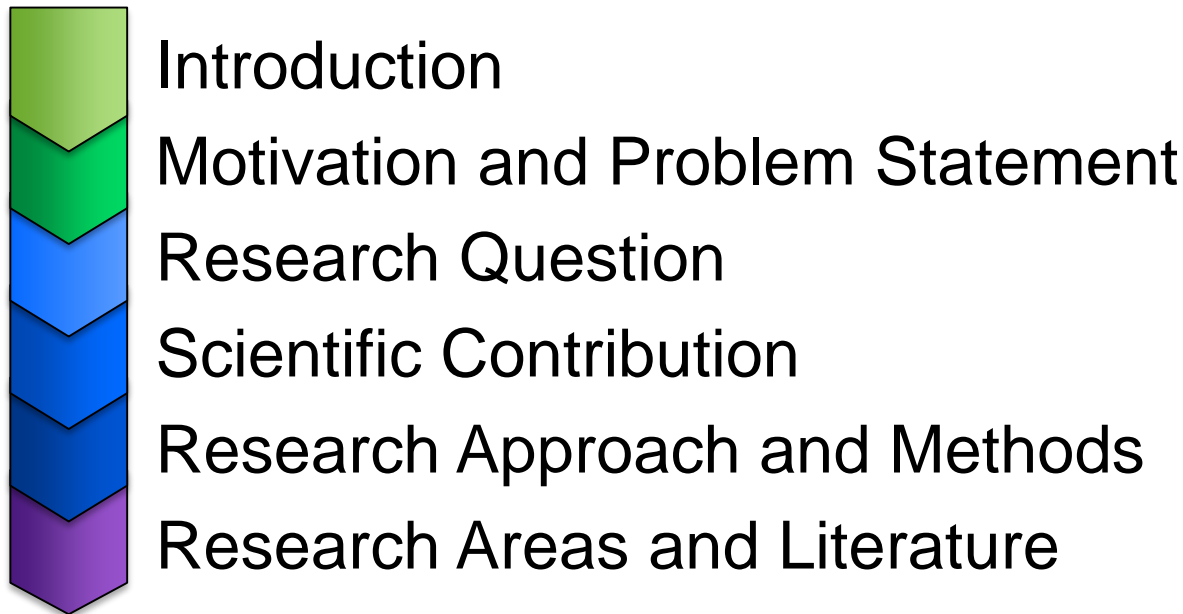


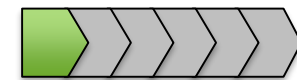
Predictive Maintenance in Discrete Parts Manufacturing

**Clemens Gutschi,
Graz University of Technology
Department of Engineering- and Business Informatics**

27.11.2017

Agenda





Introduction

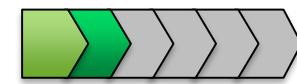
What are my work areas and goals?

Current work area and research project in cooperation with the engine production of Audi Hungaria Zrt.:

- › Project **Smart Maintenance** in automotive industry is including:
 - › Development of a **predictive maintenance (PdM)** prototype
 - › Estimation of the **economic potential** of PdM in production
 - › Strategies for the **process integration** of PdM in existing TPM-System

The **goals** of this concept presentation at the 22nd TÖK for my dissertation project are:

- › Feedback on Research Methodology
- › Expand data sources of completed PdM Projects

