TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

# Transport Infrastructure Asset Management

## A holistic framework for transport infrastructure asset management applied for inland waterways

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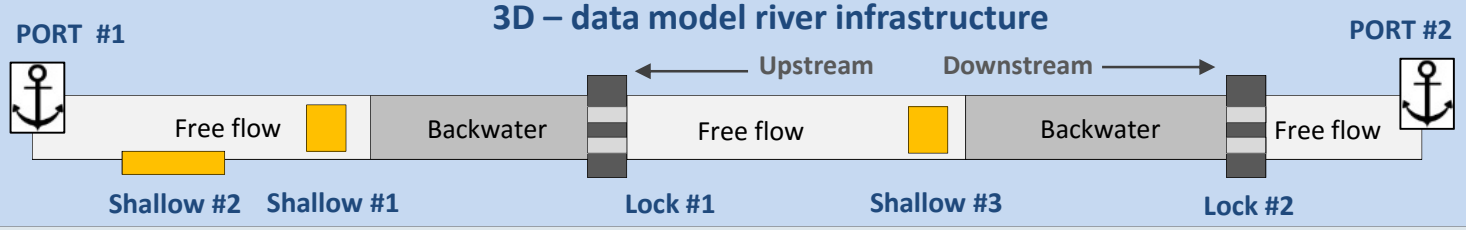
# OVERVIEW WATERWAY ASSET MANAGEMENT APPROACH

**Natural impacts**
Precipitation Temperature
Fog Wind

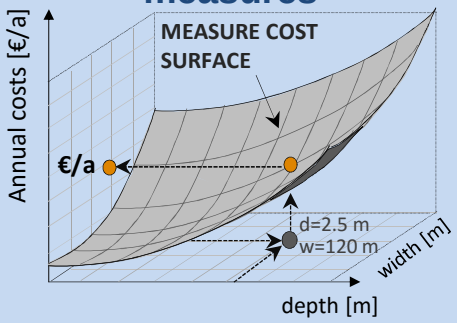
**Recommendations fairway**
AGN DC 1998 DC 2013

**Failures**
Lock failures Accidents

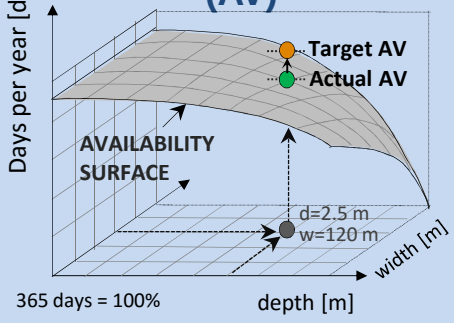
**3D – data model river infrastructure**



