

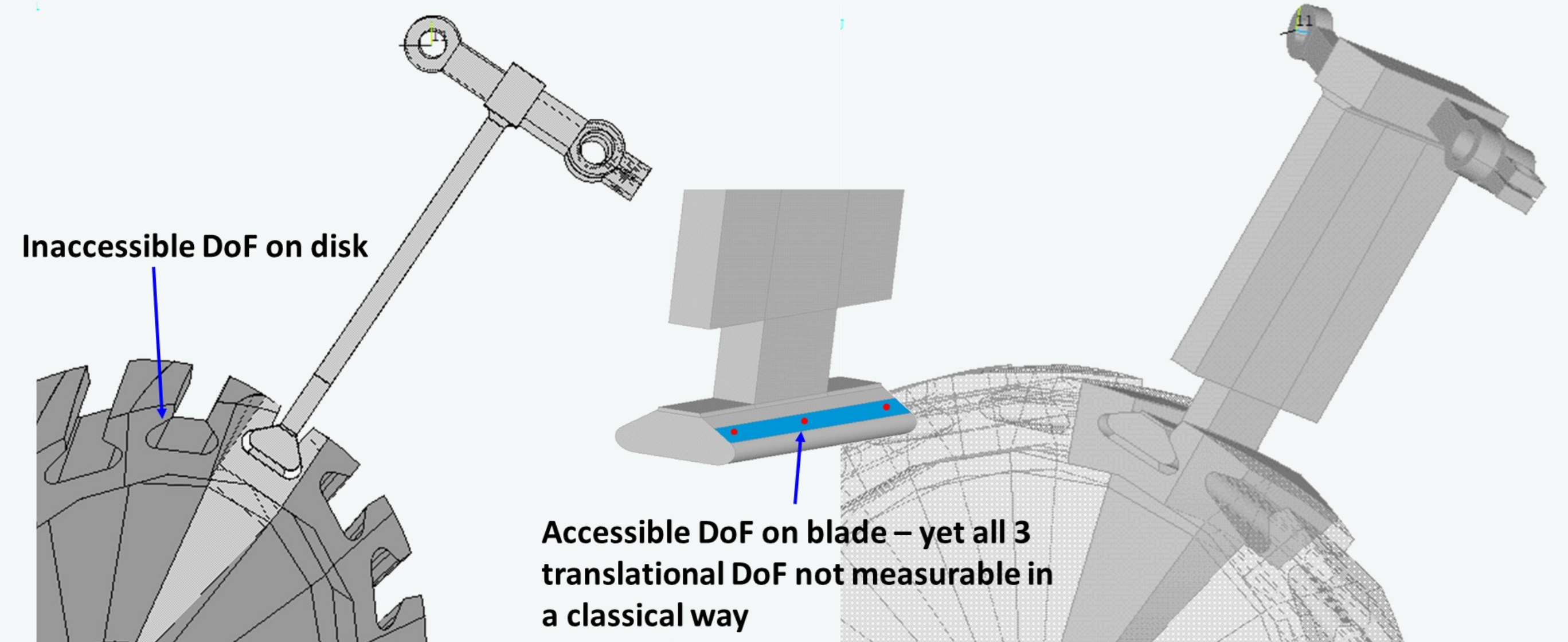
Experimental Joint Identification by SEMM Decoupling in A Bladed-Disk

RESEARCH OBJECTIVE

To experimentally identify and characterize the blade-root joints of a bladed-disk

KEY CHALLENGES

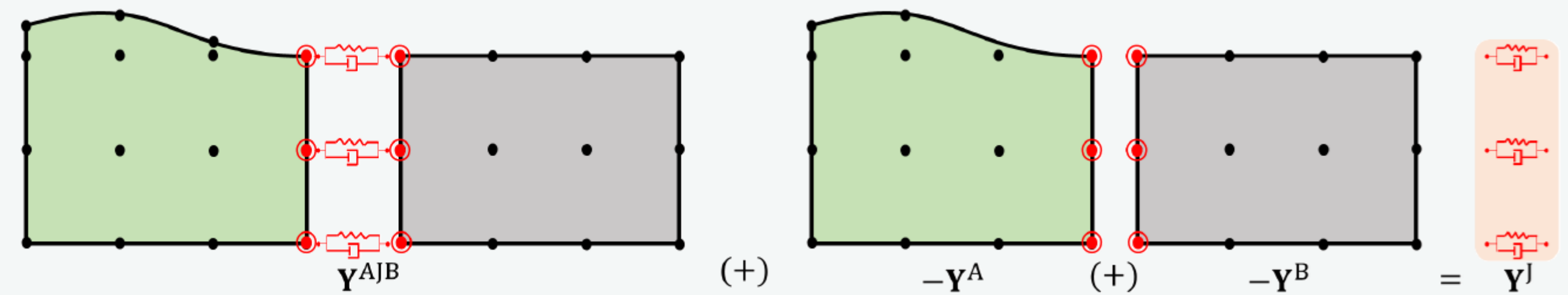
1. Inaccessibility of joint degrees-of-freedom (DoF) in assembled system
2. Inaccessibility of interface DoF in unassembled subsystems
3. Difficulties in collocated DoF set (Drive points FRF)
4. Problem in acquiring rotational interface DoF
5. Noise polluted FRF inversion



