



AWK'23

WWW.AWK-AACHEN.DE 11th / 12th MAY 2023

Sustainability in Production Lines

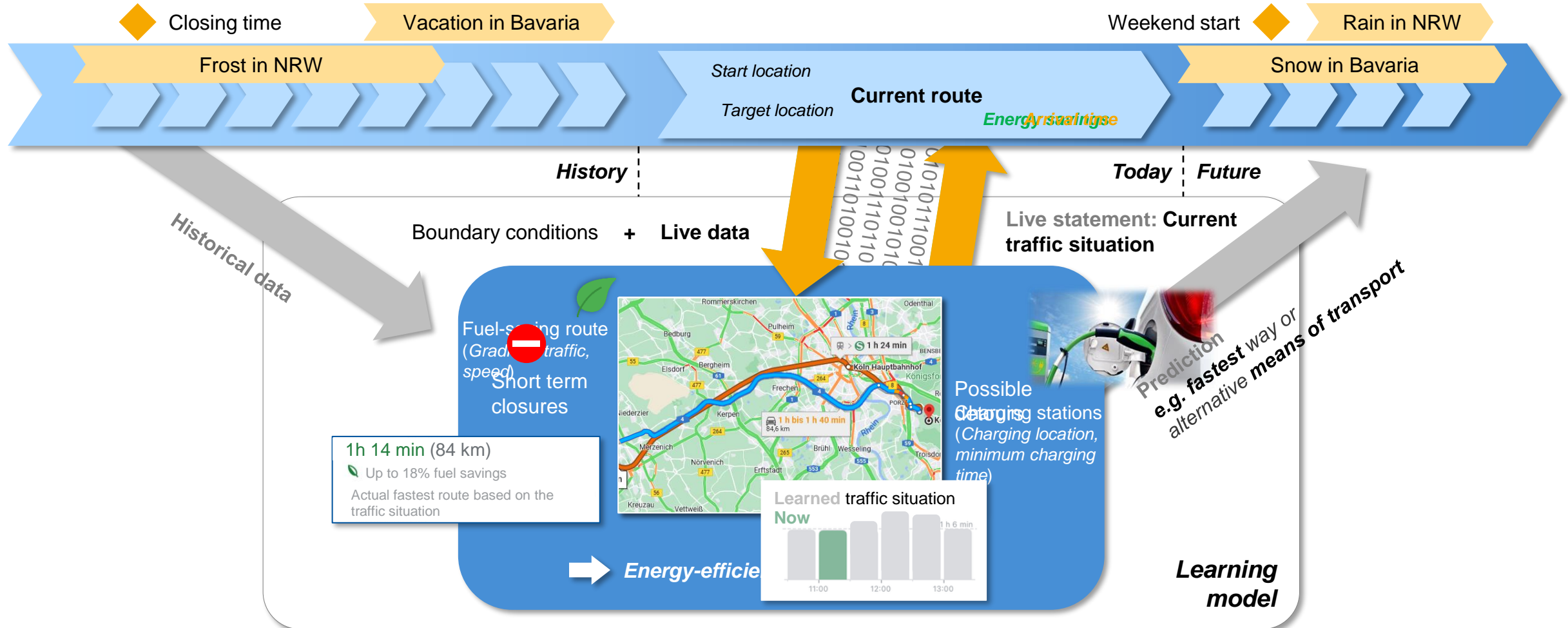
Keynote – Session 3
Prof. Dr.-Ing. Christian Brecher

Empower Green Production

Sustainability in production lines

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Analogy between route and production planning



Sources: Google, impulse.de

Status quo and scenarios for increasing the sustainability contribution

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Paradigm until 2023

Economic success correlates with use of resources

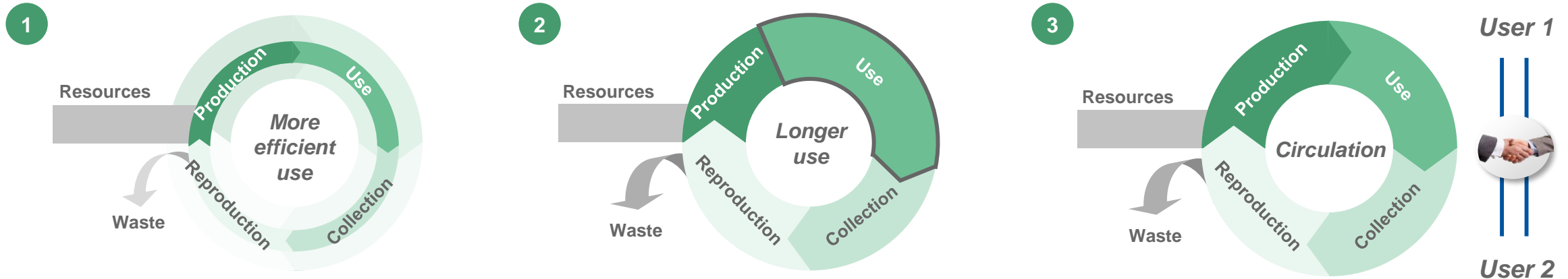
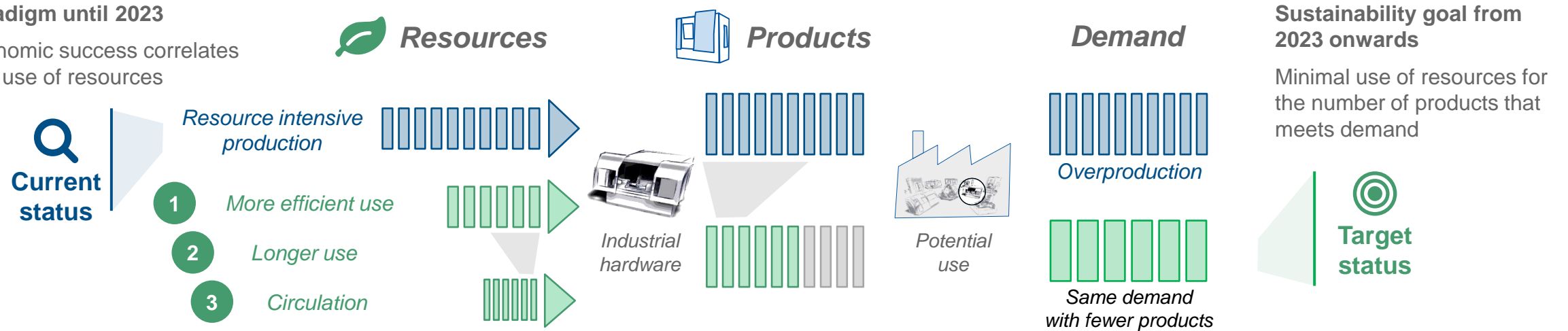
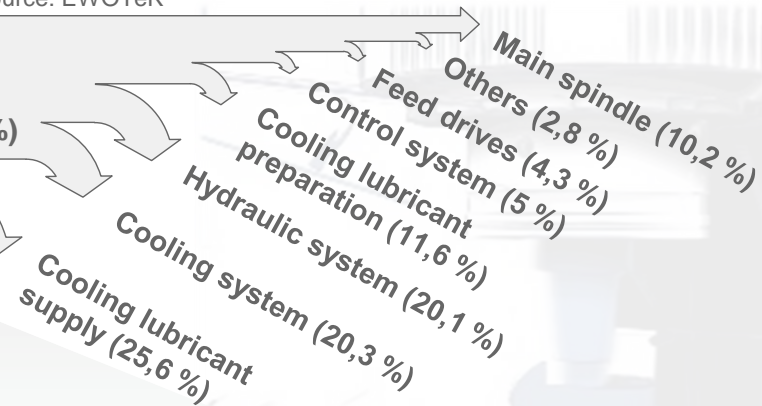




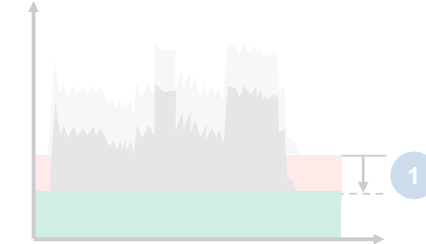
Image source: Heller

Source: EWOTeK

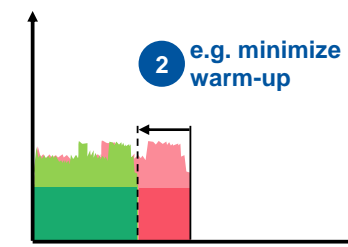
Electrical power consumption in operation (100 %)



