Universität Stuttgart

Lean Production Controlling and Tracking using Digital Methods

Advancement in Photogrammetry, Remote Sensing and Geoinformatics

56th Photogrammetric Week

Stuttgart, 15.09.2017

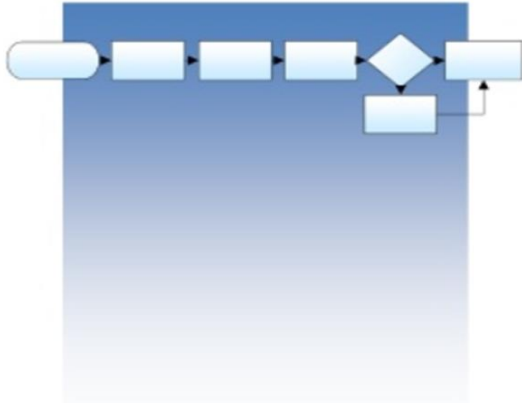**Jakob von Heyl**

Motivation

- Quote from German industry magazine "Bauwirtschaft im Südwesten" (June 2016)
  - Digitization of processes required
  - Ready-to-use technologies pretty much exist
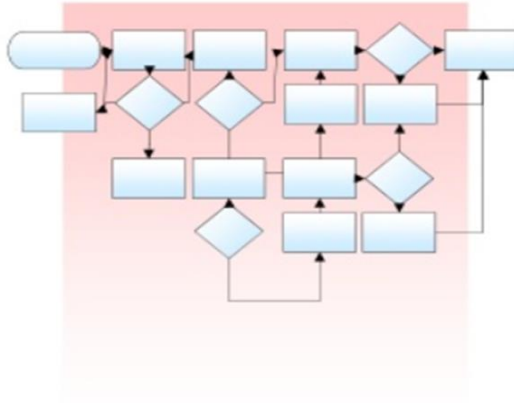 - Industry and academics lag state-of-the-art knowledge
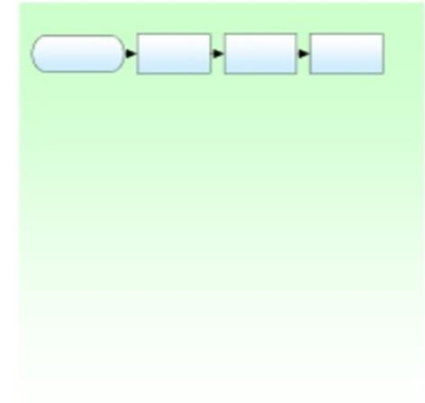
Digitization of processes

Challenge:

The manager thinks the process looks like that:

Actually the process looks like that:

Like that the process could look like (optimized):

- Many processes are organized more complex than needed.
- Often processes are unclear and intransparent.

Process optimization with Lean Management

- Lean is an approach to achieve a more efficient design of production systems.

- A stable production with low throughput times is strived for. A middle way between mass production and crafts.

- "Give the customer what he wants, deliver it as quickly as possible, and without waste."

- The value of each work step is defined by the customer. Based on this approach, the value creation process is optimized.

Origin and history of Lean Management and Lean Production

Royal Navy, Maudslay/Brunel — Production lines, Standardisation

F.W.Taylor — Scientific Management

Henry Ford — Assembly Lines

Training Within Industry — Job Instruction, Job Improvement, Job Relations

Reengineering — Identification waste, Quality tools (pareto, SPC) — Juran, Deming

Schonberger — Japanese Manufacturing Techniques (1982)

Goldratt — The Goal (1984)

Womack/Jones — The Machine That Changed the World (1990), Lean Thinking (1996)

1800   1900   2000

Sakichi Toyoda — Creation of Toyota
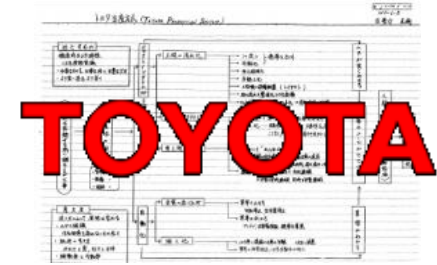
Shiego Shingo   Taiichi Ohno   Ishikawa

Weaknesses of batch production — Pull Flow, U-shaped cells, Poka yoke, Quality Circles

