

Hydrodynamic Dredging, Nautical Depth, & Other Murky Topics

Joe Wagner PE, BCEE, BNEE

Tri-Regional JETS 2025 | Session B1 | Wednesday, September 22, 2025 @ 8:40 AM



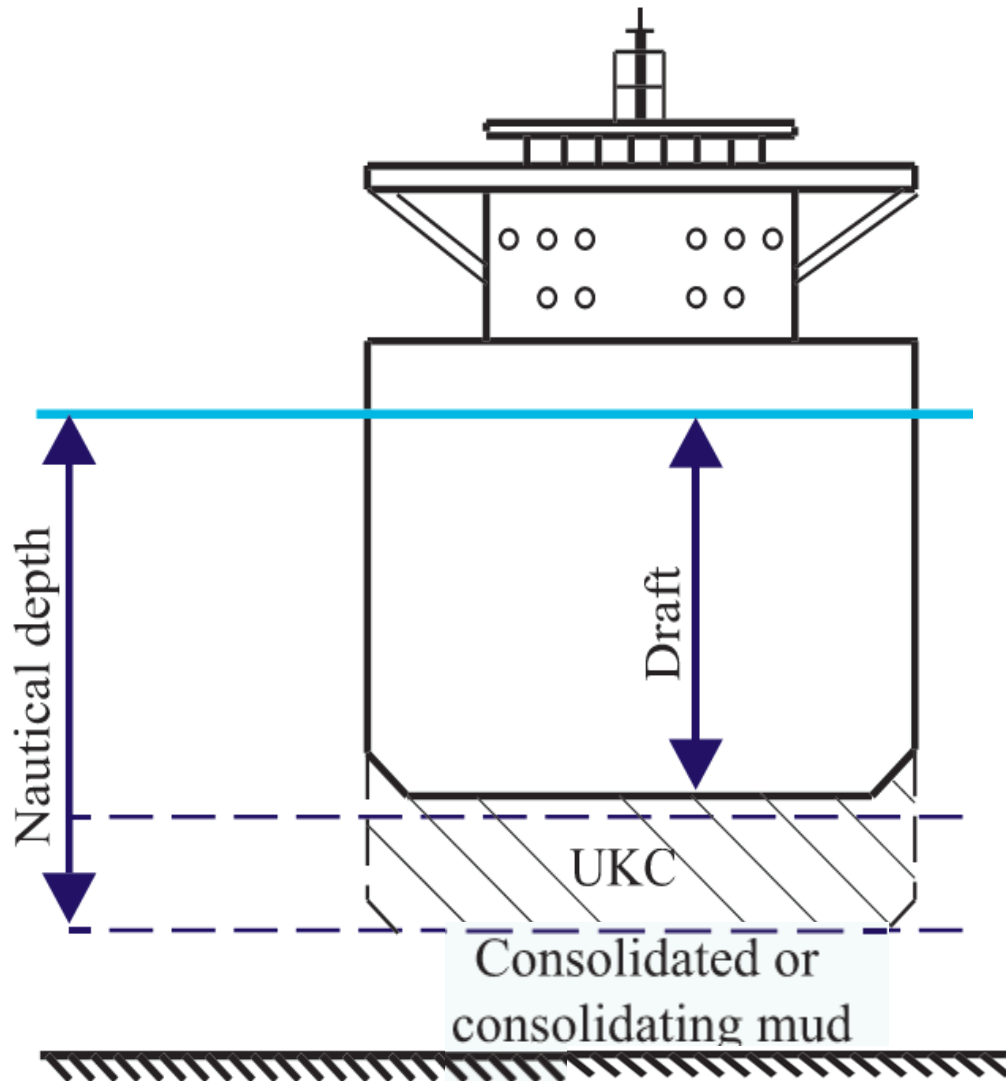
Outline

- PIANC's Current Definition
- ASCE-COPRI Subcommittee
- Smart Port: Navigation through Fluid Mud
- Fluid Mud & Nautical Depth
- Case Studies
 - North Carolina State Ports Authority, USA
 - Port of Rotterdam, Netherlands
 - Harwich Haven Authority, UK
 - Seaport Emden, Germany
 - Port of Hamburg, Germany
- Industry Transformation?



Port of Morehead City NC, Ocean Inlet

Nautical Depth



PIANC's Current Definition

Nautical bottom is the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability & maneuverability.

Modern technology has eliminated the need to rely exclusively on **density & sonar technology** to determine Nautical Depth.

