Karlsruhe Institute of Technology

Federal Ministry of Education and Research

EMOS: Development of a mobile, automated, optical inspection system for radioactive drums

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Agenda

- Starting position
- Goals of the research project EMOS
- Inspection process
- Results
- Timeline
- Summary

The Research Project - EMOS

- Sponsored by: 

  - BMBF Sponsoring Programme „Research for the dismantling of nuclear facilities” (FORKA)
- Research cooperation within the KIT
  - **Institute of Technology and Management in Construction (TMB):**
    - Development, design and construction of the inspection unit
  - **Institute of Photogrammetry and Remote Sensing (IPF):**
    - Selection and conception of the optical detection as well as creation and implementation of the evaluation algorithms

Starting position

- Currently, approximately 120.000 m³ of treated and conditioned low- and intermediate-level radioactive waste is stored in Germany.
- The waste is filled in containers, mostly 200 L steel drums.
- Their **safekeeping** must be ensured for an indefinite period of interim storage.

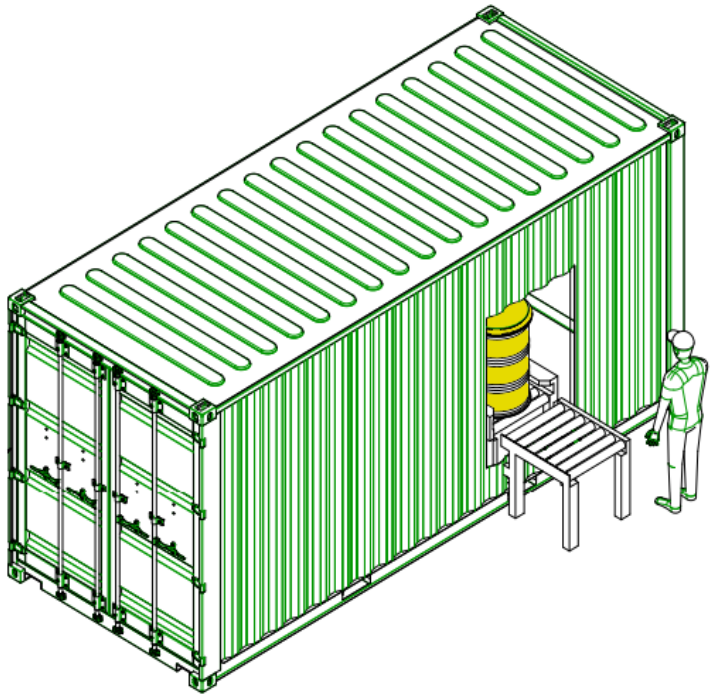
→ **Recurrent inspection of the drums is required to detect corrosion and other damages and, if necessary, to be able to initiate consequences to minimize damage.**

