RESEARCH ON MODEL-BASED (CYBER-PHYSICAL) PRODUCT DEVELOPMENT @ Machine Design

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LINKÖPINGS UNIVERSITET

MODPROD Workshop 2020
4-5/2 2020, Linköping University

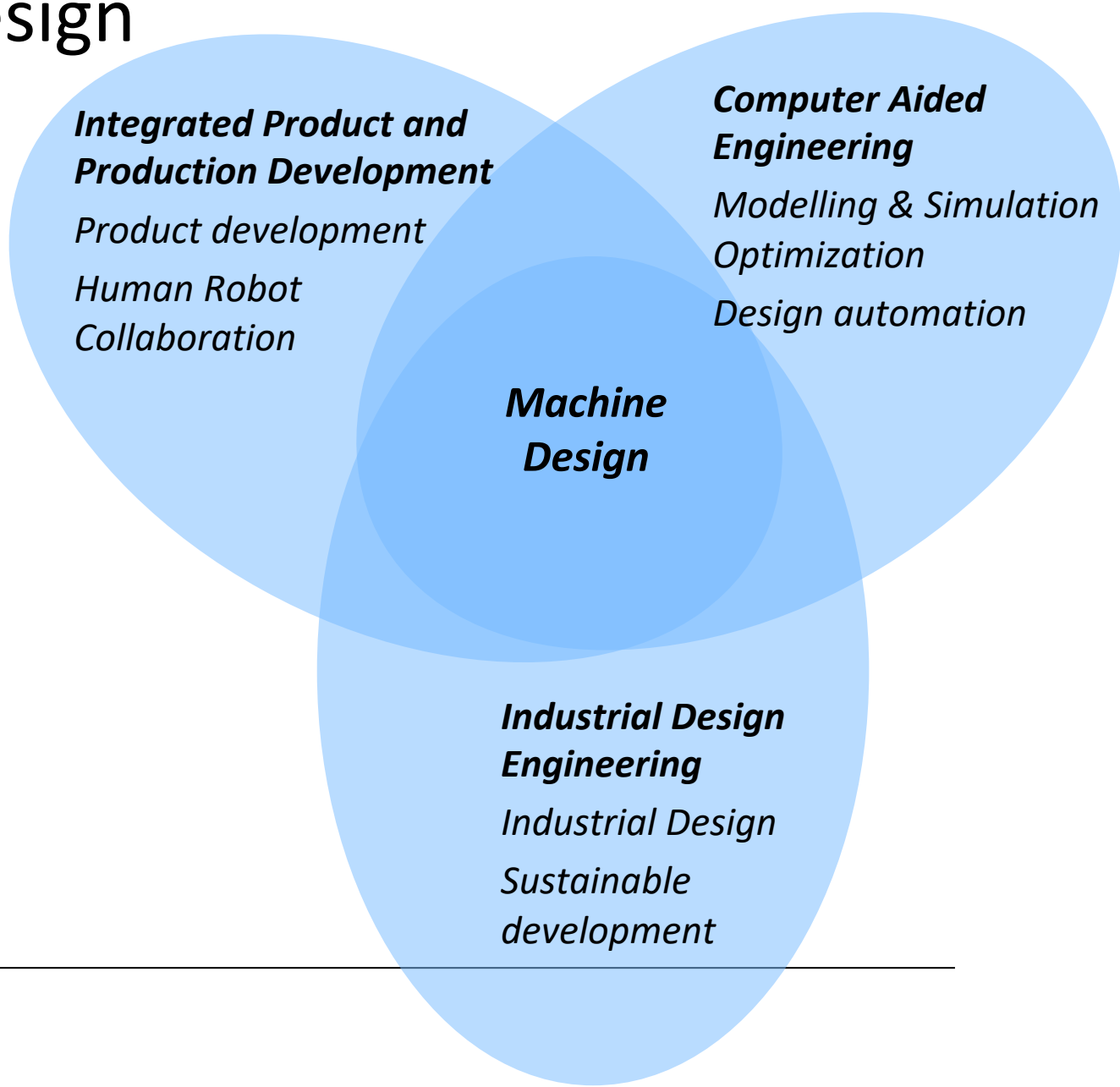
Agenda

- Who we are
- What we do
- Example of some recent PhD-projects
- Ongoing research

The Division of Machine Design

- 2 full professor
- 3 Associate professors
- 5 Senior Lecturers
- 7 Lecturers
- 4 Post docs
- 10 PhD students
- 2 Industrial PhD student
- 1 Technicians
- 1 administrator