Joint Identification by Classical Decoupling

In frequency based substructuring (FBS), decoupling known subsystems from a coupled subsystem gives the joint flexibility FRF

$$\bar{Y}^J = Y - YB^T(BYB^T)^{-1}BY, \quad \text{with} \quad Y = \begin{bmatrix} Y^{AJB} & & \\ & -Y^A & \\ & & -Y^B \end{bmatrix}$$

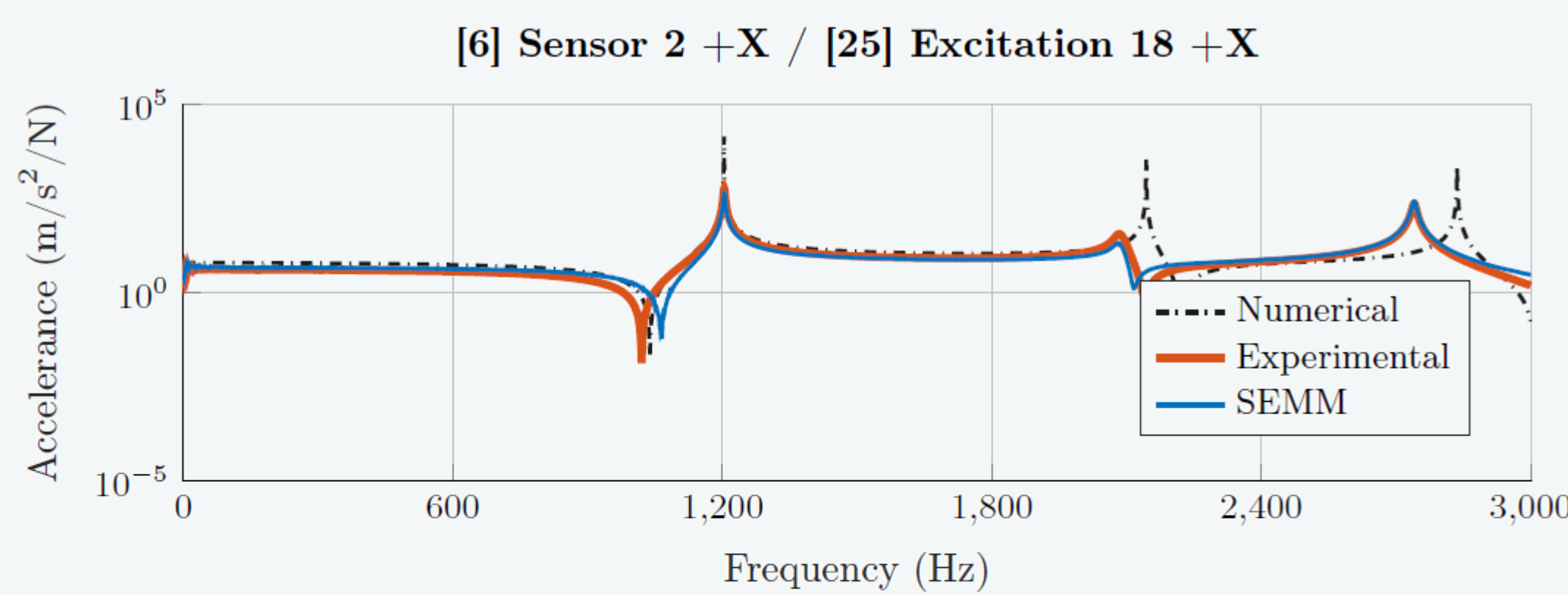
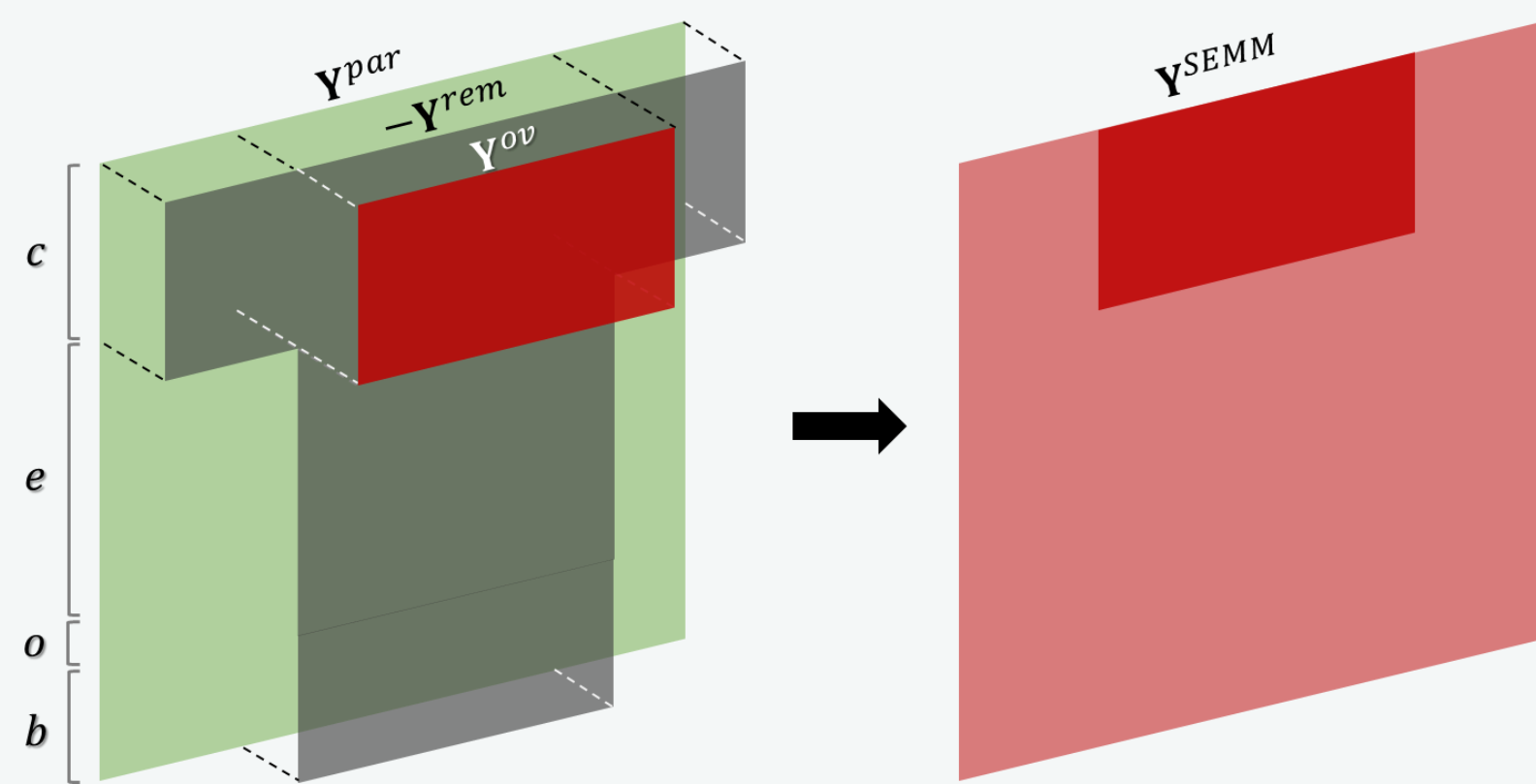
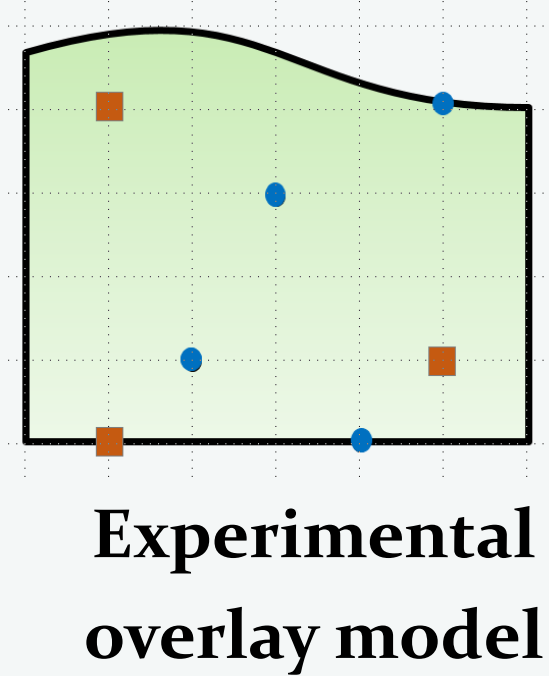
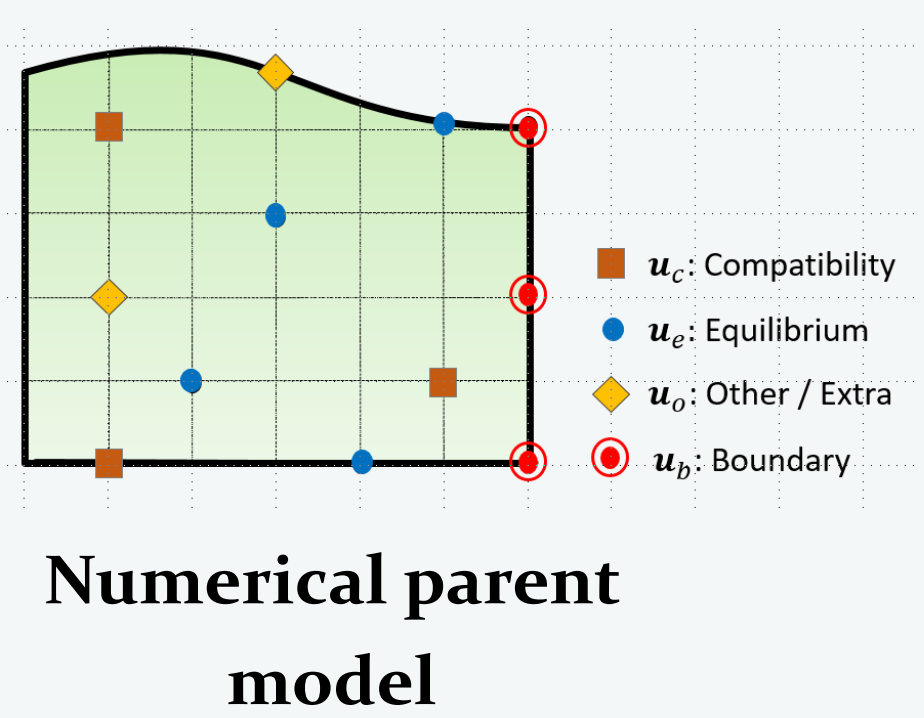