From Lean Production to Lean Construction

- **Stationary Industry**
  - Production System
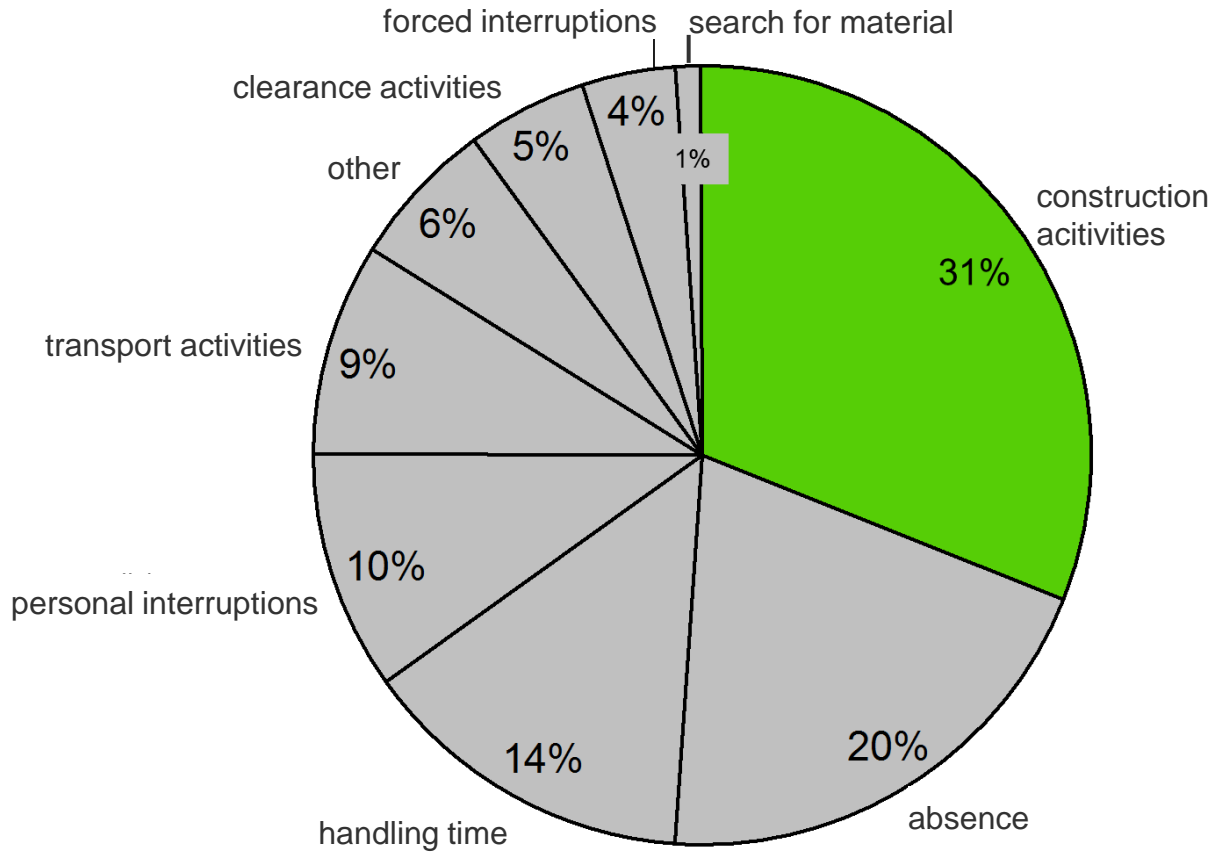 - Standardized bundle of methods and tools

