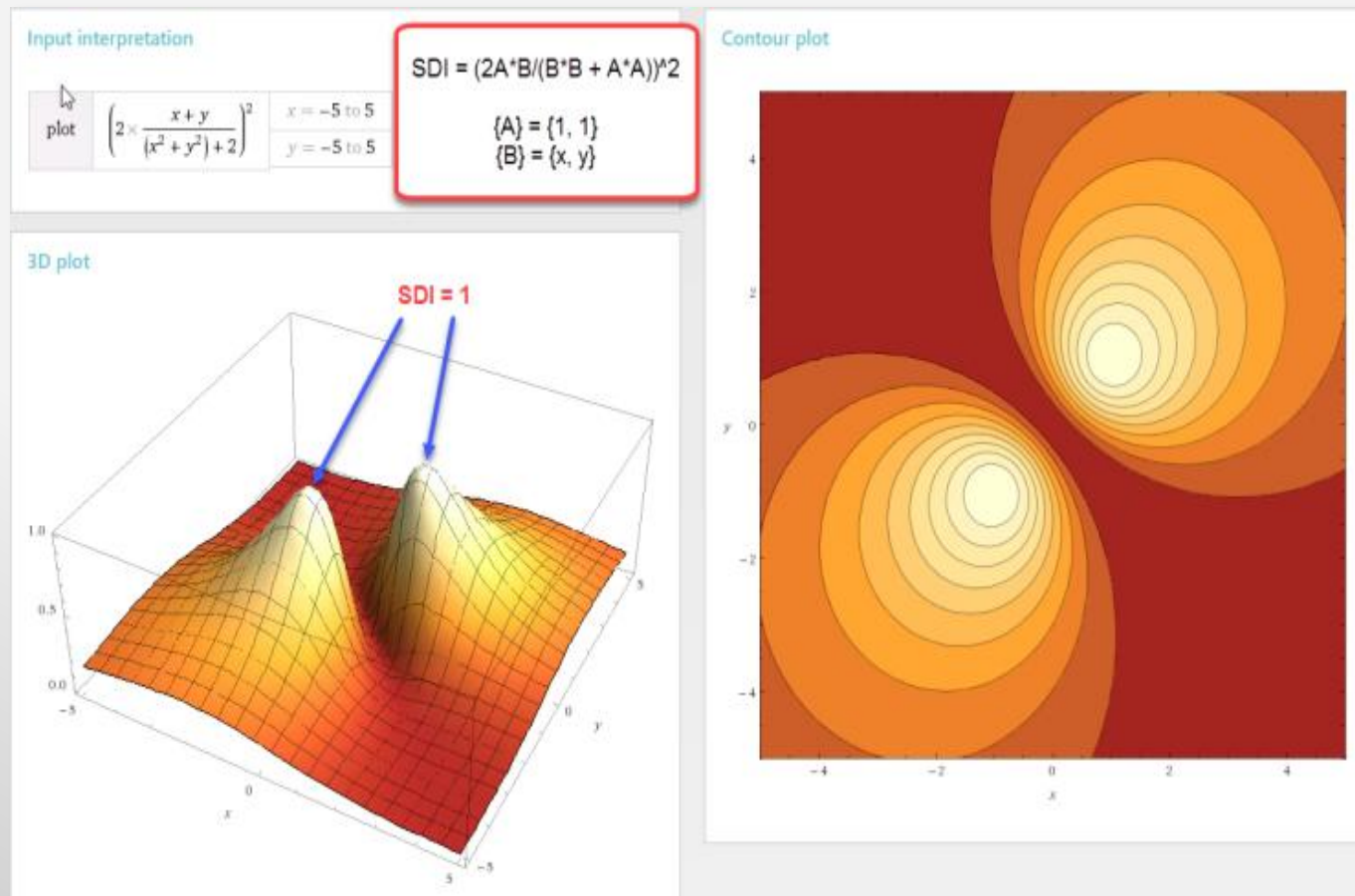


# What is SDI?

SDI is a **correlation coefficient** that measures **the difference** between two shapes

If two shapes have **identical shape components**, **SDI=1**

If two shapes have **different shape components**, **SDI<1**



# Two New Applications of SDI

## ODS Correlation

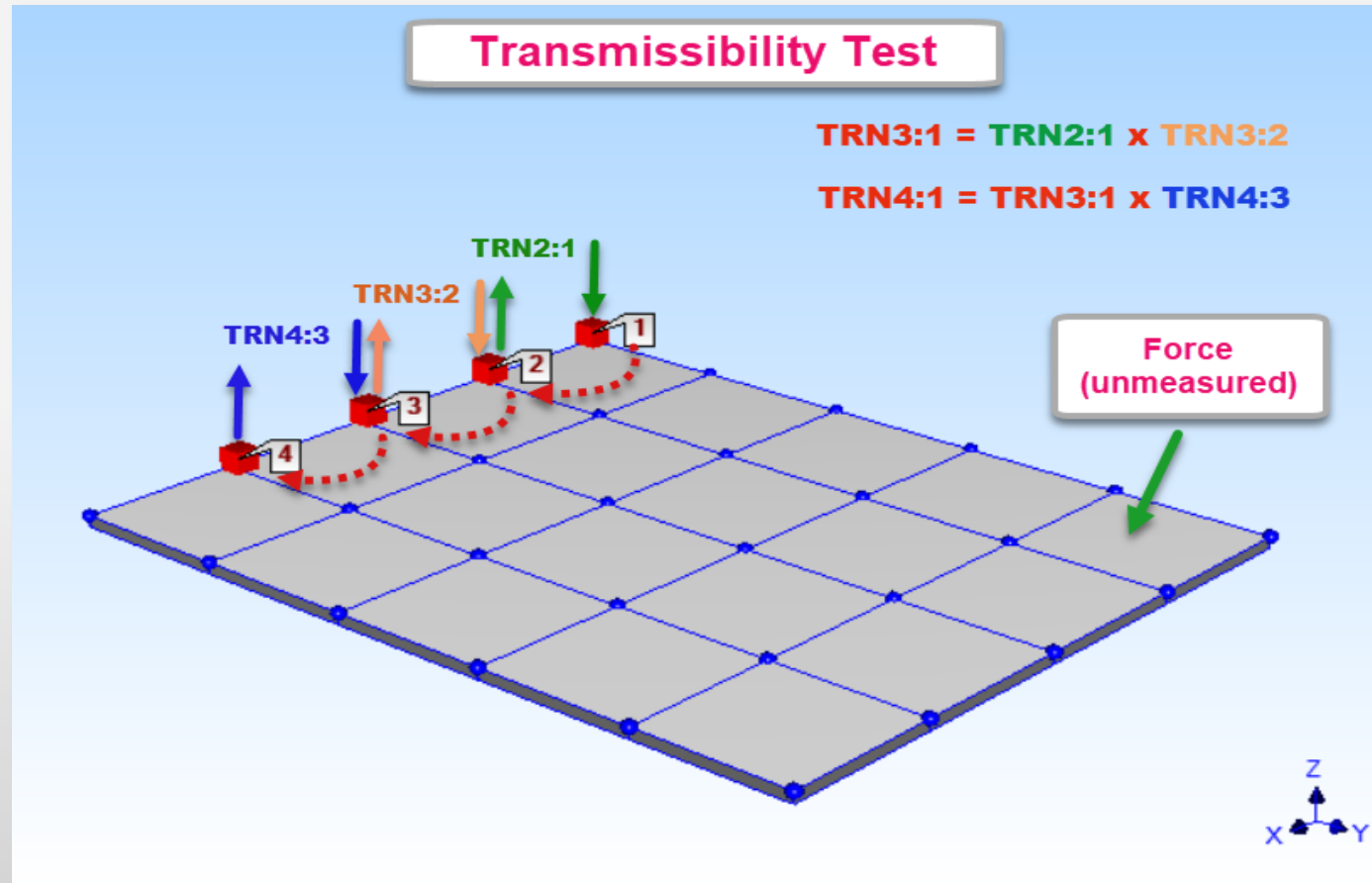
SDI measures the difference *at each frequency* between *Current & Baseline* frequency measurements

