Smart Machine - Smart Factory - Smart Company
A bottom-up approach to Digital Production

Univ.-Prof. Dipl.-Ing. Dr.techn. Franz Haas

Agenda

- 25 years – What has changed within this period?
- Smart Machine
- Smart Factory
- Smart Company
- Conclusions
- Discussion

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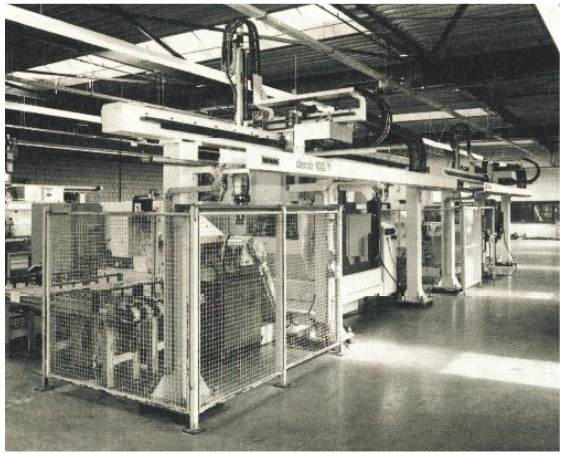
History of Development in Mobility (1992 -2017)

http://www.autobild.de/videos/video-wv-golf-3-1991-10927401.html

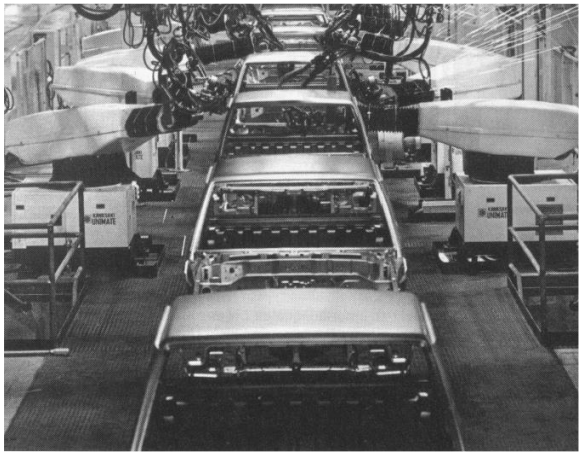
https://www.volkswagen.at/golf/golf-gti

https://ecomento.tv/modelle/tesla-model-3

History of Development in Production (1992)



Source: H.J. Klein (1992), Journal ZwF



Source: M. Stoaks, W. Klar (1992), Journal ZwF

Source: TDV-CIM (1992), Journal ZwF

History of Development in Production (2017)

https://www.tesla.com/de_AT/gigafactory

Development of the national debt in Austria

Unfortunately not fake news

1990	**EUR**	**76,518,000,000**	**56.2 % of the GDP**
1995	**EUR**	**119,834,000,000**	**68.0 % of the GDP**
2017, April	**EUR**	**295,883,195,053**	**84.6 % of the GDP**

The national debt of Austria per 22/04/2017

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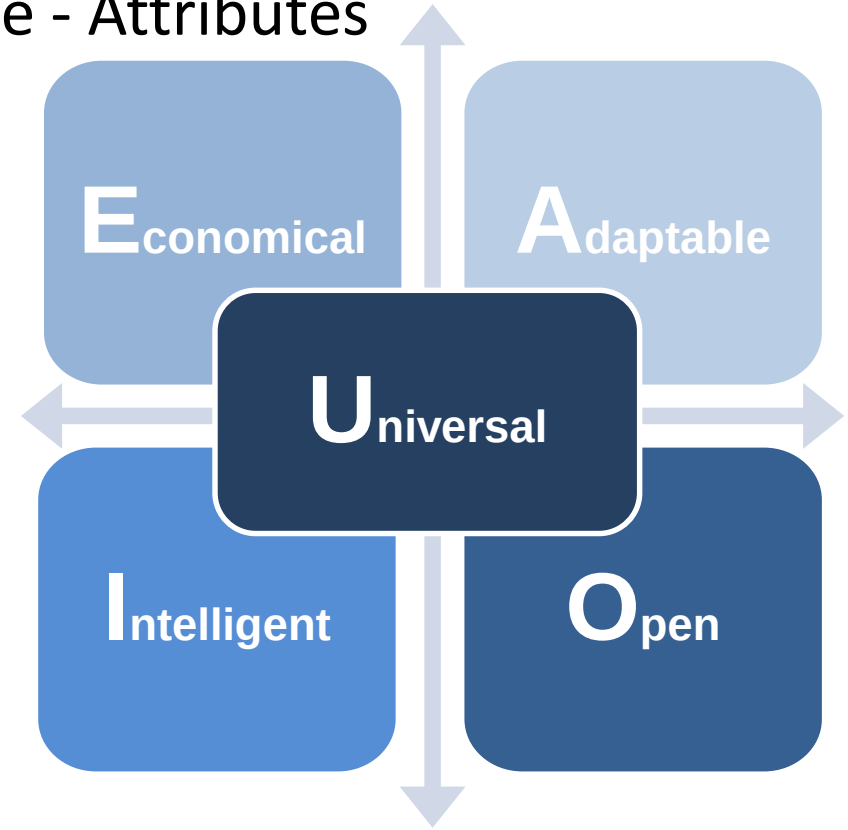
Smart Machine - Attributes



Smart (Grinding)-Machine @ IFT (TU Graz)

Design Parameters:

Overall dimension:
6 m x 3.5 m

Maximum size of the work piece:
Ø 520 mm x 1.500 mm

Controller: SINUMERIC 840Dsl

Main grinding spindle:
P = 72.5 kW
n_{max} = 6.500 min^{-1}
v_{max} = 220 m/s

Maximum grinding wheel dimension:
Ø 650 mm x 600 mm

Interior of the Research Grinding Machine

Design Parameters:

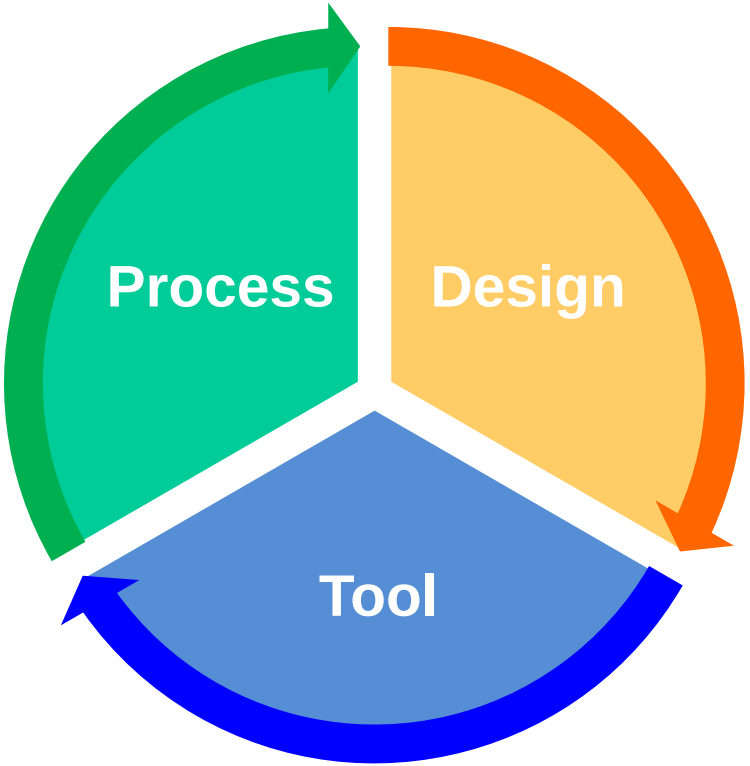
Second grinding spindle:

n_{max} = 4.500 min^{-1}

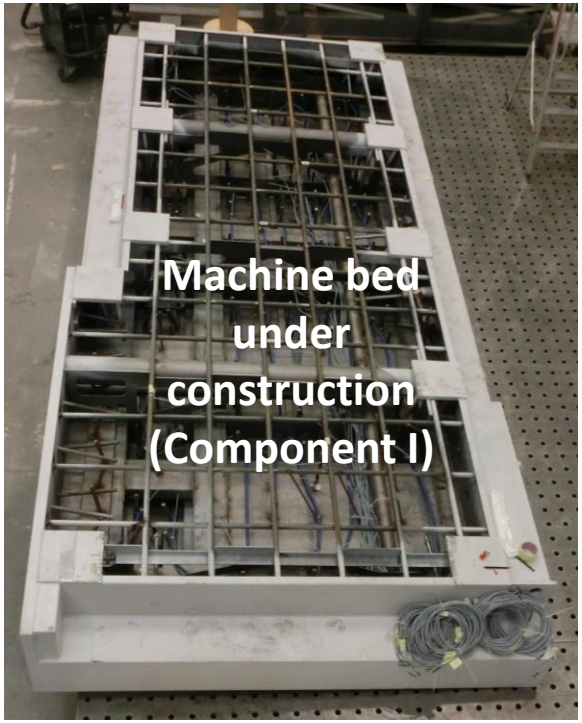
Second grinding wheel dimension:

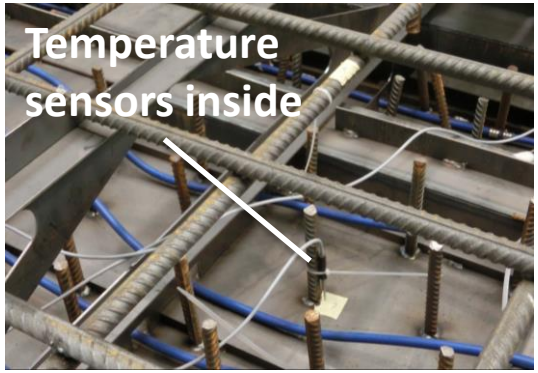
Ø 600 mm x 200 mm

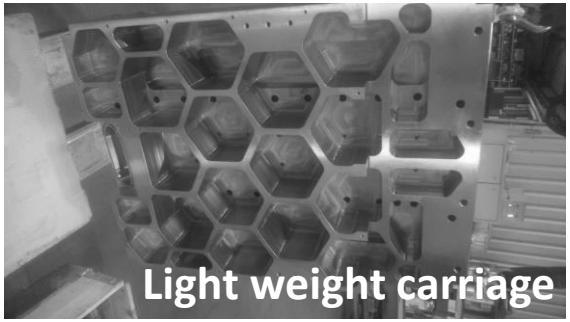
Smart (Production) Machine Principles: Design / Tool / Process



