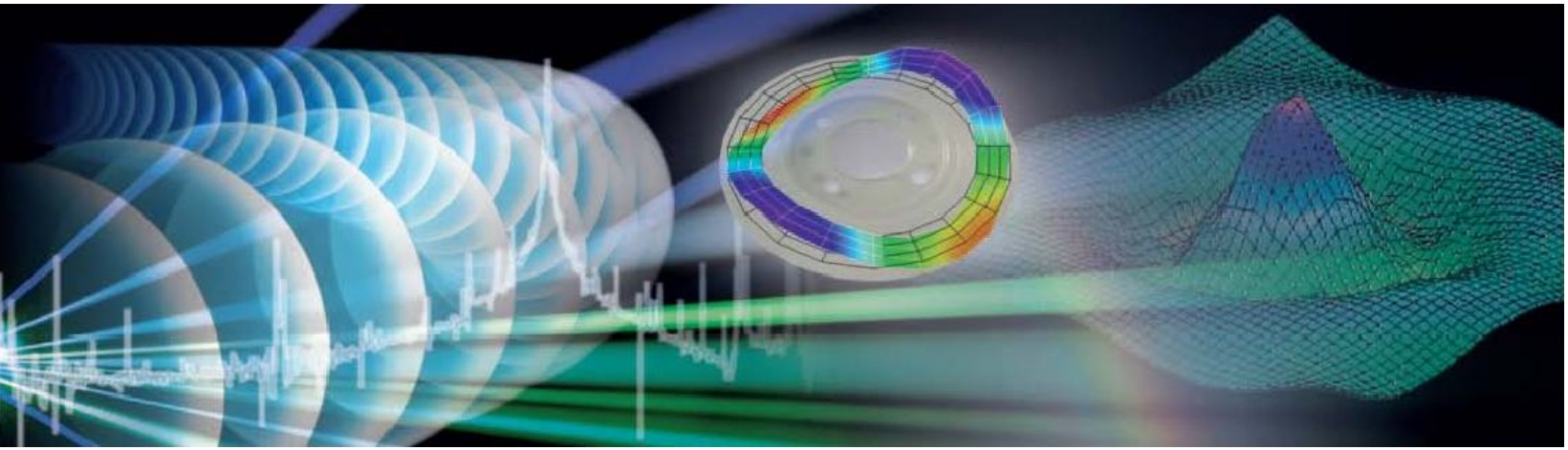
Potential for Automation in Modal Testing