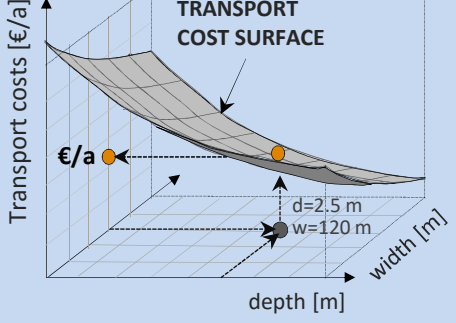

**Maintenance measures**




**Fairway availability (AV)**

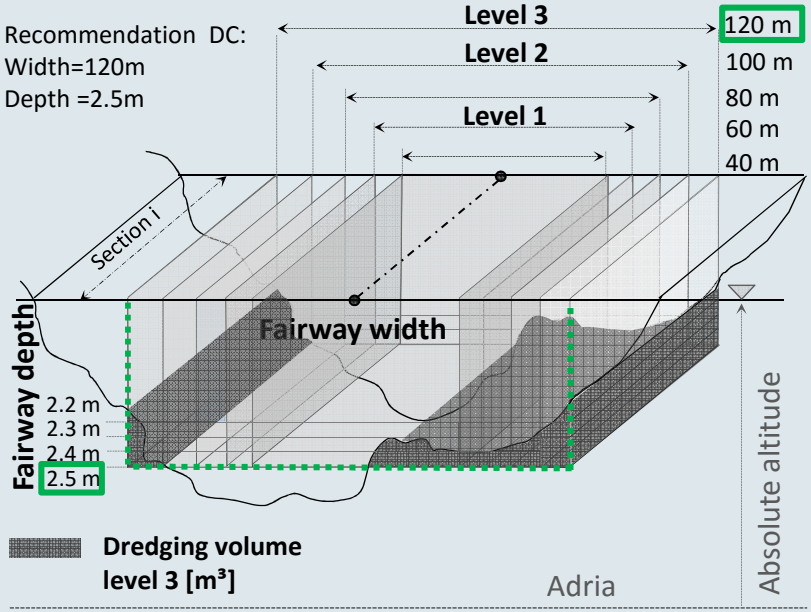



**Transport costs & savings**

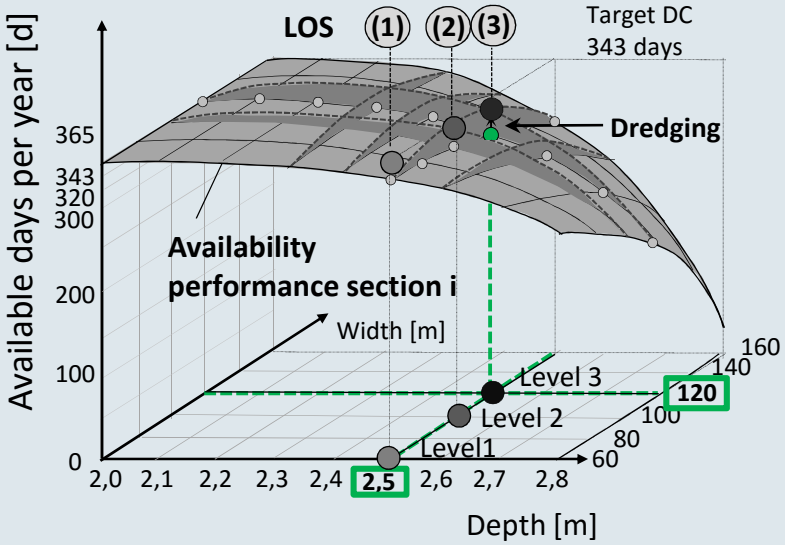


# FAIRWAY AVAILABILITY

## Classes of fairway width & depth




## Availability in days per year



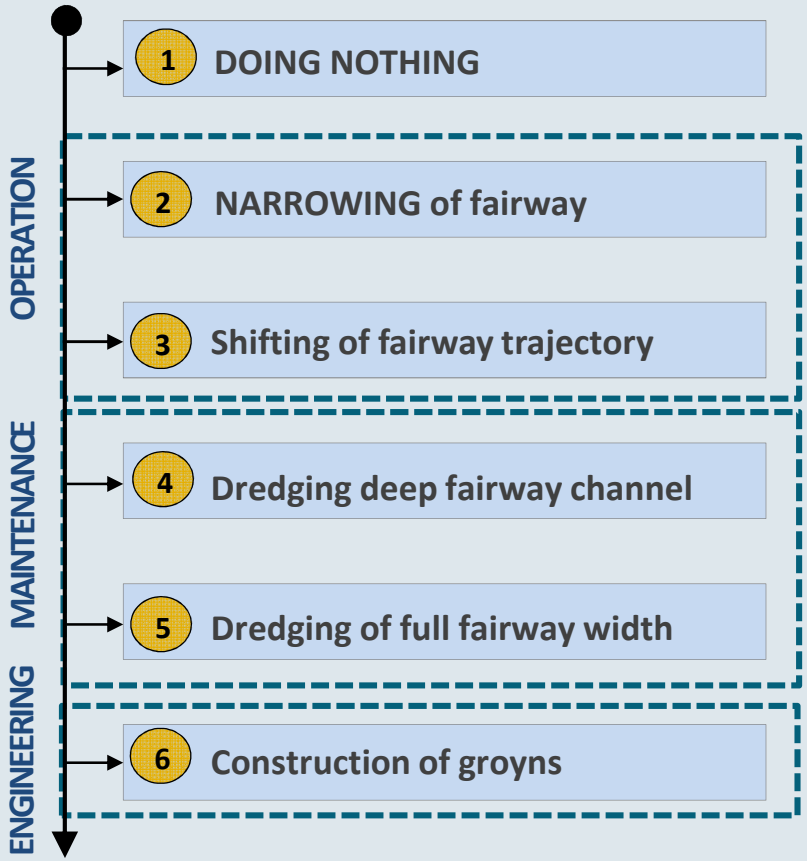

365 days = 100%

- Each combination of fairway width and depth has a certain availability in days per year **(= data point availability surface)**

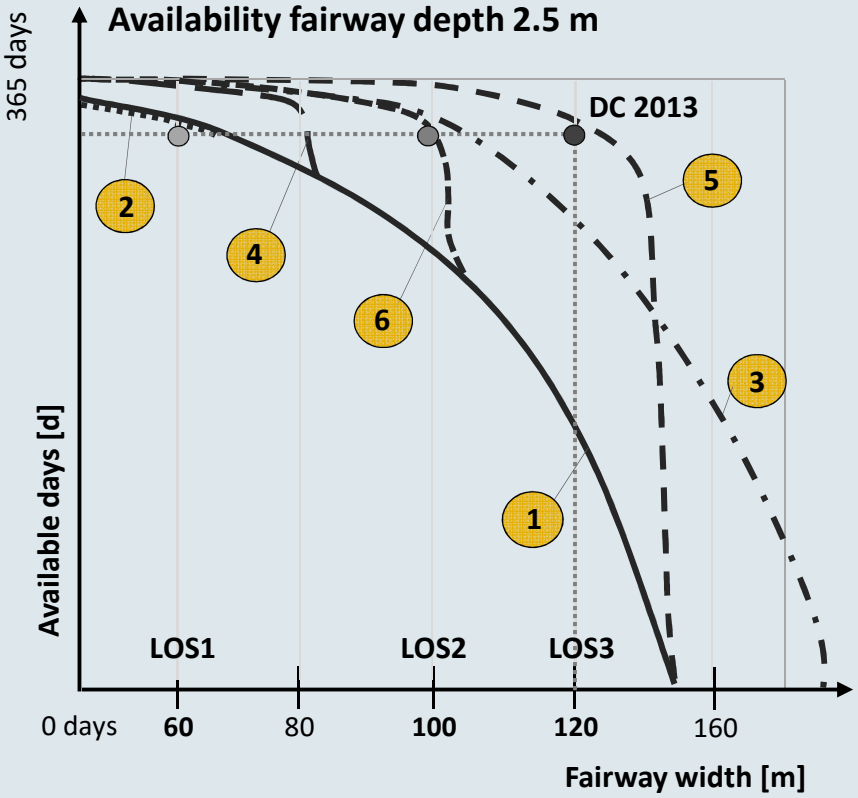
- If the **actual availability** is below the availability target **physical measures** (dredging, river engineering works) are required