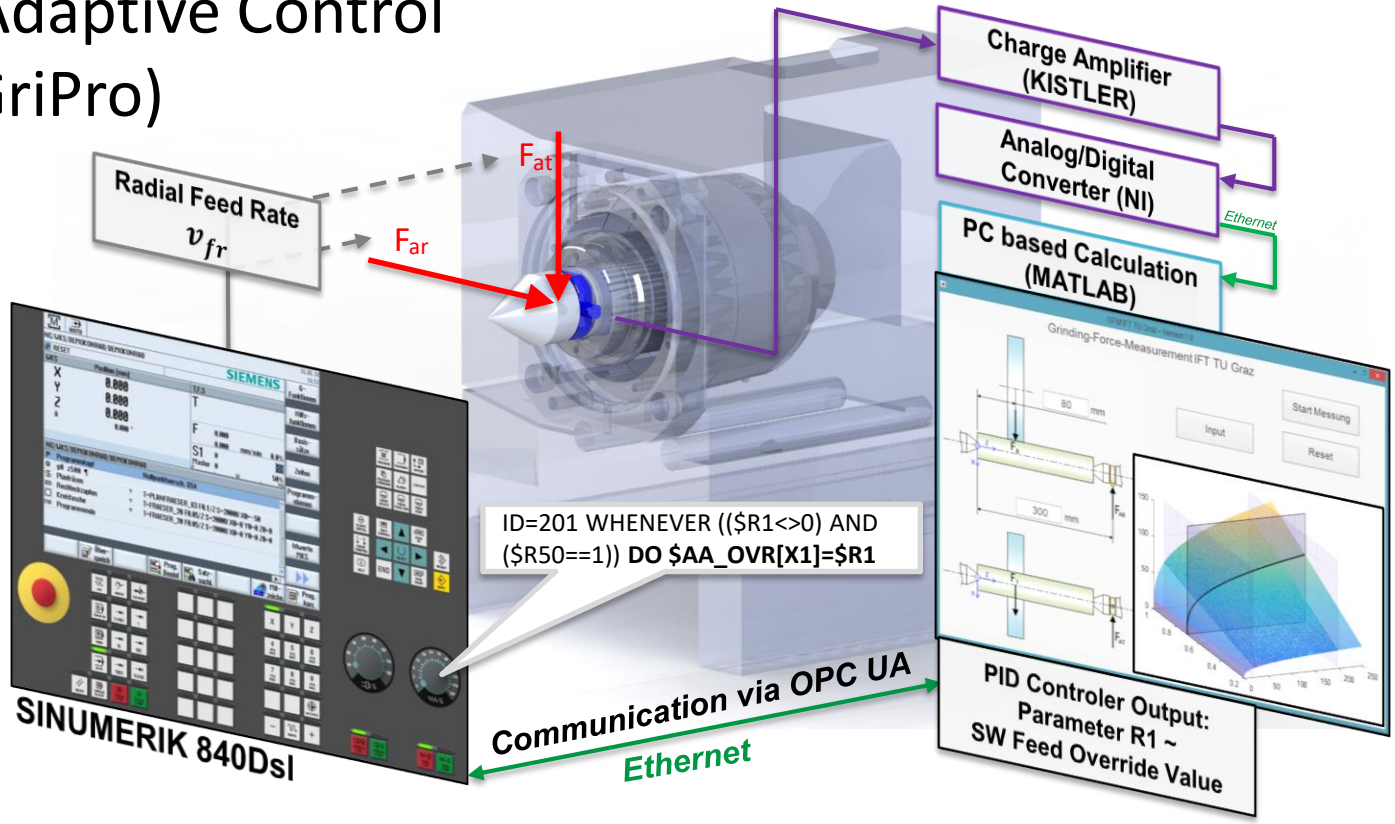
Design of Machine Structure







Design of Adaptive Control (Project AGriPro)

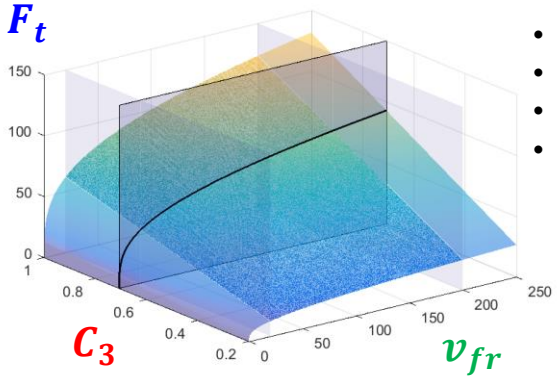


Results – Improvement of Productivity

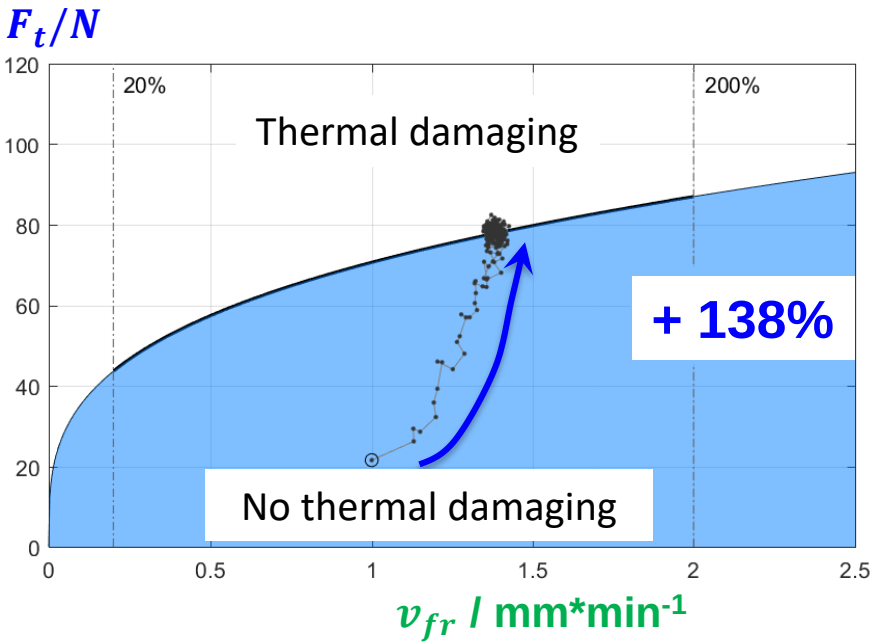
$$F_t = C_1 \cdot \left[v_{fr}\right]^{(1+C_2)} \cdot C_3$$