Because of the stated challenges, especially the interface DoF inaccessibility, we use an expansion technique called System Equivalent Model Mixing (SEMM)

SEMM

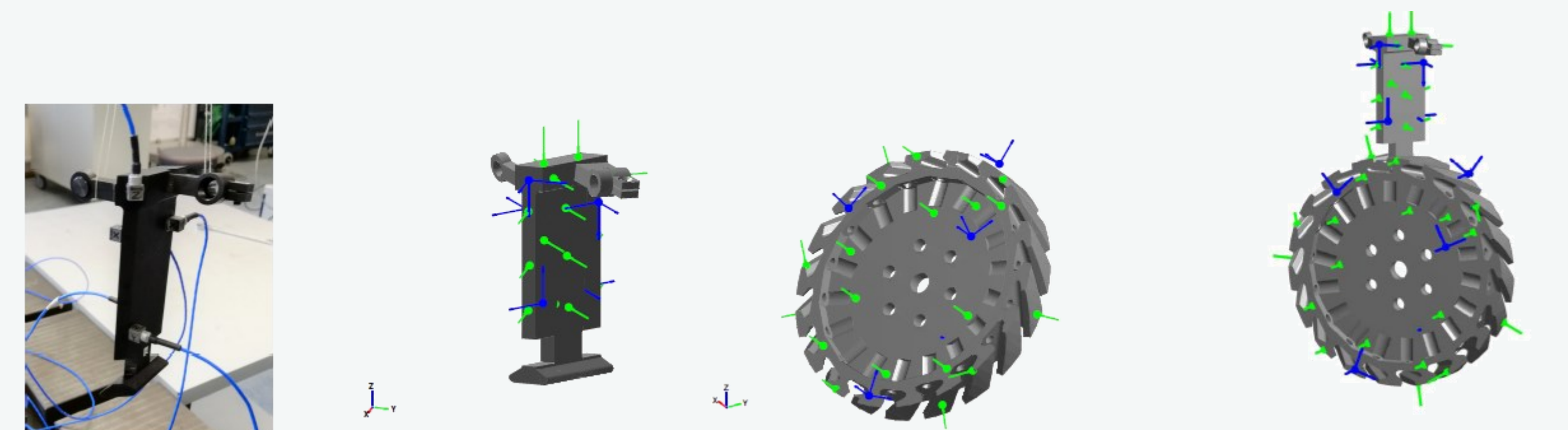