## Measurement Pairs Correlation

SDI measures the difference over a *band of frequencies* between *Current & Baseline* frequency measurements (same as FRAC)

# Repeatable Impact During Roving Response Test

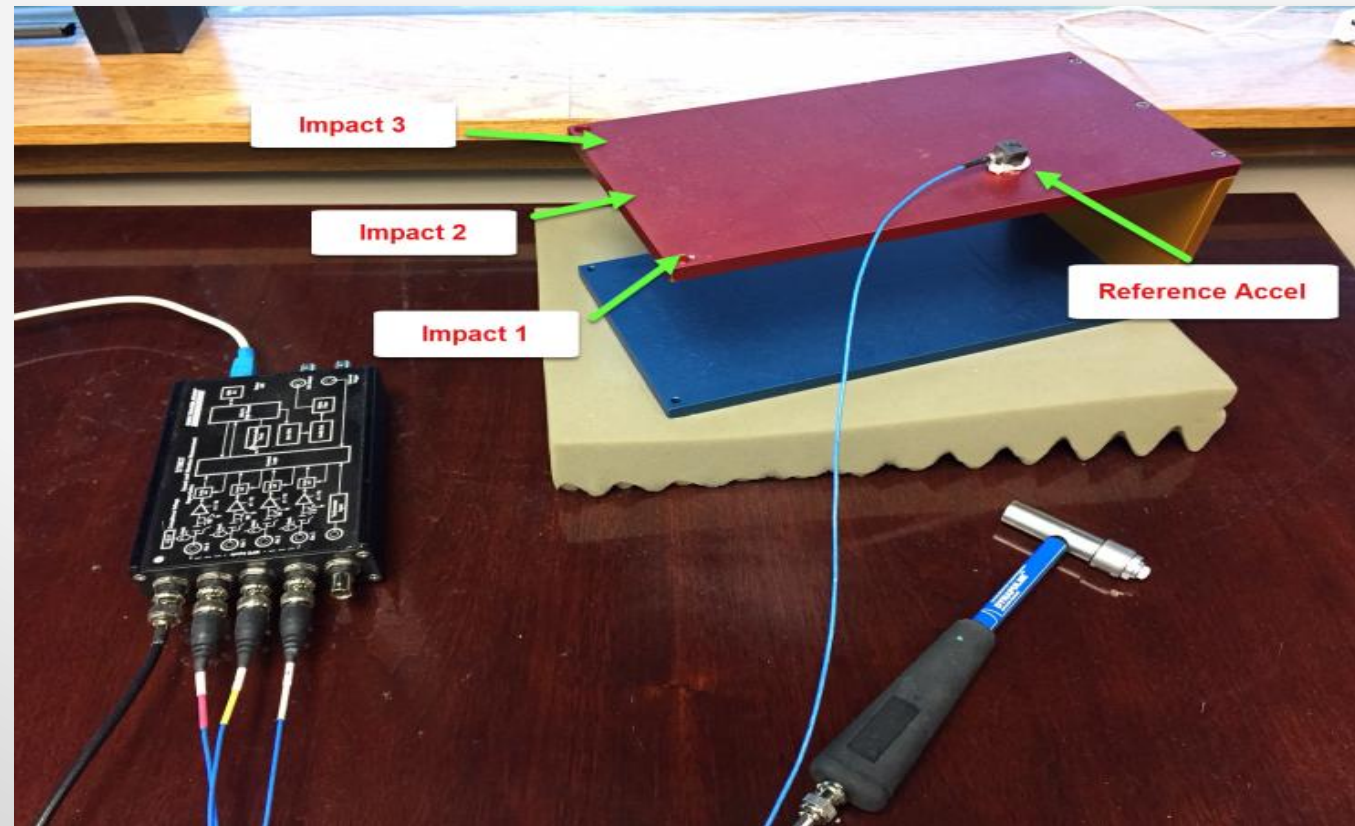
**Roving Response Impact Test:** The structure *must be impacted at the same DOF* for each measurement



