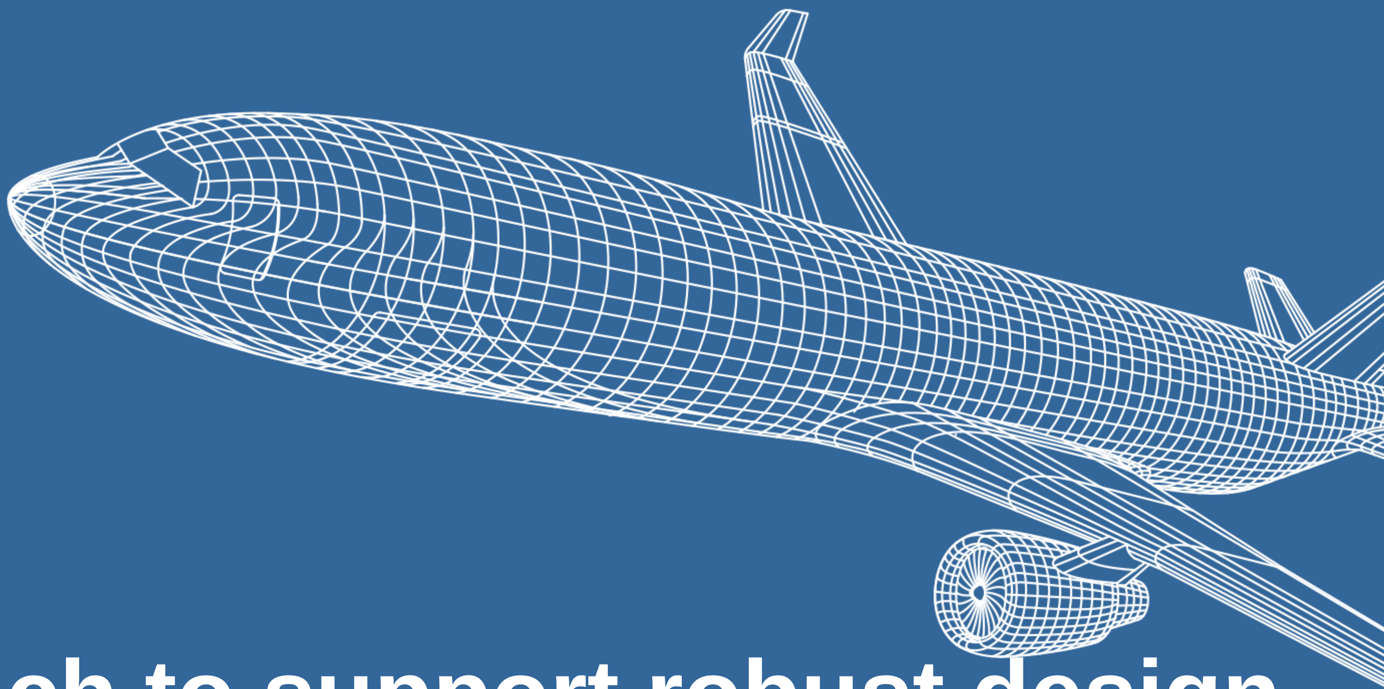

An approach to support robust design and identify producibility parameters for jet engine components

Presented at Aerospace Technology Congress (FT2016)

Johan Vallhagen, 2016-10-11

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GKN TECHNOLOGY:
MAKING THINGS FLY

These results are part of ongoing project

“Producibility and Design for Manufacturing of Aerospace Engine Components”

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Julia Madrid,Ph.D. student

Prof. Rikard Söderberg, Examiner

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GKN AEROSPACE

CHALMERS UNIVERSITY OF TECHNOLOGY

wingquist LABORATORY

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The support is gratefully acknowledged.
(NFFP - Nationella Flygtekniska Forskningsprogrammet)

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Agenda

Background

- What is Producibility?
- A case in the aerospace industry
- Problem description
- Research purpose

Conceptual framework

Example

Conclusions and future implications

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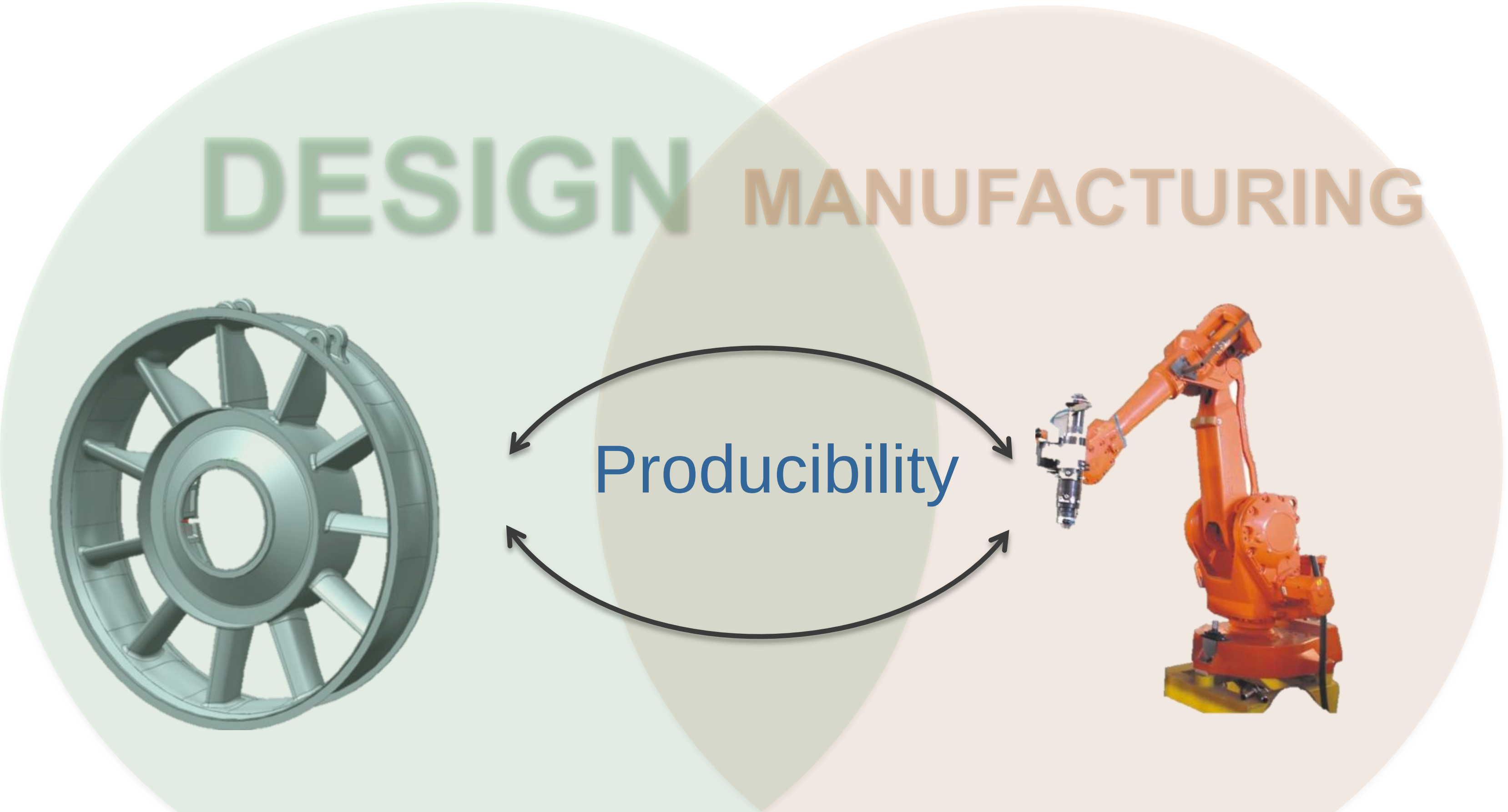