Move to more advanced & **site-specific definition** of Nautical Depth considering the rheology & hydrographic characteristics of the location.

Enabling the use of more Nature Based Dredging solutions – thereby saving **\$\$\$\$**, reducing greenhouse gases (GHG) – without impacting navigation safety.



Port of Wilmington NC, Turning Basin

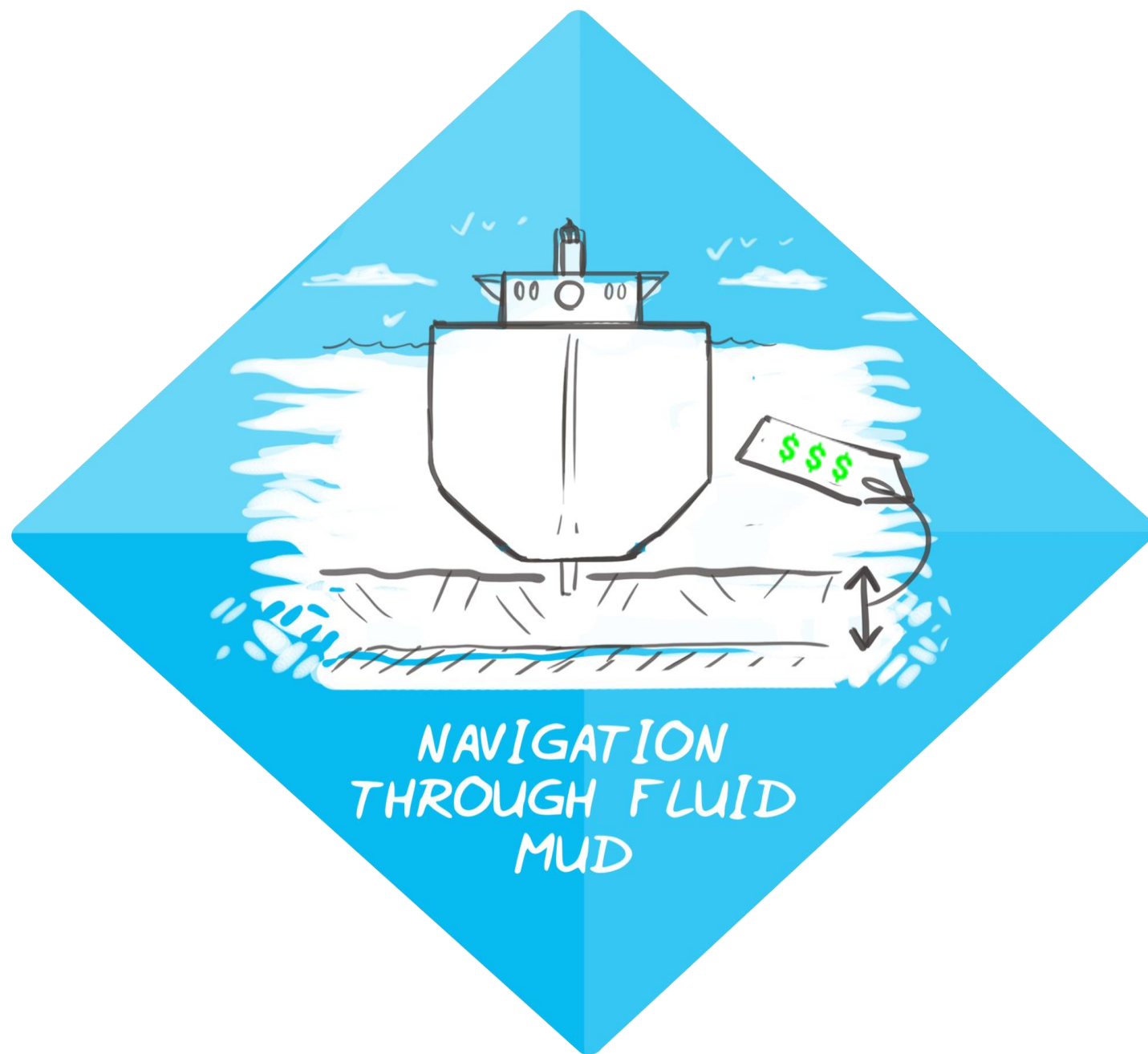
ASCE-COPRI Subcommittee

