# Robustness evaluation in early phases of product development

## Why is an early robustness evaluation needed?

- Systems must **reliably** fulfill their **functions** throughout their **life cycle**.
- Classic robust design requires a well-defined **geometry model** that is only available in **later development phases**, where iterations are costly.
- The **EFRT-Model** describes a product concept in terms of its functions in the **early development phases** without a defined geometry and evaluates its robustness.
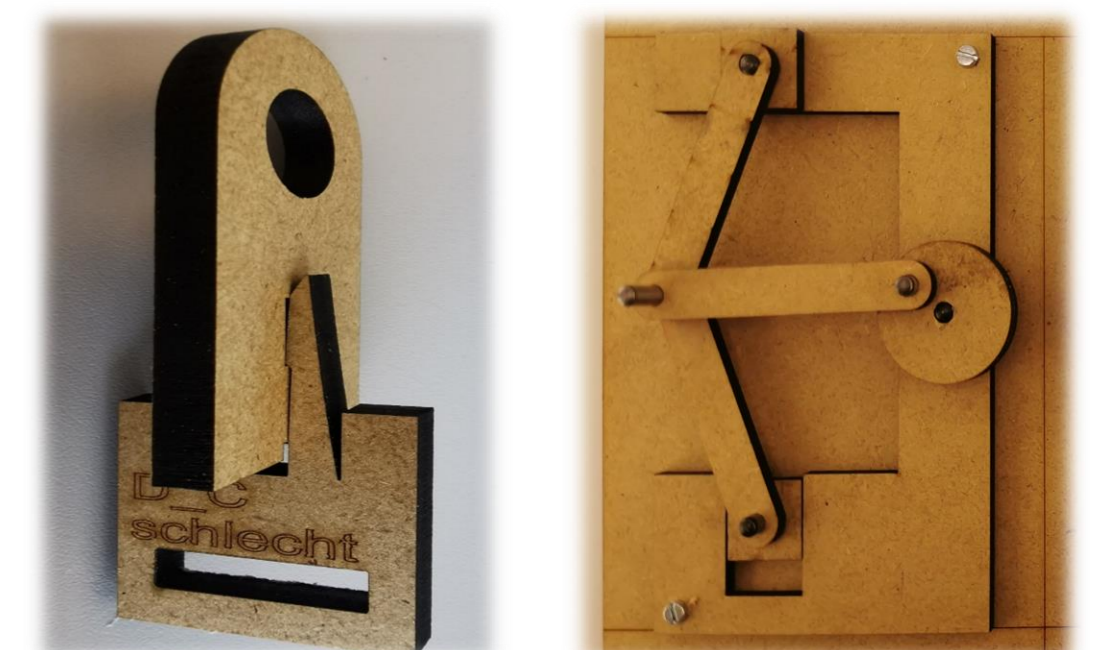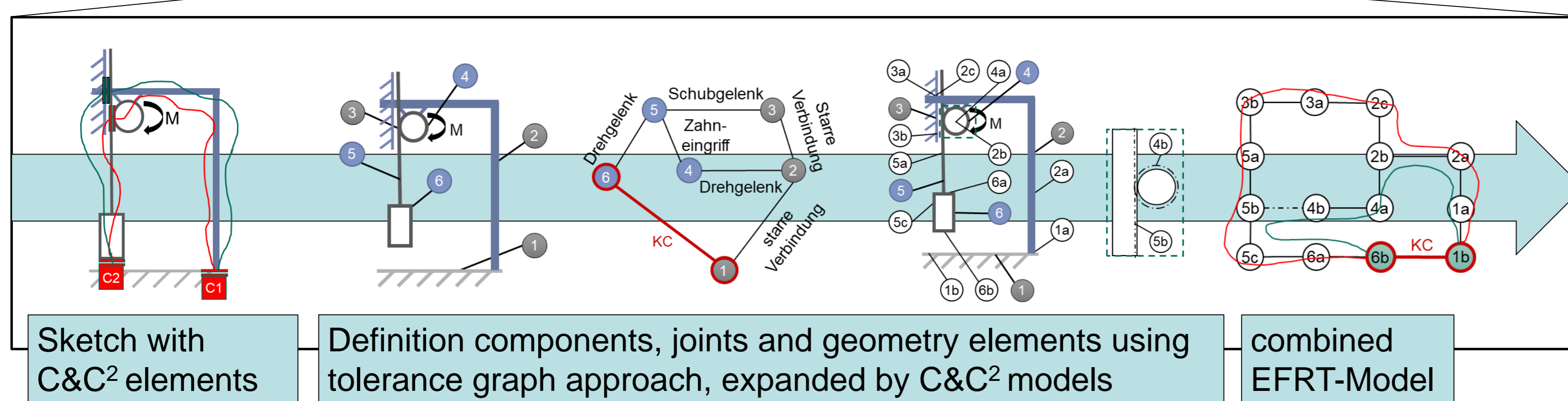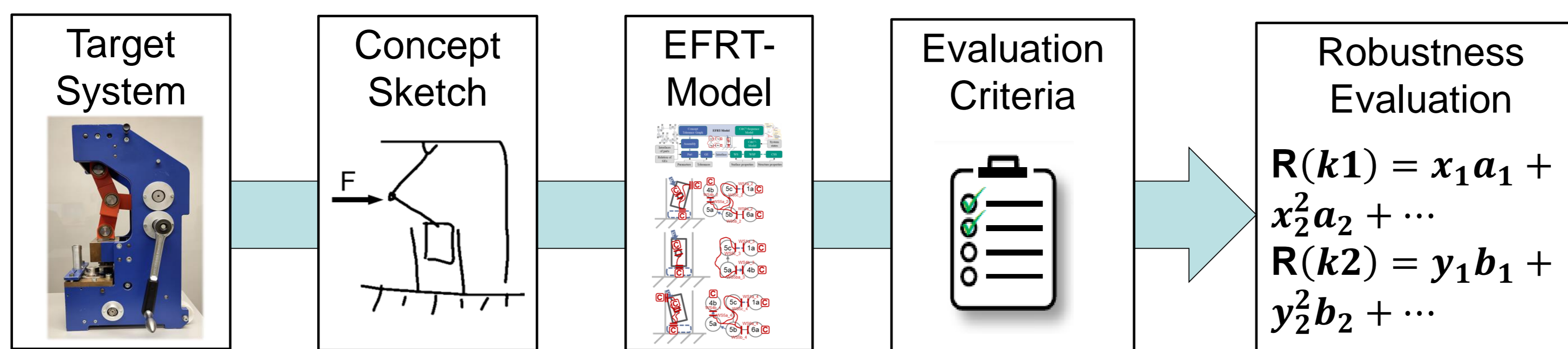
### Want to know which product concepts are more robust so you can save on costs for later iterations?