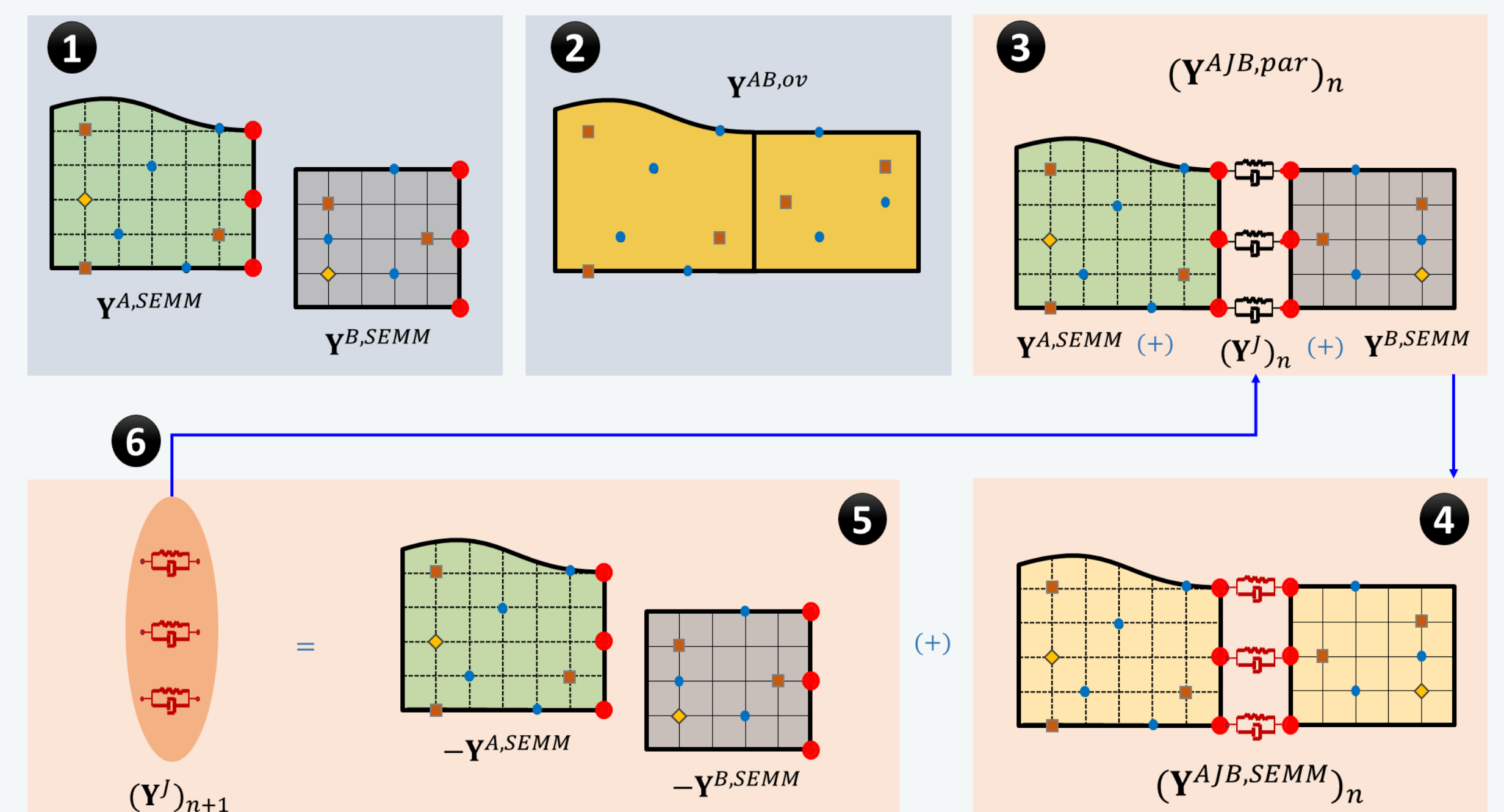
A method to mix different equivalent models of a structure that expands dynamics of an overlay model onto a parent model by a simultaneous coupling and decoupling of a removed model.