by utilizing pre-test simulation and robotized non-contact vibration sensors

Joerg Sauer

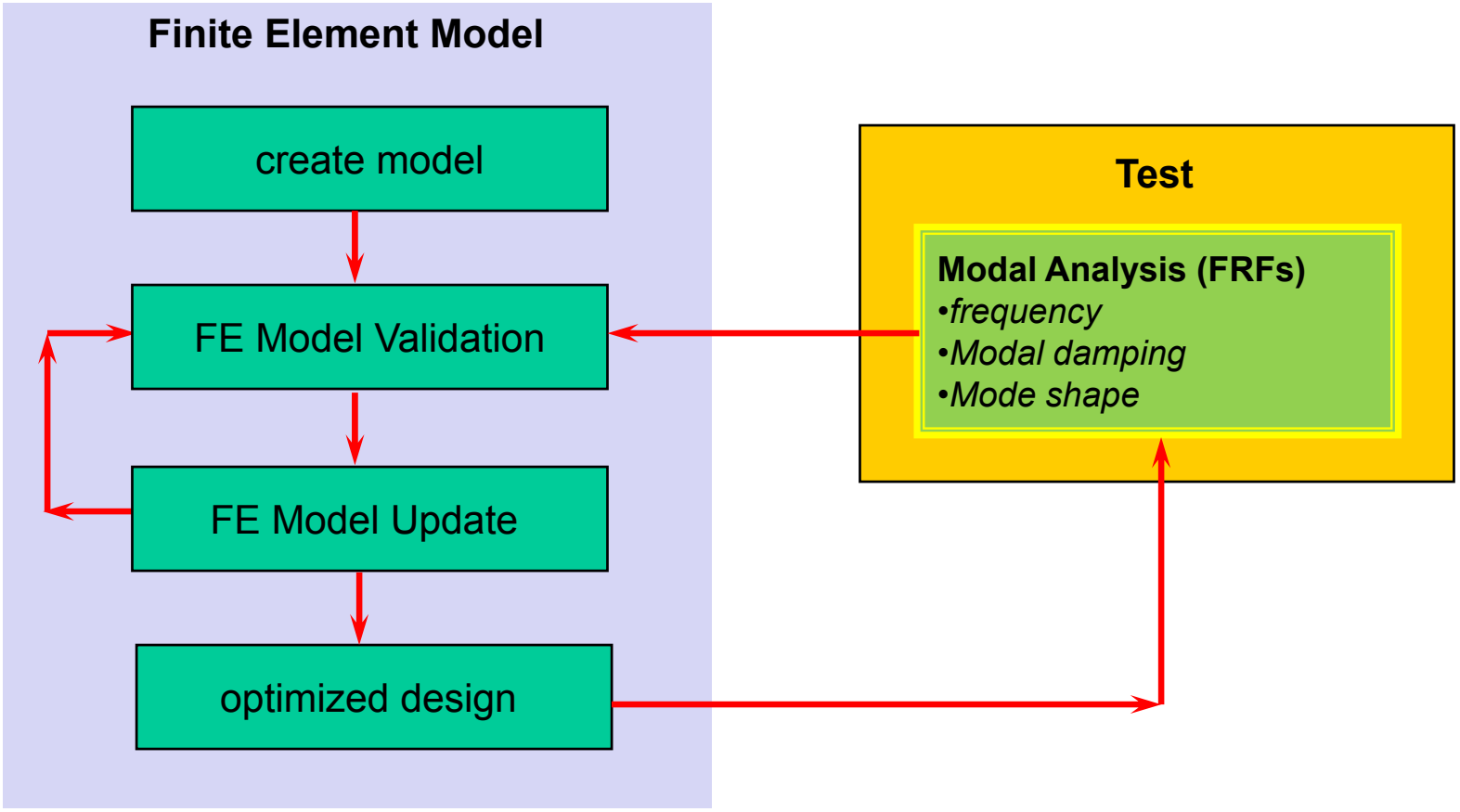
How to Achieve Increased Efficiency?

- Automate recurring tasks
- Use production means to capacity

- Optimize Time-To-Market
  - parallelize
  - reduce iterations

- Use closed data workflows

Process in Modal Testing



Requirements for Tests

- Unknown parameters for simulation
  - material properties
  - damping
  - stiffness in joints and bonds
  - tolerances model - prototype
- limited accuracy of FE model
  - complexity and calculation time
- Time effort for model modification

⟶ Test are required for a proper model

Workflow Modal Test

Accelerometers

- identification of measurement locations (manually)
- setup
  - n x: Attach accel.'s & dummy masses
  - n x: Route cabling
  - n x: Check for cross wiring and sensor integrity
  - n x: Correct local coordinate system: Euler angles
  - n x: Check phasing
  - 1 x: Set up measurement system
- 1x perform measurement
- move, retest and remove
  - n x: sensors and cables
  - n x: dummy masses
- results: FE model update

Automated (RoboVib)

- load geometry from FE
  - define meas. locations
  - simulate robot positions
- setup
  - 1 x: Define object coordinate system
- perform measurement
- results: FE model update

