

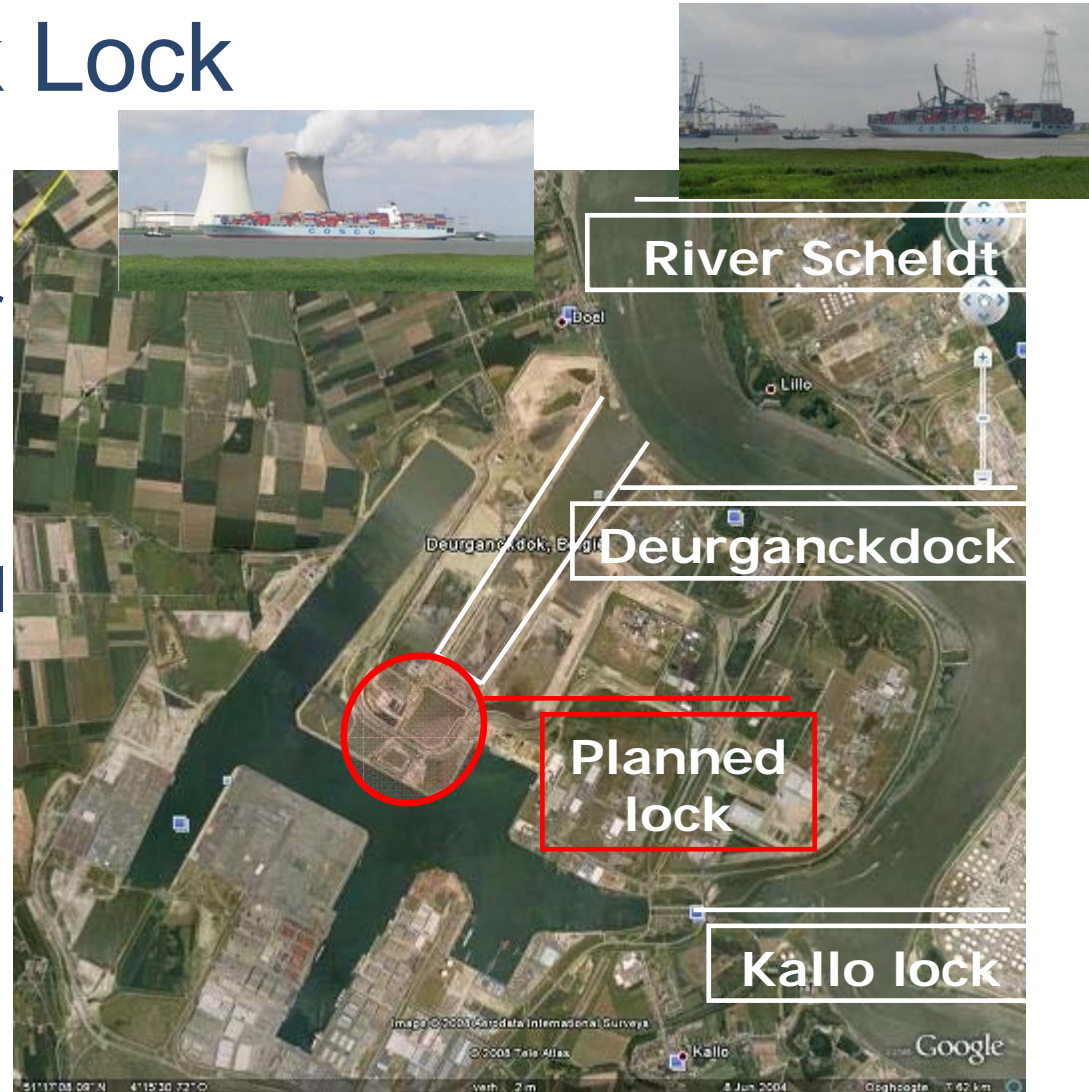
# Accessibility of Deurganckdok Lock

## Simulation studies

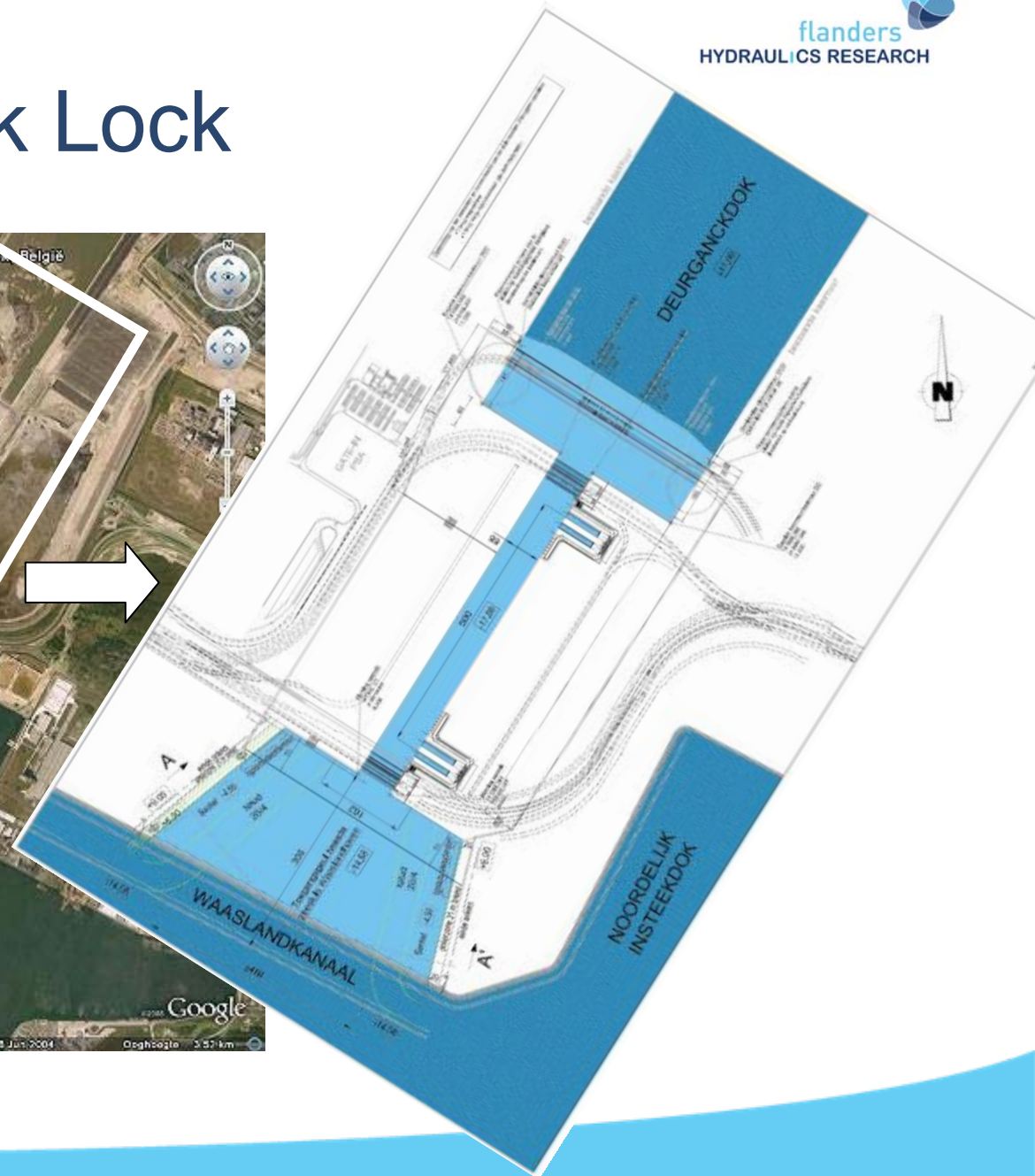
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# Deurganckdock Lock

- Kallo lock: entrance of Waasland harbour at the left bank  
360 m x 48 m x 12.5 m (TAW)
- Deurganckdock: tidal dock
- New lock planned at the end of Deurganckdock with dimensions of Berendrecht lock



