Dredging Equipment

New Approach to Deep Sea Dredging

Mark Winkelman

KIVI, 8 september 2011

New Appraoch to Deep Sea Dredging

Dredging Equipment

RECENT IMPRESSIVE DREDGING PROJECTS

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SIZE INCREASE HOPPER DREDGES

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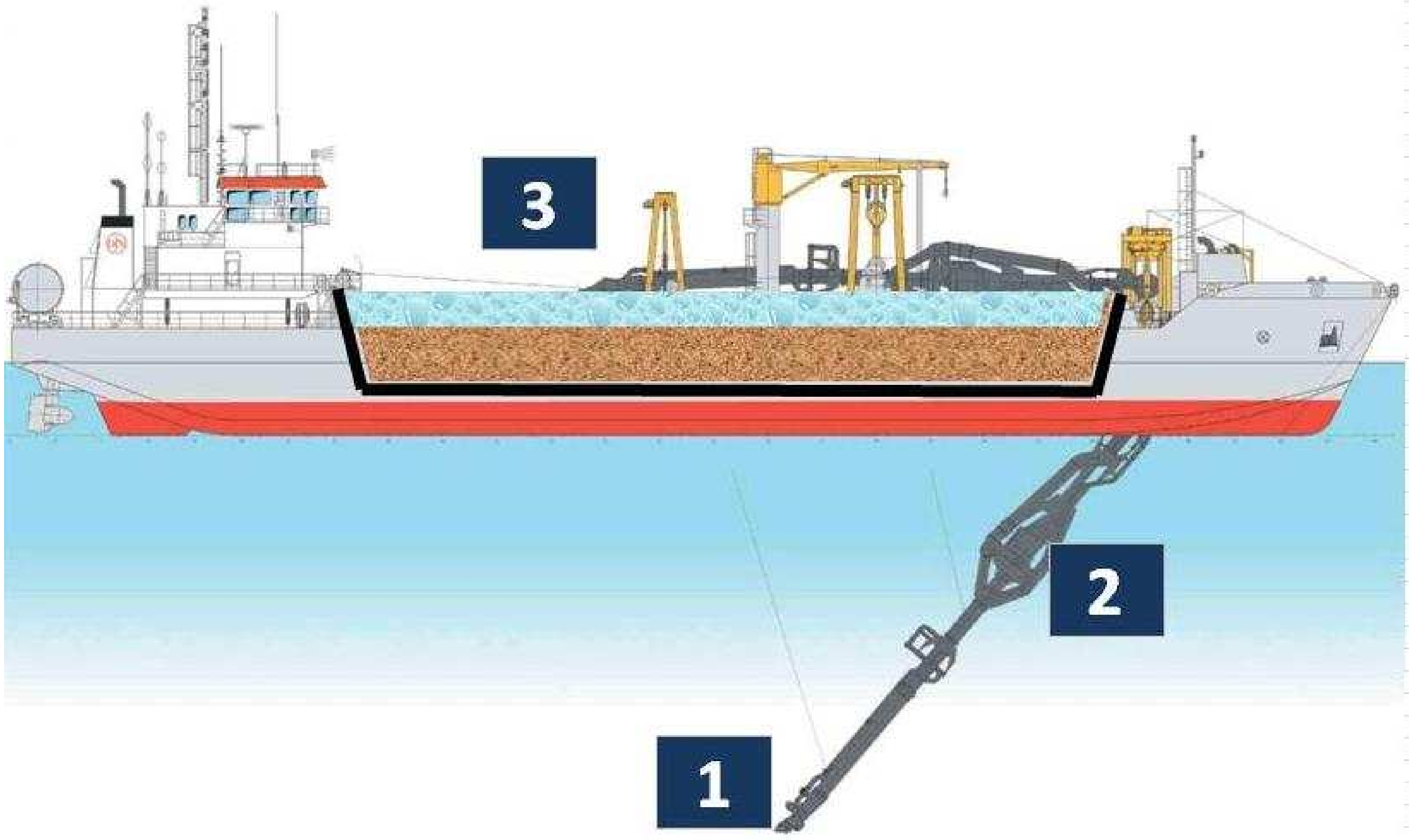
PRINCIPLE HOPPER COMPONENTS



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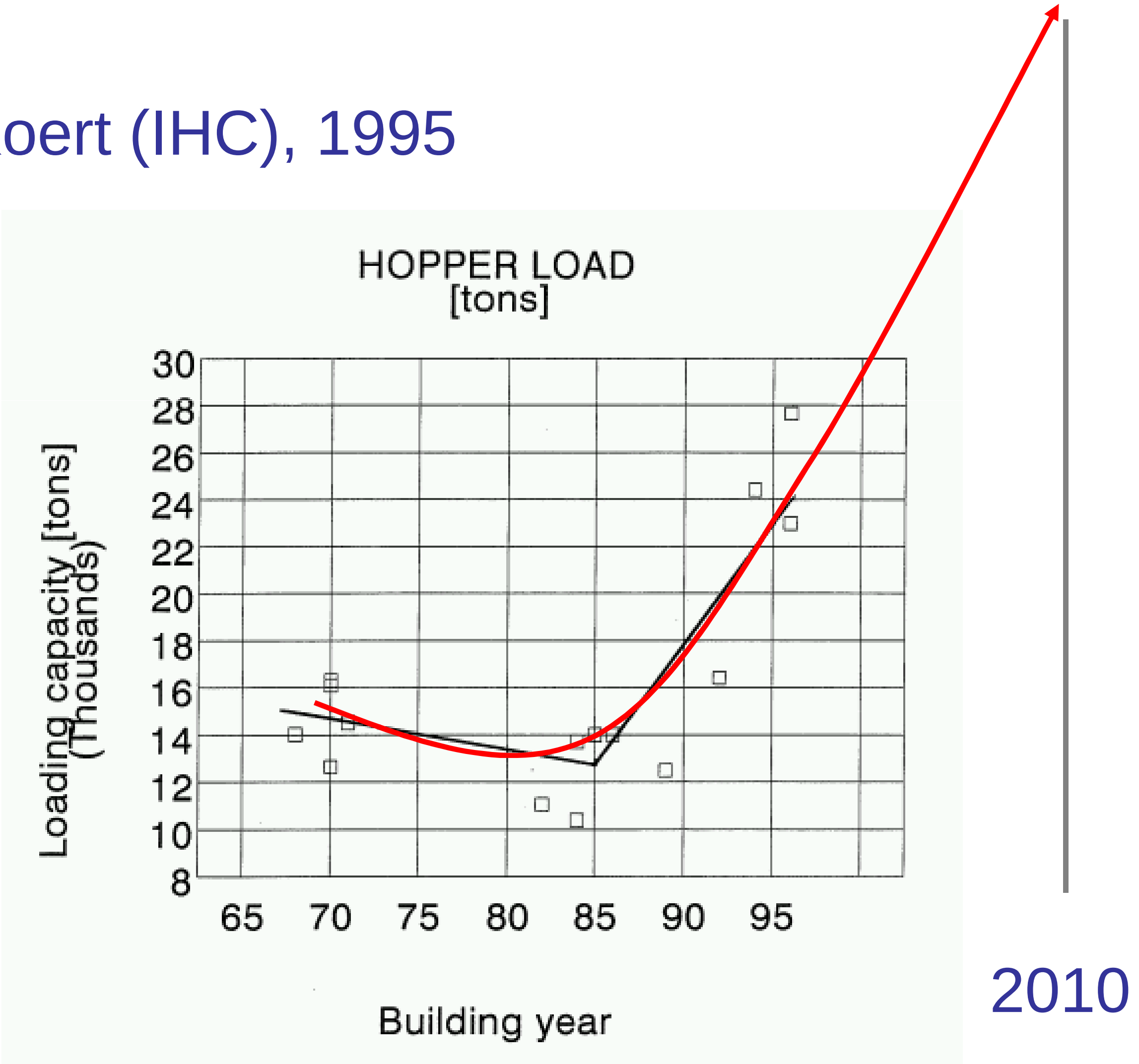
DEVELOPMENT OF HOPPER LOADING CAPACITY

Koert (IHC), 1995



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COST REDUCTION BY UPSCALING

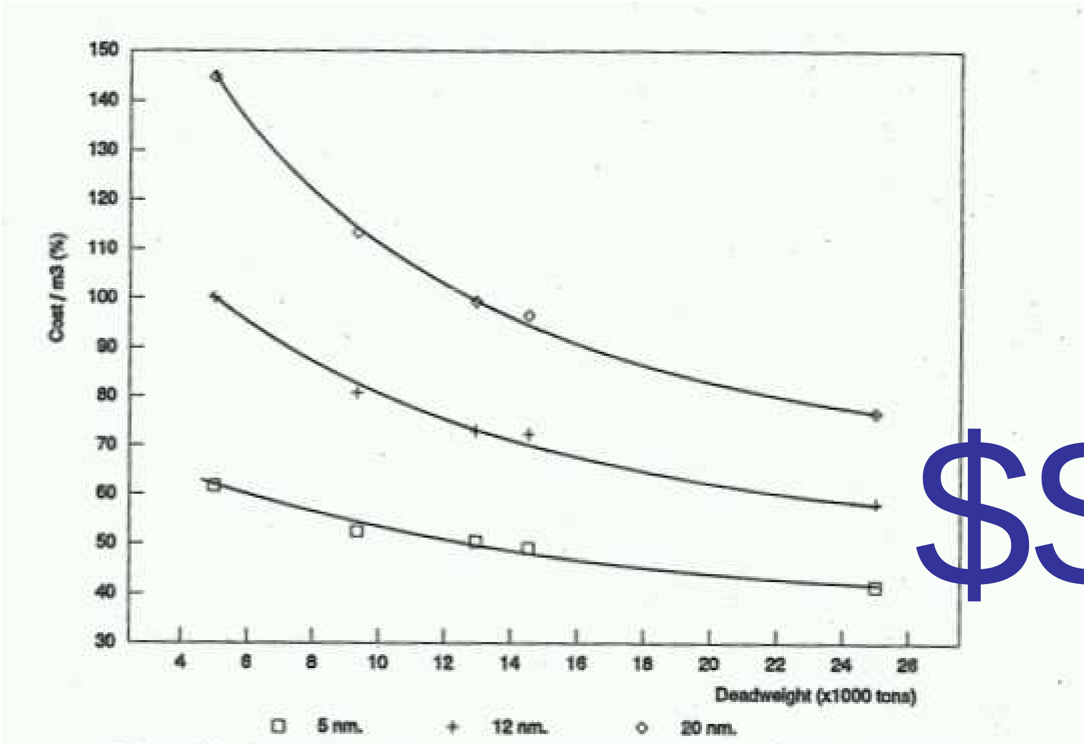

Figure 10. Operating cost per m3 versus dredger size for different sailing distances
Degree of utilization 40 weeks/year.

$$$

Verbeek (IHC), 1995

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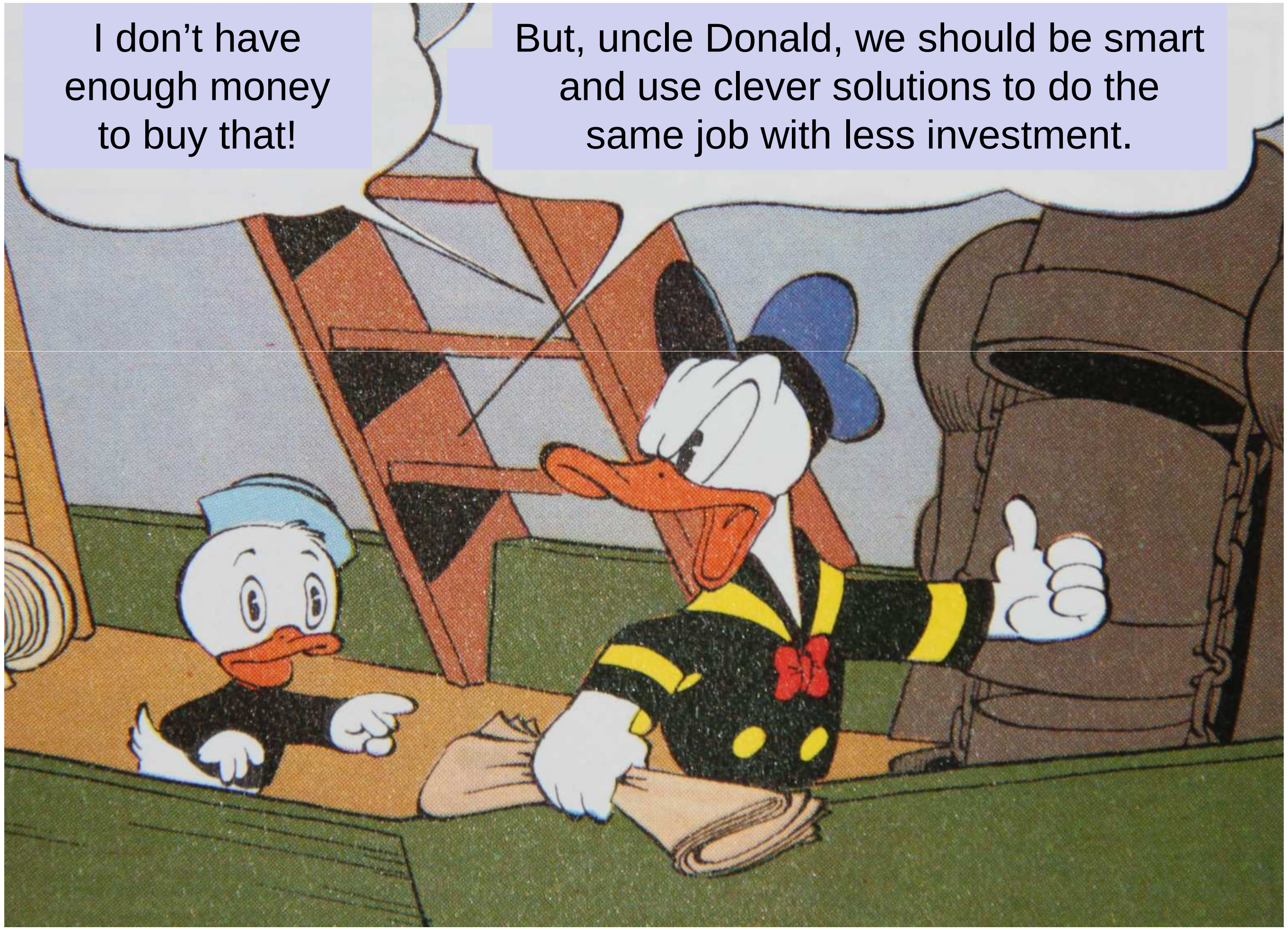
HIGH INVESTMENT COSTS FOR NEW EQUIPMENT



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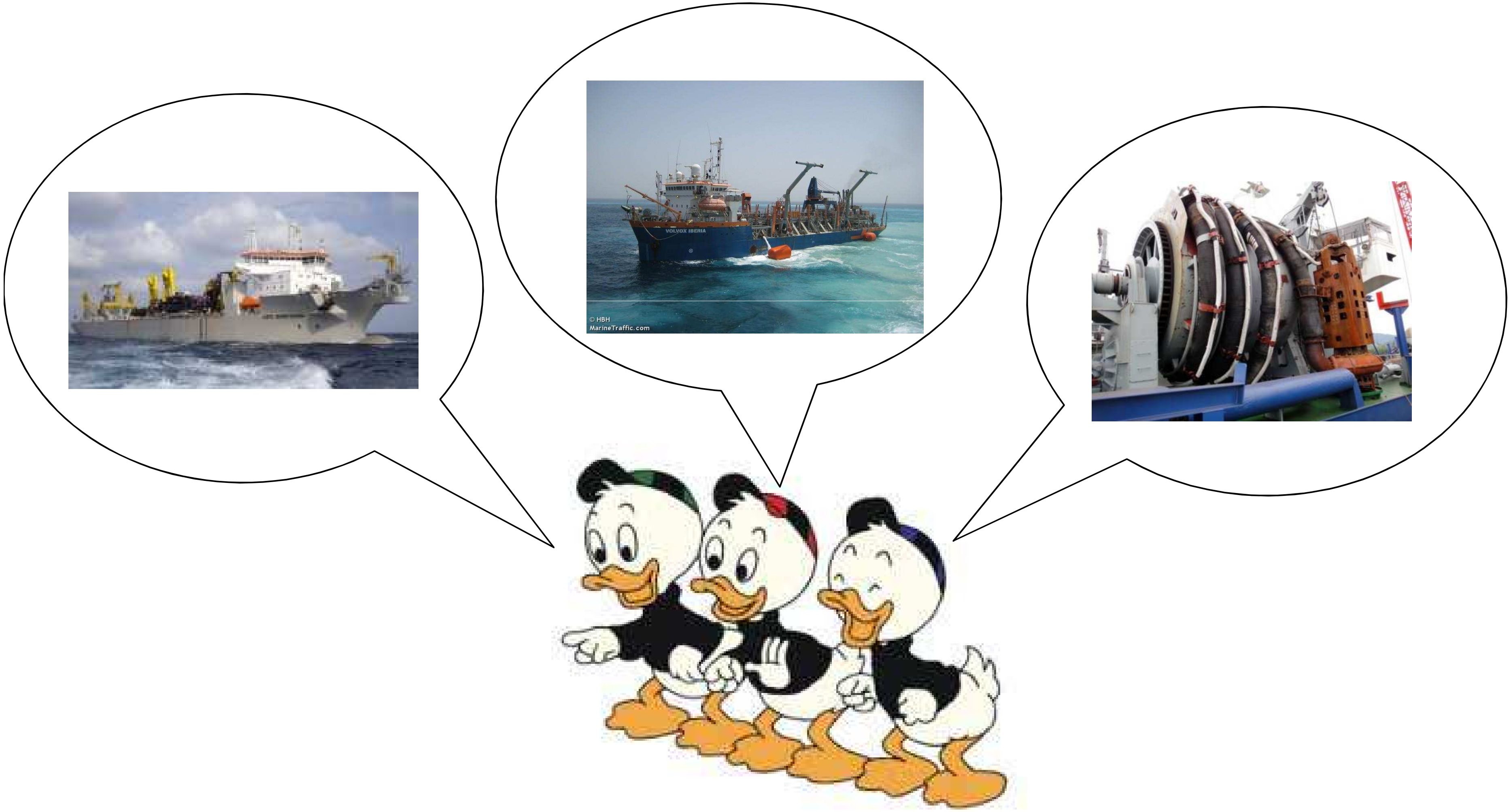
RECENT INDEPENDENT DEVELOPMENTS