Source: https://www.einblicke.de/einblicke-7/unter-tage-muss-ordnung-herrschen

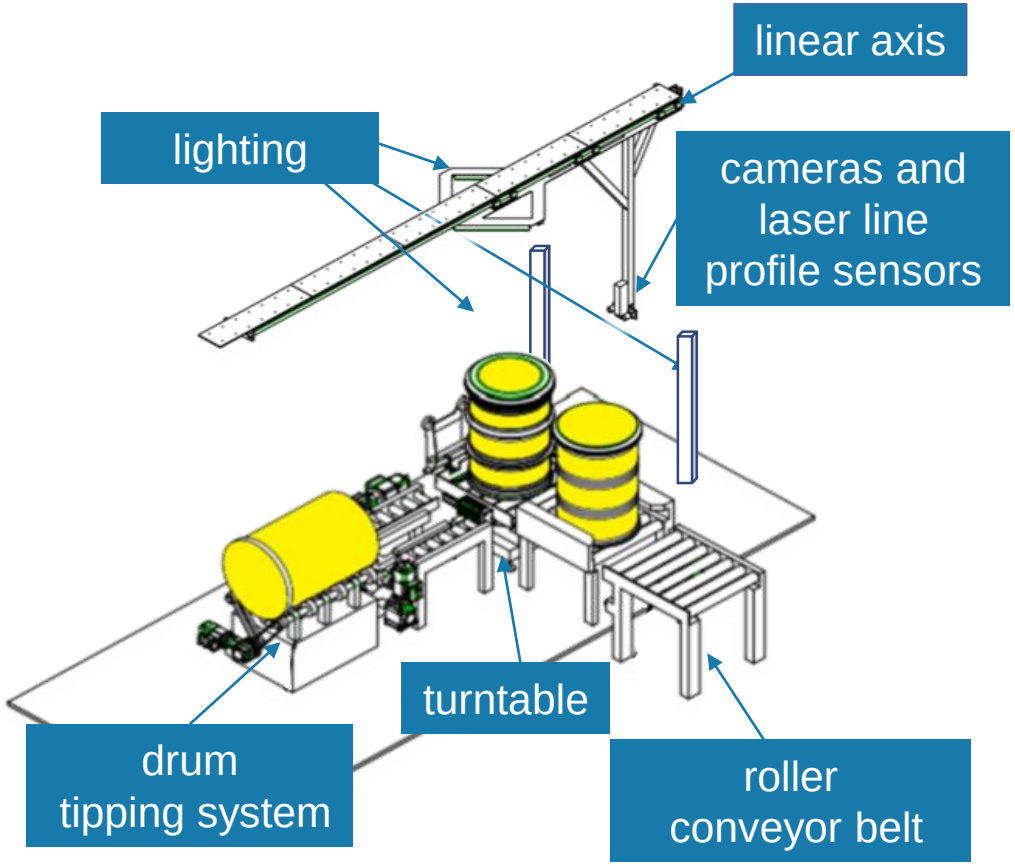
Goals of the research project

- **Automation and standardization of the inspection process of the drums**
  - Automatical detection of damage to new and stored drums
  - Categorization of damages
  - Detection of changes of damages over time
  - Indicate, when consequences must be taken to minimize damage
- **Advantages**
  - Increase in **Safety** during interim storage of nuclear waste
  - Increase in **occupational safety**: Staff is less exposed to radiation
  - **Time Gain** in the inspection process of the drums

Setting of inspection unit and components



20ft high cube container with a rolling gate at the long side



Construction of the inspection system

Mobile inspection system

20ft high cube container with a rolling gate at the long side

component installation

Inspection process

control panel remote controlled → Drum on turntable → Drum shell and drum lid scan → Drum shell and drum lid photograph → Drum on tipping system → Drum bottom scan photograph → Drum return





