

Frequency Domain Fatigue Analysis with nCode DesignLife

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nCode

ReliaSoft



Prenscia 

empowers engineers to **avoid the cost of unexpected failures** by using our **software and related services** to deliver **reliable** products and processes.

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Training & Education

- Design for reliability
- Design for durability
- Fatigue theory
- Hands-on software

Services

- Materials testing
- Solutions for design, development and test
- Solutions for asset management

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Weibull++

Reliability life data analysis

ALTA

Accelerated life testing

BlockSim

RBDs, fault trees, process flows and Markov diagrams

RENO

Probabilistic event and risk analysis

RGA

Reliability growth analysis

λPredict

Standards based reliability prediction

XFMEA

FMEA and related analyses

RCM++

Reliability centered maintenance

RBI

Risk based inspection analysis

MPC

MSG-3 Maintenance program creation

XFRACAS

Web-based failure reporting and problem resolution

SEP

Web portal for ReliaSoft applications

nCode

DesignLife

CAE-based fatigue analysis

GlyphWorks

Test data analysis and durability

VibeSys

Acoustics and vibration analysis

Automation

Data storage and reporting

Aqira

Web-based test and CAE

ReliaSoft

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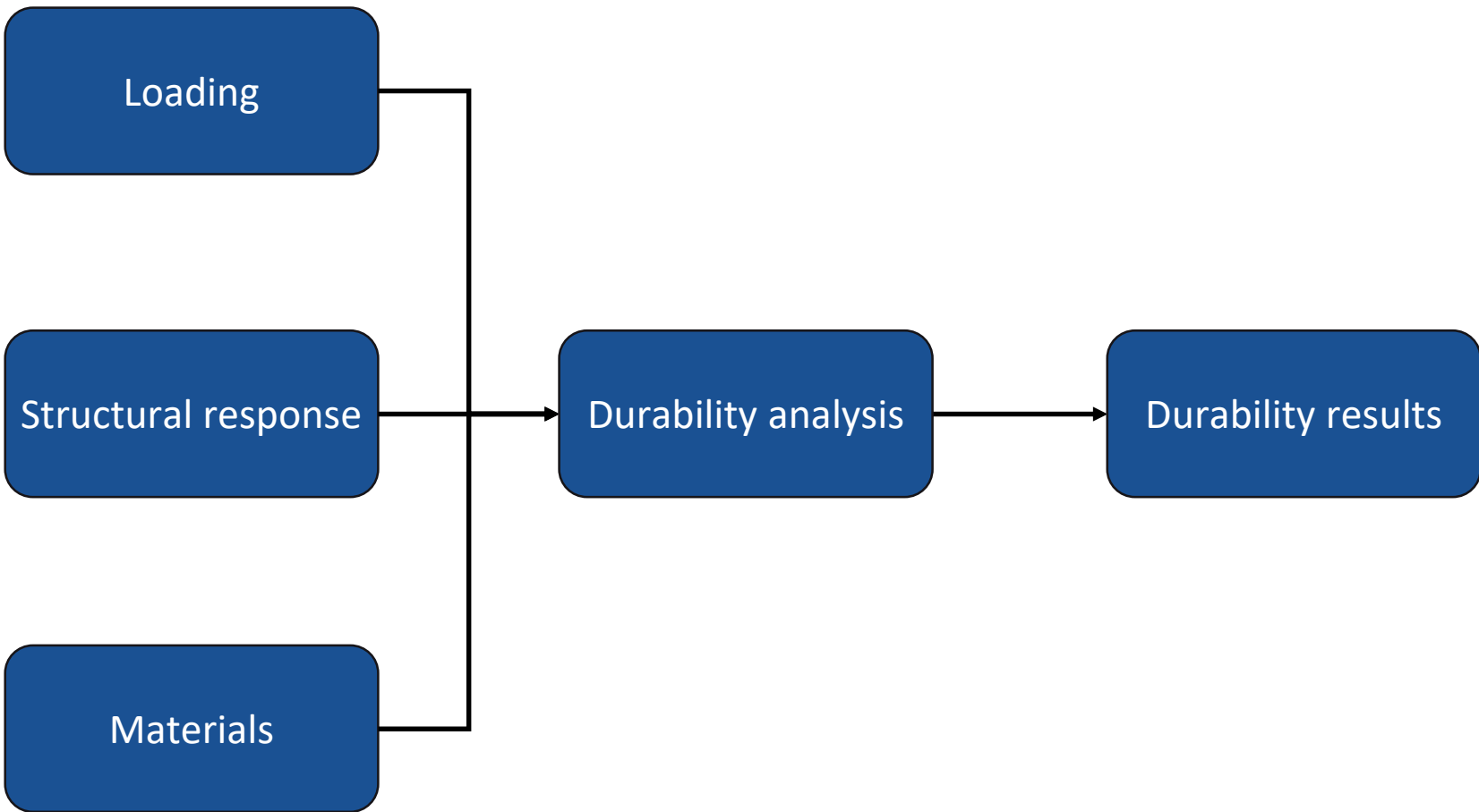
Web-based test and CAE