Process and Control Parameter:

- $\Delta t_{Controler} = 0{,}050$ s
- $f_{mess} = 500$ Hz
- $d_w = 44$ mm
- $b_{eff} = 22$ mm
- $v_c = 40$ m/s
- $K_p = 15$
- $K_i = 80$
- $K_d = 2$
- $C_1 = 100$
- $C_2 = -0{,}70$



$$C_3 = \frac{b_{eff}}{v_c} \cdot \left[\frac{\pi \cdot d_w}{60}\right]^{(1+C_2)}$$

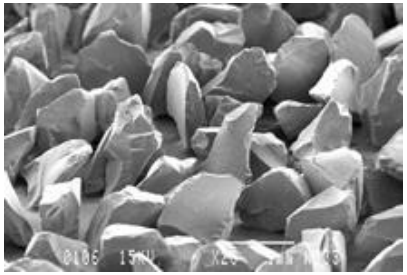


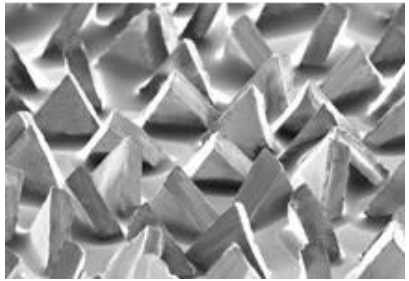
Design Man-Machine-Communication (MMC)

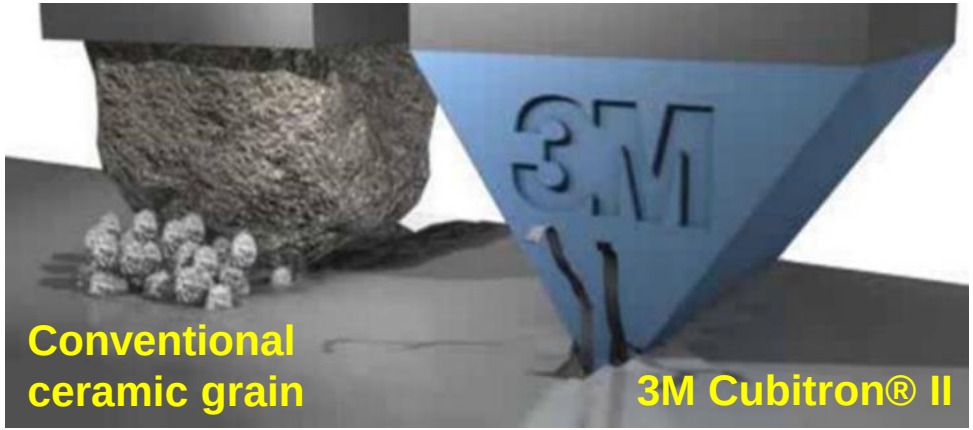
Minister for Infrastructure and Innovation Mag. Jörg Leichtfried visits IFT in January 2017

Microsoft HoloLens as a wearable for MMC

Tool: Precision Shaped Grain (3M-Cubitron® II)





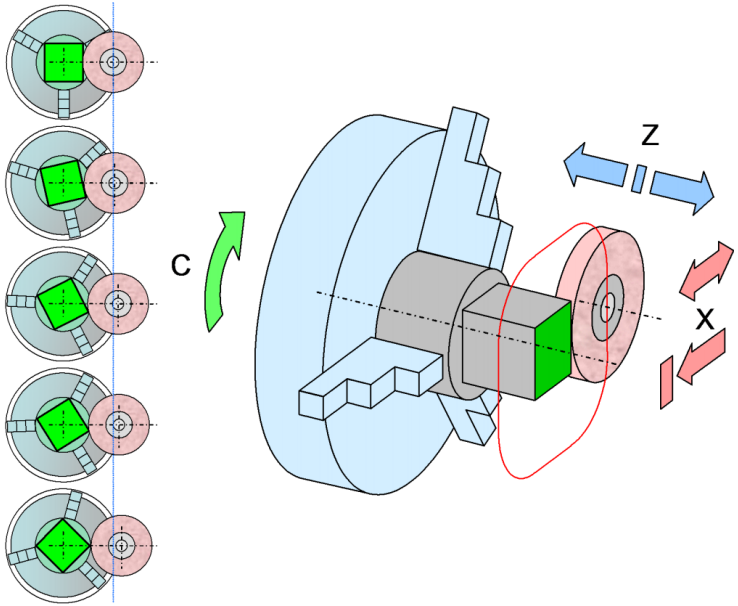


- Lower process temperature
- Continuous conditioning (shaping, sharpening) of the grinding wheel