# OVERVIEW OF MEASURES

## Decision tree measure selection

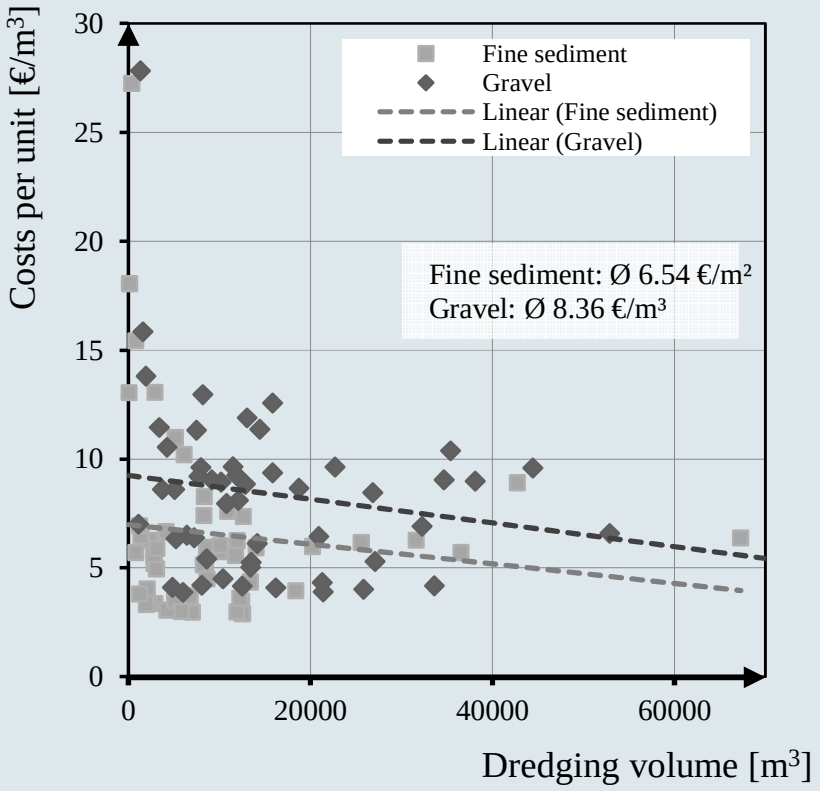



## Measure impact on availability

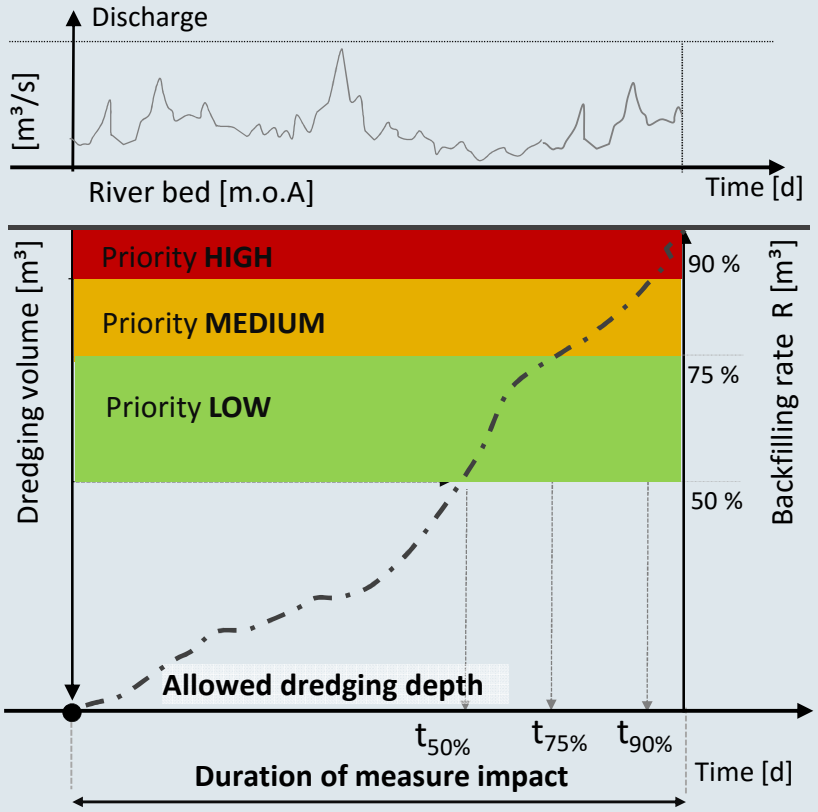


# MEASURE COSTS, IMPACT AND DURATION

## Measure costs per unit – e.g. dredging costs:

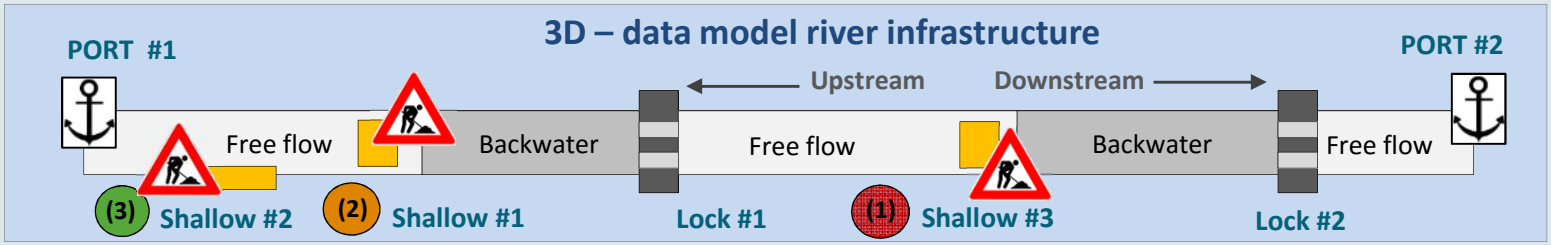


