Geographically distributed hybrid testing for wind turbine components using co-simulation

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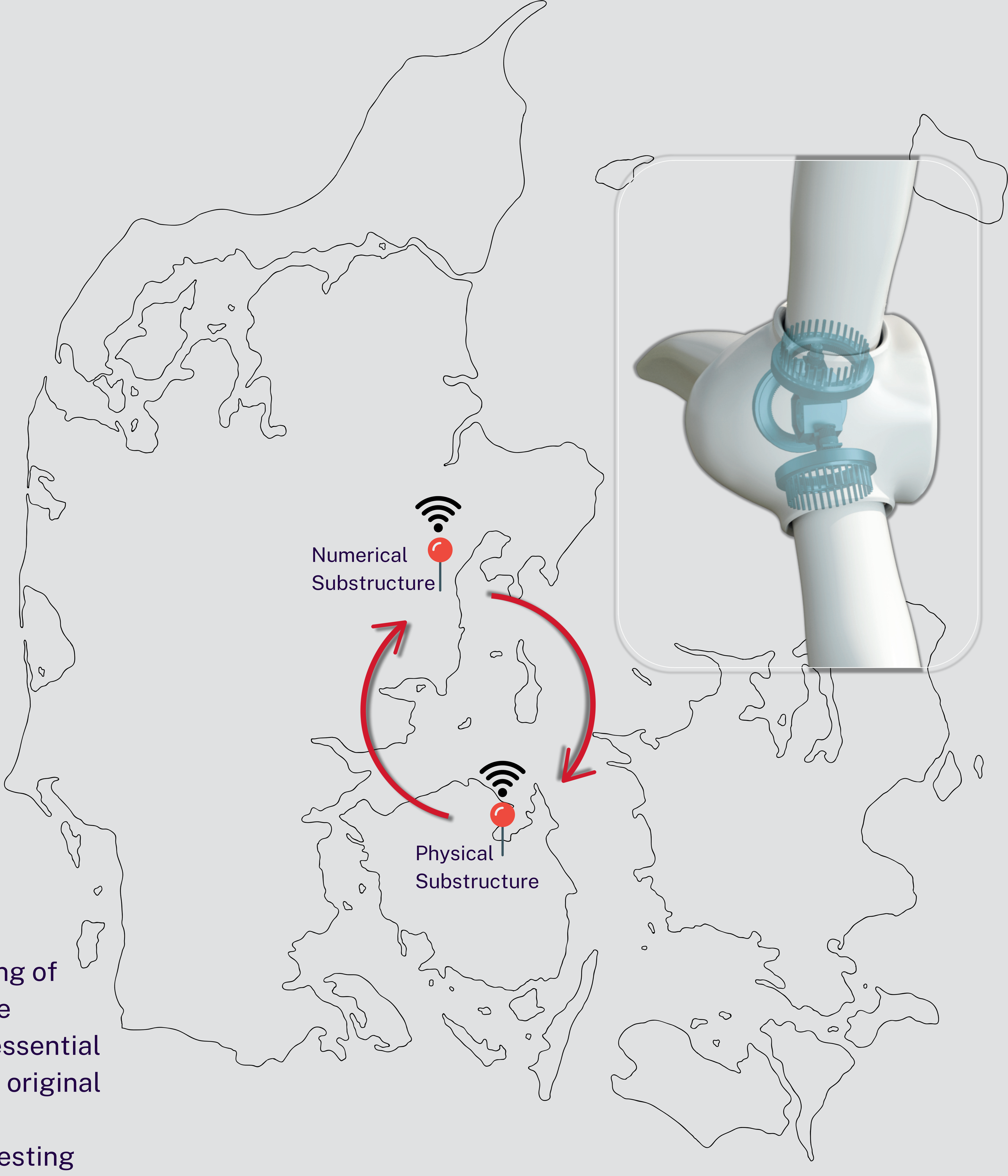
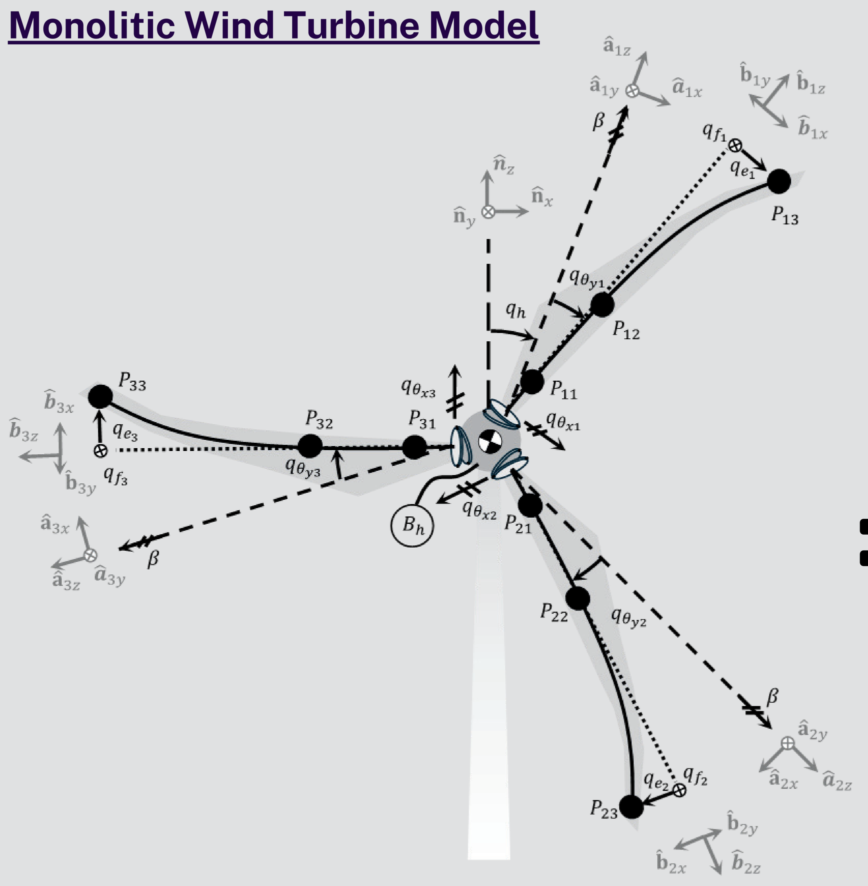


