A Standard Aeroelastic Definition of Wind Turbine Rotors

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1. Introduction

Wind energy has evolved into a large international industry involving major players in the manufacturing, construction, and utility sectors. Significant technological innovation has resulted in larger turbines and wind plants with lower associated costs of energy. However, the increasing importance of wind energy's role within the electricity sector imposes more requirements on the technology in terms of performance, reliability, and cost.

Meeting these system-level goals is a multi-disciplinary effort, requiring the coordination of diverse research groups and analytical capabilities. Over the last decade, a community of wind energy researchers and practitioners have developed software frameworks that leverages formal multi-disciplinary design, analysis and optimization (MDAO, Figure 1) approaches to tackle this system-level questions.

2. IEA Wind Task 37: Wind Energy Systems Engineering

Objectives and Outcomes

- Improve quality of systems engineering by practitioners through development of best practices and benchmarking exercises
- Promote general knowledge and value demonstrations of systems engineering tools and methods applied to wind energy RD&D

Target Audience

- Wind turbine OEMs, developers, owner/ operators, consultancies, and research community

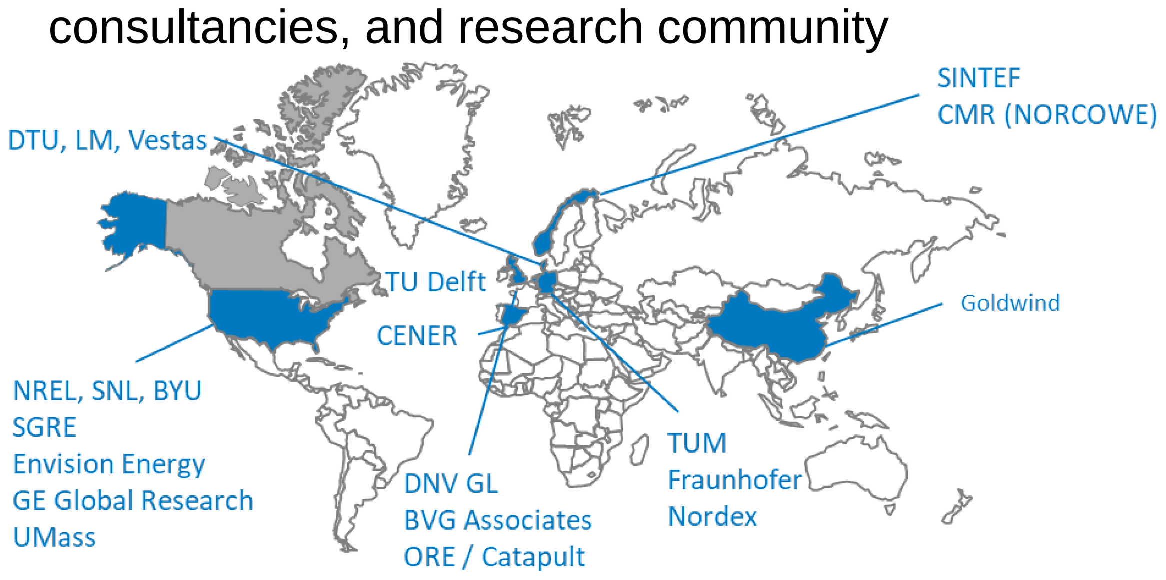

Figure 2: IEA Wind Task 37 Participants

Scope of this Project

- Provide coordination to enable collaborations, interactions, and comparisons (Figure 3)
- Develop an ***ontology*** to help standardize the representation of information that flows to and across MDAO workflows applied to wind turbine and plant design, operation and control

Ontology: A specification of a conceptualization, which provides an abstraction of all the knowledge, concepts, and objects, as well as the relationships between them, that exist within a domain