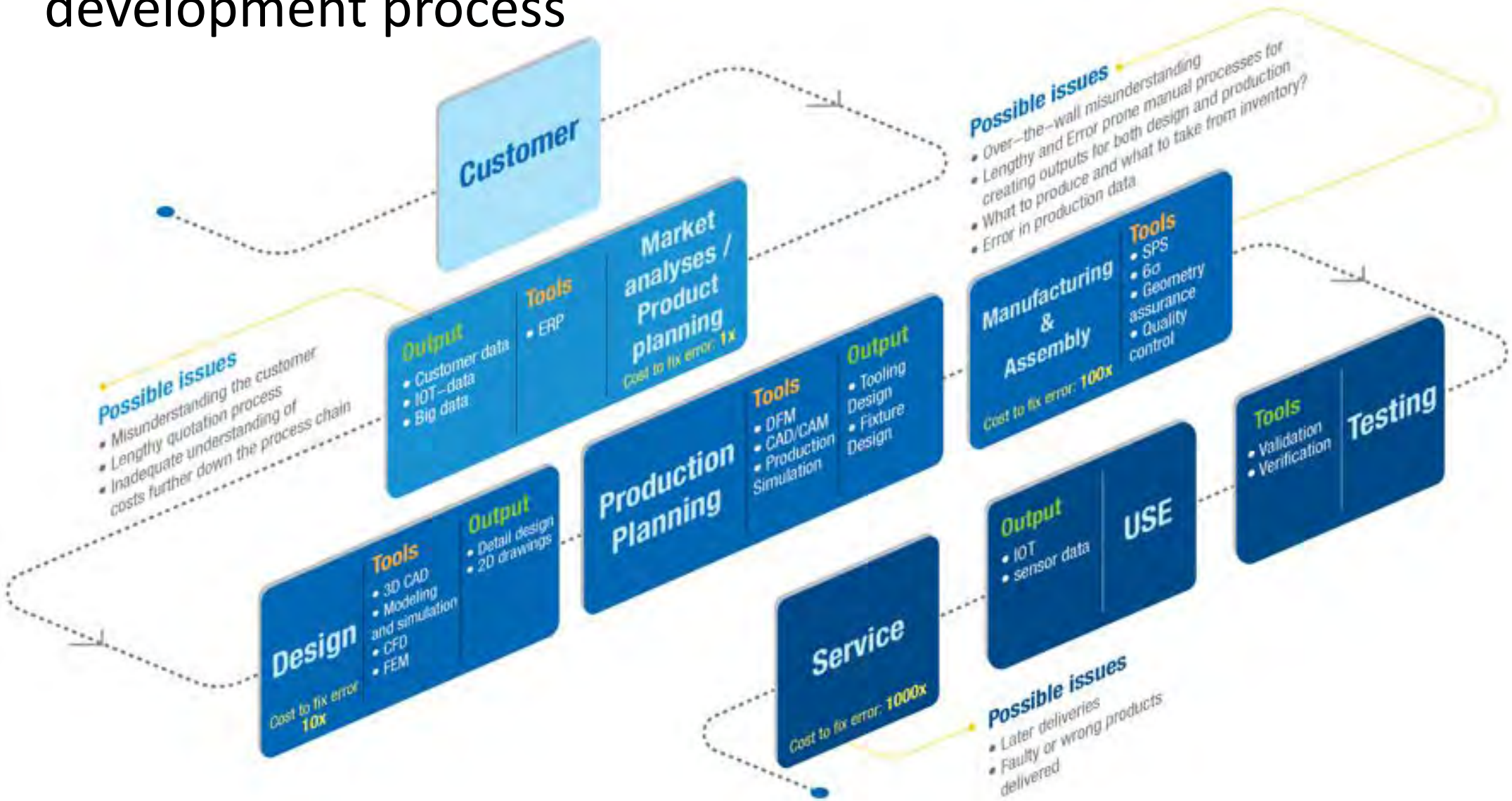
In total >35 persons, 25 FTE + ind. PhD students
Budget: Education 26 MSEK
Research 9 MSEK



What we do!

- Our aim is to make the product development process more efficient by using modelling, simulation and optimization.
- We consider physical products (cyber-physical systems) like aeroplanes, industrial robots, vehicles etc.
- We consider geometrical- as well as functional models of the product and the production system.
- We consider real-world problems meaning that they are vaguely formulated and include uncertainties
- We focus on computational efficiency using for example surrogate models.
- Most problem are addressed by multi-disciplinary and/or multi-objective optimization algorithms.
- No adays we look into AI and machine learning for product development