INTRODUCTION

Hybrid testing is an experimental approach that combines physical testing of critical structural components with the numerical model of the rest of the structure, enhancing performance evaluation. This method is becoming essential for developing and evaluating larger wind turbine components. However, original equipment manufacturers (OEMs) are often reluctant to share their computational models. To address this, we created a distributed hybrid testing platform using FMI-based co-simulation and Azure cloud services, demonstrated at the Force Technology Lindø Testing Facility, focusing on the **pitch bearing** as the experimental substructure.

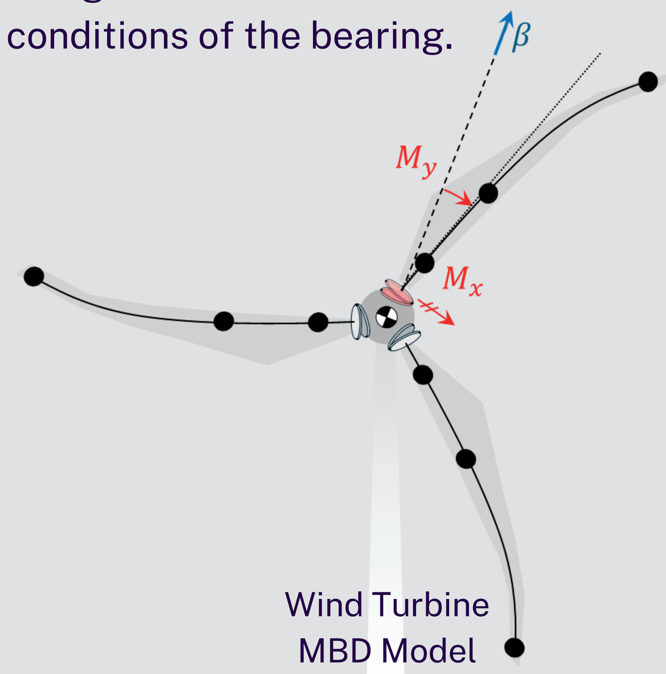
CASE STUDY

Monolitic Wind Turbine Model



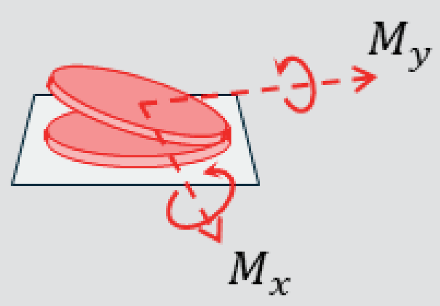
Numerical Substructure

The numerical model is a multibody dynamic simulation of the wind turbine created using **Kane's method**, which also computes the geometric transformations needed for the boundary conditions of the bearing.