"Can we produce this…?
*….at what **quality** level and what **cost**?"*

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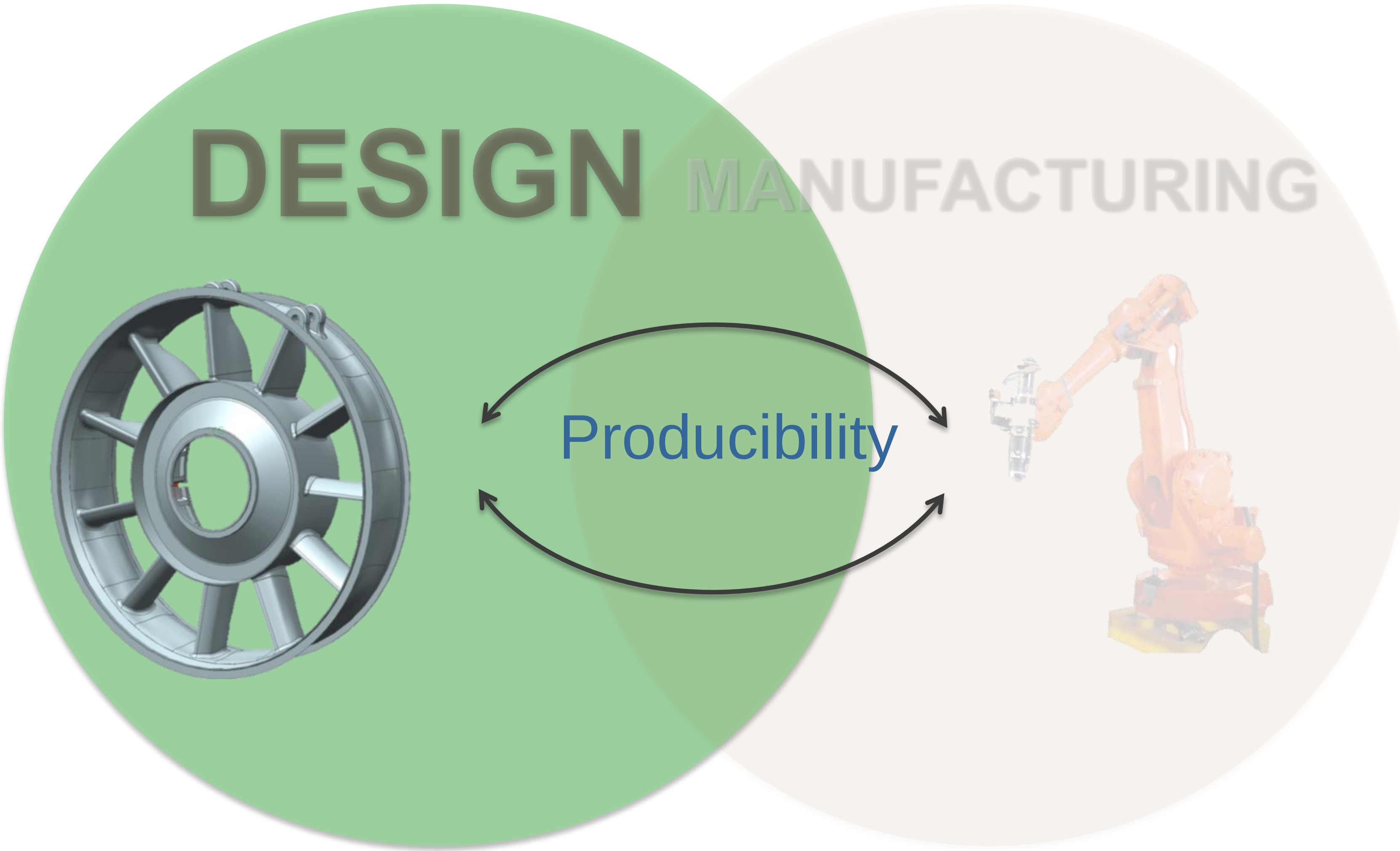

