

SAE World Congress
Fatigue Research & Applications (Part A)
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**Accurate Shock Absorber Load Modeling in an
All Terrain Vehicle
using Black Box Neural Network Techniques**

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**ATV Activity within
SAE Fatigue Design and Evaluation Committee**



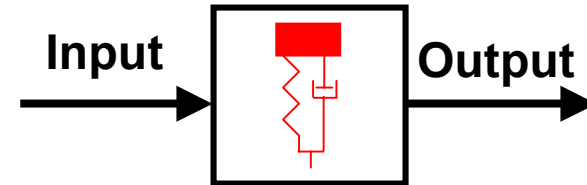
since 1997

*Systematically apply, develop, integrate,
and validate all the tools and processes
necessary to evaluate the structural
durability of a vehicle by means of a digital
simulation.*

System Identification Methods

- **White Box Methods**

- $F = m\ddot{x} + c\dot{x} + kx$



- **Black Box Methods**

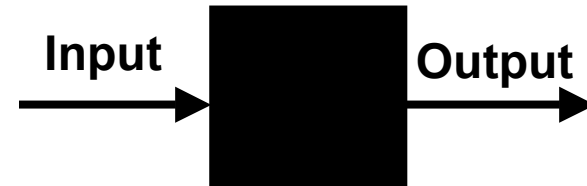
- **Frequency Response Function**

$$Y=HX$$

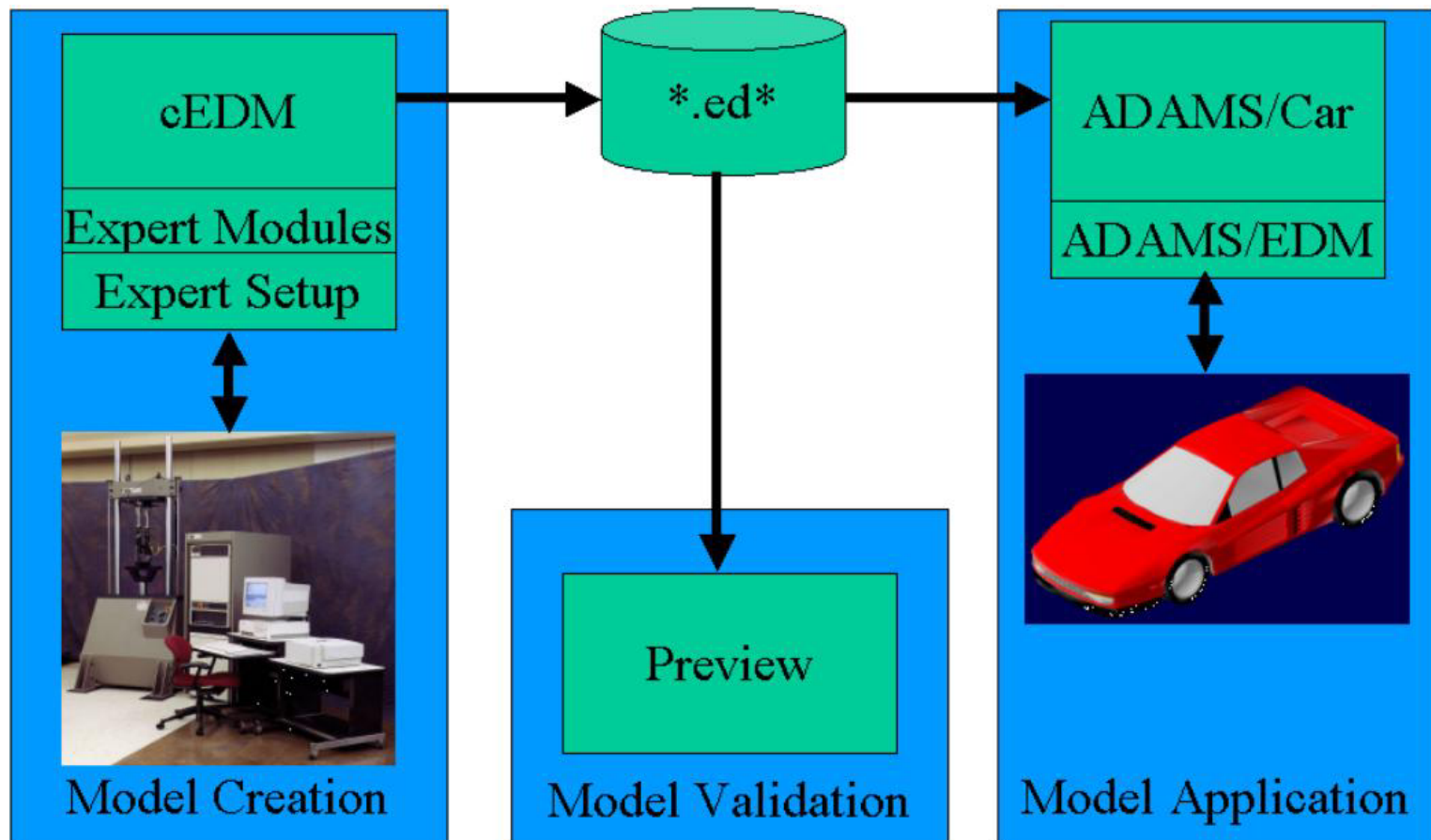
- **Polynomial/Spline**