# Deurganckdok Lock



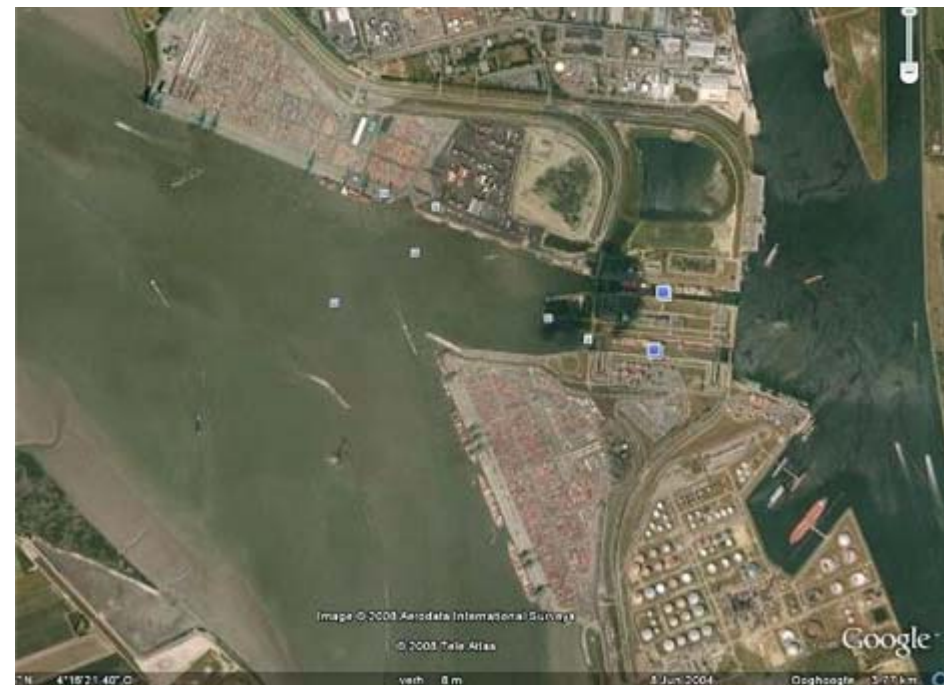
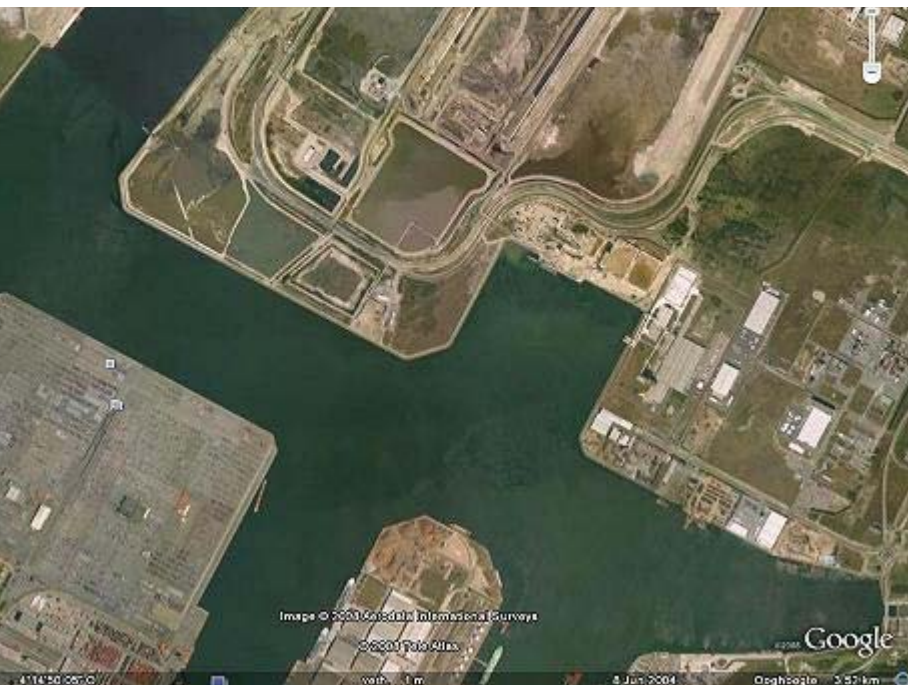


# Deurganckdok Lock



# Deurganckdok Lock

- Length between outer doors and beam identical
- Depth different: TAW -17.8 m DGD Lock, -13.5 m BED Lock
- Orientation: DGD Lock SW-NE, BED Lock W-E
- Access: entrance and departure manoeuvre at both sides differ



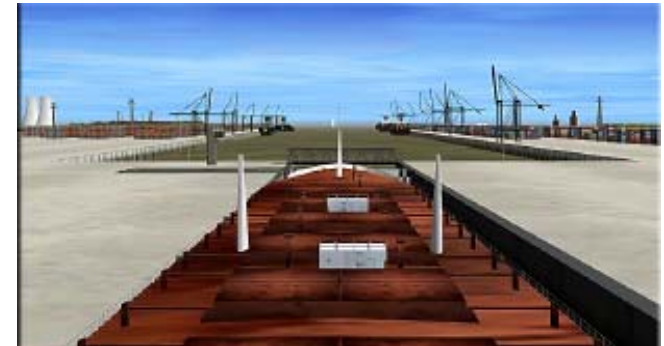
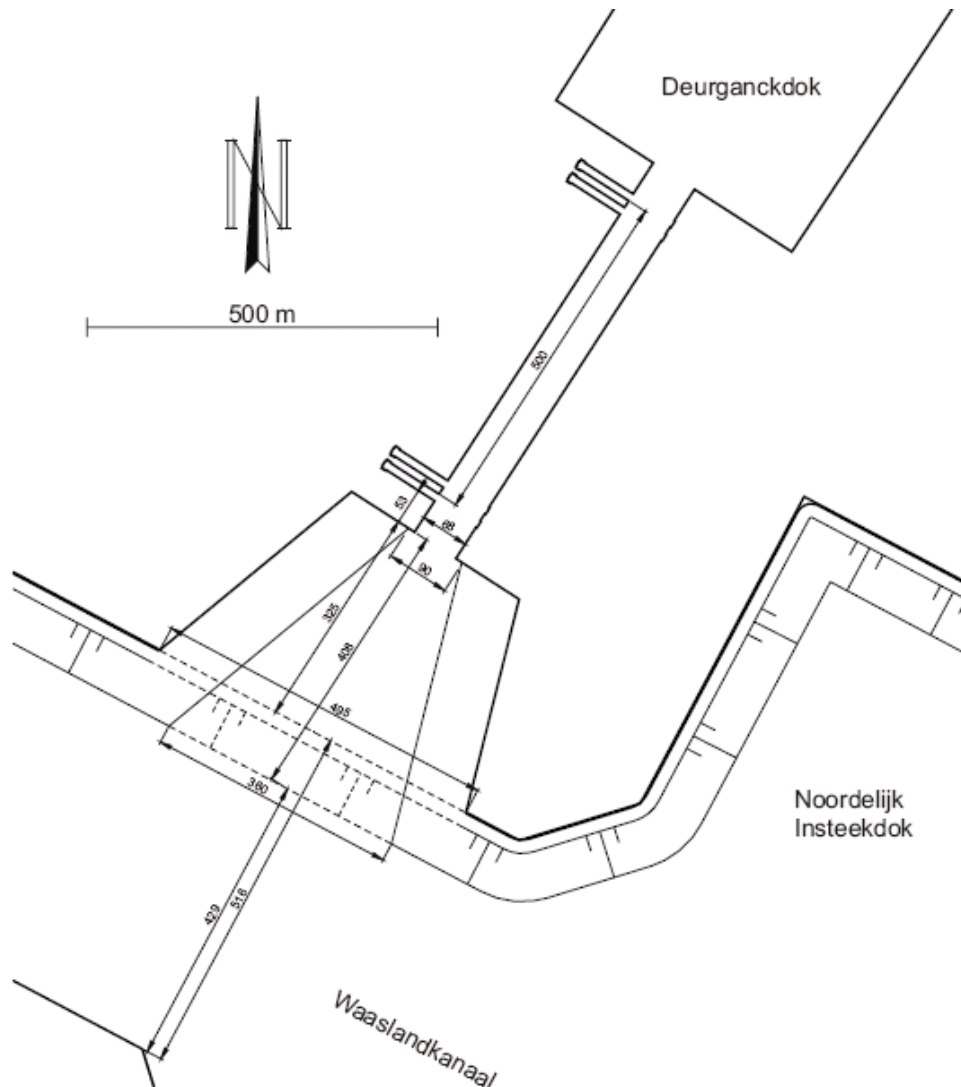


# Overview

- Simulation study in 2005 with Main Ore bulkcarrier en S-class containership
- Simulation study in 2007 with 366 m containership, modified lay-out of the entrance area at Waaslandhaven
- Simulation study in 2008 with 400 m containership with focus on contact characteristics