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INSERT BRILLIANCE

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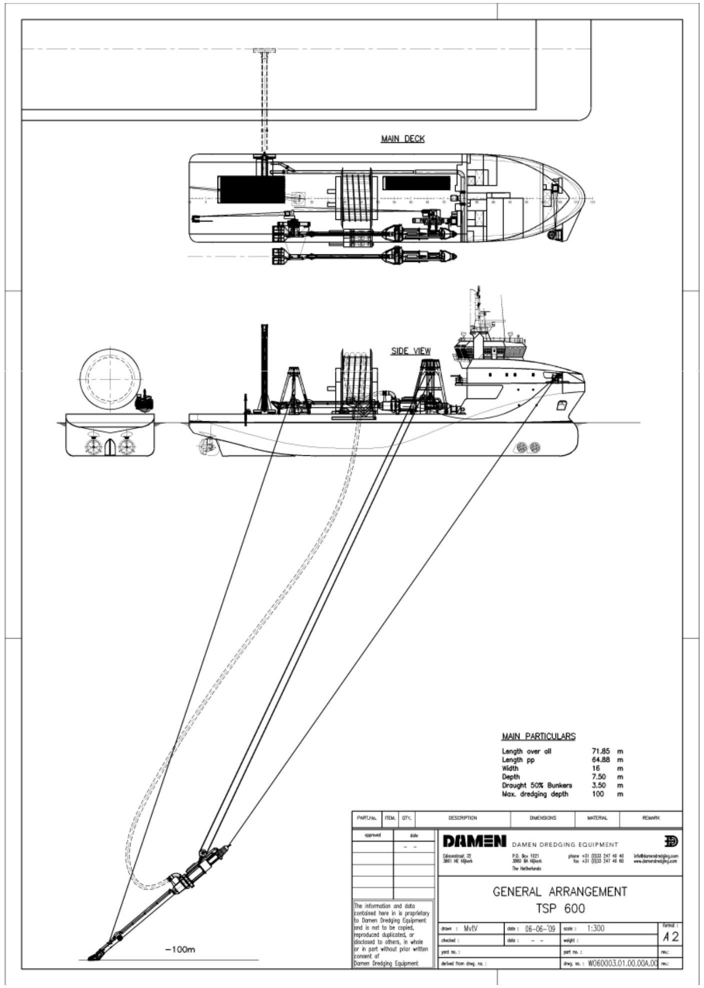
REVOLUTIONARY DREDGING CONCEPT



Roll on
Roll of

Dredge hose
on a reel

And ease of
installation

Showcase Ø600 hose

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NEW MARKET OPPORTUNITY AND ENGINEERING CHALLENGE

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NEW MARKET OPPORTUNITY AND ENGINEERING CHALLENGE

New Approach to Deep Sea Dredging

RORO DEEP DREDGE DEVELOPMENT COOPERATION

- Overall development & project management, DAMEN DREDGING EQUIPMENT
- Development subsea dredging hose, TRELLEBORG VELP B.V.
- Research transport of sediment in infinite loop / reel, TU-DELFT
- Numerical modelling/simulations of systems, IMOTEC
- Feasibility model tests for a flexible pipe deep water dredging system, MARIN
- Offloading tests, barge alongside dredger, MARIN

DAMEN DREDGING EQUIPMENT

TRELLEBORG Trelleborg Velp

MARIN

TU Delft Technische Universiteit Delft

imotec

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DAMEN DREDGING EQUIPMENT PRODUCT RANGE

DAMEN DREDGING EQUIPMENT

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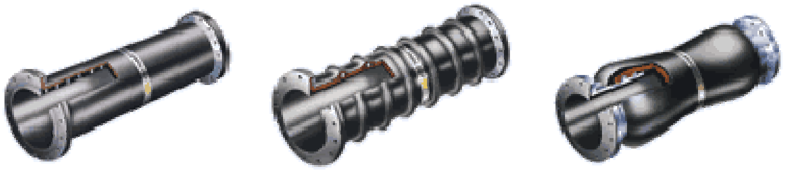
TRELLEBORG VELP PRODUCT RANGE



Does it work?

Mixture flow on reel

WEDA 2011

Barge loading
& operations

CEDA 2011

Dredging & hose vibrations

OMAE 2011

Topics to be investigated in a drum flow

- Engineering parameters
- Flow behaviour
- Critical velocity determination
- Resistance calculation
- Power requirements
- Calamity mitigation

MECHANICAL PROPERTIES TEST TRELLEBORG

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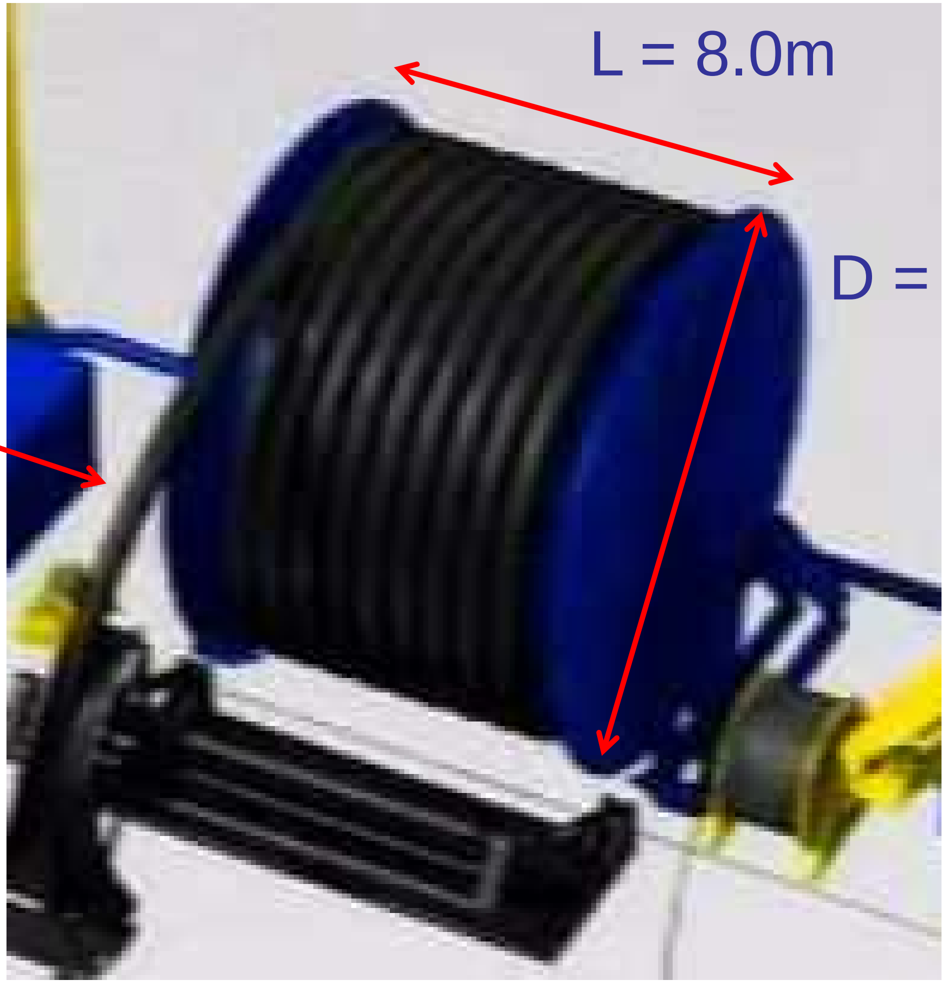
DESIGN PARAMETERS FOR CSE STUDY



d = Ø0.6m

Scale 1:3

d = Ø0.2m

D = Ø3.0m

Ltot = 225m

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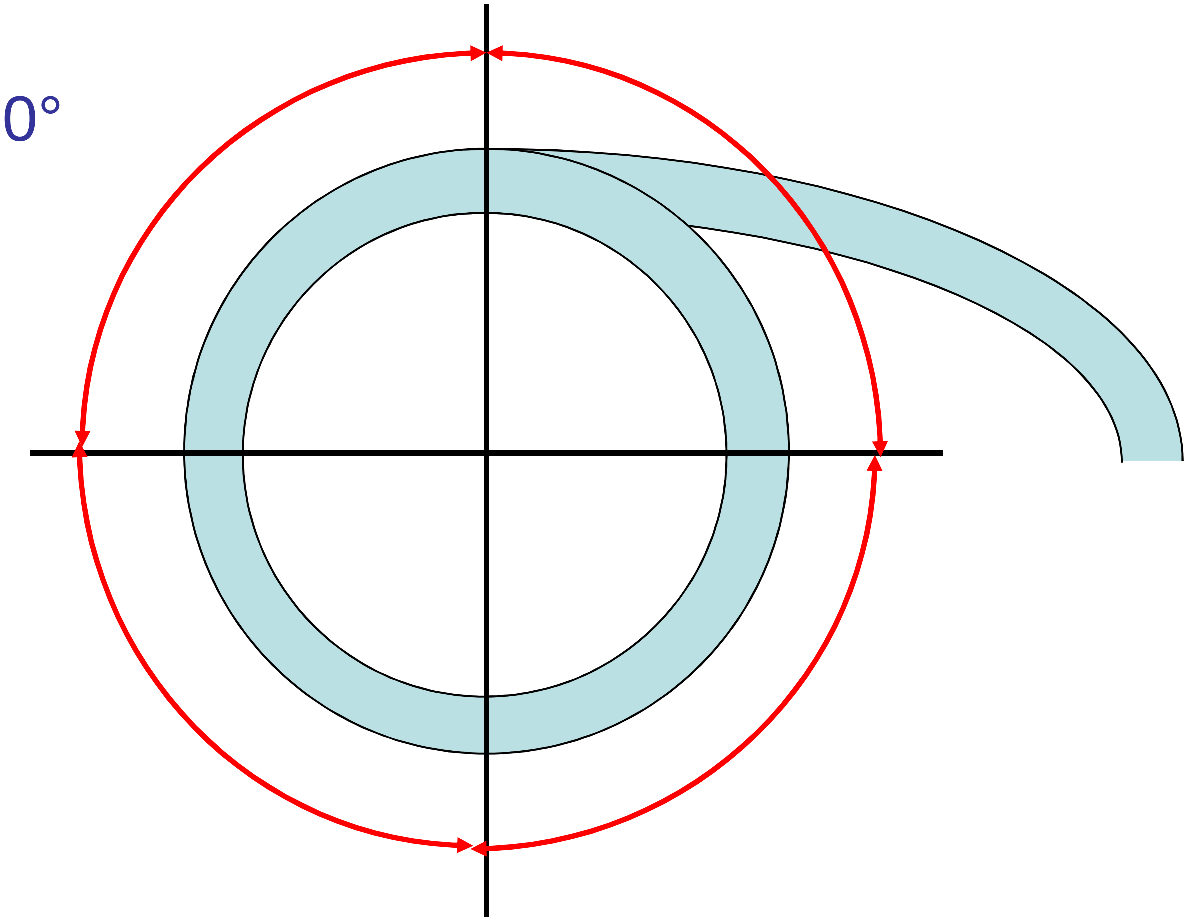
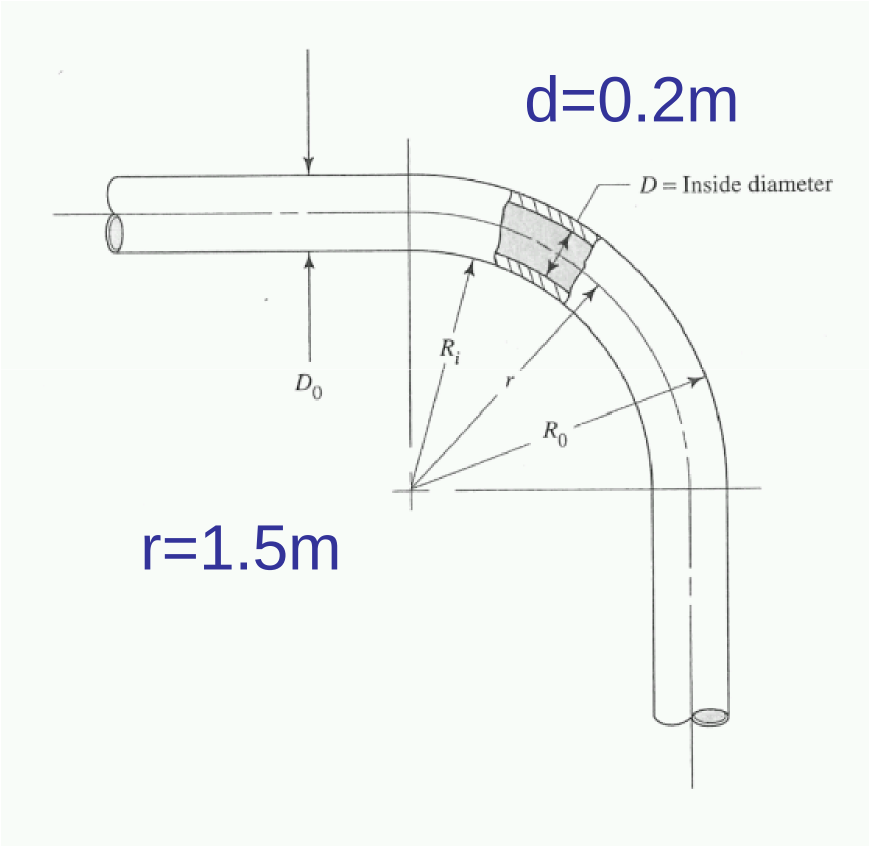
APPROACH IN CALCULATING RESISTANCE IN LOOPS

360° = 4 x 90°



GEOMETRIC PARAMETERS OF A BEND

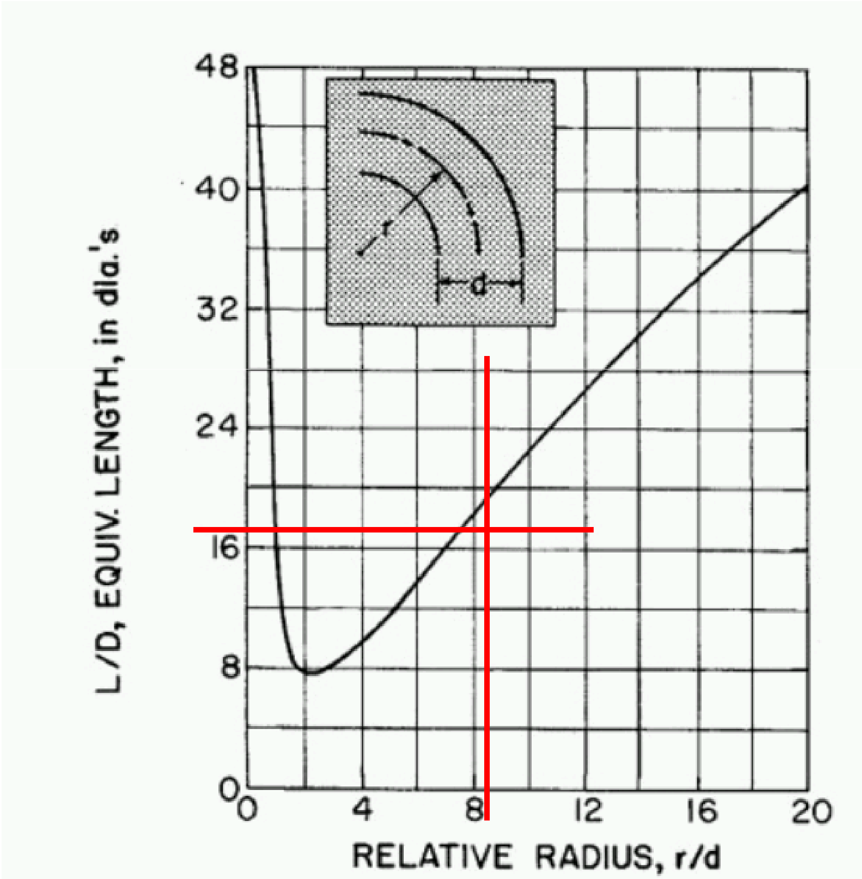


r/d=7.5

L=2.35m

L/d=11.8d

EQUIVALENT LENGTH DERIVATION OF A BEND



r/d=7.5

L/d=11.8d (straight)

L/d=17.0d (90° bend)