$$y = a_0 + a_1x + a_2x^2 + a_3x^3 + \dots$$

- **Neural Network**

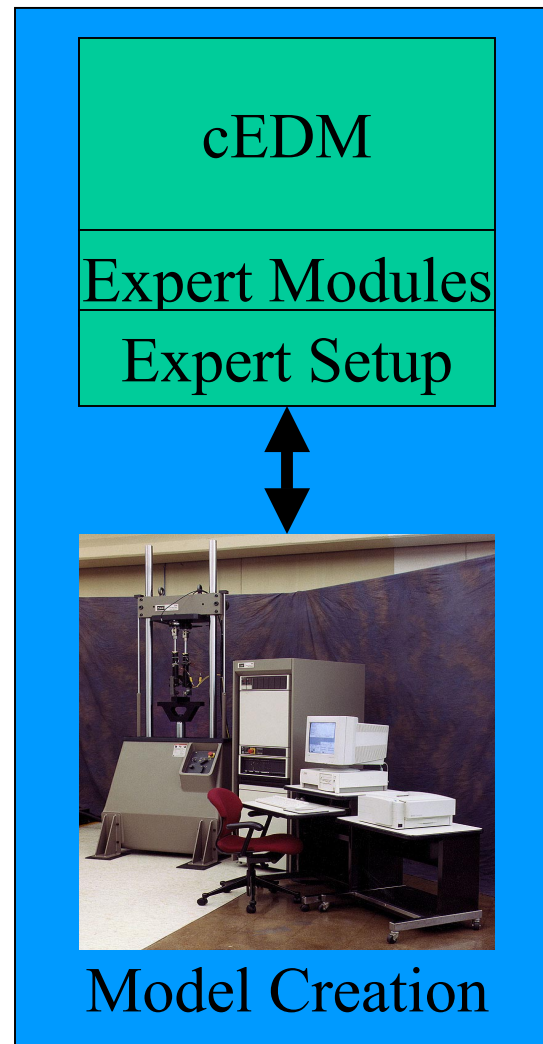


EDM Process Overview



EDM Process

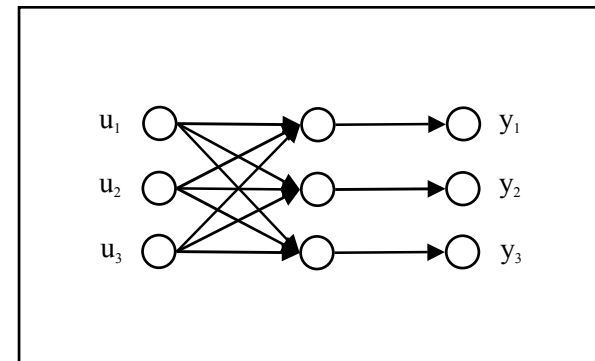
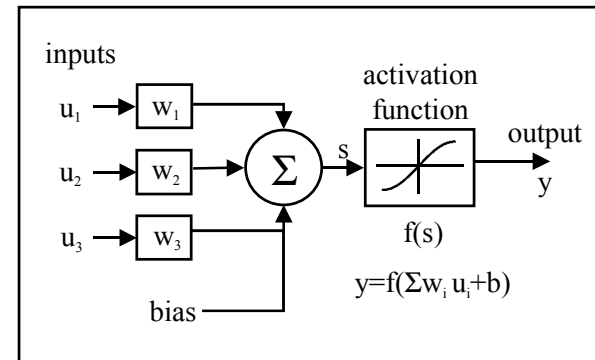
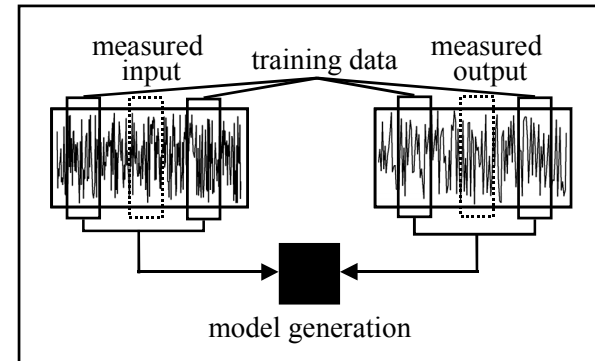
Model Creation



Neural Networks

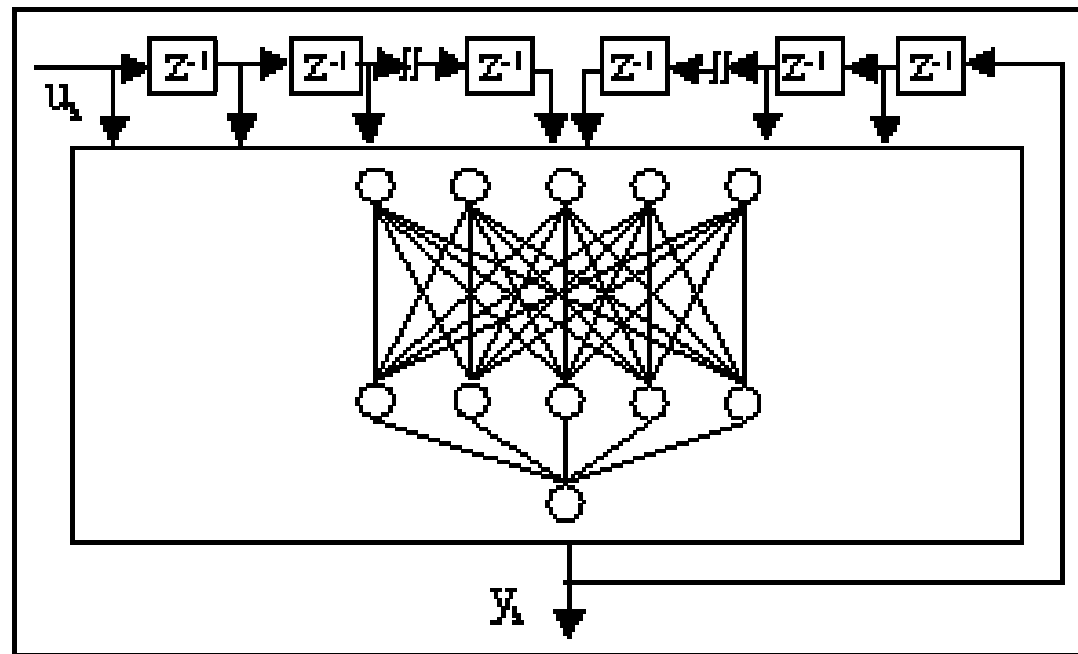
- Empirical method based on complex data
- Simple Arithmetics
- Simple Network Structure