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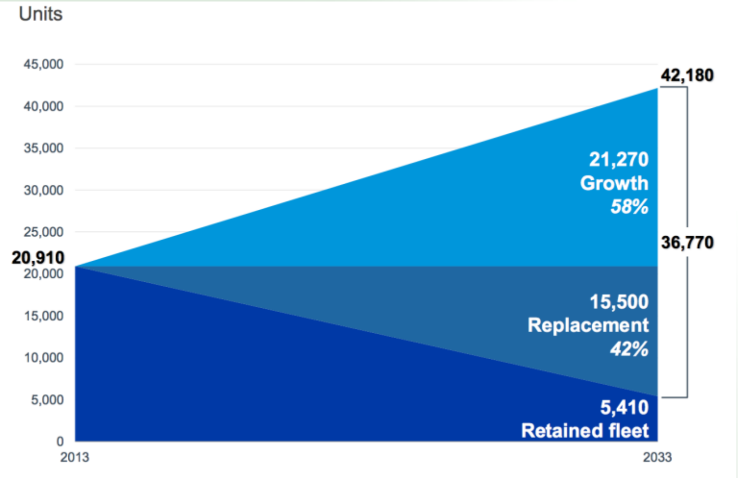
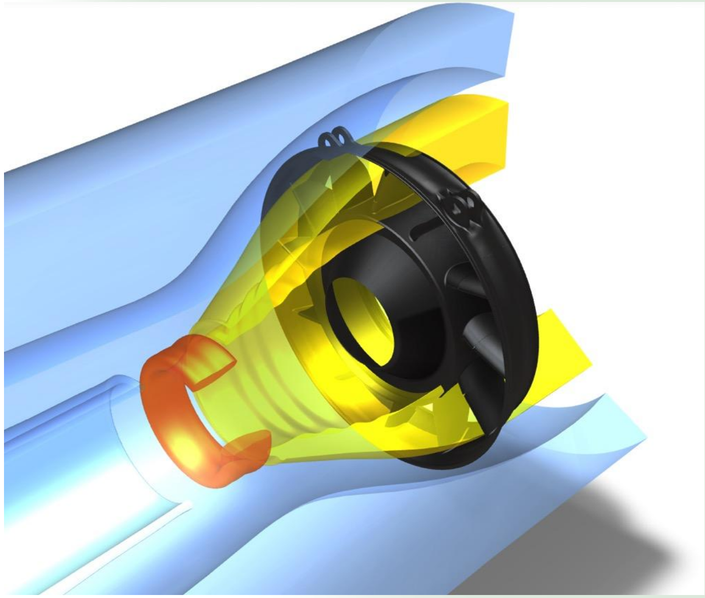
Design in aerospace industry

Market growth:
20 910 – 42 180 units
2013 - 2033 year



(Boeing, 2014)



A jet engine component

Tough performance requirements:

- Aerodynamic
- Thermal loads
- Structural loads
- Weight

Light-weight strategies to reduce weight and CO_2 emissions

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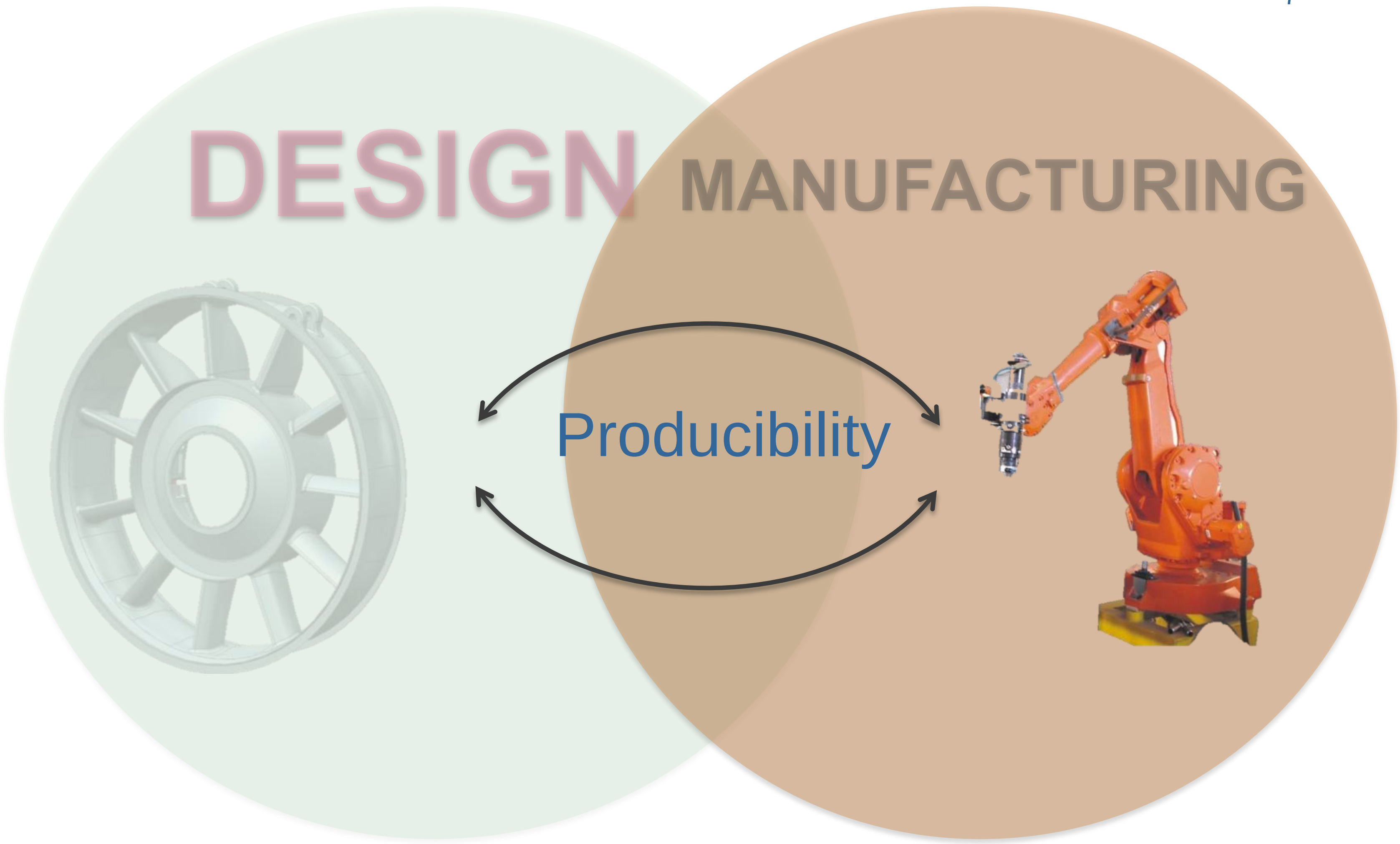
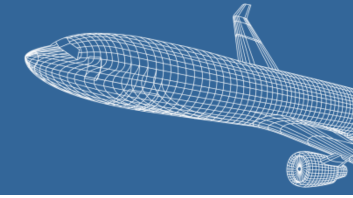