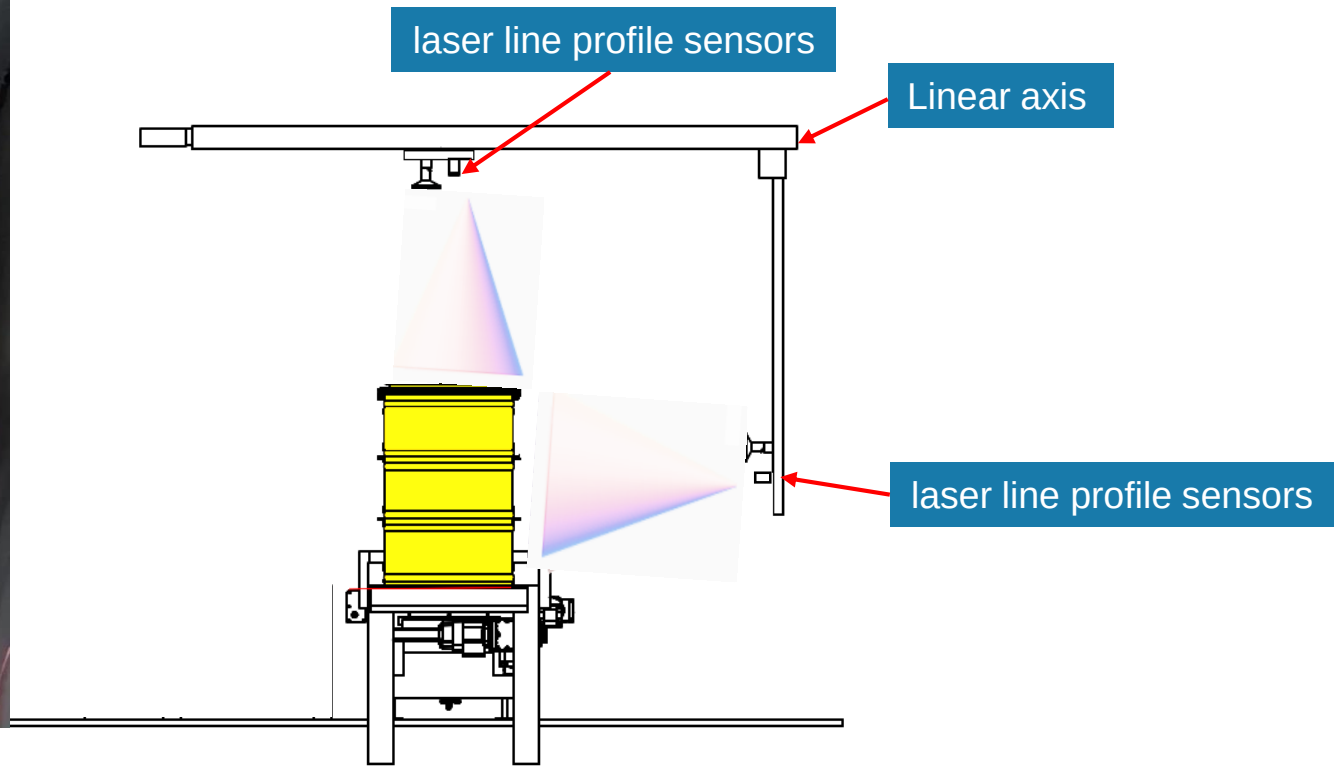


Inspection process

- Drum on Turntable - Drum is moved onto the turntable and centered

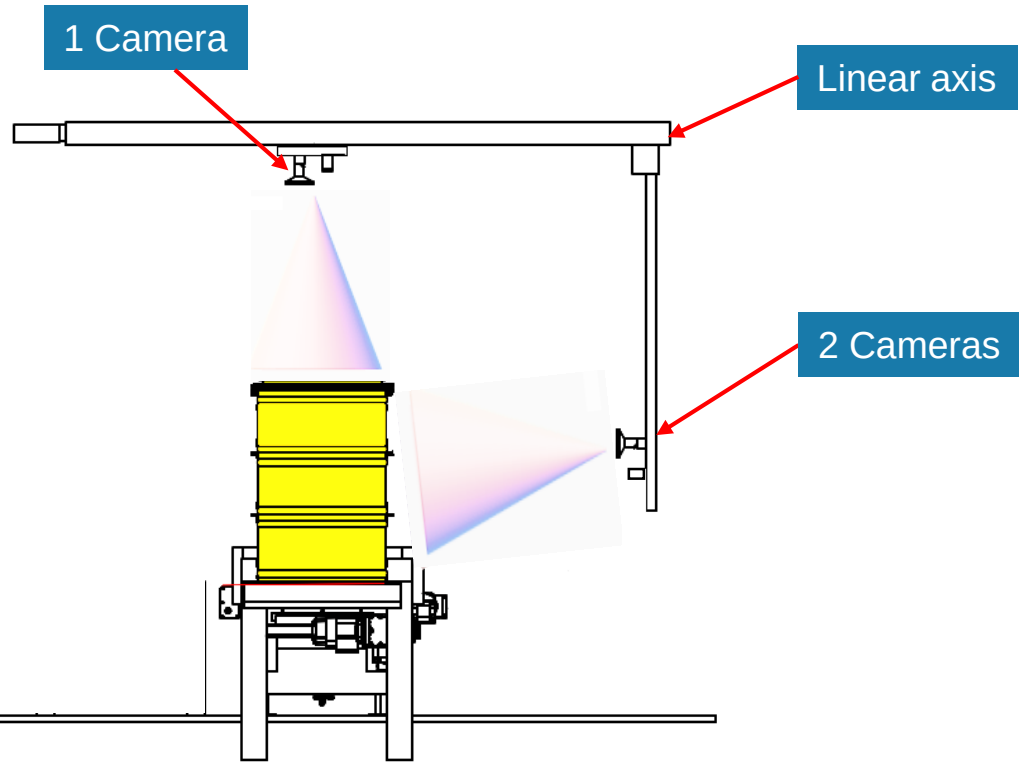
Inspection process: Laser line profile sensor

