



WORK4CE

**Digital twinning in
mechanical design, a
comprehensive approach
with students.
(M03 industry 4.0)**

[Dr ing Peter Arras](#)



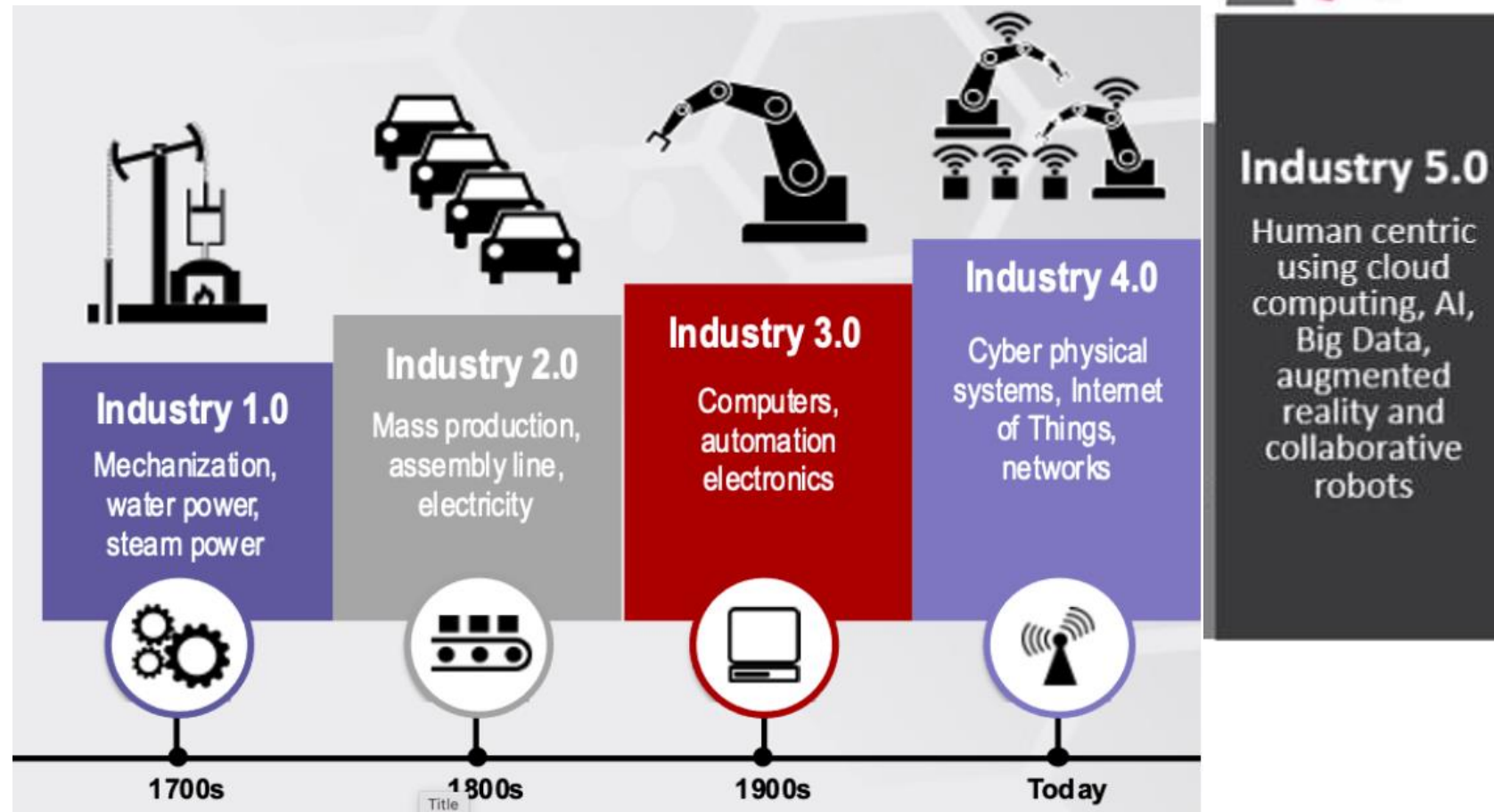
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Outline

1. Introduction to digital twins and Major challenges
2. Digital twins integration in mechanical design
3. Suggested model for a student assignment.
4. Assignment: complete model
5. Example of an informative DT: structure => simulation (MTB => kinematic study) => FEA
6. Conclusions