$$\bar{Y}^{SEMM} = Y_{gg}^{par} - Y_{gg}^{par} (Y_{cg}^{par})^+ (Y_{ce}^{par} - Y_{ce}^{ov}) (Y_{ge}^{par})^+ Y_{gg}^{par}$$



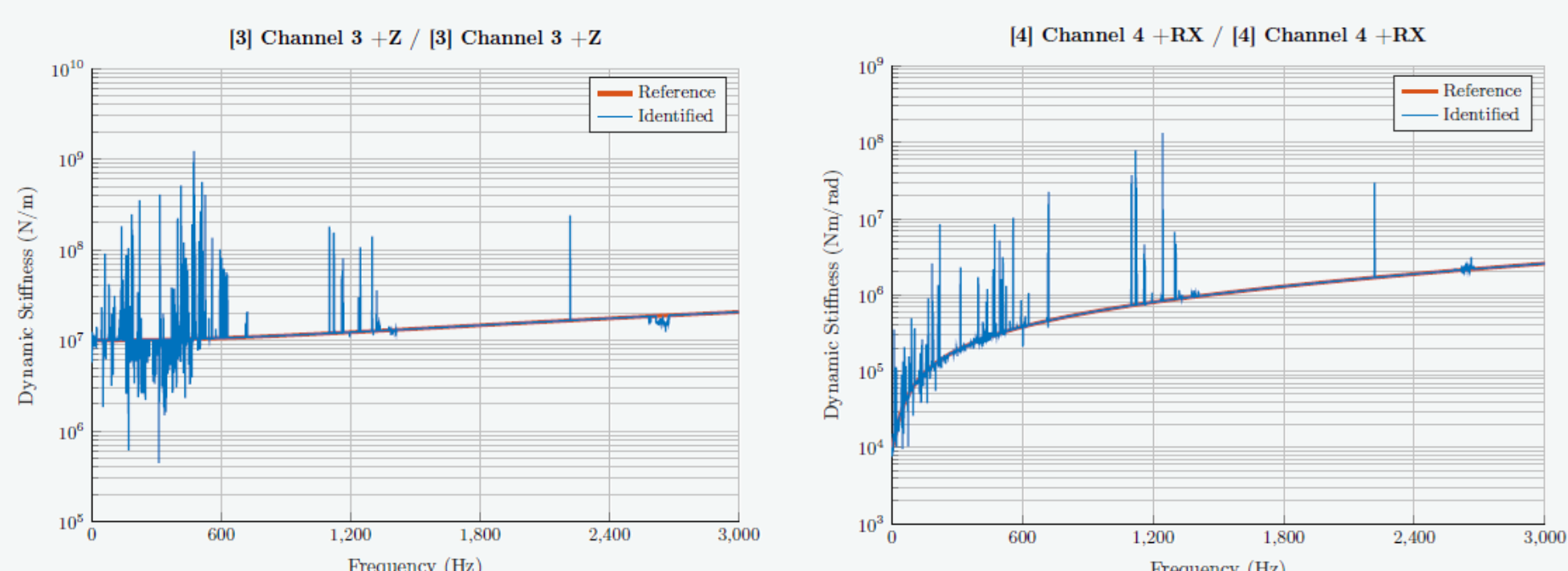
Joint Identification by SEMM Decoupling

In order to identify the joint by SEMM, the decoupling is performed iteratively until the expansion error $\epsilon = || (Y^{AJB,par})_n - Y^{AB,ov} ||$ is minimized.