- **Construction Sector**
  - Few holistic Production Systems
  - Little standardization
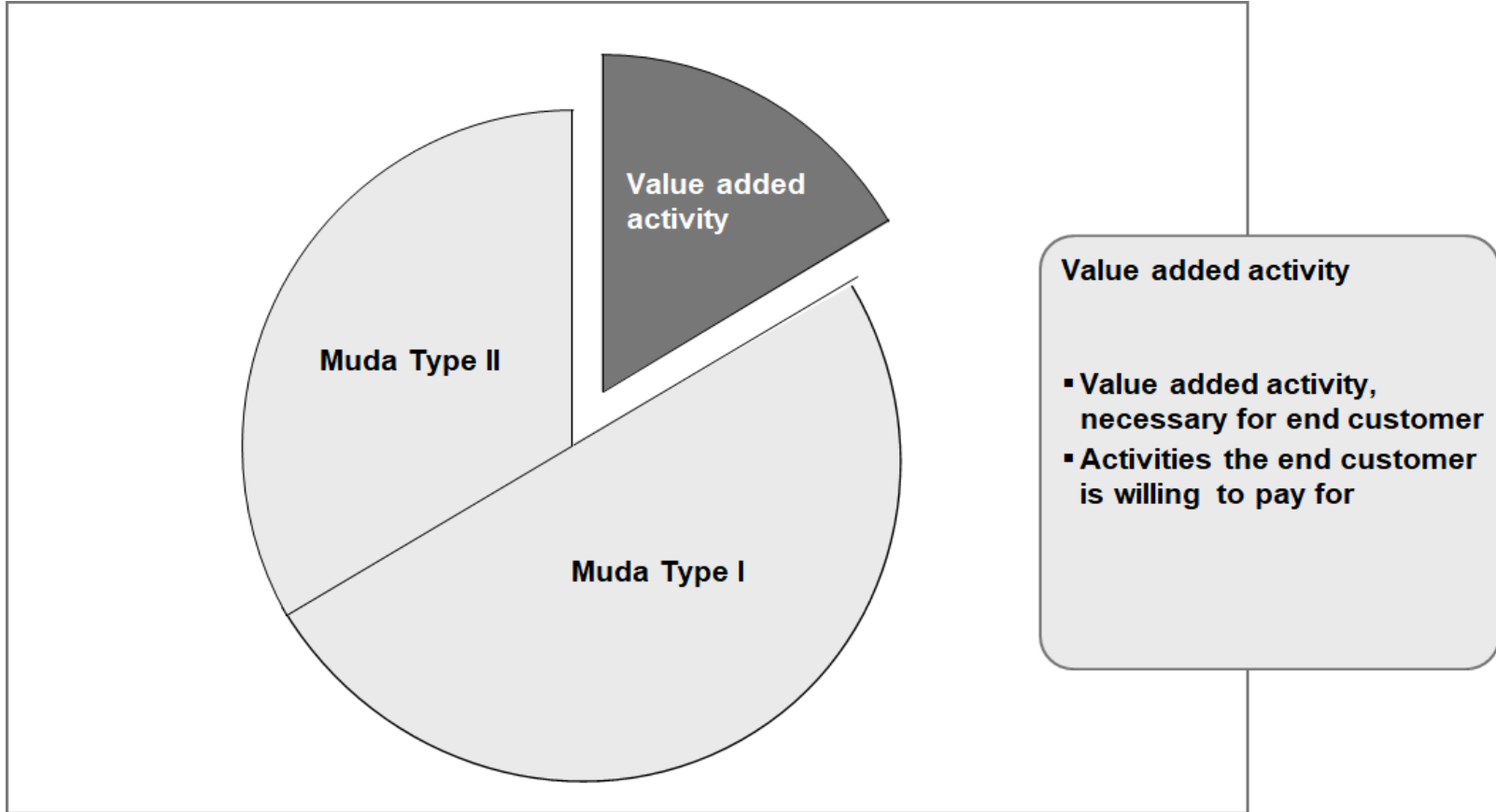 - Lean Construction concepts are being developed
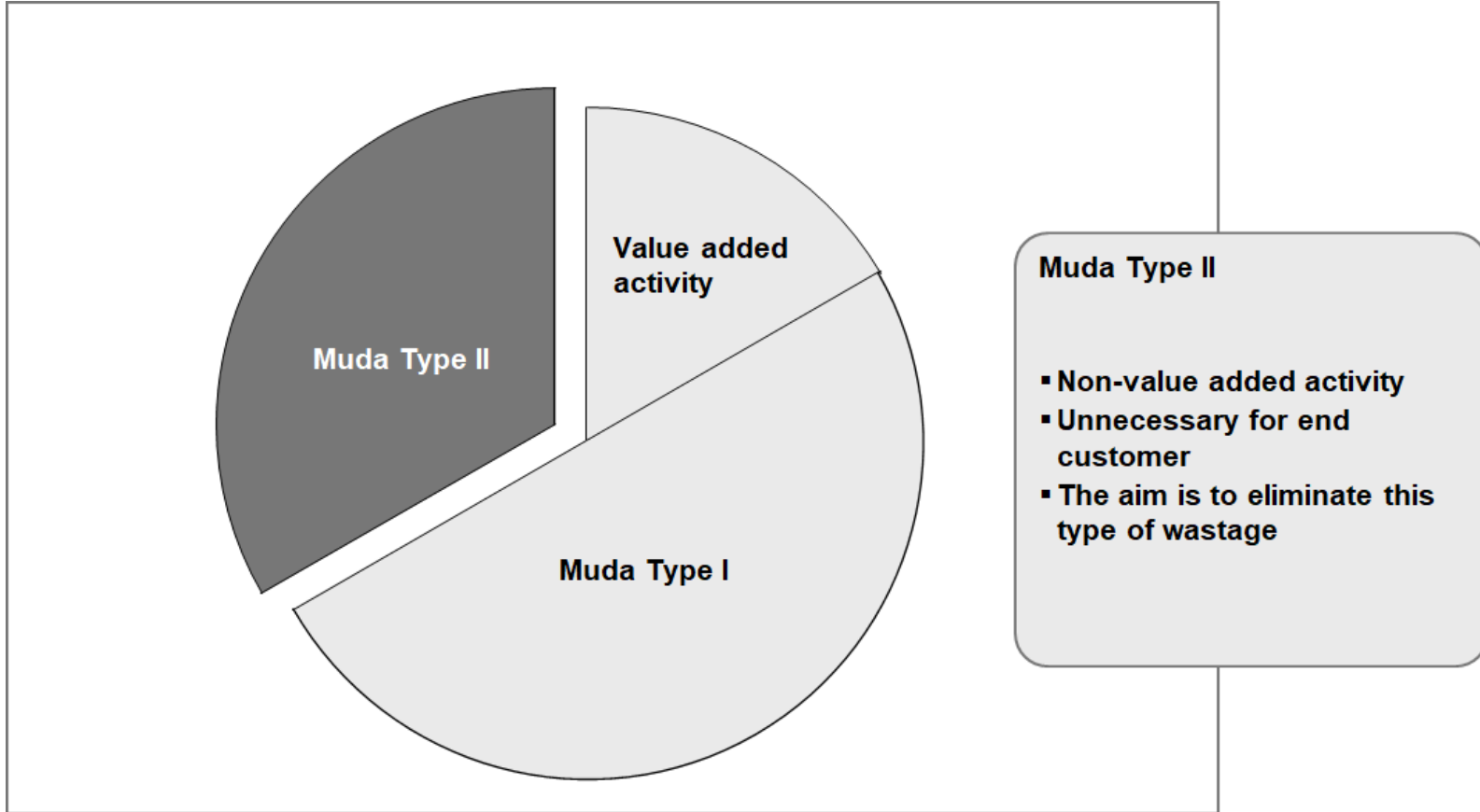
Lean Construction – productivity at building sites