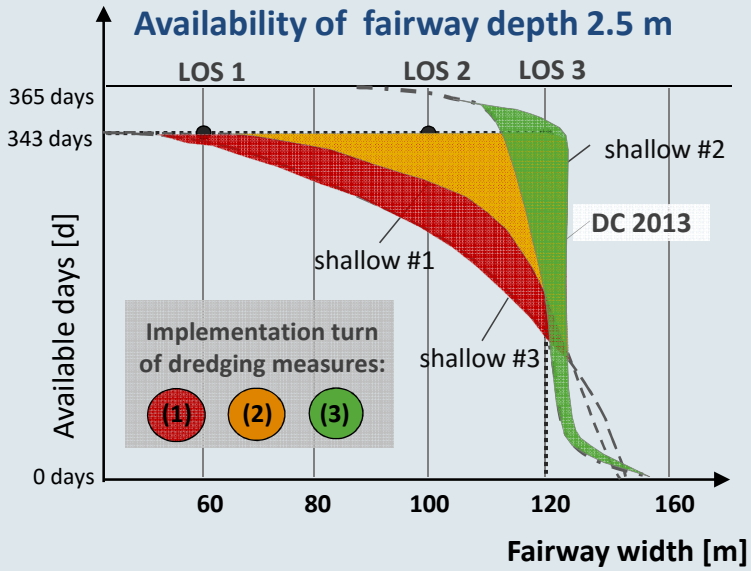

## Duration of measure impact – backfilling behavior & time:

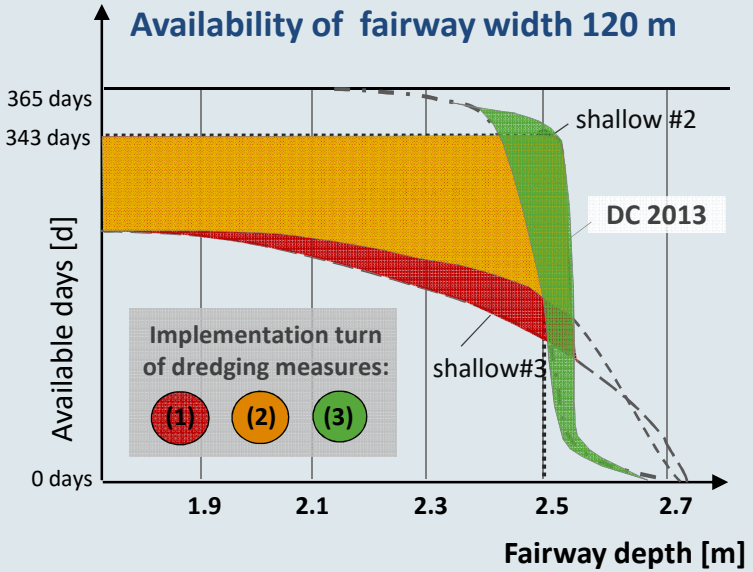


# OPTIMIZATION OF MEASURES

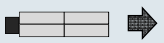
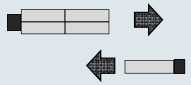
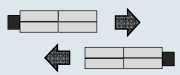
## Continuous fairway parameters on transport routs