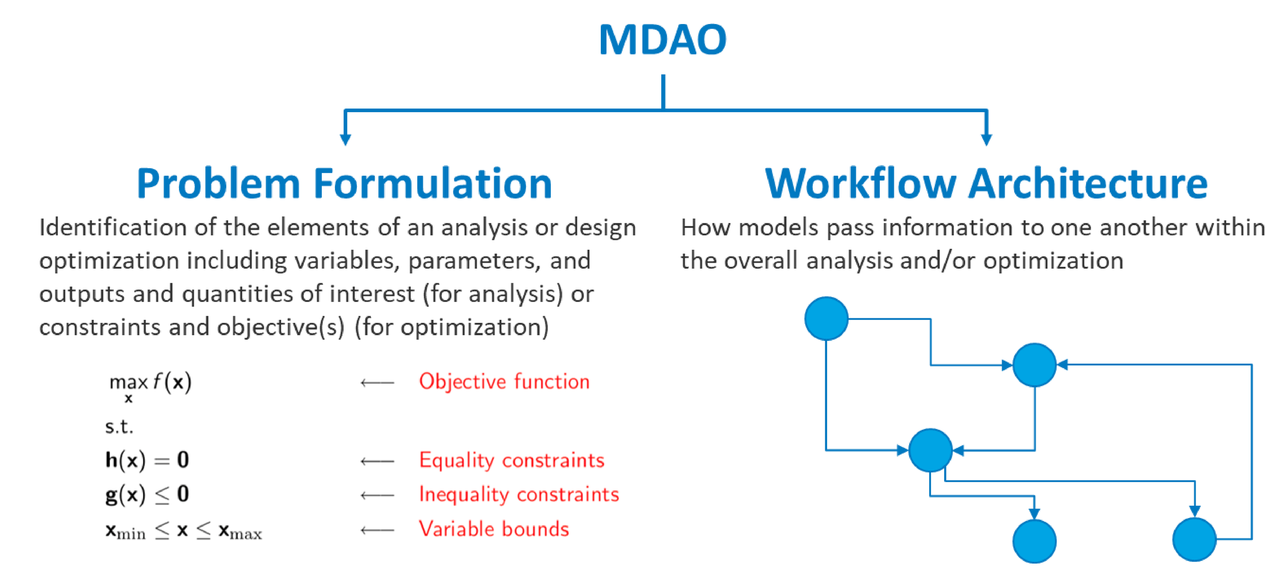

Figure 1: Core MDAO Concepts

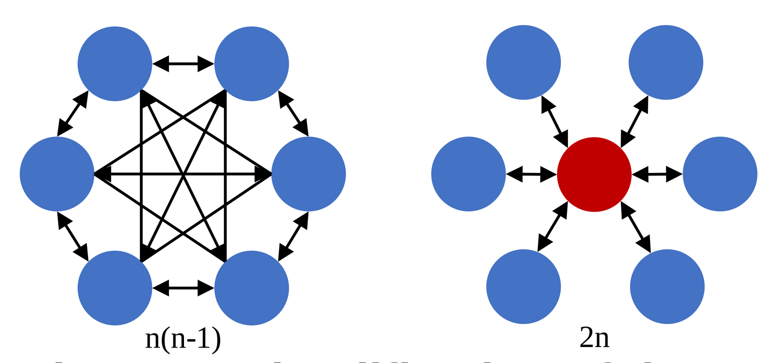

Figure 3: Simplification of data transfer through an agreed upon framework

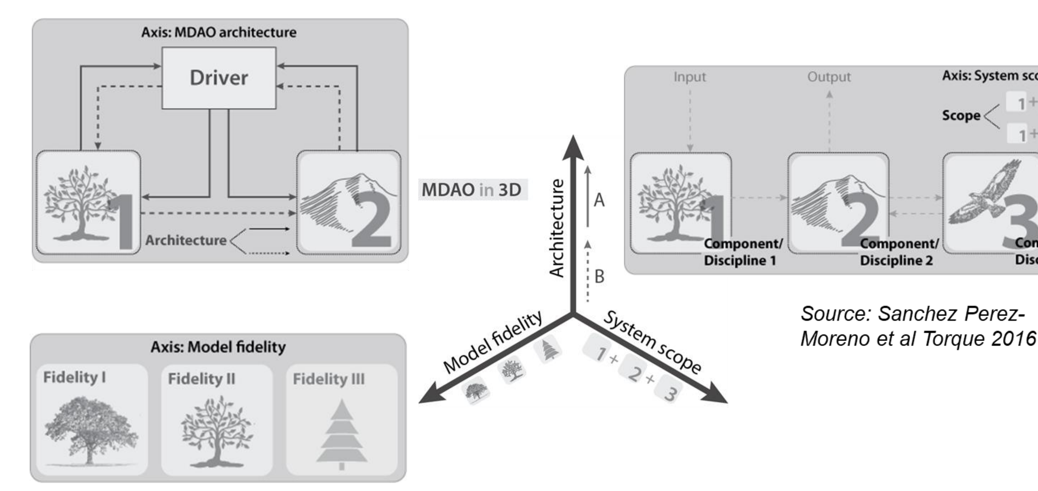