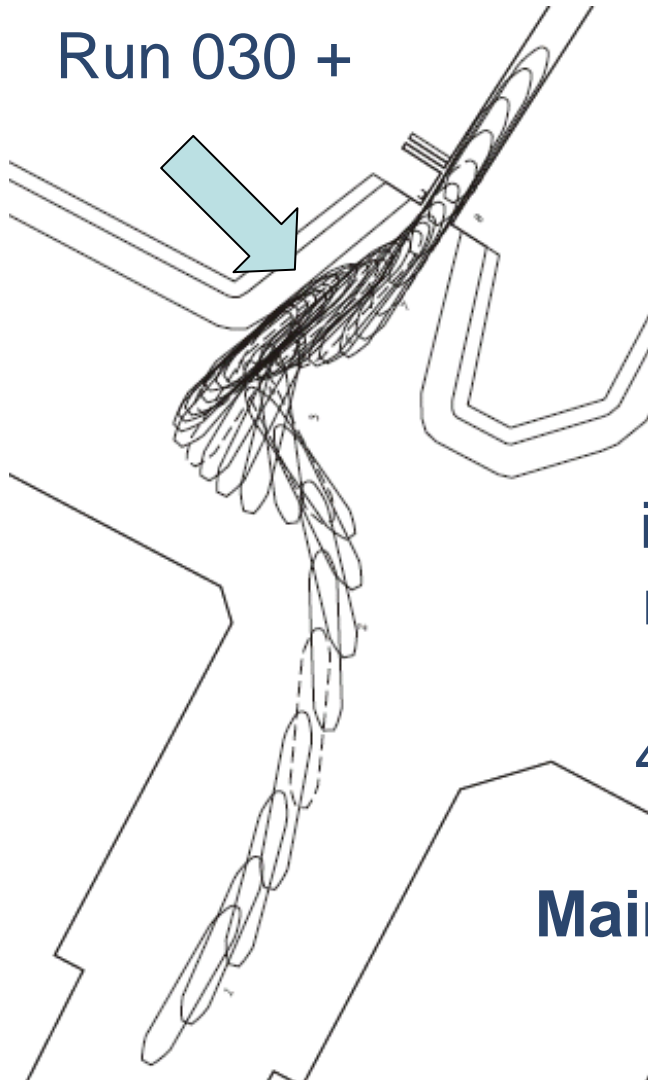
# Simulation study 2005



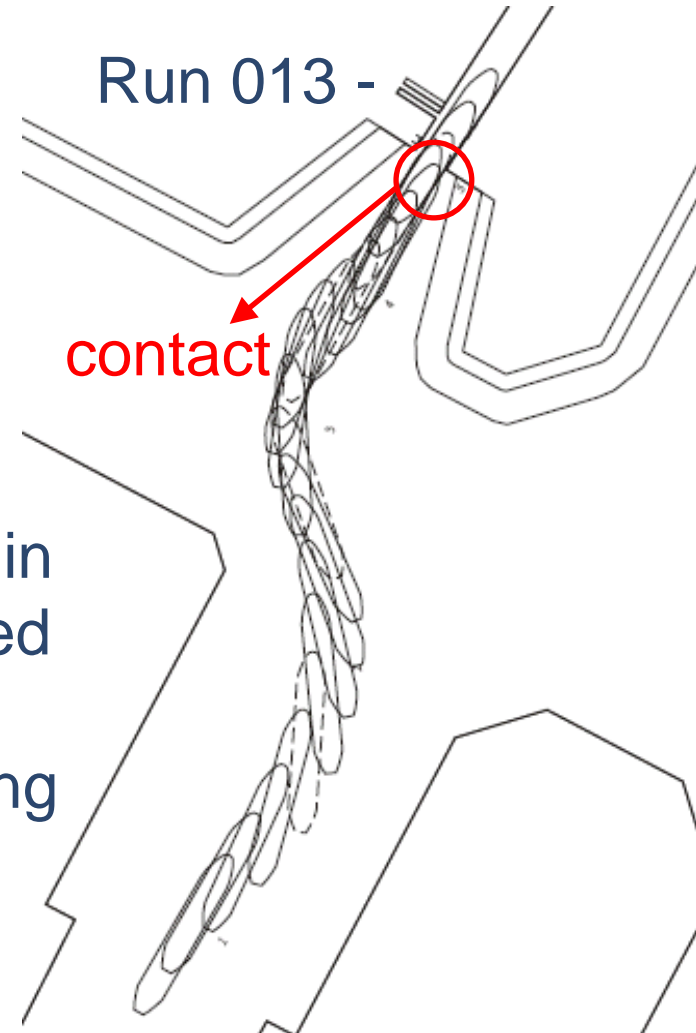
**Main Ore**  
**335 m x 52 m**  
**T = 16.36 m entrance**  
**T = 9.9 m departure**

# Simulation study 2005

Run 030 +



Run 013 -



Tugs are more intensively used in run 030 compared to run 013  
4 x 60 tons, towing