LAB TIME — sequential

OFFICE TIME — parallel

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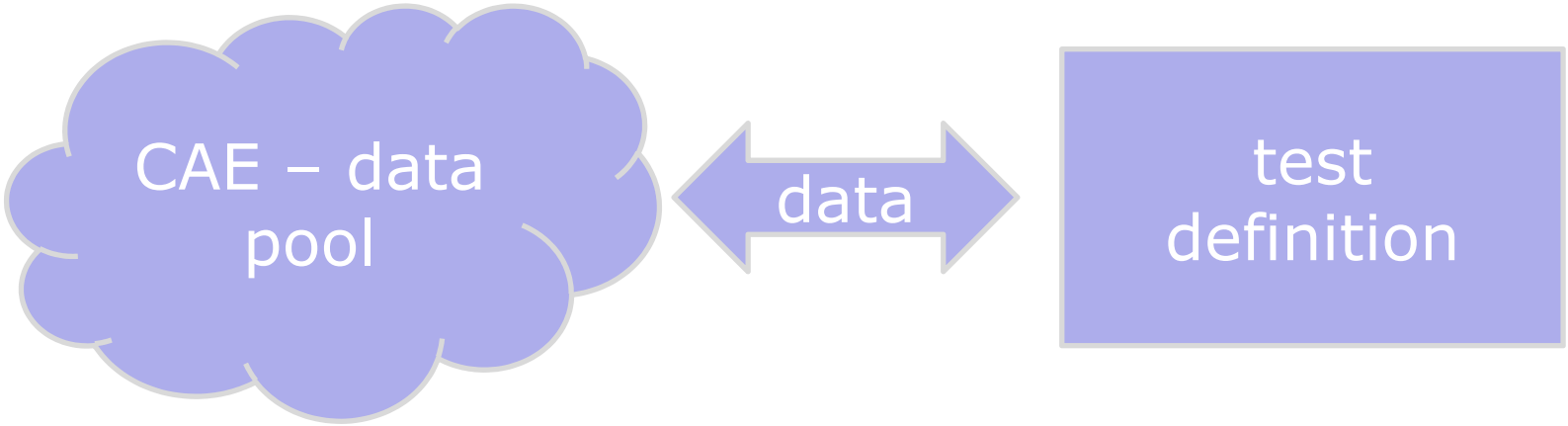
Virtualization of the Test Set-Up

- identification of measurement locations (manually)
- setup
  - n x: Attach accel.'s & dummy masses
  - n x: Route cabling
  - n x: Check for cross wiring and sensor integrity
  - n x: Correct local coordinate system: Euler angles
  - n x: Check phasing

- Use FE model
  - ➲ derive measurement grid
- Virtualize sensor mounting/cabling
  - ➲ optical vibration mapping
  - ➲ robotic repositioning

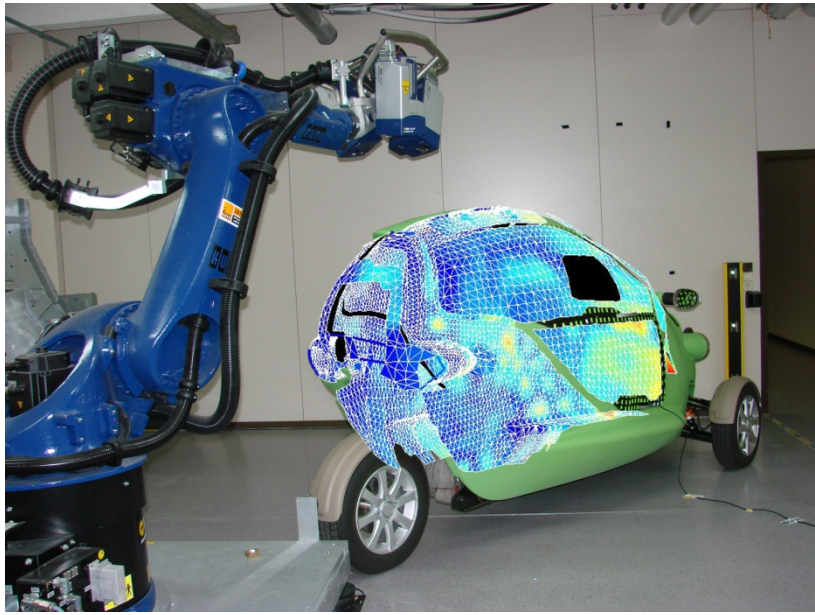
Why measuring non-contact?