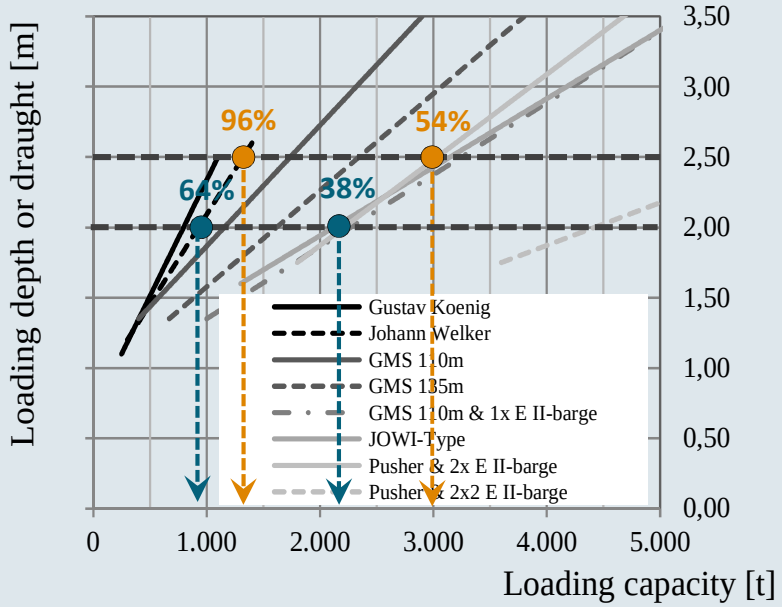



# RESULTING MEASURE PROGRAM RELATED TO LOS

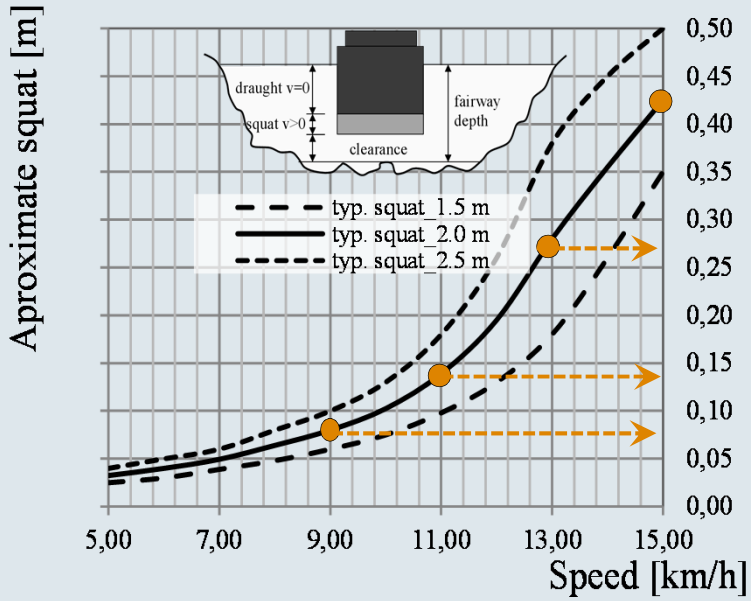
| CRITICAL ENCOUNTERS | Level of Service LOS 1 | | | Level of Service LOS 2 | | | Level of Service LOS 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | *B=60 m, T=2,5 m, D=343 d*  | | | *B=100 m, T=2,5 m, D=343 d*  | | | *B=120 m, T=2,5 m, D=343 d*  | | |
| **DREDGING LOCATION** | **Extent** | **Costs** | **Duration** | **Extent** | **Costs** | **Duration** | **Extent** | **Costs** | **Duration** |
| ALERT SYSTEM: SCHWALLENBACH | 5.500 m³ | 66.000 € | 5 days | 8.000 m³ | 80.000 € | 7 days | 12.000 m³ | 108.000 € | 10 days |
| AGGSTEIN | 8.000 m³ | 80.000 € | 7 days | 11.000 m³ | 99.000 € | 9 days | 14.000 m³ | 112.000 € | 11 days |
| WEISSENKIRCHEN | ..... | ..... | ..... | 8.000 m³ | 80.000 € | 7 days | 12.000 m³ | 108.000 € | 10 days |
| HINTERHAUS | ..... | ..... | ..... | 12.000 m³ | 108.000 € | 10 days | 16.000 m³ | 114.000 € | 12 days |
| RÜBENHAUFEN | ..... | ..... | ..... | ..... | ..... | ..... | 14.000 m³ | 112.000 € | 11 days |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| HAINBURG | ..... | ..... | ..... | ..... | ..... | ..... | 17.000 m³ | 120.000 € | 13 days |
| **TOTAL** | **150.000 m³** | **1.5 Mio. €** | **115 days** | **290.000 m³** | **2.6 Mio. €** | **210 days** | **420.000 m³** | **3.6 Mio. €** | **330 days** |
| DURATION: Market capacity e.g. for dredging (z.B. Aug. – Feb.) | 250 days | | | | | | | | |
| COSTS: Available budget e.g. for dredging | 2,8 Mio. € | | | | | | | | |

# FAIRWAY DEPTH AND UTILIZATION OF LOADING CAPACITY

## Draught vs. loading capacity




## Static draught, dynamic squat & underkeel clearance



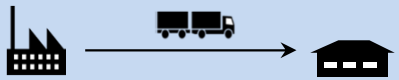

- $AV_d$= static draught + dynamic squat + clearance
- Underkeel clearance:

≥ 0.2 m (riverbed = gravel); ≥ 0.3 m (rocky riverbed)

- Johann Welker: 2.5 m draught → utilization = 96%
  2.0 m draught → utilization = 64%
- Pusher & 2 barges (2.5 m = 54%; 2.0 m = 38%)