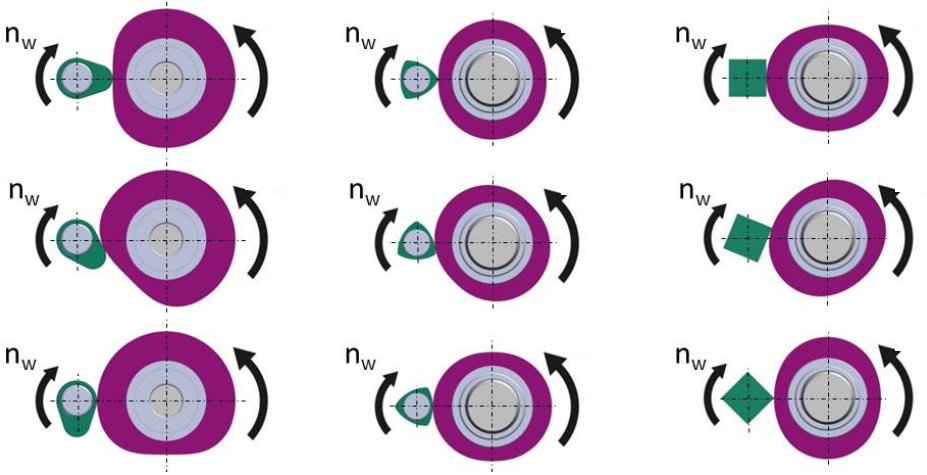
Source: Helmut Gaisberger, 3M GmbH (Suisse), Grinding congress 2017 in Stuttgart-Fellbach

Non-circular Grinding

Oscillating Non-circular grinding



RPM-synchronous Non-circular grinding

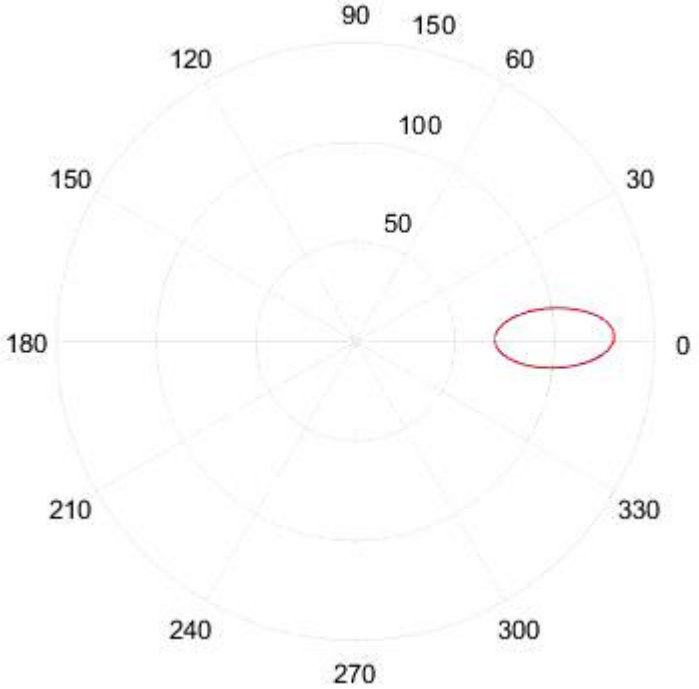


Cam
$n_G : n_W = 1 : 1$

Polygon
$n_G : n_W = 3 : 2$

Square
$n_G : n_W = 2 : 1$

Grinding Wheel Profile



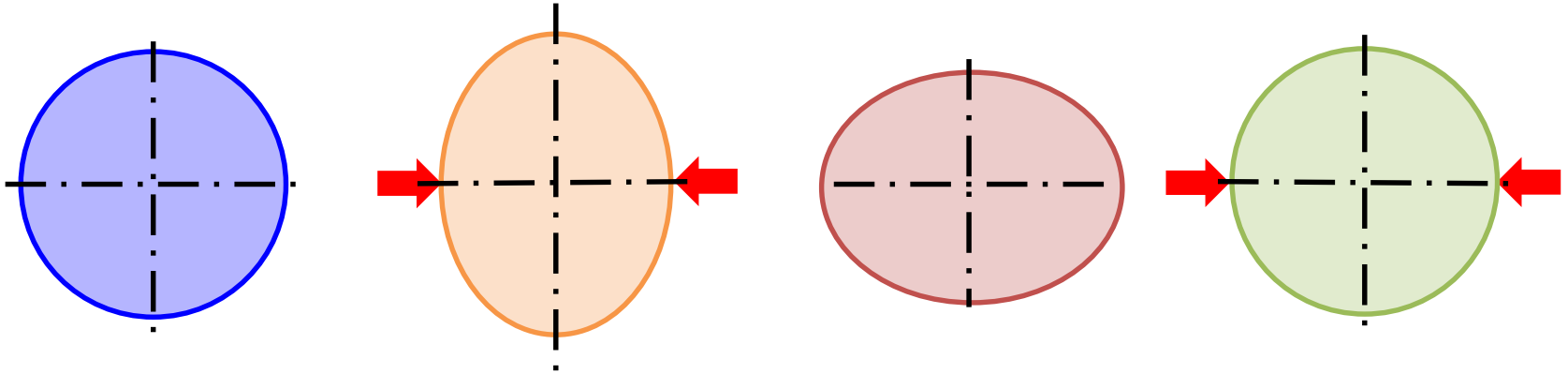
Work piece profile

Grinding wheel

- The **grinding wheel profile** results for one plane as the **envelope** of the **common tangent** of the **wheel itself** on the one hand and on the other hand of the **rolling off work piece**.
- Mathematic iteration is essential.