Model complex behavior



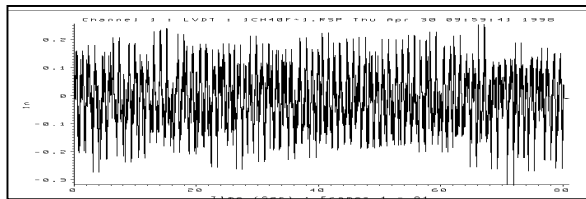
Neural Networks

- Time delay on
 - Input
 - Output

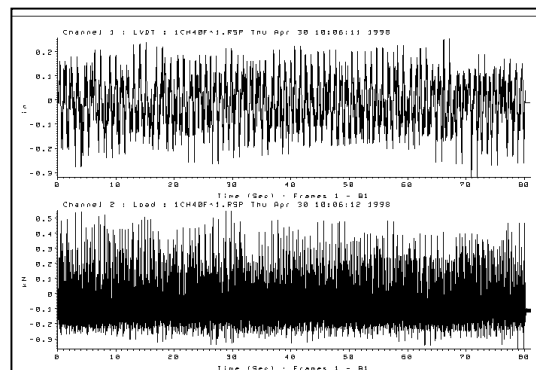
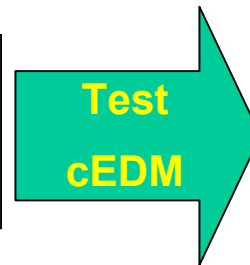


Model time dependent behavior

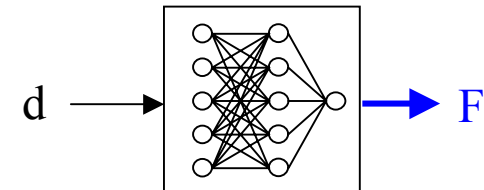
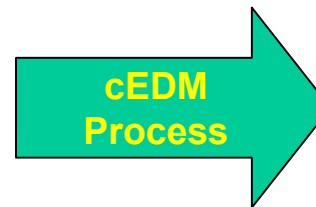
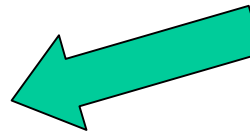
EDM Shock Absorber