Figure 4: Challenge: Every model & workflow is different

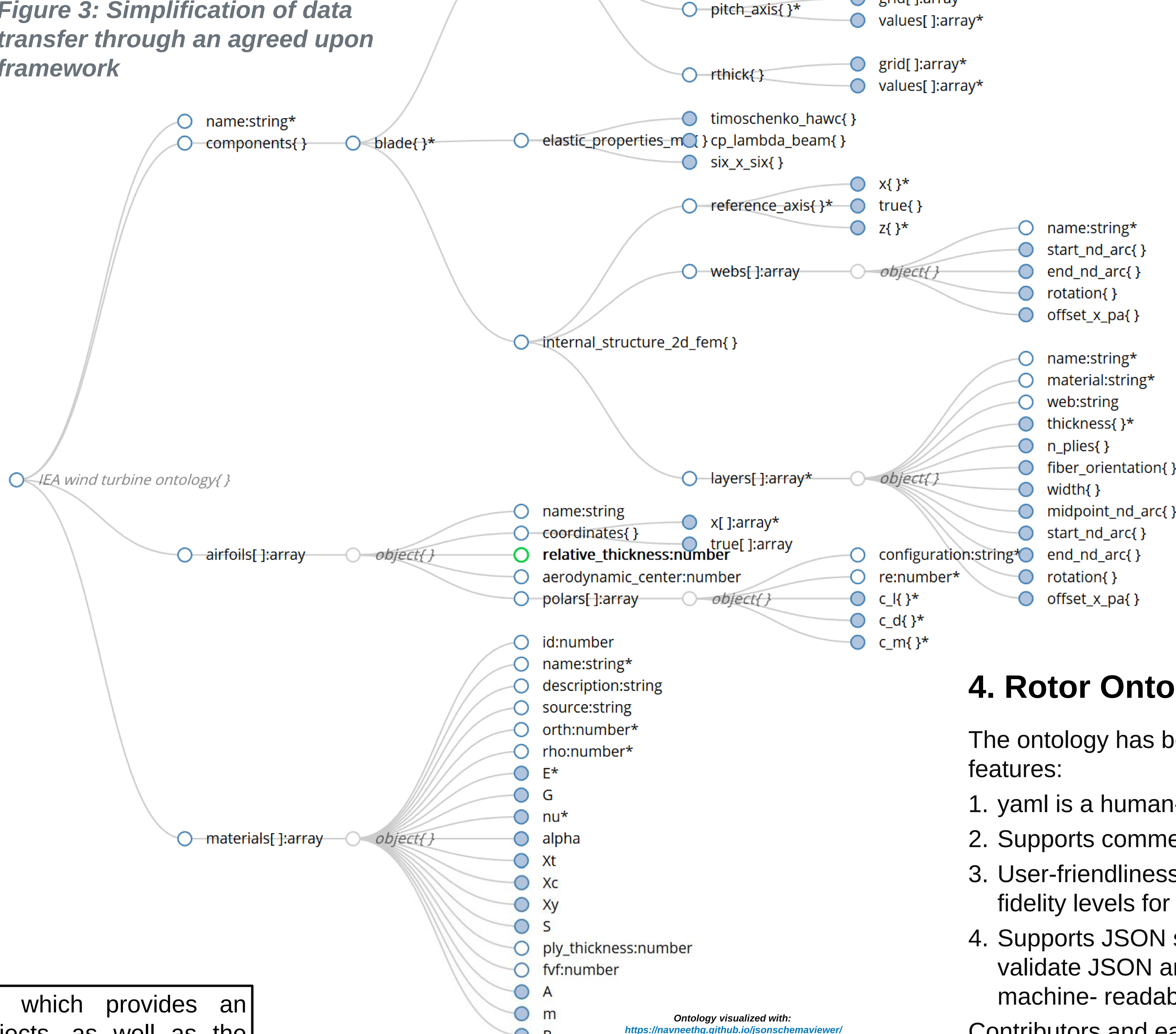

Figure 6: IEA Wind Turbine Ontology Data Structure

3. Development of a Rotor Ontology

A non-exhaustive survey of existing wind turbine rotor MDAO tools was conducted.