DESIGN
MANUFACTURING
Producibility

Manufacturing in aerospace industry



MANUFACTURING

Fabricated aerospace component

Smaller parts are **welded** together into the final shape

<u>Advantages:</u>

Increased number of potential **suppliers**

Configuring several **materials and geometries** allows **weight optimization**

Design freedom → Increased number of design **variants** for the same product definition

Possibility to **reuse knowledge, technologies** and manufacturing processes

Platforms strategies to enable the creation of variants and reuse of knowledge

<u>Disadvantages:</u>

Number of **assembly steps increases**

Use of **novel technologies**: **Welding** methods and advance materials

Heat and deformation

Geometrical variation and weld quality problems

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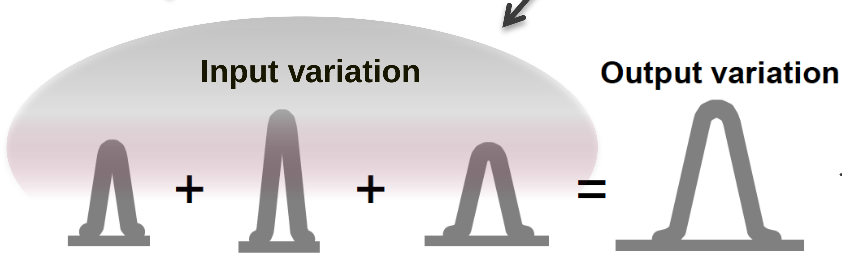
Problem description

DESIGN

Long and few product cycles
Reduce possibility of learning

MANUFACTURING

Manufacturing solution tailored to specific design
Low level of automation
Low repeatability
Insufficient capabilities



Unwanted variation
Hard to relate the effects to causes
Effects vary between product concepts

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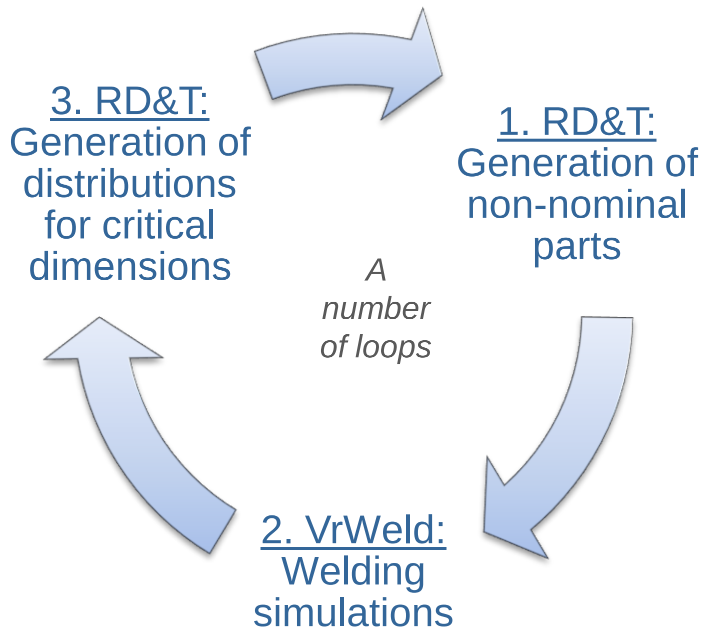
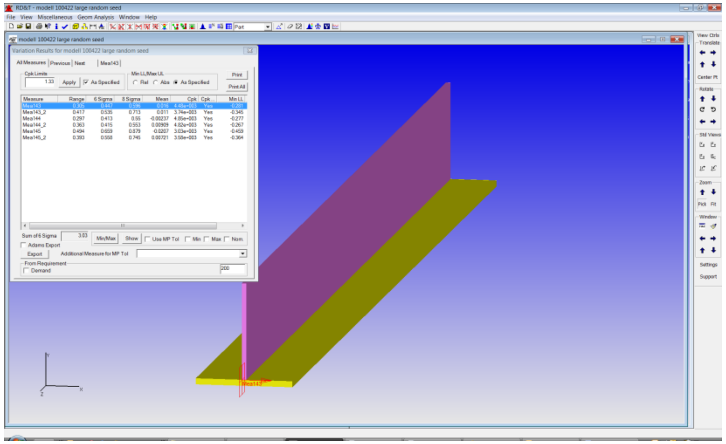
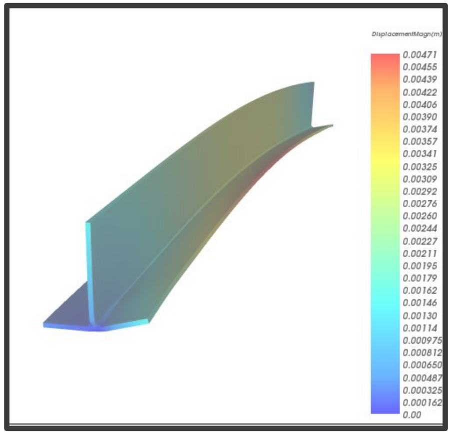
Combining variation simulation with welding simulation



Variation simulation in **RD&T**



Welding simulation in **VrWeld**



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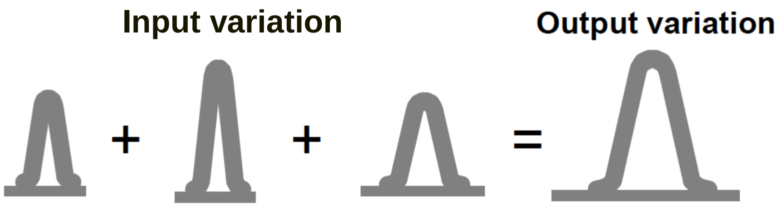
Research purpose

"Can we produce this…?
*….at what **quality** level and what **cost**?"*



*Purpose : **Variation modeling** to predict the variation effects, the impact of the product design into production system.*

What is required first?

