Energy savings potential at ship discharge

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Agenda

- **Measured Equipment in harbours for unloading and conveying**
- **Different removal phases in cargo holds and suitable equipment**
- **Impacts on an efficient discharge process of ship holds**
- **Savings potential during removal of residues**

Background of the showed data

- **In-house survey in the actual development status of conveyor equipment for bulk materials**

- **In-house survey in the clean-up efficiency of continuous ship unloader**

  - Data ascertained in 16 European grain-handling companies

  - Acquisition of data for different types of handling equipment

  - Including all common kinds of unloading equipment for grain

Comparison of equipment for unloading

Conveying equipment

	Belt conveyors	En masse conveyors	Bucket elevators
Distance/Height:	30 – 1000 m	12 – 150 m	20 – 90 m
Raising:	0° - 9.5°	0° - 38.3°	90°
Capacity:	up to 1500 t/h	up to 1000 t/h	up to 1000 t/h
Power Consumption:	0.25 Wh/tm (only horizontal)	1.30 Wh/tm (only horizontal)	3.80 Wh/tm (only vertical)

Unloading equipment

	Chain Type	Screw Type	Pneumatic	Belt Type
Capacity (max):	~ 1000 t/h	~ 700 t/h	~ 265 t/h	~ 1200 t/h
Efficiency:	~ 85 %	~ 75 %	~ 55-65 %	~ 60-70 %
Power Consumption:	~ 0.4 kWh/t	~ 0.9-1 kWh/t	> 1 kWh/t	~ 0.4 kWh/t

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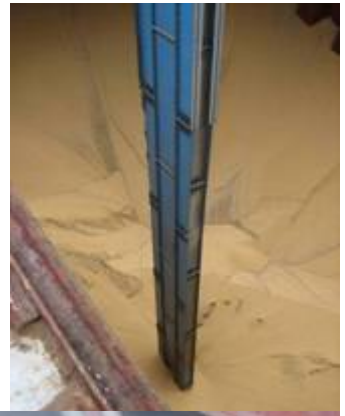
Differentiation of the unloading process of one hold in 3 characteristic Phases