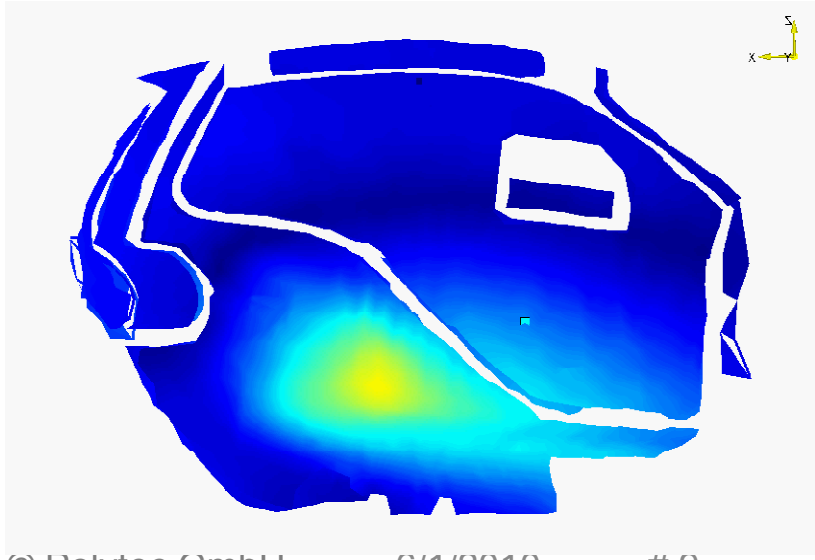
- „Automate recurring tasks”
  - define location ➲ use FE data grid
  - mounting sensors ➲ virtual definition
  - measure orientation ➲ 3D alignment



Body: Electric Car

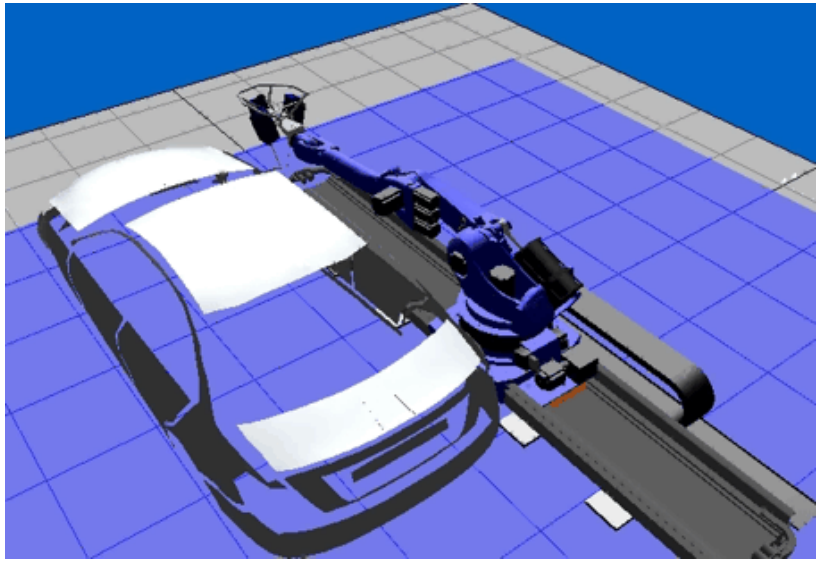
- SAM
  - Cree AG, Switzerland
- Modal test
  - 4300 points; 12900 DOF
  - Excitation: shaker
  - Duration:
    - set-up 2h
    - measurement time 3h