A basic model of the process to identify variation sources during the production sequence and how these affect the product performance, i.e. the quality of the product.

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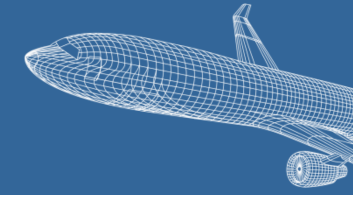
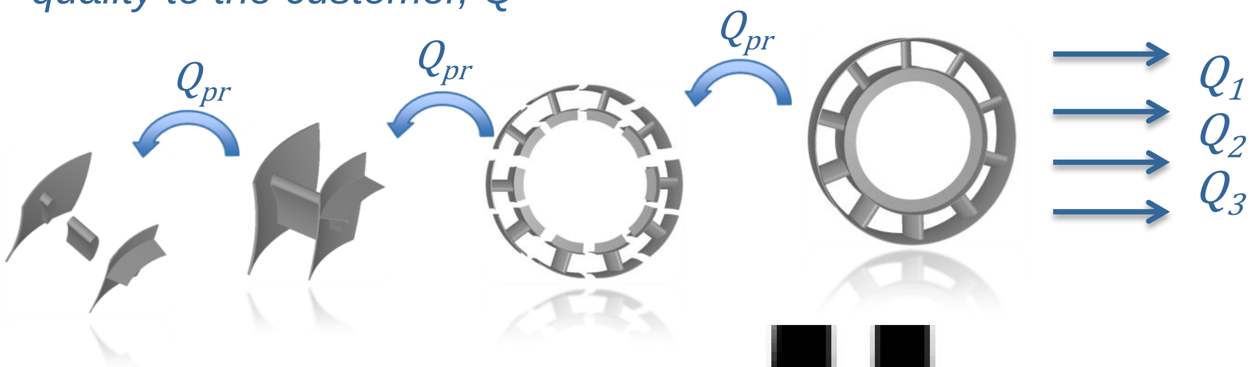
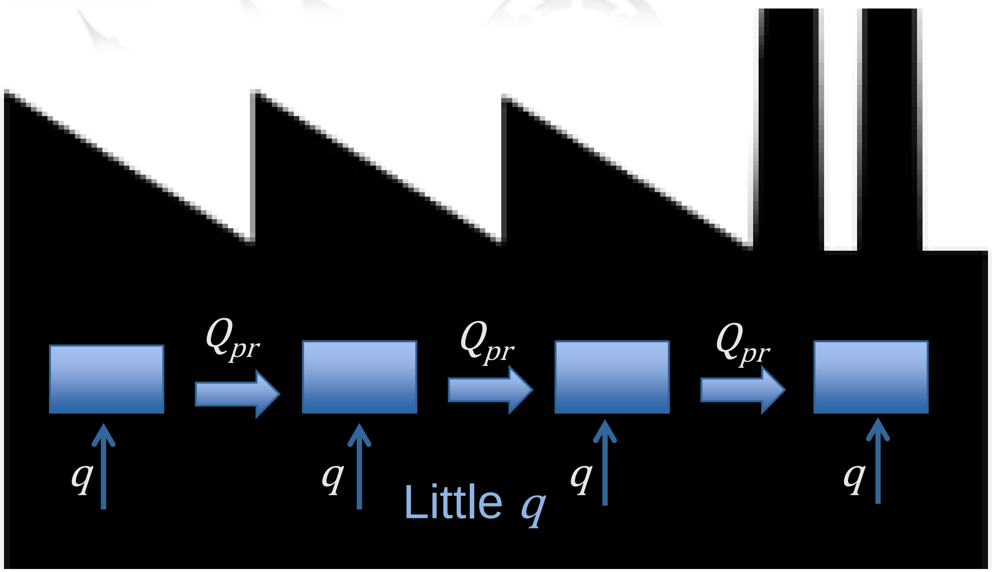
Mind-set behind conceptual framework



Product properties/features, $Q_{pr,}$, deliver quality to the customer, Q

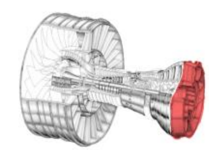
Big Q





VOC:
General specification of the product quality

- Aero
- Strength & Life
- Weight
- Interfaces interaction



Manufacturing operations (with their control parameters, q) transforms features, Q_{pr}, at each operation to deliver the final quality , Q .

(Big Q and little q, concept adapted from Mikkel Morup, 1993)