Physical Substructure

The main component of the physical substructure is the pitch bearing, controlled by three actuators in the physical setup. The top actuators apply the bending moments (Mx and My), while the pitch actuator manages the pitching (β).

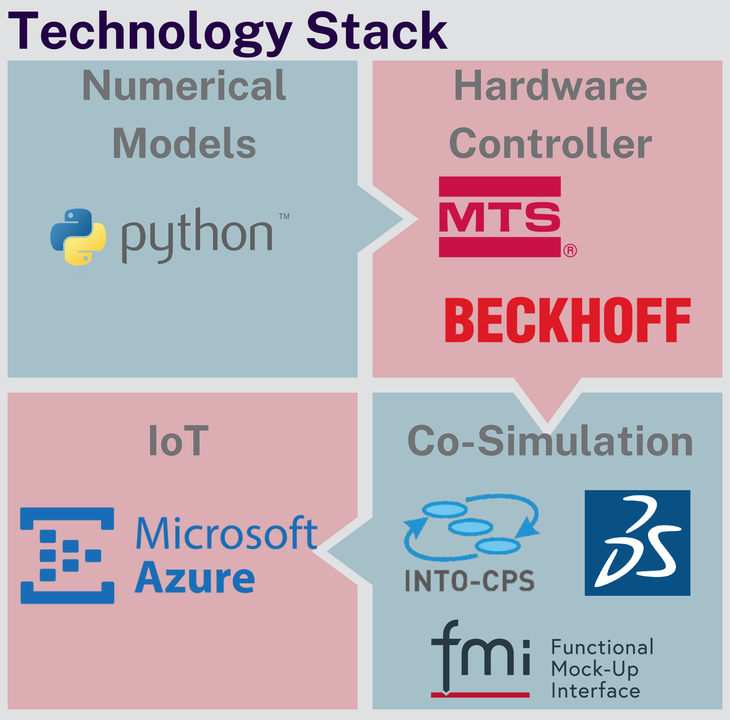


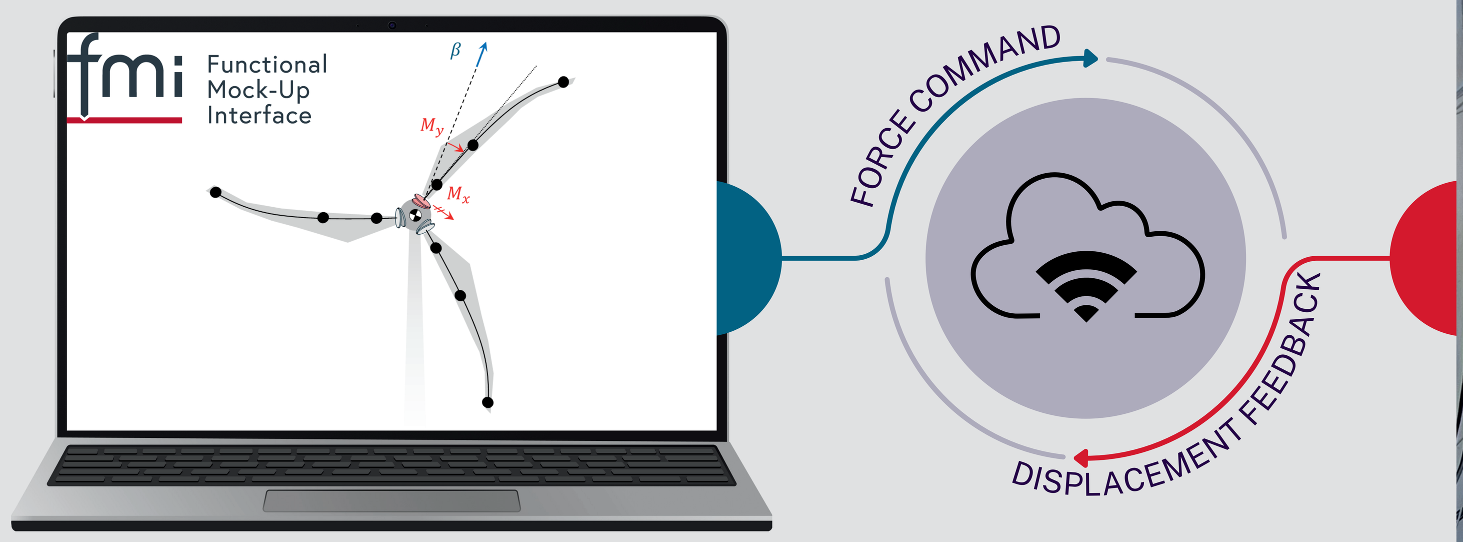
Pitch Bearing DOFs

HYBRID TESTING

The model computations were performed at Aarhus University (Aarhus, DK), while physical testing took place at Force Technology Lindø (Odense, DK).