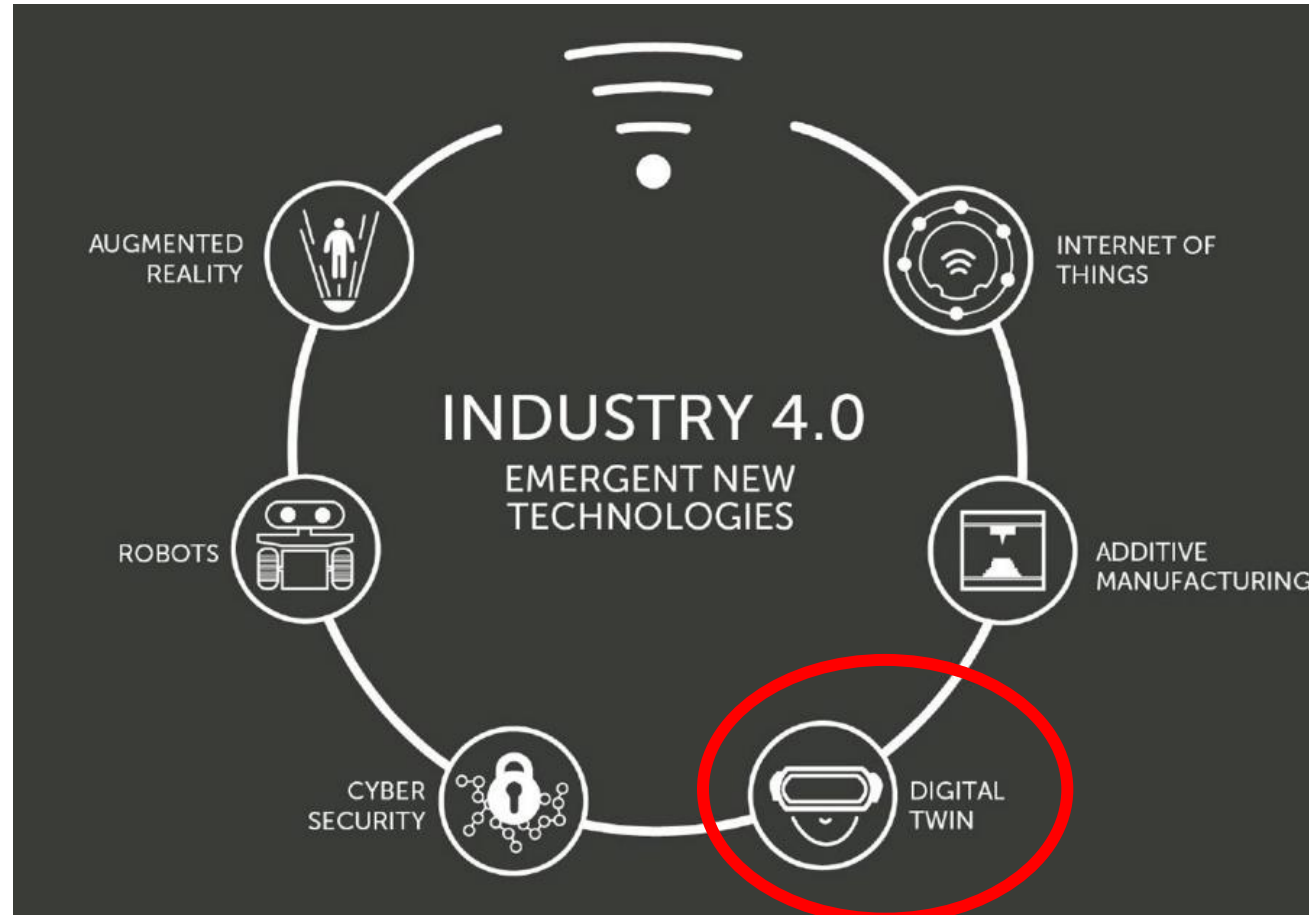
1 Introduction and Major Challenges



1 Introduction and Major Challenges

Emerging technologies of Industry 4.0.

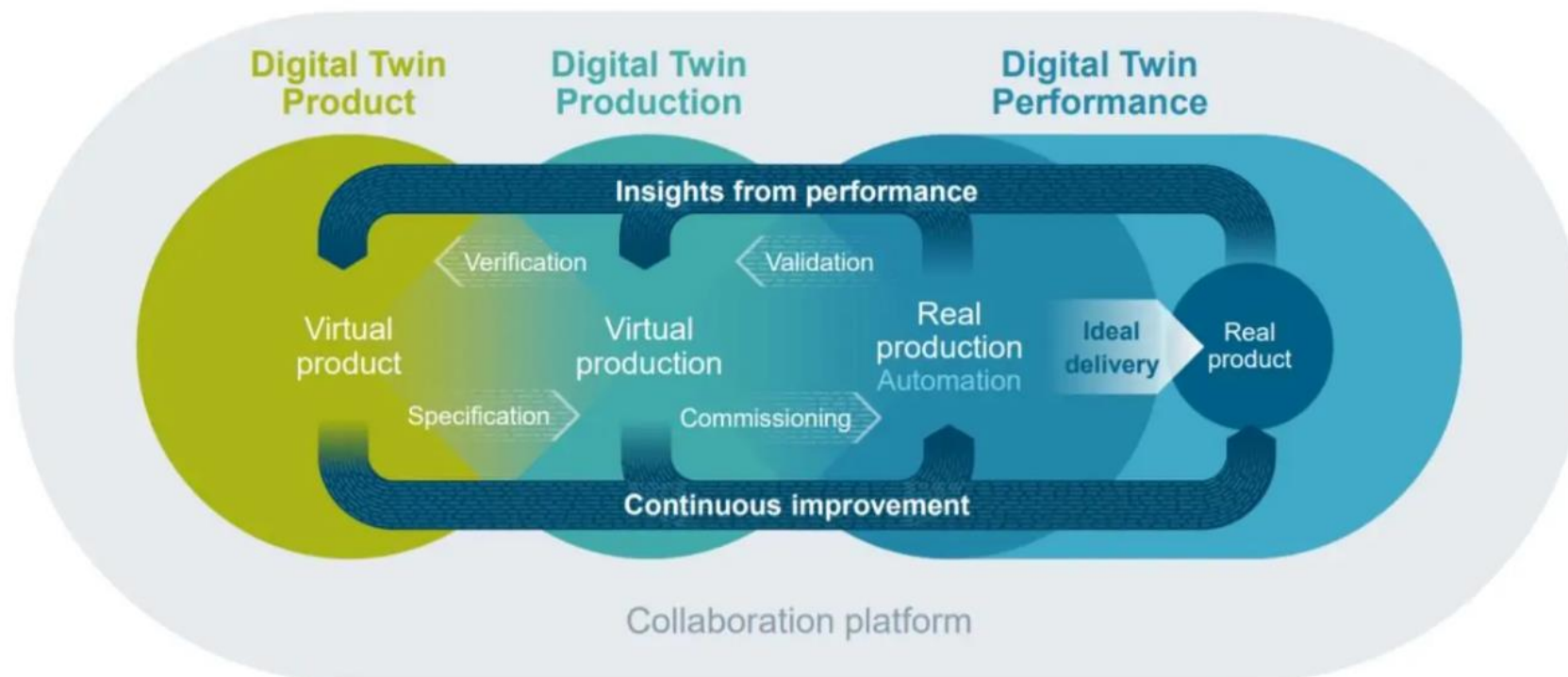
- Digital Twins



1 Introduction to digital twins and Major Challenges

DT refers to a digital replica of potential and actual physical assets (physical twin), processes, people, places, systems and devices that can be used for various purposes.

A DT consists in three big parts: the digital copy, the physical asset/process and its environment, and the communication channel or digital thread between the physical and virtual representations.