44% increase in resistance

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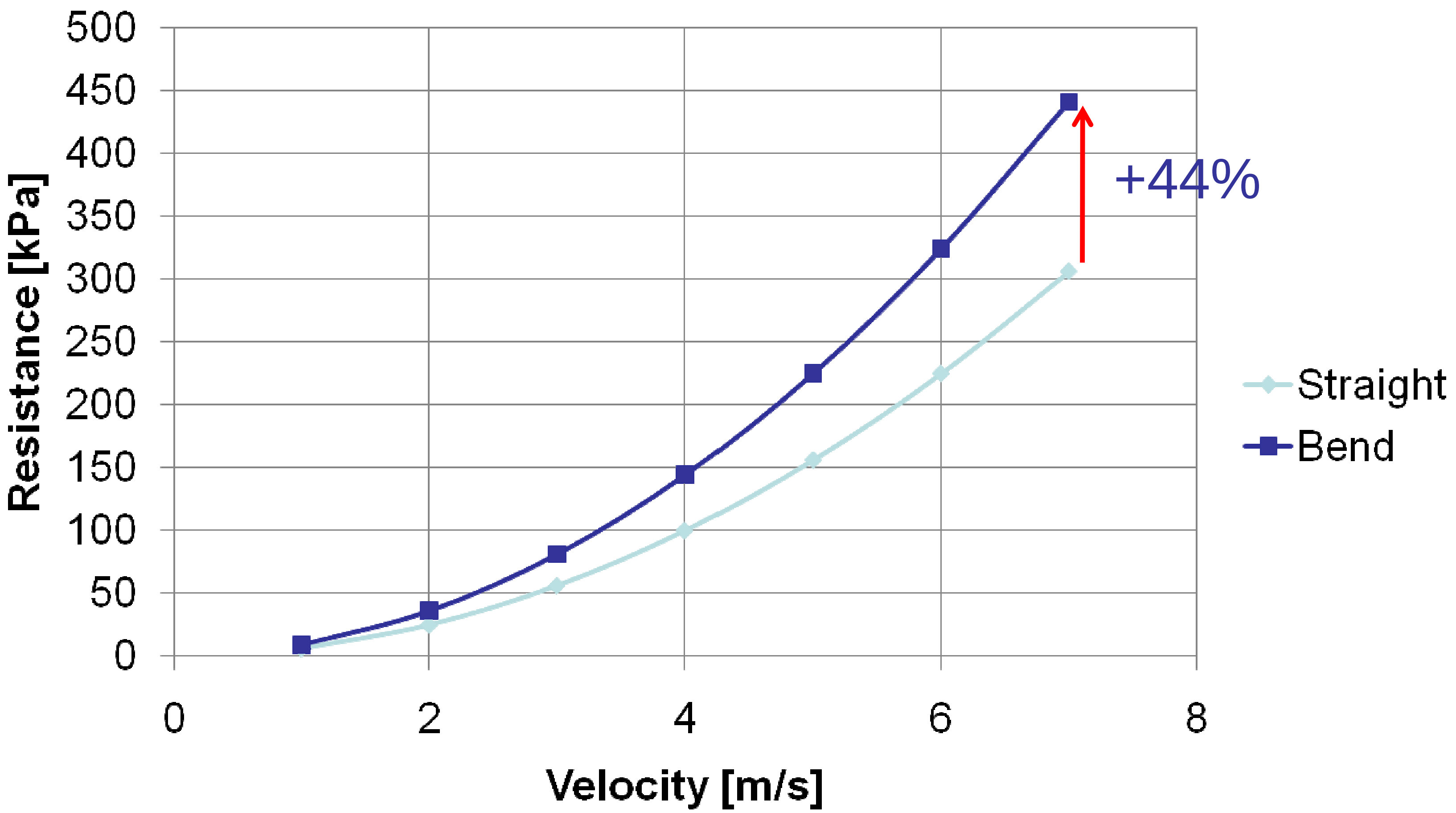
RESISTANCE CHANGE DUE TO ROLLING UP OF HOSE



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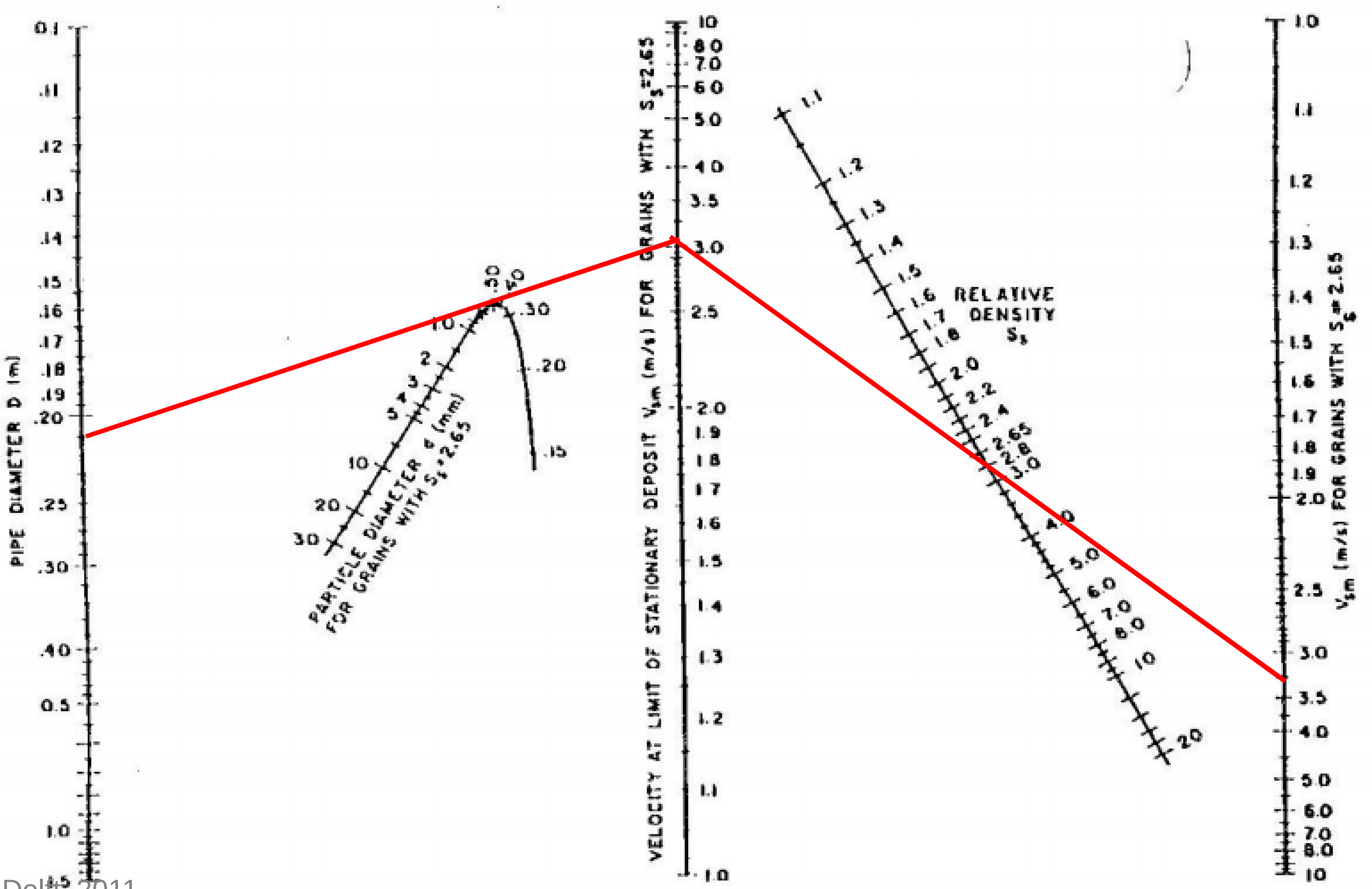
WILSON DIAGRAM



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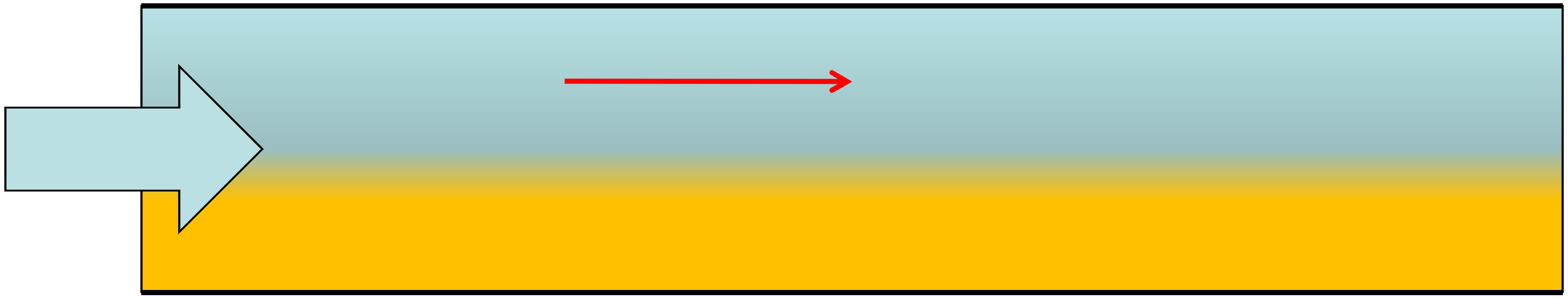
STRATIFIED MIXTURE FLOW IN A STRAIGHT PIPE



Increase of resistance due to:
-Settling of the particles
-Wall – particle interaction