# Using a Reference Sensor for ODS Correlation

The Reference Sensor can be *located anywhere* on the test article

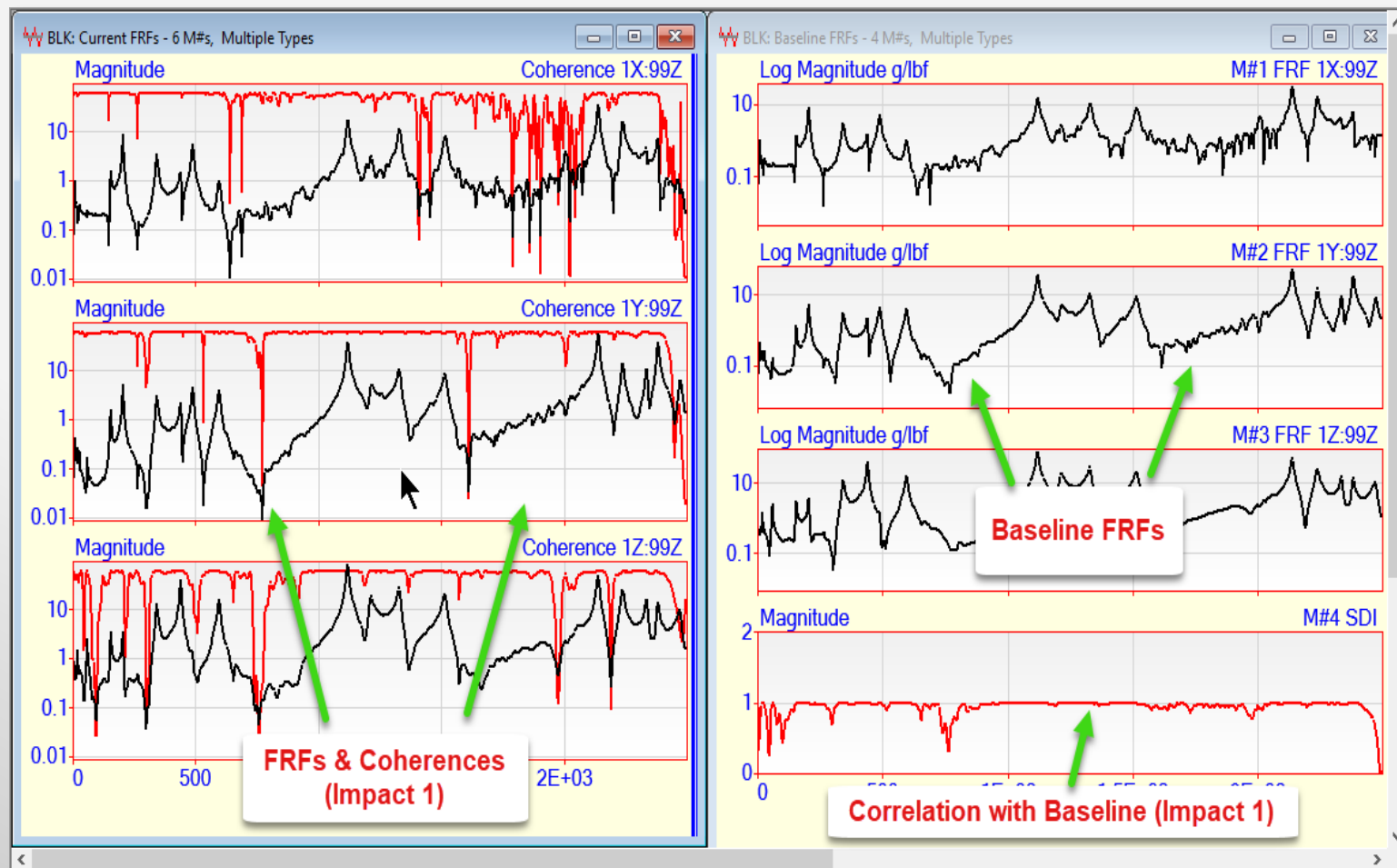
The test article must be impacted *at the same DOF*





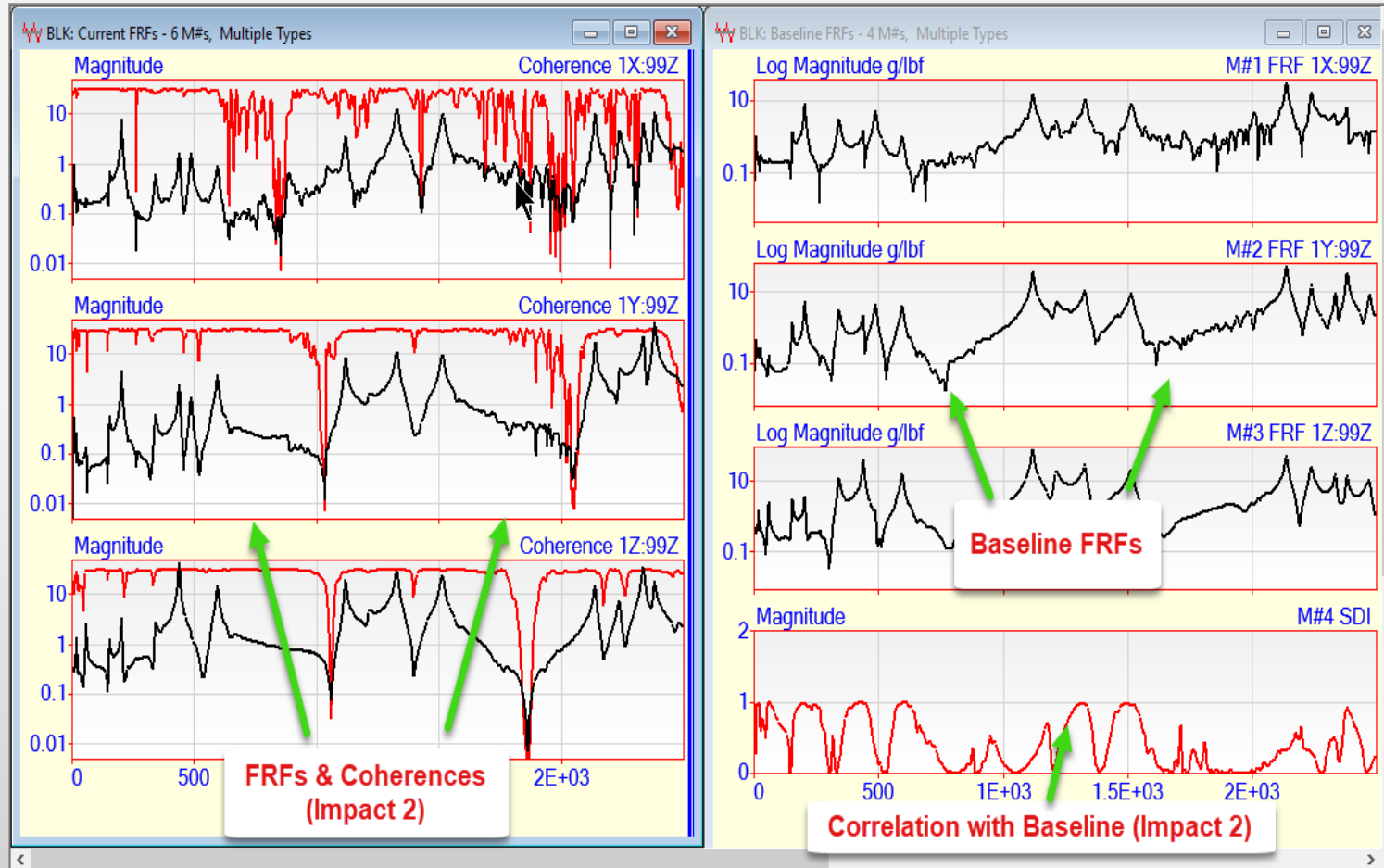
# ODS Correlation Indicates a Repeated Impact