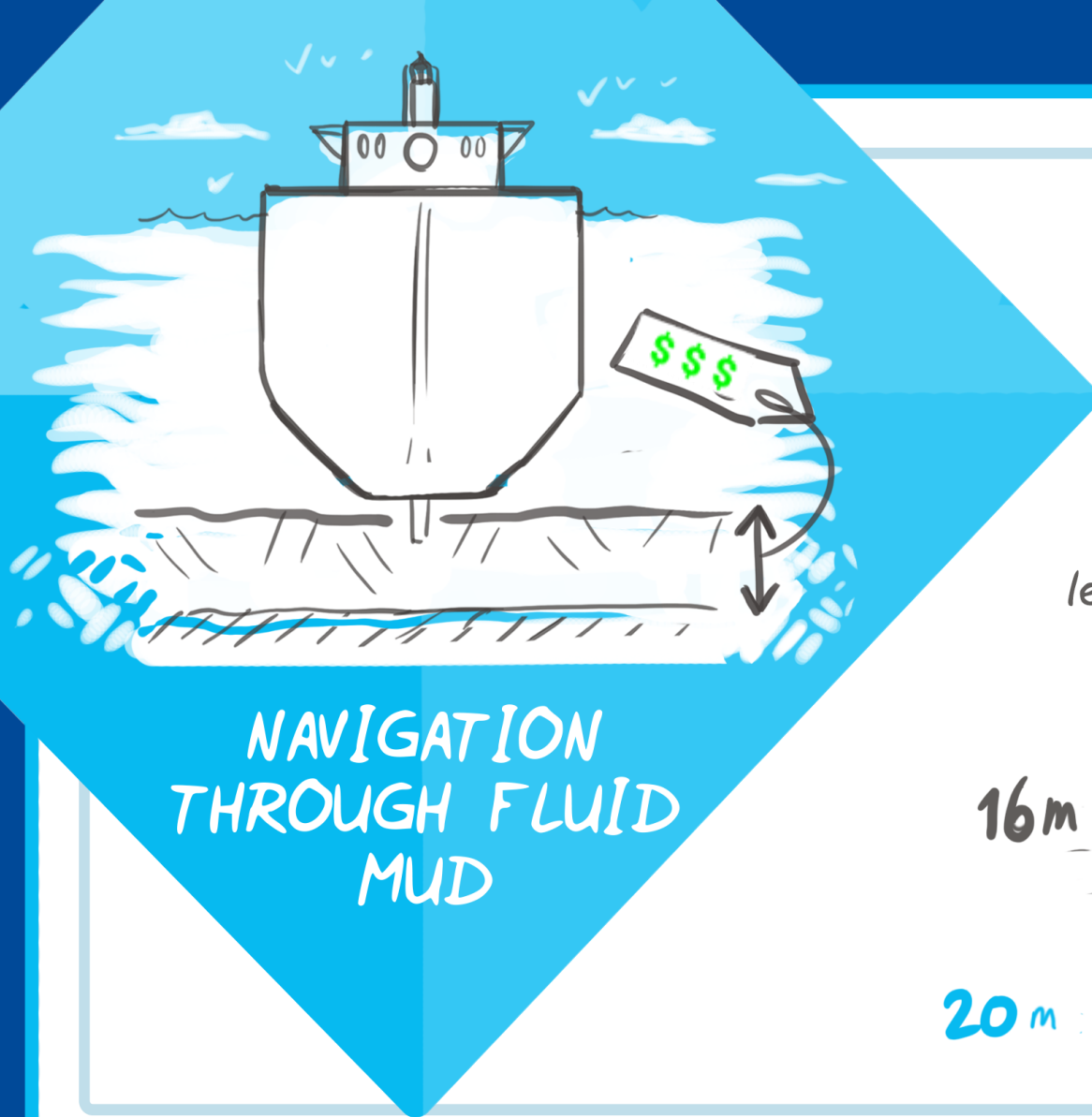
- ***Nautical Depth Frameworks:*** Hopes to standardize approaches for managing fluid mud at U.S. ports.
- ***Sediment & Vessel Interaction:*** Aligns sediment behavior with vessel dynamics & regulatory needs.
- ***Expert Collaboration:*** Draws on USACE, ERDC, academia, & consulting expertise.
- ***Technology Integration:*** Supports modeling, simulation, & real-time monitoring for fluid mud assessment.

