SP 3

Model-based damage analysis

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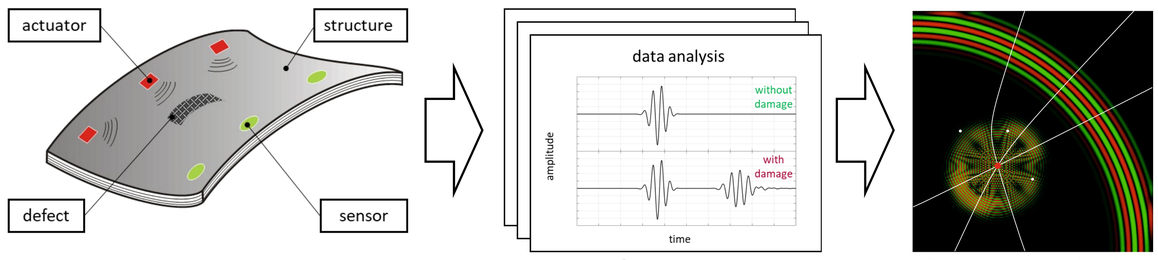
Objectives of the first funding period

Research hypotheses:

- Development of suitable and robust mathematical model which reflects the main effects of wave propagation in undamaged FML considering environmental effects like temperature and moisture.
- Powerful inverse algorithms are formulated.
- Sensors are integrated into both the mathematical and mechanical model to investigate unwanted effects in the forward and inverse simulation and to guarantee high precision measurements.
- Different damage scenarios are implemented into the forward model, that are typical for material with layers of large impedance differences.



SP 3 work flow

Results

Wave propagation characteristics

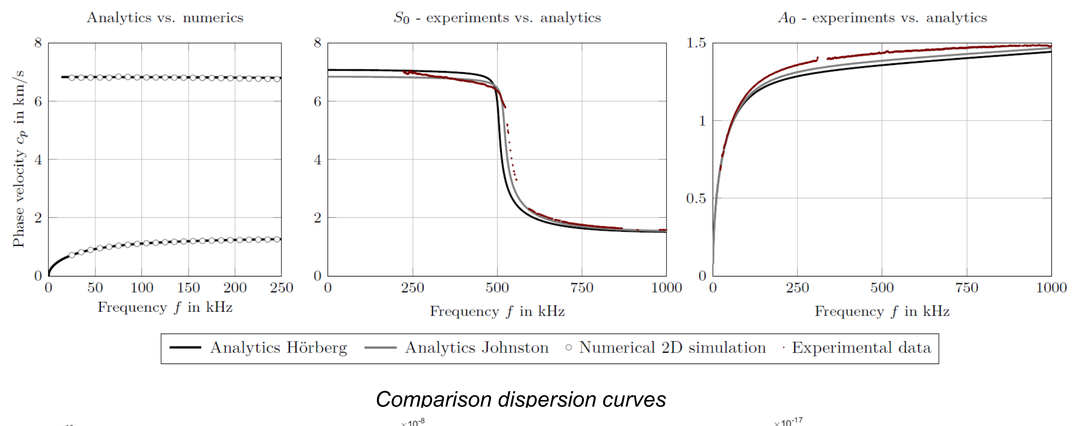
- The dispersion diagrams derived from numerical simulations and experimental investigations meet the theoretical framework of GUW in thin-walled structures.
- The analysis of the displacement field in FML reveals a complex and frequency dependent particle motion over the thickness of the waveguide GUW.

Parametric model-order reduction

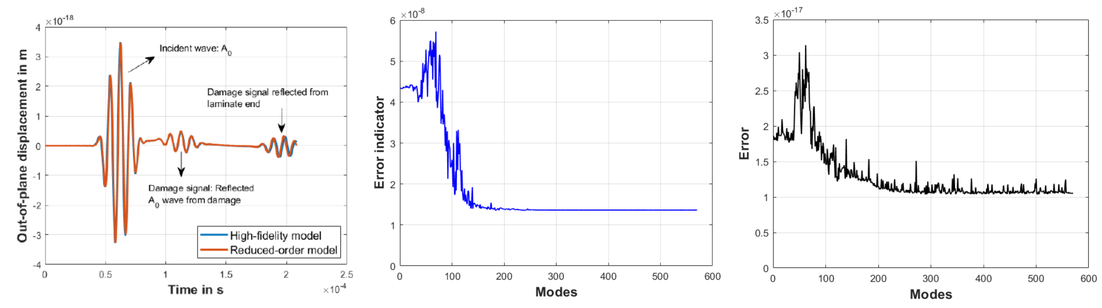
- A robust reduced-order model that is 33.82 times faster than the high-fidelity model of wave propagation in FML with minimal loss of accuracy is successfully developed.
- The reduced-order model was then utilized together with the sensor data by inference methods within the Bayesian paradigm to localize, characterize and quantify the damage parameters.

Interphase modelling

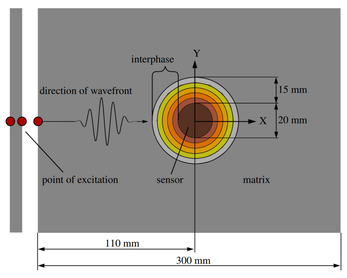
- A sensor matrix interphase is designed, by adding tungsten particles to the uncured resin, where the content of tungsten particles varies in the radial direction
- Radial distribution which can be approximated by a quadratic or a cubic function yields (i) reduce reflections from the sensor and (ii) lead to an amplification of the measured sensor signal.



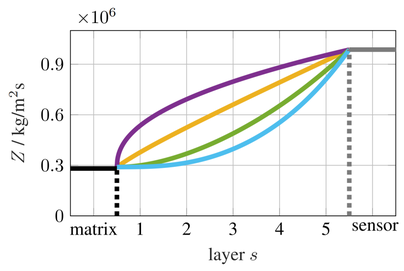
Comparison dispersion curves



Parametric model-order reduction



Interphase modell



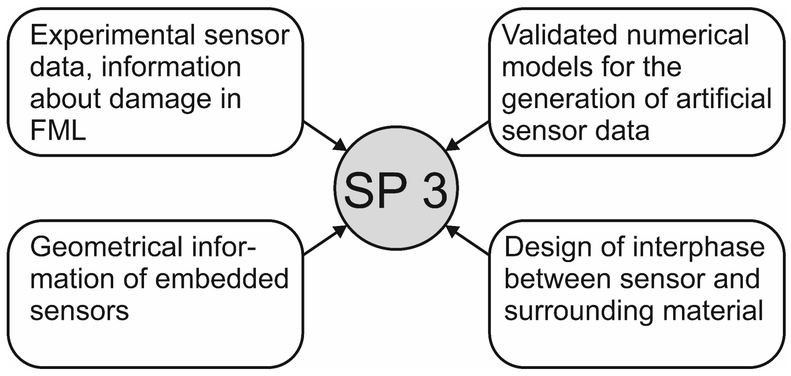
amplitude difference / %

	reflection	transmission
linear	−78.9	−3.7
square root	−63.4	−8.4
quadratic	−91.9	+1.8
cubic	−86.5	+4.2

Interphase design and resulting amplitude difference

Added value for the research unit

- Main wave propagation characteristics of GUW in FML
- Interaction of wave propagation with artificial damage
- Reduced parametric numerical model for use within the probabilistic framework
- Damage identification by Bayesian paradigms
- Knowledge about optimal senor interphase design
- Synthetic sensor data for experimental validation and model-free approaches



SP 3 within the research unit

Ultrasonic Monitoring of Fibre Metal Laminates Using Integrated Sensors
Research Unit FOR3022