- construction acitivities — 31%
- absence — 20%
- handling time — 14%
- personal interruptions — 10%
- transport activities — 9%
- other — 6%
- clearance activities — 5%
- forced interruptions — 4%
- search for material — 1%

Source: Guntermann, 2007

Differentiation of value added activities and wastage

Muda (無駄) – japanese for wastefulness

Value added activity

Value added activity

- Value added activity, necessary for end customer
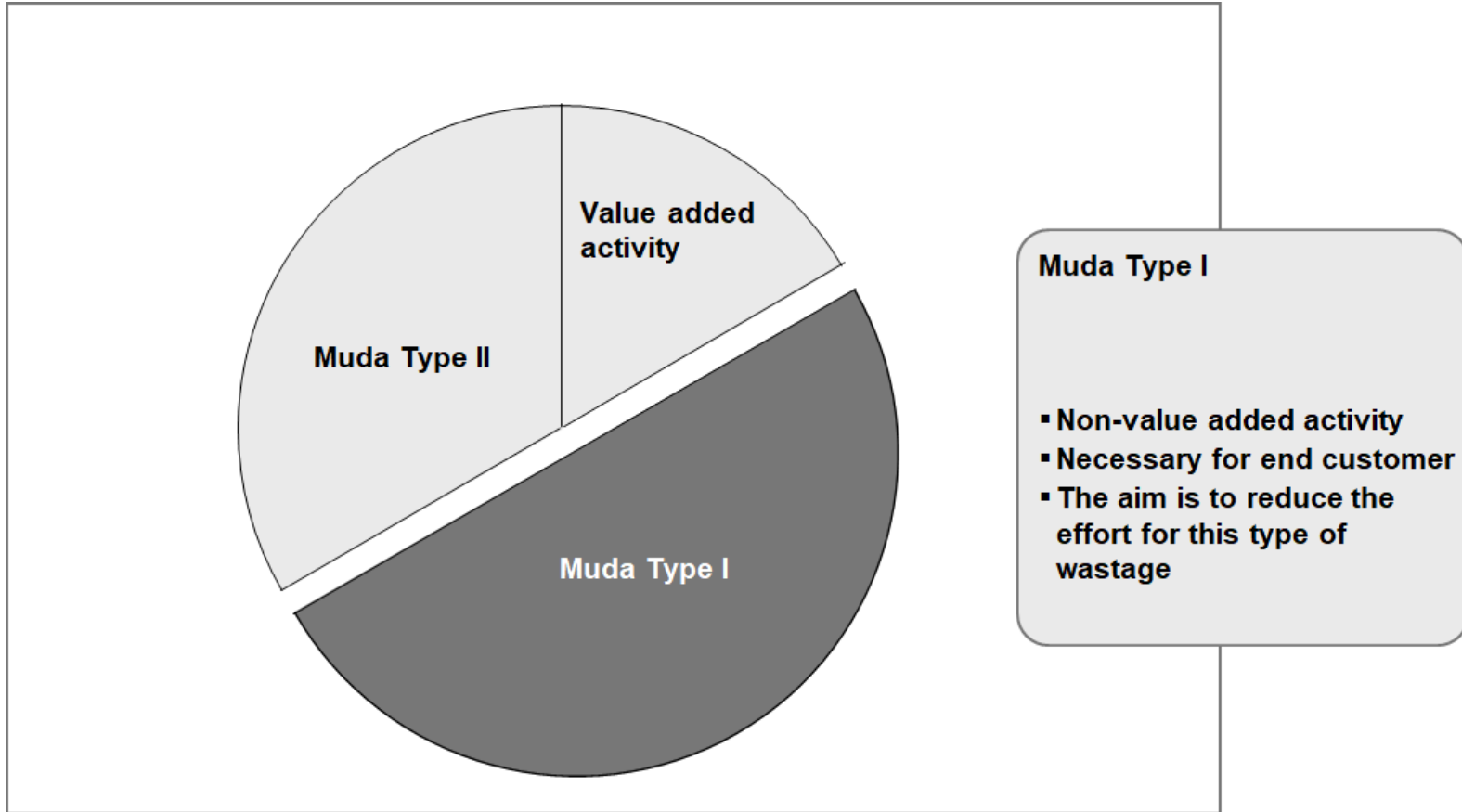- Activities the end customer is willing to pay for