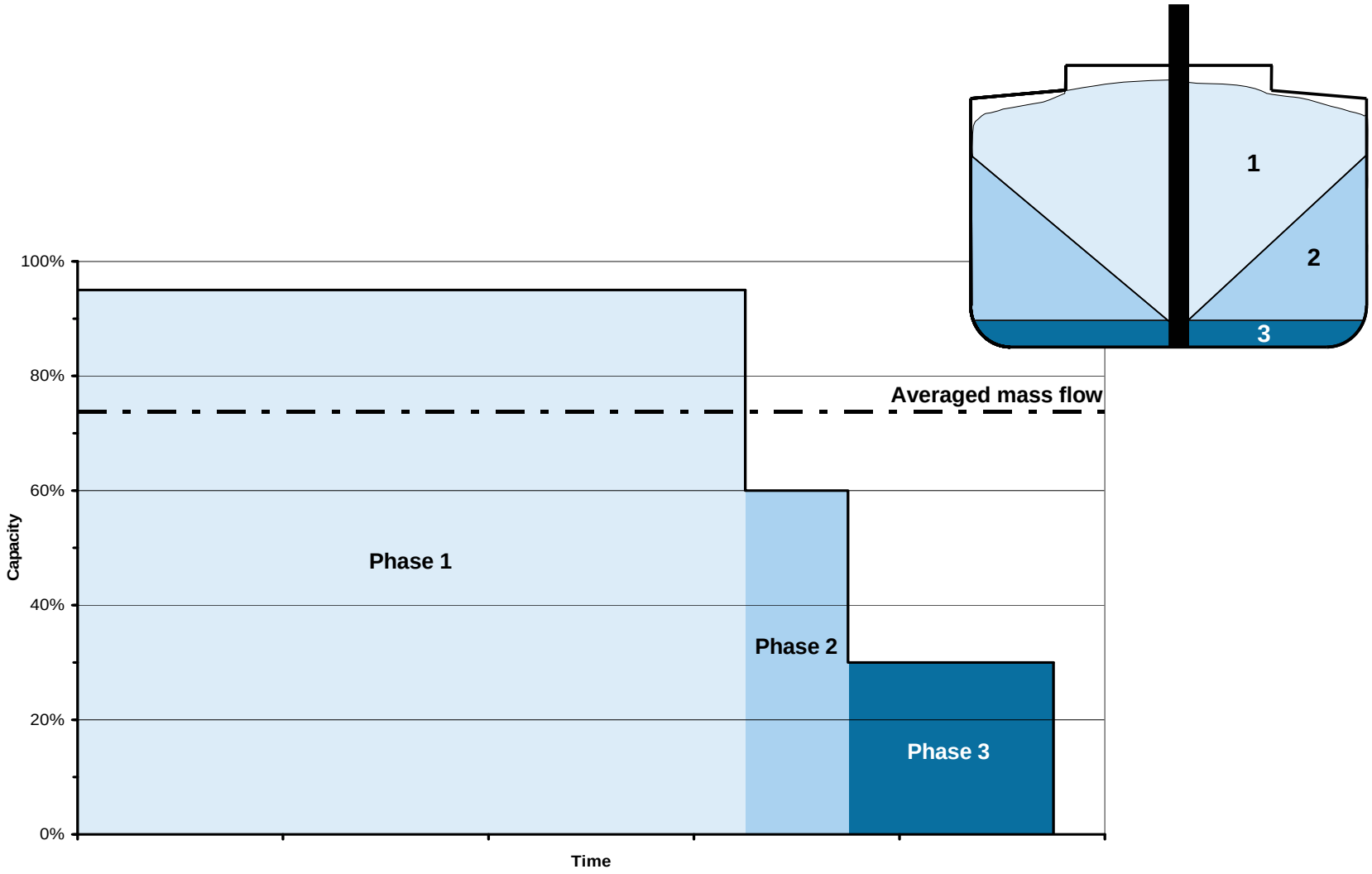


- **Phase 1**
  - Normal removal by the unloader in one position
  - Capacity near the maximum

- **Phase 2**
  - Unloader has to change position often
  - Use of wheel loader / bulldozer is profitable
  - Capacity decreases

- **Phase 3**
  - Unloader has to be fed by wheel loader / bulldozer
  - Capacity is mainly influenced by the feeding, not by the unloader

→ Different Phases can be detected in a mass flow diagram:



Which equipment can be used in the different phases?

- **Not all kinds of unloader are suitable for all three phases**
- **Reasons are for example:**
  - Kind of absorption of material
  - Minimum material height in hold
  - Restrictions by statutory provisions
  - Efficiency of unloaders

Which equipment can be used in the different phases?

- **Chain Type:**
  - Optimal working in Phase 1
  - Good working in Phase 2 with kick-in and kick-out and feeding is allowed
  - Less suitable in Phase 3 if conveyor with high capacity due to low efficiency

- **Screw Type:**
  - Same like Chain Type

- **Pneumatic:**
  - Less suitable in Phase 1 & 2 due to less capacity
  - Less suitable in Phase 3 if conveyor with high capacity due to low efficiency, optimal for final clean-up

- **Grab-Type**
  - Works in all phases, but not very optimal.