Agenda

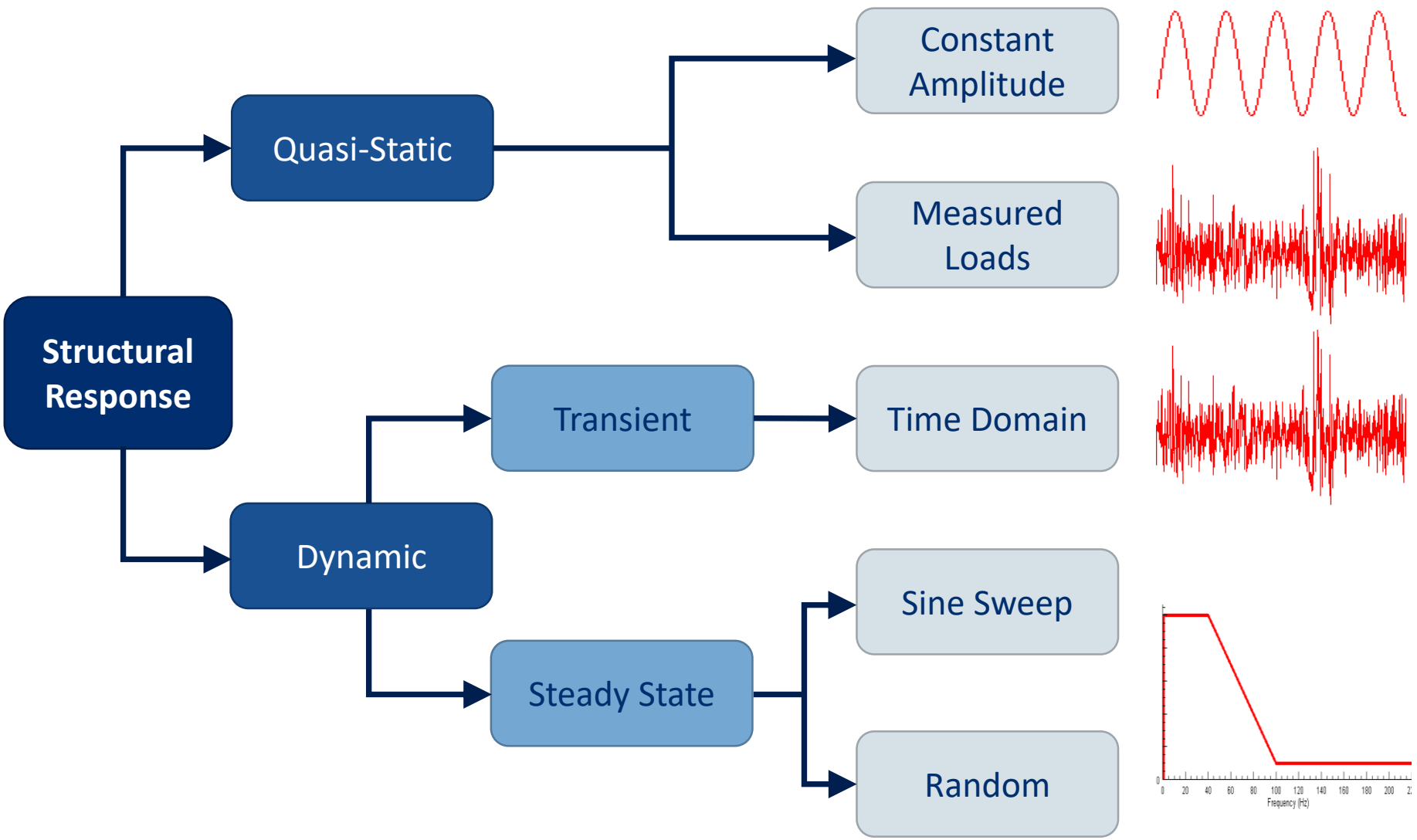
- Introduction to vibration fatigue
- Single-axis, random excitation
- Multi-axis, sequential, random excitation
- Multi-axis, simultaneous, random excitation
- Advanced features of vibration fatigue
- Summary