ODS Correlation indicates *a repeated impact* at **Point 1**



# ODS Correlation Indicates a Non-Repeated Impact

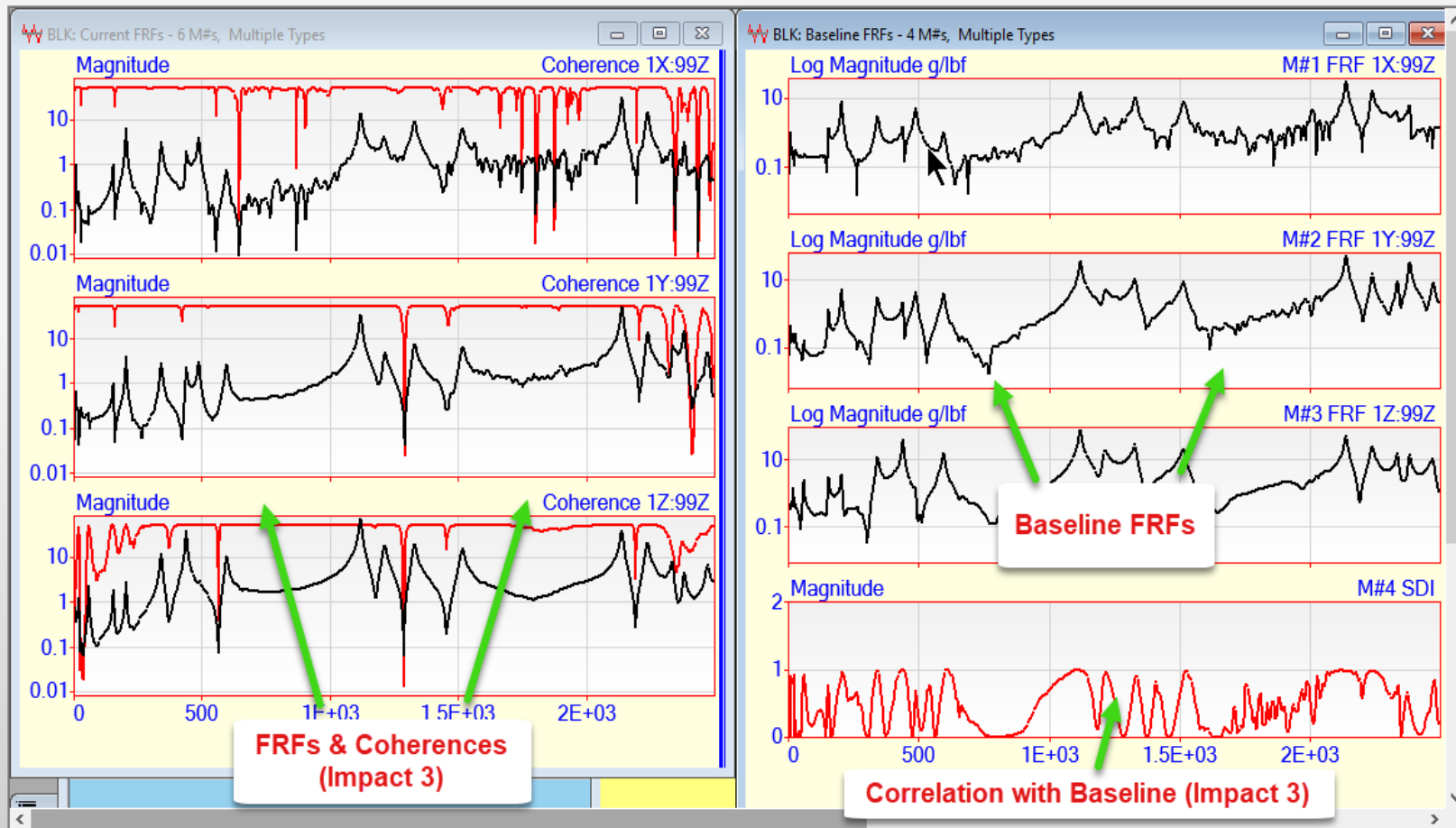
ODS Correlation indicates ***a non-repeated impact*** at **Point 2**





# ODS Correlation Indicates a Non-Repeated Impact

ODS Correlation indicates *a non-repeated impact* at **Point 3**



# High ODS Correlation at Some Frequencies

## Same ODS Components

**High SDI values** indicate that the **current & baseline** ODS components are ***nearly the same***

## Same Mode Shape Components

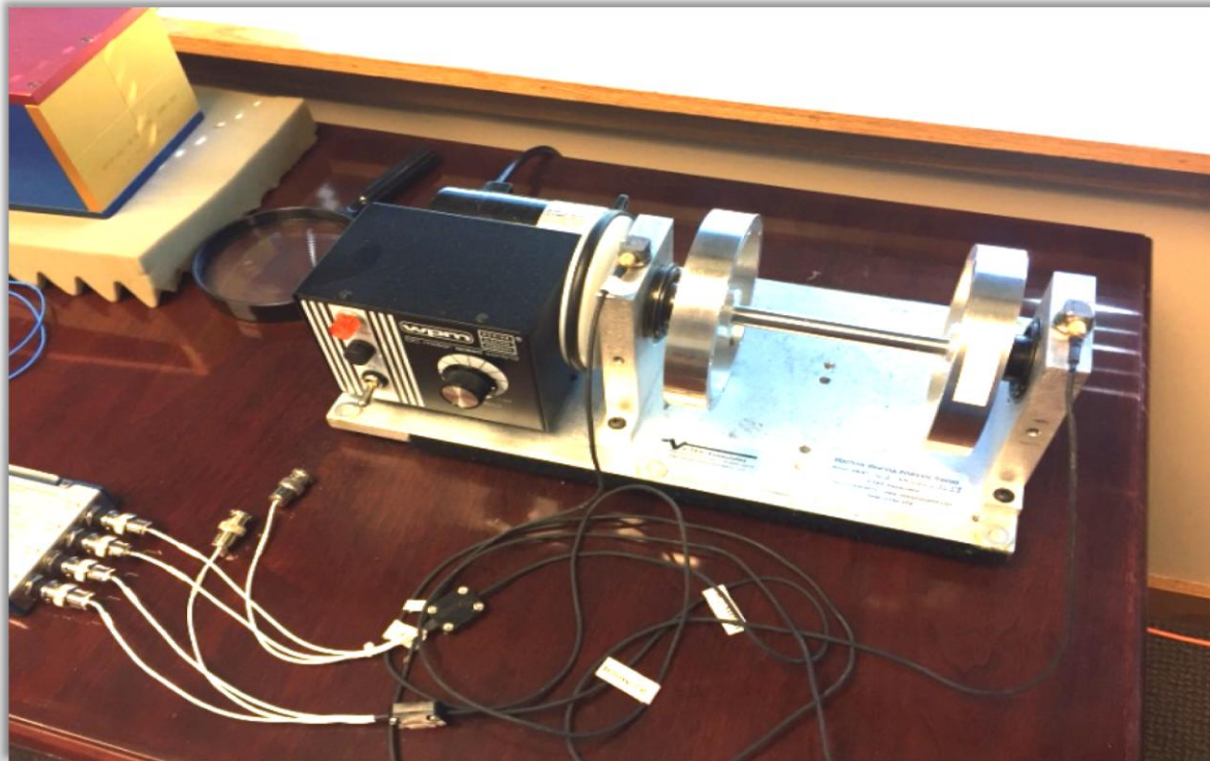
At Some Frequencies

For ***lightly damped*** structures where a ***mode shape dominates the ODS***, **high SDI values** indicate that the **current & baseline** mode shape components are ***nearly the same***