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Constraints for removal

Cargo:
- Kind of material in each hold
- Quantity of cargo to discharge

Guidelines by captain
- Strength of ship
- Sequence of holds

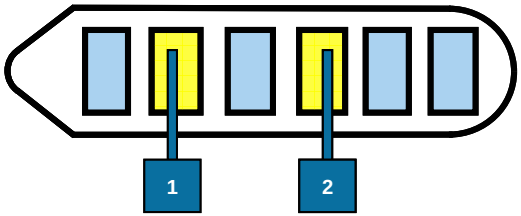
Constraints by environment
- Tide
- Weather

Unloading equipment:
- Kind and number of unloader
- Applicability of unloader for cargo

Constraints by law
- Noisiness, dust, …
- Working time

Ship:
- Number and size of holds
- Size of hatches

Ship Discharge



Efficiency of the removal process can be quantified by the achieved mass flow:

→ $$\textbf{Efficiency} = \frac{\textbf{achieved mass flow}}{\textbf{installed capacity}}$$

Consequences of an efficient discharge are:

- Faster removal
- Less energy consumption
- Less personnel costs
- Higher Profitability

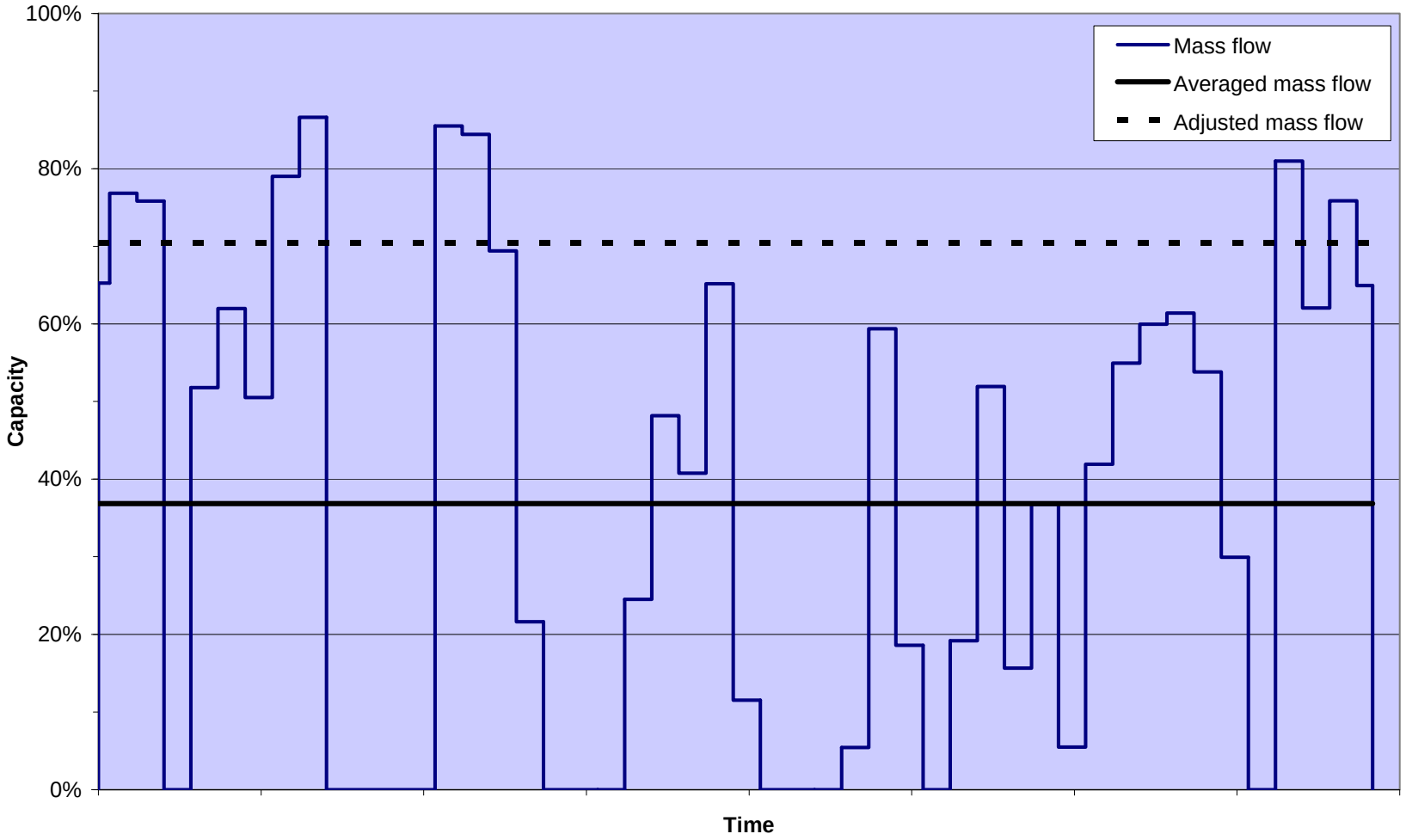
According to the results of our survey is the efficiency of a ship discharge influenced by:

- Driving route on the quay
- Breaks by employees
- Interruptions due to breakdown of silo or quay conveyor
- Strategy of using different unloaders and feeding equipment
- Strategy of using the unloader in the hold

Example mass flow diagram of a ship discharge

Averaged mass flow: **including all breaks and interruptions**

Adjusted mass flow: **pure conveying time**

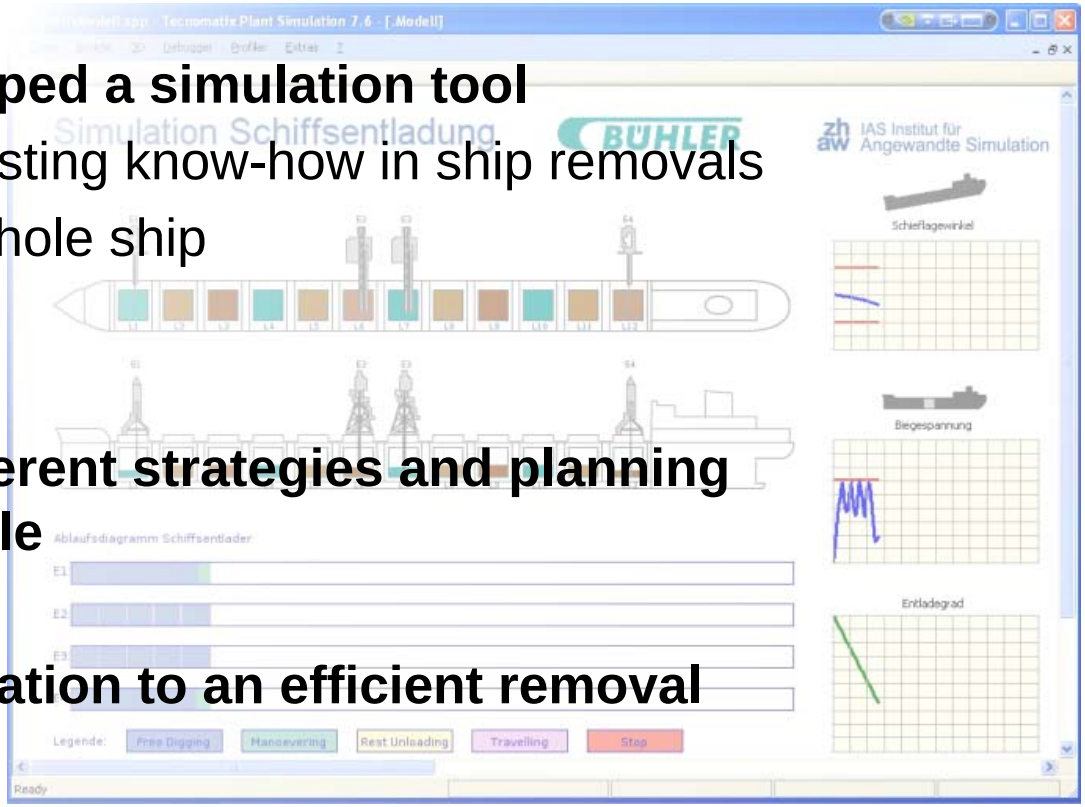


Simulation tool developed at our chair for the Buhler AG

- Basing on the results of the survey
- Combination of different unloaders and strategies
- Simulation of the removal of one hold