Information flow and digital models in the product development process



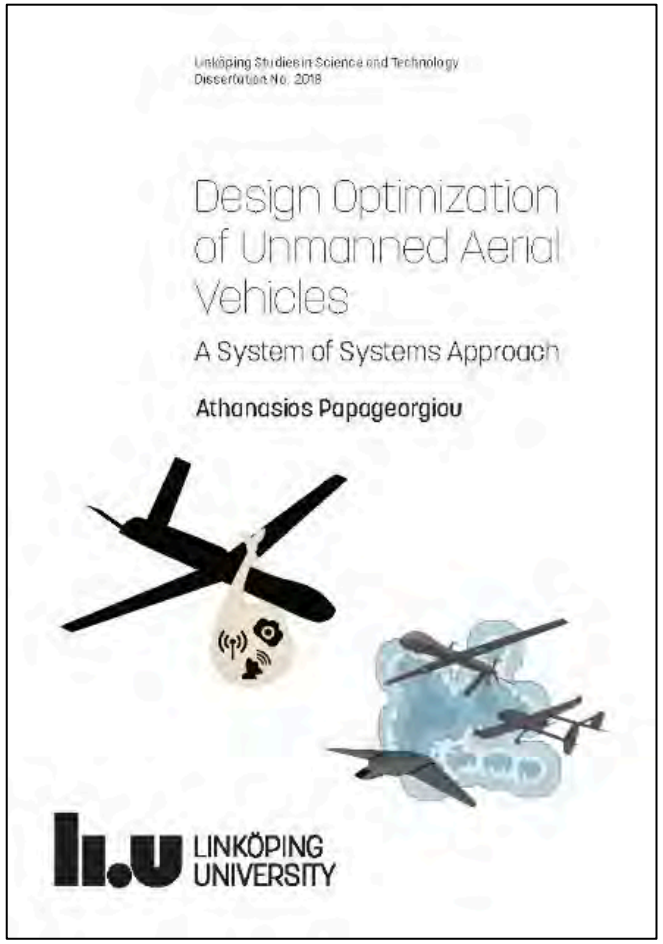
Recent PhD-projects

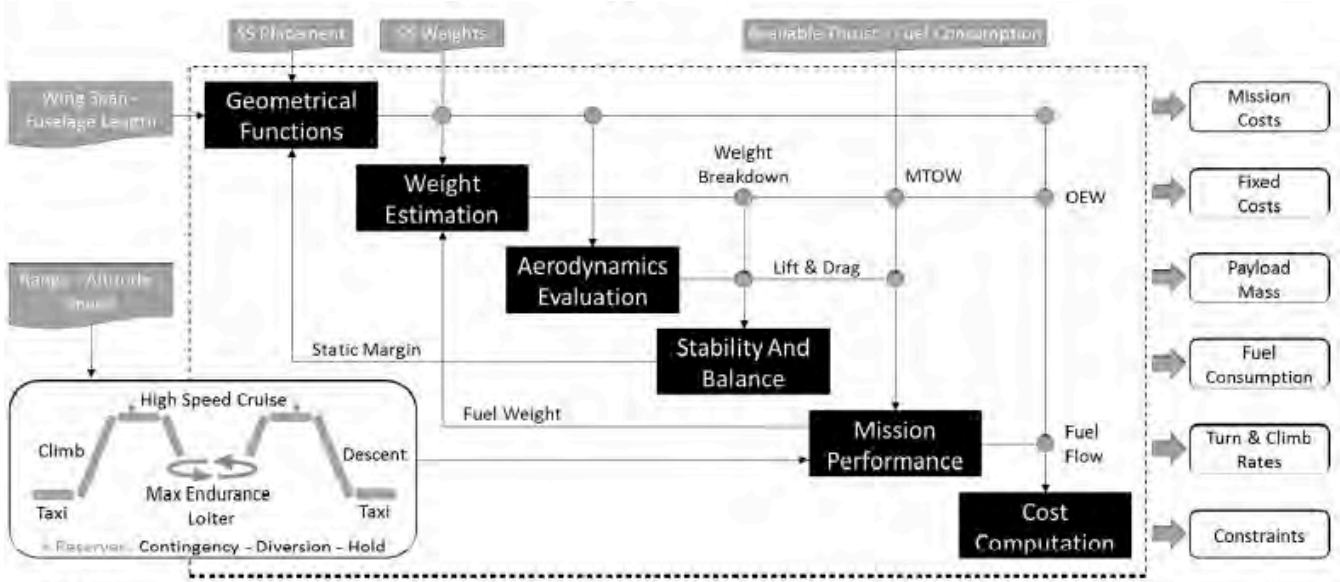
Multi-disciplinary optimization of UAV

Design automation for Additive Manufacturing

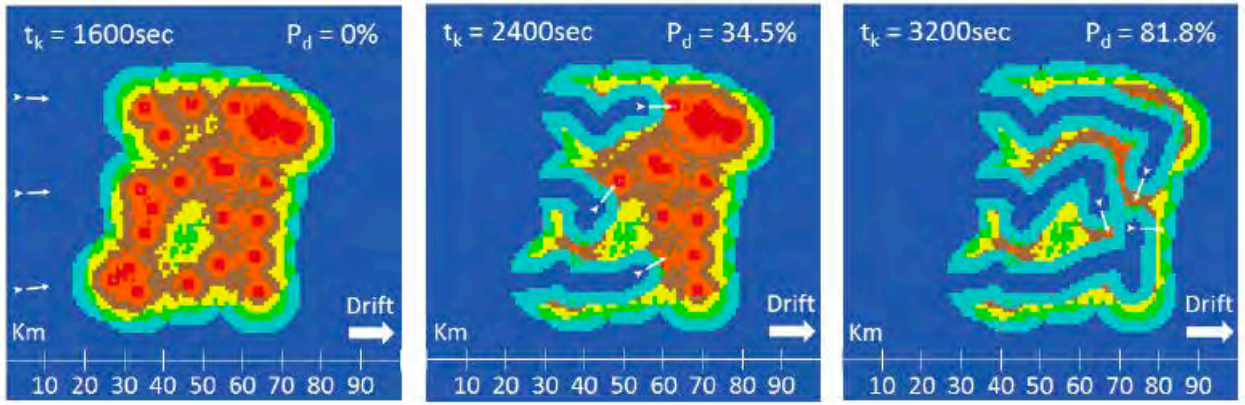
Design automation for industrial robot grippers