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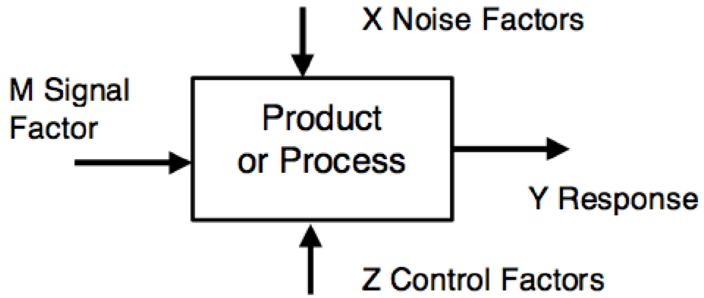
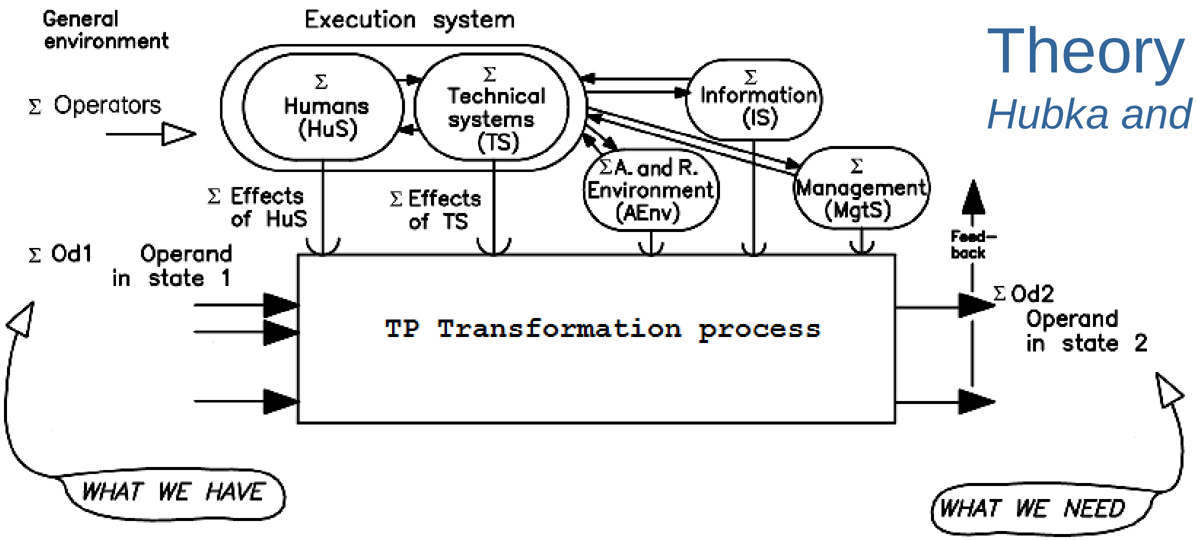
Modeling manufacturing process

P diagram, *Phadke 1989*



Theory of Technical Systems, *Hubka and Eder 1988*



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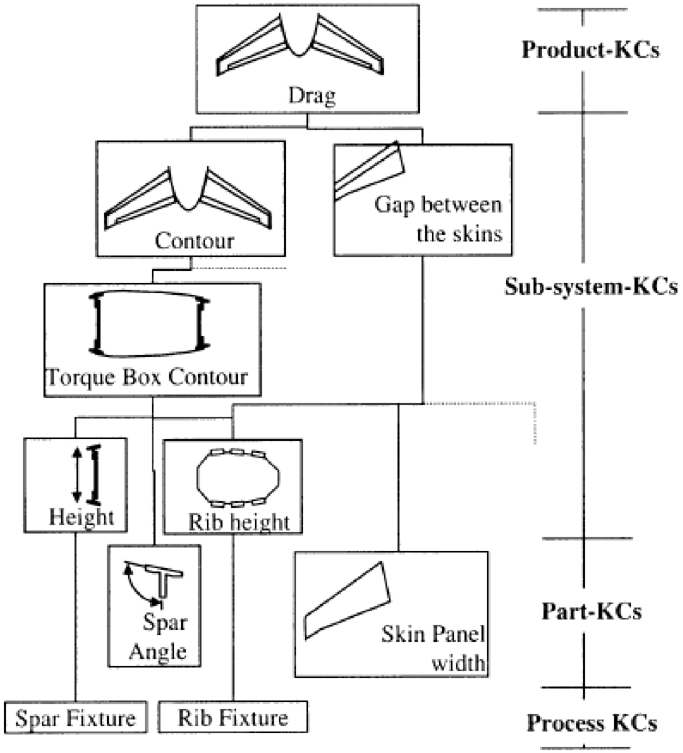
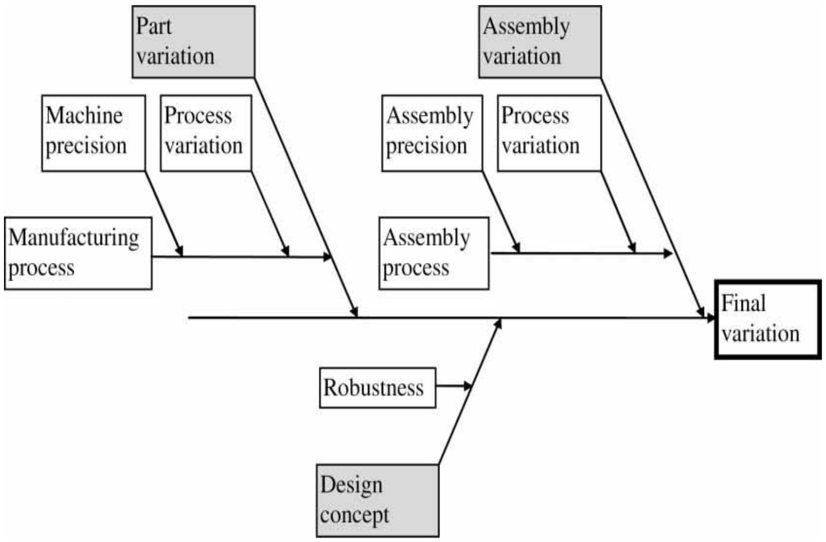
Variation propagation modeling