#	Name	Organization	Research/Commercial
1	BladeOASIS	CENER, ES	Research
2	Cp-Max	TU Munich, DE / Politecnico di Milano, IT	Research
3	FOCUS6	Knowledge Centre WMC, NL	Commercial
4	HAWTOPT2	DTU Wind Energy, DK	Research, partially open-source
5	LMS Samtech Samcef Wind Turbines	LMS Samtech (Siemens), DE	Commercial
6	OneWind Modelica Library	Fraunhofer IWES, DE	Research, partially open-source
7	QBlade	TU Berlin, DE	Research, fully open-source
8	Turbine.Architect	DNVGL, UK	Commercial
9	WISDEM	NREL, USA	Research, fully open-source

Every model is different (even for the exact same discipline and fidelity level) and every workflow is different, making it challenging to share data across tools (Figure 4). A wind turbine rotor discipline/fidelity matrix was created, spanning the methods used by all surveyed tools (Figure 5). Here, the green cells represent the most common combinations.

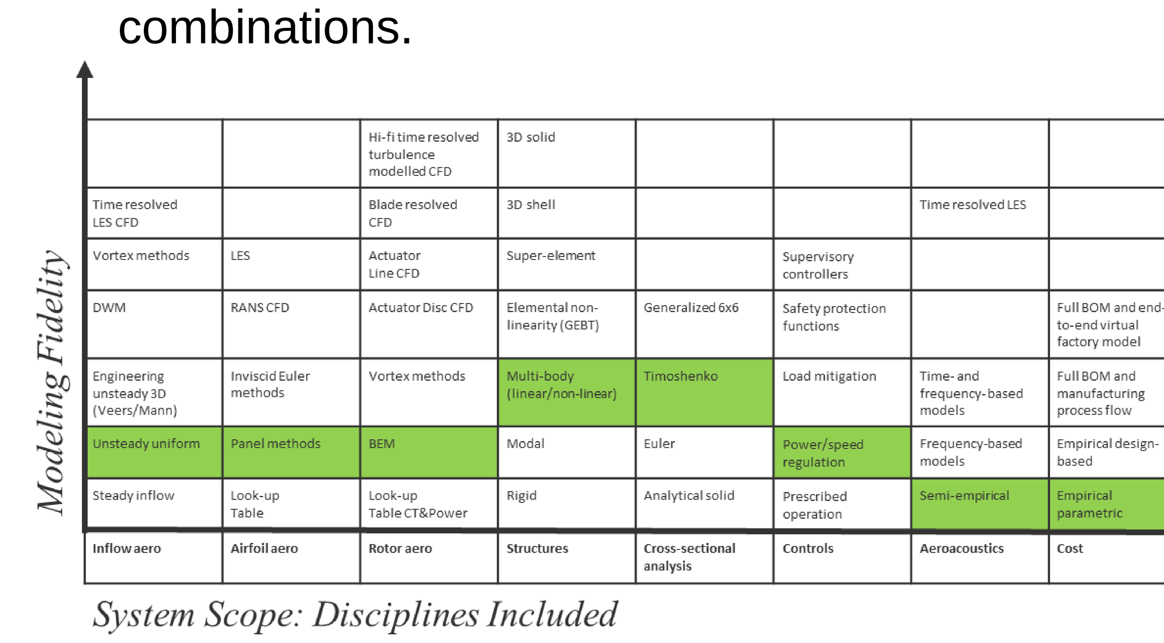

Figure 5: Wind turbine rotor discipline/fidelity matrix

A wind rotor turbine ontology was developed that allows the specification of arbitrary blade geometries, with a focus on Aero-Elastic modeling. Figure 6 shows the nested data structures for defining blade properties.

4. Rotor Ontology Features

The ontology has been coded into a **.yaml** file, which offers some nice features:

1. yaml is a human- and machine- readable data-serialization language
2. Supports commenting and descriptions
3. User-friendliness and flexibility to accommodate multiple disciplinaries and fidelity levels for each component
4. Supports JSON schema, which is a vocabulary that allows to annotate and validate JSON and YAML documents, providing clear human- and machine- readable documentation

Contributors and early adaptors include DTU, NREL, SNL, TU Delft, TU Munich, and Uni Stuttgart

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