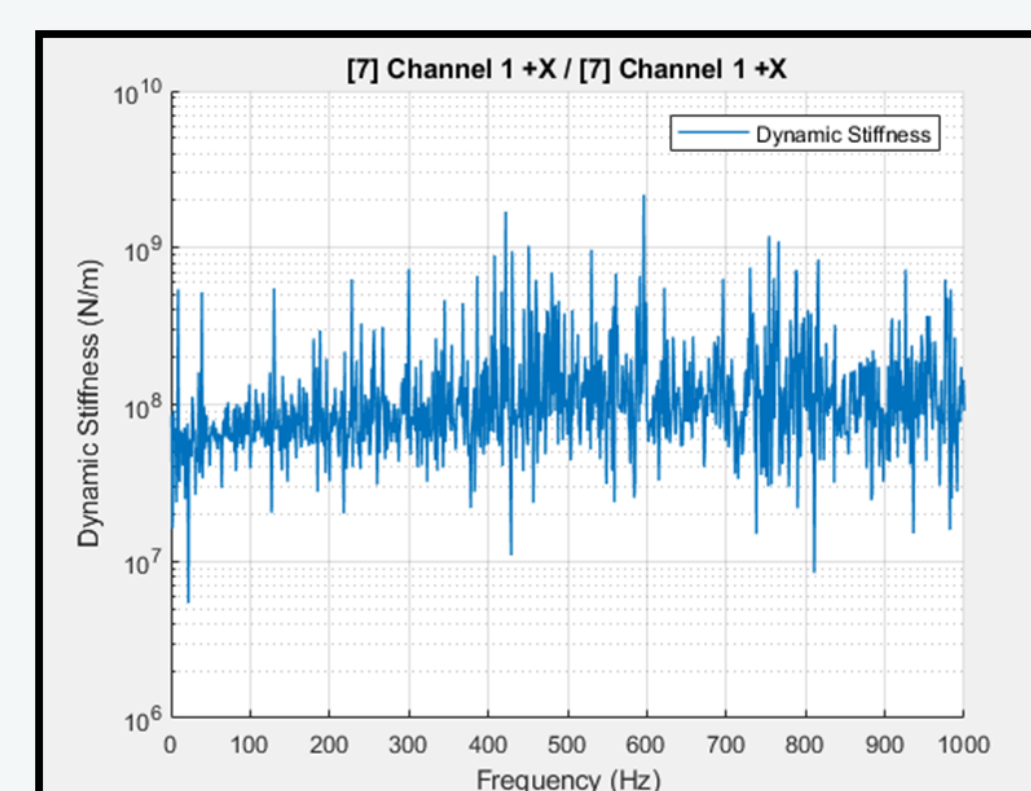


Validation of Identification by A Simulated Joint

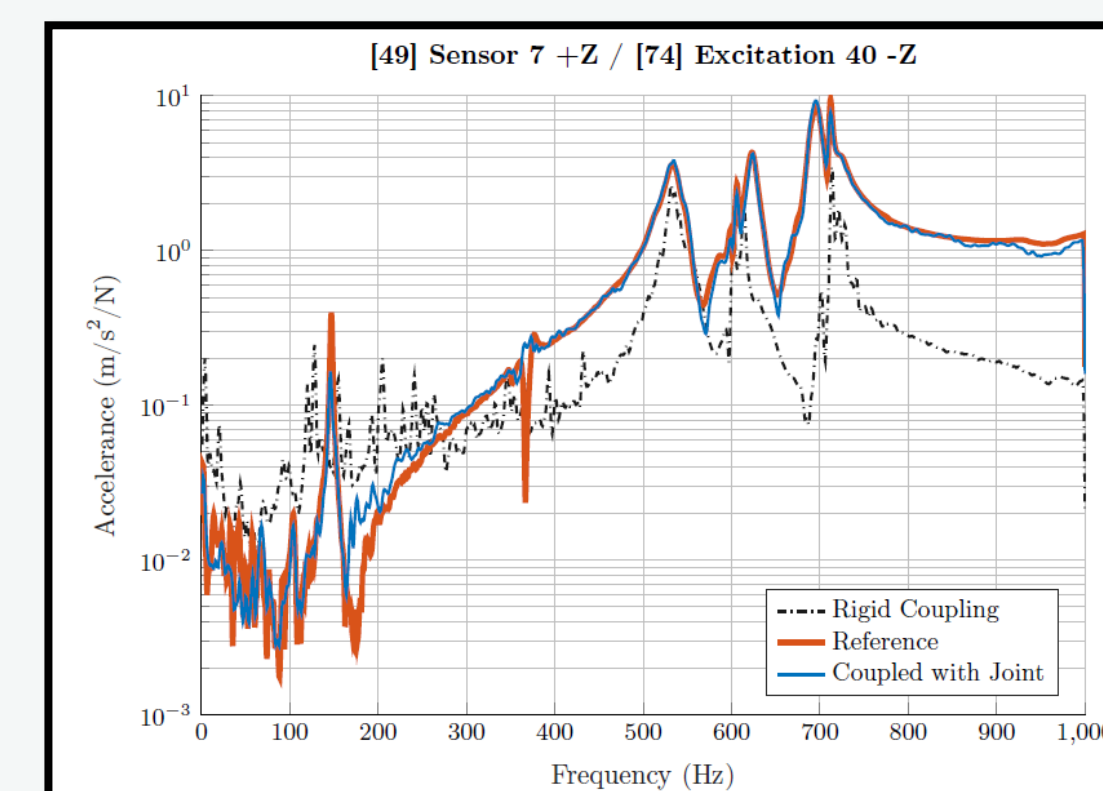
	Translational	Rotational
Stiffness Coefficient	1×10^7 N/m	1×10^4 Nm/rad
Damping Coefficient	1×10^3 Ns/m	1×10^2 Nms/rad
Mass Coefficient	5 g	5 gm^2/rad