Introduction to vibration fatigue

Fatigue analysis roadmap

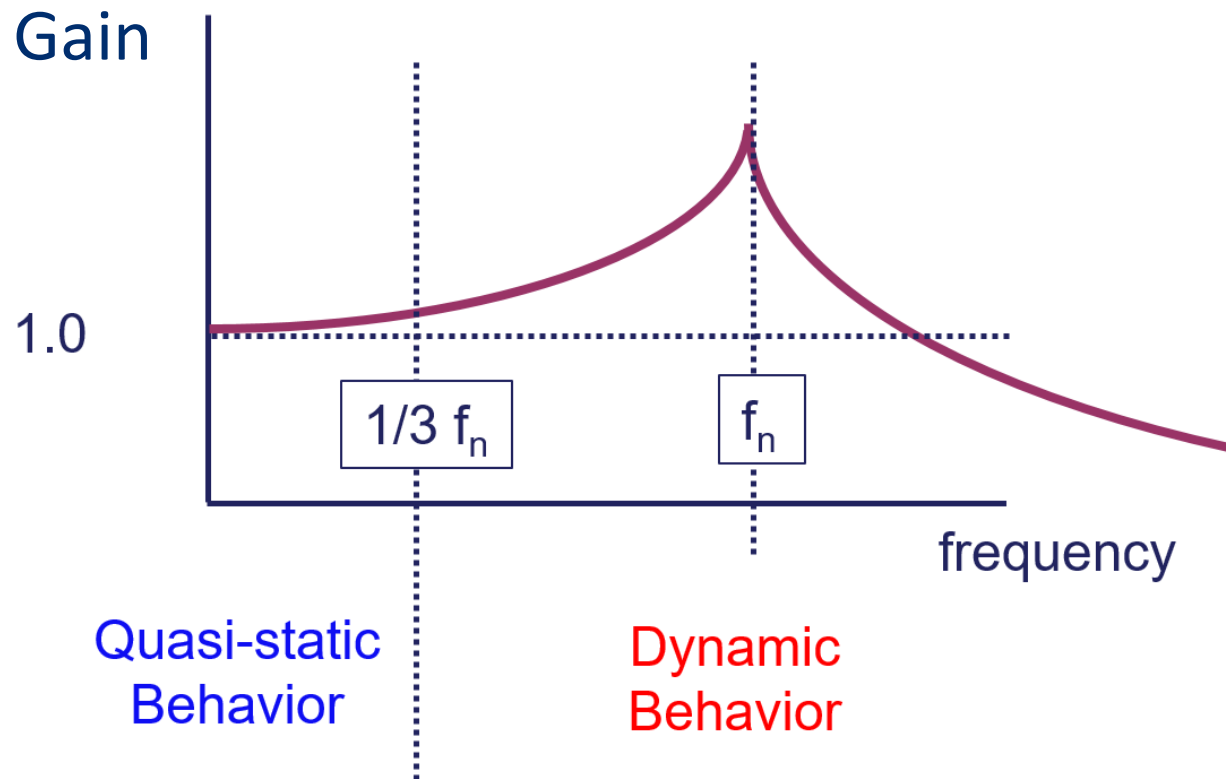


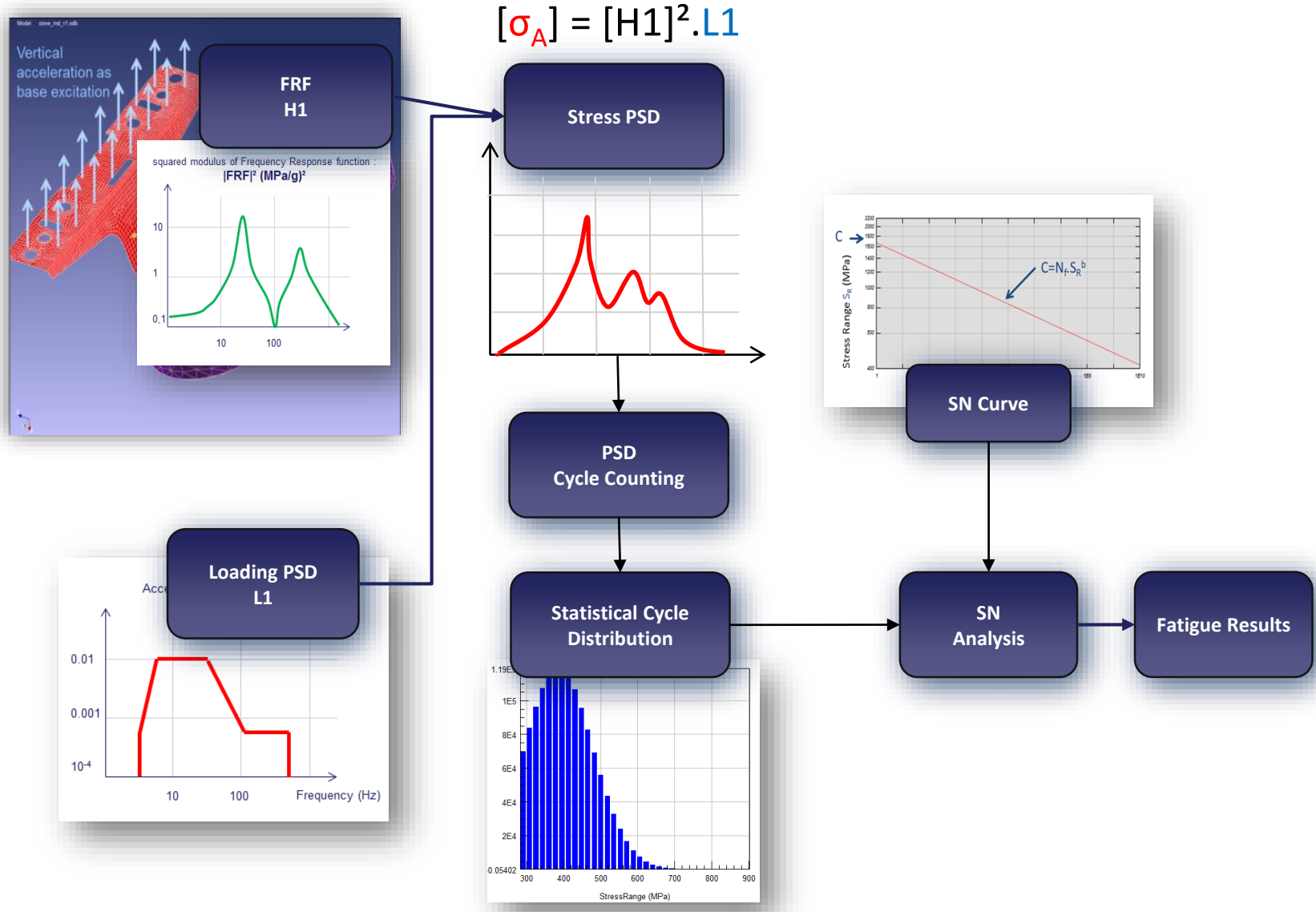
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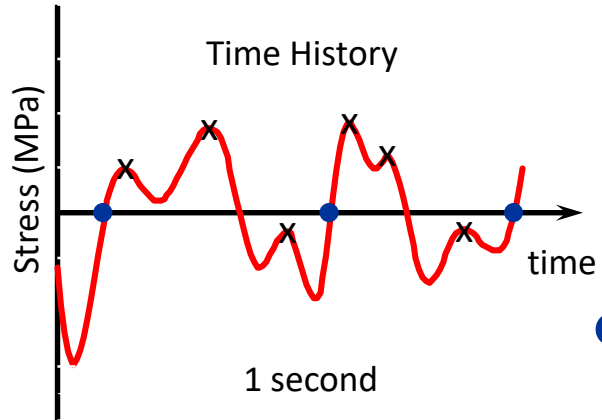