- Drum shell and drum lid scan



Inspection process: Camera

- Drum shell and drum lid photograph

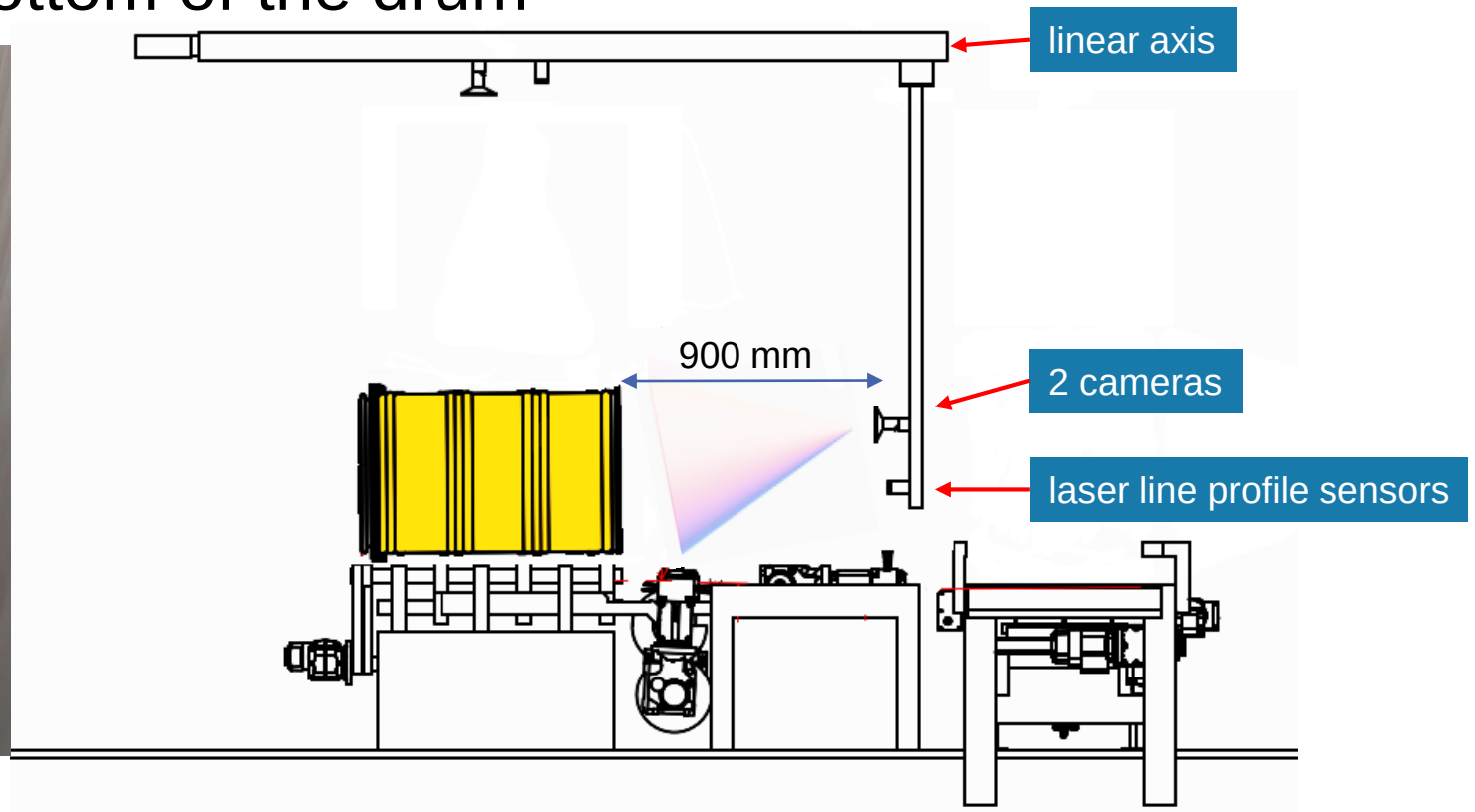


Inspection process

- Drum on tipping system - Drum is transported to the tipping system and tipped

Inspection process