1 Introduction and Major Challenges

What is a digital twin:

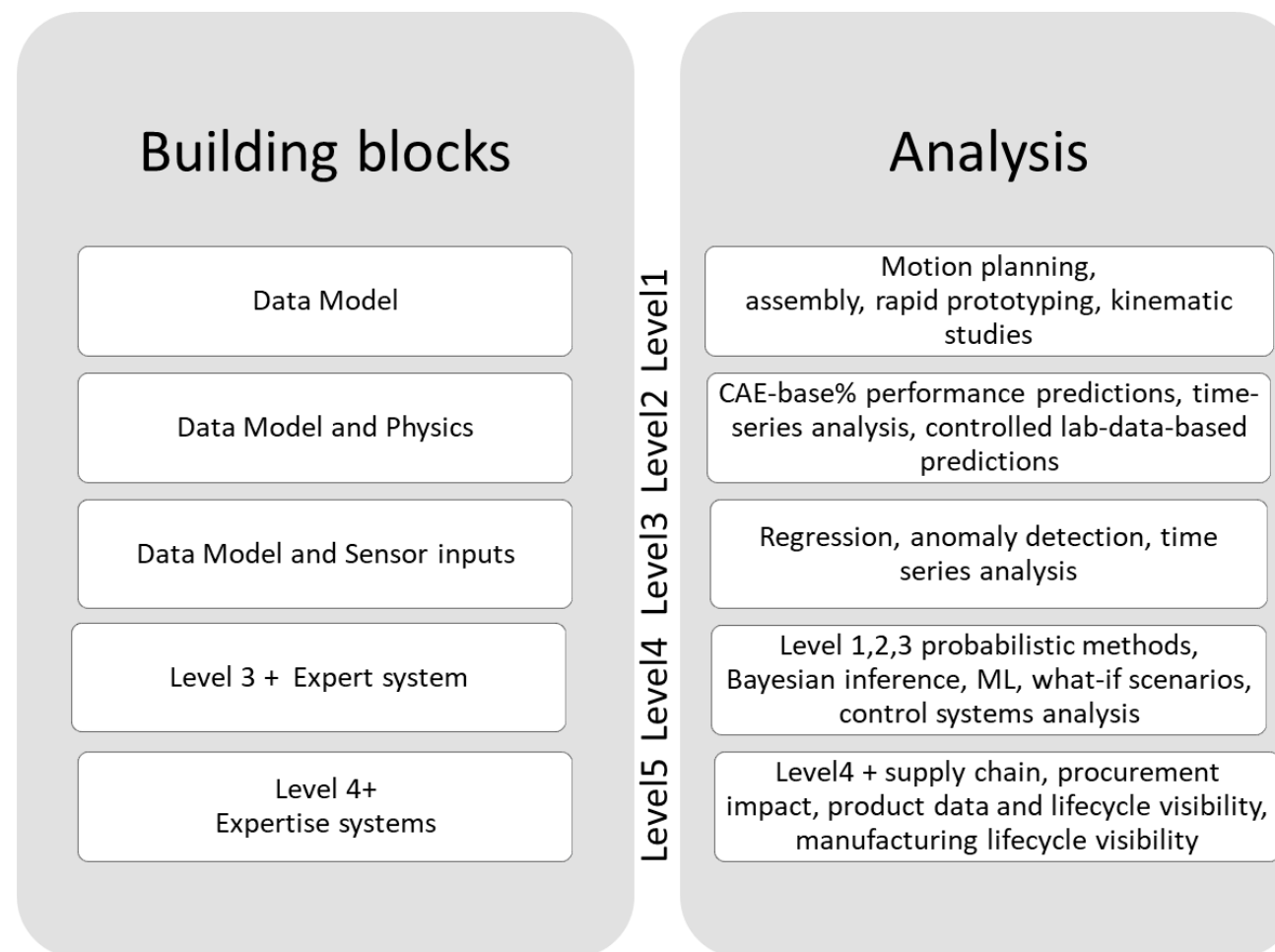
<https://youtu.be/6quHZNzZnsw>

Different types of digital twins in design:

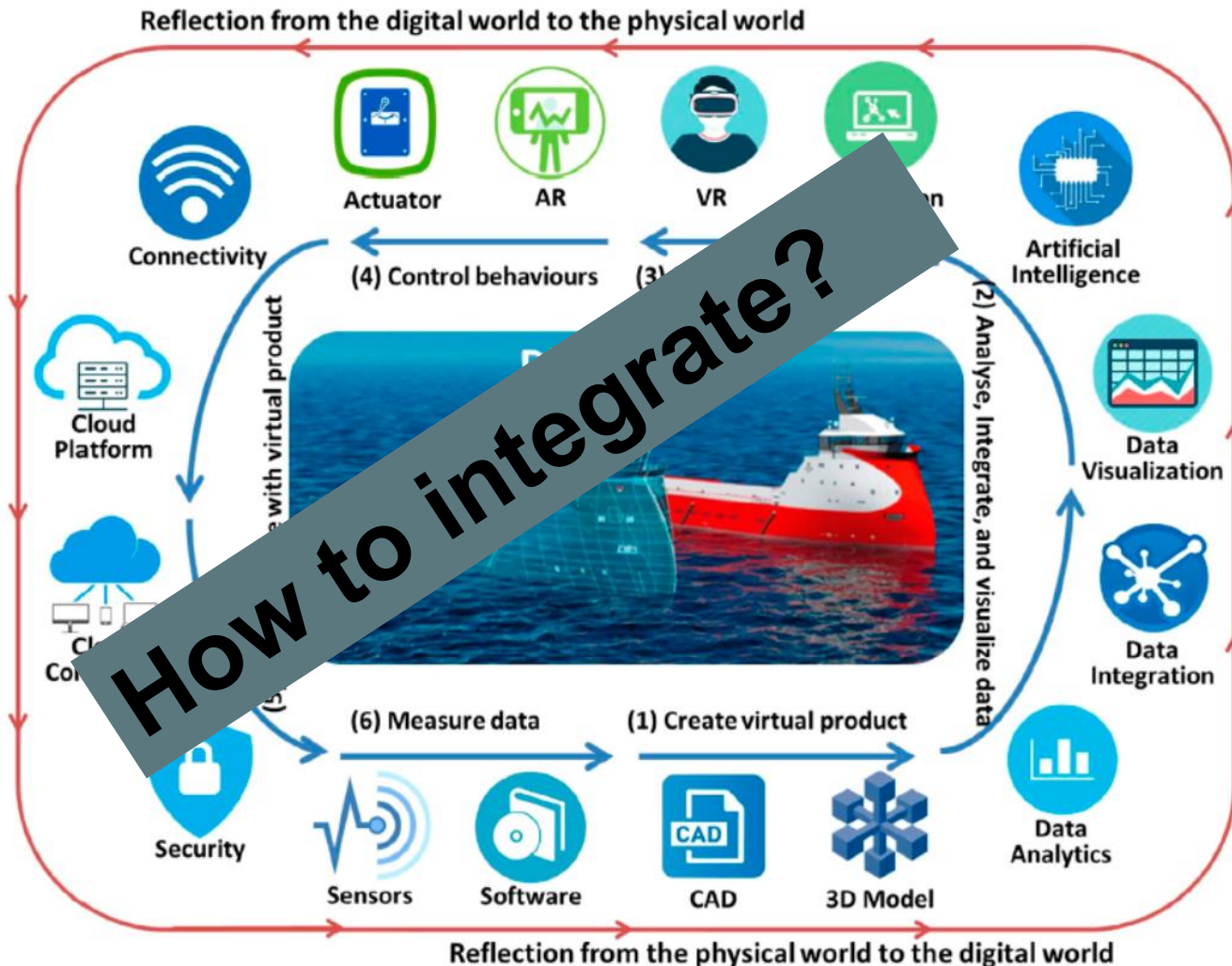
- **Descriptive twin:** a live and editable version of the design and construction data. E.g. an elaborated CAD-model.
- **Informative twin:** contains an added layer of operational and sensory data or a predictive twin able to use operational data to gain insights. E.g. in mechanical design this would be a virtual prototype, in architecture and construction a BIM-model.
- **Comprehensive twins:** to simulate future scenarios and considers “what-if” questions.
- **Autonomous twins:** which have the ability to learn and act on behalf of users.