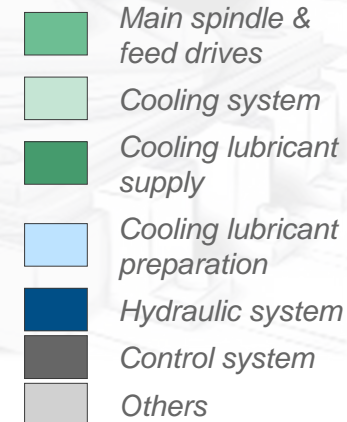
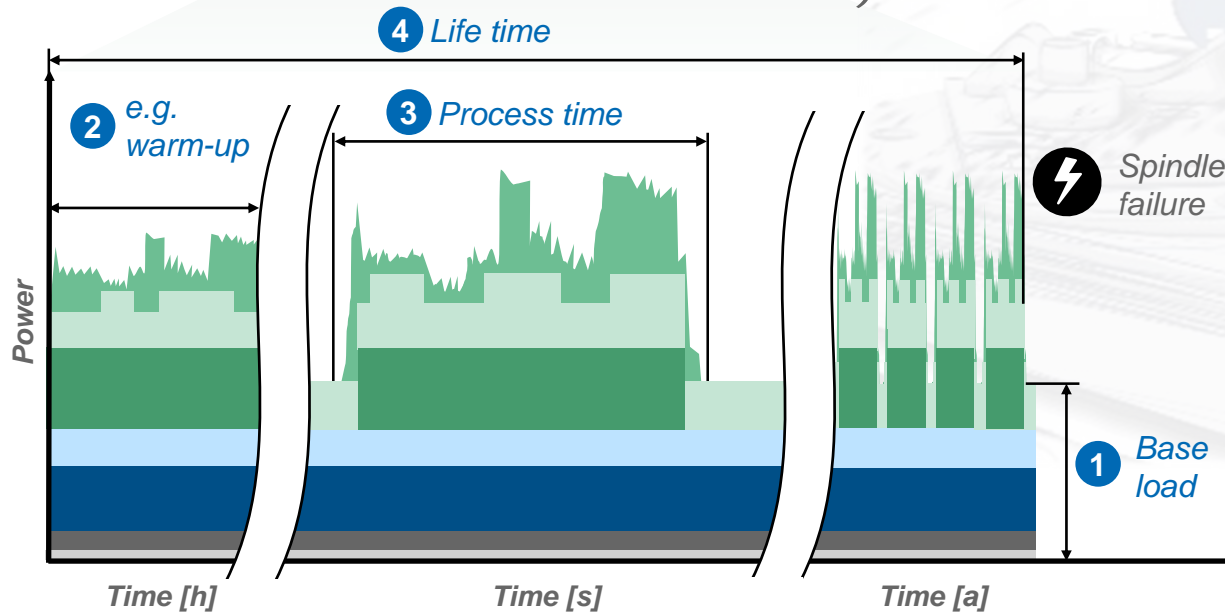
Targets for sustainable production lines



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Minimization of base load



Demand-oriented use of auxiliary units



Optimized temperature management for an efficient operation

Status quo

- Long warm-up phases
- High thermal variations during operation
- Non-shutdown of machines / High base load of auxiliary units



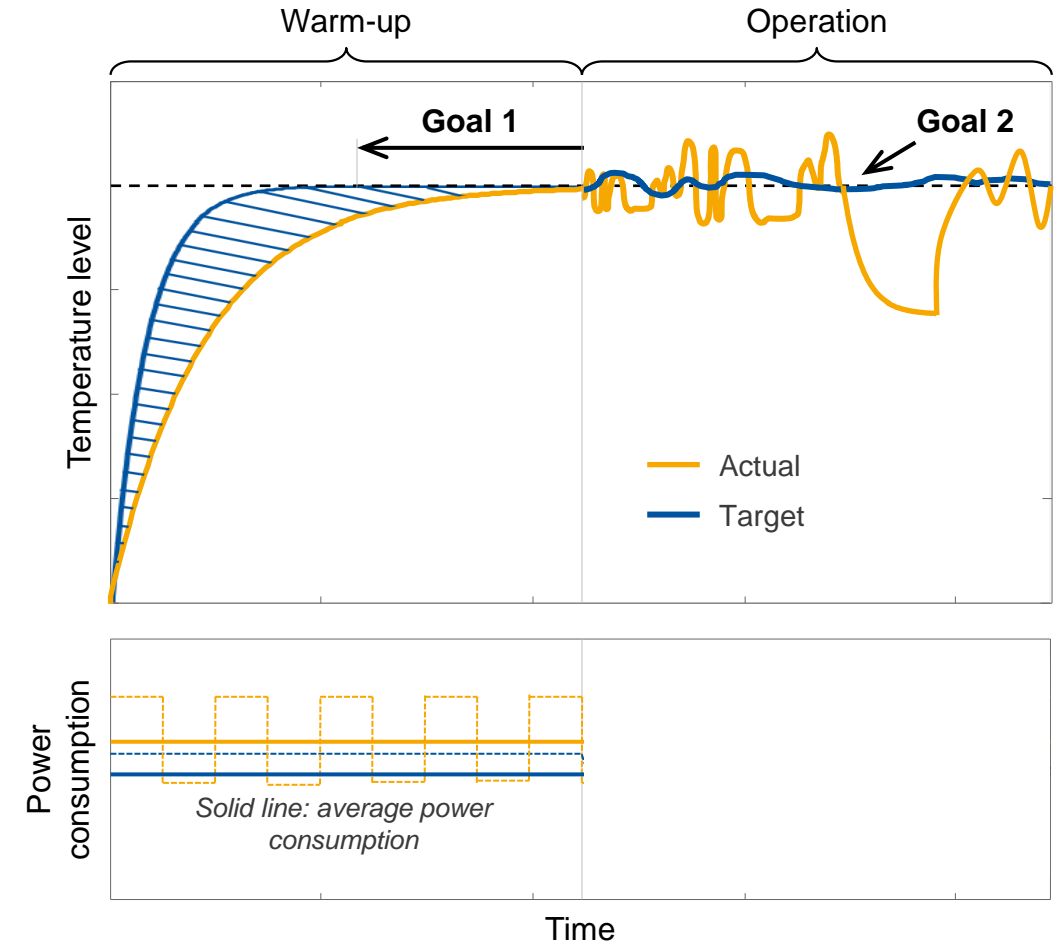
Goal 1: Reduction of warm-up phases (**Productivity**)



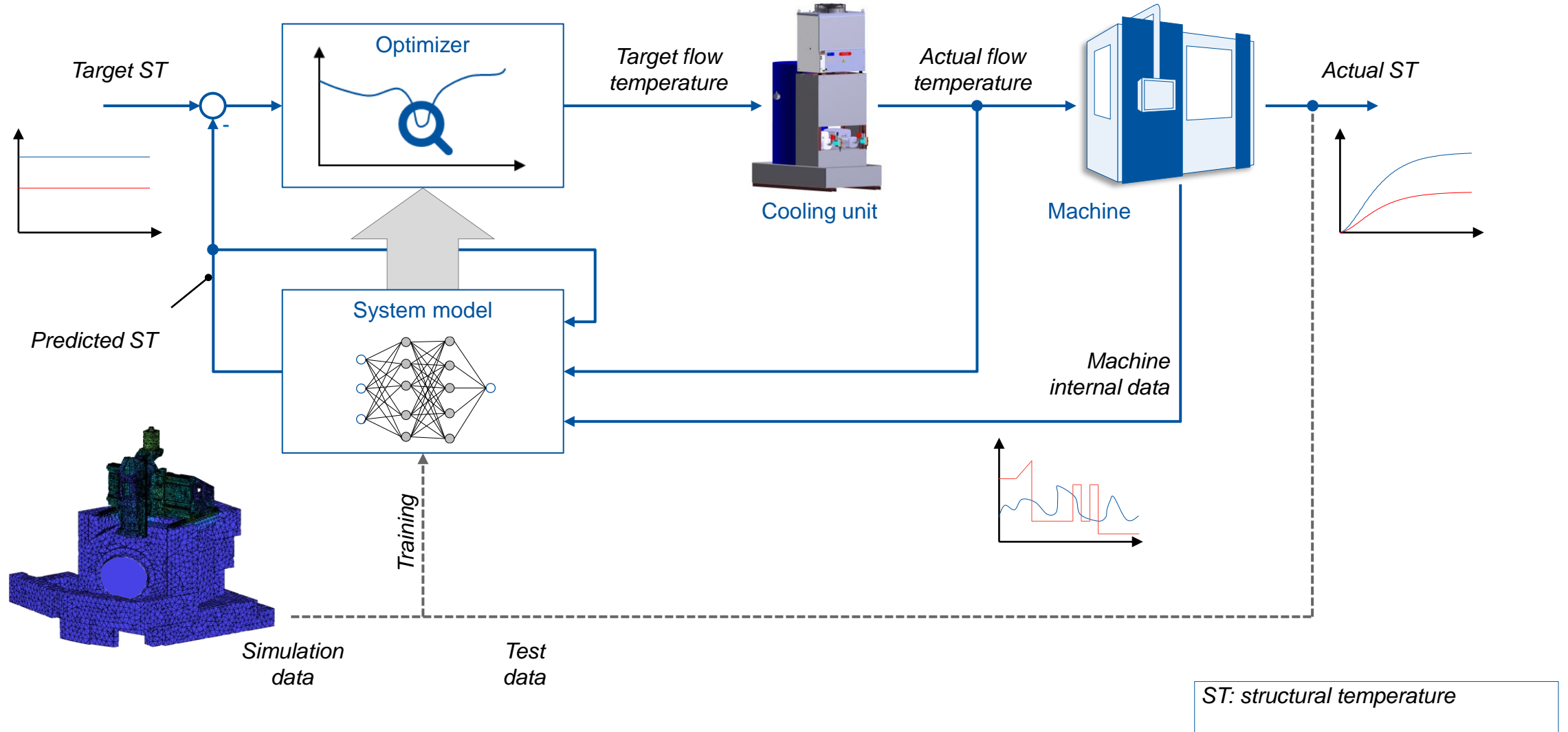
Goal 2: Increase of machining accuracy (**Quality**)



Goal 3: Reduction of energy consumption (**Energy use**)