Design Optimization of UAV:s – *A. Papageorgiou*





Multi-disciplinary optimization framework



Agent-based mission simulation

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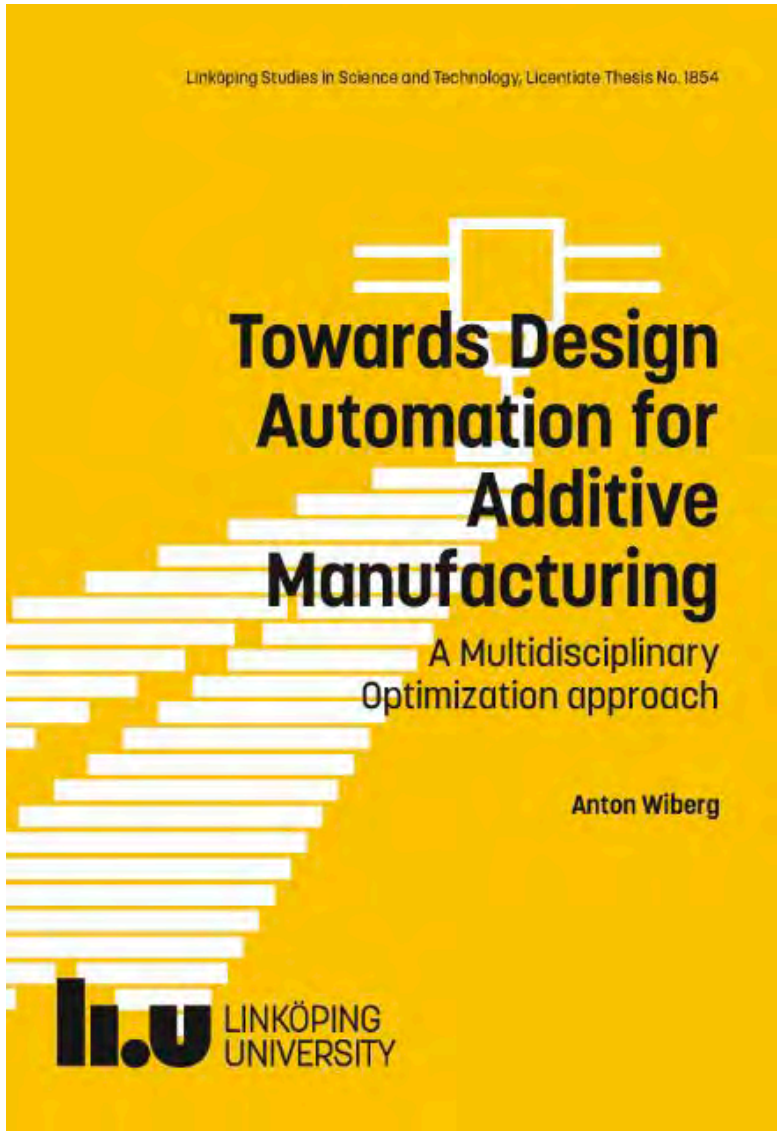
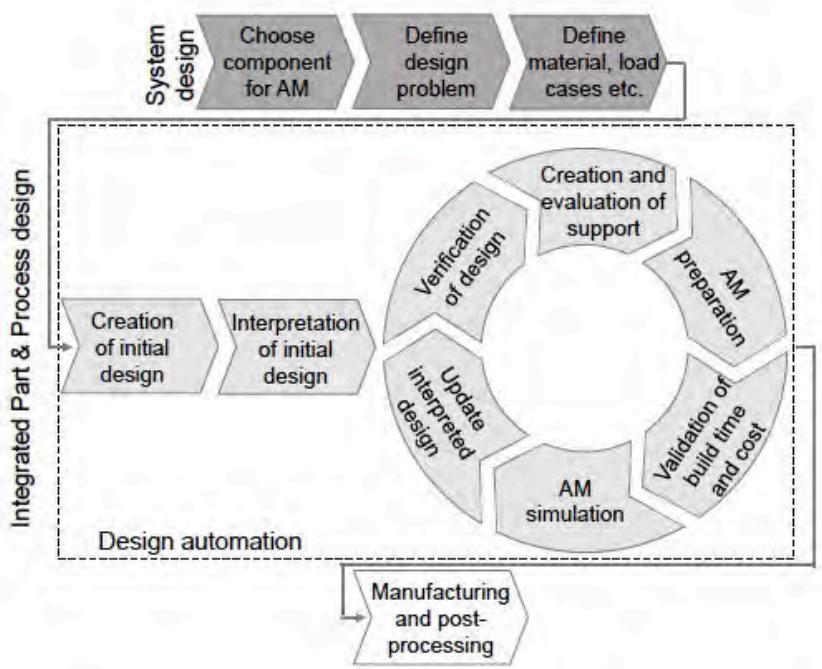
Design Automation for Additive Manufacturing – *A. Wiberg*