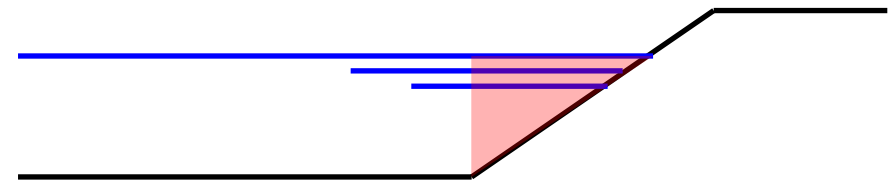
**Main Ore T = 9.9 m**  
**NW 6 Bf**



# Simulation study 2005

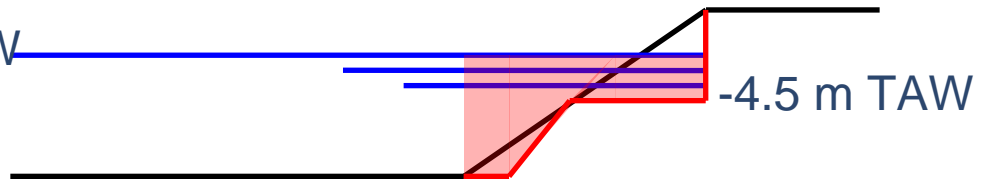
Run 030 +

Lay-out of banks is negatively evaluated



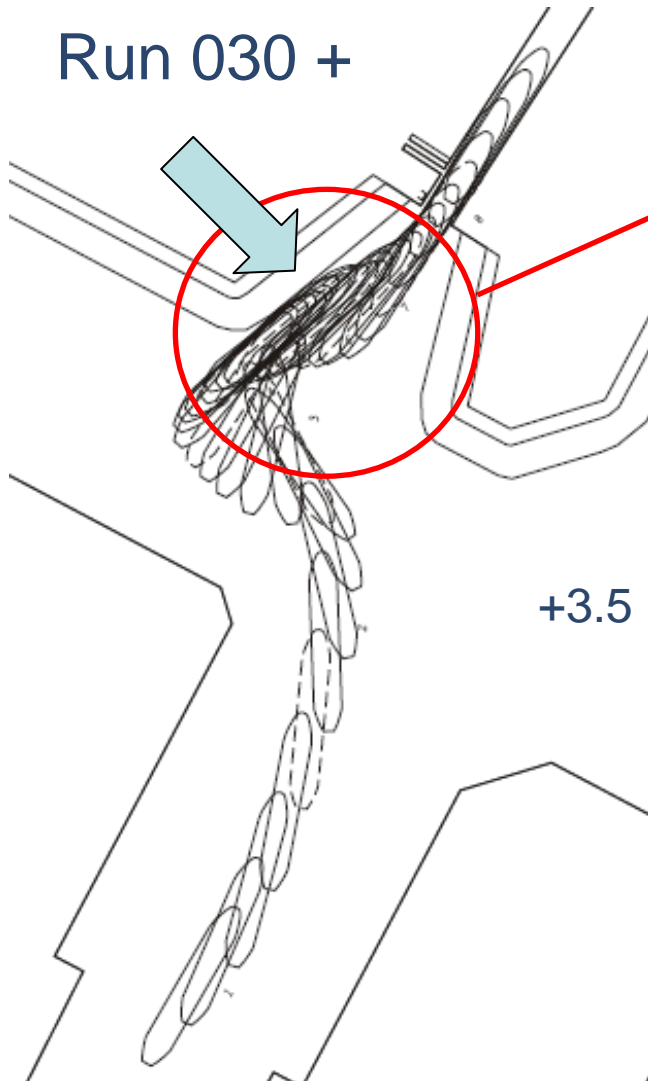
Sloped bank

+3.5 m TAW



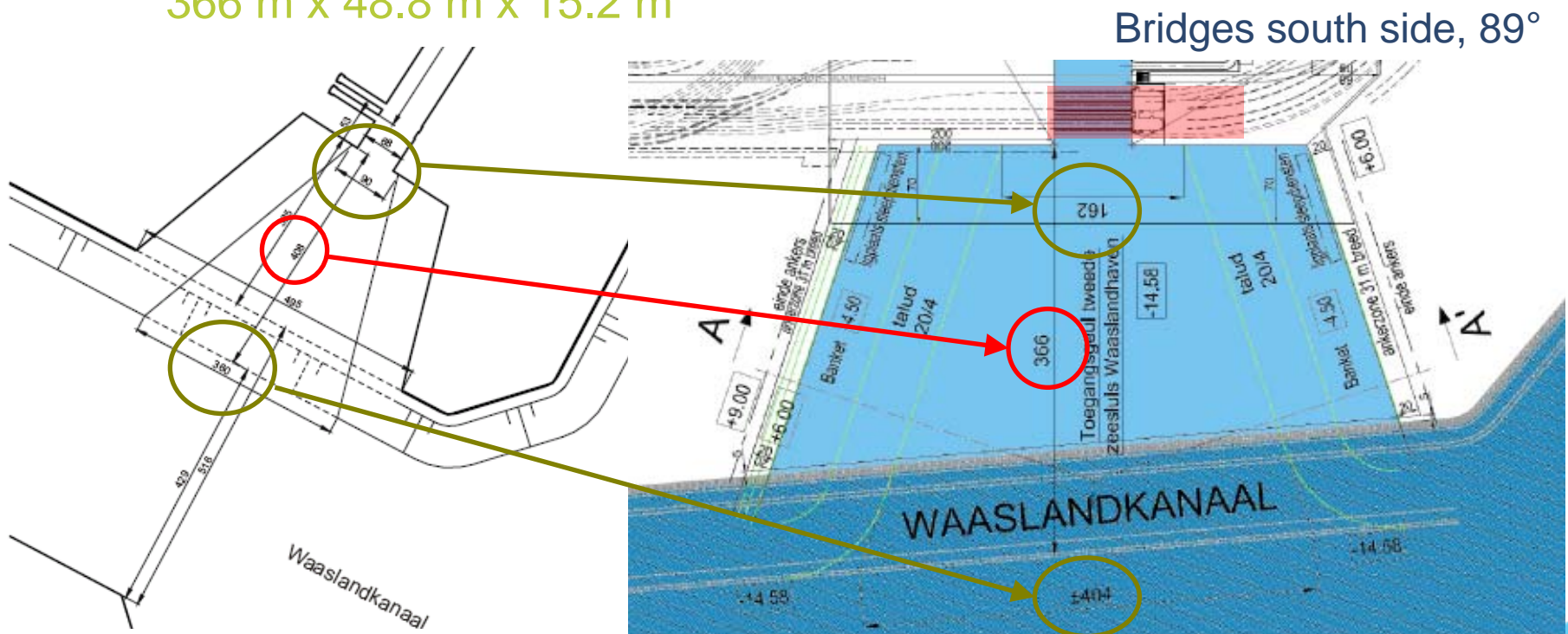
-4.5 m TAW

Sloped bank with horizontal plate, tugs can use the total area



# Simulation study 2007

- Simulations have been executed with the design ship of the new locks in Panama: 12000 TEU container ship  
366 m x 48.8 m x 15.2 m



# Simulation study 2007

- Mathematical models of 12000 TEU containership based on scaling of smaller containership from simulator database, validation based on experience of pilots

	Toerental (rpm)	Diepgang (m)			Snelheden (knoop)
		15.0	14.5	12.0	
Sea Full	<b>94.2</b>	26.1	26.4	28	
Harbour Full	<b>64.8</b>	17.9	18.2	19.3	
Half	<b>49.8</b>	13.8	13.9	14.8	
Slow	<b>34.8</b>	9.6	9.7	10.3	
Dead slow	<b>24</b>	6.6	6.6	7.1	

Deep water

Tabel 2 - Scheepssnelheden in knoop bij 100% kielspeling

	Toerental (rpm)	Diepgang (m)			Snelheden (knoop)
		15.0	14.5	12.0	
Harbour Full	<b>64.8</b>	16.6	16.8	17.9	
Half	<b>49.8</b>	12.8	12.9	13.8	
Slow	<b>34.8</b>	8.9	9	9.6	
Dead slow	<b>24</b>	6.1	6.2	6.6	

Shallow water

Tabel 3 - Scheepssnelheden in knoop bij 14% kielspeling



# Simulation study 2007

- Wind conditions: wind force and wind direction, frequency of occurrence and distribution of wind force

Windrichting	Windsterkte					Frequentie windrichting
	1-2 Bf	3-4 Bf	5-6 Bf	7-8 Bf	> 8 Bf	
N	2,150	4,041	0,183			6,37
30	2,674	4,718	0,209			7,60
60	3,522	4,326	0,241			8,09
O	3,480	3,028	0,080			6,57
120	3,130	3,515	0,028			6,67
150	0,938	1,805	0,116			2,86
Z	2,658	7,308	1,314	0,037		11,32
210	2,512	10,830	2,871	0,132	0,002	16,35
240	2,938	9,190	2,173	0,168	0,002	14,47
W	2,116	3,853	1,425	0,133	0,002	7,53
300	1,747	4,396	1,015	0,065	0,002	7,23
330	1,065	3,411	0,459	0,014		4,95

Tabel 9 - Voorkomen van wind per richting en kracht ter hoogte van de Zandvlietsluis

Beaufort	Gem. Snelheid [m/s]	3Bf	4Bf	5Bf	6Bf	7Bf	8Bf	9Bf	10Bf	11Bf
4	6.7	2.7	84.6	12.7						
5	9.4	0.7	18.5	61.6	18.9	0.3				
6	12.3	0.1	1.9	21.6	54.9	20.5	1			
7	15.5		0.2	3.5	23.7	46.8	23.6	2.2		
8	19			0.6	5.1	23.1	42.1	24.6	4.3	0.2

Tabel 8 - Vlaggerigheid van de wind per windkracht

# Simulation study 2007

Conditie	Diepgang (m)	Wind	Startpositie	Aantal
Conditie 1	14.5	NW5	sluis	3
Conditie 5	14.5	NW6	sluis	1
	12			3
Conditie 6	12	NO6	sluis	1
Conditie 6+	12	O6	sluis	2
Conditie 3	14.5	NW5	vrasedok	3
	12			1
Conditie 4	14.5	NO5	vrasedok	1
Conditie 4+	14.5	O5	vrasedok	1
			waaslandkanaal	1
Conditie 7	14.5	NW6	vrasedok	1
			waaslandkanaal	1
			vrasedok	3
Conditie 8	12	NO6	vrasedok	1
			waaslandkanaal	1
<b>TOTAAL</b>				<b>24</b>

Tabel 11 - Beknopt overzicht van de simulatievaarten uitgevoerd door groep 1



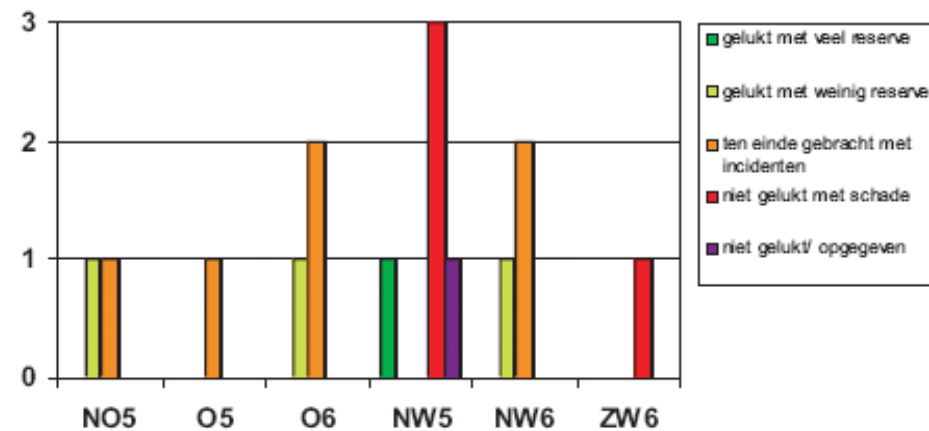
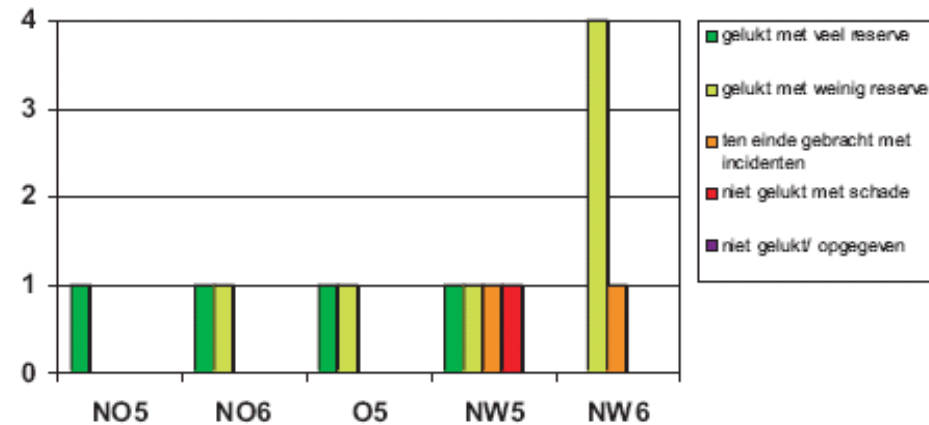
- 2 groups of pilots, with and without experience with the largest containerships coming to Antwerp in 2007