} Influence of gravity

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CENTRIFUGAL FORCES ACTING ON MIXTURE ON A DRUM

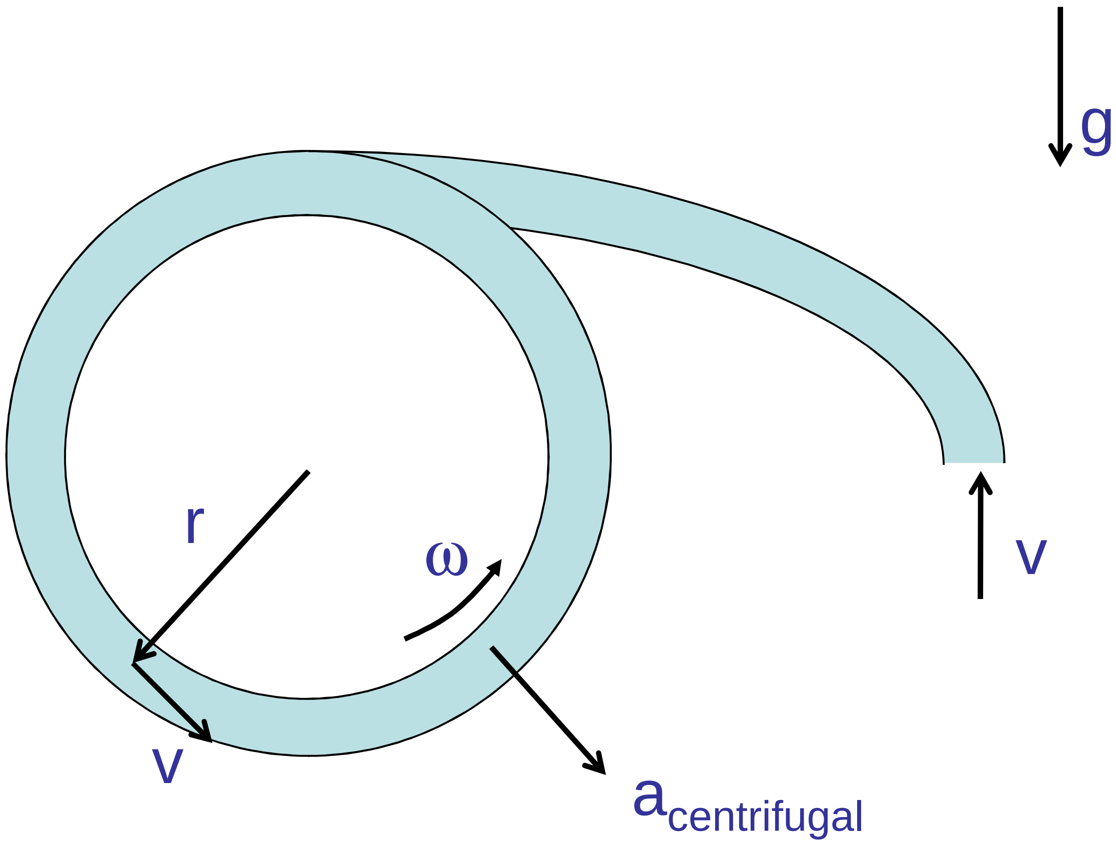
$v = 5$ m/s
$r = 1.5$ m

$\omega = v/r$

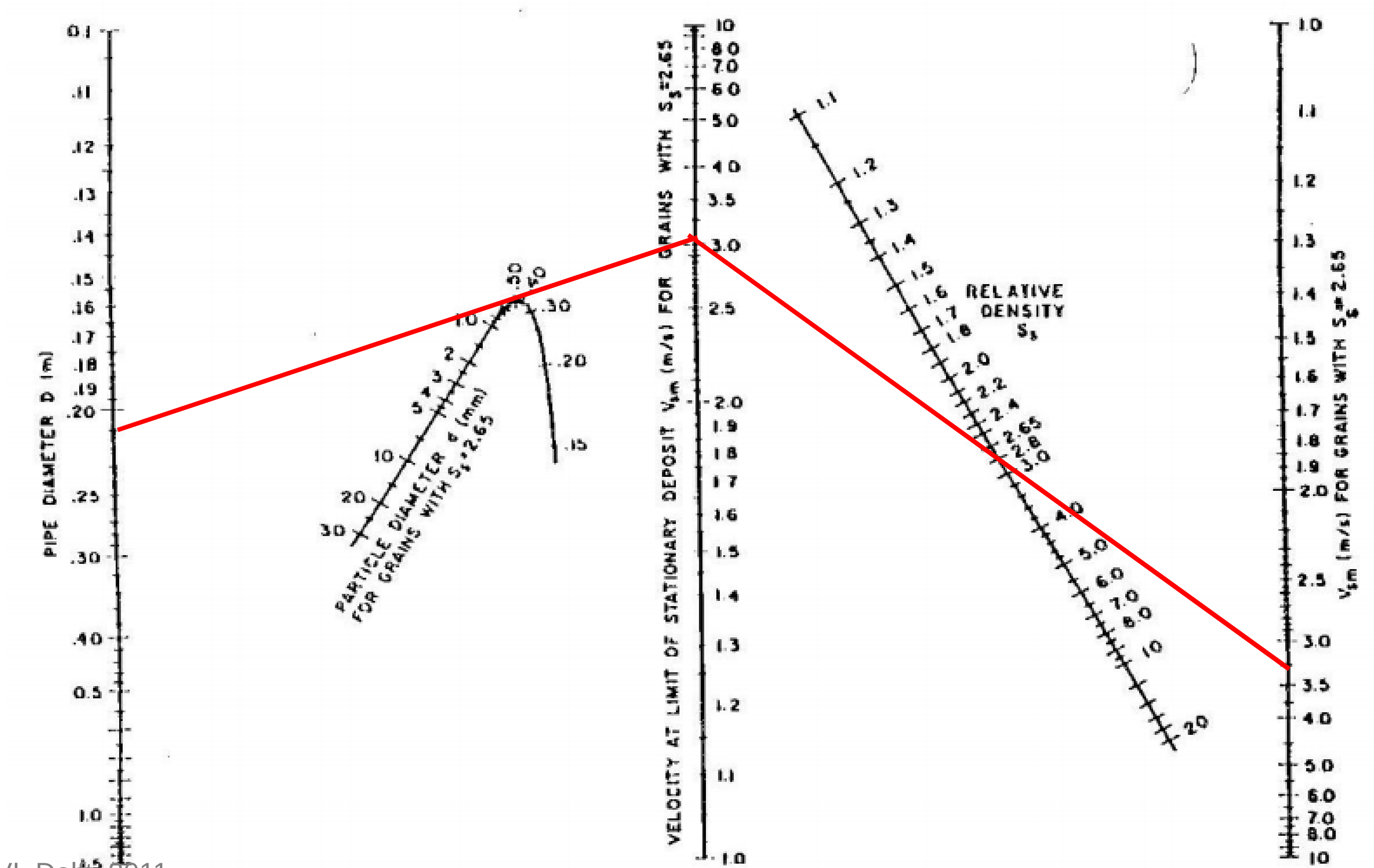
$\omega = 3.33$ rad/s

$a_{centrifugal} = r\omega^2$

$a_{centrifugal} = 16.7$ m/s^2



INFLUENCE OF GRAVITY ON WILSON DIAGRAM



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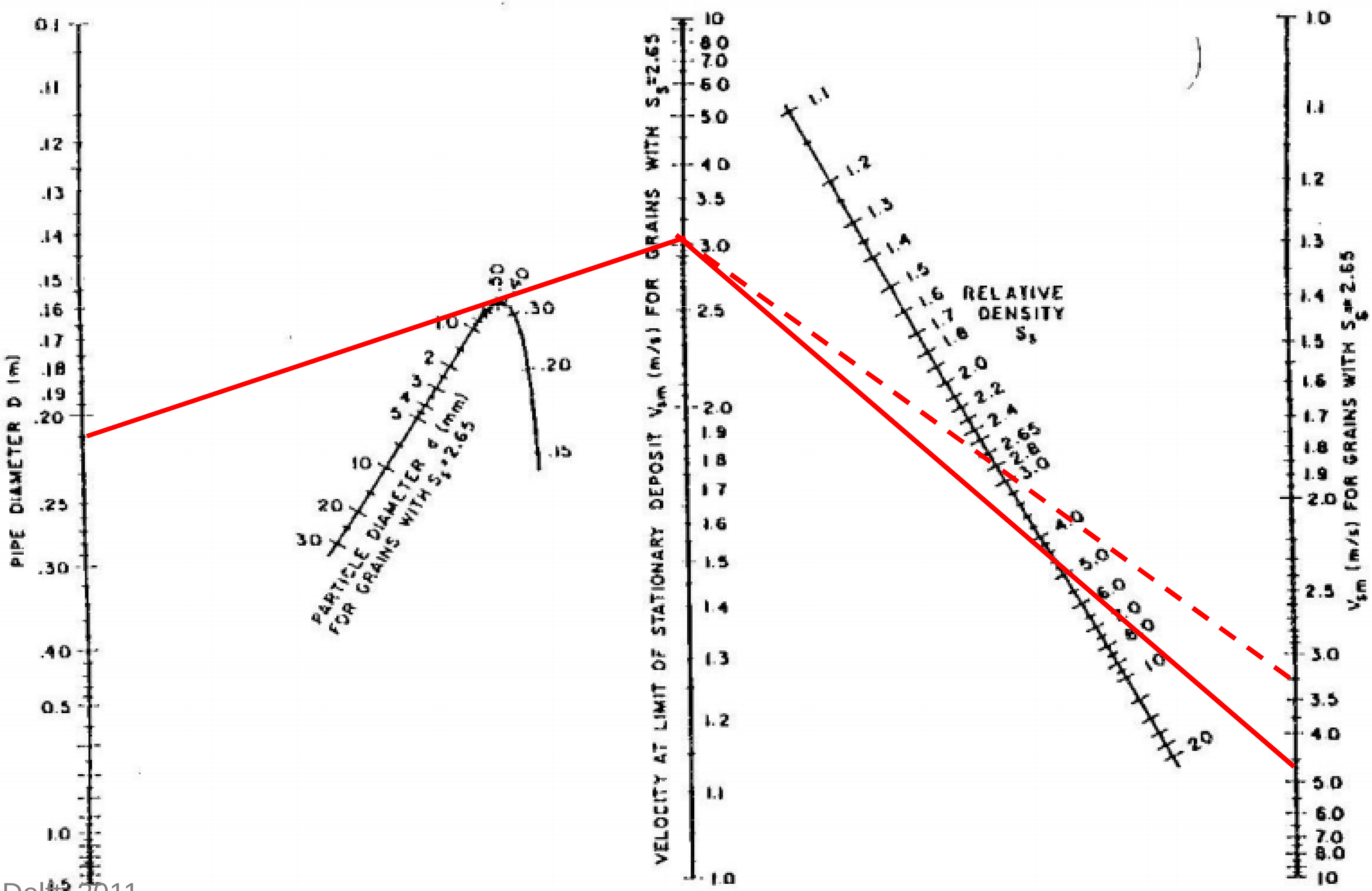
INFLUENCE OF GRAVITY ON WILSON DIAGRAM



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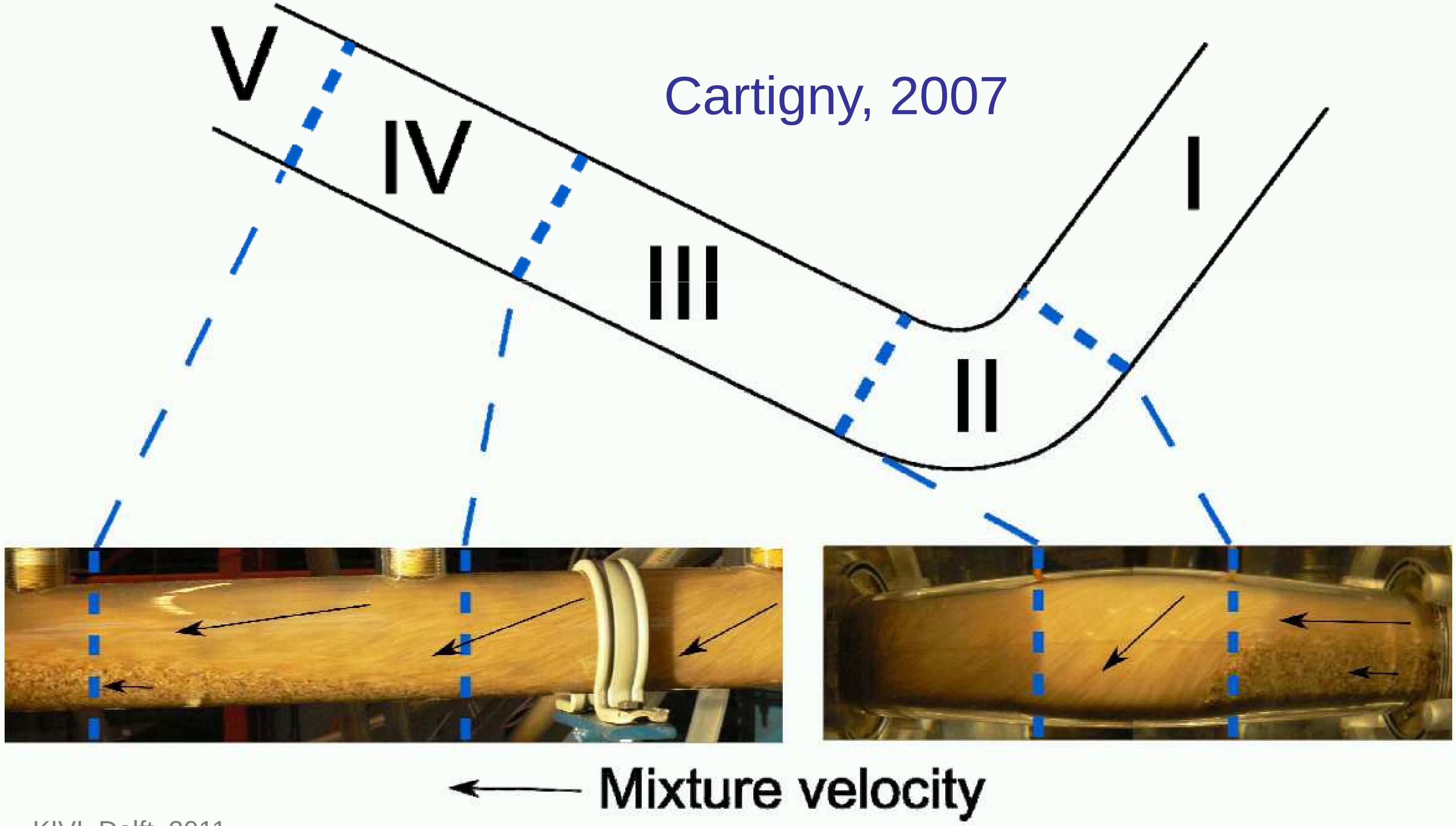
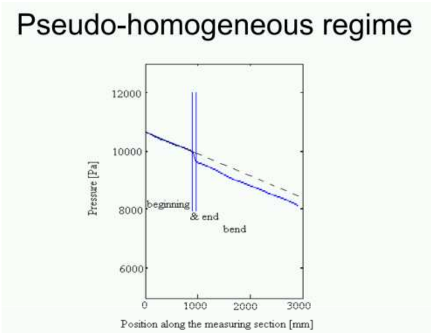
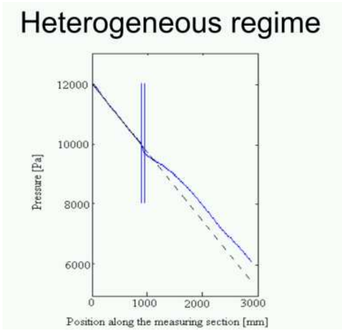
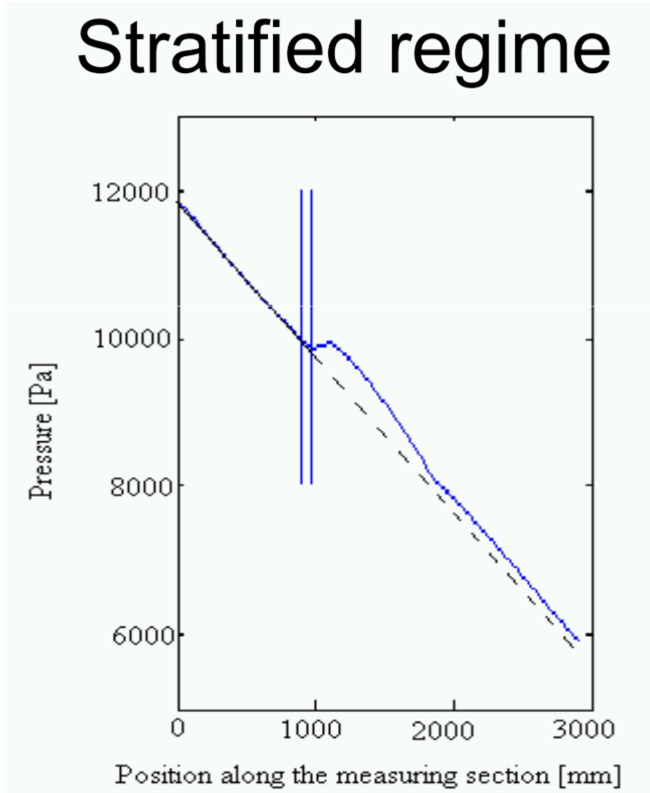
REMIXING OF STRATIFIED MIXTURE IN A 90° BEND



PRESSURE 'DROP' IN A 90° BEND







Cartigny, 2007

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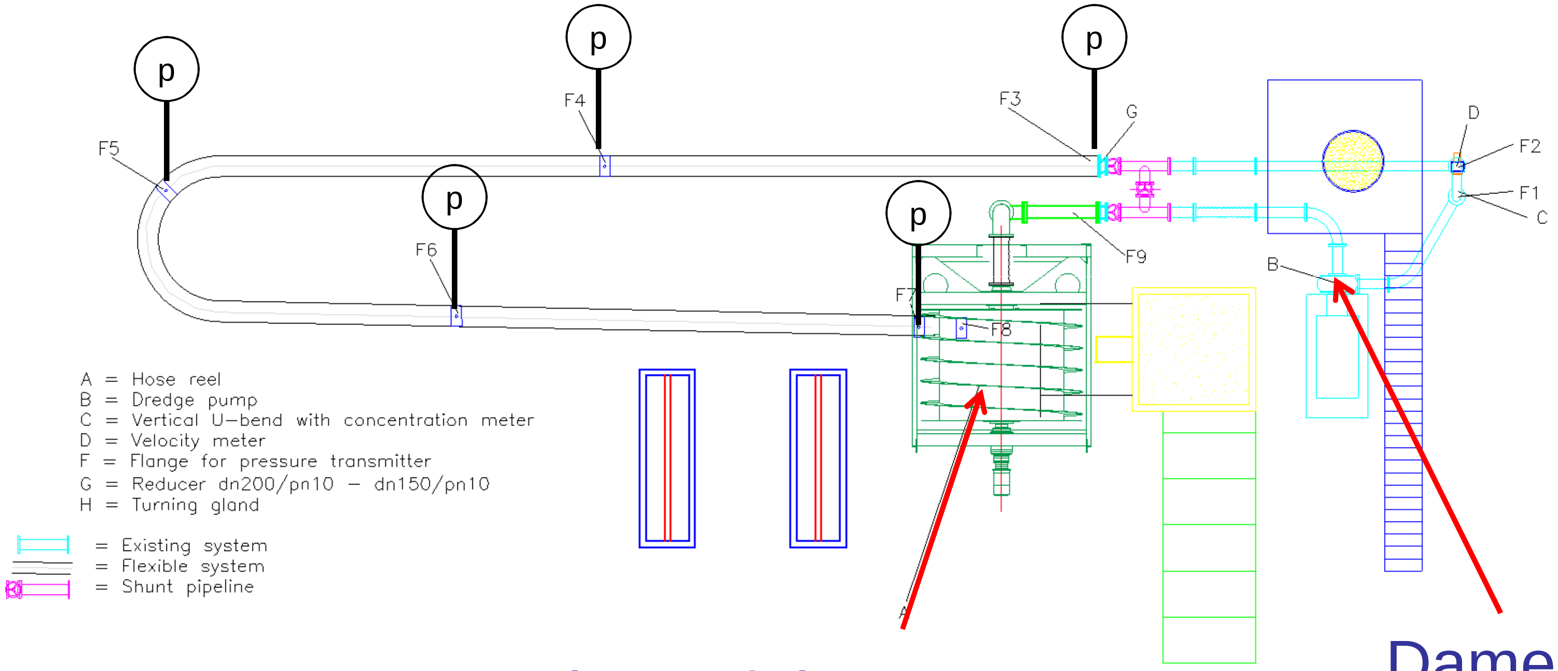
OVERVIEW TU DELFT TEST FACILITY



Scale model 3:1
of the hose reel

Damen
BP1515

TU Delft
Technische Universiteit Delft

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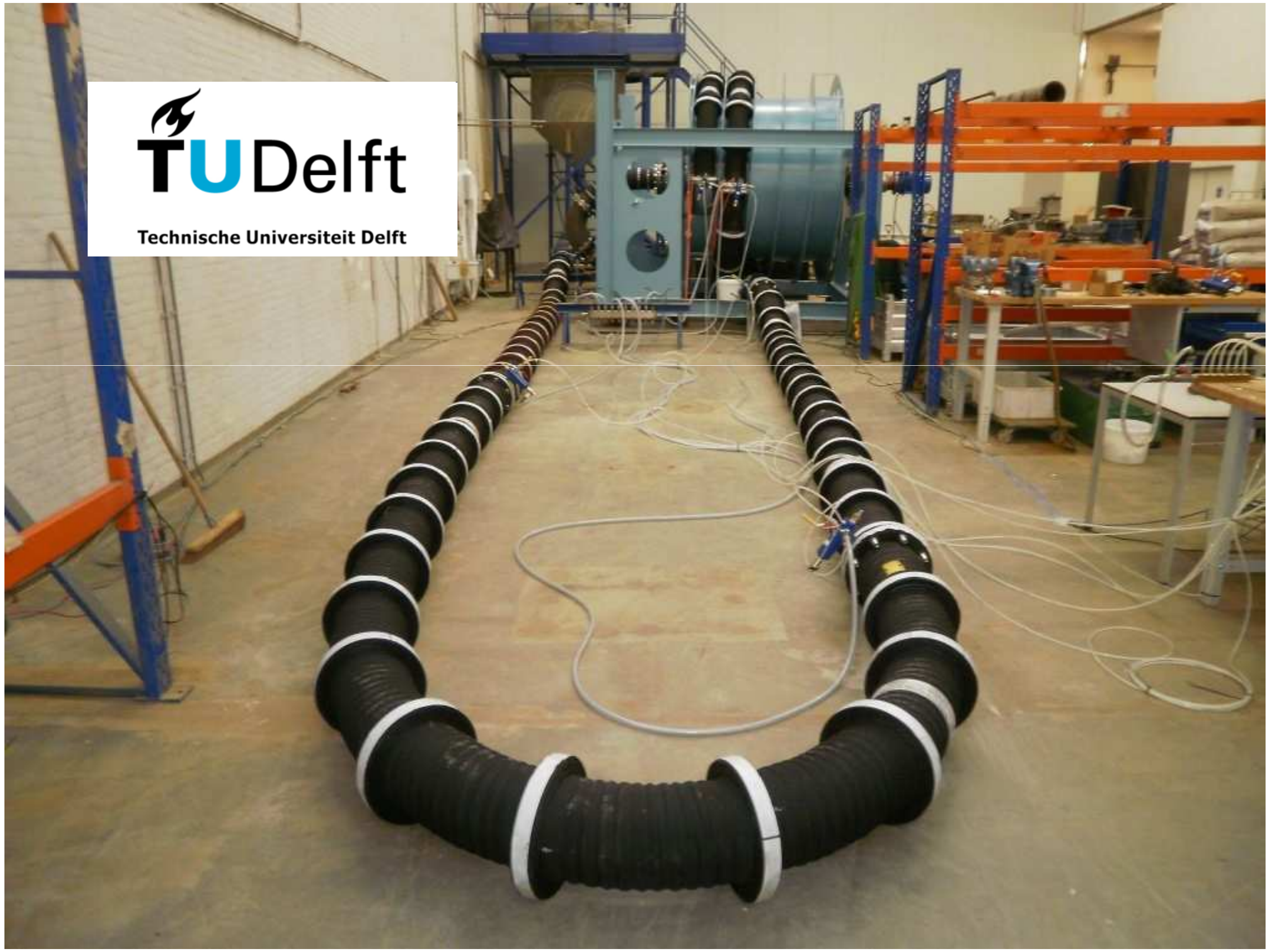
Dredging Equipment

VIEW TU DELFT TEST FACILITY



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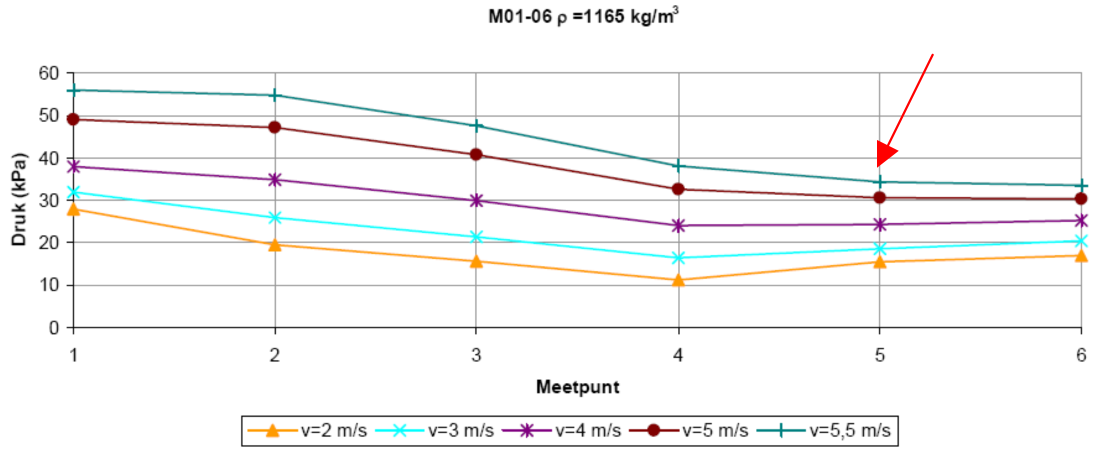
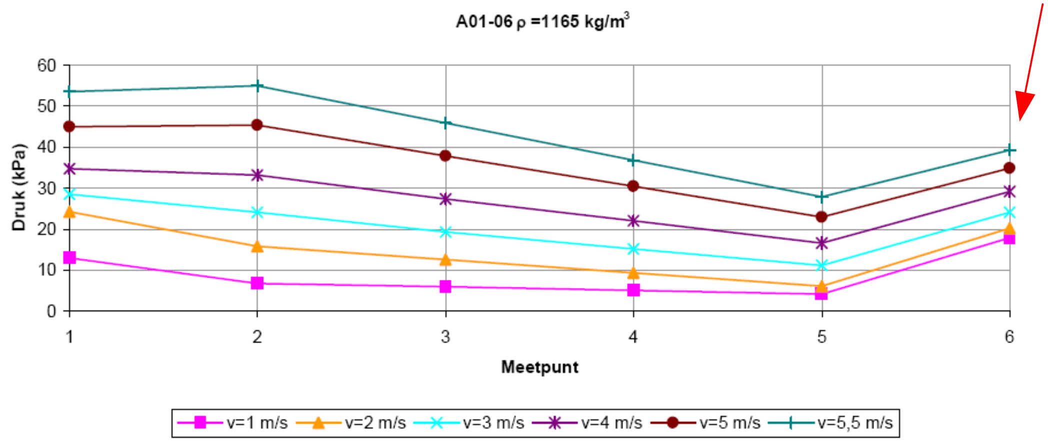
Dredging Equipment

PRESSURE ‘DROP’ IN LOOP ON DRUM





Effects of Cartigny were also measured in ‘repetitive bends’ or ‘loops on a drum’.