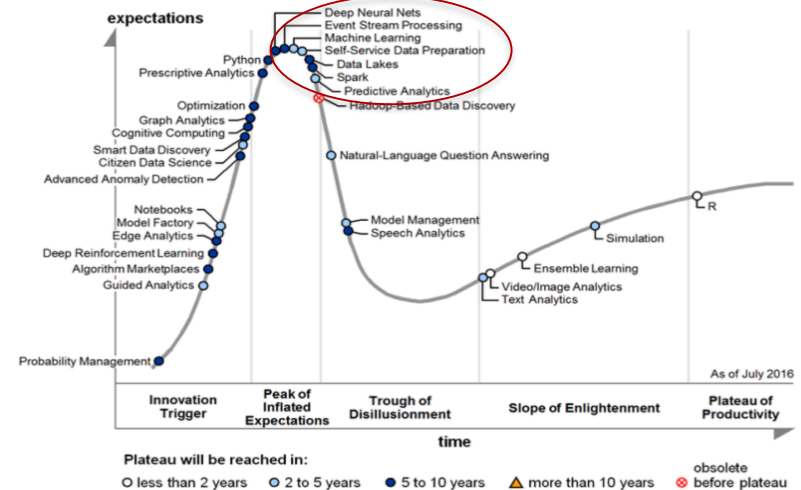


Motivation and Problem Statement

Trends regarding PdM

- Internet of Things: **High level on connected and monitored devices** in manufacturing industries.
- **Artificial Intelligence** is one of three mega trends for future business. Gartner (2017)
- Technologies like **Machine Learning, Predictive Analytics** and **Self-Service Data Preparation** enable an **extensive use of PdM** within the next 2 to 10 years. Gartner (2016)
- **Platform solutions** for analysis instead of single sensors. Hannover (2017)
- PdM is an **upcoming business** as a product and service. Hannover (2017)

Figure 1. Hype Cycle for Data Science, 2016



Source: Gartner (July 2016)



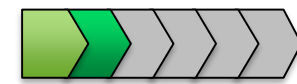
Motivation and Problem Statement

Current Status of PdM

- VDMA et al. (2017) commissioned a survey (n=152) in 2017 for answering the questions about importance, opportunities and risks of PdM for businesses:
 - PdM is **one of the key innovations** brought forth by **Industry 4.0**
 - Forecast the **remaining service life** of machine components
 - PdM is a **key issue for** current and future **business**
 - It is still **hard** for companies to **asses PdM's value as a success factor**

- Interviews with several companies¹ focusing PdM at Hannover 2017 substantiated following experiences:
 - PdM is an **upcoming business** as a product and service
 - They are working hard on the products and services, but **hardly offering any solutions** for **integrating existing** or external **data** and equipment

¹ Eaton Electric GmbH, Isah GmbH, Synop Systems UG, Schaeffler Technologies AG & Co. KG, Weidenmüller Gruppe, AVENTICS GmbH, SAP, Siemens, T-Systems, Microsoft