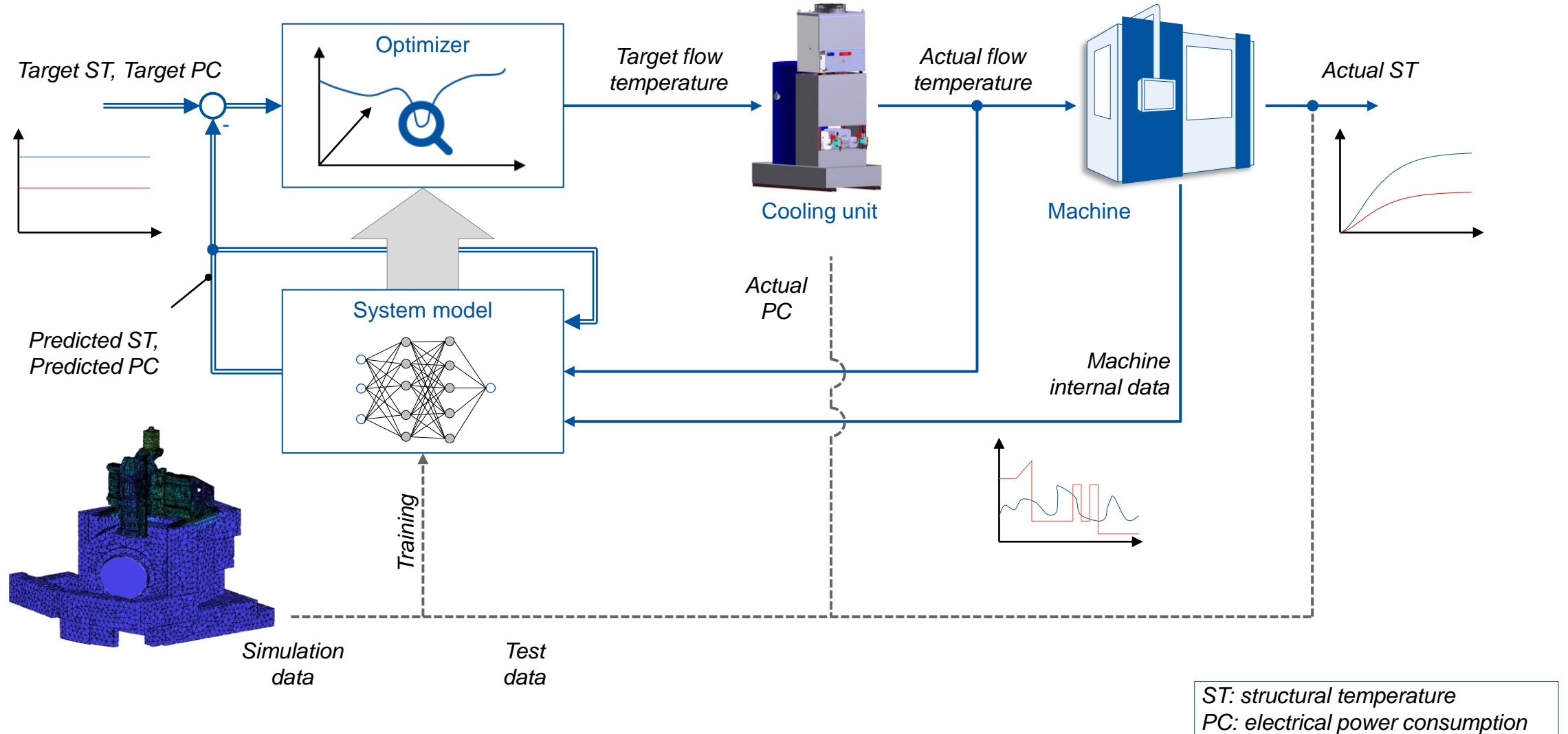


Source: Heller

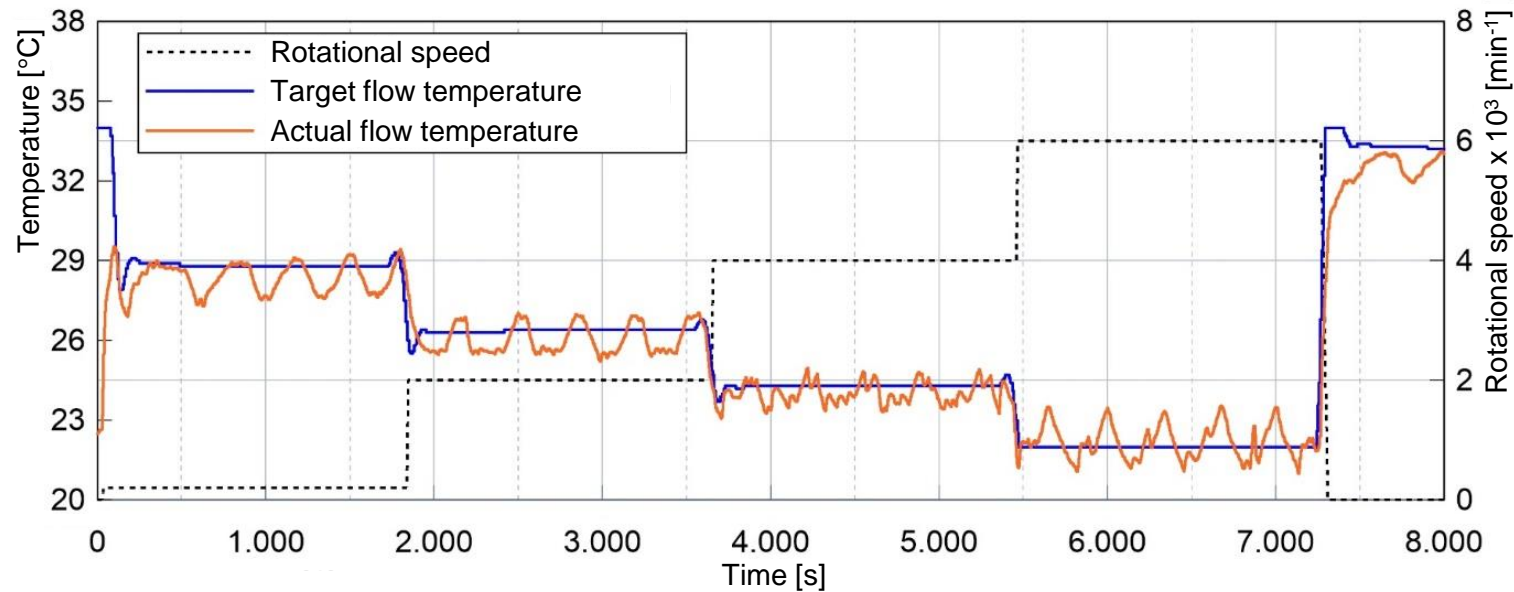


Adaptive design of active cooling systems using a model predictive multivariable controller

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Model predictive control (MPC) of active cooling systems