# Correlating Auto Spectra from a Rotating Machine

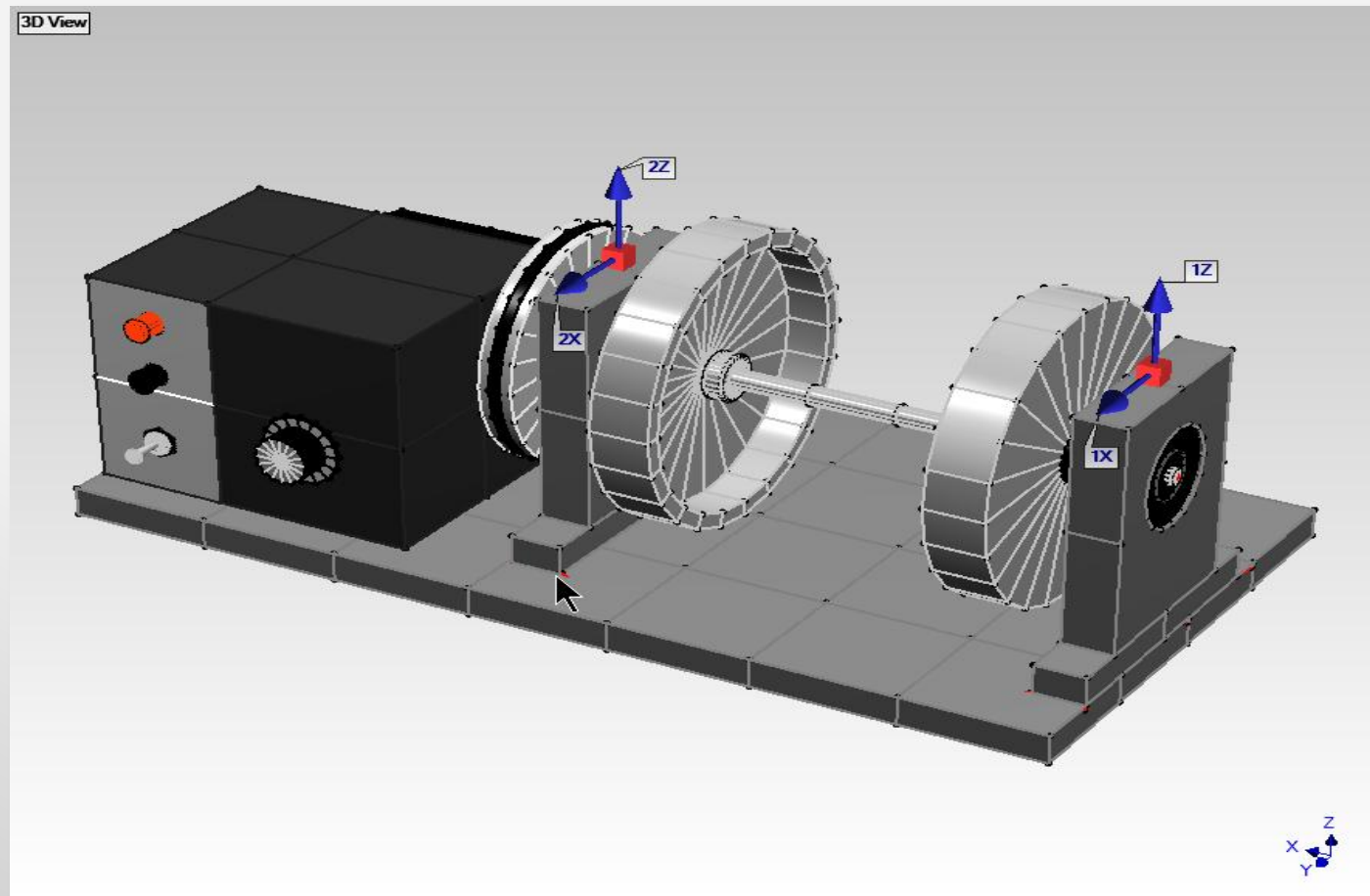
In this example, **Measurement Pairs Correlation** is combined with the **FaCTs™ database search method** to identify

1. a change in the **operating condition** of a rotating machine
2. a known **unbalance** condition in the machine