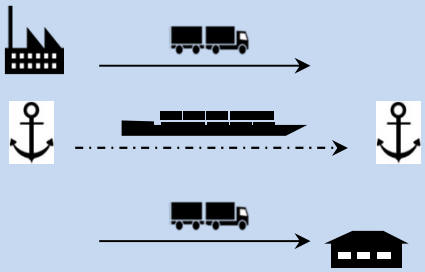
# UTILIZATION BASED TRANSPORT COSTS

## Freight transport road



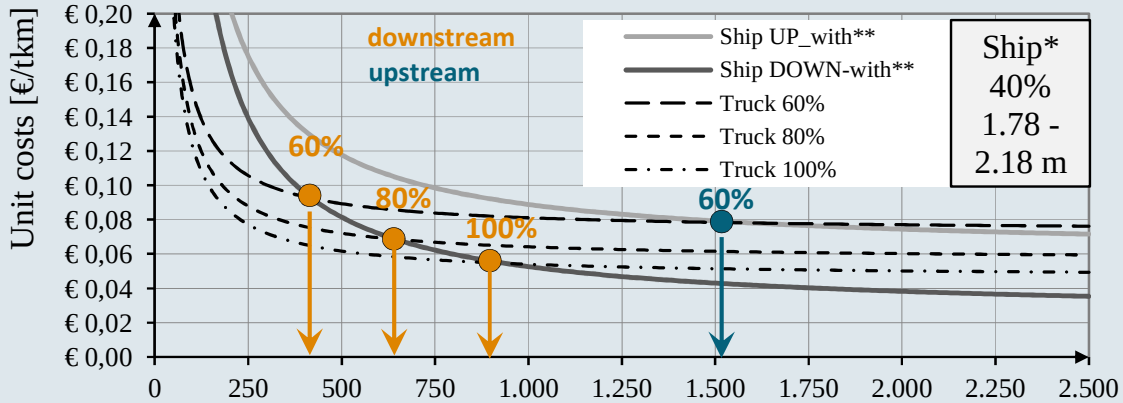
Typical Utilization between
60 to 100% (Ø 80%)
Ø Velocity v=70 km/h

**VS**

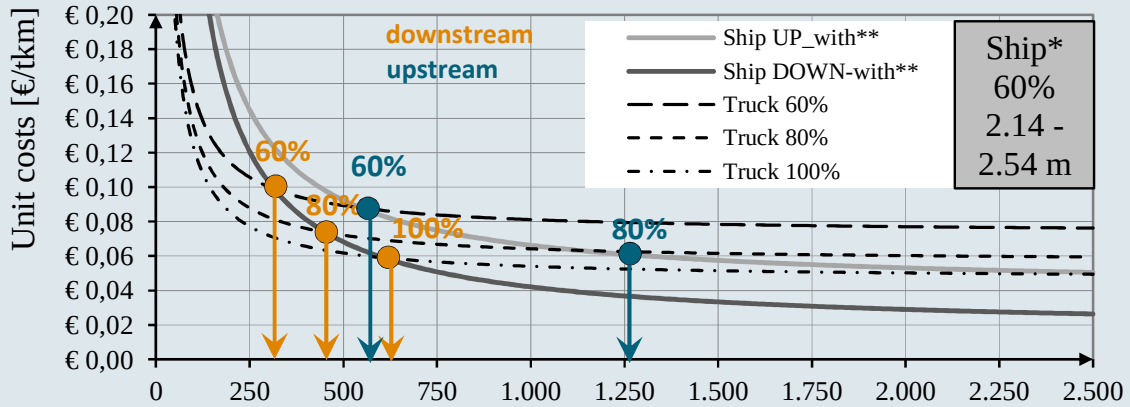


Utilization truck 80%
catchment area 50 km
Utilization ship between 40 to 80% (Ø60%)

**Truck-Ship-Truck**

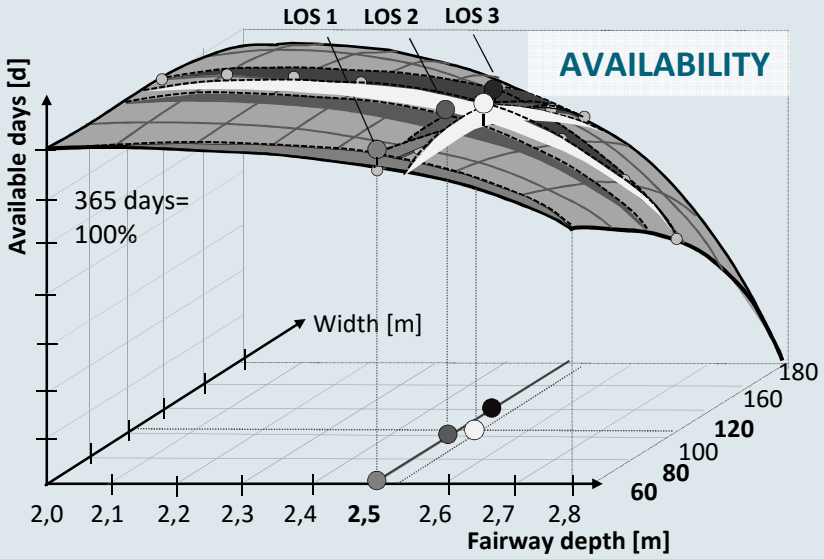


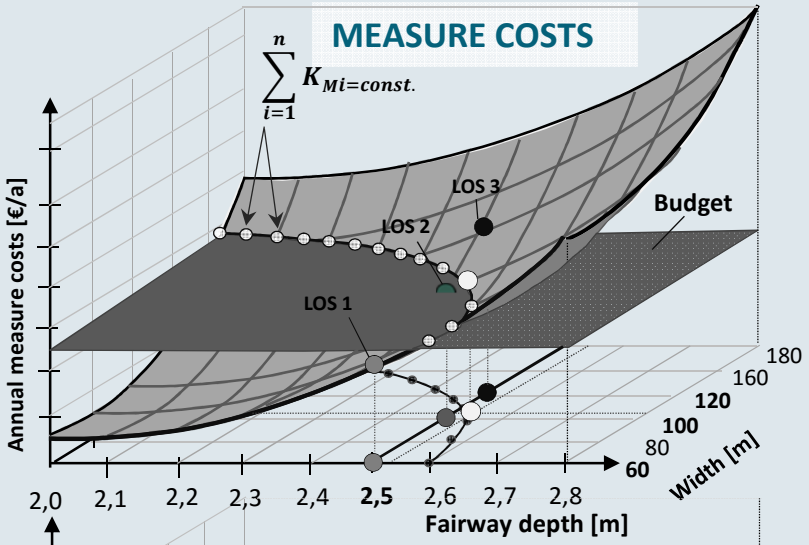

* 40% utilization = 1.48 m draught + 0.1 to 0.4 squat + 0.2 to 0.3 m clearance ≈ 1.78 to 2.18 m water depth
** with pre-haulage & end-haulage (catchment area = 50 km)