Smart Port

Navigation through Fluid Mud

www.smartport.nl/en/project/varen-door-slib

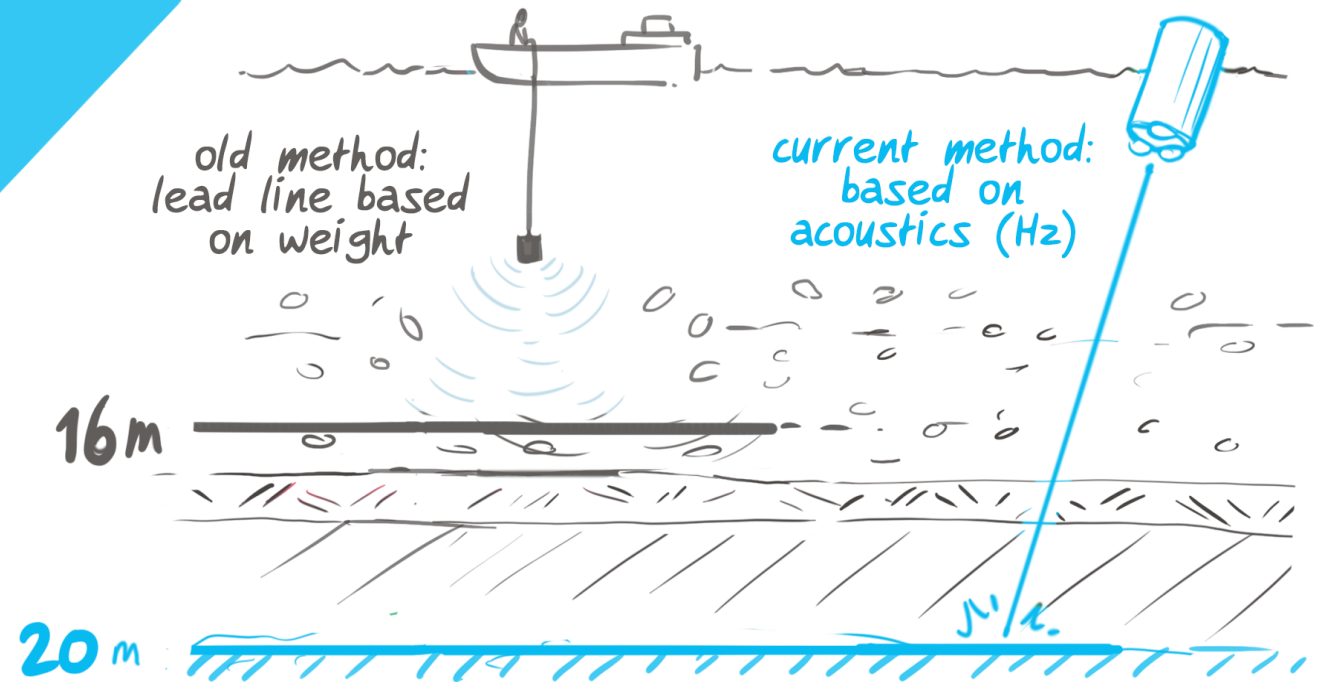




NAVIGATION
THROUGH FLUID
MUD

RESEARCH:

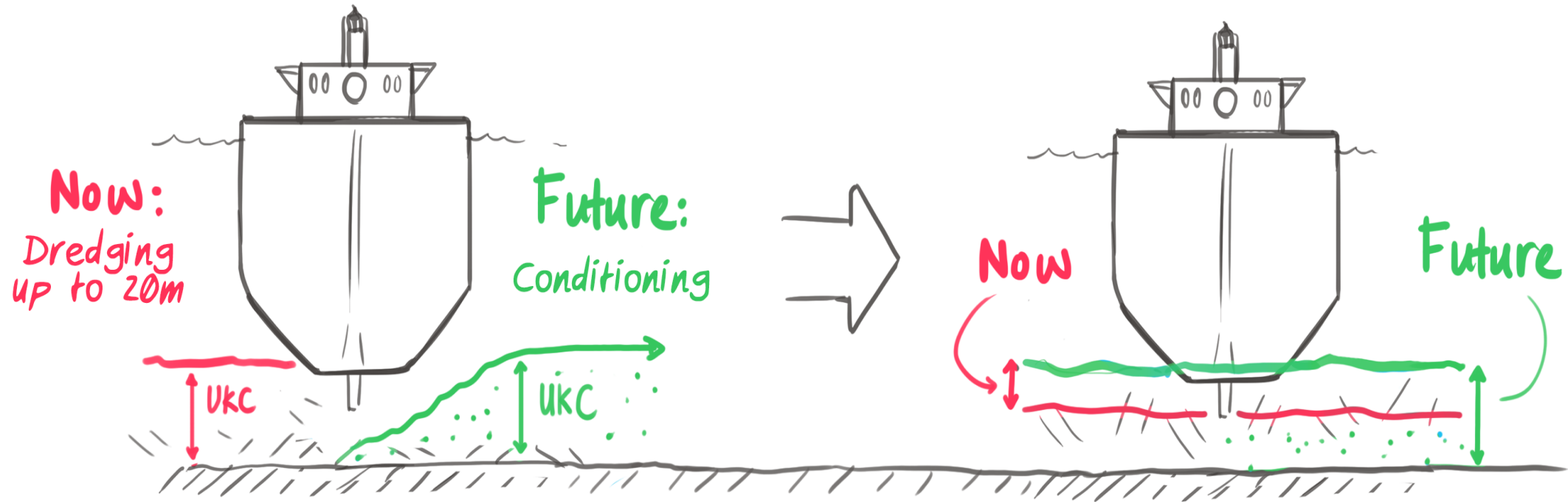
IMPROVED SURFACE DEPTH
MEASUREMENT THROUGH FLUID MUD



OPPORTUNITIES

NAVIGATION ABOVE FLUID MUD

Future: Determining effective depth

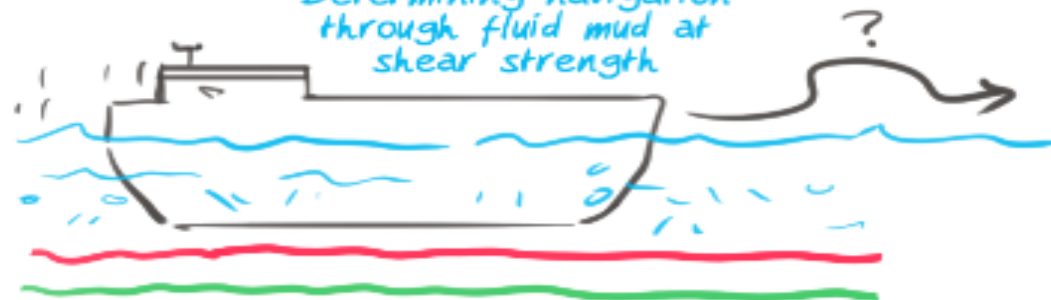


CHALLENGES:

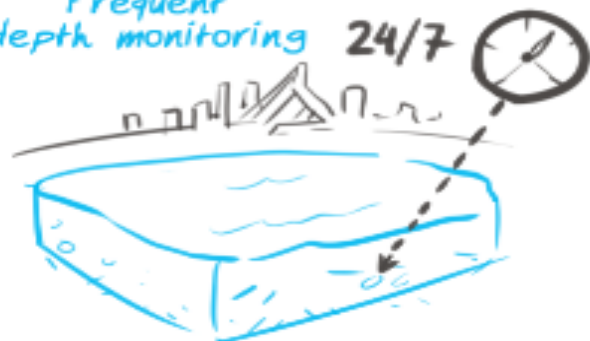
On particle level:



Determining navigation through fluid mud at shear strength



Frequent depth monitoring 24/7



Acceptance as new standard

IMPACT: 10-20% advantage in "fluid mud" areas

approx. € **1.000.000** /YEAR

SAVINGS IN DREDGING COSTS FOR RWS AND THE PORT



PARTNERS:

Deltares

TU Delft

Port of Rotterdam

MARIN



Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

**SMART
PORT**

Definitions:

'Fluid Mud'

&

'Nautical Depth'



Courtesy of University of
North Carolina at Wilmington

Fluid Mud



Hydrodynamic Dredge 'Arulaq,'
Brice Civil Constructors, Inc.

Easy to define?

Fluid mud typically has a density ranging from 1.1 to 1.35 kg/L. Initially, it exhibits a 'weak' strength but can become more rigid over time, especially in calm conditions. The current definition of fluid mud is based on its sediment density

These types of definitions are ambiguous since the proposed critical parameters do not account for the possible strength developments in fluid mud

Definition of Fluid Mud should not be confused with the definition of Navigable Mud – they are not always the same