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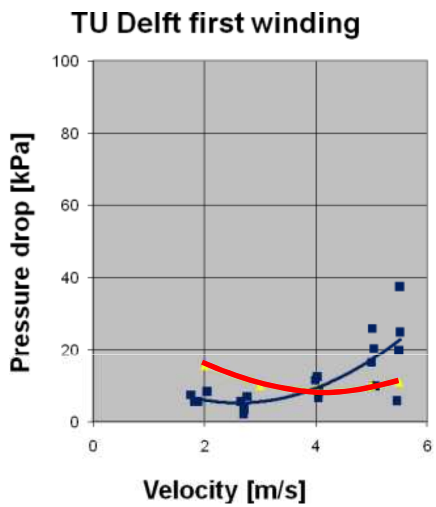
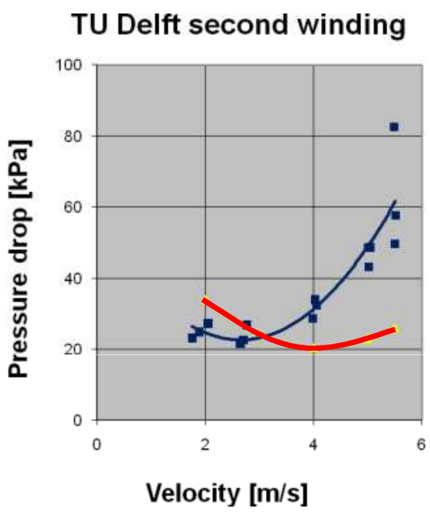
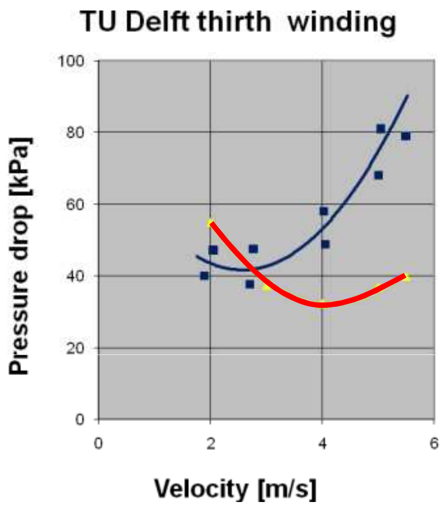
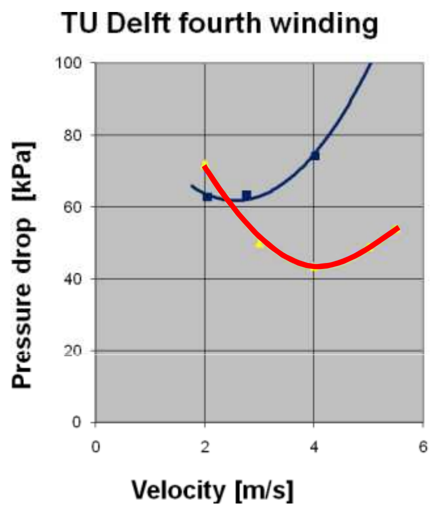
COMBINED EFFECTS ON RESISTANCE





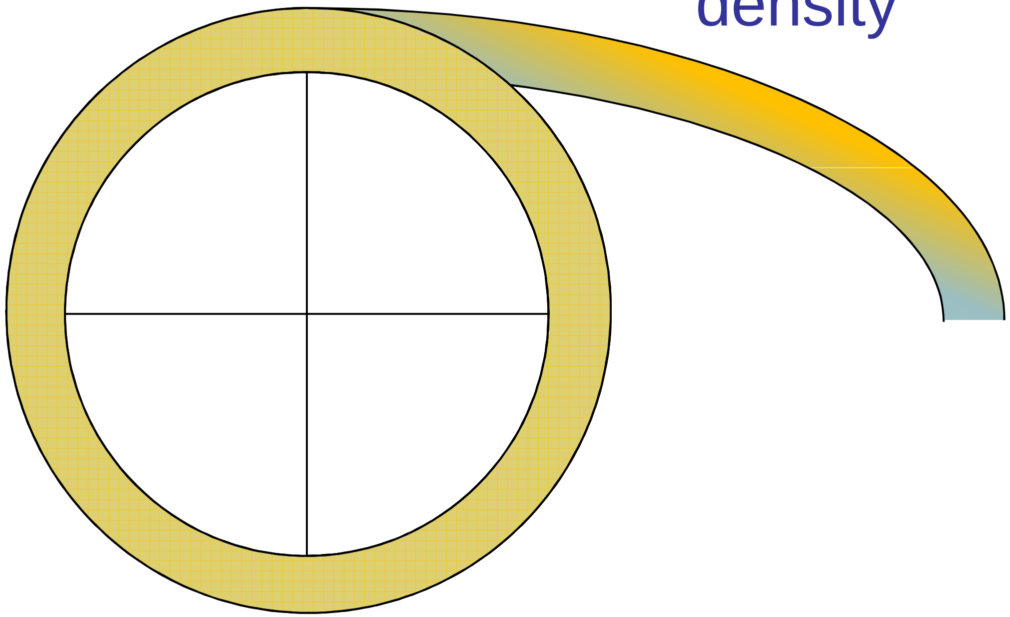




Combined effects on resistance:

- Increased base resistance due to geometry
- Increased resistance from higher ‘gravity‘
- Reduction of critical velocity due to remixing in loops

CRITICAL SITUATION



Mixture in loops on drum already under critical conditions

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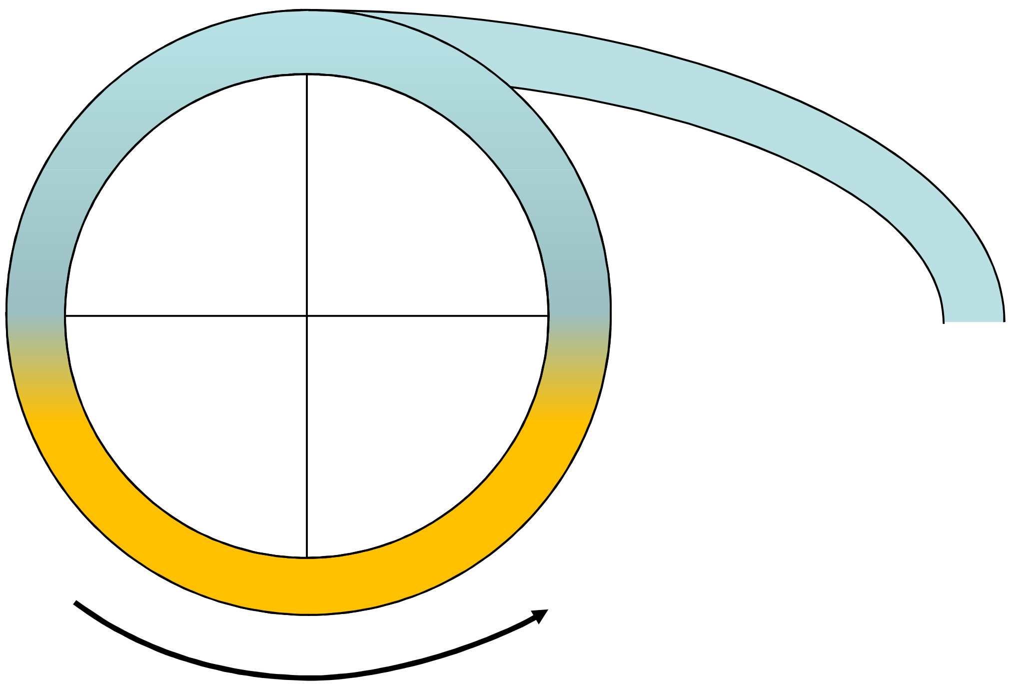
SETTLED SAND IN LOWER HALF OF LOOPS



Rotate half a turn

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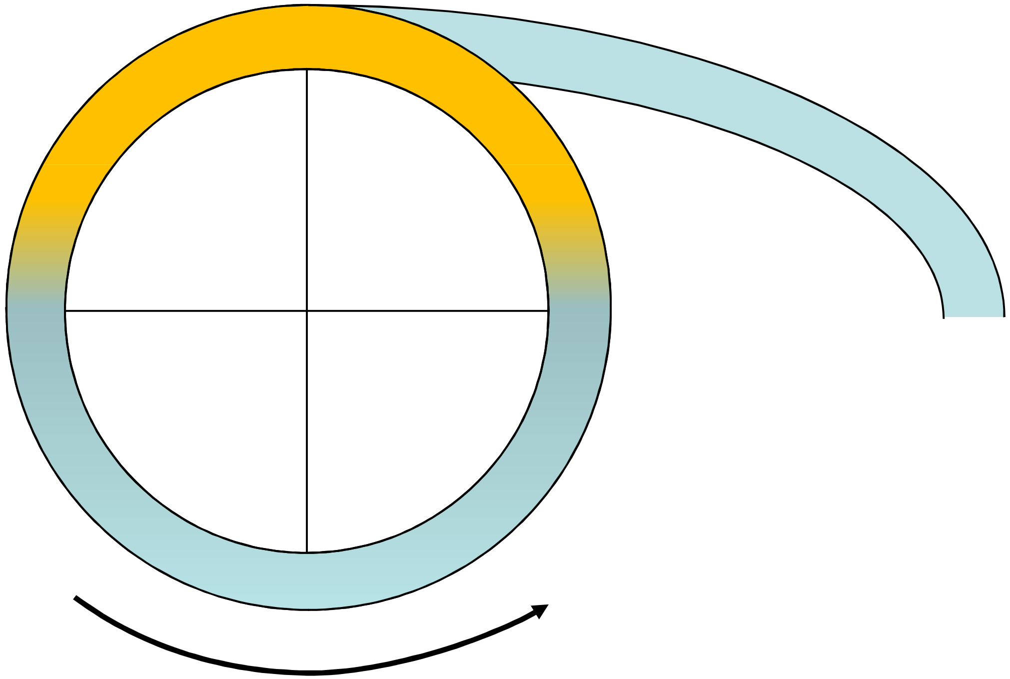
ROTATION OF DRUM



Rotate half a turn

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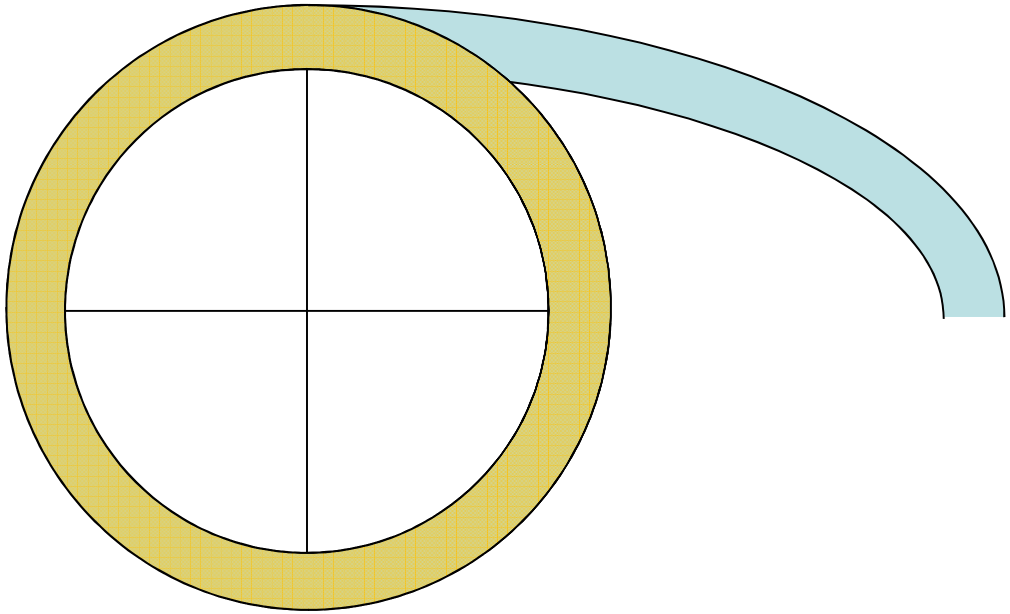
RESUSPENSION OF SEDIMENT



Sediment comes in suspension again

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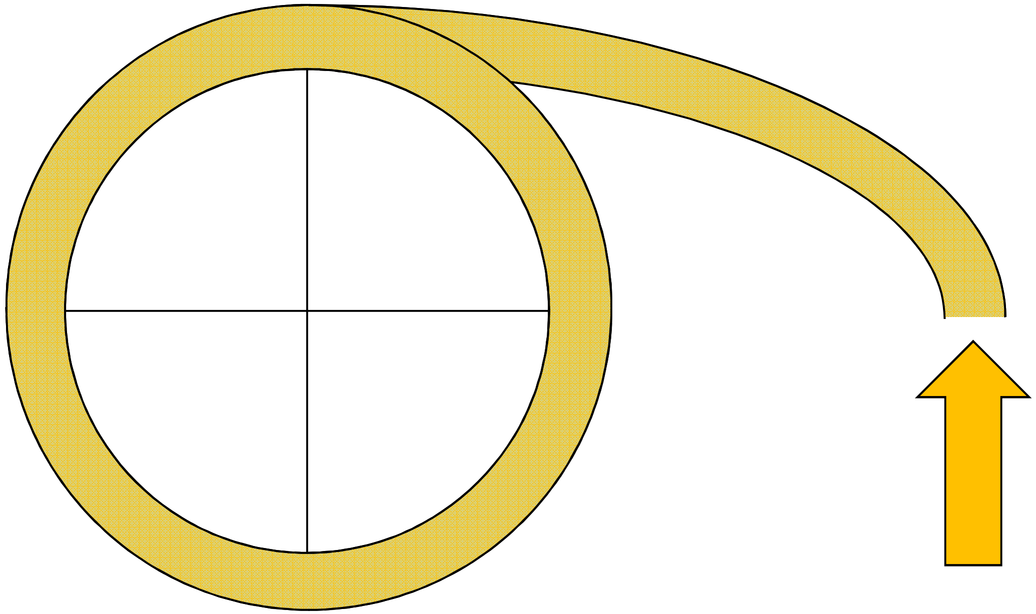

Continue dredging

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Dredging Equipment

USES OF THE PICK-UP UNIT

Spooling of dredge hose on the drum

Takes up the drag forces from the hose

Enables changing of the hoses at sea

Conclusion of the hose reel tests

- Influence of increased gravity is limited
- Repetitive loops resuspend mixture
- Further research on the Cartigny effect

- Blocked hose on reel is easily solved
- Provisions needed for handling at sea
- Reel strong enough for recovery

Does it work?