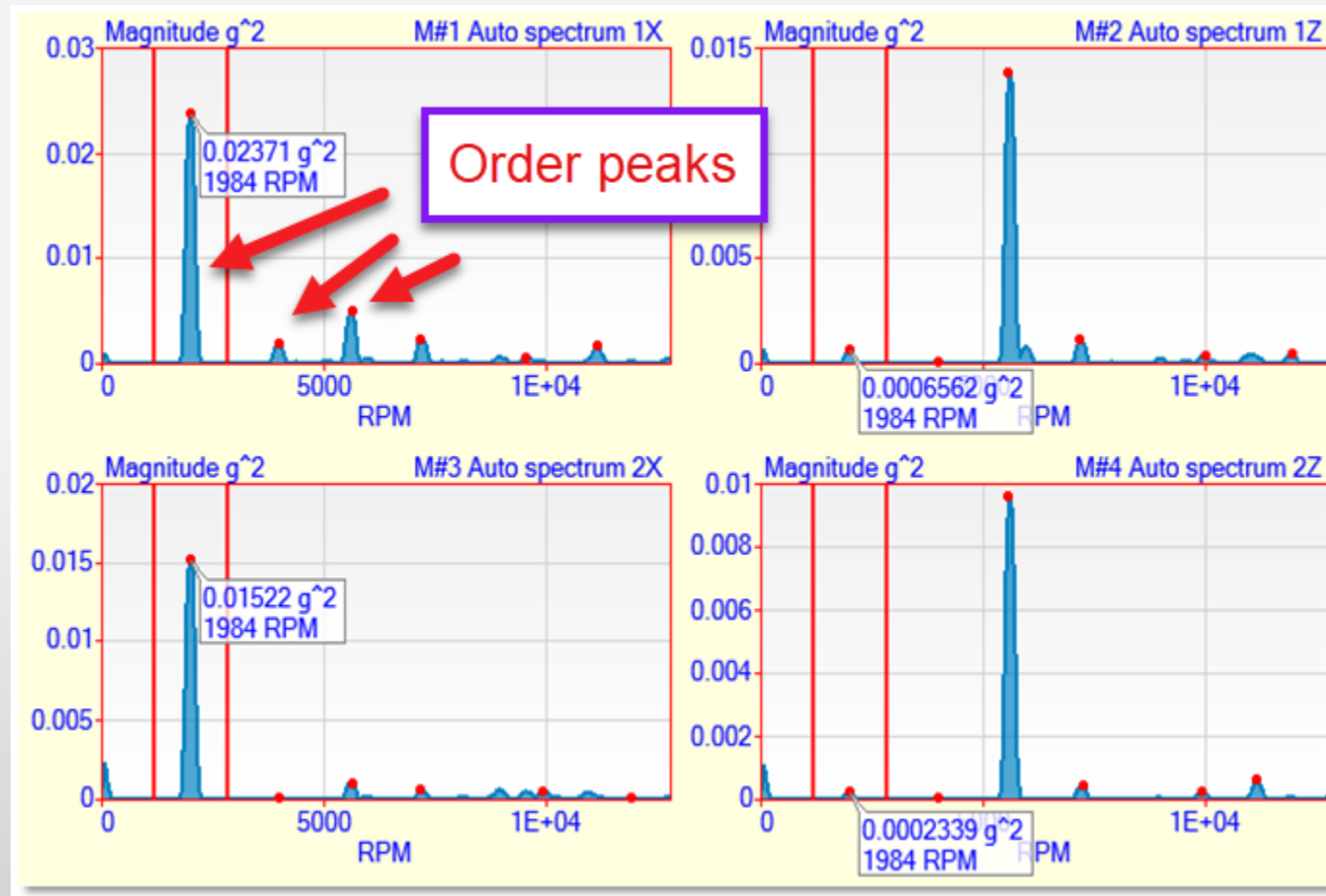
# Monitoring Bearing Block Vibration

While it was running as a constant speed, **horizontal & vertical acceleration** was acquired on the **bearing blocks** of the rotating machine



# Bearing Block Auto Spectra

**SDI** was calculated *over three 1000 RPM frequency bands*, each band surrounding one of the *first three orders*  
*12 SDI values, 4 values for each 1000 RPM frequency band*, were archived in a database



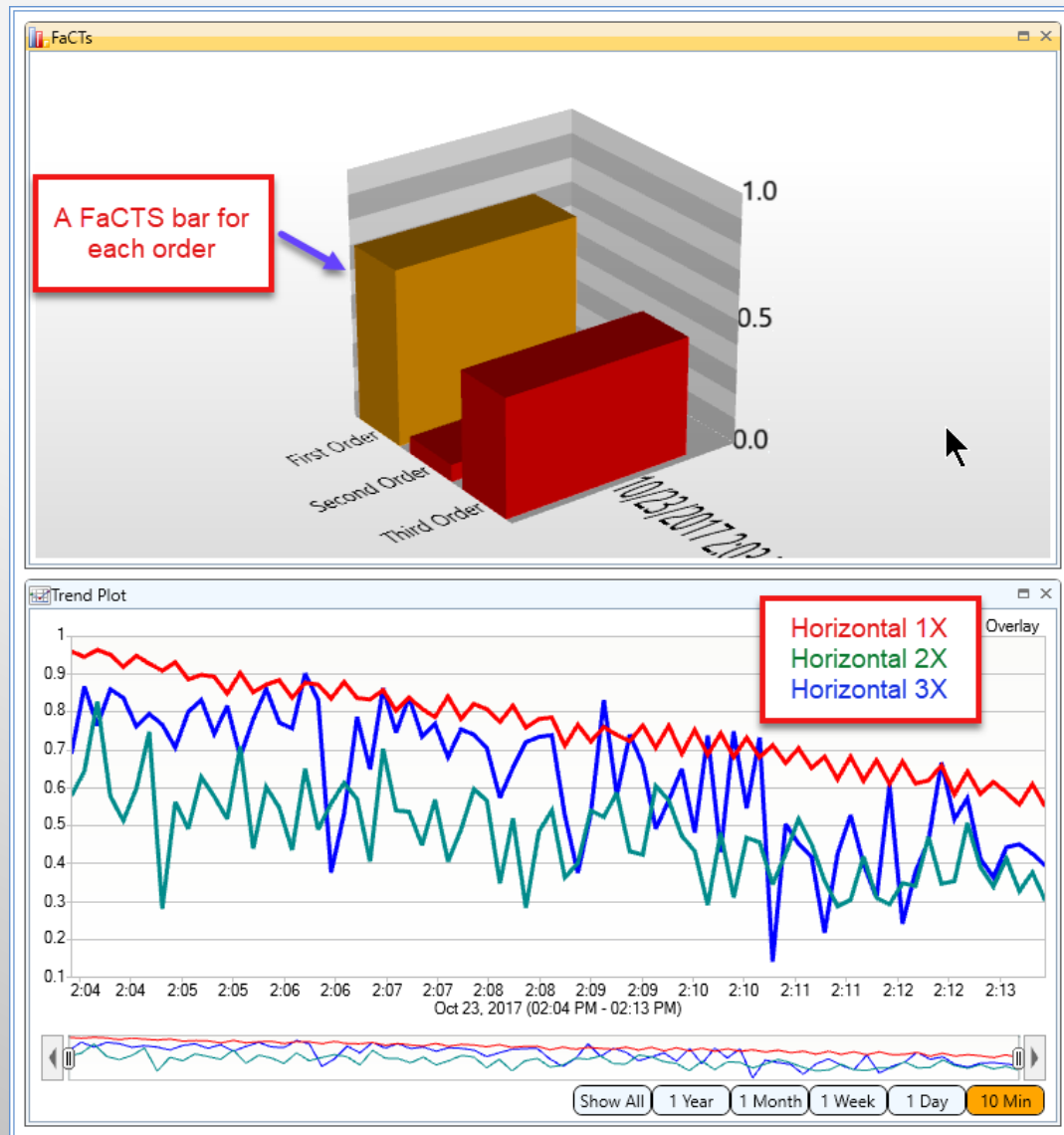
# Archived SDI Vslues

12 SDI values, **4 values for each 1000 RPM frequency band**, were archived into a database

SHP: Pairs Correlation									
Select Shape	Label								
<input type="checkbox"/> 1	First Order								
<input type="checkbox"/> 2	Second Order								
<input type="checkbox"/> 3	Third Order								
Select M#	DOFs	Measurement Type		Shape 1		Shape 2		Shape 3	
				Magnitude	Phase	Magnitude	Phase	Magnitude	Phase
<input type="checkbox"/> M#1	1X	SDI	▼	0.9171	0	0.7736	0	0.9711	0
<input type="checkbox"/> M#2	1Z	SDI	▼	0.9047	0	0.6021	0	0.9803	0
<input type="checkbox"/> M#3	2X	SDI	▼	0.8974	0	0.7734	0	0.9986	0
<input type="checkbox"/> M#4	2Z	SDI	▼	0.8868	0	0.6773	0	0.9691	0