- Scan and photograph the bottom of the drum

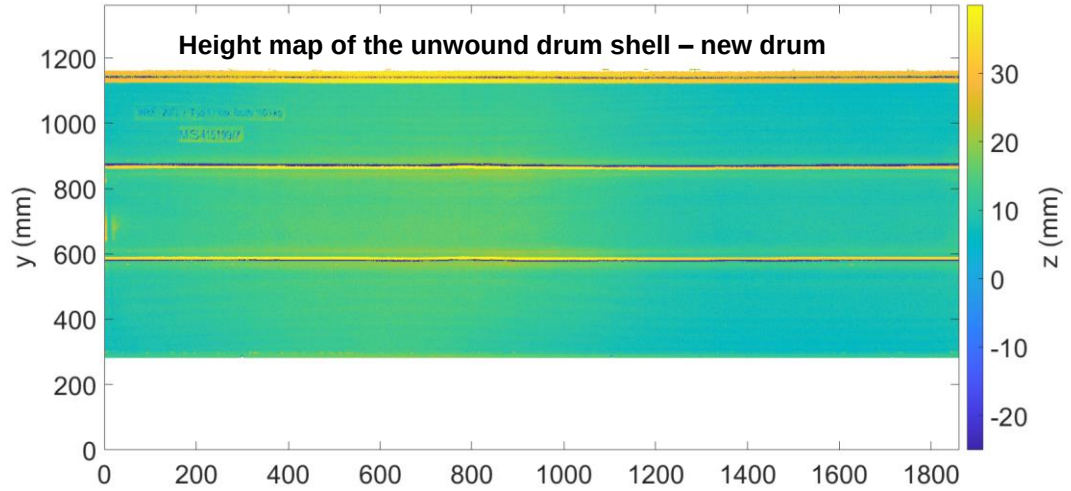


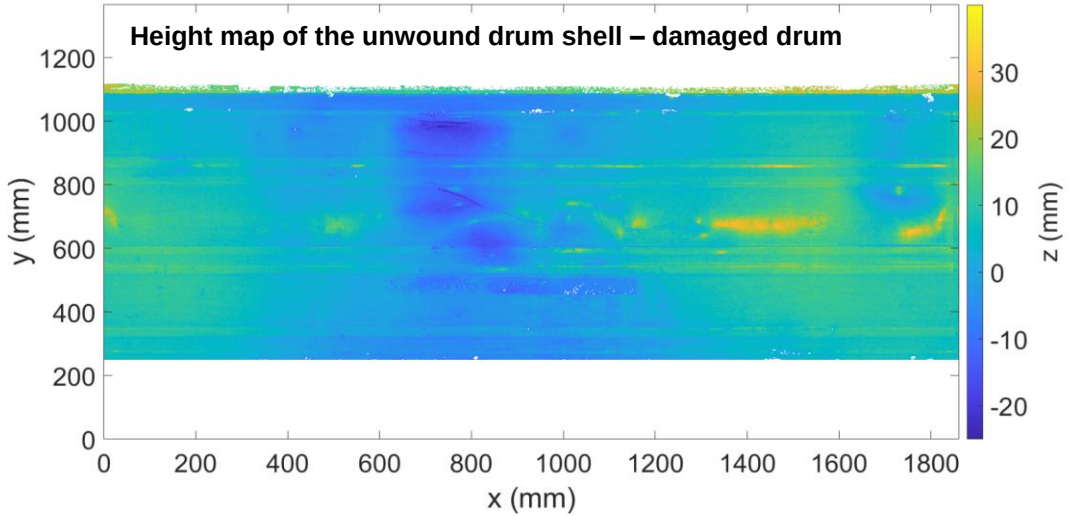
➢ In order to ensure an optimal measurement, a distance of approx. 900 mm from the bottom of the drum to the sensors is required