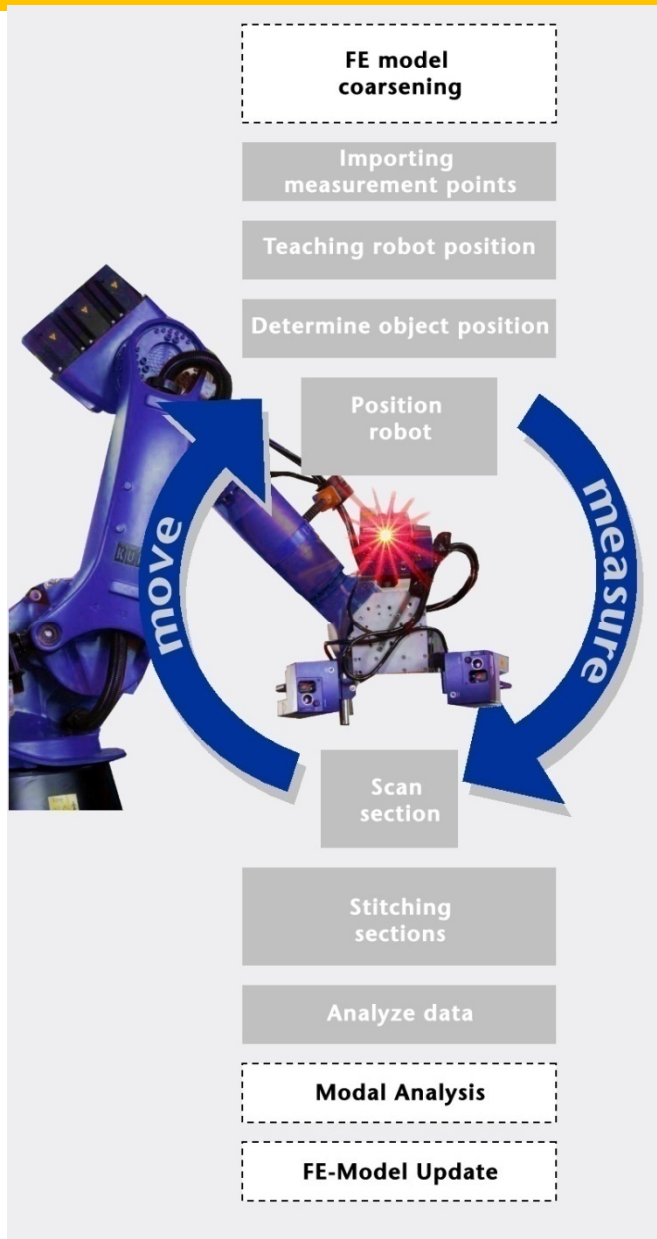




New Workflow - 1

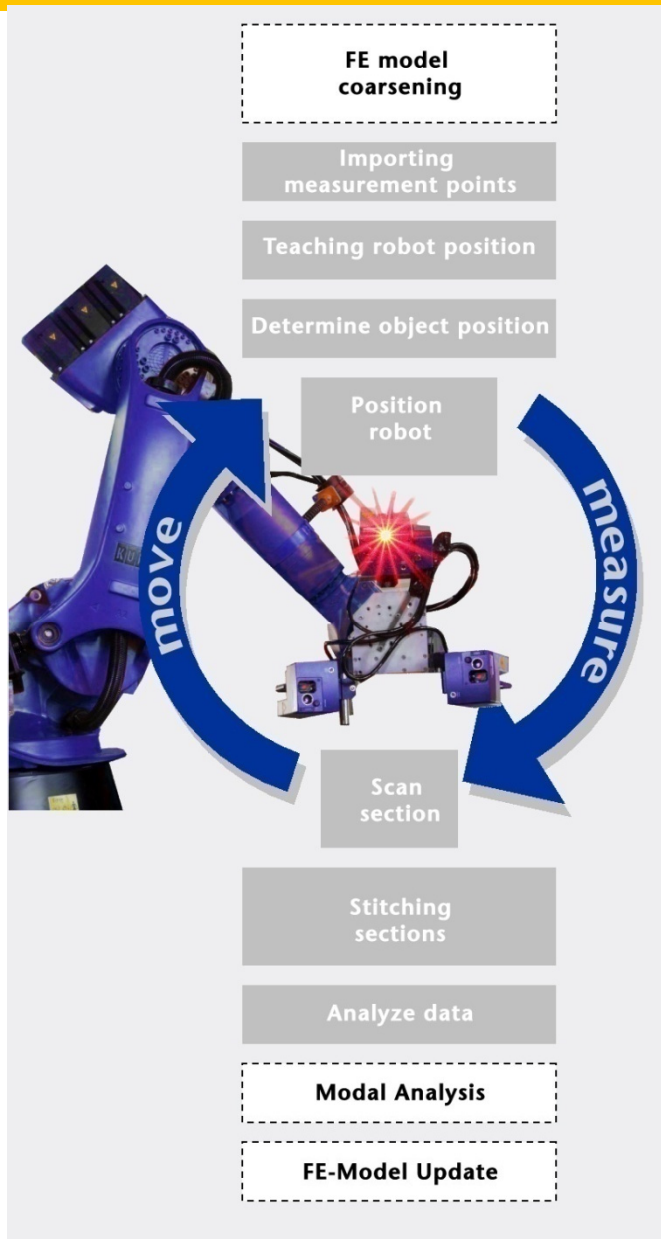
- robot program:
  - created off-line from model
- measurement locations and orientations are predefined