# FaCTs™ Bars and SDI Trend Plot

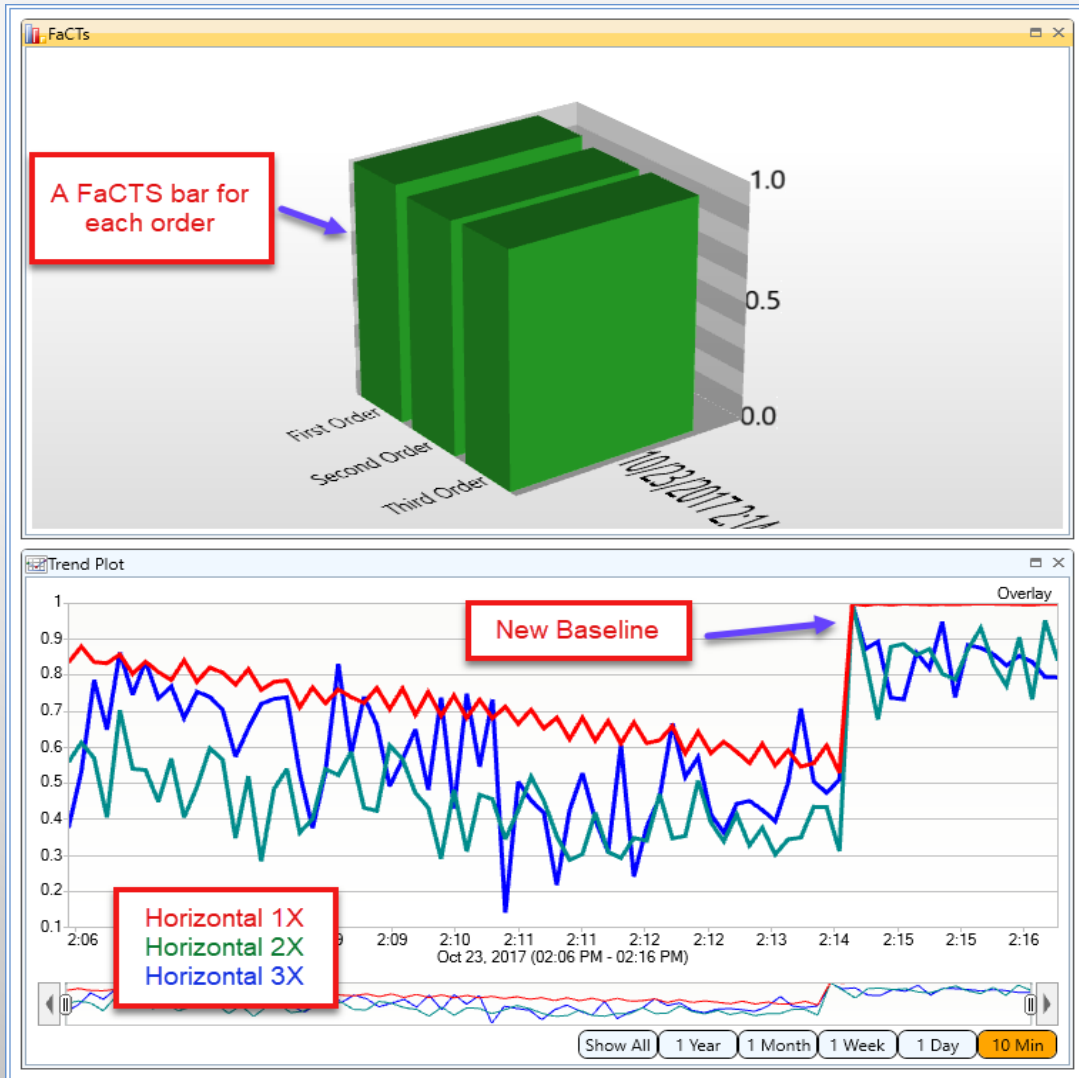


Each FaCTs™ bar correlates *Current vs. Baseline* SDI shapes

Trend plot of SDI shape components indicates *change* in the *Current vs Baseline Auto spectra*

The *downward trend* in SDI values was attributed to *belt slippage*

# Updating the Baseline SDI Shapes



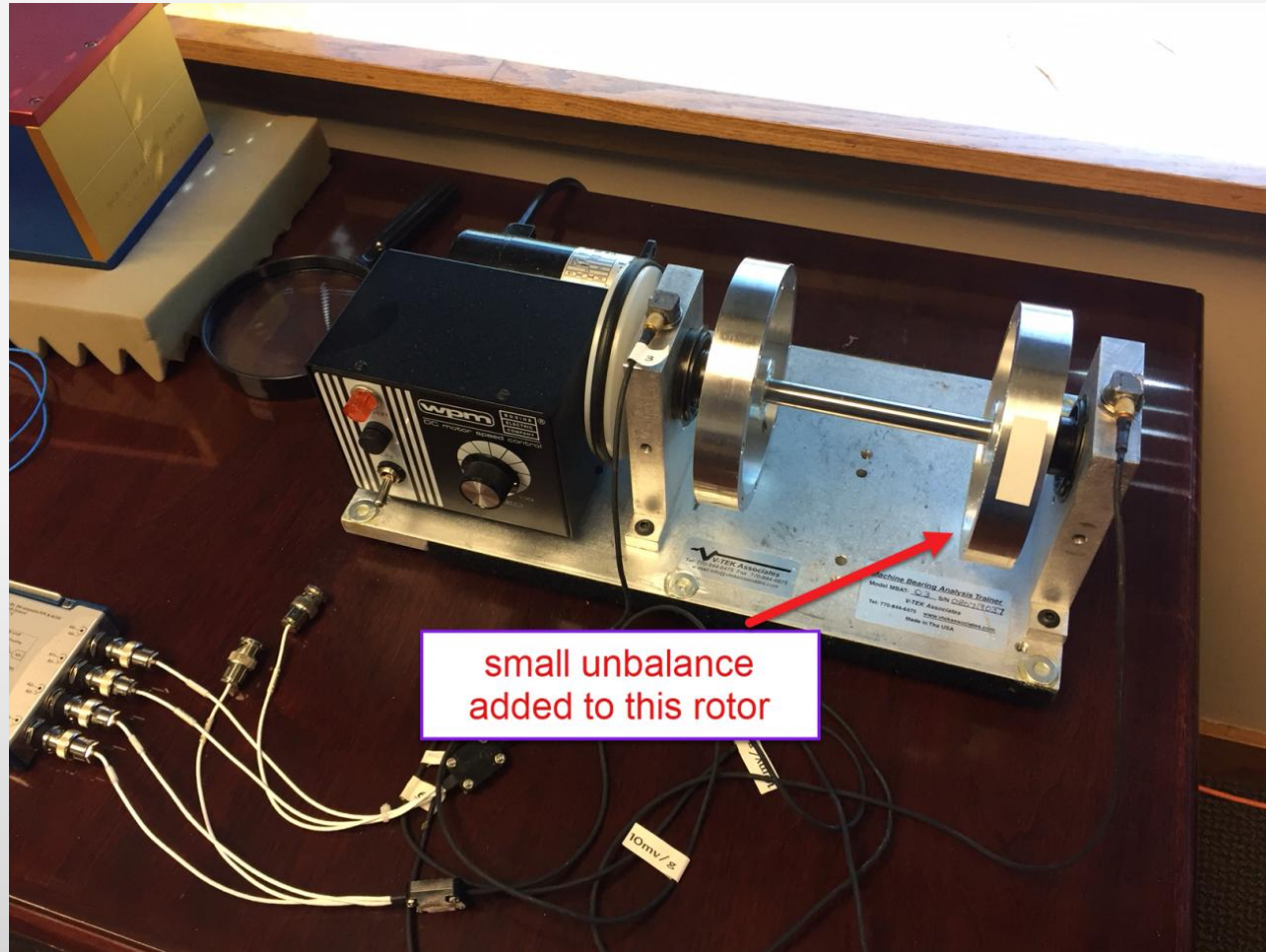
Both the **FaCTS™ bars** and **SDI Trend plot** show evidence on the **updated Baseline SDI shapes**