Robustness evaluation Embodiment-Function-Relation and Tolerance (EFRT-) Model



Target System → Concept Sketch → EFRT-Model → Evaluation Criteria → Robustness Evaluation

$$R(k1) = x_1 a_1 + x_2^2 a_2 + \cdots$$
$$R(k2) = y_1 b_1 + y_2^2 b_2 + \cdots$$

*Please feel free to take part in our survey!*

*Check out our demonstrator!*



Sketch with C&C² elements | Definition components, joints and geometry elements using tolerance graph approach, expanded by C&C² models | combined EFRT-Model

## Selected criteria for the early robustness evaluation

### 1. Criterion Load Path (can be determined via combined sketch)



Shorter Load Path | Longer Load Path | Longer and indirect Load Path | Short and direct load paths increase the robustness of the product concept

### 2. Criterion System Mobility (can be determined automatically in the EFRT-Model)



Degree of freedom = 1 | Degree of freedom = 2 | Degree of freedom = „0" | Over/underconstrained systems decrease the robustness of the product concept

### 3. Criterion Design Clarity (can be determined via combined sketch)



Clearly defined Working Surface Pairs (WFPs) | Unclearly defined Working Surface Pairs | WFPs running in parallel decrease the robustness of the product concept

[1] Jiahang Li, Dennis Horber, Christoph Keller, Patric Grauberger, Stefan Goetz, Sandro Wartzack, Sven Matthiesen (2023), Utilizing the embodiment function relation and tolerance model for robust concept design, 24th International Conference on Engineering Design ICED23, Bordeaux, France

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