<https://youtu.be/60eCpw0Toy4> (general overview of DT)

Classification according to the five level taxonomy of Leeway Hertz for DT



2 Digital Twins in mechanical design



Fei Tao, Fangyuan Sui, Ang Liu, Qinglin Qi, Meng Zhang, Boyang Song, Zirong Guo, Stephen C.-Y. Lu & A. Y. C. Nee (2019) Digital twin-driven product design framework, International Journal of Production Research, 57:12, 3935-3953, DOI: [10.1080/00207543.2018.1443229](https://doi.org/10.1080/00207543.2018.1443229)

3 Suggested model for a student assignment.

Suggested model: Design Movable solar panels with suntracker.

- A Multi-disciplinary project
- Recognizable for students
- Appealing in an era of sustainable energy

Advantages:

- Comprehensible to teach
- Offering possibilities to integrate all technologies

Timeframe: (9ECTS spread over academic year)

- 3ECTS design of a digital twin from early design stage
- 3ECTS course on digital twin technologies
- 3ECTS implementation of a digital twin

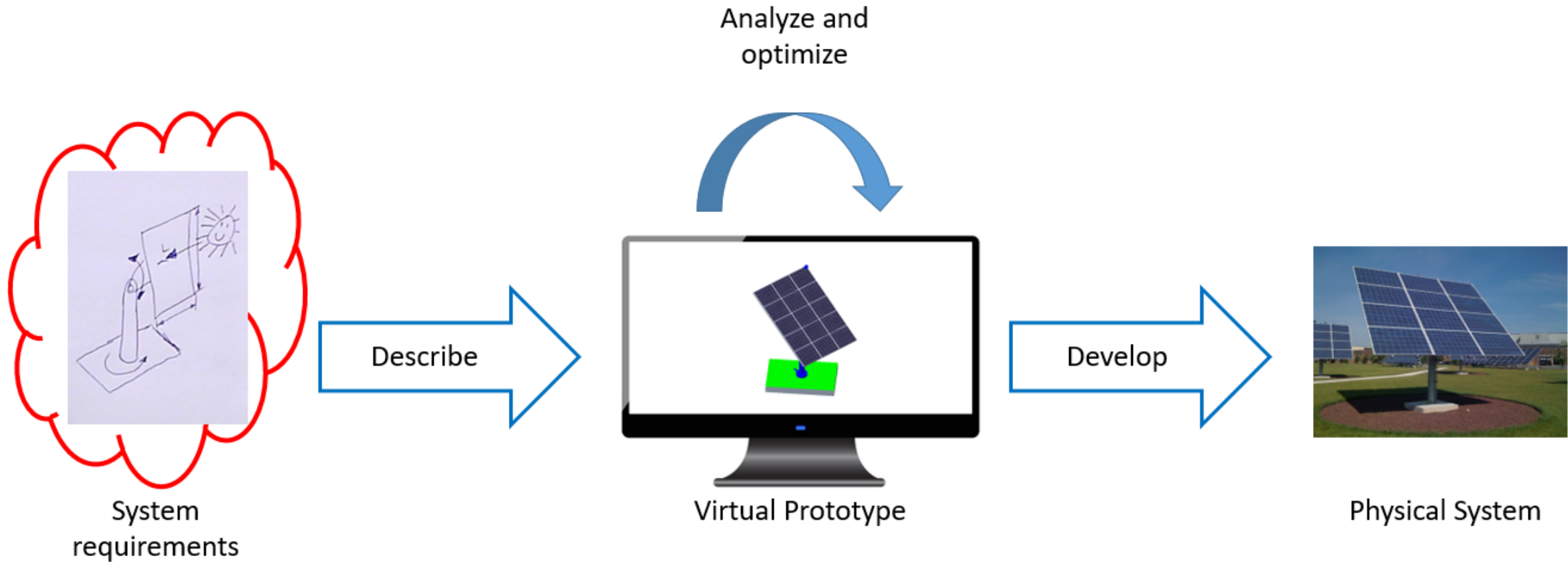
Teamwork

Overarching competences:

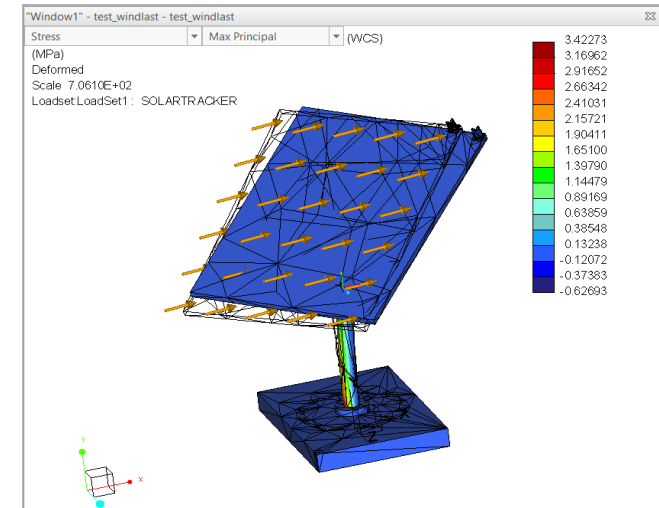
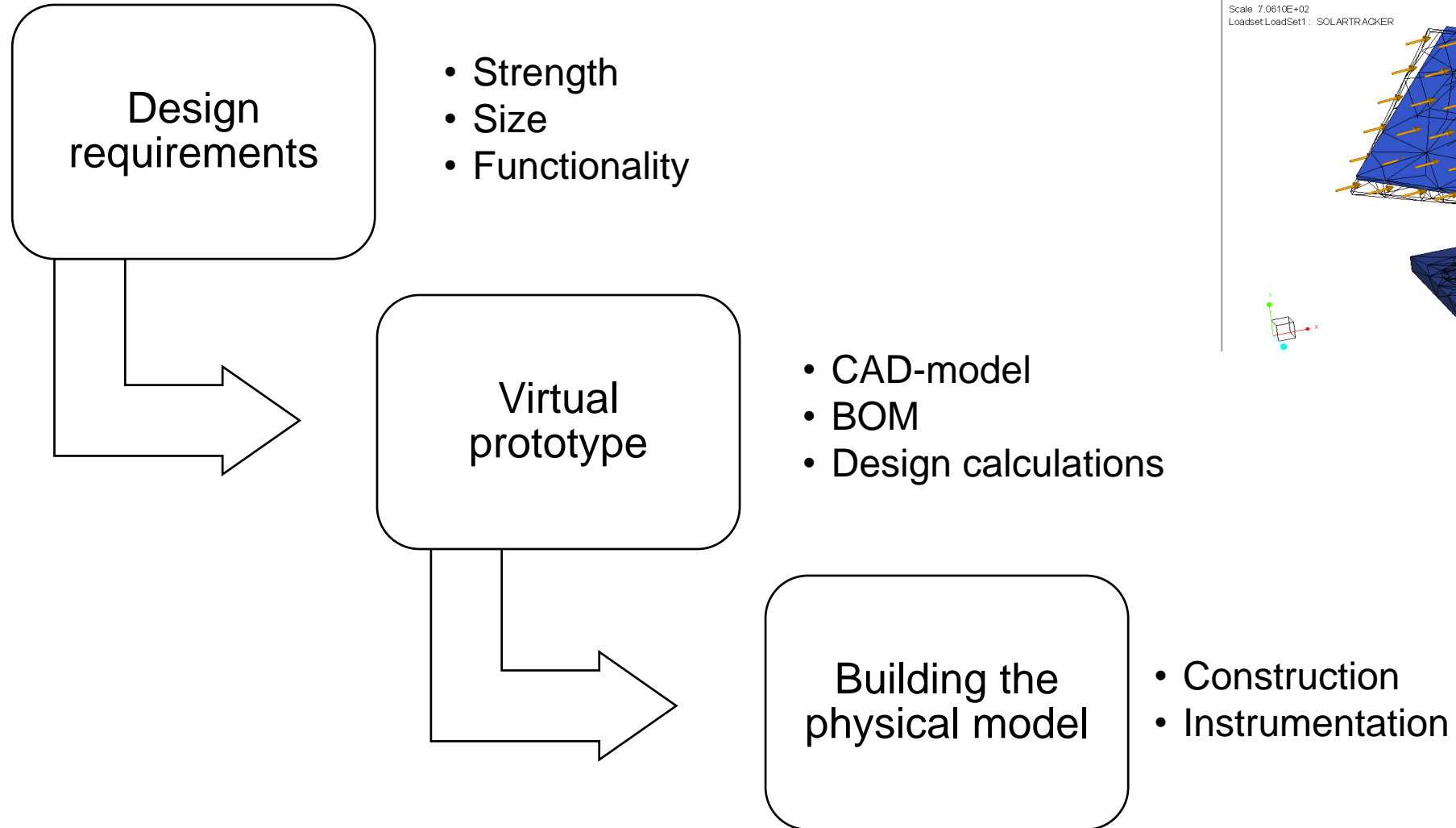
- Group dynamics
- Project management: planning, milestones, deliverables
- (scientific)(technical) reporting
- Communication: pitching



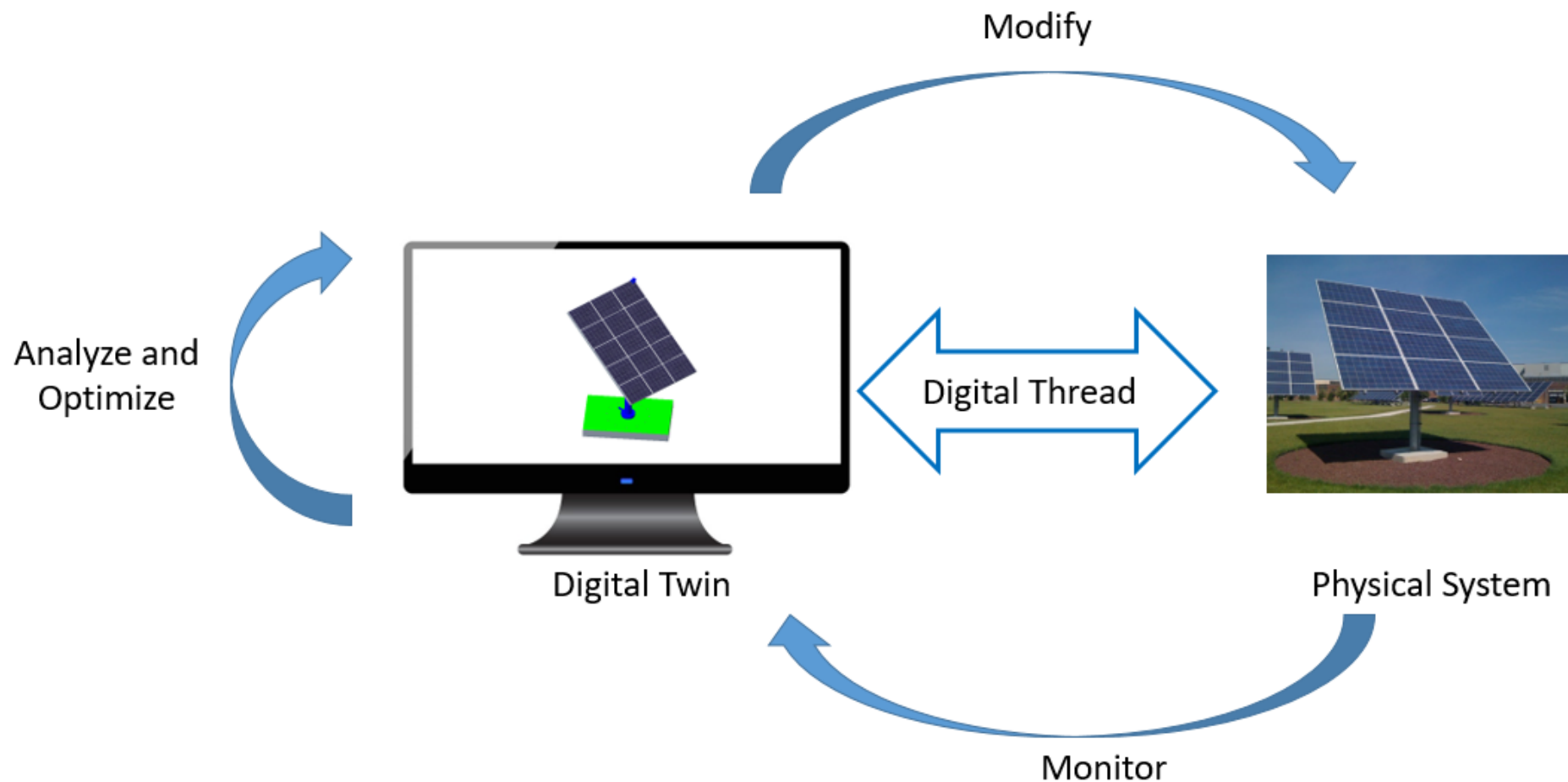
3.1 Virtual prototype: part 1 mechanical design of the DT hardware