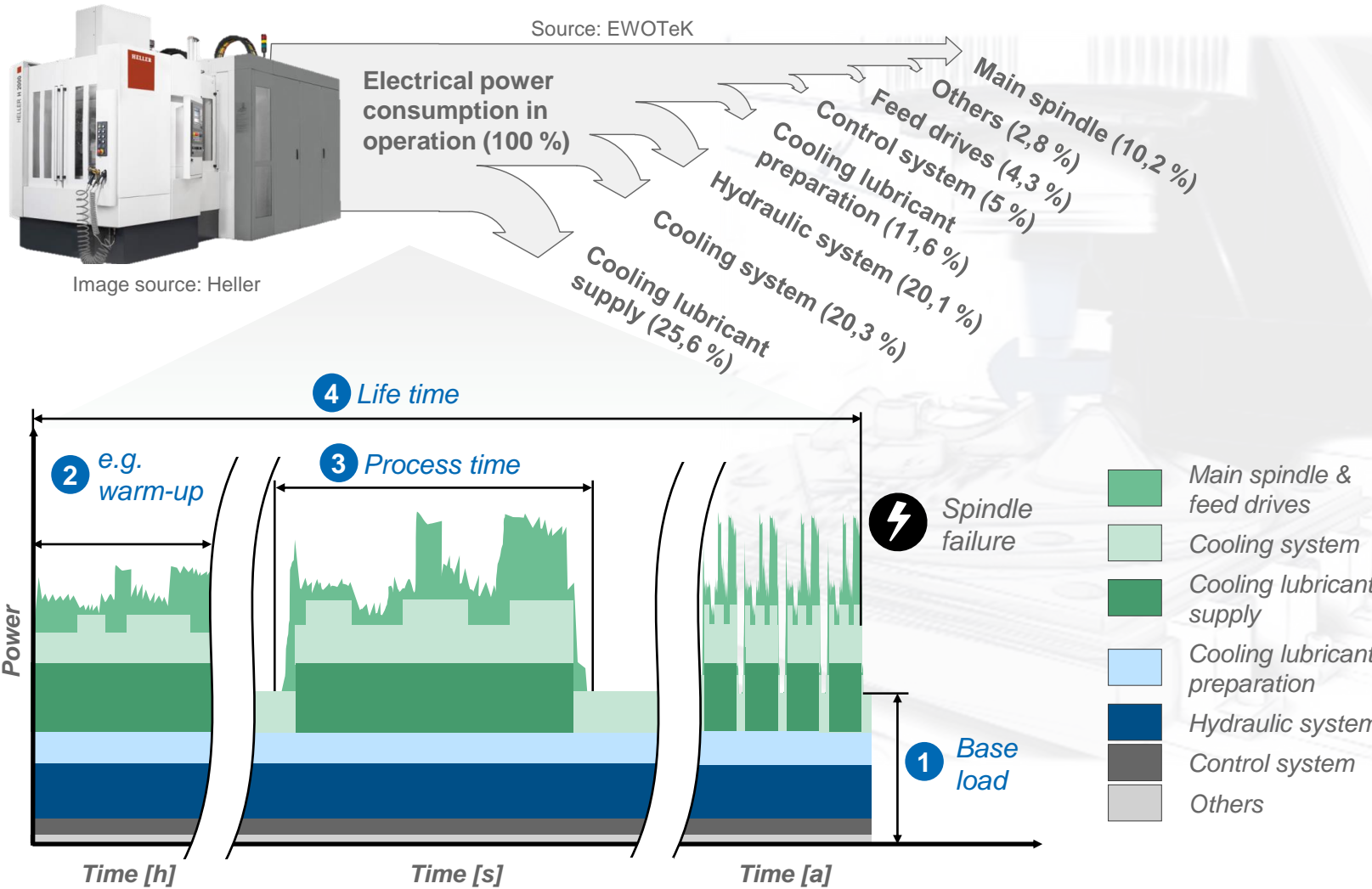


Research object:
motor spindle

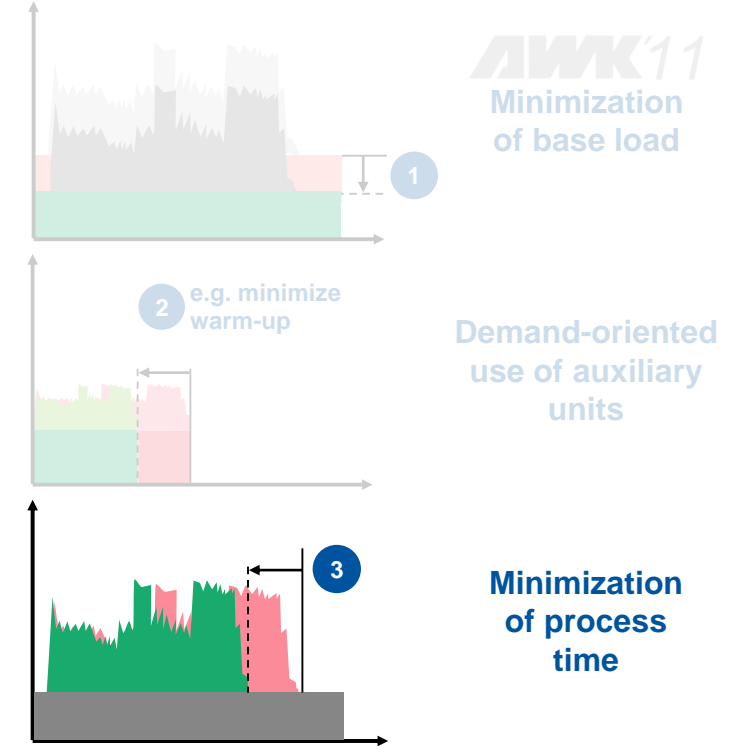


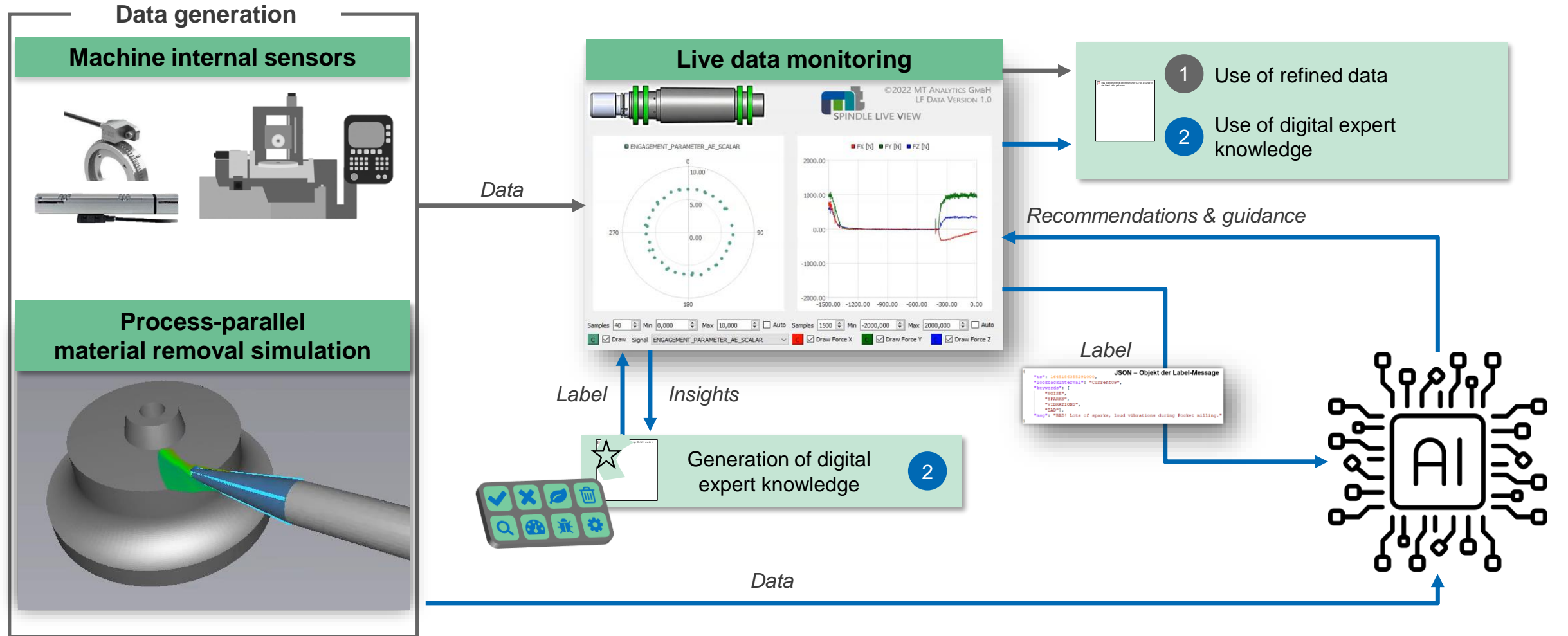
Results

- 1) Reduction of warm-up phase
- 2) Stabilization of thermal behavior during operation
- 3) Bridging of break times



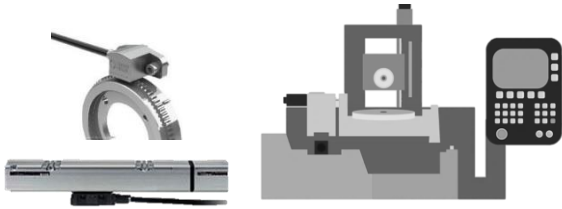
Targets for sustainable production lines





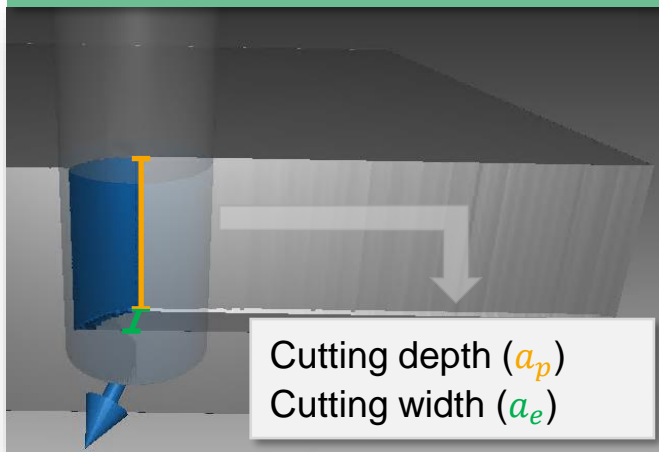
Process parallel determination of cutting data

Machine internal sensors



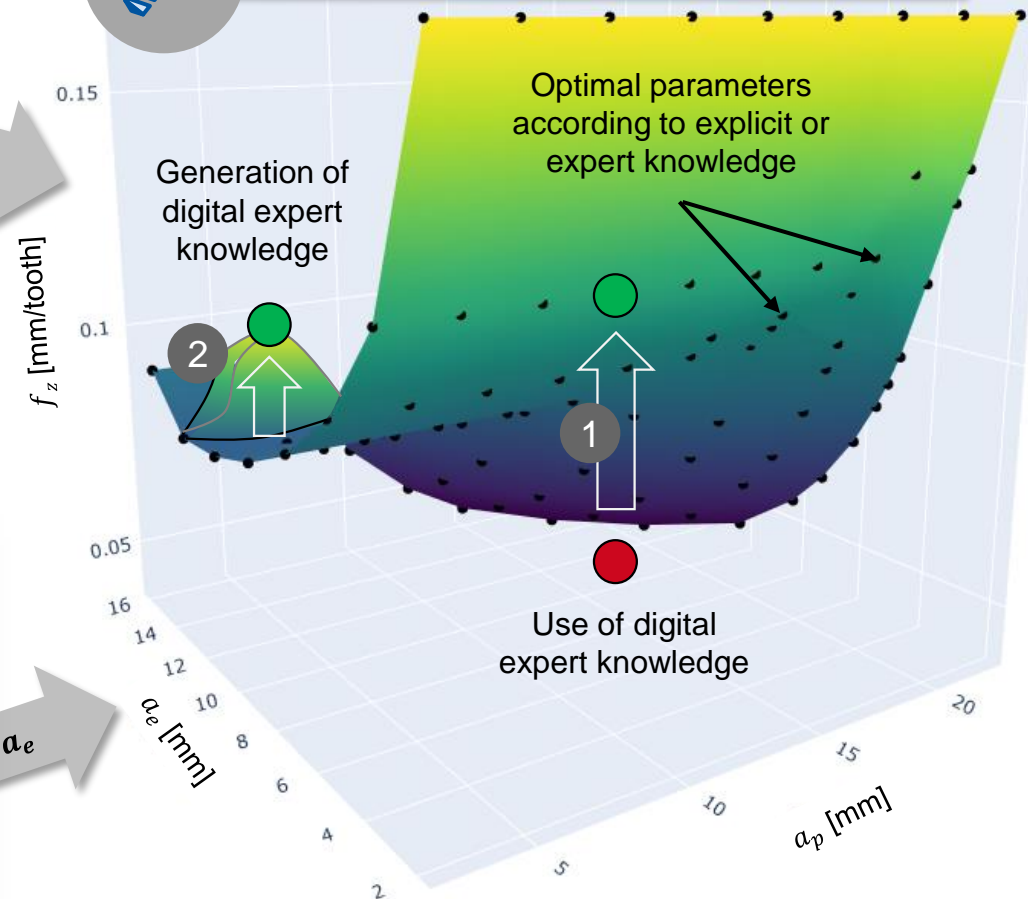
Cutting speed (v_c)
Feed per tooth (f_z)

Process-parallel determination of the engagement situation



Cutting depth (a_p)
Cutting width (a_e)