Random Displacement Command

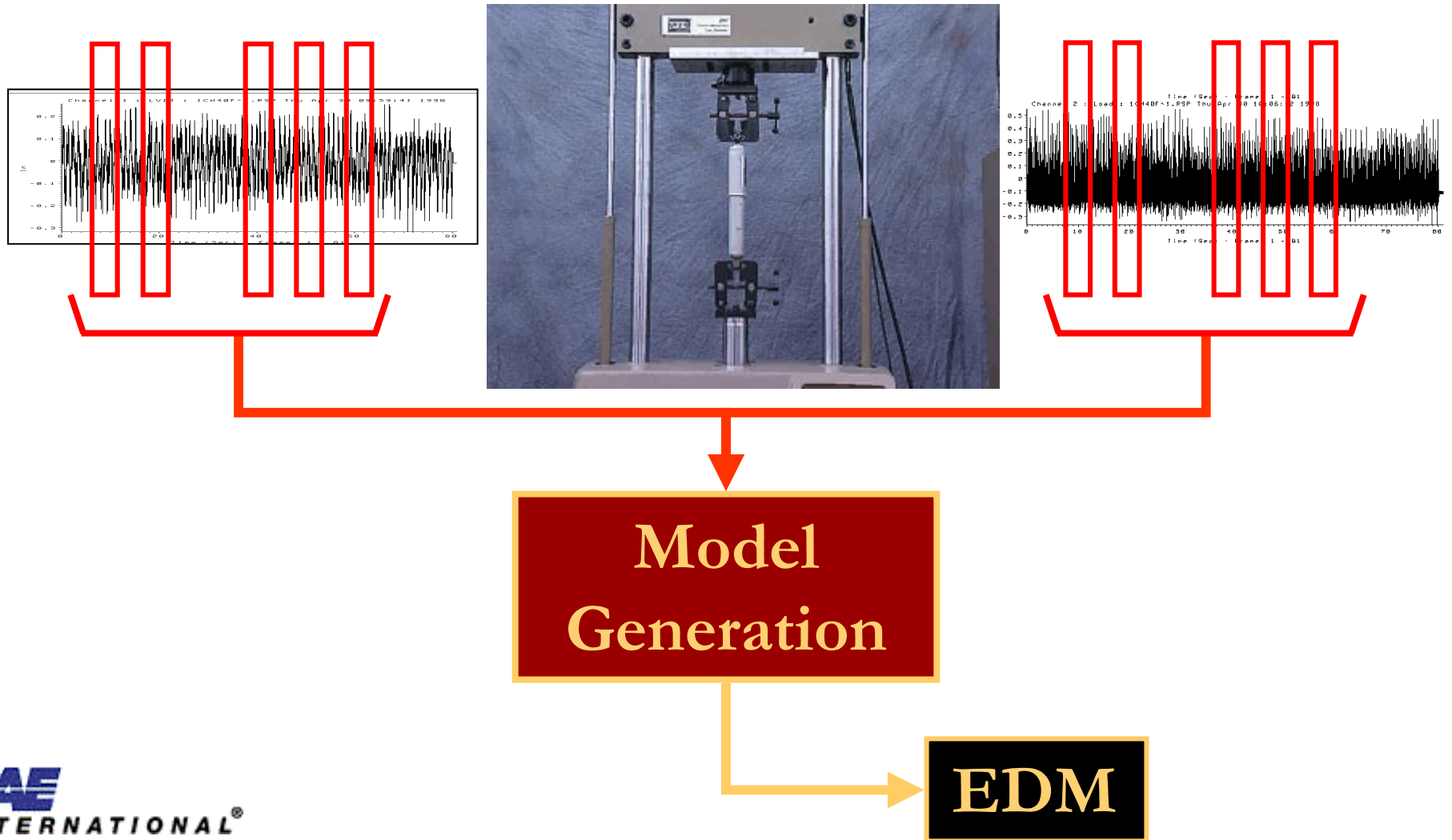


Measured Force and Displacement

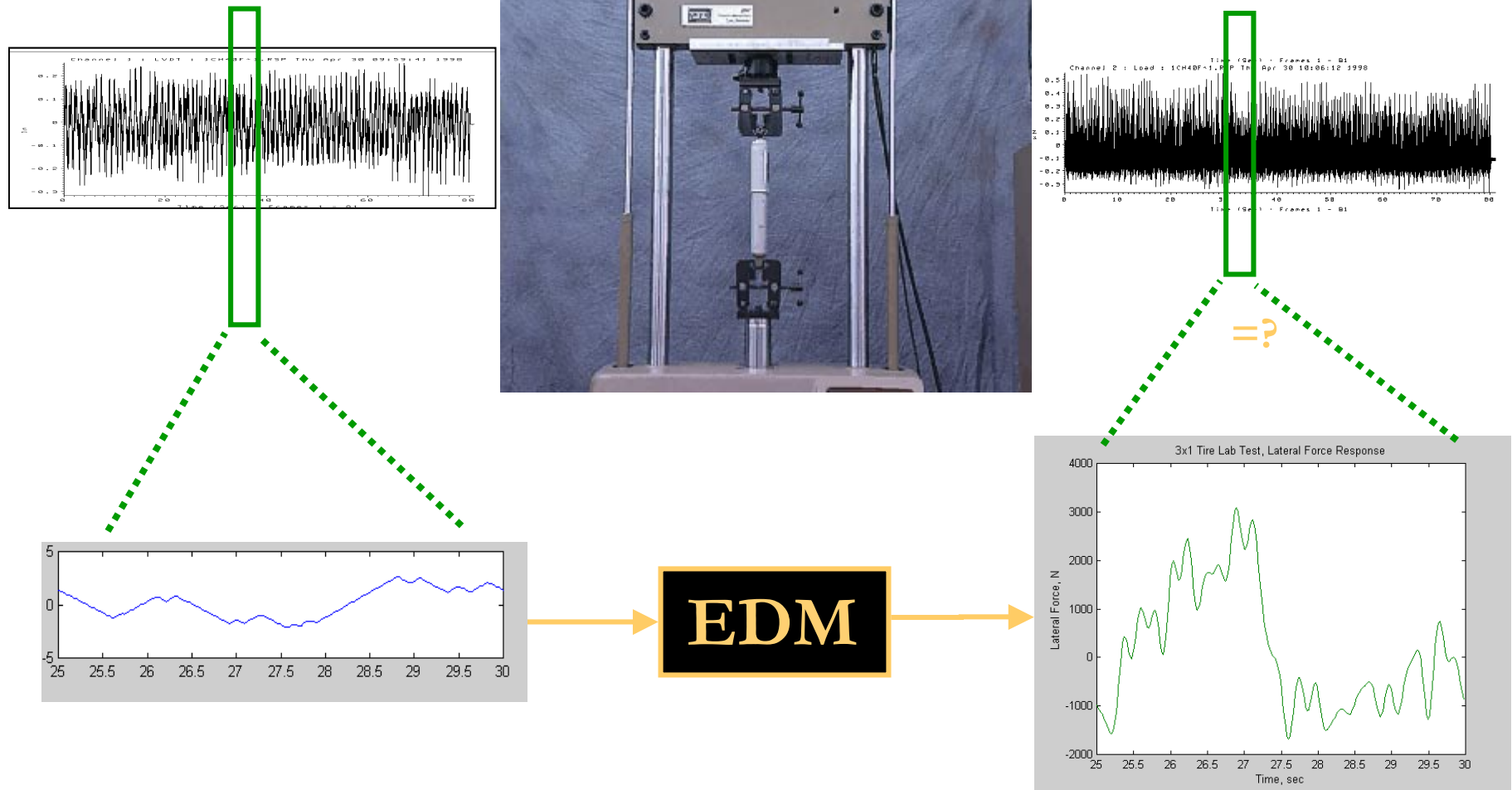


Model Build - Training

Training the Model

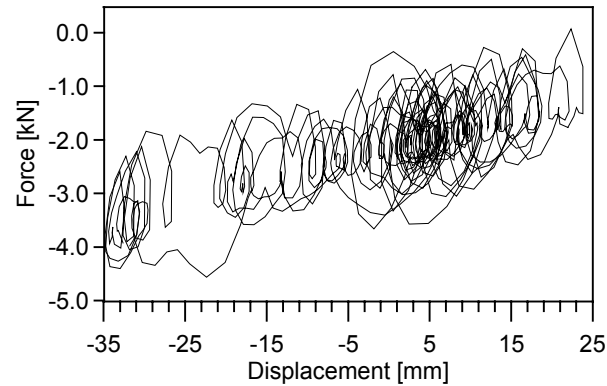