Dynamic finite element analysis

- Dynamic behavior needs to be accounted for if excitation frequencies are greater than $1/3$ of the structure's lowest resonant frequency



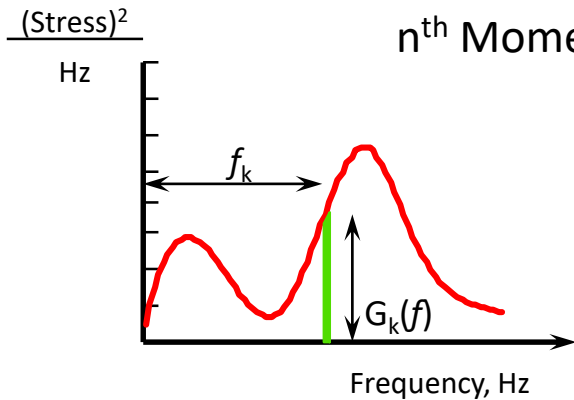




Number of upward zero crossings, $E[O] = 3$

Number of peaks, $E[P] = 6$

$$\gamma = E[O]/E[P]$$



n^{th} Moment of area under PSD

$$m_n = \sum f^n \cdot G(f) \cdot \delta f$$

Number of upward zero crossings,

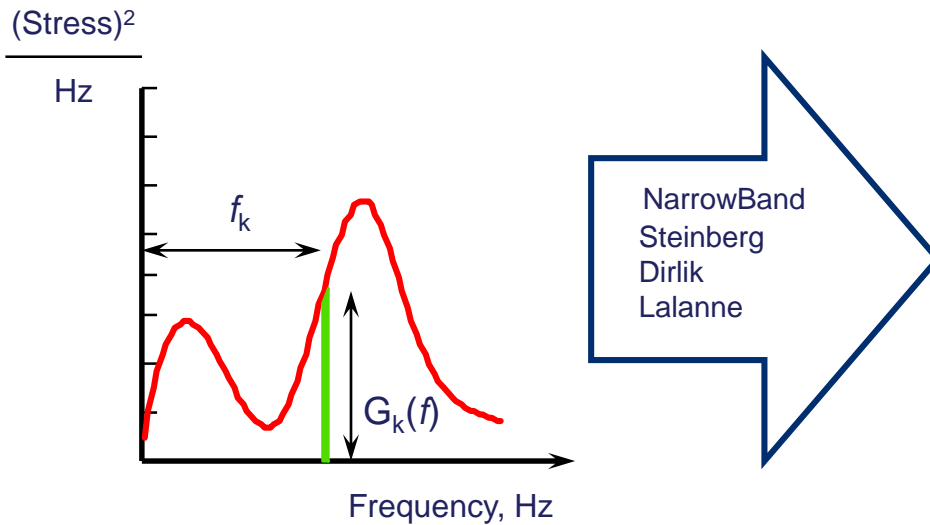
$$E[O] = \sqrt{\frac{m_2}{m_0}}$$

Number of peaks,

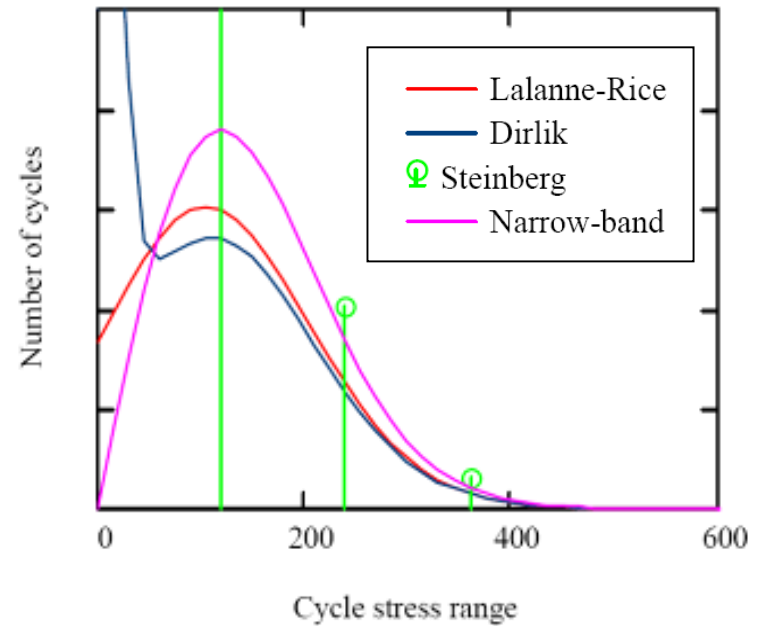
$$E[P] = \sqrt{\frac{m_4}{m_2}}$$

(Theory of SO Rice, 1954)