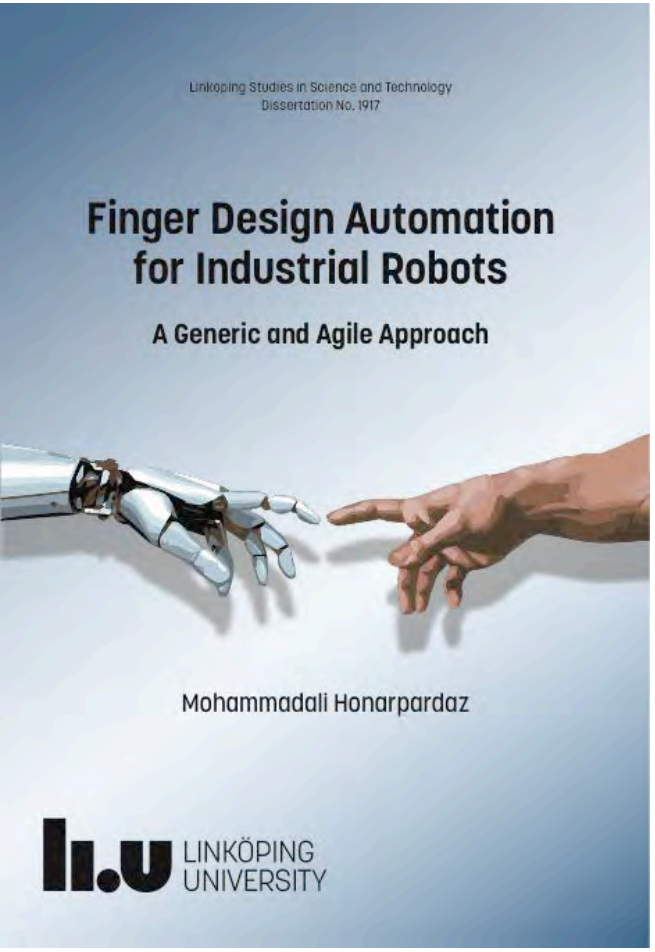




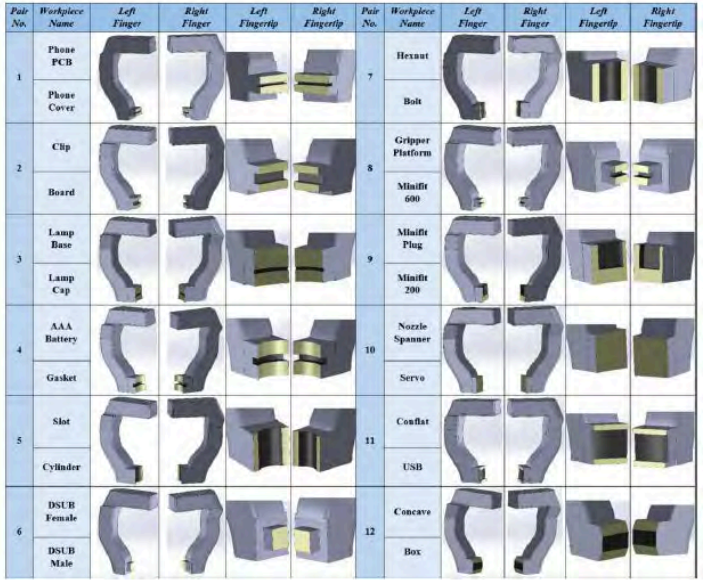
Topology optimized result

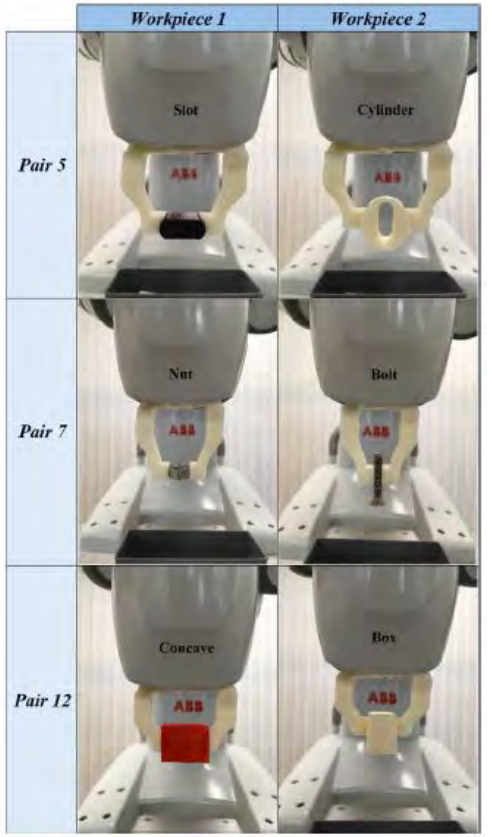
Final result

Design automation of robotic fingers: *M. Honarpardaz*



Pair No.	Workpiece Name	Workpiece CAD Model	Pair No.	Workpiece Name	Workpiece CAD Model	Pair No.	Workpiece Name	Workpiece CAD Model	Pair No.	Workpiece Name	Workpiece CAD Model
1	Phone PCB		4	AAA Battery		7	Hexnut		10	Nozzle Spanner	
	Phone Cover			Gasket			Bolt			Servo	
2	Clip		5	Slot		8	Gripper Platform		11	Conflat	
	Board			Cylinder			Minifit 600			USB	
3	Lamp Base		6	DSUB Female		9	Minifit Plug		12	Concave	
	Lamp Cap			DSUB-Male			Minifit 200			Box	