Conditie	Diepgang (m)	Wind	Startpositie	Aantal
Conditie 1	14.5	NW5	Sluis	1
	12			1
Conditie 5	14.5	NW6	Sluis	2
	12			2
Conditie 6+	14.5	O6	Sluis	1
Conditie 3	14.5	NW5	vrasedok	3
	14.5		waaslandkanaal	1
	12		vrasedok	1
Conditie 4	14.5	NO5	vrasedok	2
Conditie 4+	14.5	O5	vrasedok	1
Conditie 7	14.5	NW6	waaslandkanaal	1
	12		vrasedok	1
	12		waaslandkanaal	1
Conditie 7+	14.5	ZW6	vrasedok	1
Conditie 8+	14.5	O6	vrasedok	1
	12		waaslandkanaal	2
<b>TOTAAL</b>				<b>22</b>

Tabel 12 - Beknopt overzicht van de simulatievaarten uitgevoerd door groep 2

# Simulation study 2007

- Evaluation of the simulation - Waasland harbour to the lock - by group 1 and group 2
- Experience and thus know-how on the job is very important
- Maximum number of tug boats is 4, Voith Schneider tugs with 50 ton BP each





# Simulation study 2007, conclusions

- Is the modified lay-out at Waasland harbour positively evaluated?

Enough area for design ship and tug boats.

- Is the accessibility of the lock guaranteed for all wind directions and wind force up till 6 Beaufort (12.3 m/s)?

Simulations have been executed with wind force 5 and 6 Beaufort from NE, E, NW and SW. The lock is accessible for all wind directions up to 6 Beaufort unless a good tug boat configuration is used. Simulations with lateral wind direction and 6 Beaufort gave more incidents but with enough experience with the largest containerships and simulator training these wind conditions can be dealt with.

- Which tug boat configuration gives good results taking into account the wind direction?

Manoeuvre from the lock to Waasland harbour: 5 Bf – 2 tugs of 50 ton BP, 6 Bf lateral wind – 3 tugs (2 x 50 ton BP + xx BP) or 2 tugs of 58 ton BP

Manoeuvre from Vrasenedock to the lock: 5 Bf – 2 tugs of 50 ton BP, 6 Bf lateral wind – 3 tugs of 50 ton BP, 1 mid for, 1 mid aft and 1 pushing

# Simulation study 2008

- Is Deurganckdok lock accessible for the largest containership, 397.5 m x 56.4 m and the lay-out proposed in 2007?
- Are there mathematical models available which incorporate the latest information of this 14000 TEU containership?
- Can information be collected about the impact on the wheel fenders due to contact with the ship?
- Can additional forces acting in the lock (cushion effect, waves due to translation, current due to reflection) be predicted?

# Simulation study 2008

Preparation of the ship manoeuvring simulator

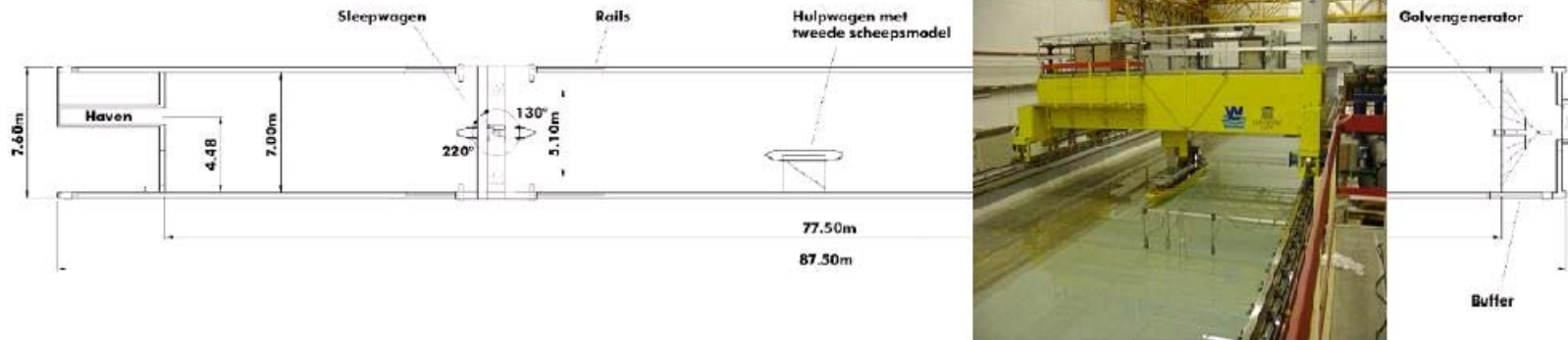
1. Mathematical modelling of 400 m containership
2. Contact dimensions with wheel fenders
3. Additional forces for manoeuvring in the lock



# Simulation study 2008

1. Mathematical modelling of 400 m containership
2. Contact dimensions with wheel fenders
3. Additional forces for manoeuvring in the lock

# Simulation study 2008

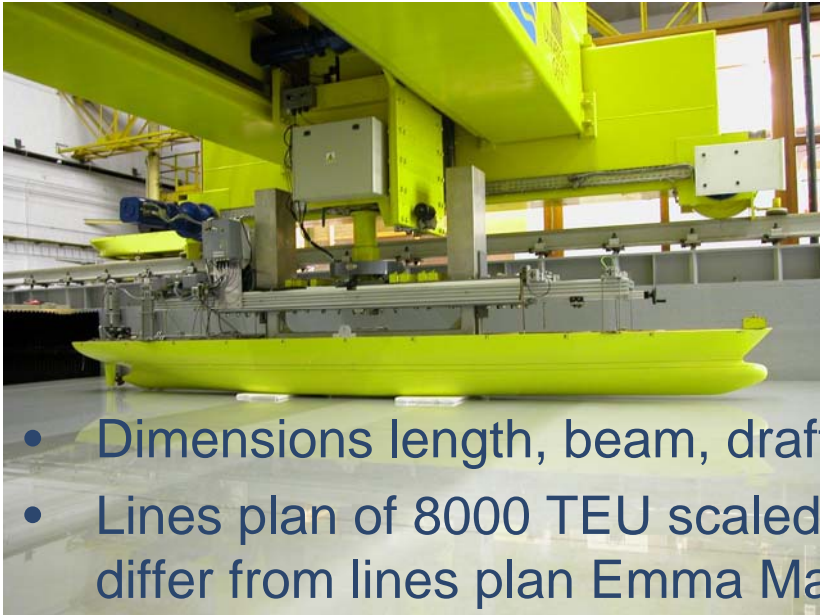


- Model tests executed with a ship model of an 8000 TEU, 352 m x 42.8 m, draught between 14.5 m-12 m in deep and shallow water (UKC 100% - 35% - 10% of ship's draught)
- Scaled to 366 m – 380 m – 400 m long containership

	Schaalfactor	80.8	85.119	88.263	91.573
LoA (m)	4.360	351.96	365.50	379.00	397.55
LPP (m)	4.106	331.76	349.50	362.41	376.00
B (m)	0.530	42.82	45.11 (48.4)	46.78 (51.0)	48.53 (56.4)
T <sub>1</sub> (m)	0.181	14.61	15.41	15.98	16.57
T <sub>2</sub> (m)	0.168	13.61	14.30	14.83	15.38
T <sub>3</sub> (m)	0.150	12.16	12.77	13.24	13.74

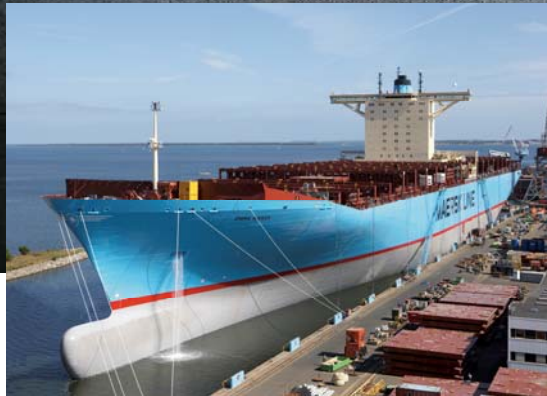
Tabel 4 – Karakteristieken na opschaling van model U volgens de lengte tussen de loodlijnen en gebaseerd op bestelde en gebouwde containerschepen

# Simulation study 2008



- Dimensions length, beam, draft are not identical after scaling
- Lines plan of 8000 TEU scaled to 14000 TEU containership differ from lines plan Emma Maersk
- A scale model of an 14000 TEU containership is developed, but original lines have not been provided by the shipping company or the shipyard.
- Free-running model tests have been executed in Bulgarian Ship Hydrodynamic Centre, Varna, Bulgaria