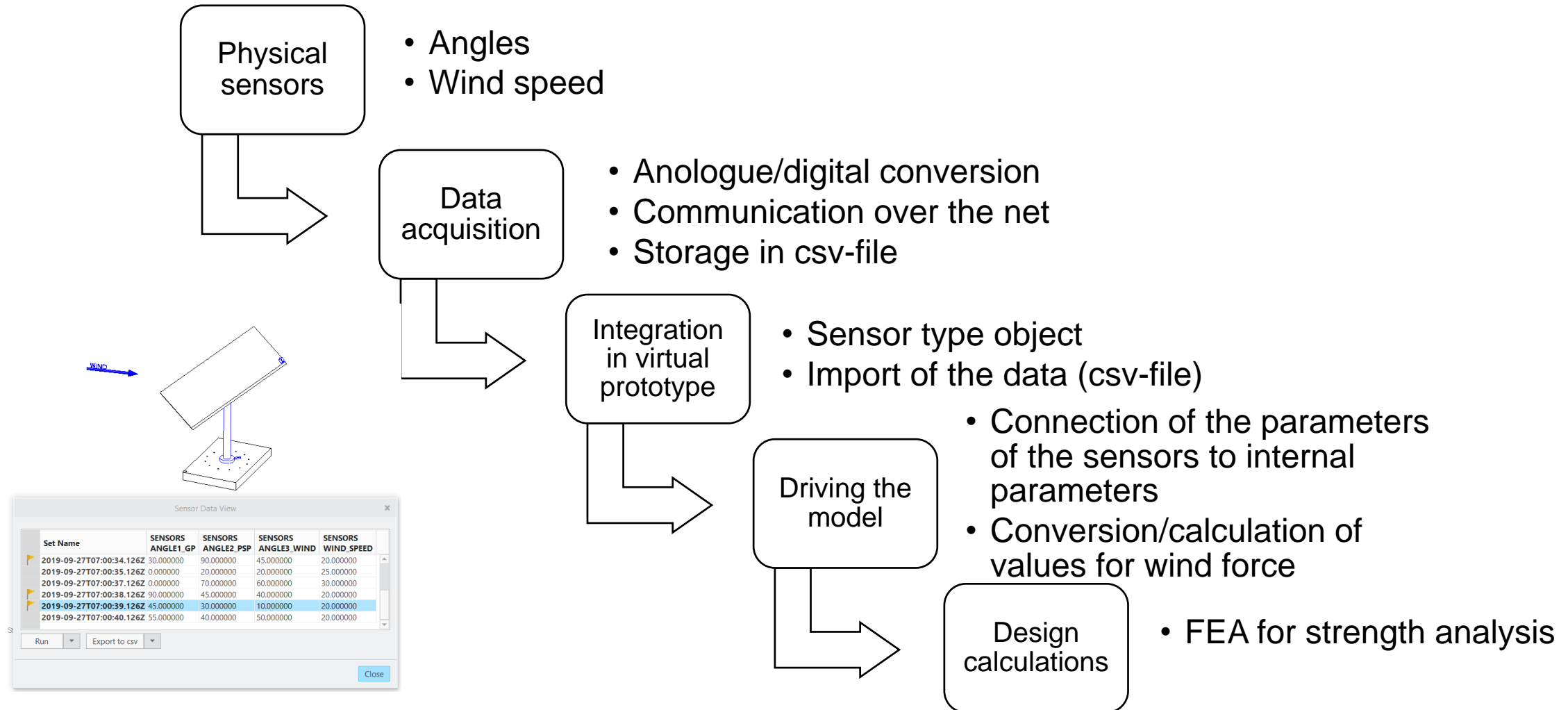
3.1 Virtual prototype



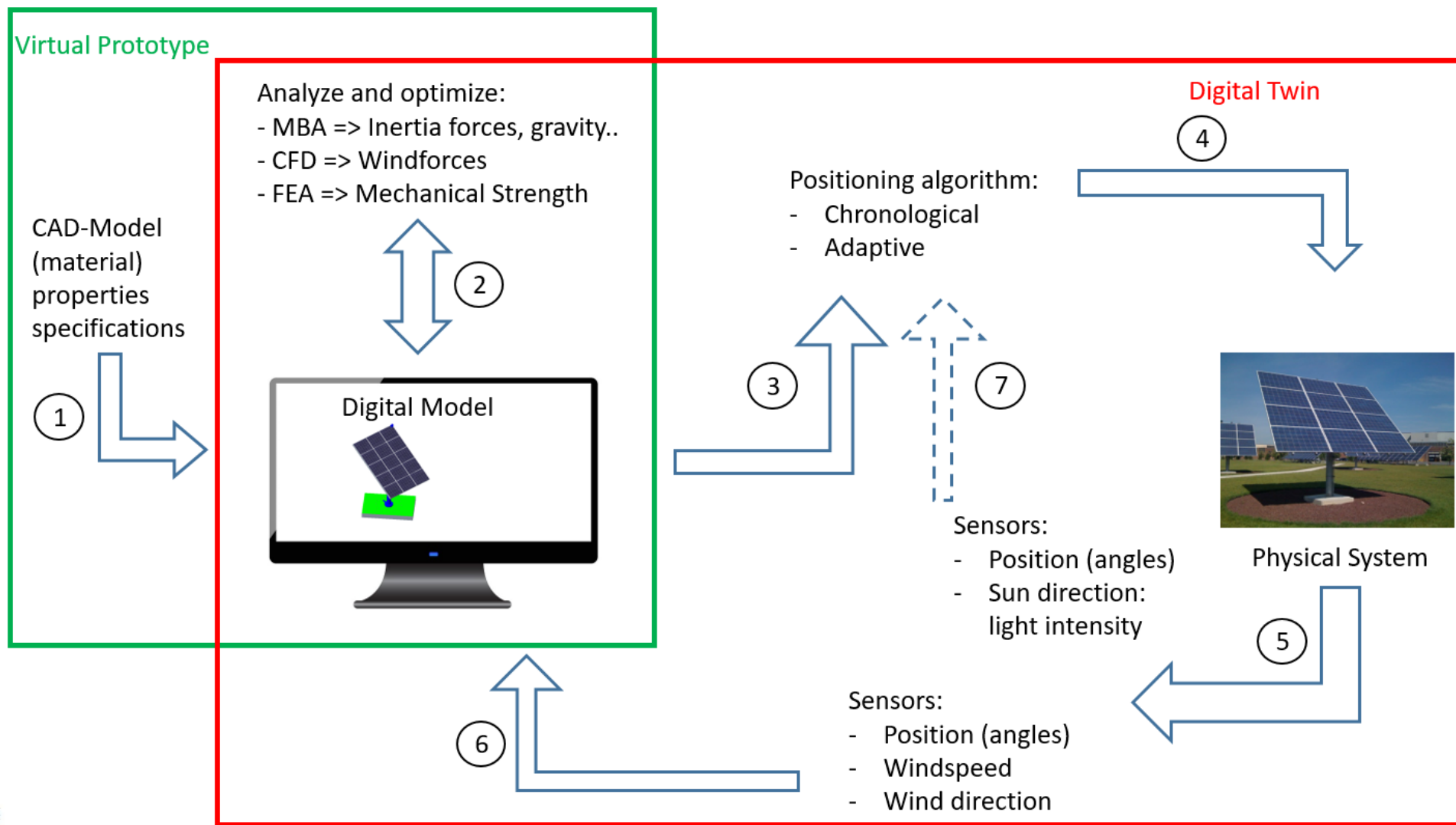
3.2 To expanding to digital twin: part 2, implementation of DT