Also Buhler AG developed a simulation tool

- Basing on long lasting know-how in ship removals
- Simulation of a whole ship

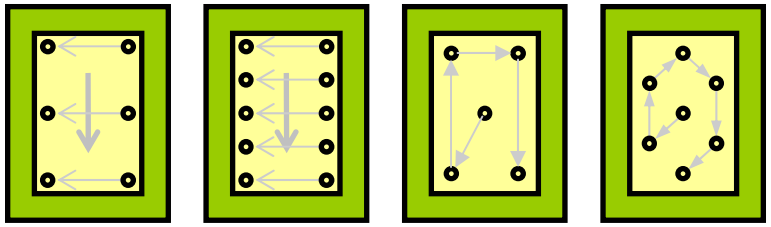


→ **Comparison of different strategies and planning of removals possible**

→ **Systematic optimization to an efficient removal**

Simulated removal strategies:

- Mechanical unloader with capacity of 600 t/h
- Phases 1 & 2 without any feeding
- Removal of residues unconsidered
- Breaks and interruptions not considered



	Mass in hold [t]	Conveyed mass [t]	Conveying time [h:min]	Mass flow [t/h]	Efficiency [%]
3 stripes	9910	7466	14:08	528.3	**88.0**
5 stripes	9910	7604	14:36	520.8	**86.8**
5 points	9910	7371	13:59	527.1	**87.9**
7 points	9910	7458	14:12	525.2	**87.5**

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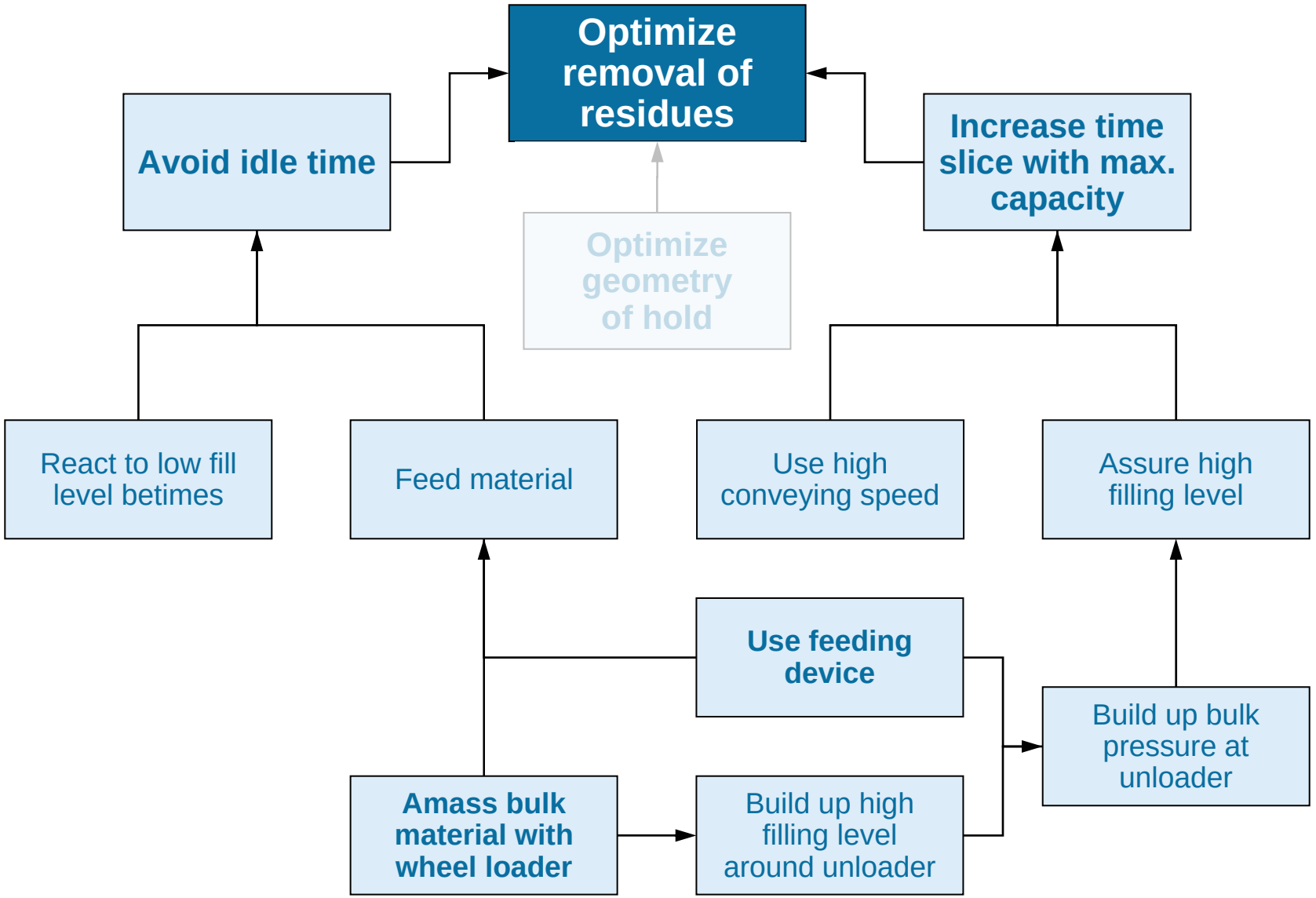
Options to advance the clean-up