# Simulation study 2008



- Acceleration tests
- Turning circle tests
- Zig-zag tests
- Crash stop tests



# Simulation study 2008

1. Mathematical modelling of 400 m containership
2. **Contact dimensions with wheel fenders**
3. Additional forces for manoeuvring in the lock

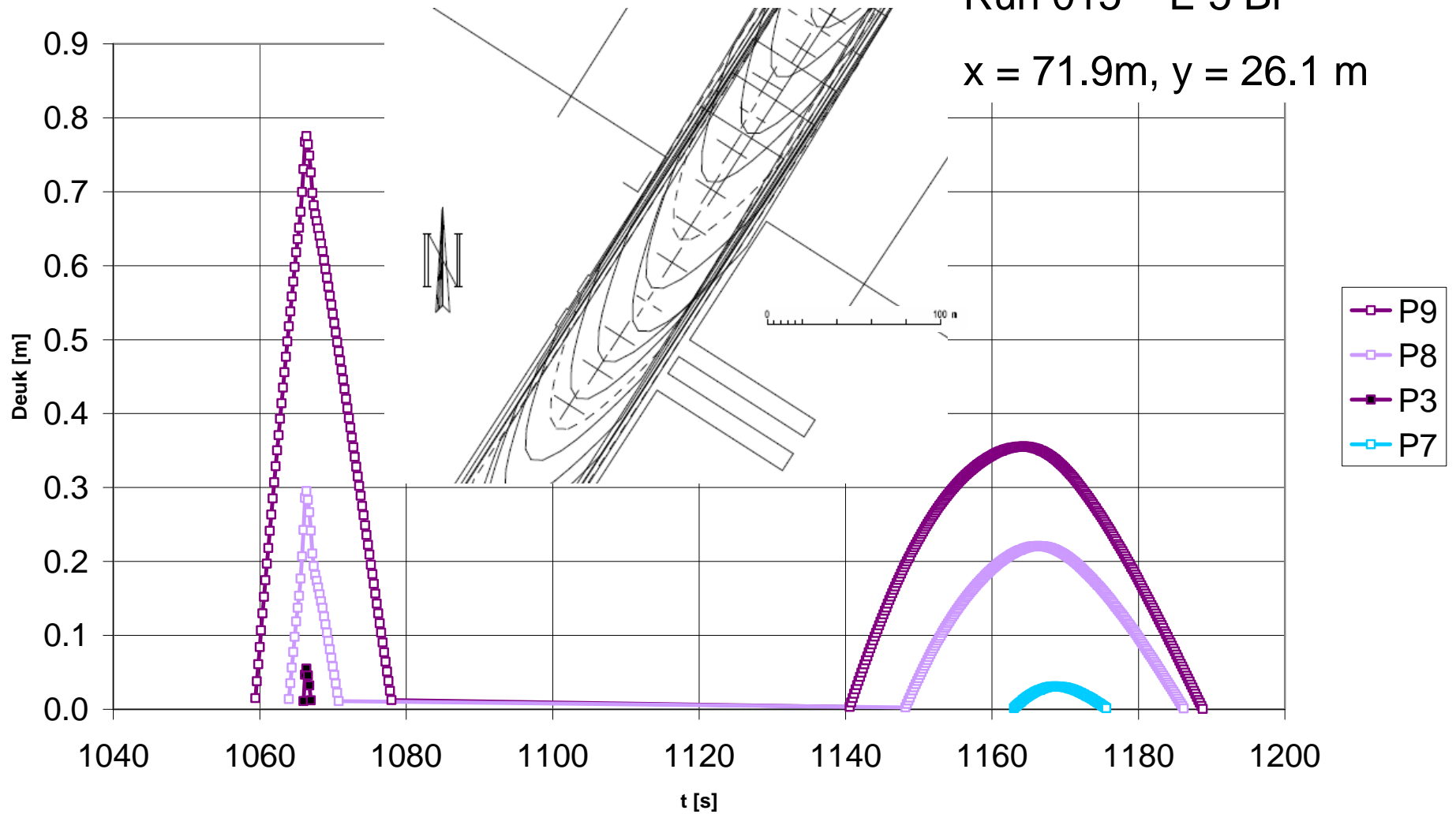
# Simulation study 2008



# Simulation study 2008

Run 015 – E 5 Bf

x = 71.9m, y = 26.1 m



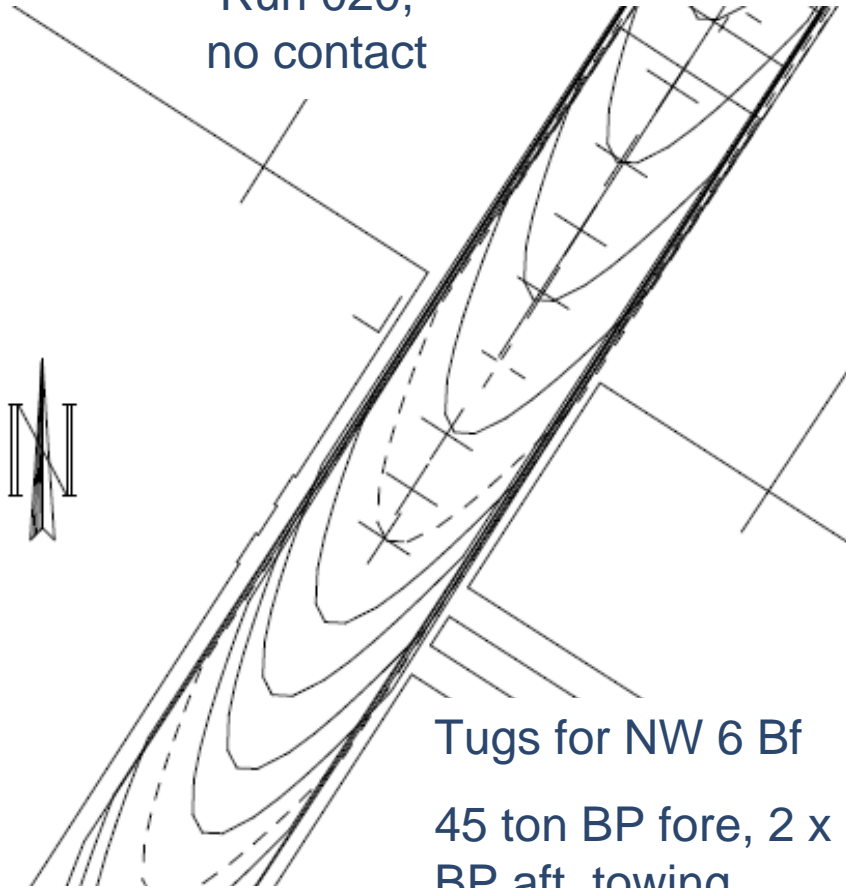
# Simulation study 2008

1. Mathematical modelling of 400 m containership
2. Contact dimensions with wheel fenders
3. Additional forces for manoeuvring in the lock
  - cushion effect: lateral movement towards the lock wall
  - waves due to translation: longitudinal movement in the lock,  
wave generated in front of and along the ship's hull
  - current due to reflection: additional resistance force