3.2 Expanding to digital twin



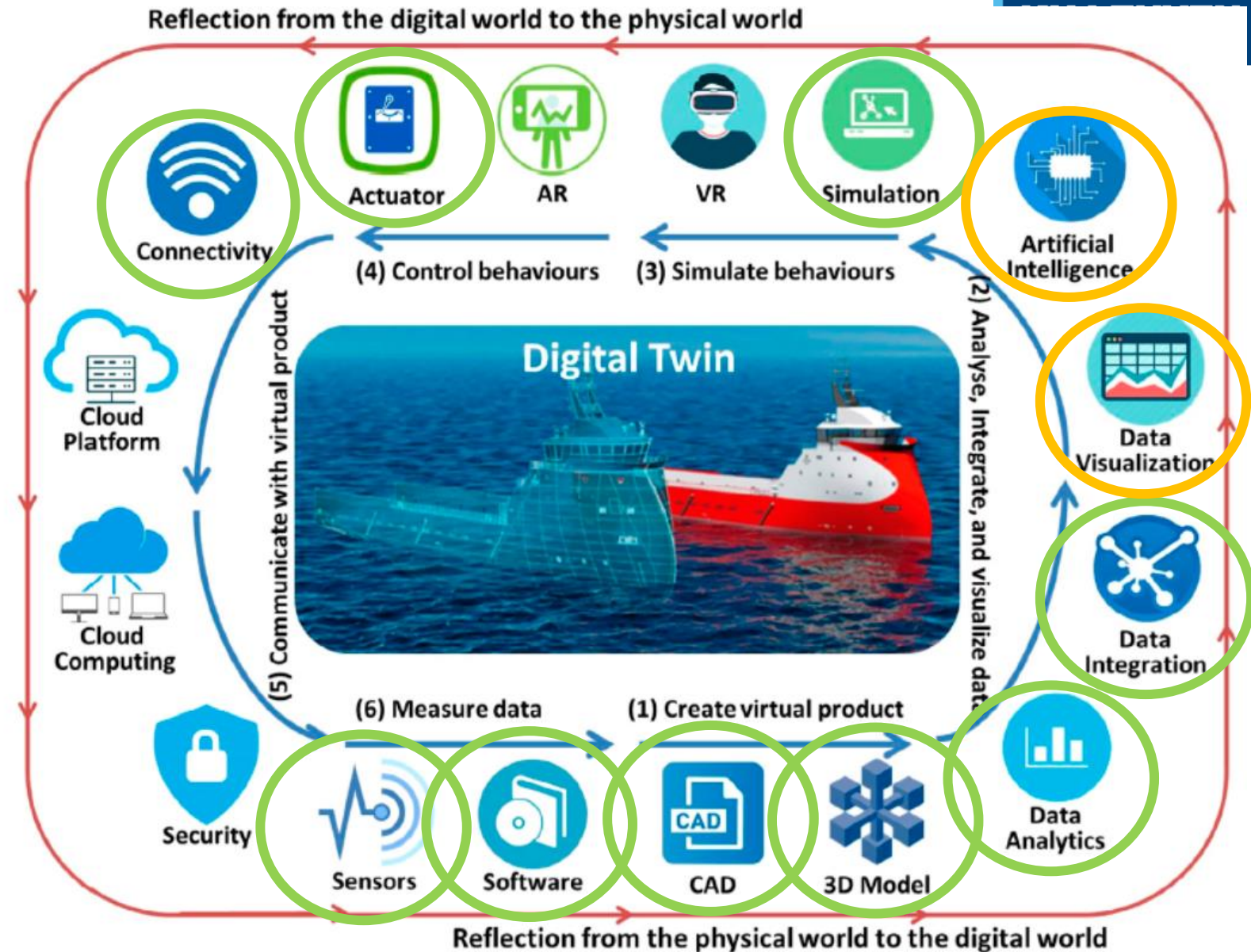
4 Assignment: complete model



4.1 Results

Model integrates a lot of technologies.