Inspection process

- Duration of complete inspection process: about 9 minutes

Results: Laser line profile sensor

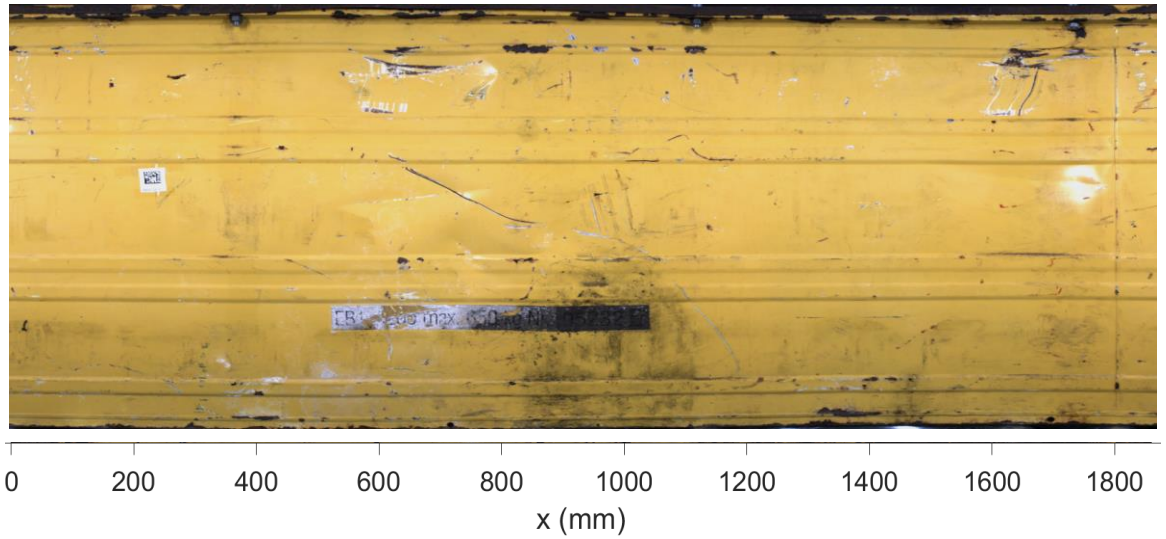




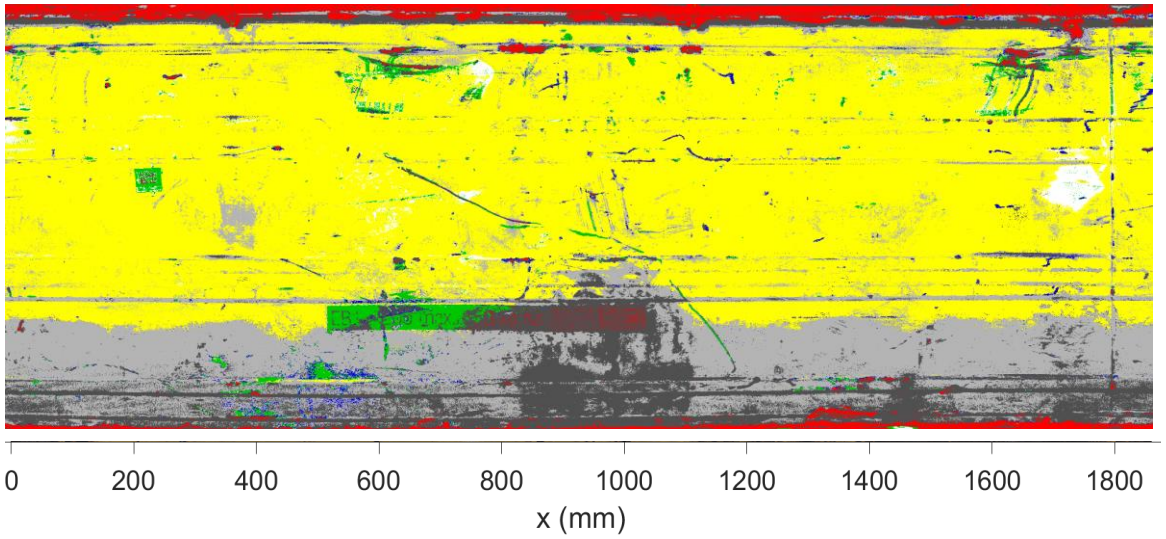
- Detection of geometric damage, such as bumps and dents