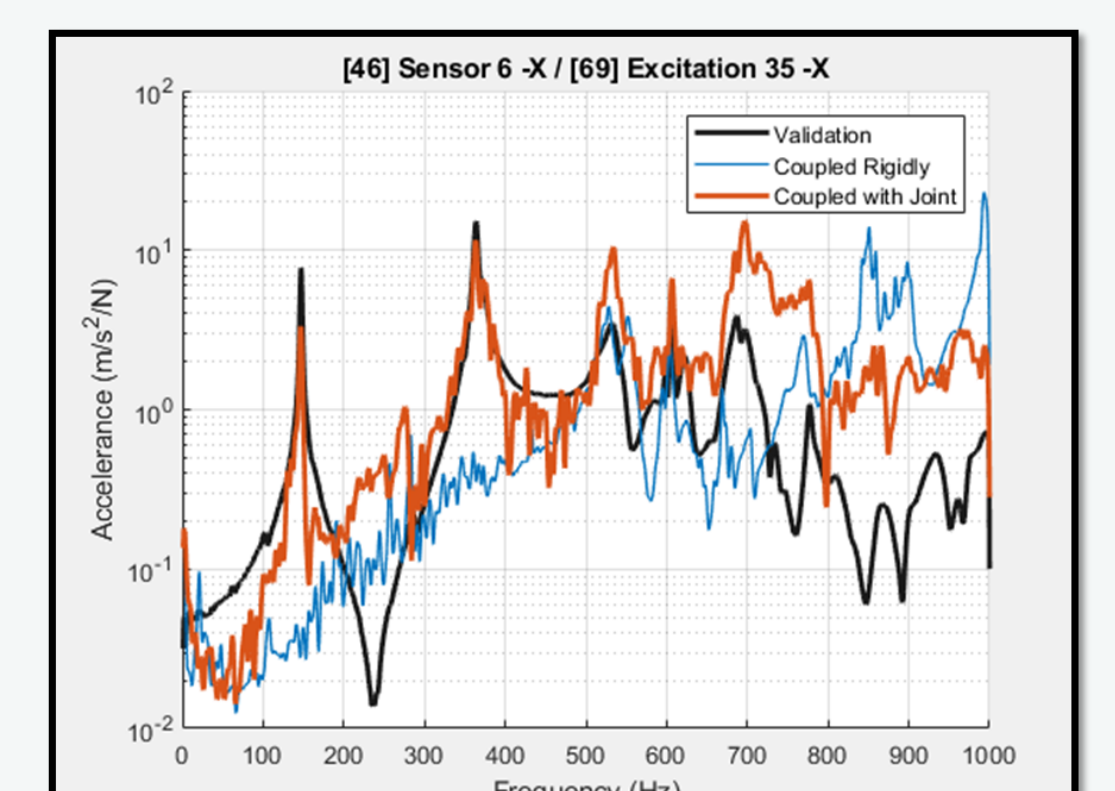
The Actual Joint Identification



Translational DoF



Agreement—all measurement channels included in the decoupling



In-situ Validation—excluded one response and one reference measurement channels included in the decoupling

Future Work

- Improve observability as well as expansion
- Identify all the blade-root joints—

Publications

- I. Saeed, Z., Klaassen, S. W. B., Furrone, C. M., Berruti, T. M., "Experimental Joint Identification Using System Equivalent Model Mixing in A Bladed-Disk" - Under Review
- II. Saeed, Z., C. M. Furrone, and T. M. Berruti, "Substructuring for Contact Parameters Identification in Bladed-disks." *Journal of Physics: Conference Series*. Vol. 1264. No. 1. IOP Publishing, 2019.
- III. Saeed, Z., et al. "A Test-Case on Continuation Methods for Bladed-Disk Vibration with Contact and Friction." *Nonlinear Structures and Systems, Volume 1*. Springer, Cham, 2020. 209-212.