Process parameter map for a tool-material combination



Use of digital expert knowledge

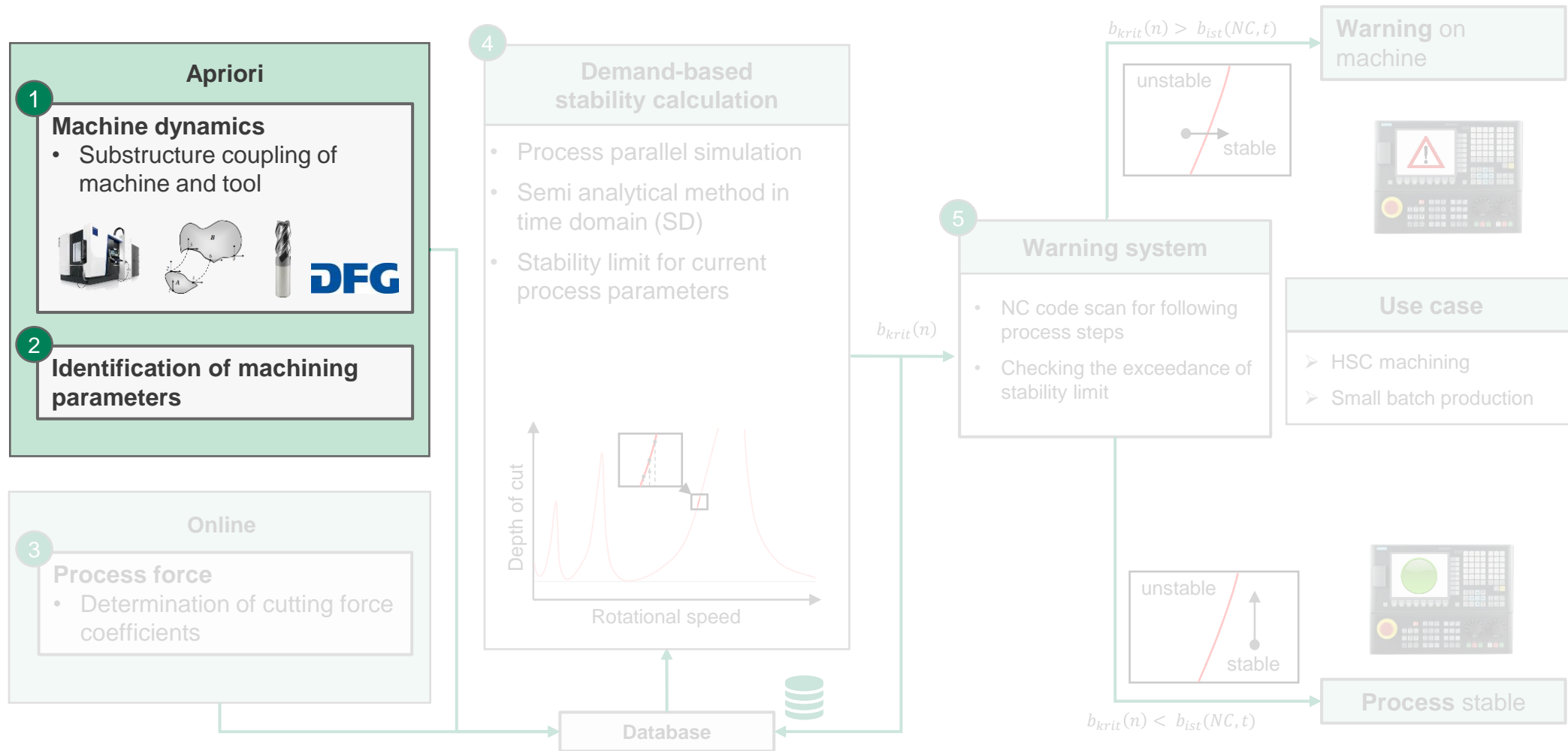
1

- Provision of relevant information (e.g. optimal v_c and f_z for current a_p and a_e)

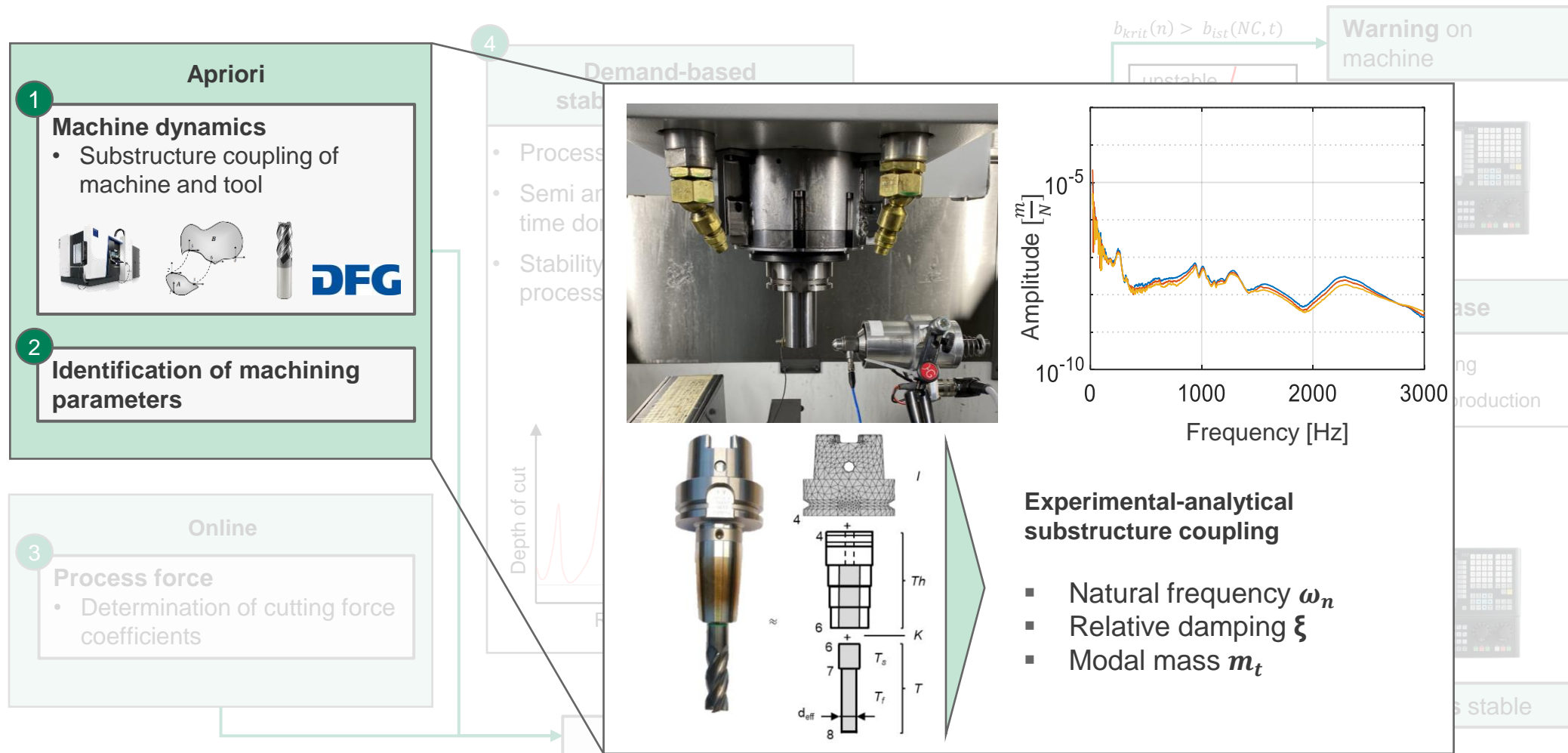
Generation of digital expert knowledge

2

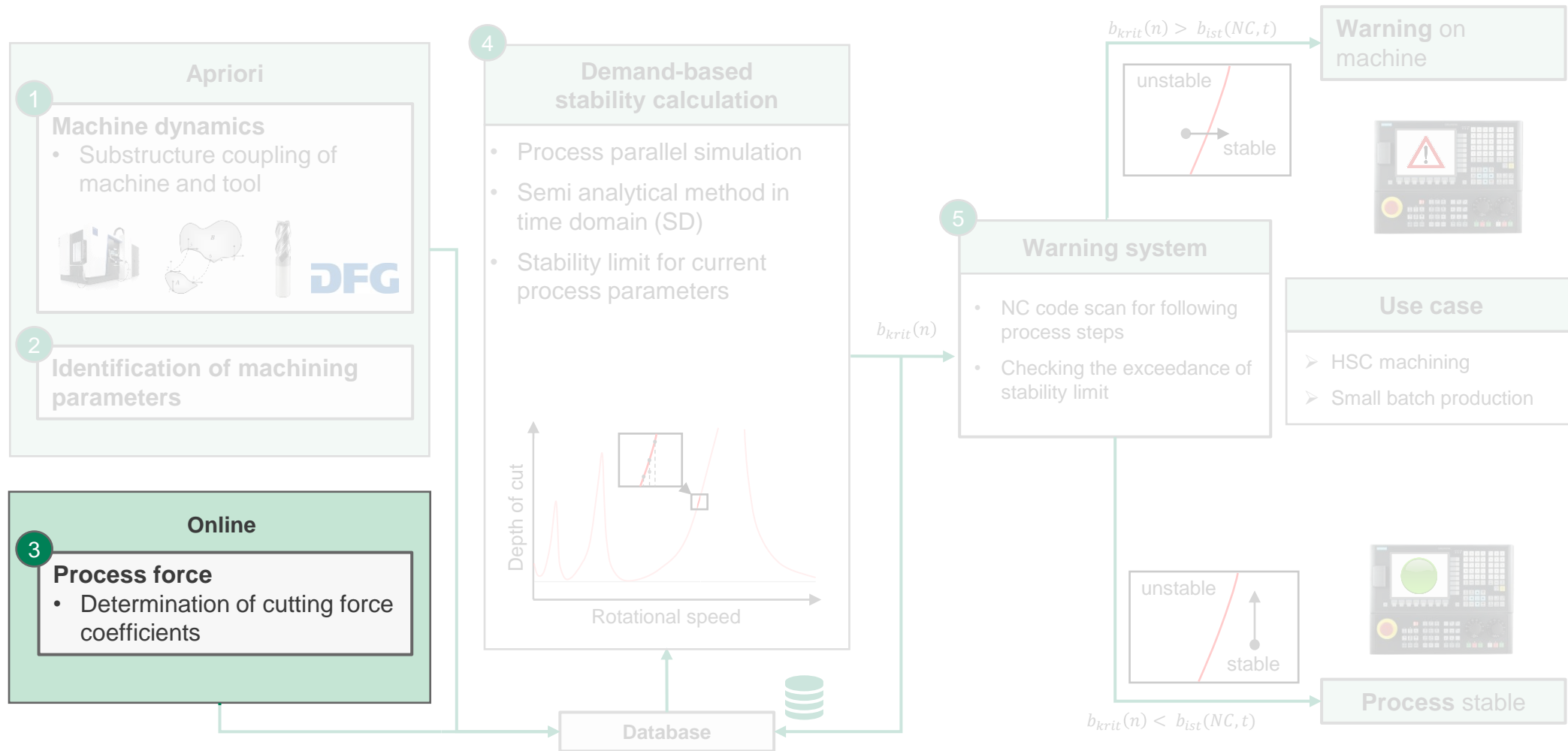
- Experts exceed the defined optimal parameter
- After subjective expert evaluation, there is a possibility to **acknowledge new limits**
- Complete digital **contextualization** (Override speed and feed) **enables** process-parallel **digitalization of expert knowledge**