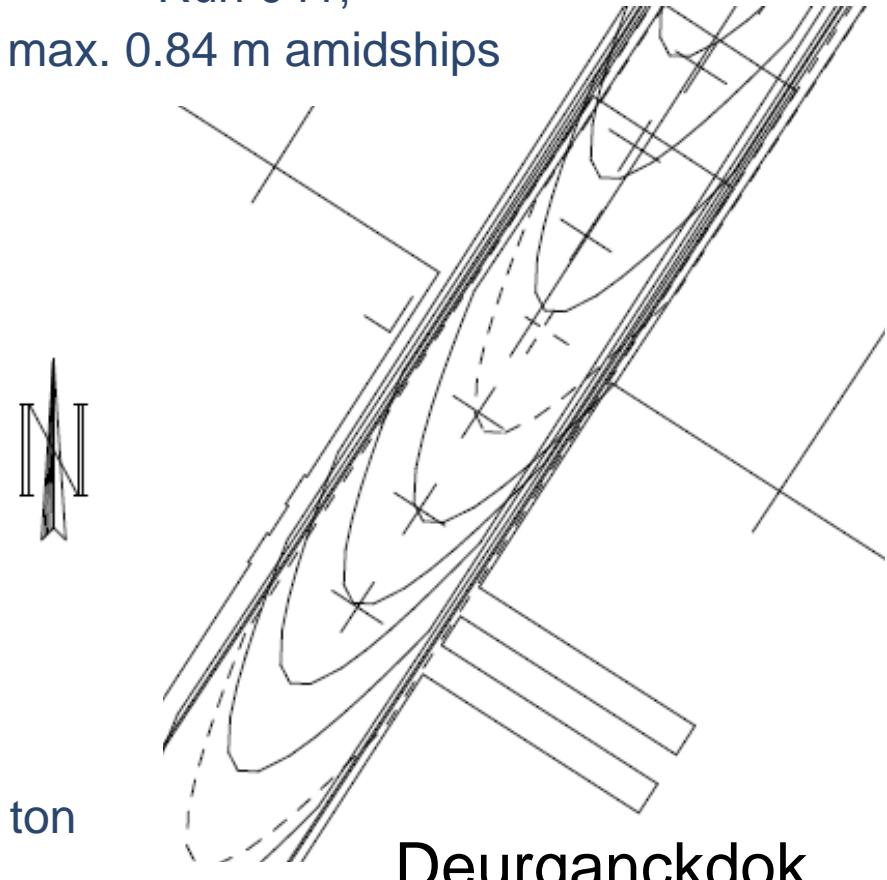


# Simulation study 2008, simulations

Run 020,  
no contact



Run 041,  
max. 0.84 m amidships



Tugs for NW 6 Bf

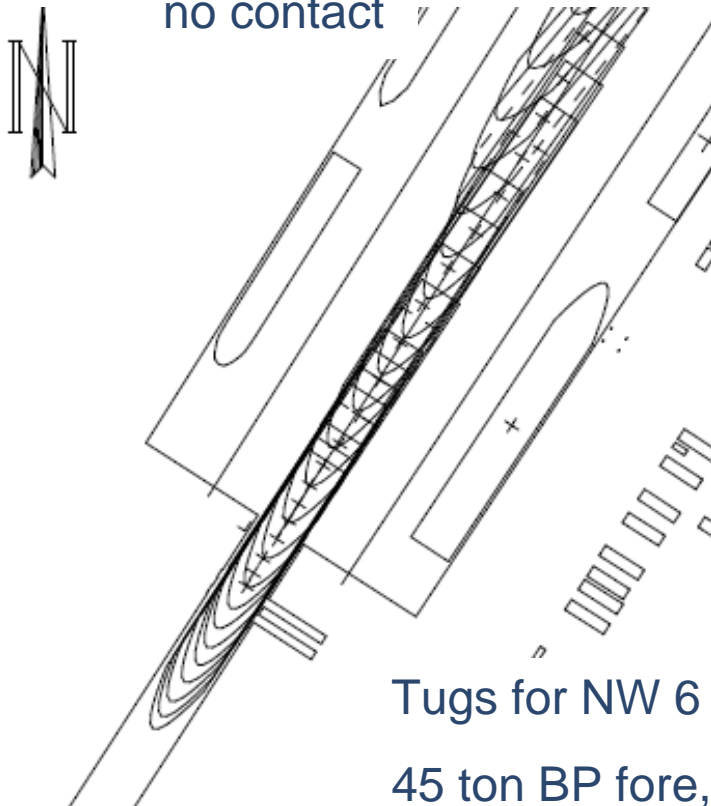
45 ton BP fore, 2 x 60 ton  
BP aft, towing

45 ton BP, pushing port

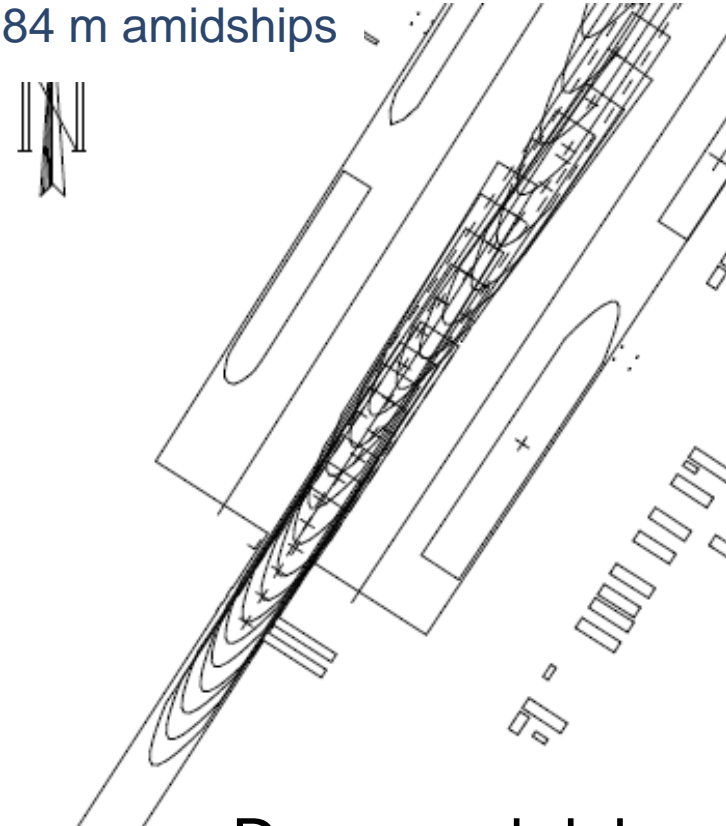
Deurganckdok

# Simulation study 2008, simulations

Run 020,  
no contact



Run 041,  
max. 0.84 m amidships



Tugs for NW 6 Bf

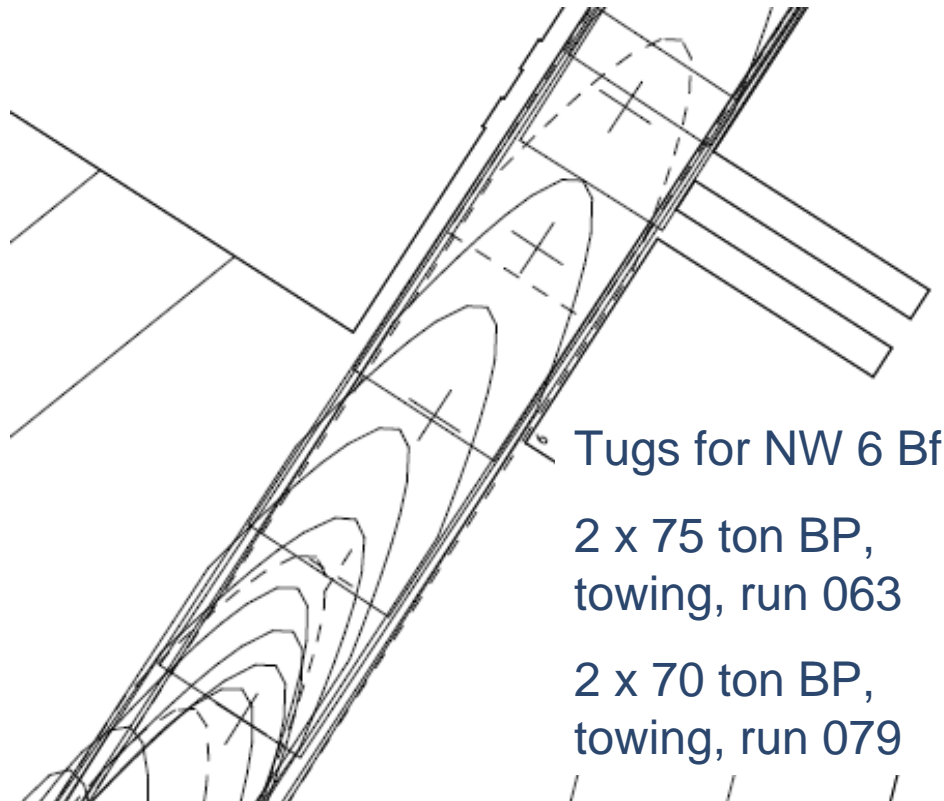
45 ton BP fore, 2 x 60 ton  
BP aft, towing