Muda Type II

Muda Type I

Differentiation of value added activities and wastage

Muda (無駄) – japanese for wastefulness

Value added activity

Muda Type II

Muda Type I

Muda Type II

- Non-value added activity
- Unnecessary for end customer
- The aim is to eliminate this type of wastage

Differentiation of value added activities and wastage

Muda (無駄) – japanese for wastefulness

Value added activity

Muda Type II

Muda Type I

Muda Type I

- Non-value added activity
- Necessary for end customer
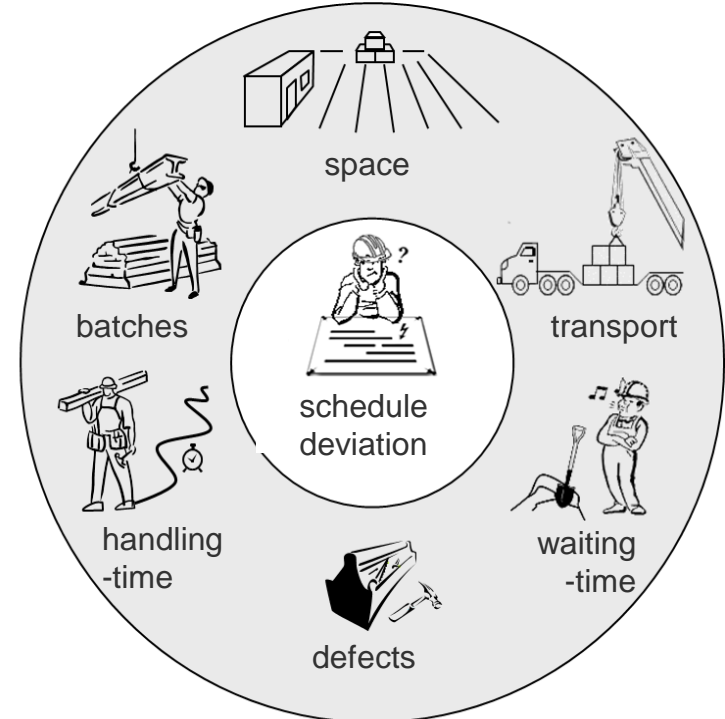- The aim is to reduce the effort for this type of wastage

Lean Construction – different categories of wastage (Muda type I and II)