Process: Preformed 3D-Grinding

Source: Kolbenschmidt



Theoretical profile

Shaped profile under load

Preformed profile

Final profile under load

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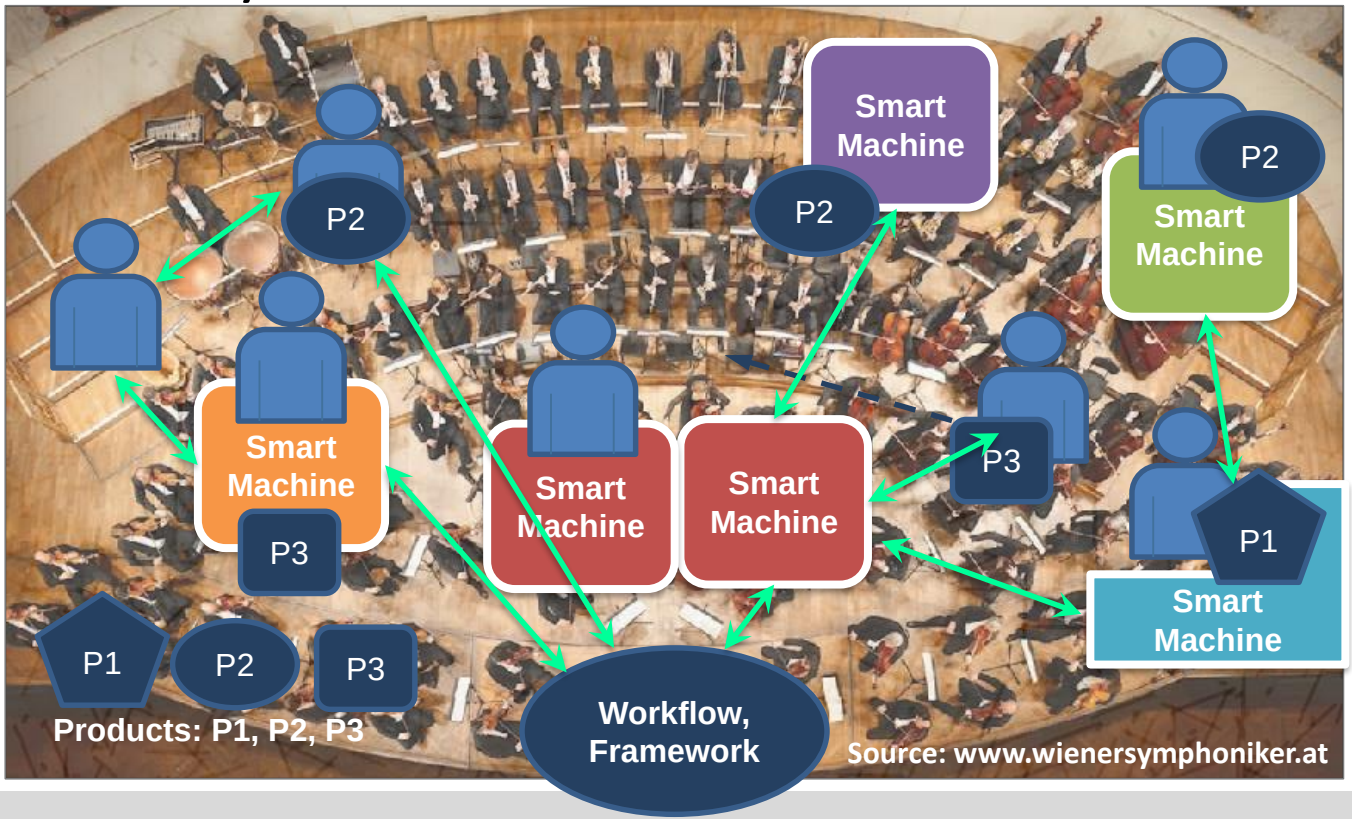
Smart Factory as a concert hall



Smart Factory at TU Graz

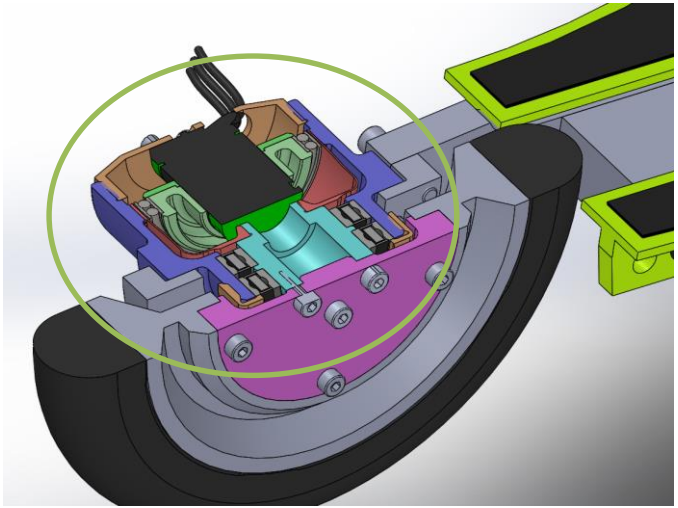
Univ.-Prof. Dr.techn. Rudolf Pichler
Head of the Smart Factory