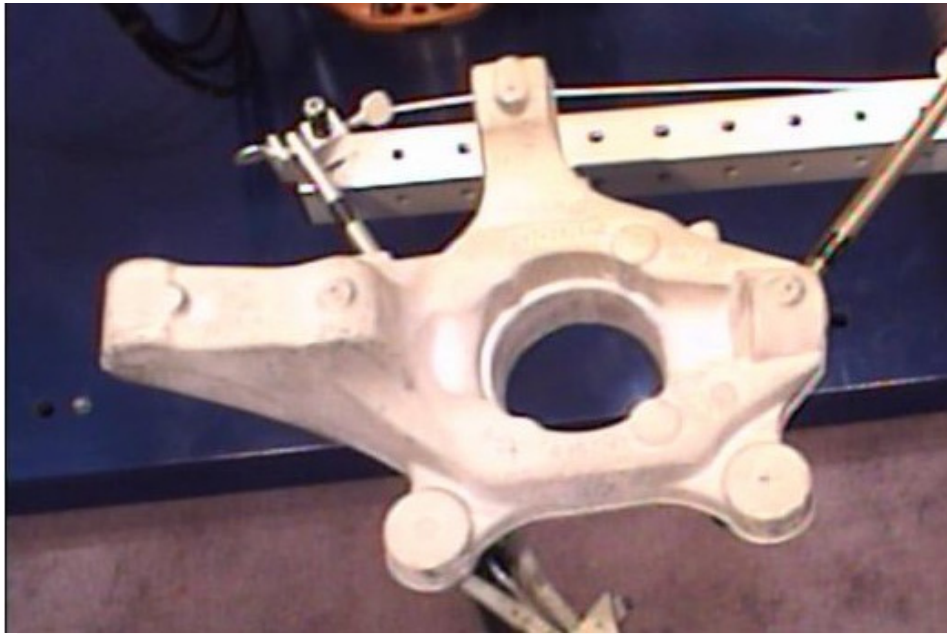
New Workflow - 2

- robot supported scanning
  - RoboVib
- data linked to the FE nodes in the predefined coordinate system
- closed CAE data workflow



Optical Measurement

- enables automation
  - virtual point definition
  - non-contact, unaltered condition
- high data quality and density
  - better model update also at higher modes
  - FE nodes are used for point definition w/o interpolation



knuckle: results from measurement; 4416 DOF

Solution: Scanning Vibrometry

- non-contact
- point oriented and full field
- works with virtual points
- accepts robot mounting
- accepts FE geometries
- allows to work with object coordinate systems
- general properties
  - high resolution (frequency and amplitude
  - robust

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- Optimize Time-To-Market
  - parallelize
  - reduce iterations

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Why measuring non-contact?

- Use production means to capacity
  - instrumentation field ➲ offline preparation
  - manual instrumentation ➲ offline preparation
  - prototype for preparation ➲ prototype only for actual measurement
  - closing time ➲ measurement continues automatic

An Efficient Combination

- Industrial robots
  - established
  - safe
  - fast
  - off-the-shelf
- Scanning Laser Doppler Vibrometry
  - no physical contact to the object under test
  - allows simple robot programs
    - „enveloping“ trajectory sufficient
    - robot programs reused for other model series