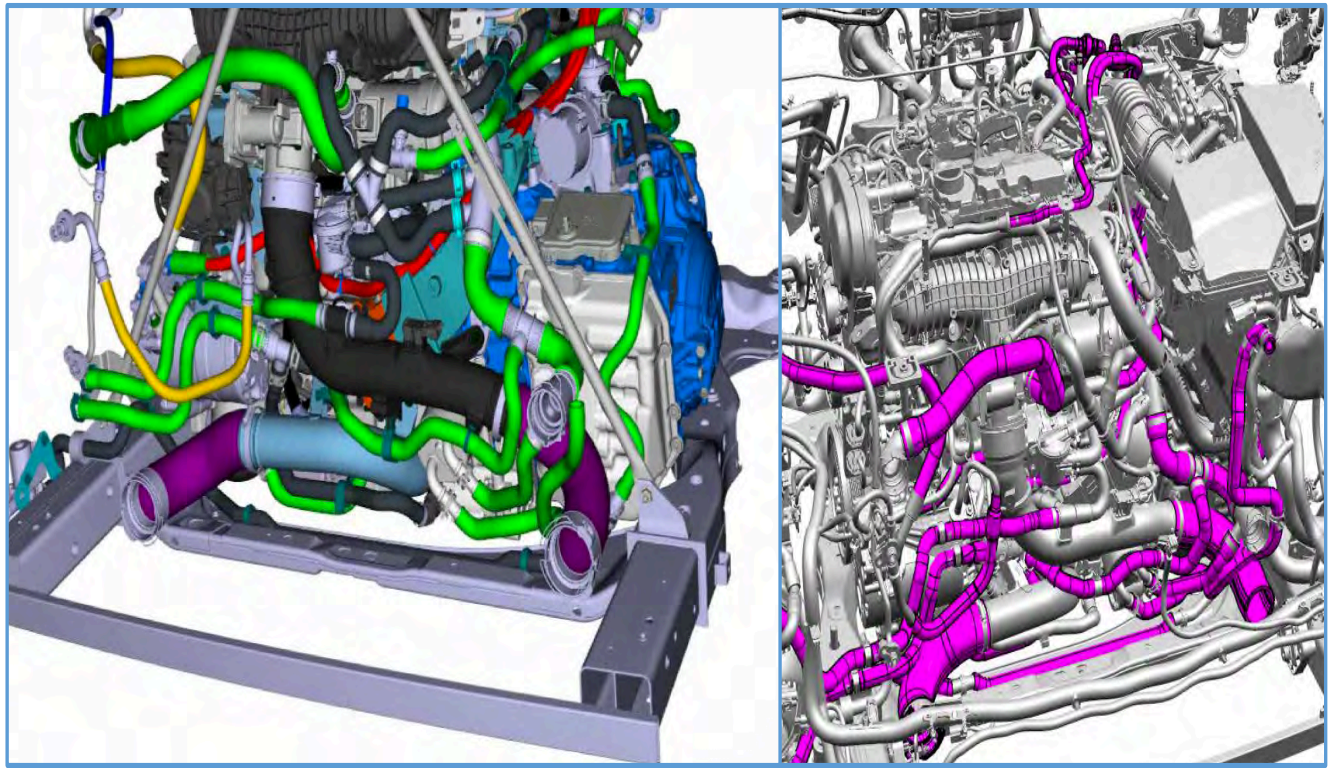




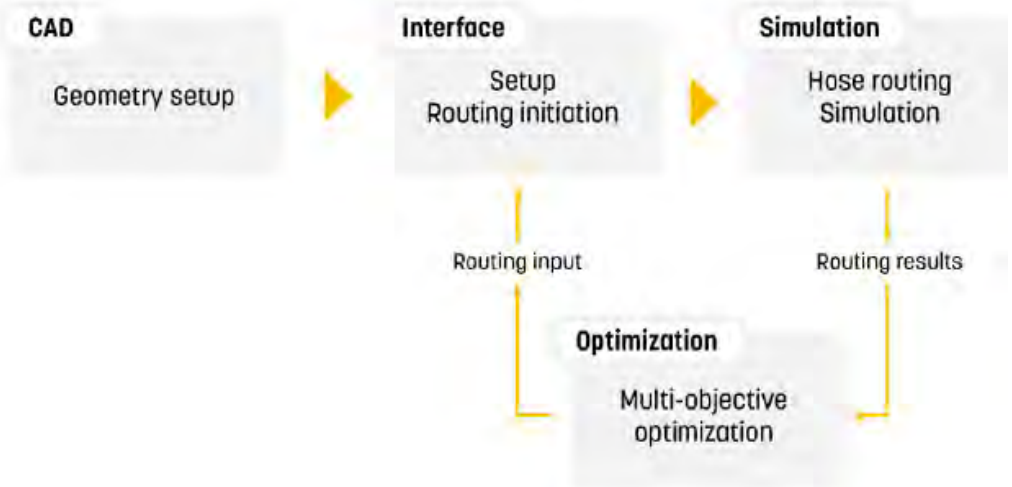
On-going research projects

AutoPack - Automatic packaging of pipes and hoses based on optimization and machine learning