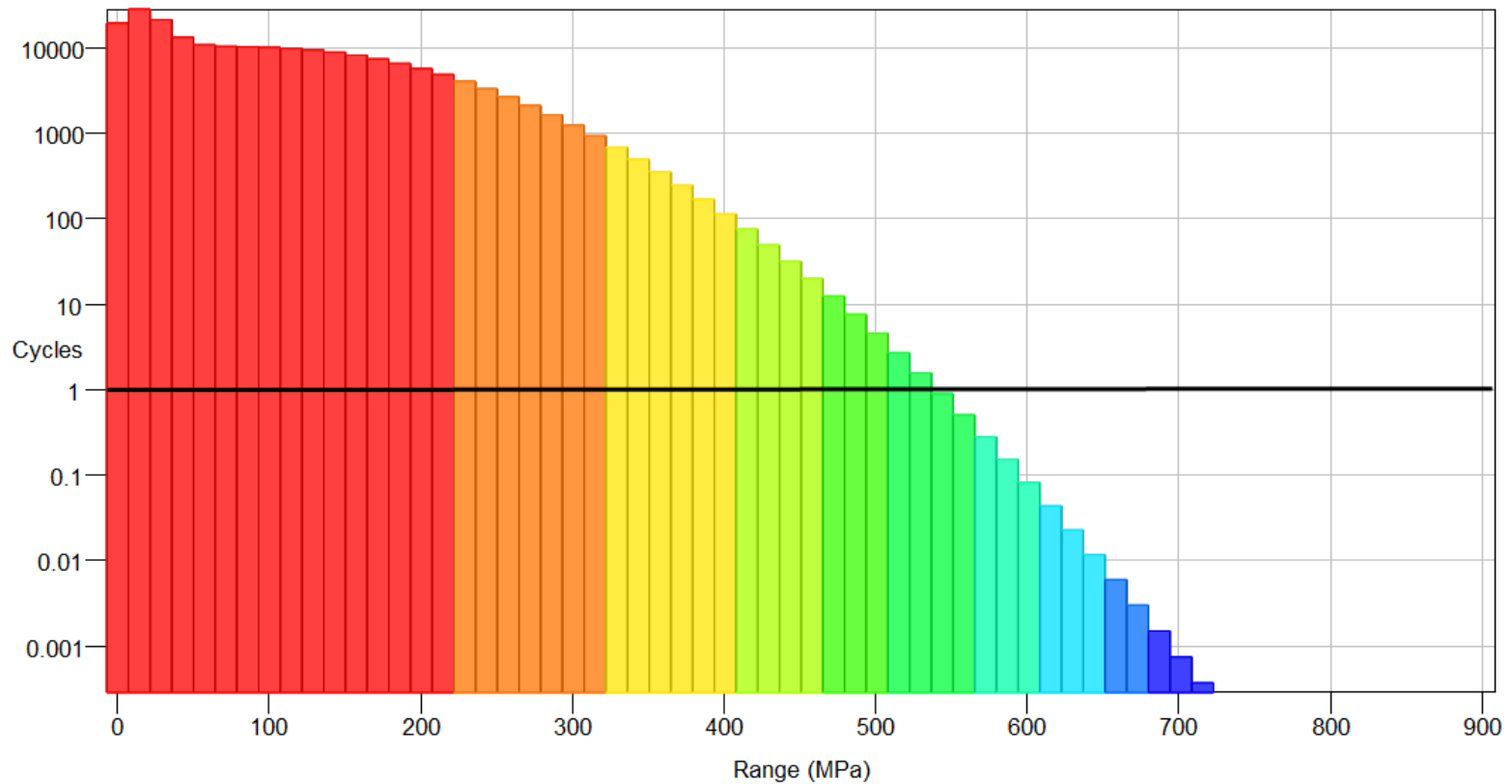
From the area moments of the stress PSD, the number of cycles per second and the range distribution of the cycles are estimated.



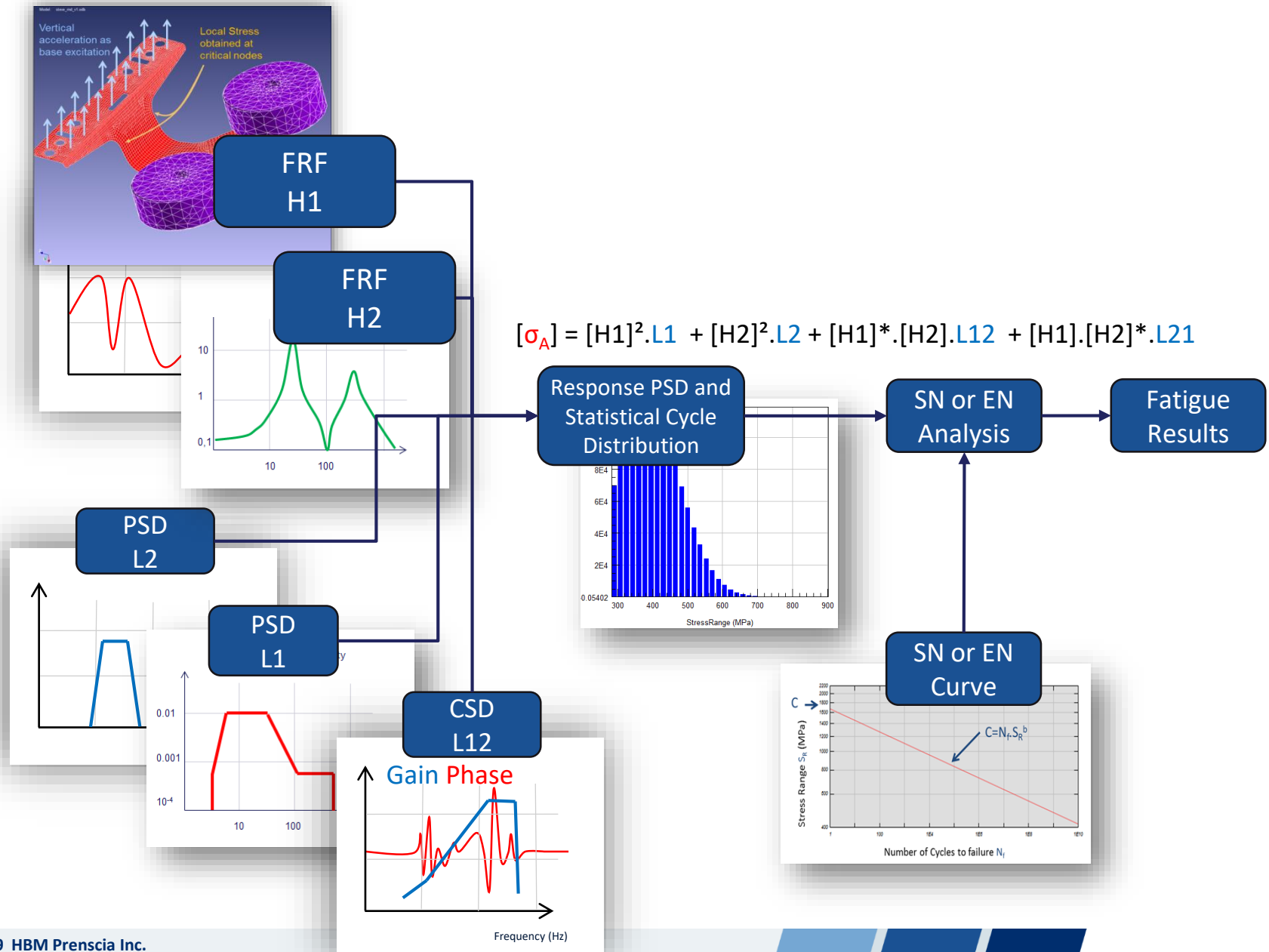
Stress Range Probability Density Function