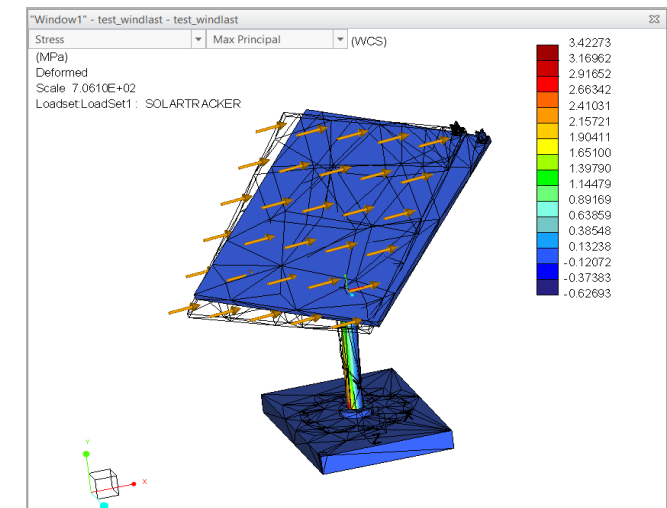
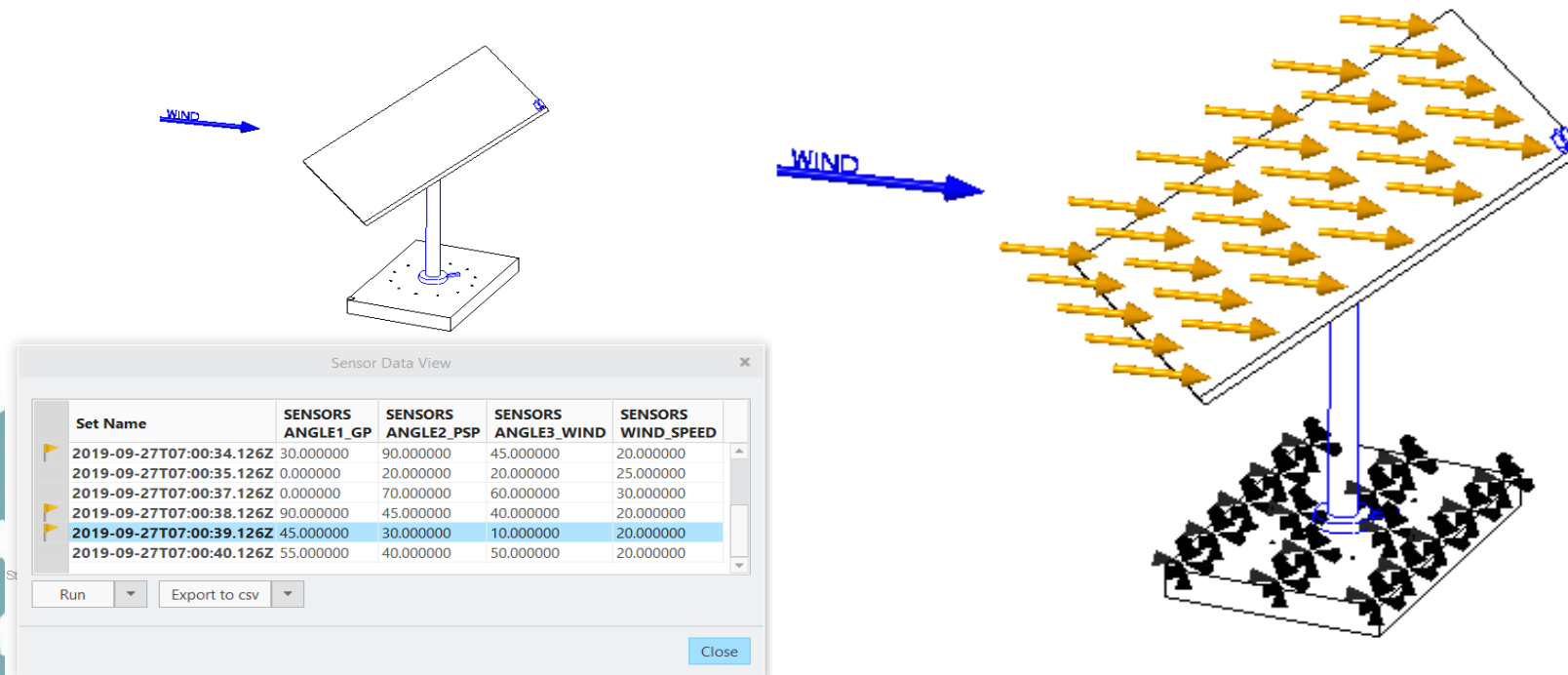
Room for expansion to other disciplines and techniques



- Adapted from Fei Tao, Fangyuan Sui, Ang Liu, Qinglin Qi, Meng Zhang, Boyang Song, Zirong Guo, Stephen C.-Y. Lu & A. Y. C. Nee (2019) Digital twin-driven product design framework, International Journal of Production Research, 57:12, 3935-3953, DOI: [10.1080/00207543.2018.1443229](https://doi.org/10.1080/00207543.2018.1443229)

4.2 Results of integration

Digital twin part: integration is challenging part



5 Conclusions

Digital twin technologies as a combination of different subject makes integration complicated.

The challenge of making a comprehensive case to teach students which is compact to fit in the available timing of students' curriculum while still containing all technologies enabling digital twins has been realized.

The model uses a step-by-step introduction from virtual prototype to digital twin

Multi-disciplinary approach between mechanical engineers, automation/electronics engineers and software engineers.

It offers possibilities for future integration of extra technologies.

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