*Welp et. al 2017

*Shakeel et. al 2019

Oxidized Suspended particulate matter SPM

Fluid mud FM

Oxidized or reduced

Pre-consolidated sediment PS

Reduced

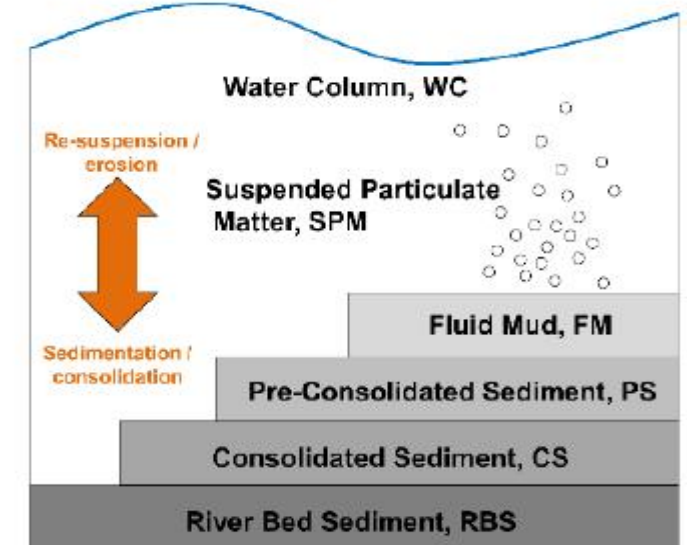
Consolidated sediment CS

Reduced



A detailed look reveals...

- A multi-layered system
- Chrono-sequence of consolidation, redox potential, organic matter degradation
- > 80% fines (< 63 μm)
- ~ 10% organic matter



What sediments can be found in the Port of Hamburg?

Suspended Matter

SPM

Review for the sailing ship aspects

Areas that, according to the investigations, may still be safe to sail

Review for the moored ship aspects

Areas that are certainly not easily navigable, but where - according to the investigations – a ship may still safely sink into fluid mud layers at the berth

Areas that will not be usable in the future for navigation purposes, but can be well maintained with hopper dredger

Bottom below the target depth, which is not maintained by default

Custard



Fluid Mud (FM)
(Density < 1.15 kg/l)

Baby porridge



Pre-Consolidated (PS)
(Density < 1.20 kg/l)

Pudding



Pre-Consolidated (PS) bis Consolidated (CS)
(Density < 1.25 kg/l)

Semolina pudding



Consolidated (CS)
(Density < 1.30 kg/l)



FM

PS

PS-CS

CS



What is its density? / Is it fluid mud?



Quick Poll

- *Fluid mud?*
- *Pre-Consolidated?*
- *Consolidated mud?*

Case Studies

Port of Rotterdam

Rotterdam, Netherlands



Port of Rotterdam

Case Studies

Harwich Haven Authority
(HHA)

Harwich, UK



Harwich Haven Authority (HHA)

- HHA has the Port of Felixstowe, the UK's largest container terminal (5 MTEU) in its jurisdiction
- A Ramsar protected site
- HHA Disposal Site TH027 is ~16 miles offshore
- Annual maintenance dredging is more than 4 MCY of silt/mud (thixotropic)
- Working with Nautical Depth & Navigable Mud for the last 40 years
- Determined its Nautical Depth parameters through sediment sampling & testing, hydrographic model at 100 PA
- Survey using MBEIS (Multibeam Echosounder Imaging Systems), SBES (Single Beam Echosounder), & Rheotune

- Cost saving of about 50% (US\$ ~5M/YR)
- Keeping about 2.5 MCY/YR of sediment in estuarine system
- Maintaining Nautical Depth at 52.8 ft
- Allowing the biggest & deepest container vessels to access the Port of Felixstowe
- Reduction in CO² emissions of about 33%
- HHA is working on refining its definition of Nautical Depth, still using Pressure, but trying to make it more dynamic:
 - Considering weather
 - Type of Vessel & Draft
 - Number of Tugs



Case Studies

Seaport Emden

Emden, Germany



Port of Emden

- Located behind lock gates on the River Ems in Northern Germany
- Previously disposed of sediment on land, but this became unfeasible after 2000
- Conducts annual maintenance dredging of over 4 MCY of thixotropic silt & mud
- Managing fluid mud for the past 24 years, with roughly 50% of the channel depth (33 FT) consisting of fluid mud
- Performs dredging through recirculation, conditioning the sediment for approximately 50 HR/WK by overflowing it from a TSHD (Trailer Suction Hopper Dredger)
- Determined its nautical depth to be 100 PA through sediment sampling, testing, & hydrographic modeling
- Initially set the nautical depth at 70 PA, but further testing confirmed 100 PA as safe