- The cycles histogram is actually a probability density
- Damages are calculated for fractions of cycles

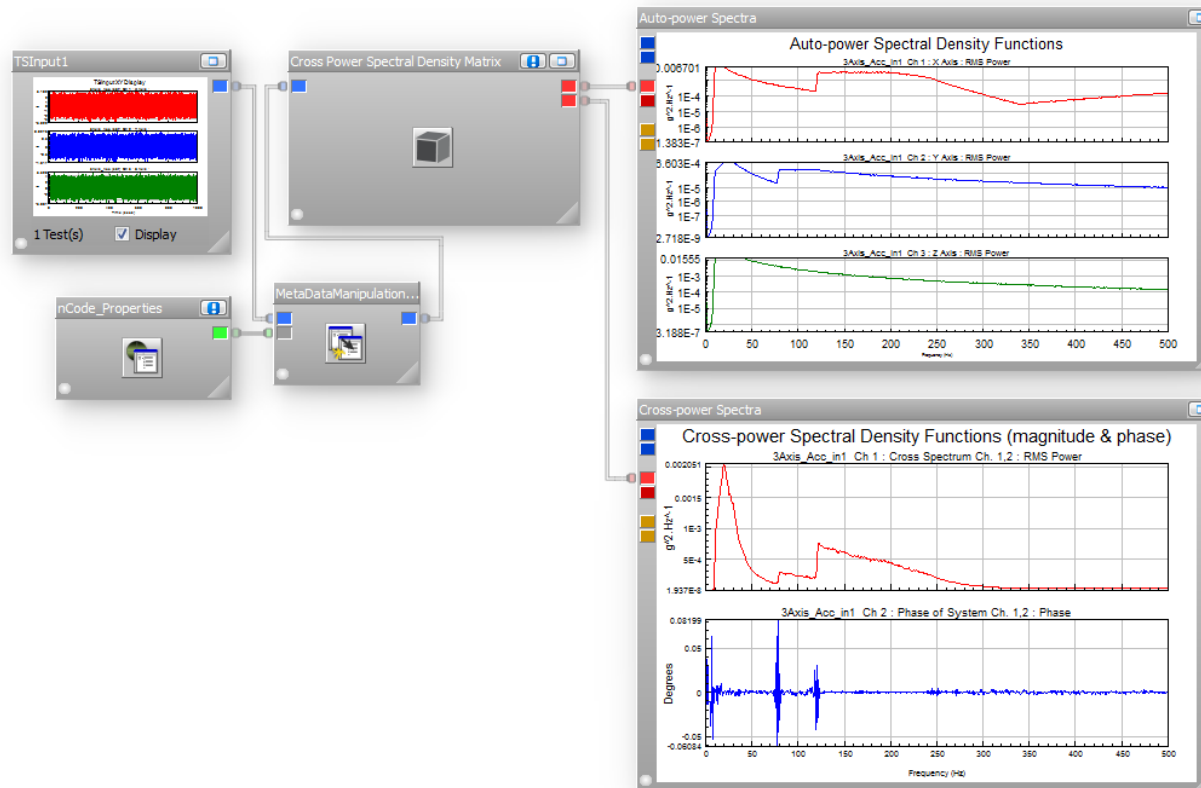


Vibration fatigue from multiple inputs



Generating the PSDs and CSDs

- PSDs and Cross Spectral Densities (CSDs) can be created from time series data
- An *.mpl* file can be used to simplify the assignment of the PSDs and CSDs



Multi-axis, simultaneous, random excitation

Edit Load Map (VibrationLoad)

Loading Type: **Vibration**

Load Case Descriptions: **All**

Configuration Method: **Interactive** | Filename: | Browse... | Save...

Modal | FRF | Static | Temperature

Available FRF Load Cases

Description	1	2	3
1 - MOUNTING BRACKET SHAK...	1 - X Axis (3Axis_Ac	1 - Chan1 (MC_Ch_	1 - Chan1 (MC_Ch_
2 - MOUNTING BRACKET SHAK...	2 - Y Axis (3Axis_Ac	1 - Chan1 (MC_Ch_	1 - Chan1 (MC_Ch_
3 - MOUNTING BRACKET SHAK...	1 - Chan1 (MC_Ch_	1 - Chan1 (MC_Ch_	3 - Z Axis (3Axis_Ac
4 - MOUNTING BRACKET SHAK...			