KC-flowdown, from Variation Risk Management theory (VRM), *Anna Thornton 1999*



Contributors to final geometrical variation, *Söderberg 1998*



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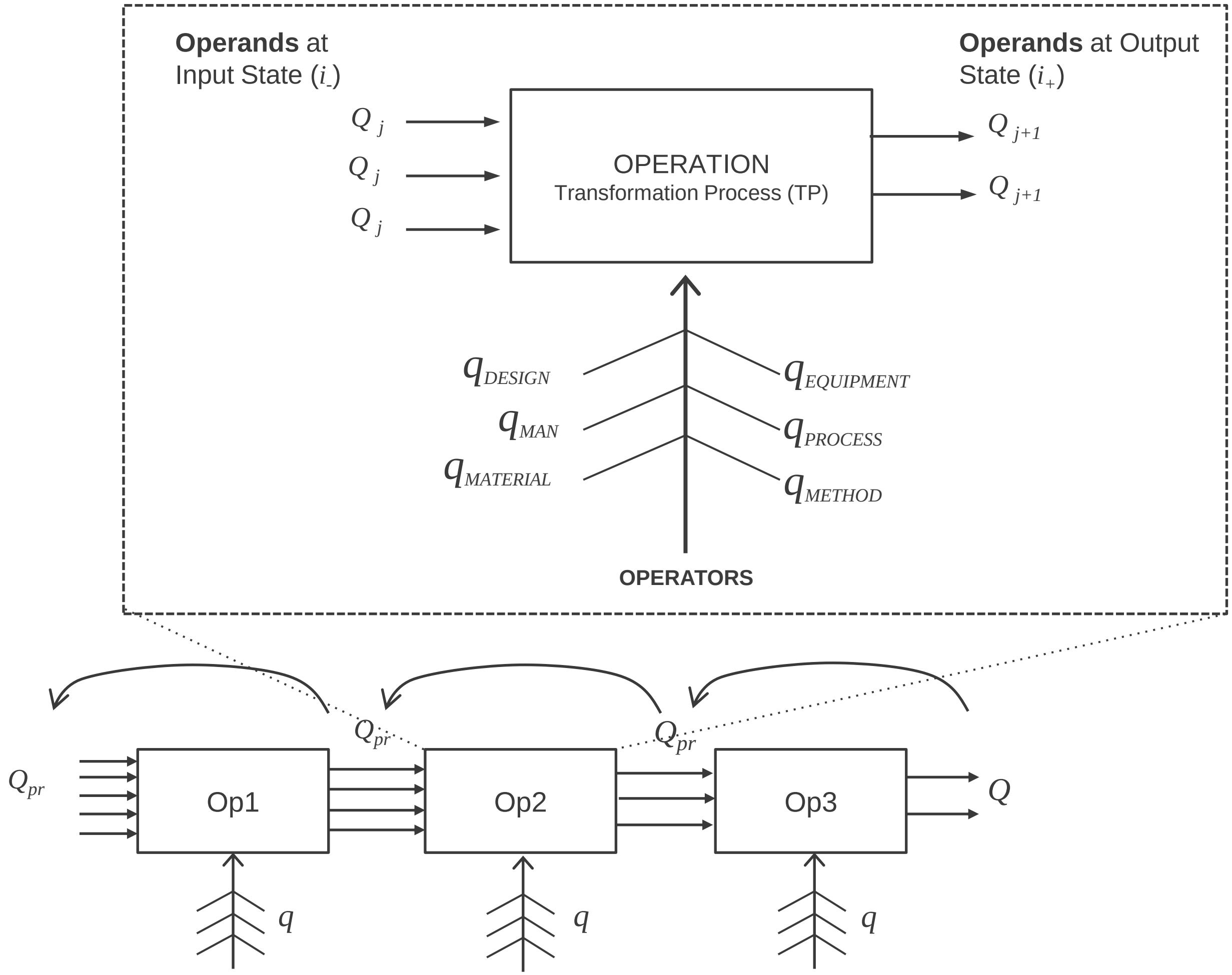
Variation propagation modeling



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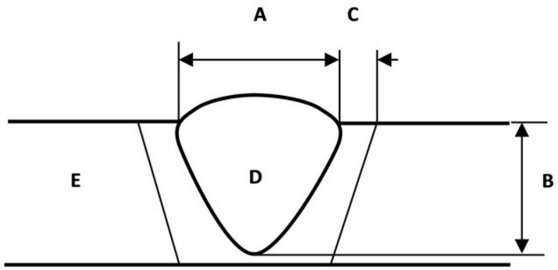
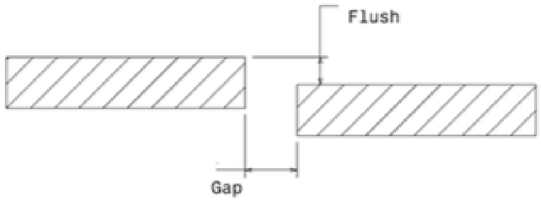
Example

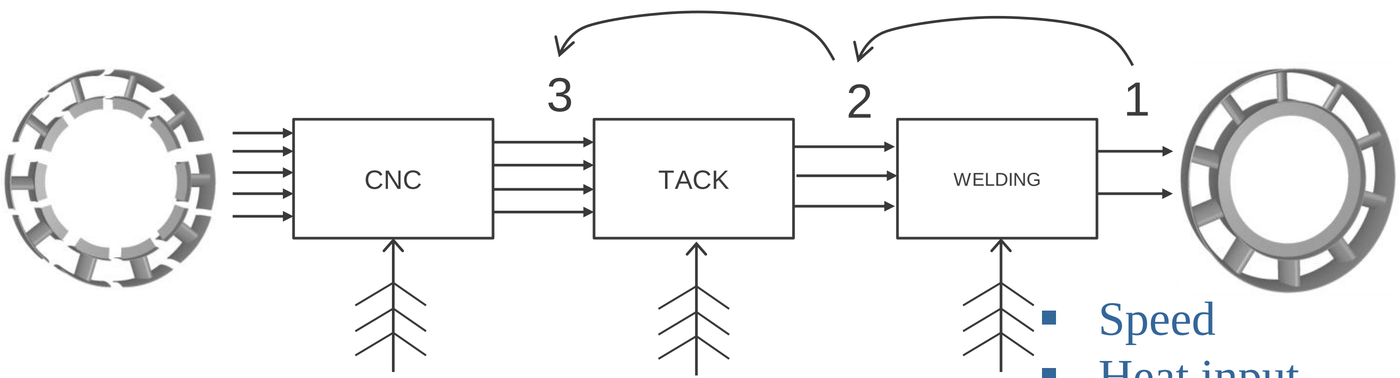
Big Q

1. Acceptance limits for weld geometry
2. Relative positioning between parts (gap, flush etc.)
3. Initial part conditions (weld interface profile, flatness)