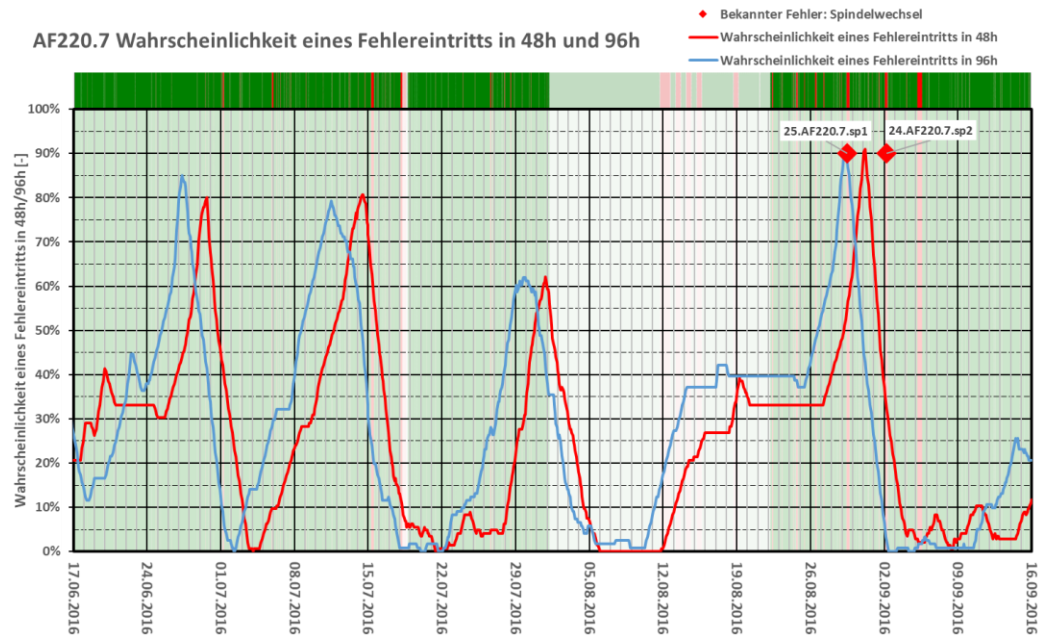


Motivation and Problem Statement

A gap between theoretical performance and practical use of PdM

A PdM prototype at an ongoing research project predicted/anticipated **more than 50% main spindle breakdowns**, which accounts for 30% of all long term machine breakdowns. This theoretical **possible reduction** of total downtime **could not be assessed fully** because of indispensable, highly-utilized production capacities, lacking maintenance staff and non-adjusted repair processes.

- PdM has to be integrated into an existing **mix of maintenance strategies**
- Minimizing maintenance costs does not mean **maximizing profit and throughput** of production systems





Research Question

Findings and Research Question

Summarizing previous findings there is a **gap between theoretical and practical performance of PdM** related to the mix of current maintenance strategies and according to VDMA et al. (2017) companies find it still **hard to assess PdM's value as a success factor**. These findings leads to following research question:

What is the **optimal mix of maintenance strategies** for discrete parts manufacturing

- with a **high degree of automatization and informatization** (e.g. automotive industry)
- as laid out in **Internet of Things** concepts.



Scientific Contribution

Research Gap

Many publications (see Literature) on sensor- and log-based PdM show that:

- **predicting remaining useful life of components is state of the science**
- there are **just a few concerning the integration of PdM as a new maintenance strategy into an existing mix of maintenance strategies**

As researched by Swanson (2001)², the issue for a company is not to optimize maintenance costs, but to **maximize a companies performance by an optimal maintenance mix**. There is a positive influence of proactive maintenance to the companies performance.

There is a need for investigating the **economic impact of PdM** integrated in existing maintenance strategies concerning the total costs.

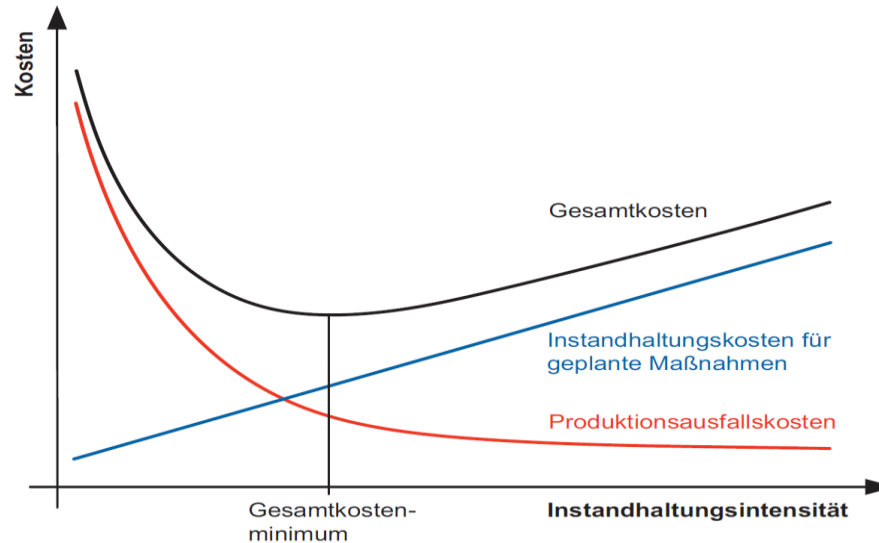
² Swanson (2001) conducted a survey on 125 plant and 162 maintenance managers of SME, investigating a correlation of reactive, proactive or aggressive maintenance strategies and the companies performance. The result showed a positive influence of proactive maintenance strategies on the companies performance.