Production
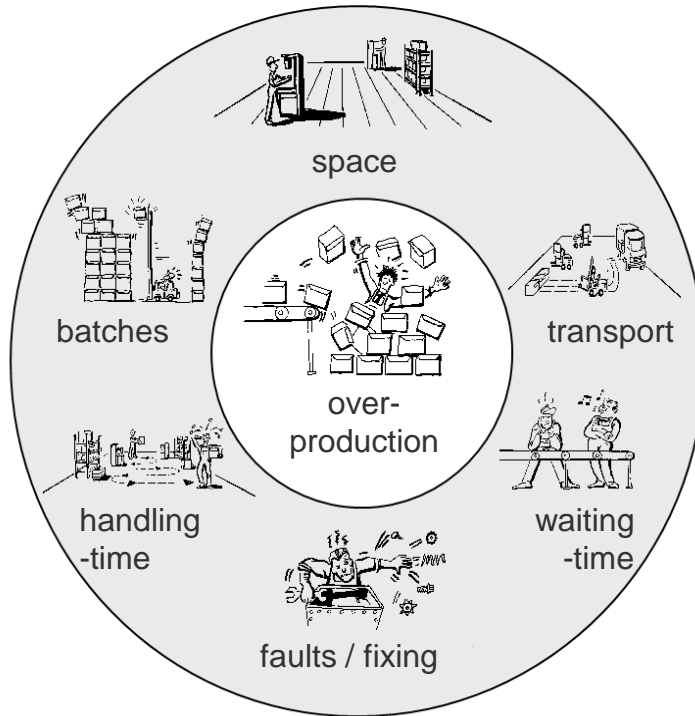
Construction

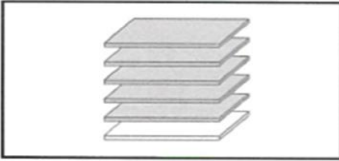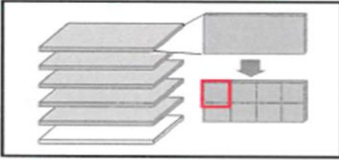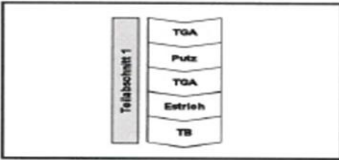- Overproduction as most crucial wastage, causing all kind of other categories of wastage
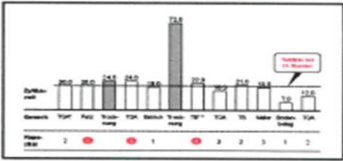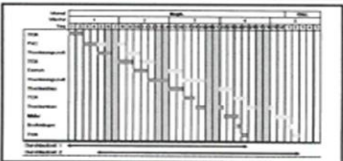
- Schedule deviation as most crucial wastage, causing all kind of other categories of wastage
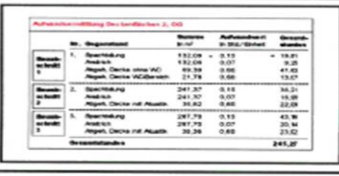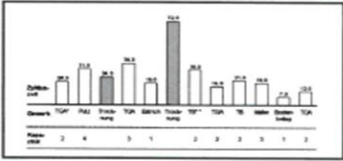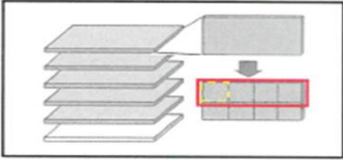
Production Planning and Control in Construction

- Existing Production Planning and Control Methods of the stationary industry can´t be applied without adaptions
- The specifics of construction projects have to be adressed
- Two Production Control Methods are gathering momentum in the Construction Sector:
    - Taktplanning and Taktcontrol (TPTC)
    - Last Planner System® (LPS)
    - TPTC and LPS are both focussing on reduced schedule variation, improved reliability and stabilized workflows.

Taktplanning and Taktcontrol (TPTC)

Step	Content	
1	• Identification of repeatable and non repeatable elements	
2	• Definition of smallest common denominator (e.g. room)	
3	• Determination of trade sequence incl. process caused waiting times	
4	• Determination of work content for smallest common denominator	

Step	Content	
5	• Creation of a work distribution diagram per smallest common denominator	
6	• Definition of work per unit (completed work per day/week, area and trade)	
7	• Takt identification and harmonization	
8	• Creation of production schedule	

Last Planner System®

Master Schedule → Set milestones and key dates

Should Do — Phase Schedule → Specify handoffs between trades

Can Do — Look-Ahead Plan → Make ready and initiate re-planning as required

Improving — Feedback & Learning → Weekly Work Plan — Will Do

Progress Tracking — Doing & Done

Measure progress and remedy issues
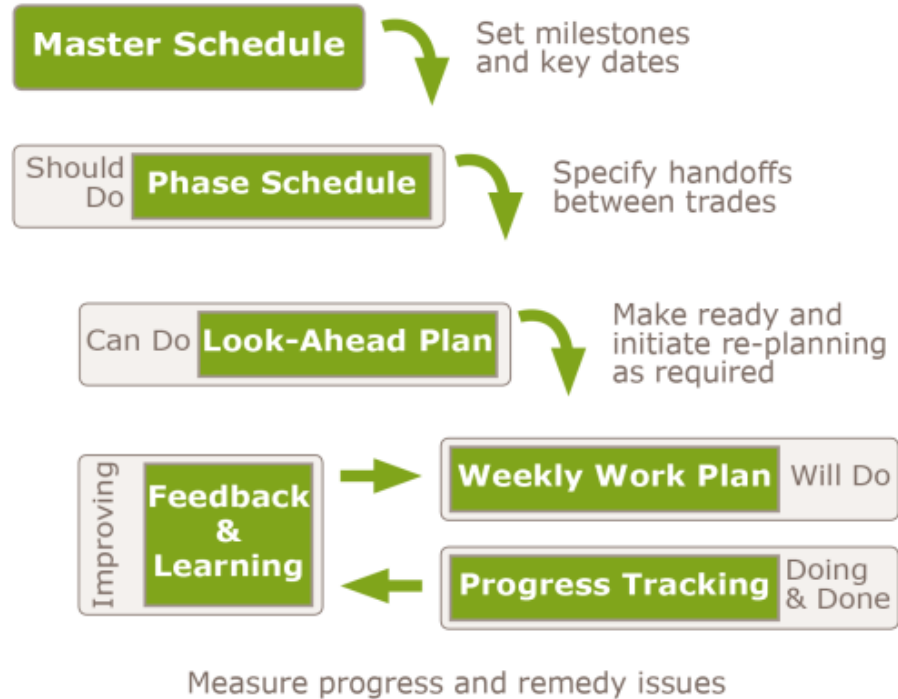
LPS® aims to reduce schedule variation through:

- Cooperative scheduling generates commitment
- Communication, commitment and visualization create transparency
- Forward-looking planning minimizes interruptions, faults, etc.
- Planning the immediate work packages on a weekly basis.
- Progress measurement and the immediate use of empirical values and key figures

Comparison of LPS® and TPTC

Criteria	LPS®	TPTC
Management Direction	Bottom-up	Top-Down
Collaboration	High	Low-Medium
Spatial Link	Low-medium	High
System-Stability	High	High, when little variability
System-Flexibility	High	Low

- LPS® and TPTC work differently, but can be implemented together

- Possible Combination with further Methods:
  - Location Based Management System (LBMS)
  - Critical Chain Project Management (CCPM)
  - Earned Value Analysis (EVA)

Information Management – Data Flow and Data Source

Data Flow:
Control Loop
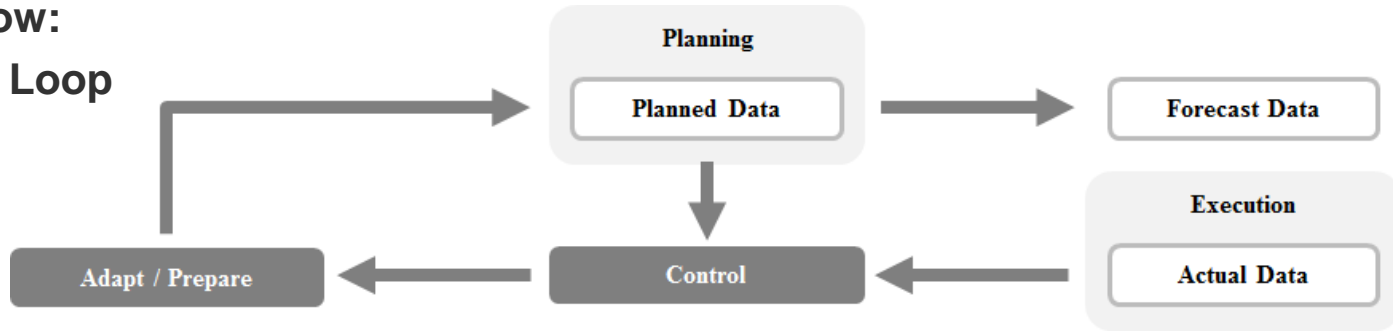
Data Source:
Building Information Model

Gathering of Actual Data – Technology

- **Available technology (selection):**
  - Global Navigation Satellite Systems (GNSS)
  - Unmanned Vehicles (drones)
  - Electronic Tachymetry
  - Photogrammetric Images
  - 3D-Scans / LIDAR.
  - Long Range Wide Area Network (LoraWan)
  - Bluetooth Low Energy Beacons (BLE)
  - Barcode
  - Mobile Devices
  - Cloud Computing
  - etc.