Results: Camera

Composite image of the unwound drum shell



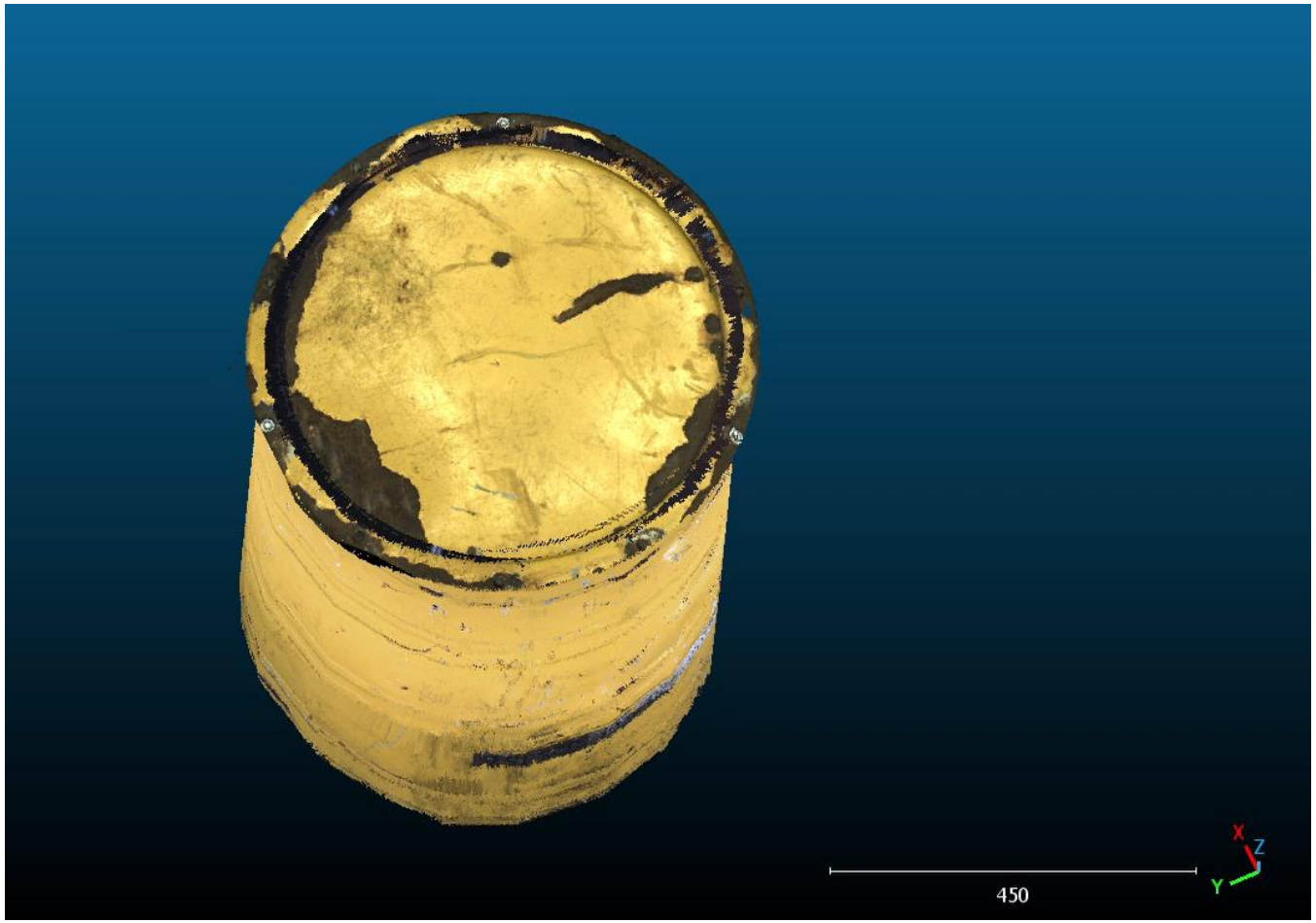
Detection and classification of visual damage