45 ton BP, pushing port

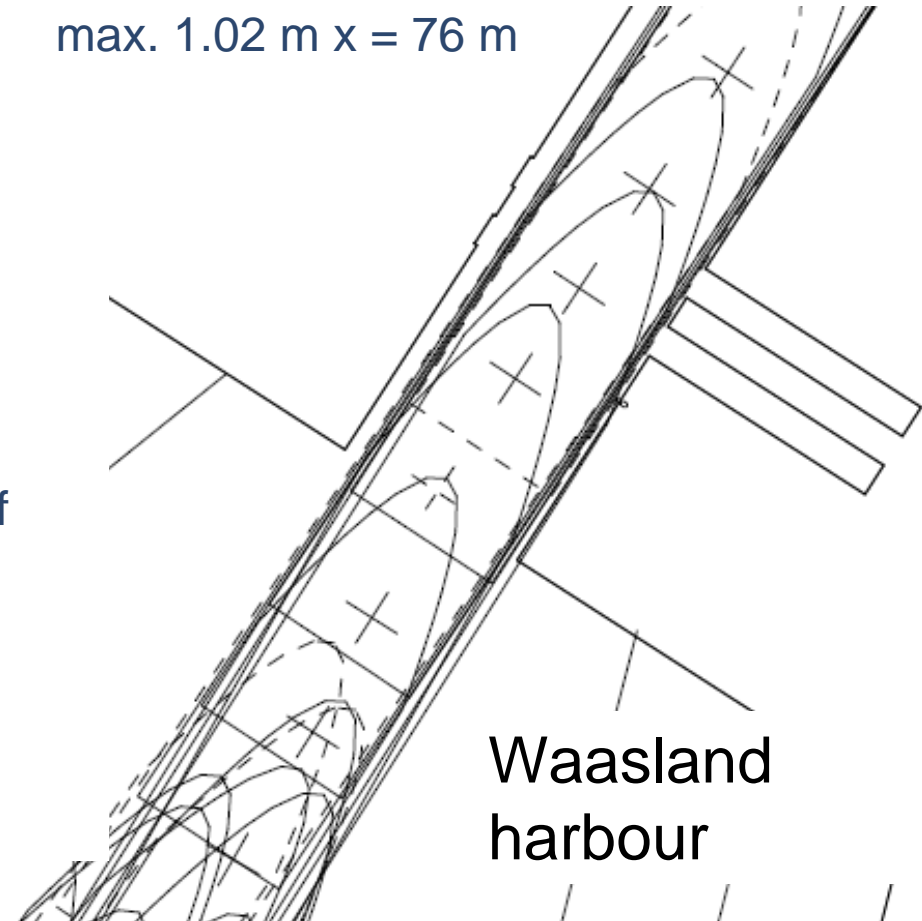
Deurganckdok

# Simulation study 2008, simulations

Run 063,  
no contact

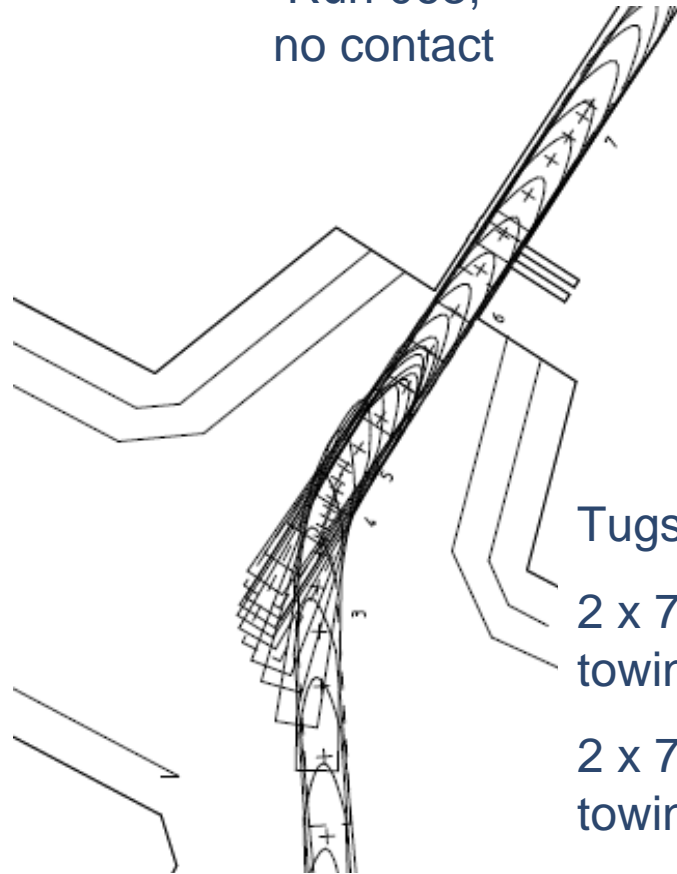


Run 079,  
max. 1.02 m x = 76 m



# Simulation study 2008, simulations

Run 063,  
no contact

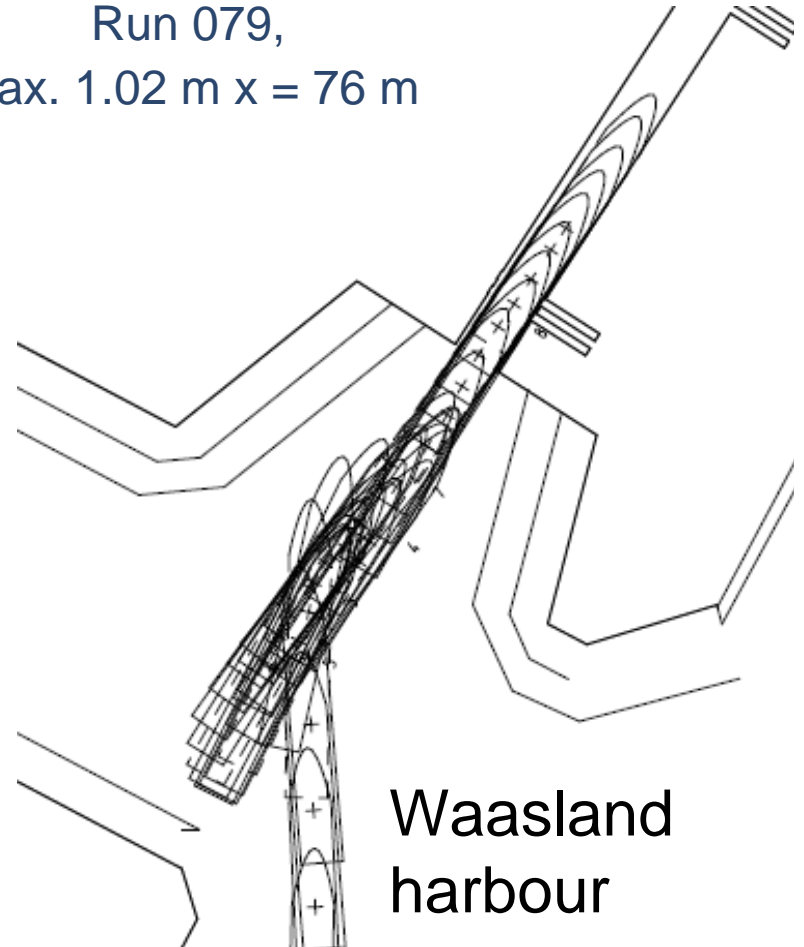


Tugs for NW 6 Bf

2 x 75 ton BP,  
towing, run 063

2 x 70 ton BP,  
towing, run 079

Run 079,  
max. 1.02 m x = 76 m



Waasland  
harbour



# Simulation study 2008, conclusions

- Is the lock accessible for 14000 TEU containerships?

Due to the larger beam (56.4 m) compared to the containerships now coming to Berendrecht lock (45.5 m) contact with the wheel fenders will occur more frequently, especially in heavy weather conditions. An increase of the breadth of the lock is not wanted due to enormous impact on price (lock doors, bridges etc.)
- Is the accessibility of the lock guaranteed for all wind directions and wind force up till 6 Beaufort (12.3 m/s)?

Simulations have been executed with wind force 5 and 6 Beaufort, wind direction parallel or lateral compared to the lock orientation. No main problems occur with wind forces up to 5 Bf. With higher wind forces and lateral wind (NW – W – E) contact with the wheel fenders will occur although most of the time the maximum dent is below the maximum available movement of 1.16 m for one wheel fender. A good tug boat configuration must be used (enough BP) and training on the ship manoeuvring simulators can help pilots in finding the good balance to handle these ships.

# Simulation study 2008, conclusions

- Which tug boat configuration gives good results taking into account the wind direction?

## Manoeuvre from Deurganckdock to the lock (pilots, Flemish pilotage)

Preference is given to use two tugs of 60 ton BP each aft. Depending on the wind direction and the wind force, one (towing) or two additional tugs (towing and/or pushing) are used with 45 ton BP each.

## Manoeuvre from the lock to Waasland harbour (BRABO pilots)

Two tugs of 55 ton BP each can be sufficient for all wind directions and wind forces up to 6 Bf.

## Manoeuvre from Waasland harbour to the lock (BRABO pilots)

5 Bf – 2 tugs of 55 ton BP each

6 Bf – 2 tugs of 75 ton BP each, while an additional pusher with lower BP can help in guiding the ship into the lock in case of lateral wind directions

# Other research



- Accessibility of Western Scheldt for 366 to 400 m containerships
- Accessibility of Berendrecht lock for 380 m containerships
- Accessibility of Delwaidedok for 380 m containerships
- New tidal dock at left bank



flanders  
**HYDRAULICS RESEARCH**

KNOWLEDGE CENTRE MANOEUVRING  
IN SHALLOW AND CONFINED WATER



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