Scientific Contribution

Research Gap

Following Matyas (2016), the major aims of maintenance are to **maximize the reliability of production equipment** and to **minimize total costs**.



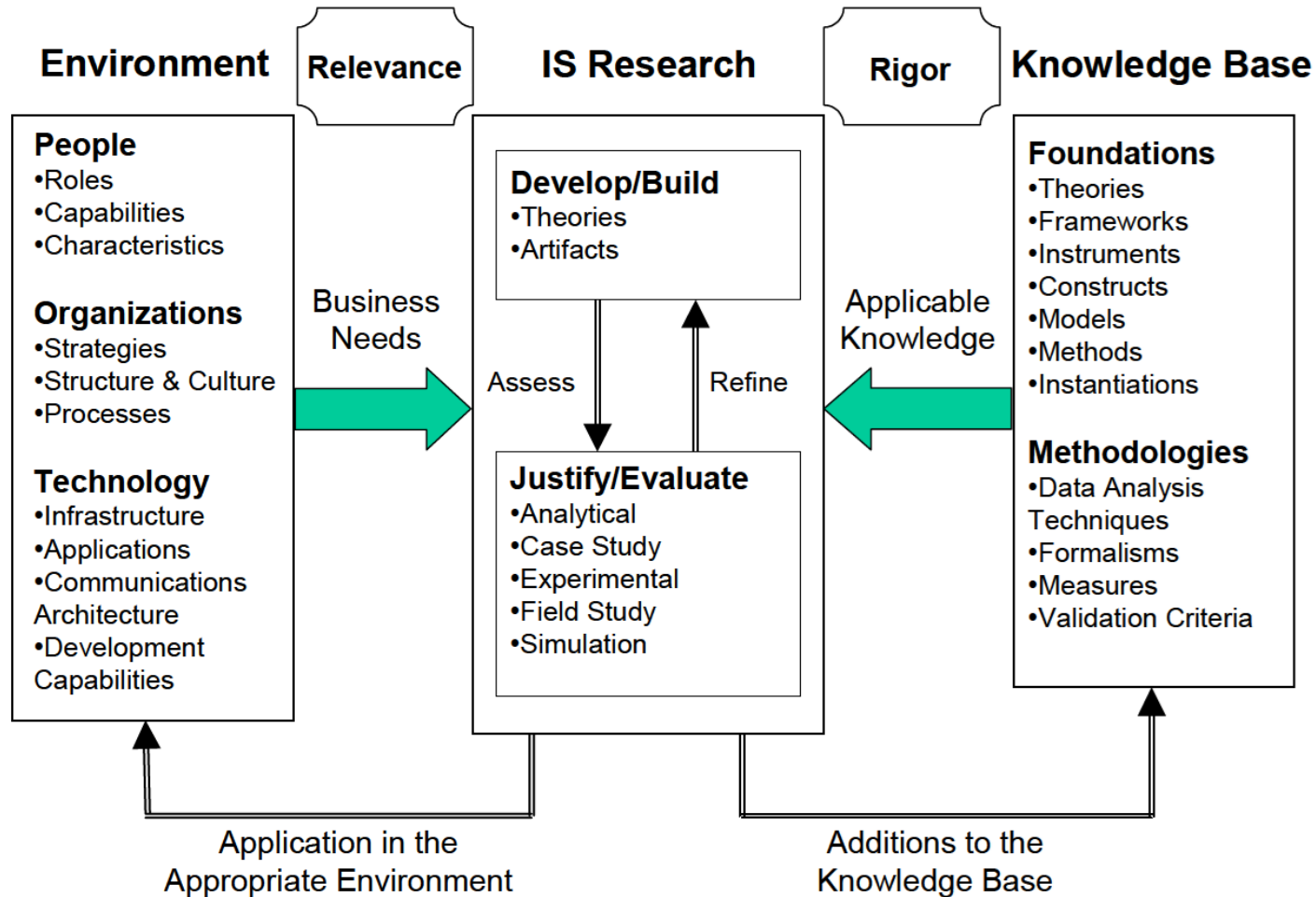
Source: Matyas (2016)