- 3,9% corrosion
- 57,6% unaffected
- 21,2% light dirt
- 12,5% dark dirt
- 1,5% reflection
- 2,0% undercoat
- 1,3% color spots

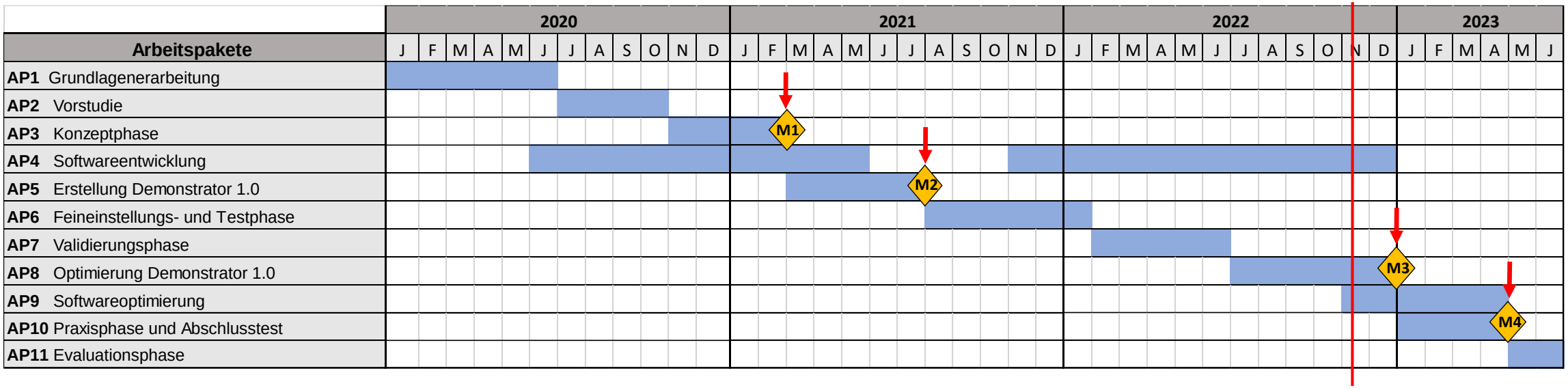
Source: D. Haitz et al. (2022): „Corrosion Detection for Industrial Objects: From Multi-Sensor System to 5D Feature Space"

Results: 3D model of a damaged drum



- Three-dimensional visualization of drums
- 3D-model is manually computed by combination of laser profiles and camera recordings

Timeline



Milestones

- M1 Finished Concept
- M2 Construction Demonstrator 1.0
- M3 Optimization Demonstrator 1.0
- M4 Final maturity Demonstrator 1.0

Summary

- Concept development, creation and construction of a functional inspection system that enables the automated inspection of temporarily stored drums to be reproduced and consistently accurate
- Self-developed software
- New recording and description of the surface condition of a drum
- Automatic detection of critical deviations from the normal state, e.g. the differentiation of uncritical color changes (e.g. due to slight color abrasion of a gripper arm) from dangerous changes due to significant indentations or bulges or rust formation

Summary

- Combination and interaction of the laser light section process and the optical recording for the new and exact recording of a container surface
- Monitoring of drum surface changes over the duration of storage

Opportunities for further development:

- Detection of corrosion and reaction inside the drums
- Optimization of the setup of the drum inspection unit
- 3D model and digital twin of the drum surface

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Thank you very much for your attention!