The **FaCTS™ bars** measured **no difference** between the **Current & Baseline SDI shapes**

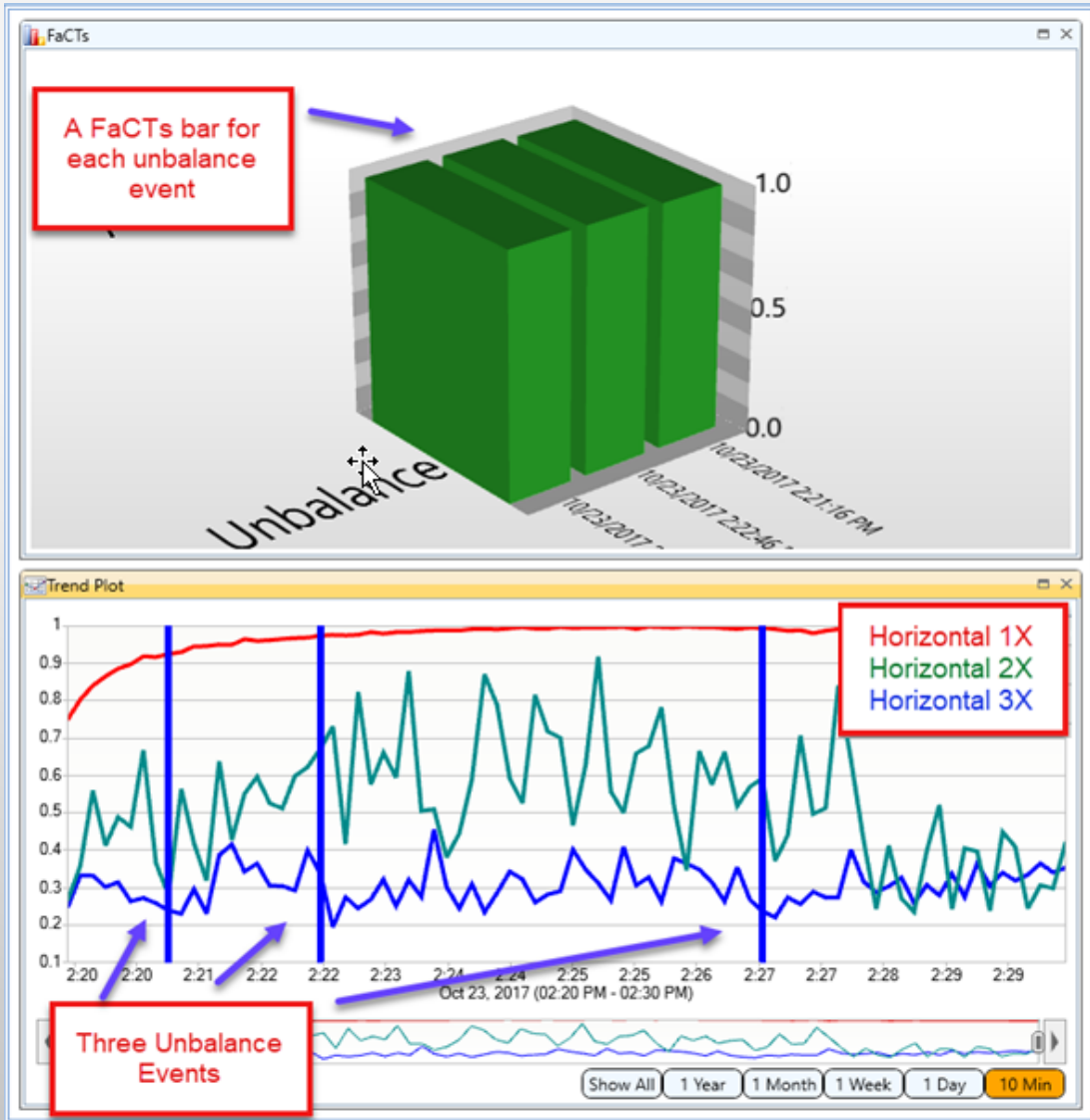
The **SDI Trend Plot** measures **no difference** between the **Current & Baseline Auto spectra** for the **first order frequency band**

# Machine Unbalance

**A *small unbalance* screw was added to the outboard rotor**



# Identifying Machine Unbalance



All three FaCTs™ bars indicate *no difference* between the *Current SDI shape* and *three archived Unbalance Events*

*Current SDI values* are displayed on the *right side* of the Trend Plot as each SDI shape is archived

Low SDI values indicate that the unbalance weight caused a *significant difference* between the **Current (unbalanced machine)** spectra and **Baseline (balanced machine)** spectra

# Conclusions

- ◆ **Two new applications** of the SDI metric were demonstrated
- ◆ **ODS Correlation** measures the difference between two sets of spectral measurements *at each frequency sample*
- ◆ **Measurement Pairs Correlation** measures the difference between a pair of spectral measurements *over one or more frequency bands*
- ◆ It was shown how **ODS Correlation** can be used to ensure repeatability of the impact DOF (point & direction) during a Roving Response Impact Test
- ◆ A **Slinky Test** is a good application of **ODS Correlation**
- ◆ It was shown how **Measurement Pairs Correlation** combined with the **FaCTs™ database search method** will detect **changes in operating condition** and identify **previously defined unbalance** events