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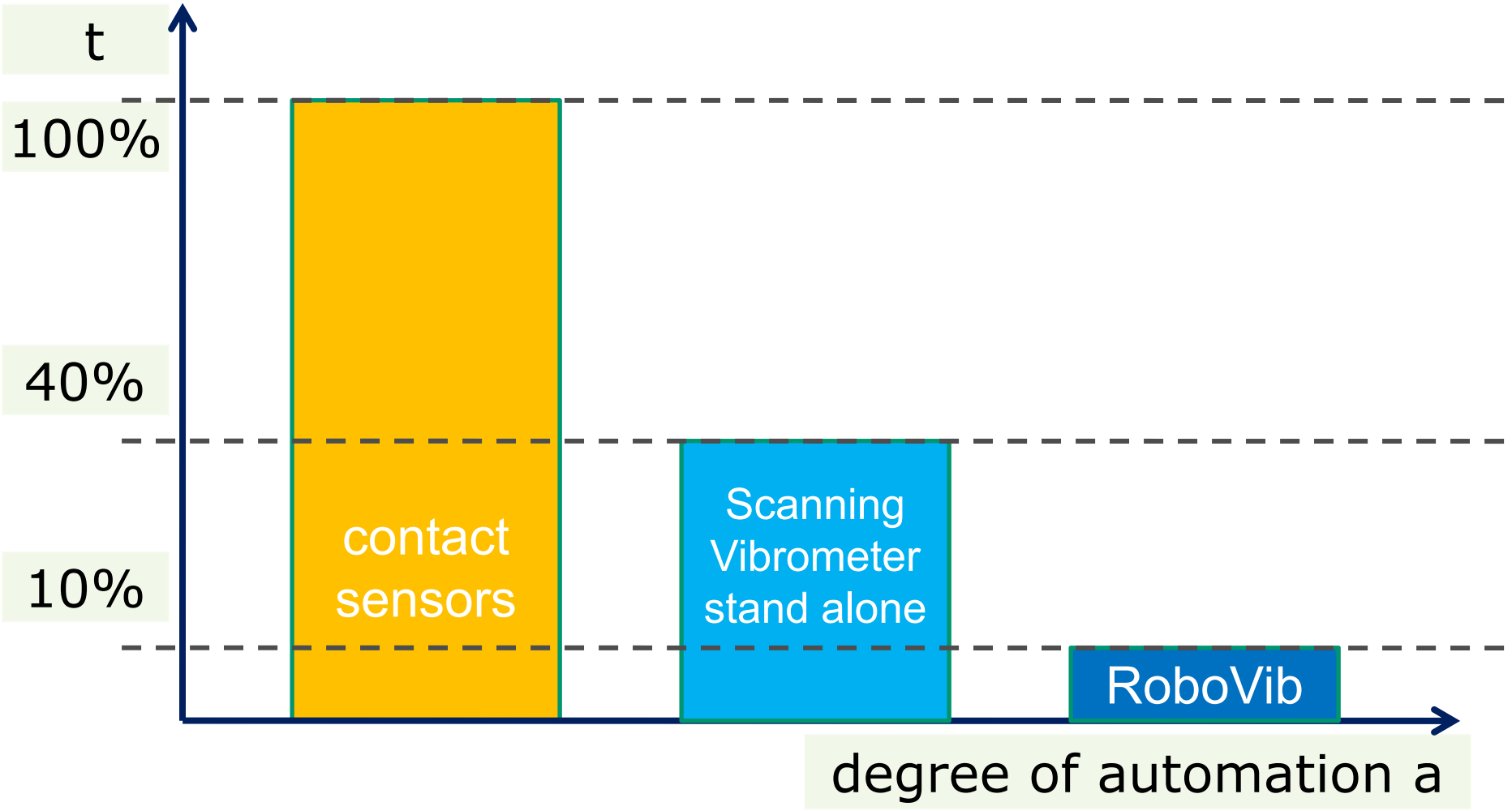
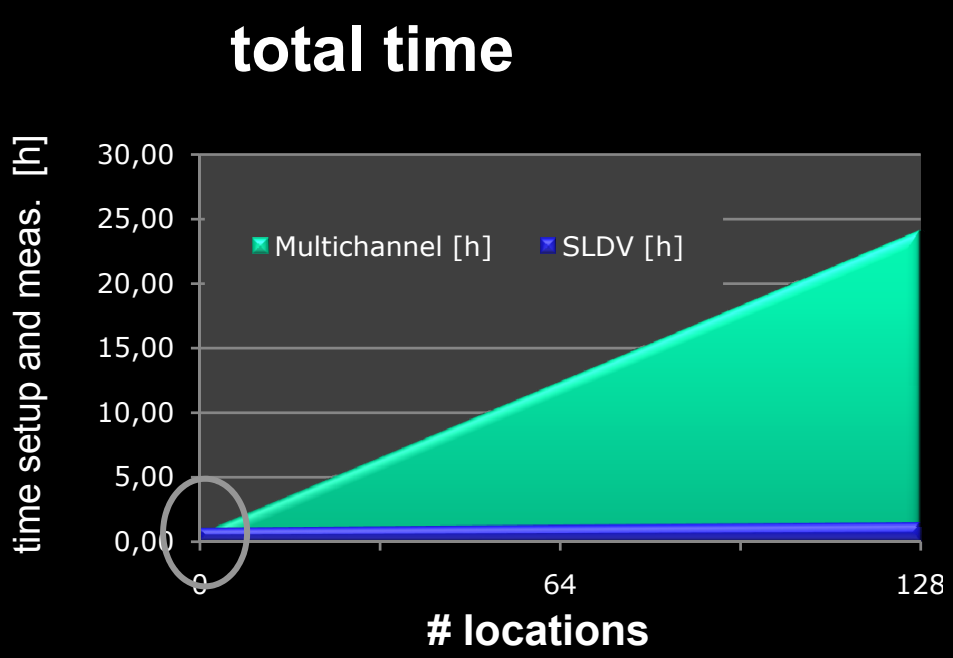
Why measuring non-contact?