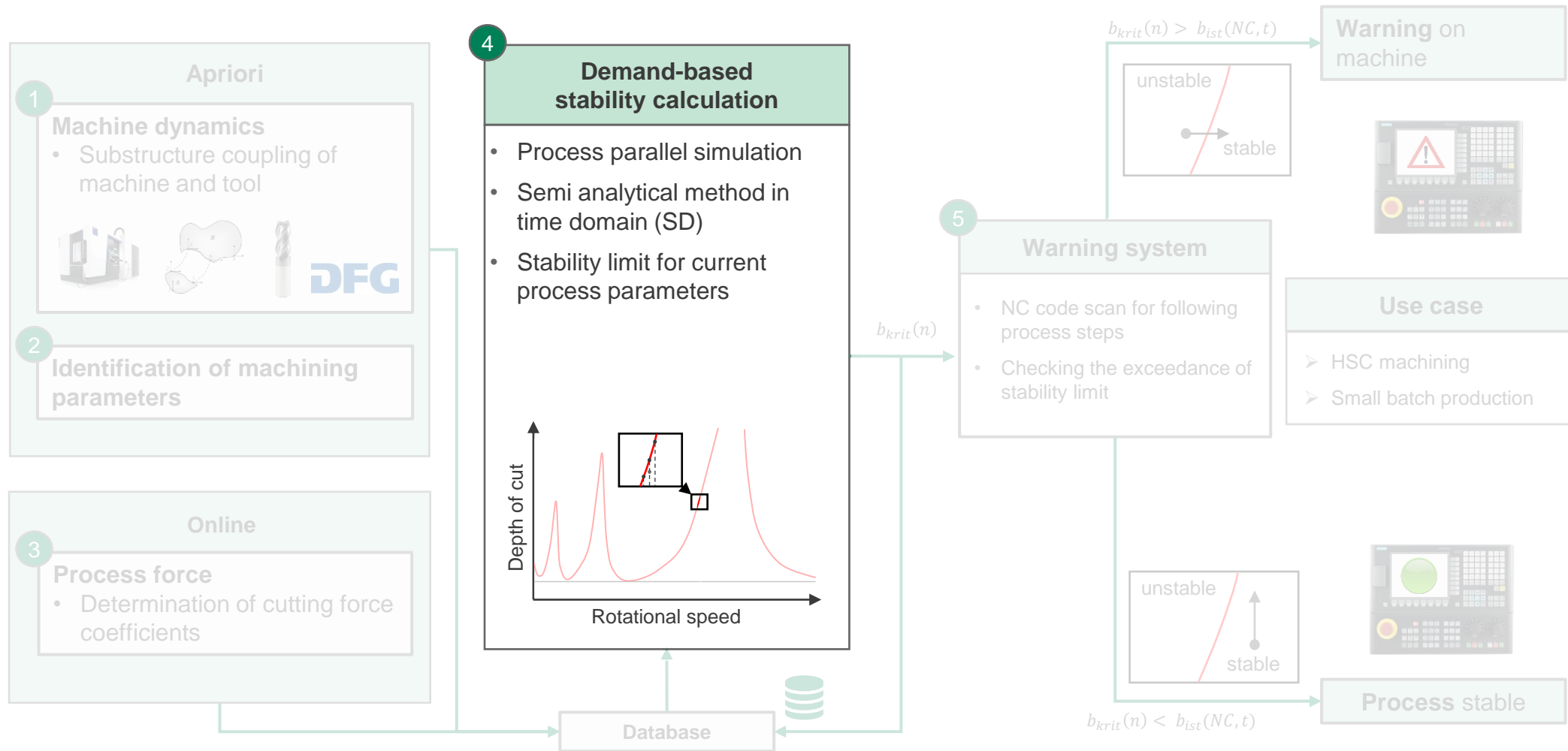
Sources: Heller, Sandvik, Siemens



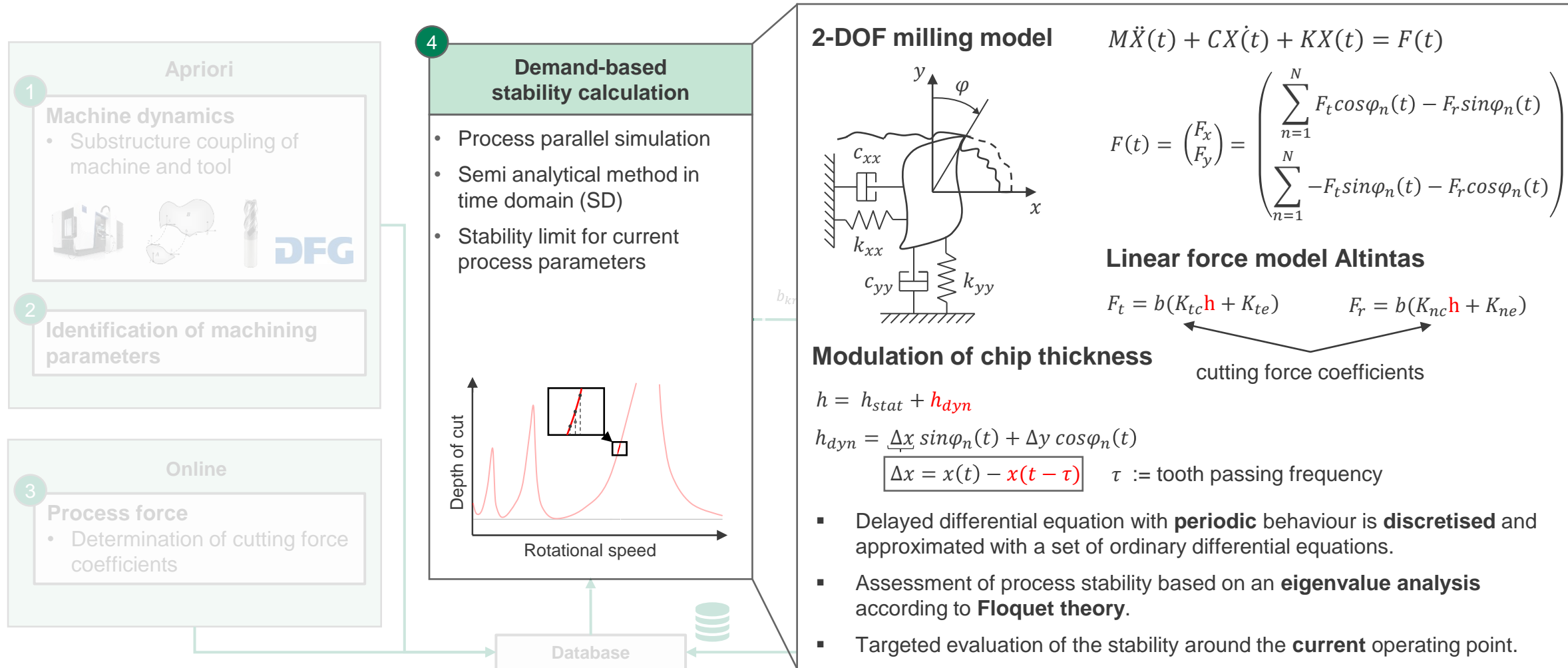
Sources: Heller, Sandvik, Siemens



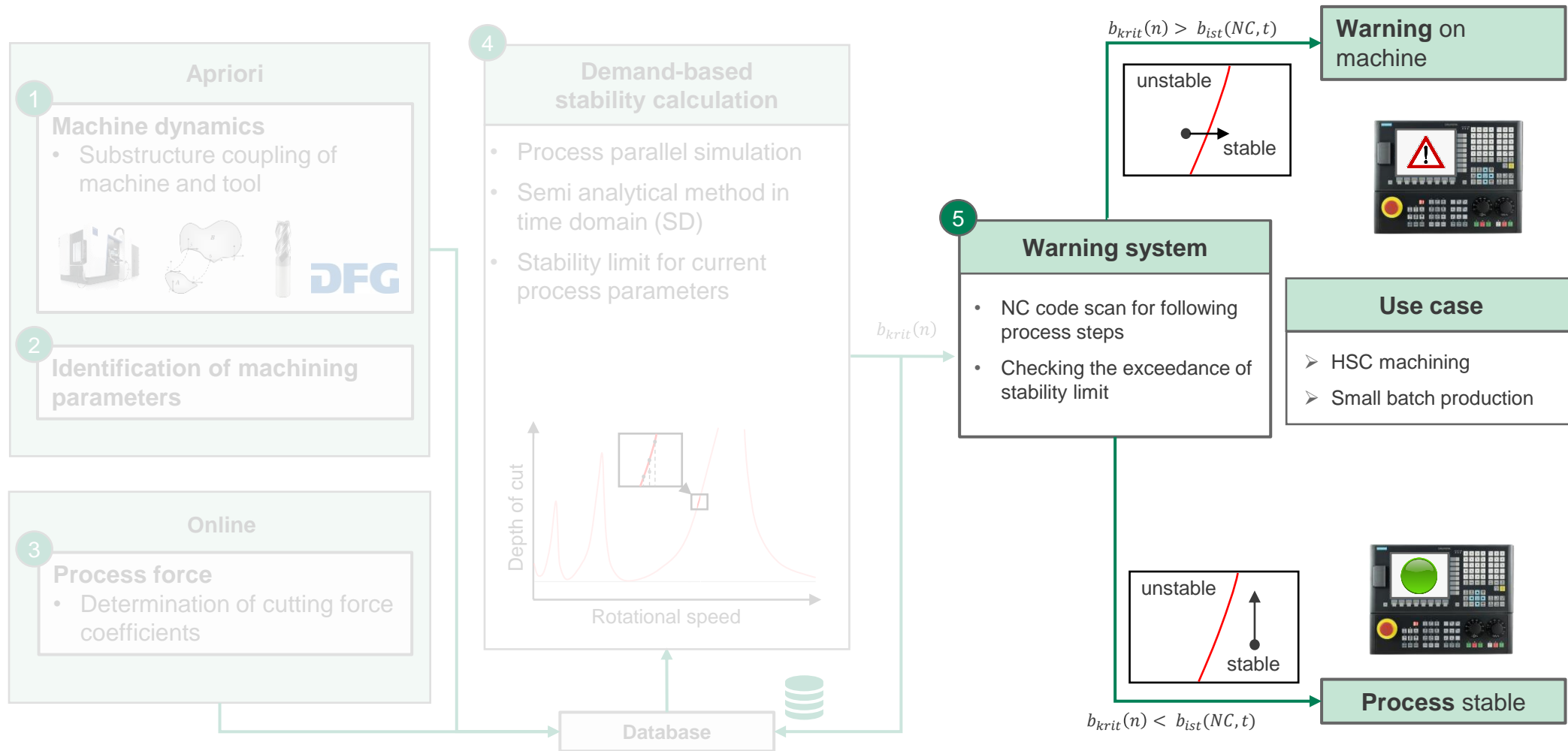
Sources: Heller, Sandvik, Siemens