Mixture flow on reel

WEDA 2011

Barge loading & operations

CEDA 2011

Suspension & tracking

OMAE 2011

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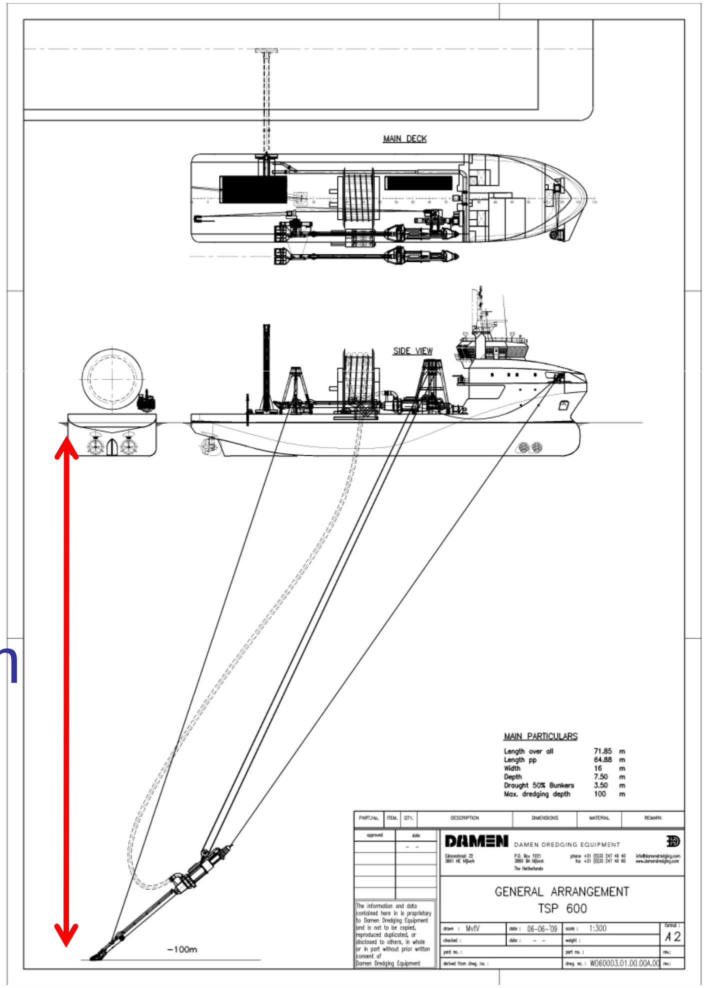
Dredging Equipment

REVOLUTIONARY DREDGING CONCEPT

200m



Roll on
Roll of

Dredge hose
on a reel

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CONTROL BY WIRE SUSPENSION

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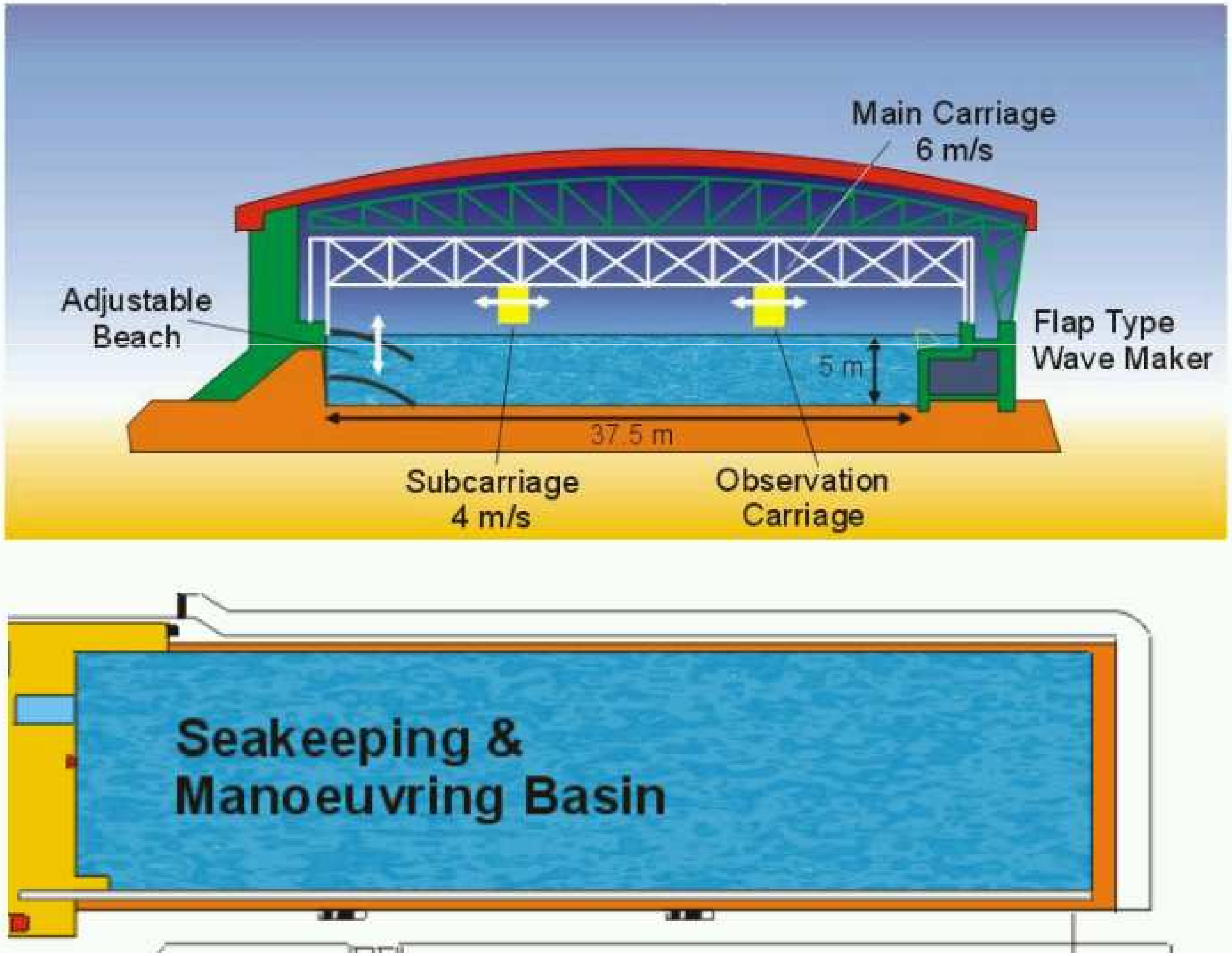
MARIN TEST FACILITY



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SCALE MODEL OF THE PLATFORM SUPPLY VESSEL

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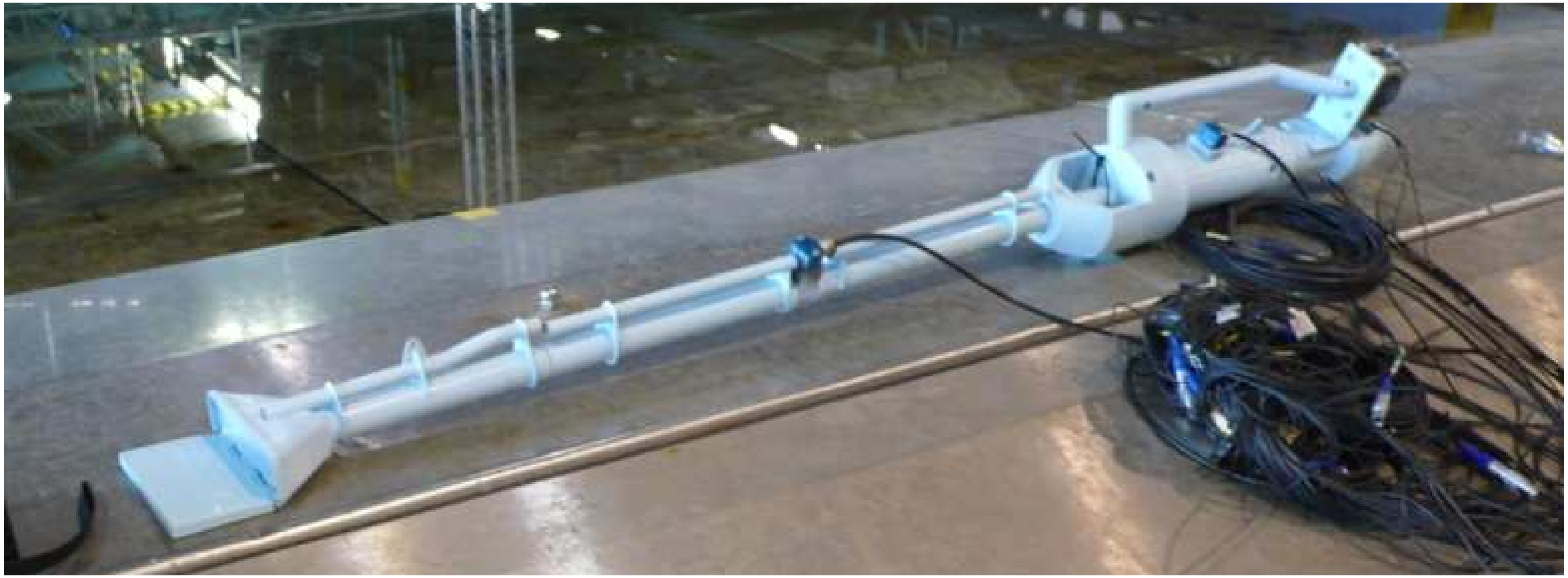
DETAIL OF THE HOSE ATTACHMENT FORCE GAUGE

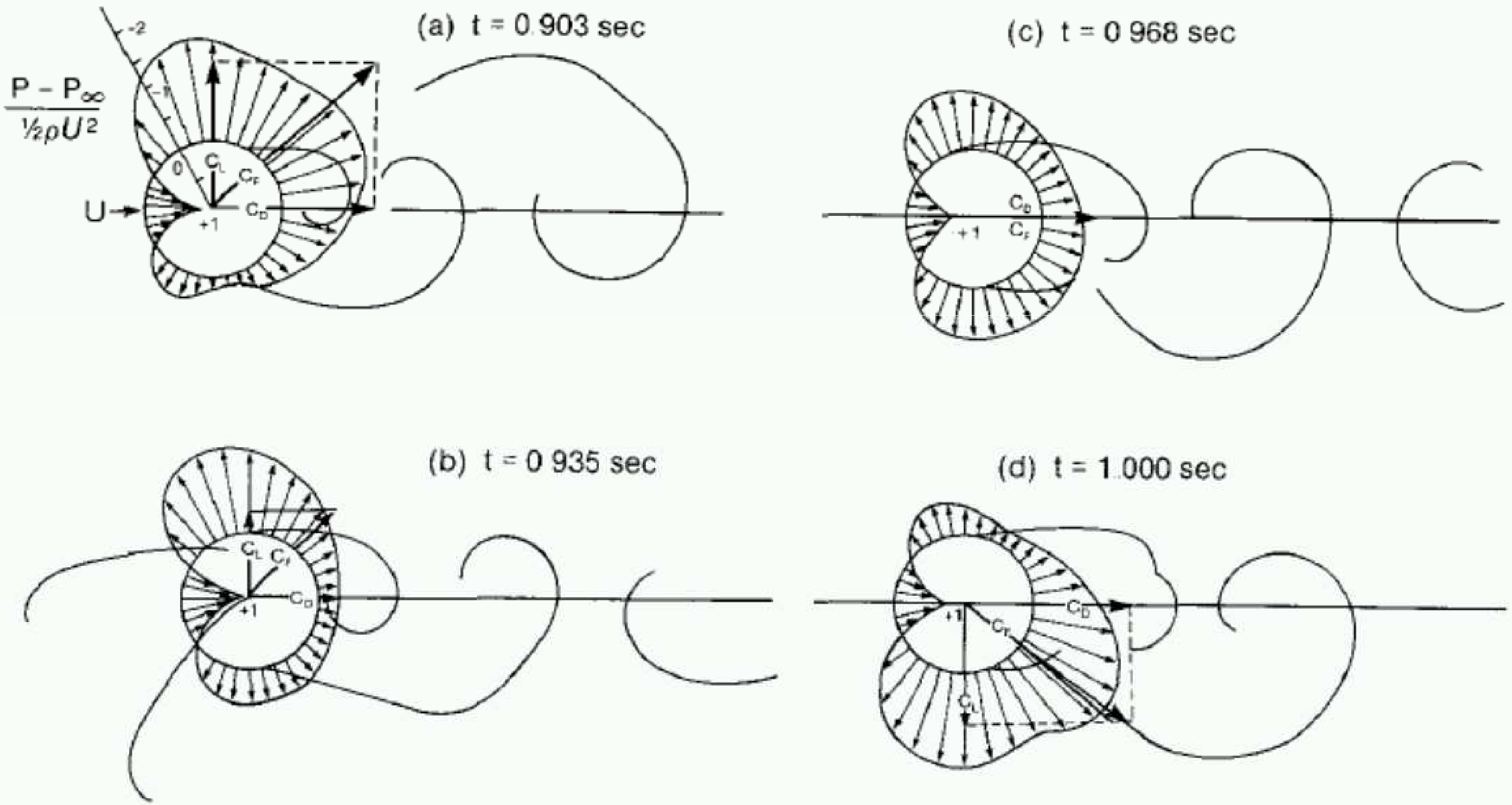
SCALE MODEL OF SUBMERGED DREDGE UNIT



WORK PACKAGE OBJECTIVES

Topics addressed in these tests

- VIV Analysis dredge hose
- Hose and line, motions and forces
- Dredge track accuracy
- Modeling of test results for engineering



Pressure distribution around the cylinder changes due to vortex-shedding

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MECHANICAL PROPERTIES TEST TRELLEBORG

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SCALE MODEL OF DREDGE HOSE

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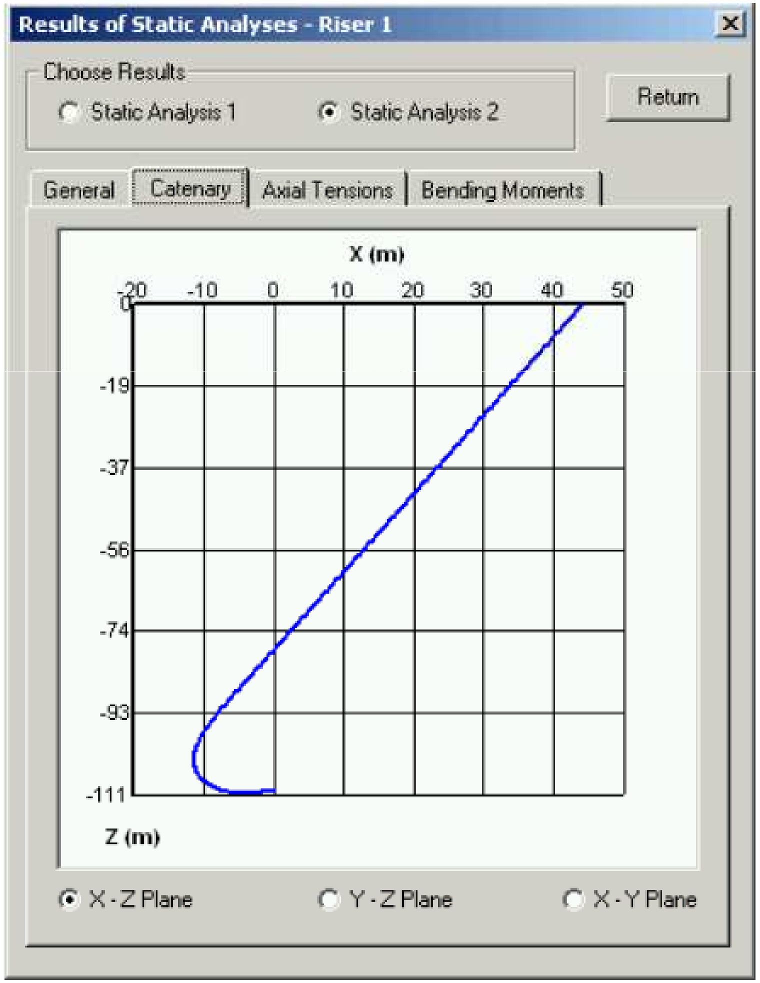
VIV ARRAY INPUT