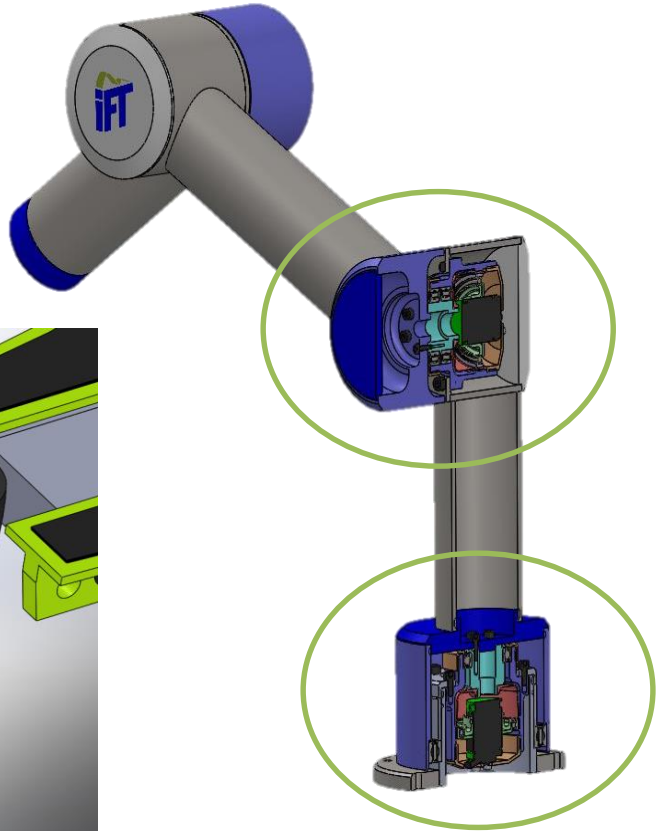
Pilot Factories 4.0
Initiative of Austrian Research Promotion Agency

FFG

What will be produced?

Drive-System (Gearbox) for E-Axles





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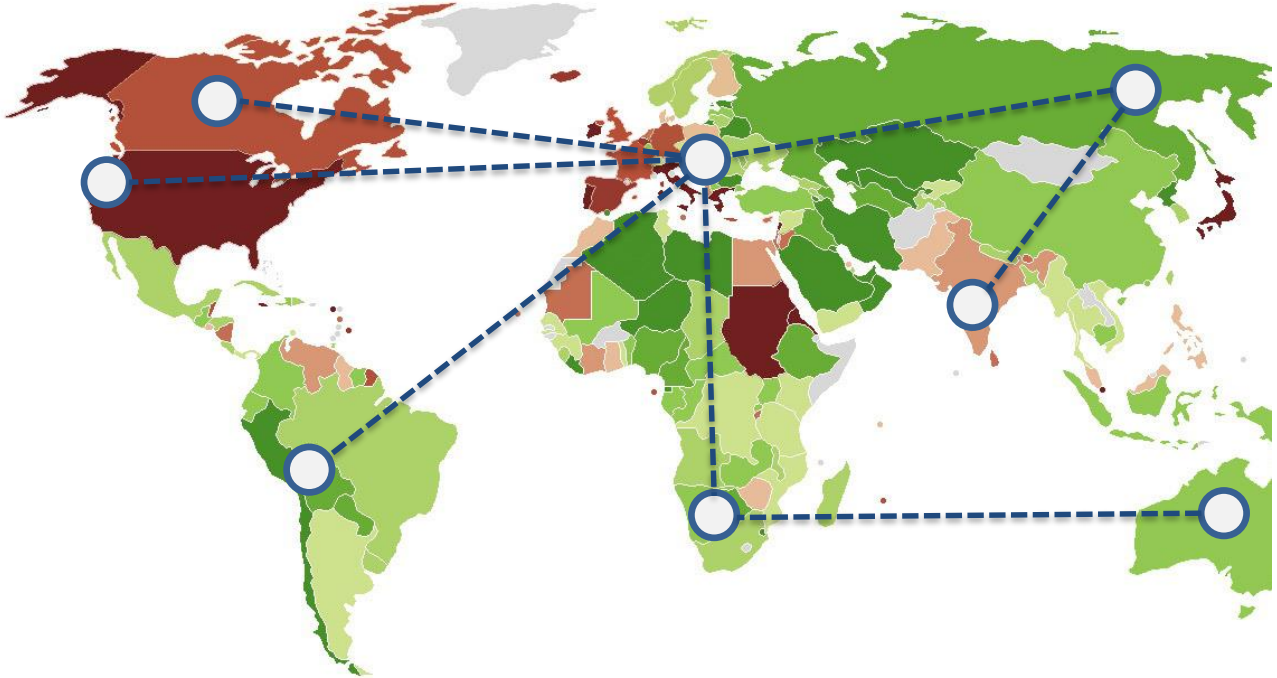
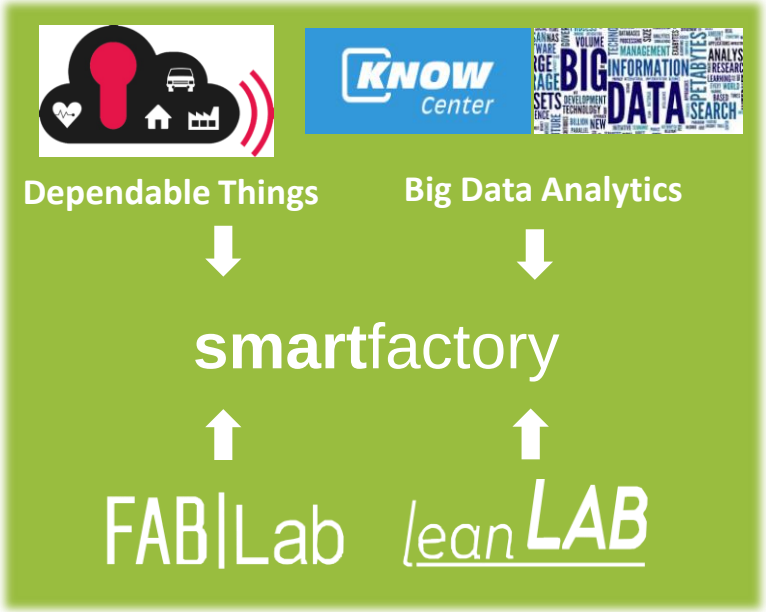
Smart Company – Node within an international production network