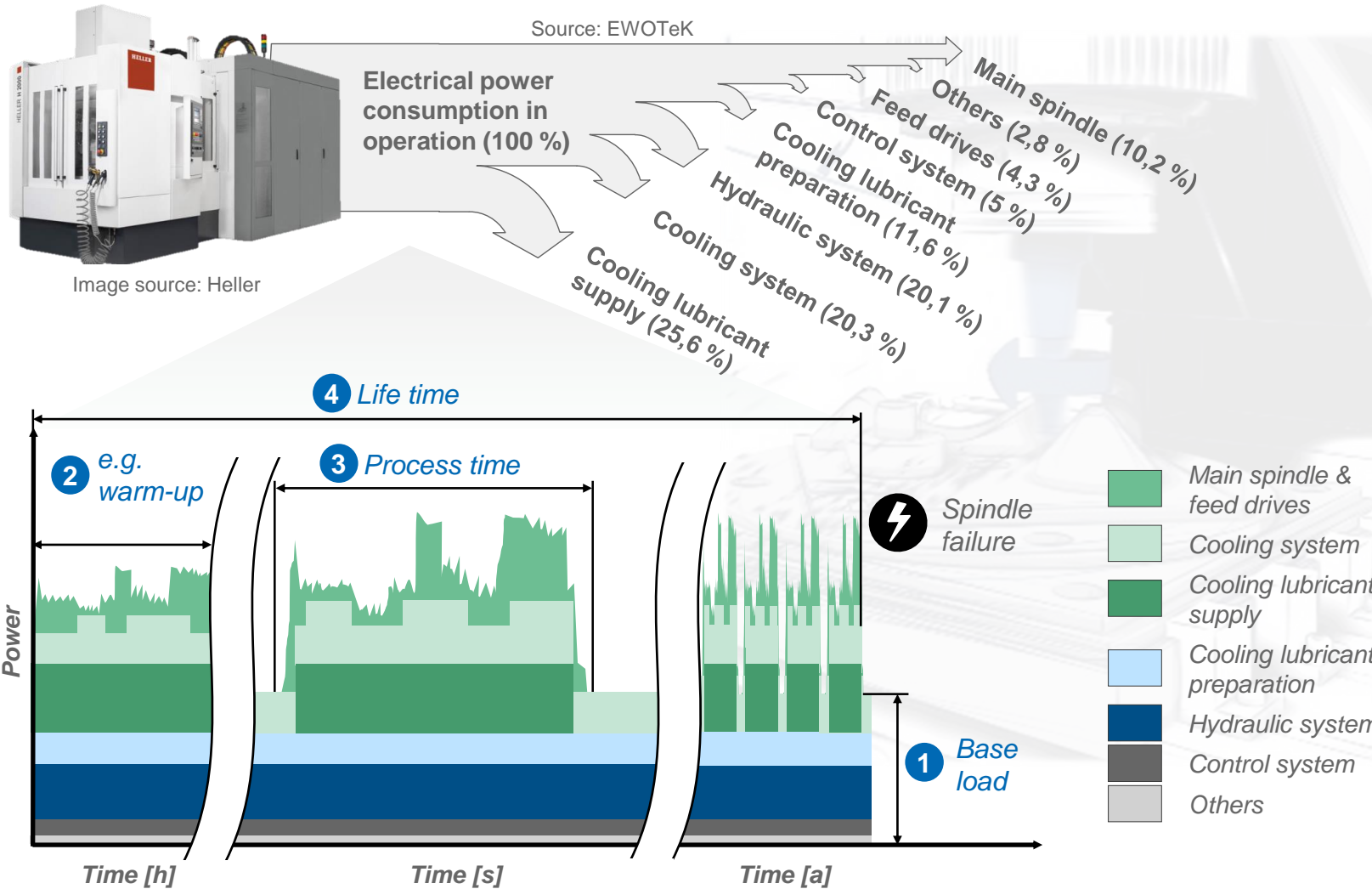
Sources: Heller, Sandvik, Siemens



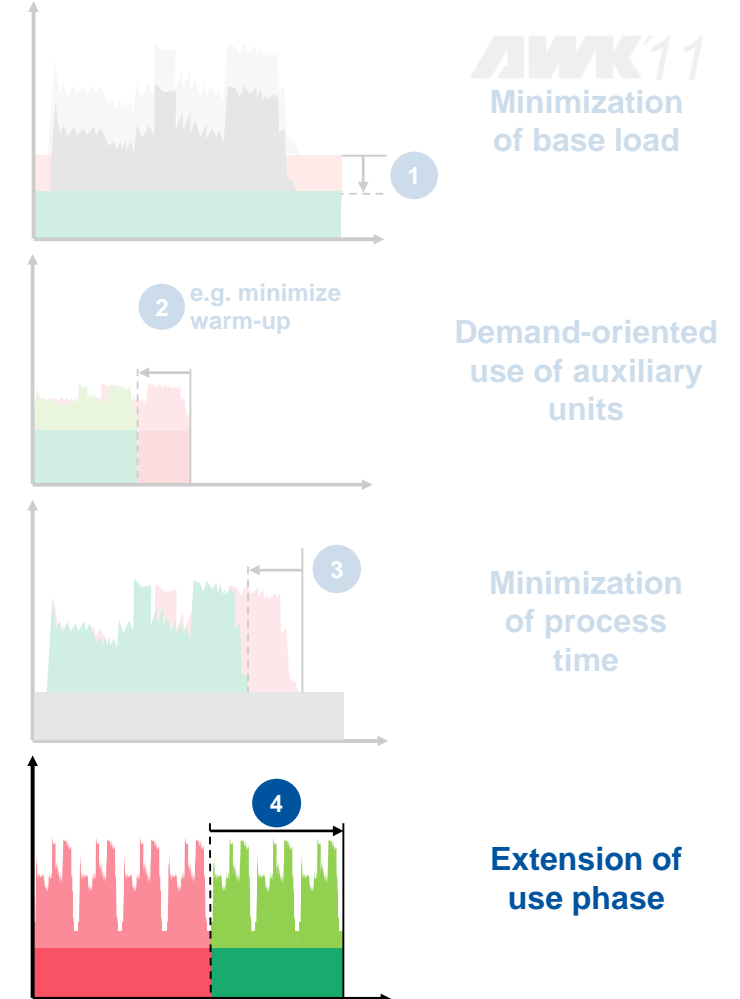
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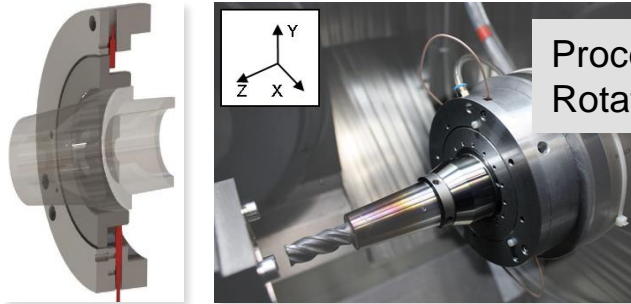