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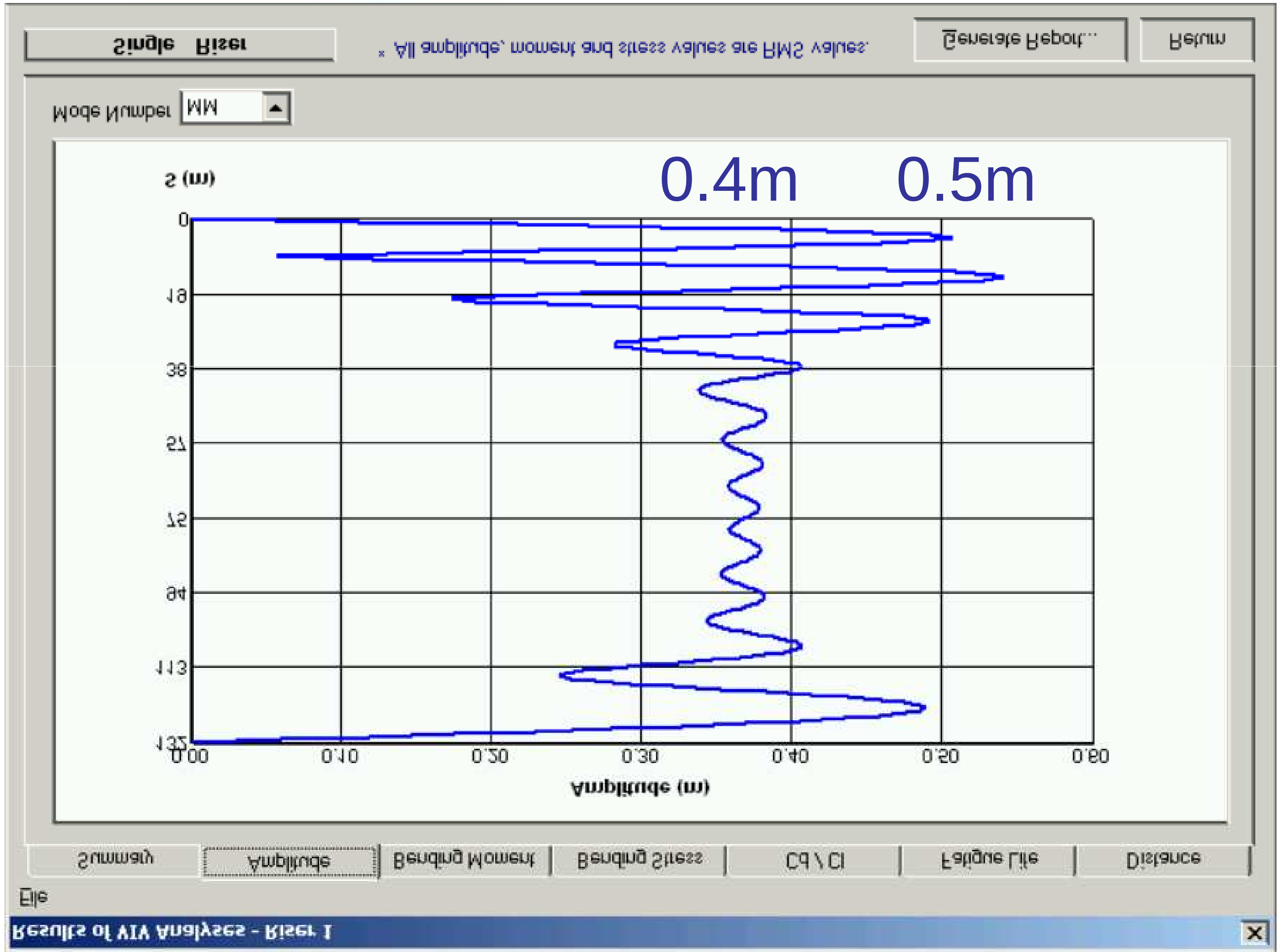
MARIN

VIV ARRAY RESULTS



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VIV MEASUREMENTS

Speed	f_measured	f_Strouhal
2 knot	0.20 Hz	0.27 Hz
3 knot	0.30 Hz	0.40 Hz
4 knot	0.35 Hz	0.53 Hz

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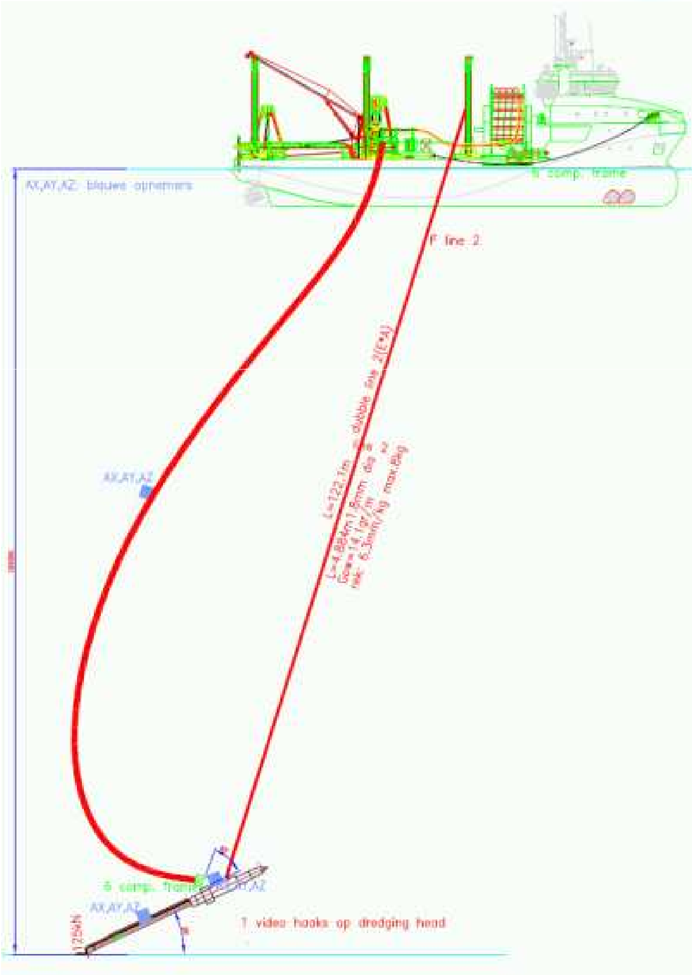
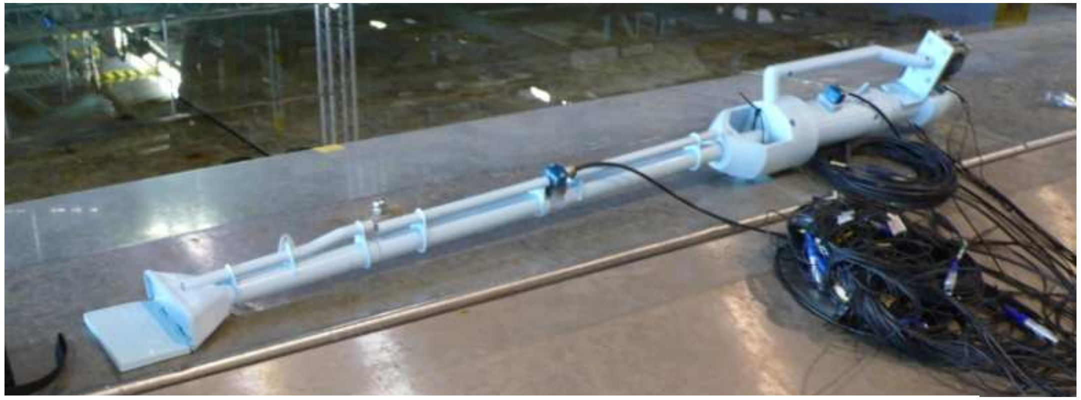
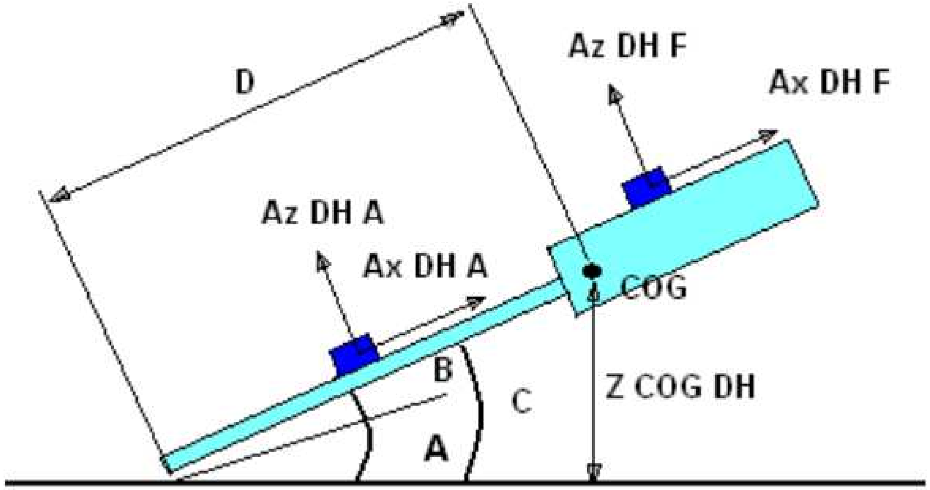
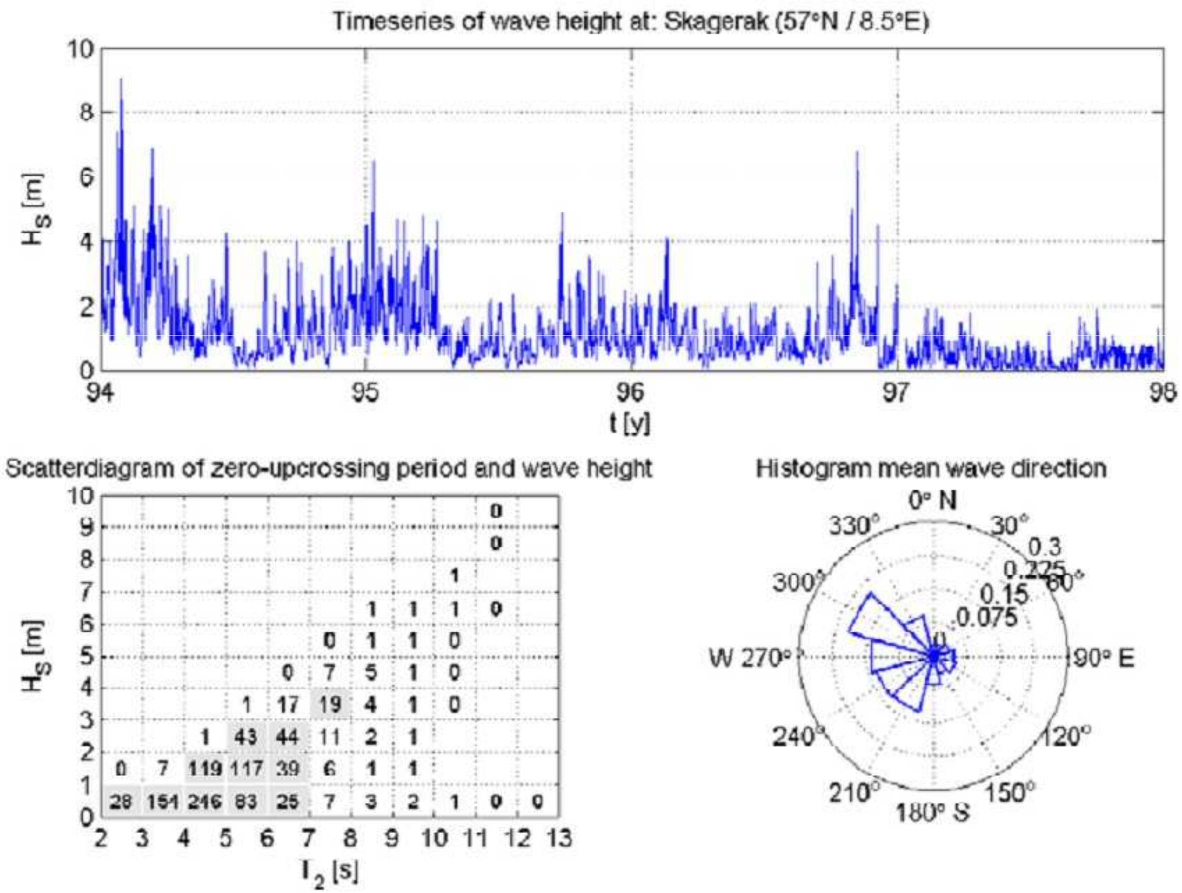
SCALE MODEL OF UNDER WATER UNIT







SEA STATES OF SELECTED DREDGING AREAS



MEASURED LINE FORCES

TEST NO.	Hose Length	V SHIP	TOT THRUST kN	FX HOSE	FY HOSE	FZ HOSE	MX HOSE	MY HOSE	MZ HOSE
[-]	[m]	[knots]	MEAN [kN]	MEAN [kN]	MEAN [kN]	MEAN [kN]	MEAN [kNm]	MEAN [kNm]	MEAN [kNm]
302007	132	1.90	126	-92	2	-287	68	67	-2
302008	132	2.98	205	-148	-3	-274	86	98	-29
302004	132	3.96	298	-213	3	-236	213	175	-37

Forces and increase with increase speed, however the forces and moments are also depended on the shape and position the hose takes.

Pitch angle can be used as a control parameter for the behaviour of the under water unit.

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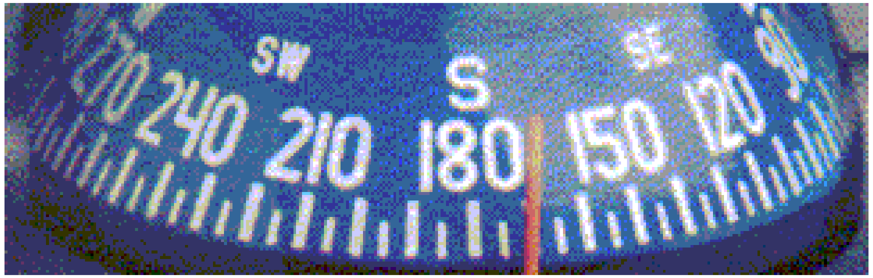
COURSE KEEPING



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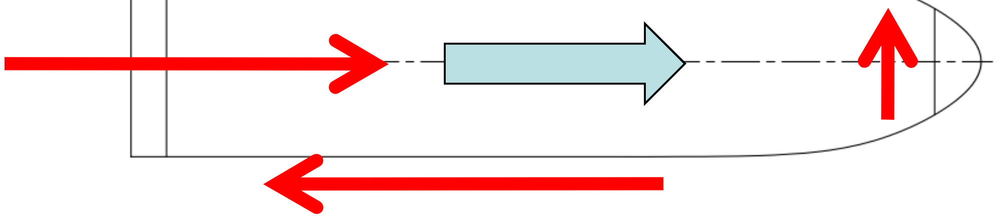

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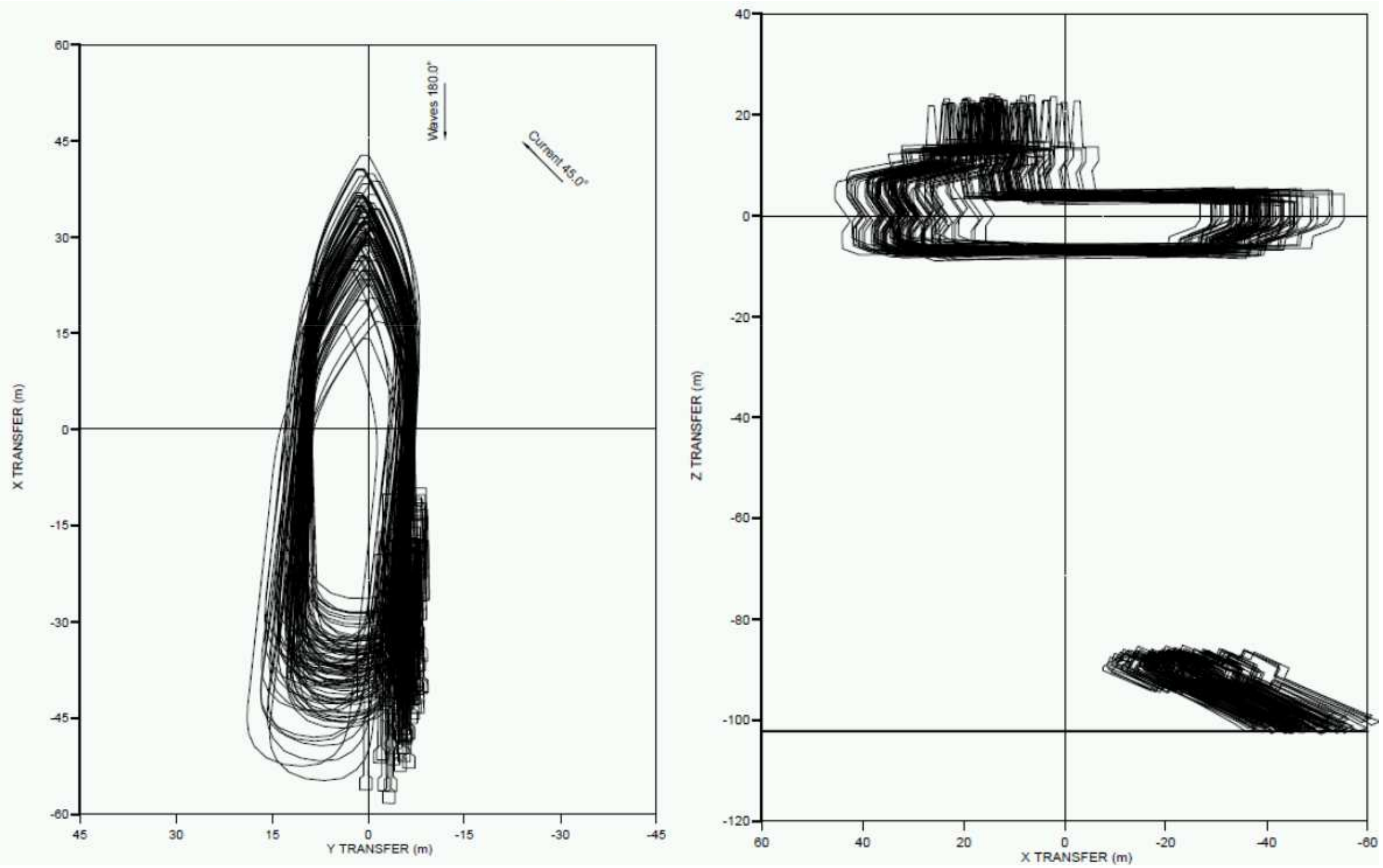
aNySIM ANALYSIS STATION AND COURSE KEEPING