Determining the cumulative curve of total costs **is very hard**, because the response of changing the intensity or strategy of maintenance has a **very high delay in real experimental environments**. → **Simulation Based Investigation**



Research Approach and Methods

Research Framework for Information Systems by Hevner et al.

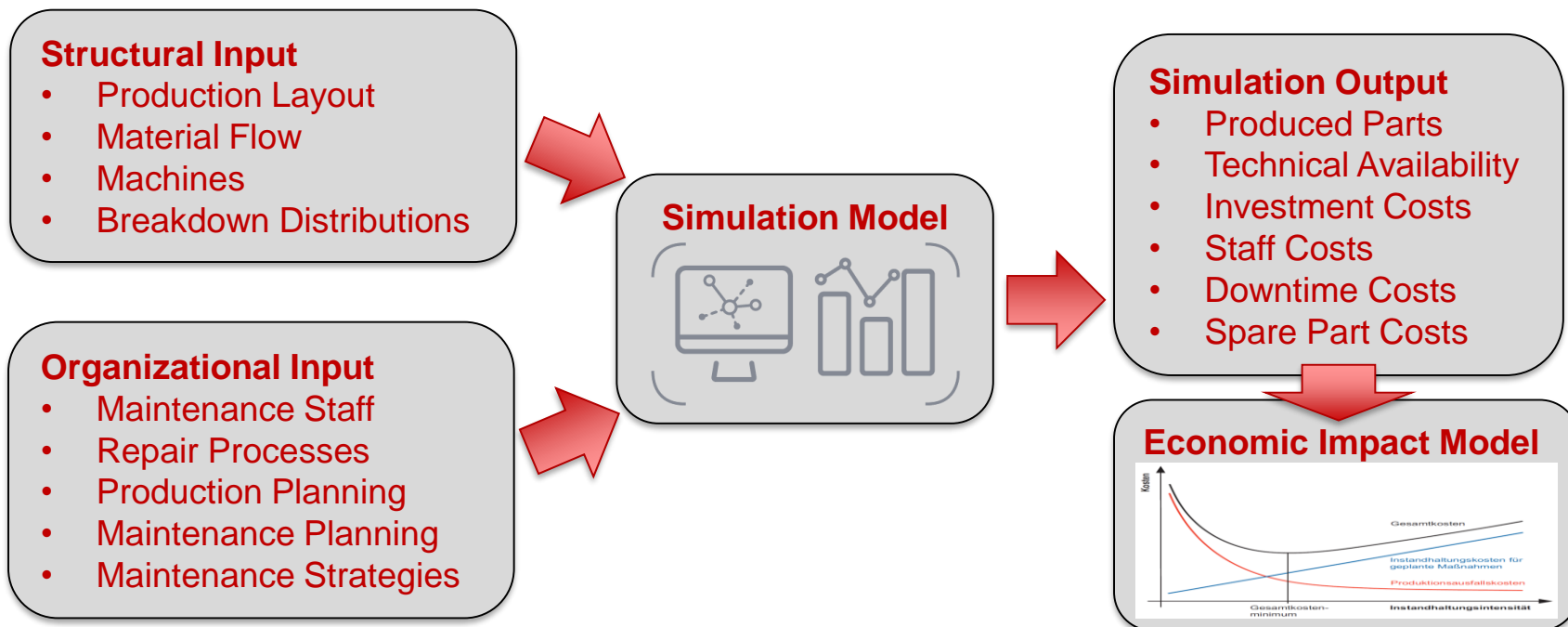


Source: Hevner et al. (2004)

Research Approach and Methods

Simulation Based Approach

The simulation based investigation is build by **structural and organizational inputs**. The structural input is defining production layout, material flow and machine behaviors. Organizational input represents available staff, processes as well as production and maintenance planning including the mix of maintenance strategies.