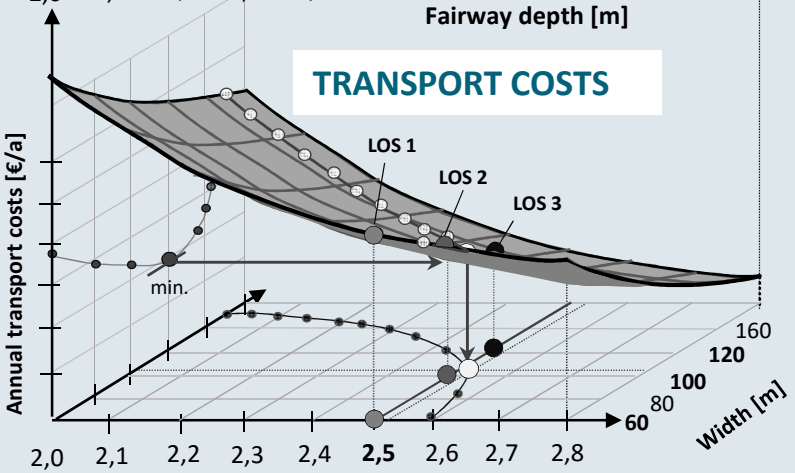



* 60% utilization = 1.84 m draught + 0.1 to 0.4 m squat + 0.2 to 0.3 m clearance ≈ 2.14 to 2.54 m water depth
** with pre-haulage & end-haulage (catchment area = 50 km)

# OPTIMIZATION APPROACHES




**LOS 3**
*B=120 m*
*T=2,5 m*
*D=343 d*

Availability: + 60 days
Measure costs: 3,6 Mio. €
Transport costs: DC

**LOS 2**
*B=100 m*
*T=2,5 m*
*D=343 d*

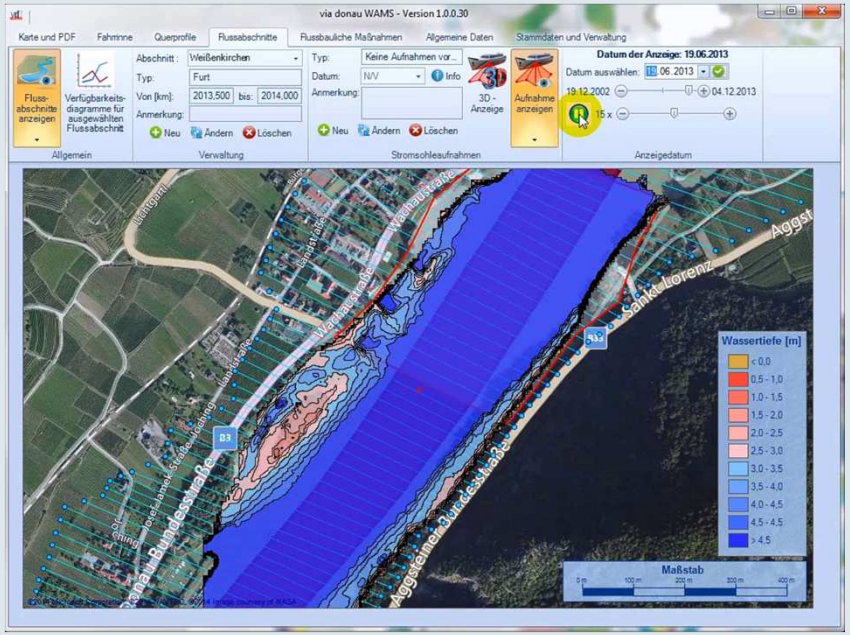
Availability + 30 days
Measure costs: 2,6. Mio. €
Transport costs: DC + 10%

**LOS 1**
*B=60 m*
*T=2,5 m*
*D=343 d*

Availability: + 20 days
Measure costs: 1,5. Mio. €
Transport costs: DC + 20%

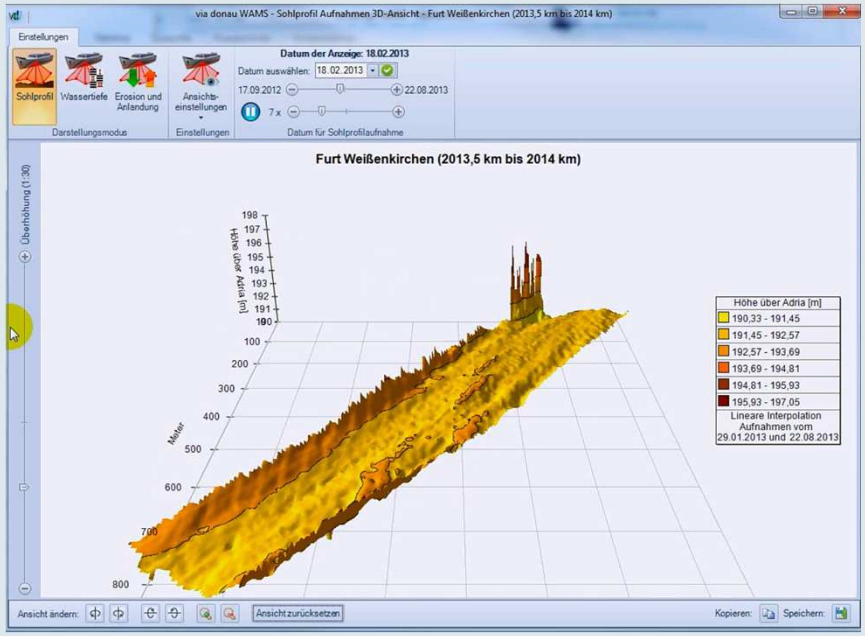
# SELECTED RESULTS WAMS SOFTWARE TOOL

## Information on current water depth




- Visualization of water depth development at ford **Weissenkirchen** during the periode June – November 2013