Amass bulk material with wheel loader / bulldozer

- Use suitable type
- Use optimal number of equipment
- Use optimal size of loader

→ **Simulation of the use of 1 small, 2 small or 1 big wheel loader for the clean-up**
Unloader with capacity of 600 t/h

	Achieved mass flow
1 small loader	388 t/h
2 small loader	482 t/h
1 big loader	488 t/h

Use feeding device

- Sensible for mechanical unloaders
- Use in phase 2 to achieve a filling level of few decimetres
- Attachable for phase 2 to profit by efficient use of unloader in phase 1

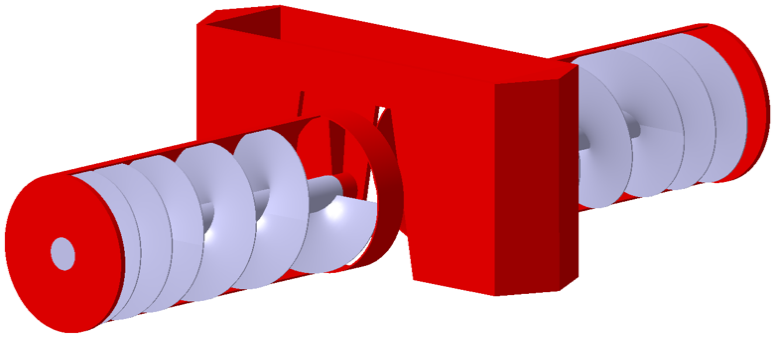
→ **Simulation of the discharge of the same hold, once with feeding device, once without it.**