House installation and simulation framework



Optimal routing framework



$$min \begin{cases} f_1 = sum(V_i(\bar{x}, y), \dots, V_n(\bar{x}, y)) \\ f_2 = max\ (\sigma_i(\bar{x}, y), \dots, \sigma_n(\bar{x}, y) \end{cases}$$

$$max \begin{cases} f_3 = clearance_{between\ hoses}(\bar{x}, y) \\ f_4 = clearance_{to\ component}(\bar{x}, y) \end{cases}$$

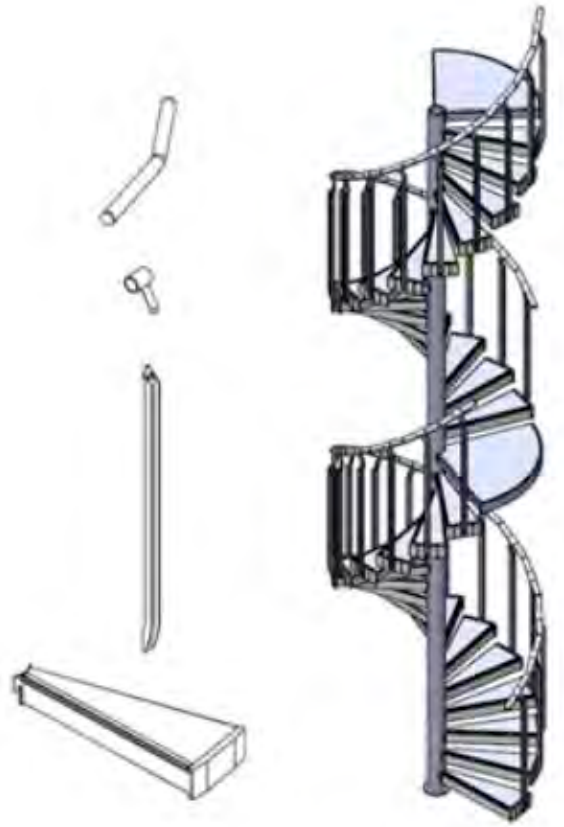
subject to:

$$1 \le y \le n!$$

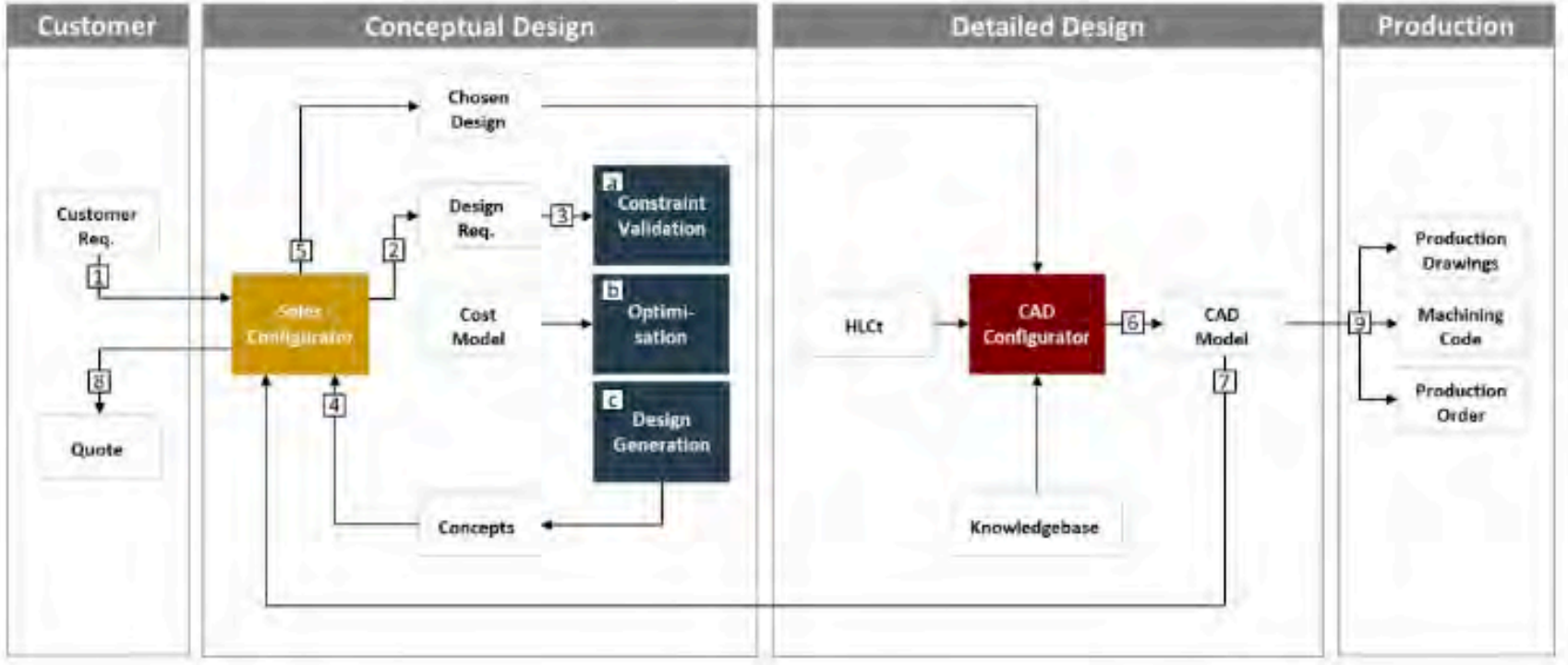
$$\bar{x} = \begin{bmatrix} x_{1,1} & \dots & x_{1,j} \\ & \vdots & \\ x_{i,1} & \dots & x_{i,j} \end{bmatrix} = \begin{bmatrix} r_{1,1} & \theta_{1,1} & \varphi_{1,1} & \cdots & r_{1,p} & \theta_{1,p} & \varphi_{1,p} \\ & & & \vdots & & & \\ r_{n,1} & \theta_{n,1} & \varphi_{n,1} & \dots & r_{n,p} & \theta_{n,p} & \varphi_{n,p} \end{bmatrix}$$