Possible Lean-IoT-BIM process with Mobile Devices and BLE-Technology

Realized and tested Concept

- **Original idea**
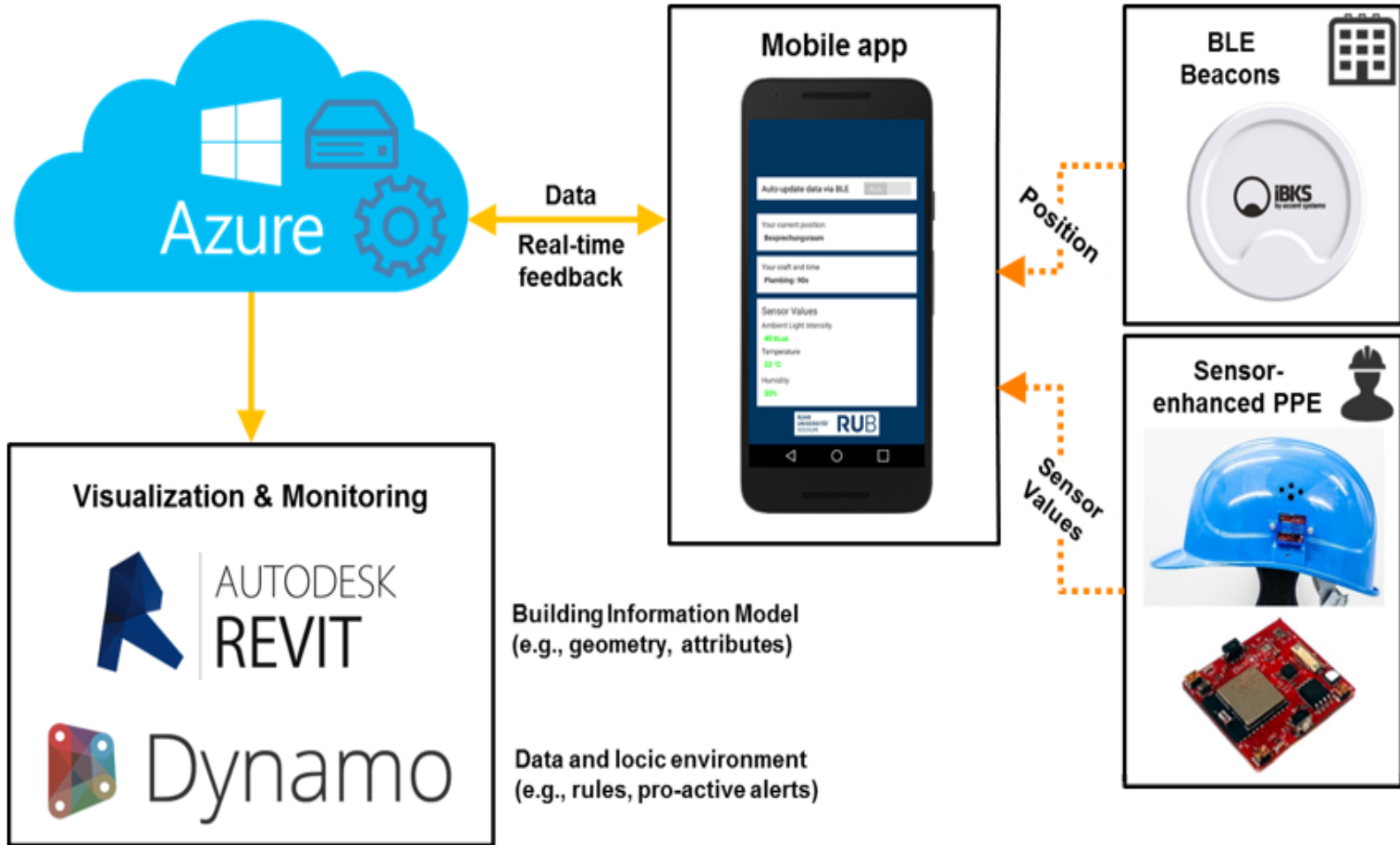 - based upon the SmartHat-concept (Teizer and Reynolds 2012)

FIATECH 2010

- **Proposed system**
  - Beacons at each workstation
  - App for setting up sensor-infrastructure
  - User interfaces (desktop and mobile status monitors) for real-time location sensing, status monitoring, and data visualization

Realized and tested Concept

Source: von Heyl / Teizer, 2017

Experimental setup, preliminary results and future work

- **Experimental setup**
  - Interior finishing tasks
  - 4 trades
  - 2 work days observation time
- **Method**
  - Before/after monitoring (several cycles of the same work tasks)
  - Ground truth comparison using manual note taking by independent human observers at work stations and critical waypoints (i.e. temporary warehouse on site)

- **Preliminary results**
  - Reduction in production time of up to 44 %
  - Reduction in interior travel time of up to 20 %
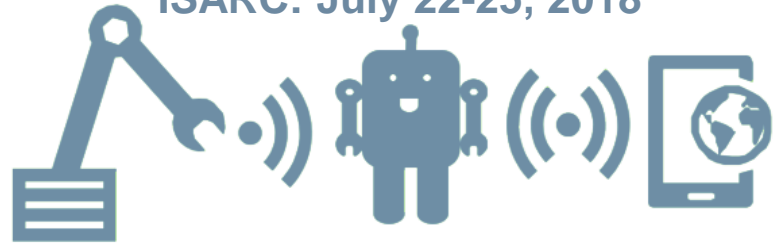 - Near real-time awareness of delays caused by rework (within minutes)
- **Future work**
  - Collect and analyze more data
  - Search alternative for beacons
  - Develop education and training tools for workforce and management engagement

More details to this project to be presented at …

International Symposium on Automation and Robotics in Construction

Berlin, Germany
Hackathon: July 20-22, 2018
ISARC: July 22-25, 2018

http://www.isarc2018.org