Available Loads (drag onto FRF load case above)

- Histogram Input (NO DATA - In Histogram Input(Histogram input from pipe) : Pipe data access not set.)
- 3Axis_Acc_1 (c:\Program Files\Code\Code 11.0 64-bit\GlyphWorks\demo\designlife\10_Vibration\3Axis...
 - 1 - X Axis
- 3Axis_Acc_2 (c:\Program Files\Code\Code 11.0 64-bit\GlyphWorks\demo\designlife\10_Vibration\3Axis...
 - 2 - Y Axis
- 3Axis_Acc_3 (c:\Program Files\Code\Code 11.0 64-bit\GlyphWorks\demo\designlife\10_Vibration\3Axis...

Damage Legend:

- 5.197e-008
- 1.608e-009
- 4.977e-011
- 1.540e-012
- 4.766e-014
- 1.475e-015
- 4.564e-017
- 1.412e-018
- 4.370e-020
- 1.352e-021
- Beyond Cutoff
- No Data

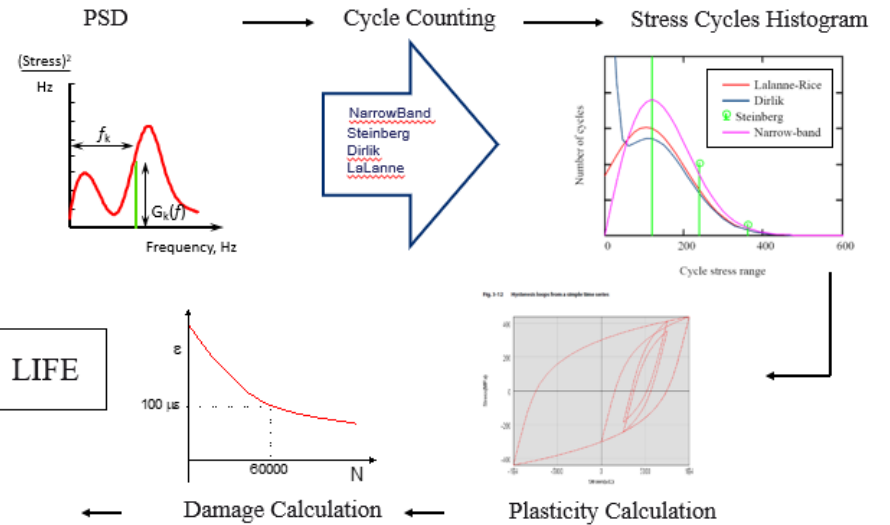
Max = 1.68E-6
At Node 984

Min = Beyond Cutoff
At Node 2916

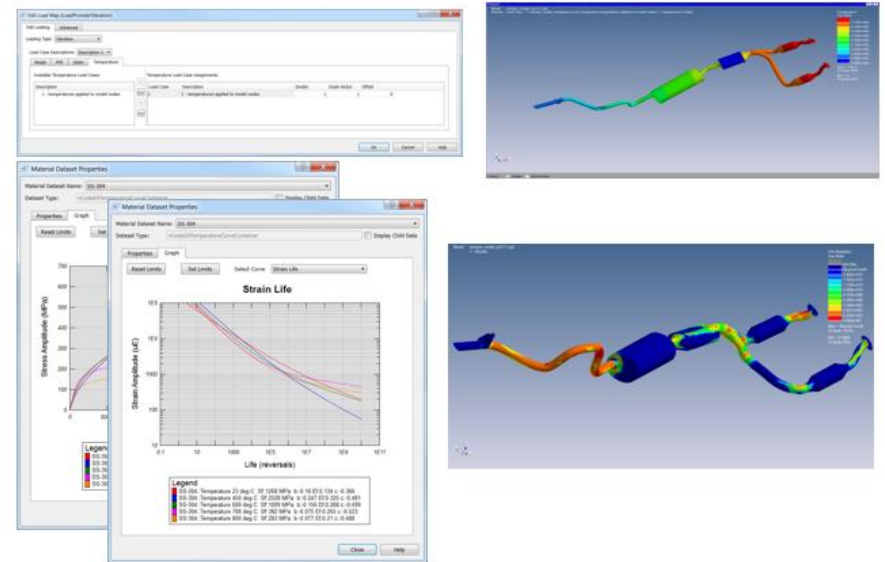
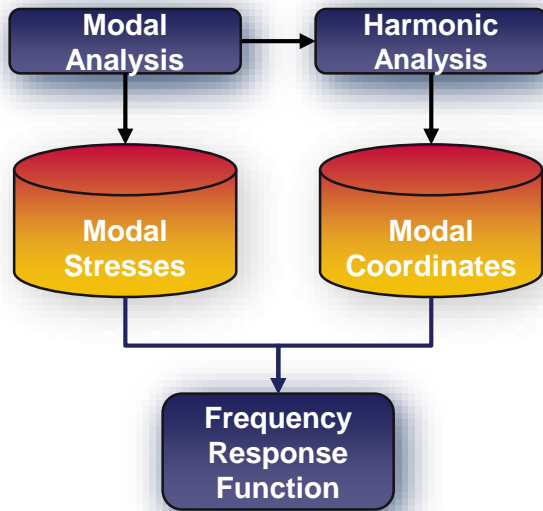
	7	8	9	10
Damage				
	Plane angle	RMS stress	Mean stress	Return
	degrees	MPa	MPa	s
	120	67.6	0	1.99
	60	67.18	0	2.75e
	130	66.39	0	5.43e
	130	66.09	0	6.84e
	70	65.9	0	8.18e
	50	65.88	0	8.29e
	50	65.62	0	1.02e
	120	65.08	0	1.67e
	60	64.65	0	2.47e
	140	64.52	0	2.78e
	110	64.2	0	3.89e
	40	64.04	0	4.33e
	70	62.82	0	1.50e
	140	62.73	0	1.62e