Targets for sustainable production lines



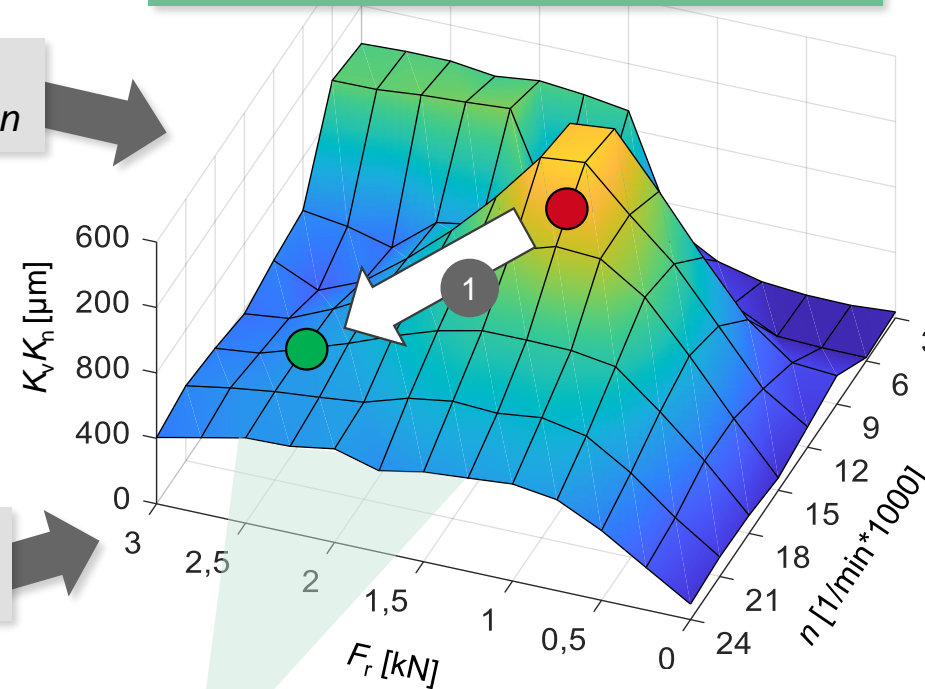
Identification of service life reducing operating conditions

Process-parallel determination of process forces

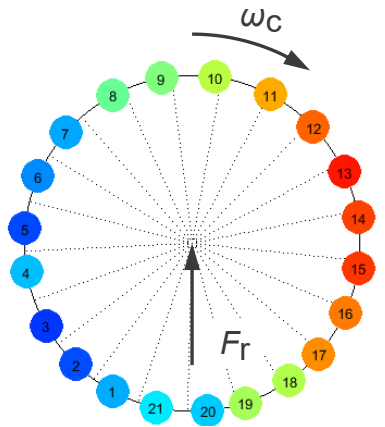


Process forces F_r
Rotational speed n

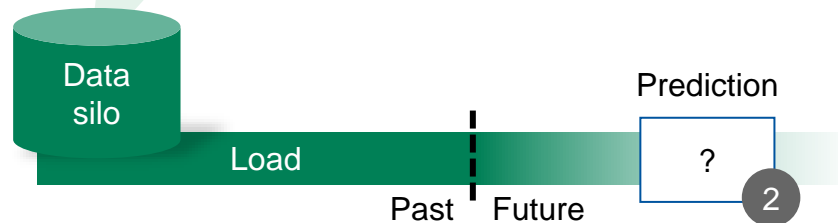
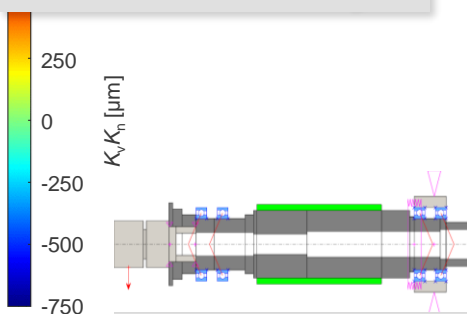
Load map of machine components



Calculation of transferable spindle & bearing characteristics



Circ. ball advance $K_v K_n$
Contact stress p_n



Use of digital expert knowledge

1

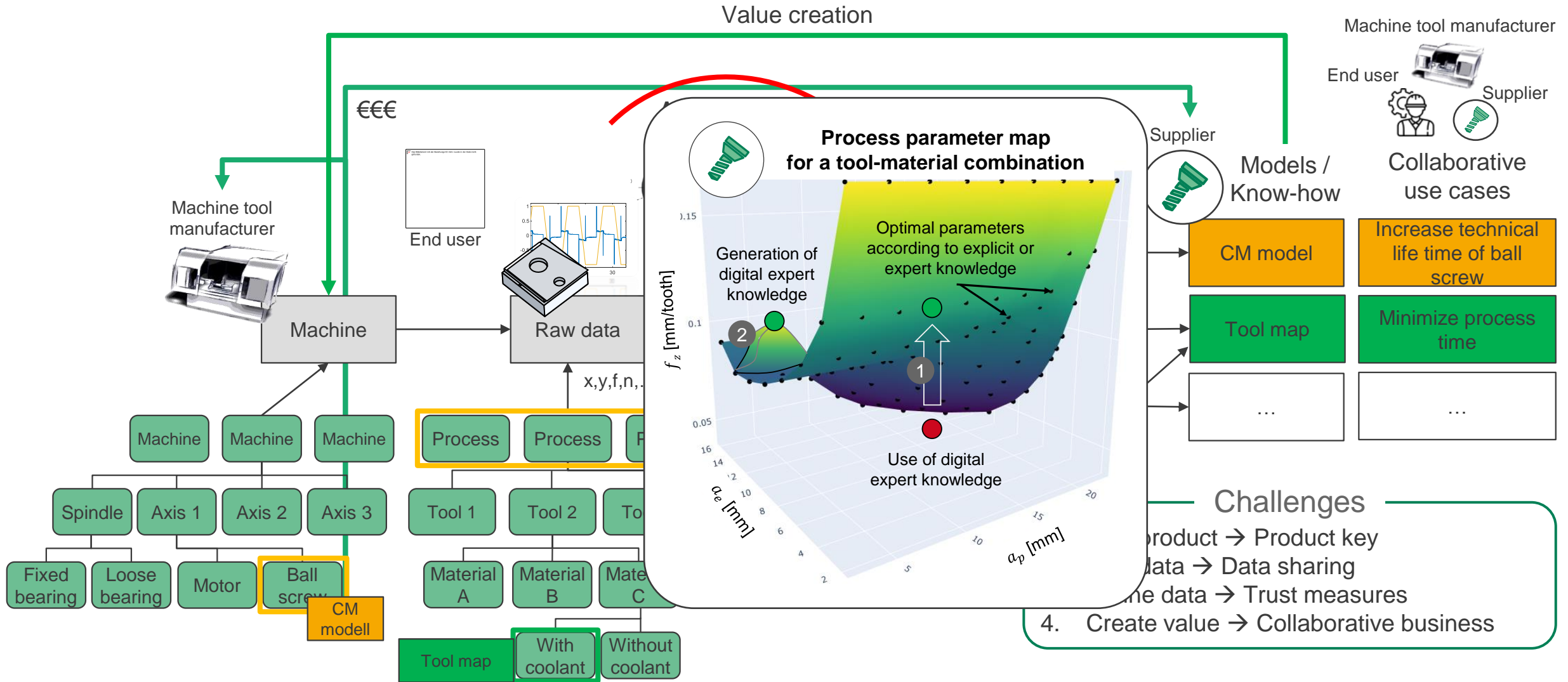
- Provision of relevant information (e.g. optimal operating conditions for the main spindle)



Increase in technical availability

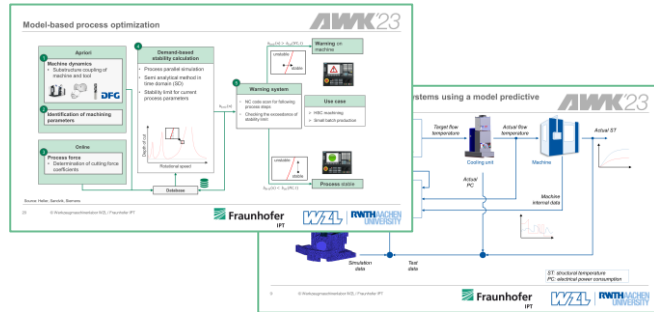
2

- Process-parallel **acquisition of transferable load conditions** of relevant machine components along their service life
- Transferability** of the parameters enables use for **machine learning approaches**



New approaches

- Optimized temperature management
- Process time minimization through digital expert knowledge
- Update capability of hard- and software
- ...



Known approaches

- Energy-efficient auxiliary units for base load minimization
- ...

Short term

Mid term

Long term

Strategic vision

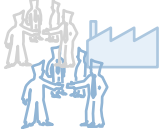
Sustainability through digital expert knowledge

- Knowledge transfer
- Increased productivity, wear reduction



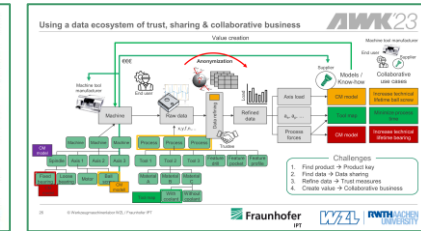
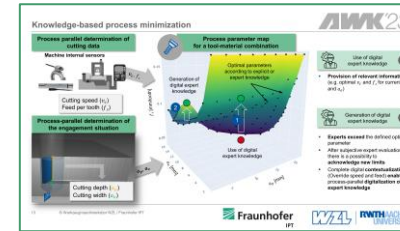
Sustainability through company-wide knowledge transfer

- Knowledge extraction and persistence as business know-how
- Cross-departmental utilization opportunities
- Meeting demographic change



Sustainability through cross-company knowledge trading

- Purchase/sale of business know-how
- Data-based price determination according to individual efficiency increase
- Requirement: Data security and anonymity



Thank you very much for your attention!