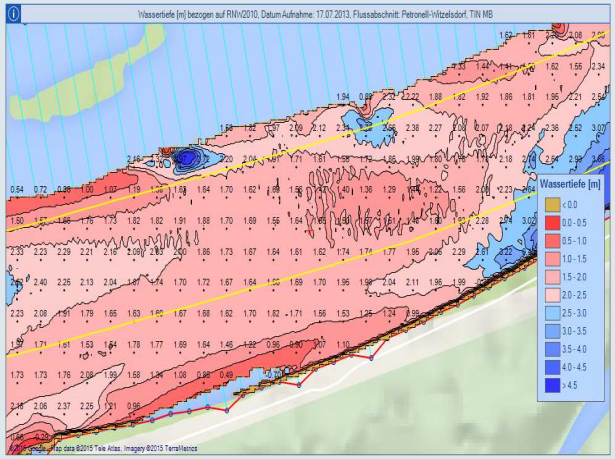
## Modelling of riverbed development



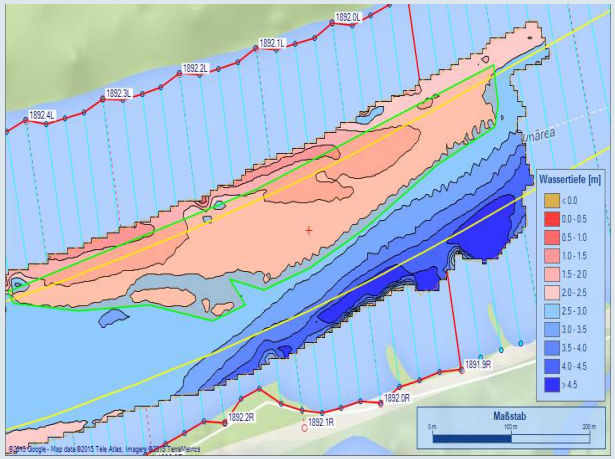

- Development of absolute riverbed altitude (based on multibeam data) at ford **Weissenkirchen** between February and September 2013

# SELECTED RESULTS WAMS SOFTWARE TOOL

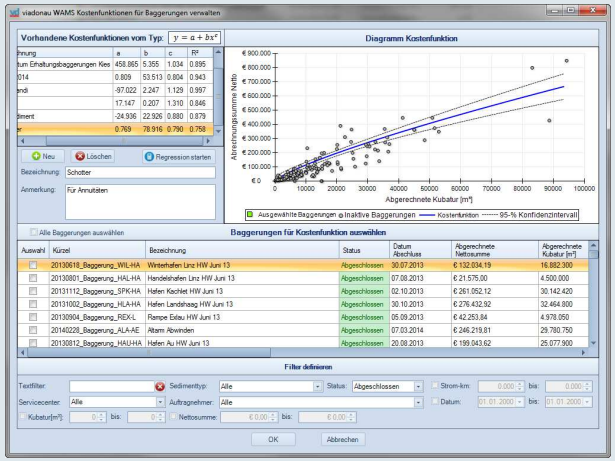
## Development of fairway depth



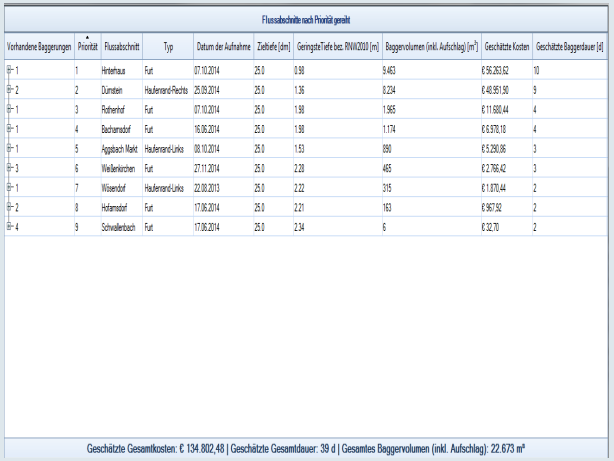

## Planning of dredging measures




## Calculation of dredging volume & costs




## Measure program and LOS



# SUMMERY AND OUTLOOK

- **Sufficient availability of fairway width and depth throughout the year** is essential for transport costs on inland waterways → **competitiveness**
- **The presented holistic waterway asset management system (WAMS)** approach accounts for all relevant factors → **optimal investment strategy**
- **Efficient maintenance measures in a serial system require a harmonized uniform fairway depth** along the entire Danube river → **harmonized measure programs for waterway administrations**
- **The methodical approach was already implemented in a comprehensive software tool named WAMS** that is already used by the Austrian waterway administration viadonau → **already empirically validated**
- **First research results have already been incorporated in the decision making process → additional investments in harmonized fairway parameters and fairway availability**