Research Areas and Literature

Motivation and Problem Statement

Gartner (2016)

Gartner: Hype Cycle for Data Science 2016, July 2016

Gartner (2017)

Gartner: Hype Cycle for Emerging Technologies 2017, July 2017

Hannover (2017)

<http://www.hannovermesse.de/de/ausstellung/daten-fakten/after-show-report/abschlussbericht/>; 17.09.2017

VDMA et al. (2017)

VDMA., Berger, Roland: Predictive Maintenance. Servicing tomorrow – and where we are really at today. April 2017



Research Areas and Literature

Scientific Contribution and Research Approach

Hevner et al. (2004)

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in the Information Systems Research, *28*(1), 75–105. Retrieved from <http://dl.acm.org/citation.cfm?id=2017212.2017217>

Matyas (2016)

Matyas, K. (2016). *Instandhaltungslogistik. Qualität und Produktivität steigern* (6. überarbeitete Auflage). München: Hanser.

Swanson (2001)

Swanson, L. (2001). Linking maintenance strategies to performance. *Int. J. Production Economics*, *70*, 237–244. [https://doi.org/10.1016/S0925-5273\(00\)00067-0](https://doi.org/10.1016/S0925-5273(00)00067-0)



Research Areas and Literature

Sensor based Preventive and Predictive Maintenance

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- [2] Kandukuri, S. T., Klausen, A., Karimi, H. R., & Robbersmyr, K. G. (2016). A review of diagnostics and prognostics of low-speed machinery towards wind turbine farm-level health management. *Renewable and Sustainable Energy Reviews*, 53, 697–708. <https://doi.org/10.1016/j.rser.2015.08.061>
- [3] Manco, G., Ritacco, E., Rullo, P., Gallucci, L., Astill, W., Kimber, D., & Antonelli, M. (2017). Fault detection and explanation through big data analysis on sensor streams. *Expert Systems with Applications*, 87, 141–156. <https://doi.org/10.1016/j.eswa.2017.05.079>
- [4] Zhao, M., Tang, B., & Tan, Q. (2016). Bearing remaining useful life estimation based on time-frequency representation and supervised dimensionality reduction. *Measurement: Journal of the International Measurement Confederation*, 86. <https://doi.org/10.1016/j.measurement.2015.11.047>
- [5] Hameed, Z., Hong, Y. S., Cho, Y. M., Ahn, S. H., & Song, C. K. (2009). Condition monitoring and fault detection of wind turbines and related algorithms: A review. *Renewable and Sustainable Energy Reviews*. <https://doi.org/10.1016/j.rser.2007.05.008>



Research Areas and Literature

Log based Predictive Maintenance

- [6] Zhang, K., Xu, J., Min, M. R., Jiang, G., Pelechrinis, K., & Zhang, H. (2016). Automated IT System Failure Prediction : A Deep Learning Approach, (March 2017), 1291–1300. <https://doi.org/10.1109/BigData.2016.7840733>
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- [8] Salfner, F., Marksches, C., Coy, W., Malek, M., Hommel, G., & Reinefeld, A. (2008). Event-based Failure Prediction An Extended Hidden Markov Model Approach. Retrieved from <https://www.informatik.hu-berlin.de/de/Members/salfner/publications/salfner08eventbased.pdf>
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- [10] Sipos, R., Fradkin, D., Moerchen, F., & Wang, Z. (2014). Log-based predictive maintenance. In *Proceedings of the 20th ACM SIGKDD international conference on Knowledge discovery and data mining - KDD '14* (pp. 1867–1876). <https://doi.org/10.1145/2623330.2623340>

Thank you for your attention!

Questions & Discussion

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27.11.2017

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