Fusion weld requirements







- Speed
- Heat input

Little *q*

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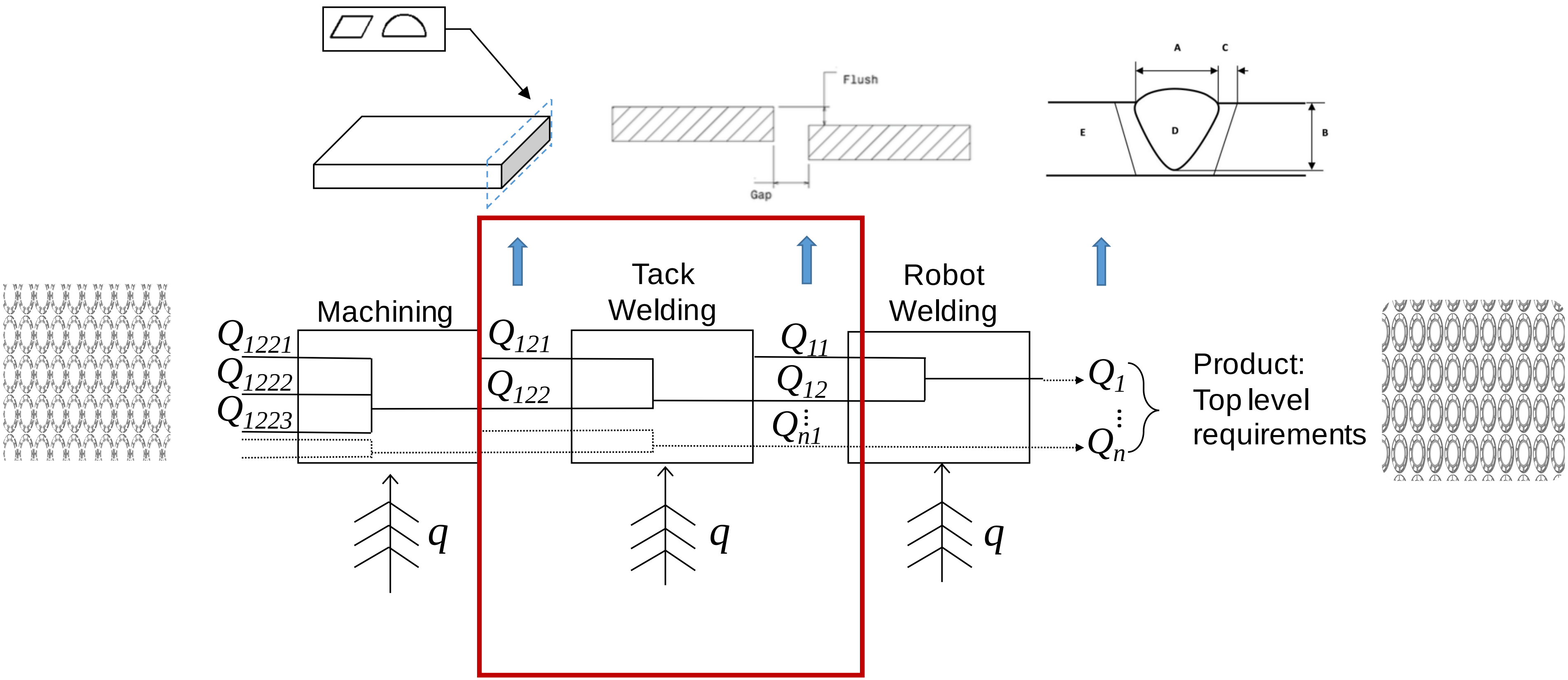
Example



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Conclusions – we have proposed:

A model for the sequence of operations that can describe:

- product quality in each step
- the quality control parameters

A structured way to collect:

- information
- knowledge on product characteristics, and
- parameters that affect variation

A framework to identify what to inspect

A framework for simulations

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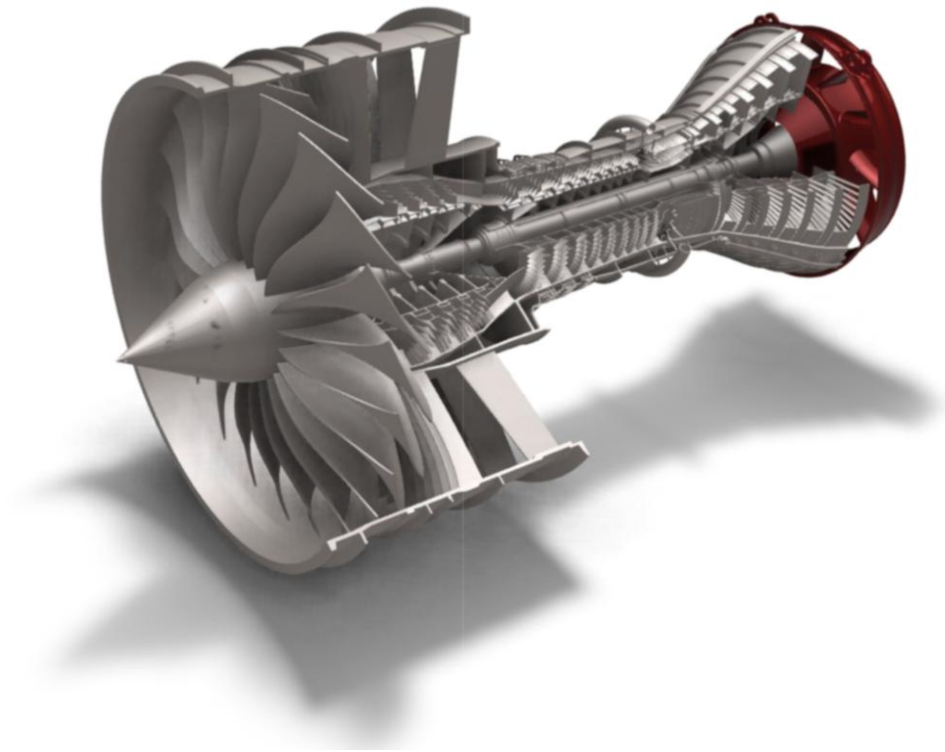
Thank you for listening



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