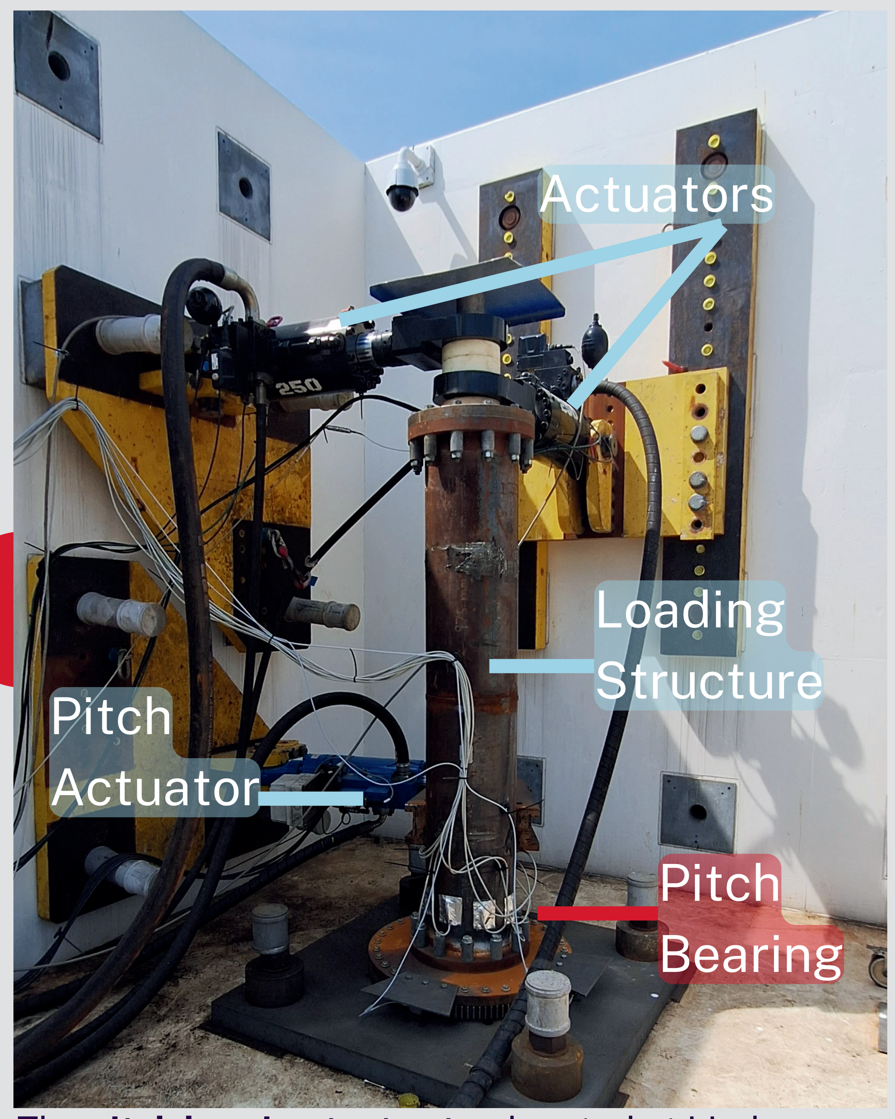
Technology Stack





Numerical substructure, wind loading and geometric transformations were prepared as FMUs for a standardized simulation interface.

Communication handled through Microsoft Azure for IP-secure hybrid testing.



The **pitch bearing test setup** located at Lindø Structural Test Facility of FORCE Technology.

CONCLUSION

We found that geographically distributed testing is feasible, secure, and robust, but not suitable for real-time applications. Additionally, Kane's method effectively couples physical and numerical models in a multibody dynamic context.

ACKNOWLEDGEMENTS

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R&D TEST SYSTEMS

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