Validating the Model

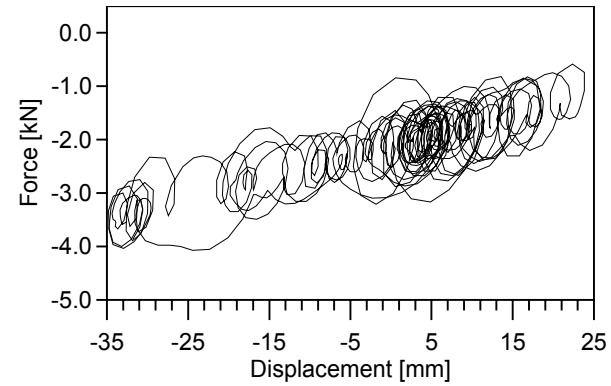


System Identification

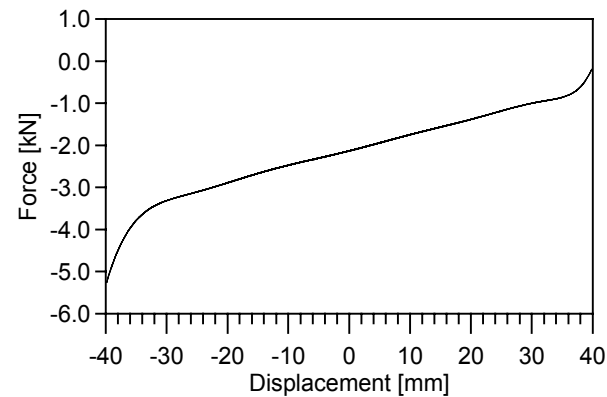
Data



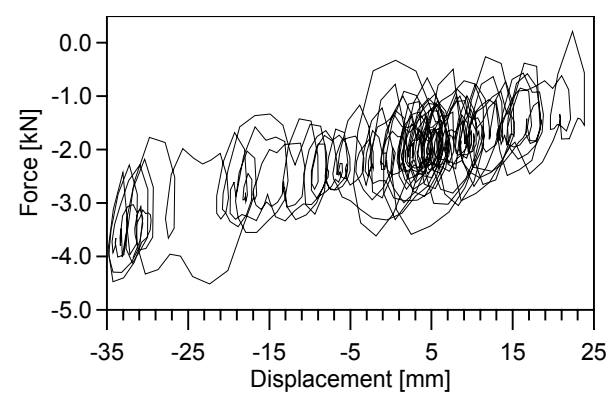
FRF



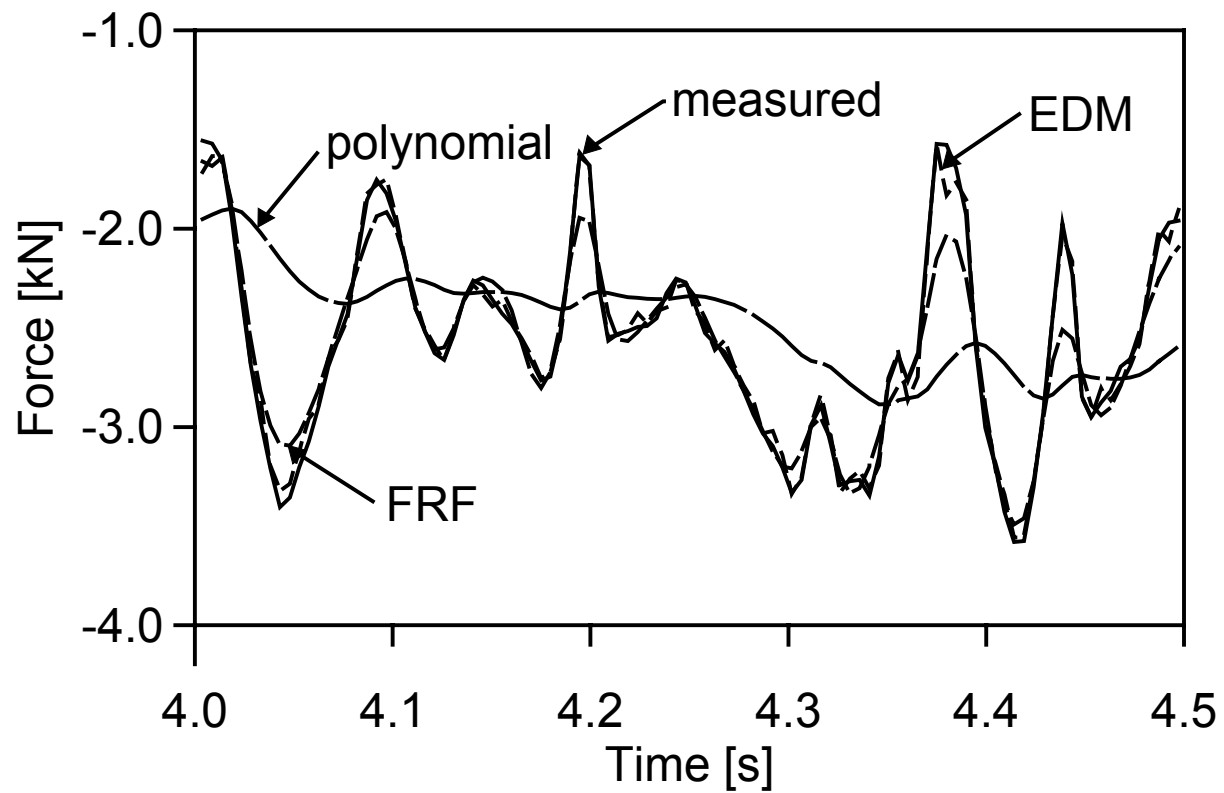
Polynomial



EDM



Time History Comparison



Fatigue Life Comparison

Pseudo
Component
Fatigue Life

History Type (Force Output)	Fatigue Life
Measured	1
FRF Fit	8.2
Polynomial Fit	308.7
Empirical Dynamics Model	0.98