Smart Production Graz – Initiative within the Field of Expertise Mobility and Production



SMART PRODUCTION GRAZ

Pro2Future – New Competence Centre (JKU Linz, Profactor, TU Graz)

It started in April 2017.

Ö-WGP – Austrian Association of Professors in Production Science at TU Wien, TU Graz, MU Leoben, JKU Linz

Hubert Biedermann
Friedrich Bleicher
Bruno Buchmayr
Alois Ferscha
Detlef Gerhard
Franz Haas
Clemens Holzer
Ernst Kozeschnik
Stefanie Lindstaedt
Paul Heinz Mayrhofer
Paul O'Leary
Andreas Otto
Christian Ramsauer
Ralf Schledjewski
Peter Schumacher
Wilfried Sihn
Christof Sommitsch
Siegfried Vössner
Klaus Zeman

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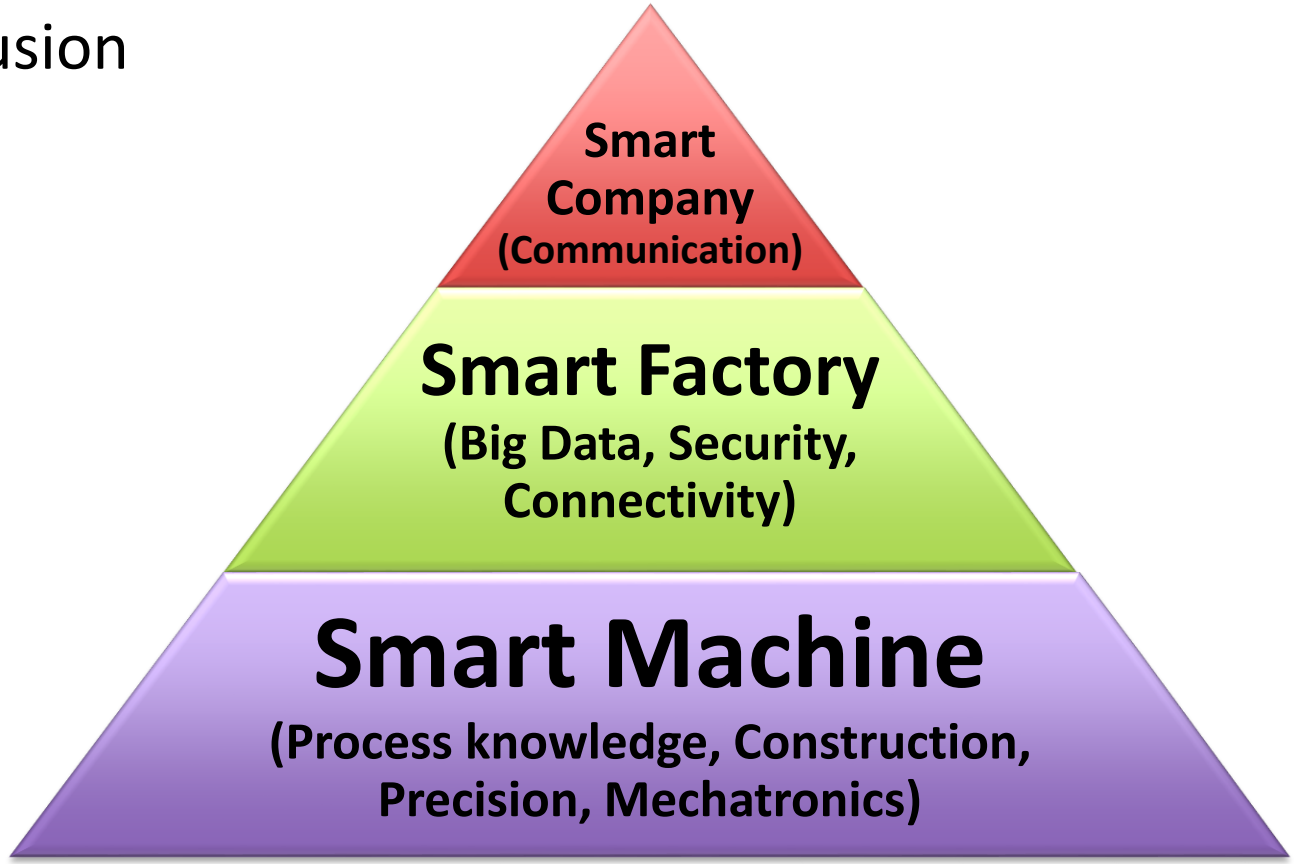
Smart
Company
(Communication)
Smart Factory
(Big Data, Security,
Connectivity)
Smart Machine
(Process knowledge, Construction,
Precision, Mechatronics)

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Precision guarantees our future.