	Achieved mass flow
No feeding device	586 t/h
Feeding device	688 t/h

+ 17.4 %

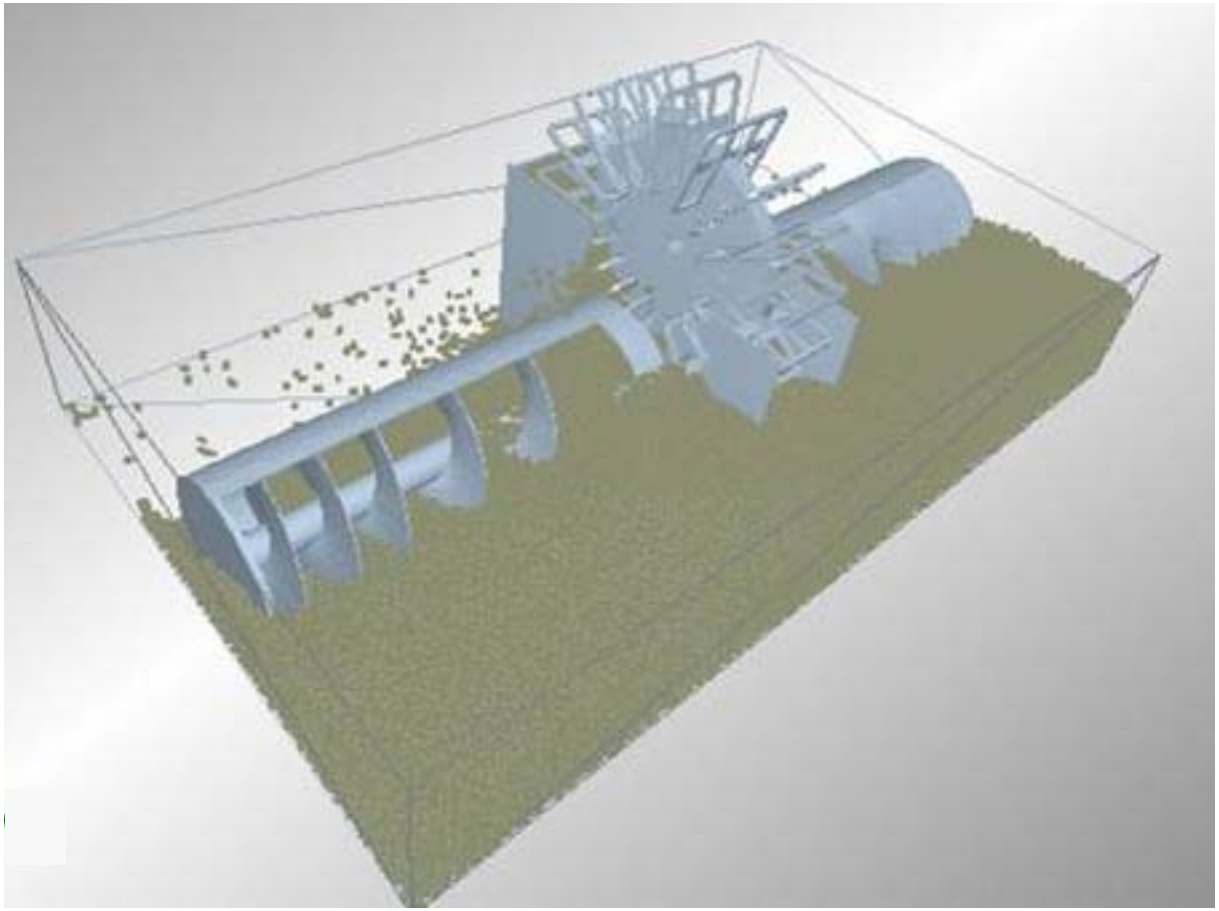
- **Optimisation of residues removal is possible as a combination of:**
  - Use of one big wheel loader / bulldozer in phase 3
  - Use of a feeding device for mechanical unloader in phase 2

→ **Cooperation of our Chair of materials handling, material flow, logistics and the Buhler AG to design a feeding device for the Portalink ship unloader based on the results of our surveys**



Simulation of feeding device with discrete elements method:

- Capacity of chain conveyor: 600 t/h
- Fill level in hold: approx. 350 mm



Summary

- **Efficiency of the clean-up process and thus total removal time can be reduced.**
- **Power consumption of discharge process occurs not only at the unloader but also at the complete conveying line to the silo.**
- **An efficient unloading process results in a short turn on time of the whole harbour installation and thus also in saving of energy.**

By assuring an efficient discharge process energy and costs can be saved!

Thank you for your attention!