$$0 \le x_{i,j} \le 1, \qquad i = 1 \dots n, \qquad j = 1 \dots 3p$$

E-Factory – Enterprise wide optimization

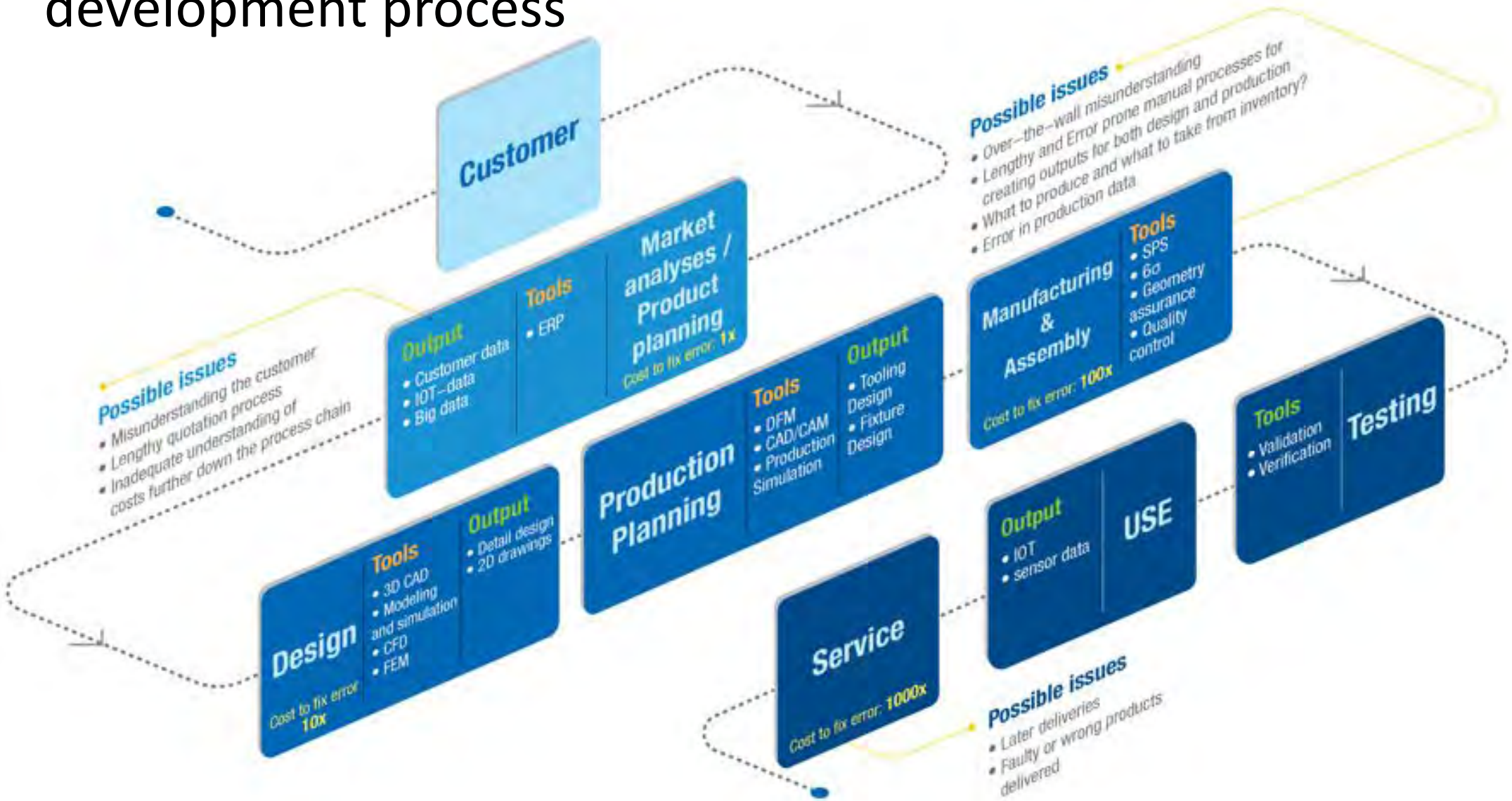


Spiral staircase configurator



"Enterprise wide" optimization framework, from sales to production

Information flow and digital models in the product development process



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