TestName: mounting_bracket_random Channel: 1 Title: Results Table: 1

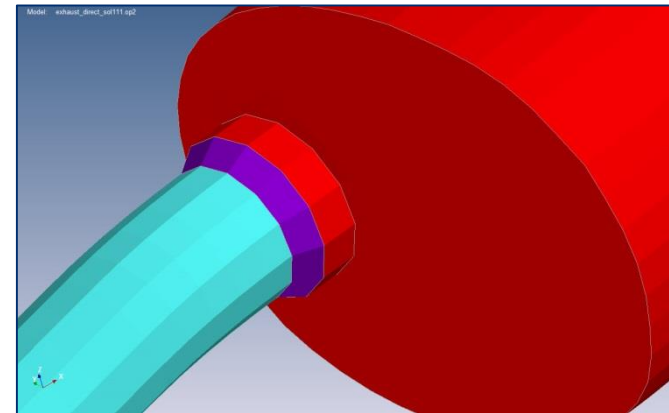
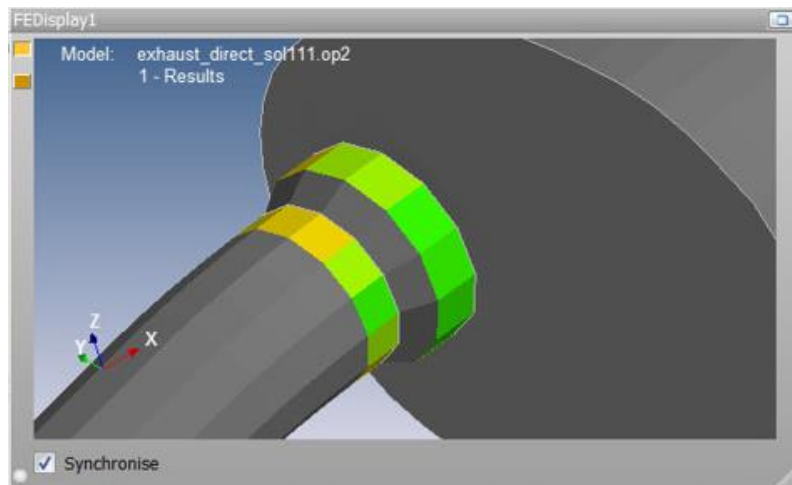
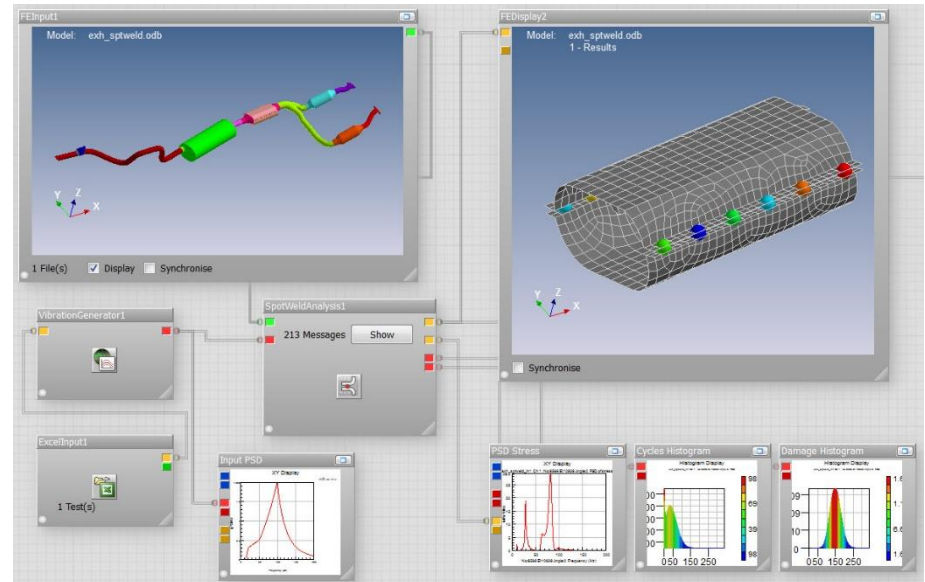
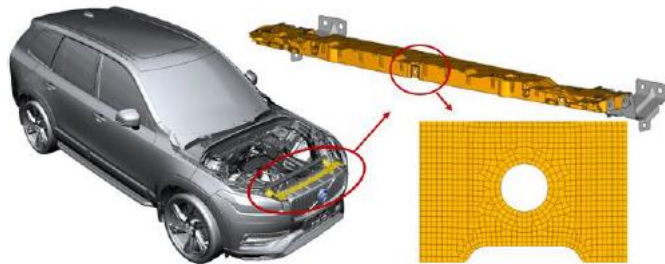
- Stress Life
- Strain Life
- Isothermal Fatigue
- Mean Stress Corrections
- FRFs calculated from modal results and modal coordinates



Modal Based FRF



- P2P and ACM Spotwelds
- Shell and Solid Seamwelds
- Short Fiber Composites



Summary

- nCode DesignLife can be used to perform vibration fatigue analysis on results from many FEA tools
 - The vibration loads can be single or multiple and can be described as:
 - Random PSDs
 - Sine on random
 - Sine sweeps
 - Sine dwells
 - Fatigue methodology includes both Stress-Life and Strain-Life
 - The vibration fatigue method can be extended to seam welds and spot welds

Questions?

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