Maneuvering with negative under keel clearance
Results and consequences of field trials in the port of Delfzijl

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Introduction: One of the primary goals of the project Sustainable Port Management is to investigate whether it is possible to optimize the tidal window of the port without a significant increase of the maintenance dredging volumes.

Methods: Based on the feasibility study in the first phase of the project it was concluded that, based on the mud conditions at that time, it was realistic to implement the Keep Sediments Navigable (short: KSN) method [1]. This was confirmed by computer simulations with experienced pilots, during which the thickness of the mud layer, the mud density and under keel clearance (UKC) during the runs in the 3D model of the port of Delfzijl were varied [2].

To confirm the maneuverability of ships with negative under keel clearance (UKC) full scale field tests were carried out with a vessel with the following characteristics; length 132m, width 23.6 m, draft 7.4 meter and 2 propellers. During the tests, the vessel's behavior (use of propeller, rudder, thruster and tugs including corresponding speeds and yaw velocities) was monitored and analyzed in a similar manner as during the computer simulation runs [3].

Before the trials and after each run the in-situ density profiles of the fluid mud were measured at pre-defined locations. Multi beam surveys were performed from this before and after the field trial as well.

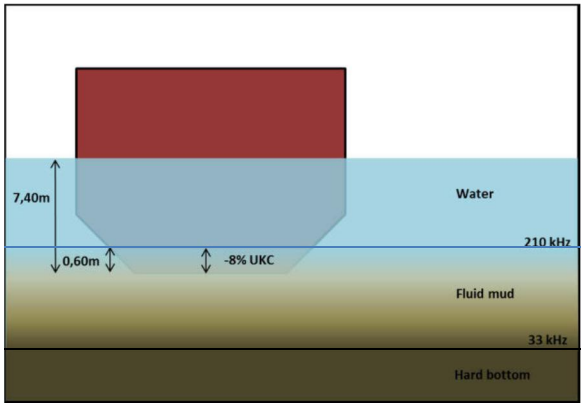

Fig. 1: *Schematic presentation of -8% UKCGross conditions in respect to the 210 kHz reflection of the single beam measurements.*

Results: Summarizing it can be stated that based on the trial runs an UKCNet between 0% and roughly +14% (up to 20%) the mud layer has a significant influence on the vessel's behavior, see colored area in figure 2. It should be noted that the current minimum operational UKCGross of +10% is already in the unfavorable range. Based on the trial runs, no reduced maneuverability is expected for an UKC less than +10% to penetration in to the sediment up to an UKC of -5%.

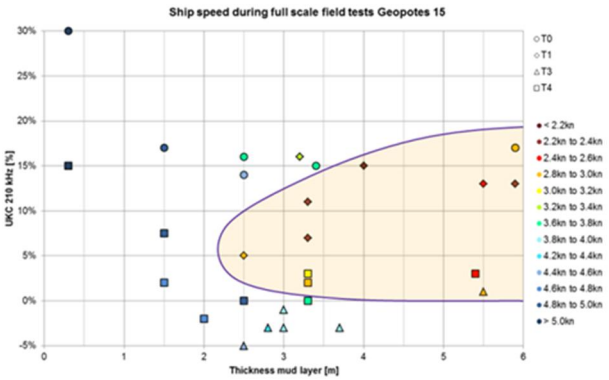

Fig. 2: *Summarizing graph of the evolution of the speed of the 'Geopotes 15' in function of the sediment layer thickness and the under keel clearance to the top of the fluid mud layer [3].*

Discussion: Based on the field trials and the present experience of the pilots in the port of Delfzijl the nautical depth was altered. Before the nautical depth was 10% the 210 kHz reflection of the single beam measurements. The new nautical is now 10% the 33 kHz reflection of the single beam measurements. This increases the tidal window of the port without a significant increase of the maintenance dredging volumes.

References:

[1] PIANC (2008), Minimising Harbour Siltation. PIANC REPORT N° 102, PIANC Secrétariat Général: Bruxelles, Belgium. ISBN 2-87223-169-2
[2] Verwilligen et al (2014), Manoeuvrability in proximity of nautical bottom in the harbour of Delfzijl, 33rd PIANC World congress.
[3] Barth et al (2016) Manoeuvring with negative underkeel clearance : 2nd full scale field test in the port of Delfzijl, 4th MASHCON, Hamburg

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