Port of Emden

- Pressure was used as the criteria for determining Nautical Depth as:
 - Viscosity changes permanently under increasing shear rates
 - Density is a static measure & does not account for ship movement
 - Density is unsuitable for determining resistance against a moving ship
- By conducting scientific investigations & studies, the port has adopted a different basis for determining Nautical Depth without compromising navigational safety, allowing the port to remain operational
- **Rheological Studies:** Like their work in Hamburg, MudNet has conducted rheological measurements to better understand the behavior of suspended sediments in the Ems estuary, which is crucial for maintaining navigable waterways

Case Studies

Port of Hamburg

Hamburg, Germany

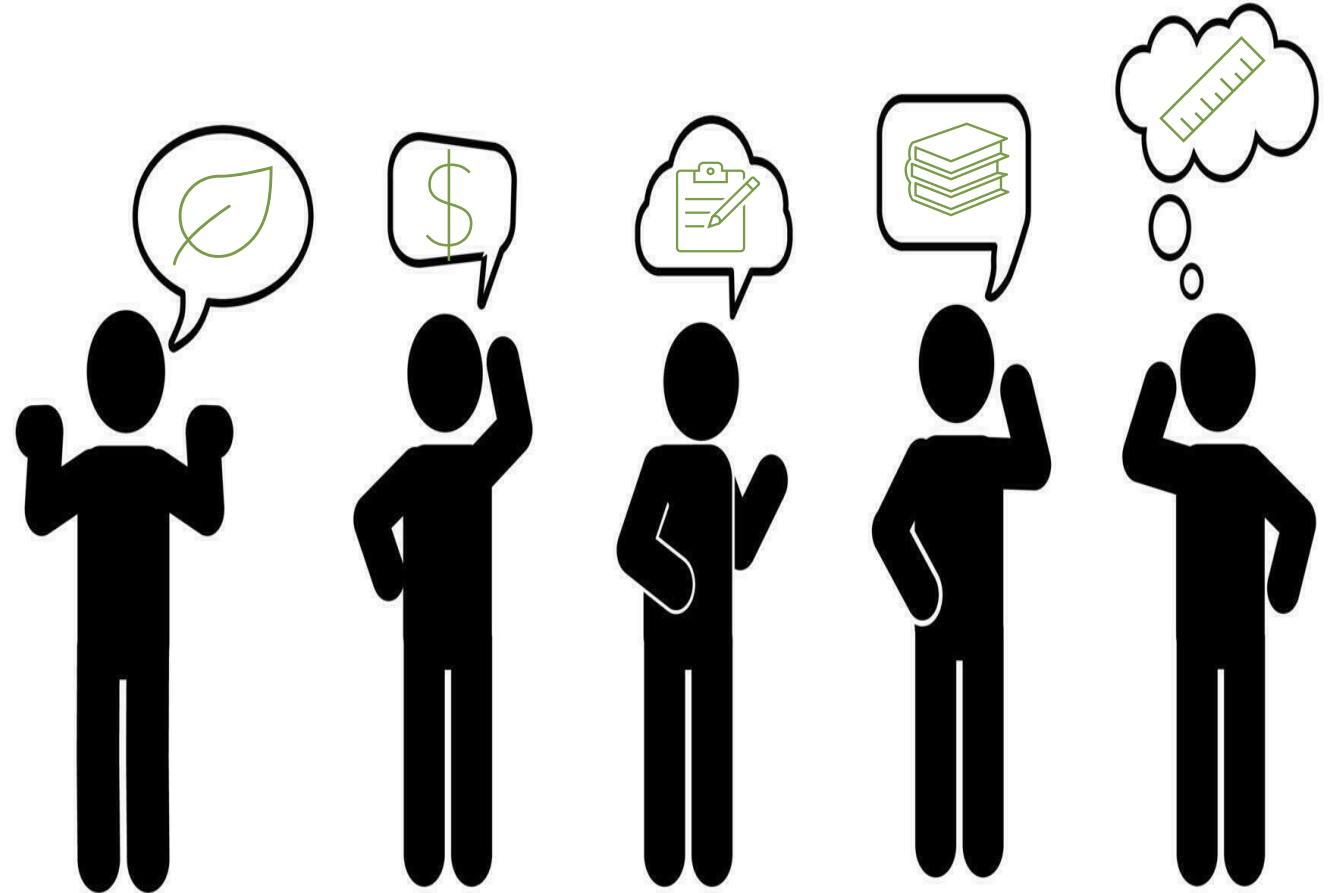


Port of Hamburg

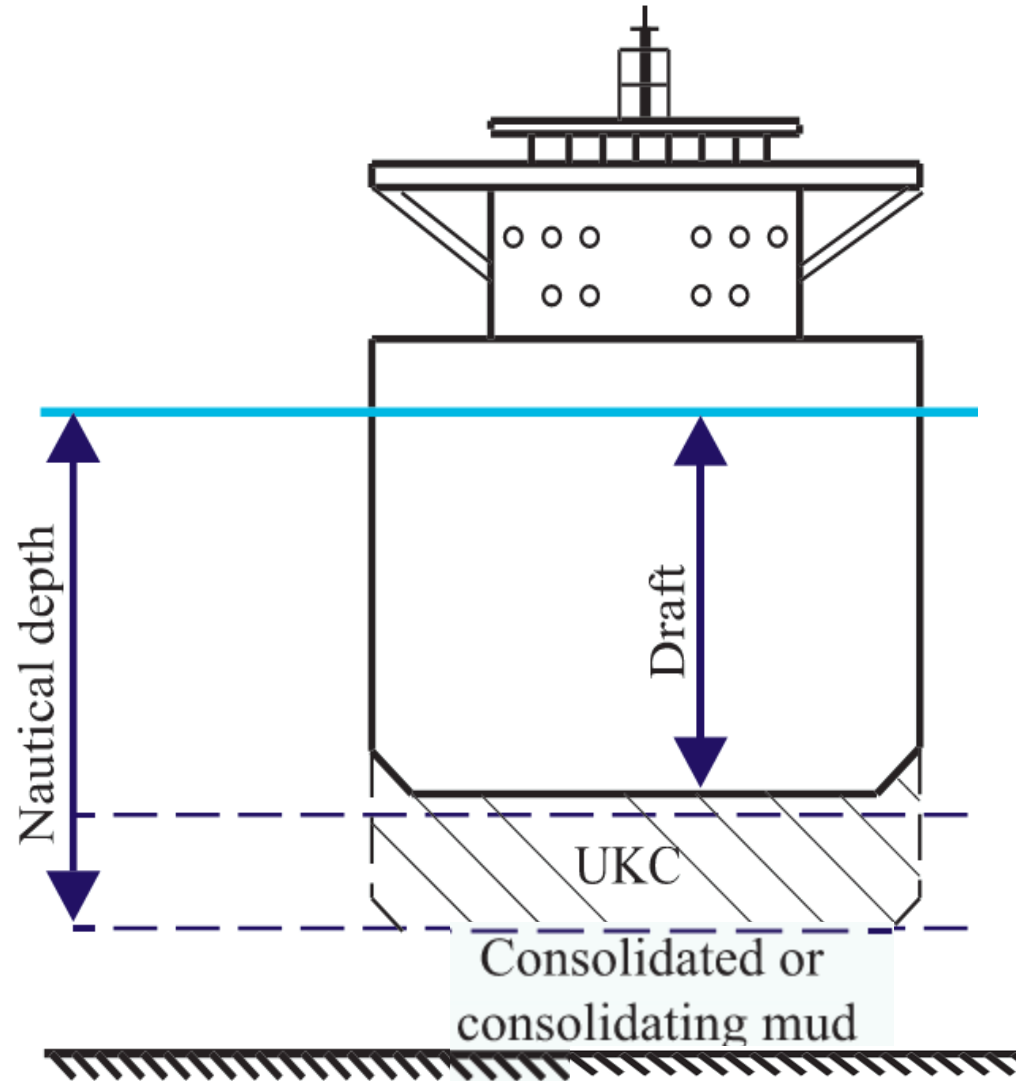
- Second largest port in Europe, situated 75 miles from open sea
- Spends about US\$ ~109 M/YR on maintenance dredging
- Save about US\$ ~27 M/YR if it can change its definition of Nautical Depth
- Nautical depth is currently the higher of density & yield stress
- Started a 2-to-3-year project to review how it defines its Nautical Depth
- Likely to be completed 2025. Moving to one based on pressure - PA (Pascals)
- Undertaking sediment sampling, testing, tank modelling & working with *MudNet*:
 - Sediment Sampling & Testing
 - Hydrographic Modeling
 - Innovative Solutions

Potential for US Port & Waterway Transformation

Technical Innovation!



Industry Transformation



Environmental Preservation

Cost Reduction

Regulatory Compliance & Public Perception

Redefining Navigable Mud

Technical Innovation

Thank You



Joe Wagner, PE, BCNE, BCEE
*National Sediment Management
and Dredging Lead*
Black & Veatch
(904) 570-7585
Wagnerjj@bv.com
<https://lnkd.in/eQKGsBgP>