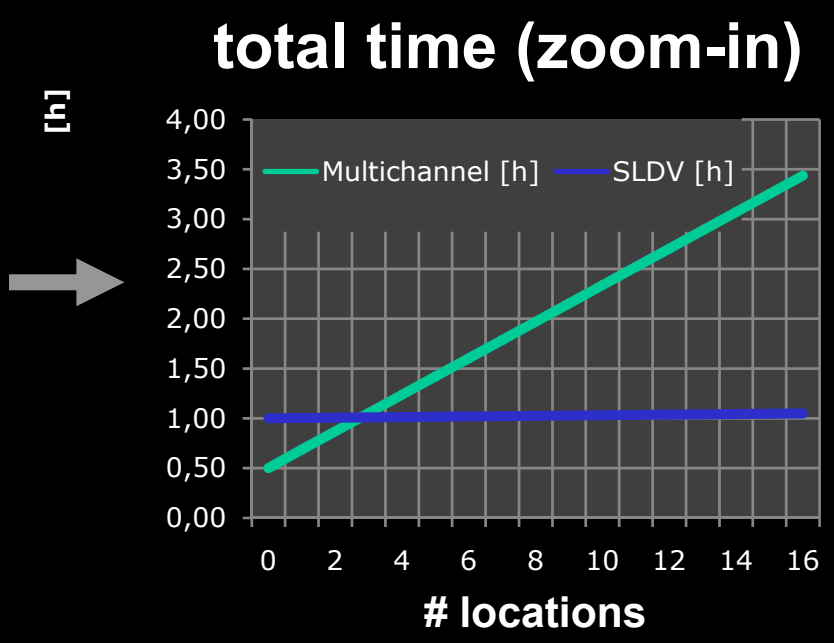
- Optimize Time-To-Market
  - parallelize
    - test preparation
      ➲ no need for a physical prototype
    - “instrumentation” of the prototype
      ➲ parallel to development using FE data
  - reduce iterations
    - limited data density
      ➲ high data density for model update at reduced costs and in less time

Total Test Time



Total Test Time





Properties:

128 locations = 384 DOF;
200Hz @ 0.25 Hz (800 FFT lines)
10 averages, 50% overlap;

Meas. time:	20 s
System setup	30 min
time per sensor	5 min
dummy mass applic.	1 min

Conclusion and Outlook

- Non-contact methods open the door to full automation
- Automation allows a better use of resources
- Virtualization of the test preparation allows parallel processes
- Robotics and Laser Vibrometry as a efficient combination