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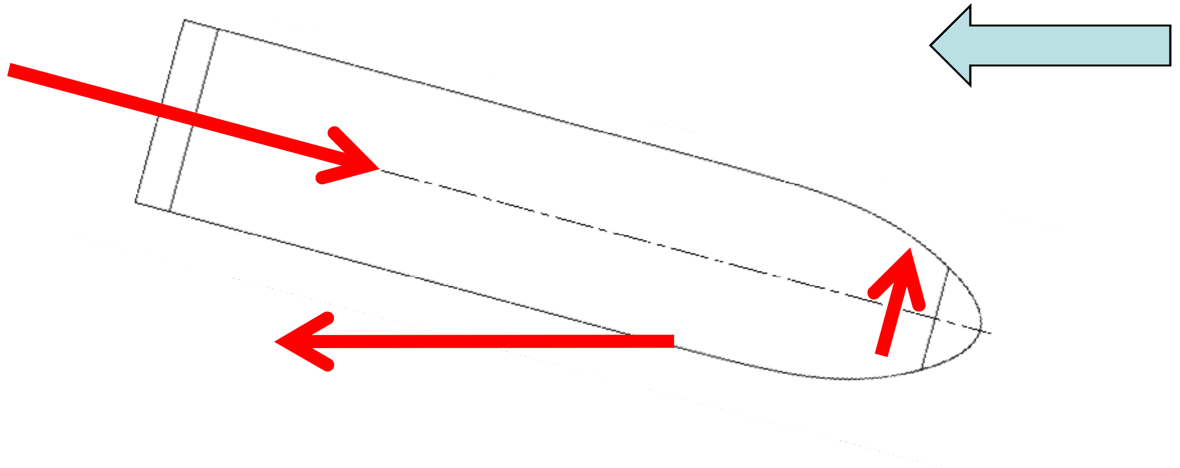
aNySIM RESULTS COURSE KEEPING



aNySIM: Vessel stationary, water moves

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MODEL TEST SET UP IN SMB

Dredging Equipment

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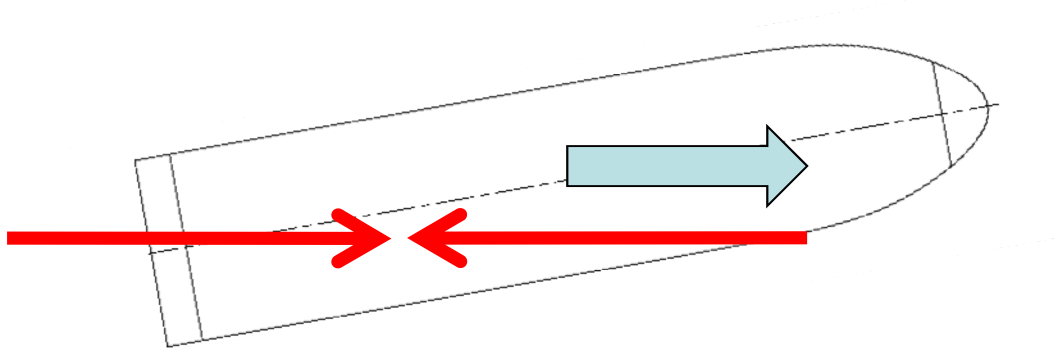
MODEL TEST RESULTS COURSE KEEPING



SMB: Water stationary, vessel moves

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DREDGE TRACK TESTS

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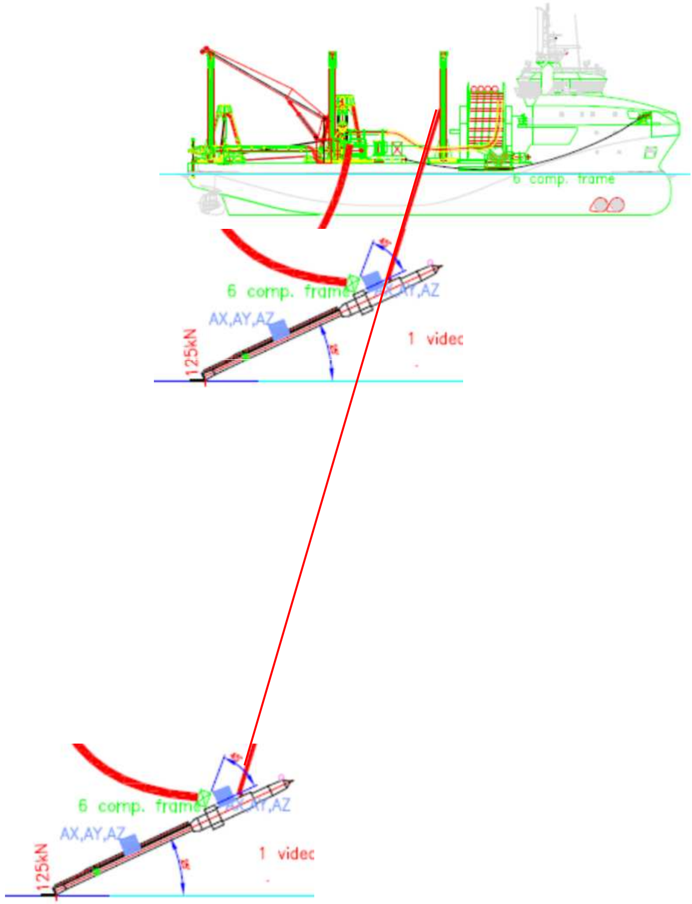
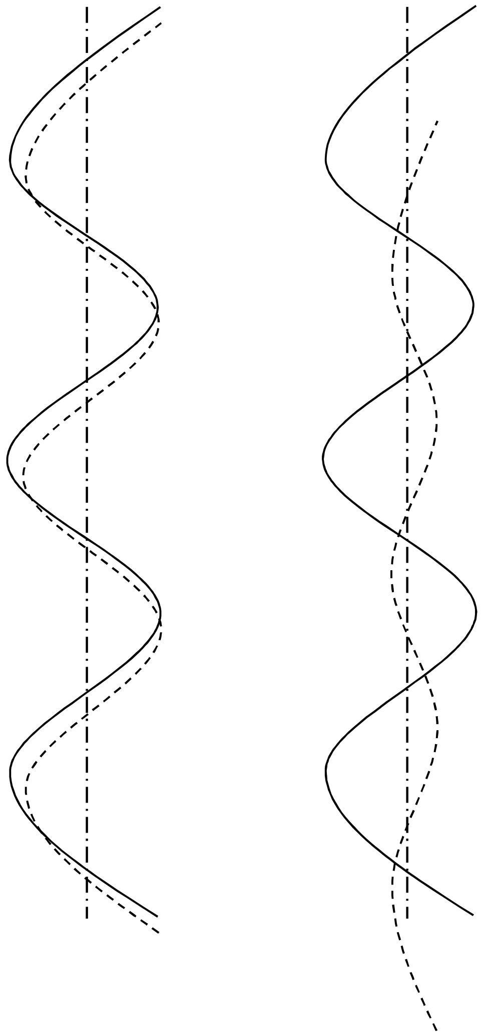
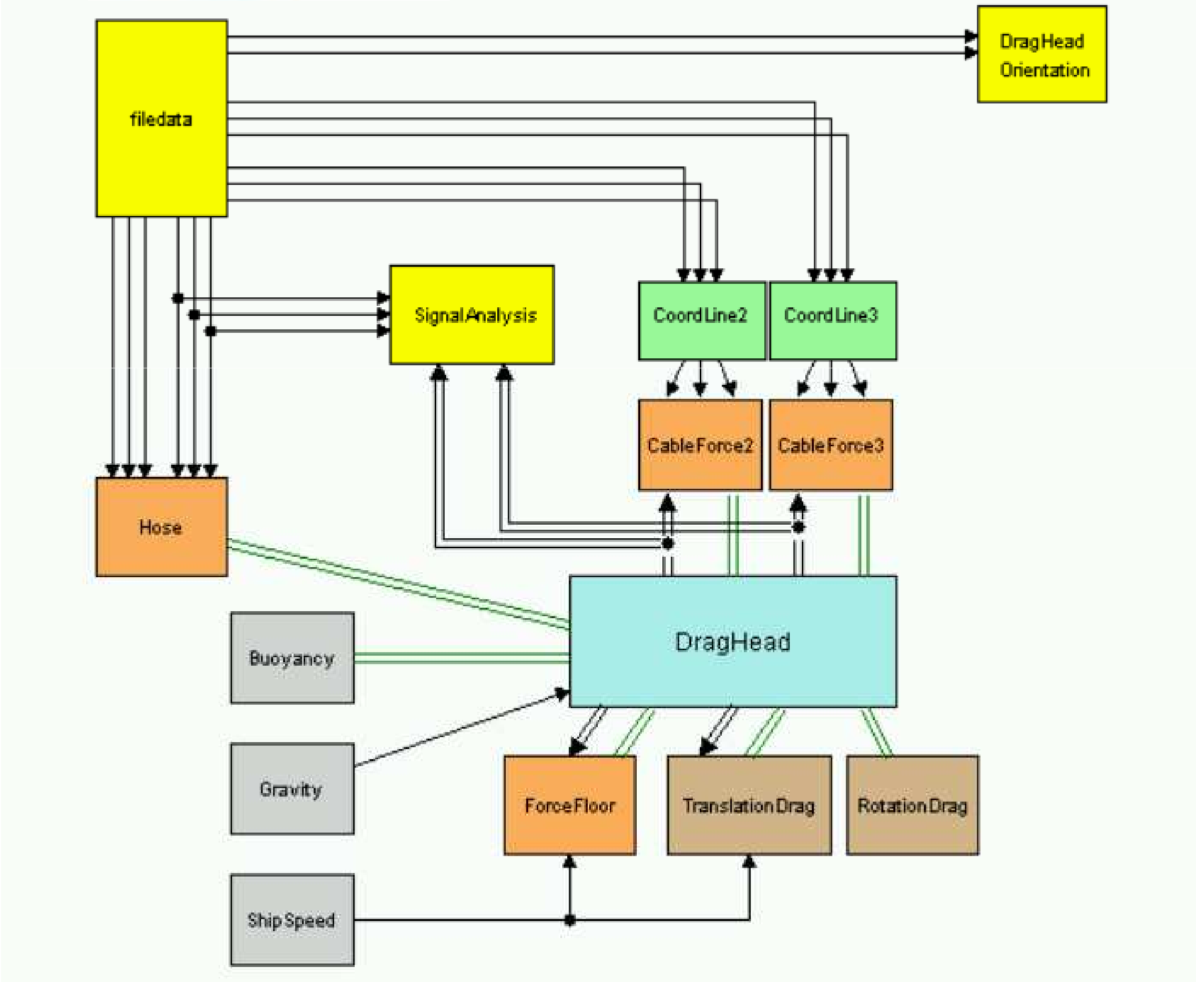
FOLLOWED TRACK PATTERN





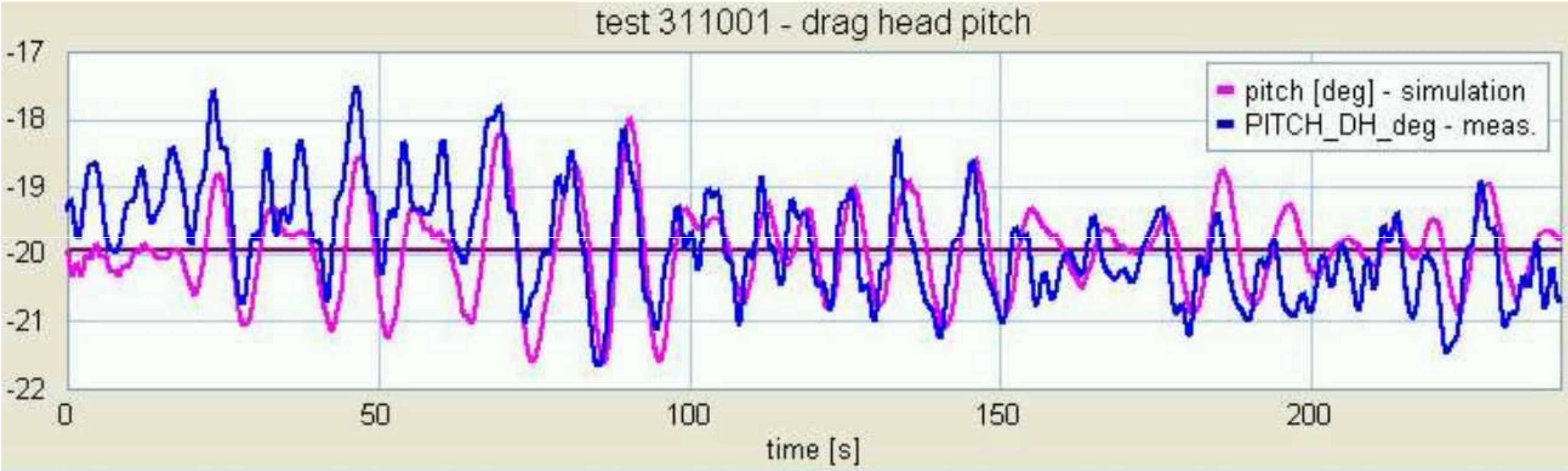
New Approach of Deep Sea Dredging

REDUCED ORDER ENGINEERING MODEL



New Approach of Deep Sea Dredging

REDUCED ORDER MODEL RESULTS



Application of Reduced Order Modeling for Design of Interacting Maritime Structures
Jan Holterman et al OMAE2011-49260
Tuesday June, 21st: Session 6-2 Marine Vehicles and Structures - I

Conclusions suspension & tracking tests

- VIV will occur, but is manageable
- Suspension forces are engineerable
- Pitch angle to control behaviour of unit
- Course keeping is normal as for TSHD’s
- Track accuracy comes naturally
- Engineering model is reliable

Dredging Equipment

New Approach of Deep Sea Dredging

IMPROVED WIRE CONTROL AND SUSPENSION

Does it work?

Mixture flow on reel

WEDA 2011

Dredging & hose vibrations

OMAE 2011

Barge loading
& operations

CEDA 2011

DAMEN

New Approach to Deep Sea Dredging

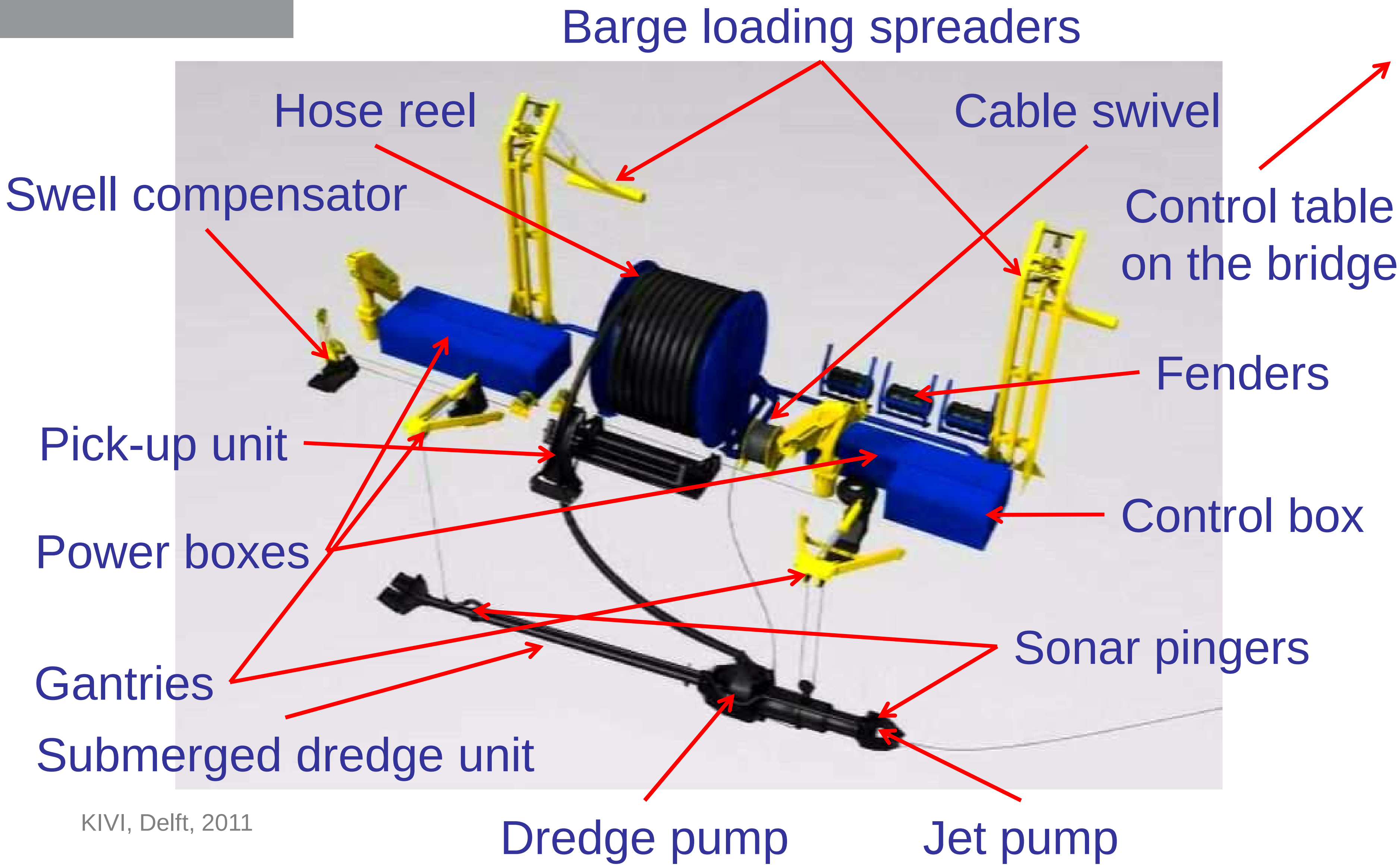
Dredging Equipment

DISCHARGING AND SIDE BY SIDE MANEUVRING TESTS

New Approach of Deep Sea Dredging

Dredging Equipment

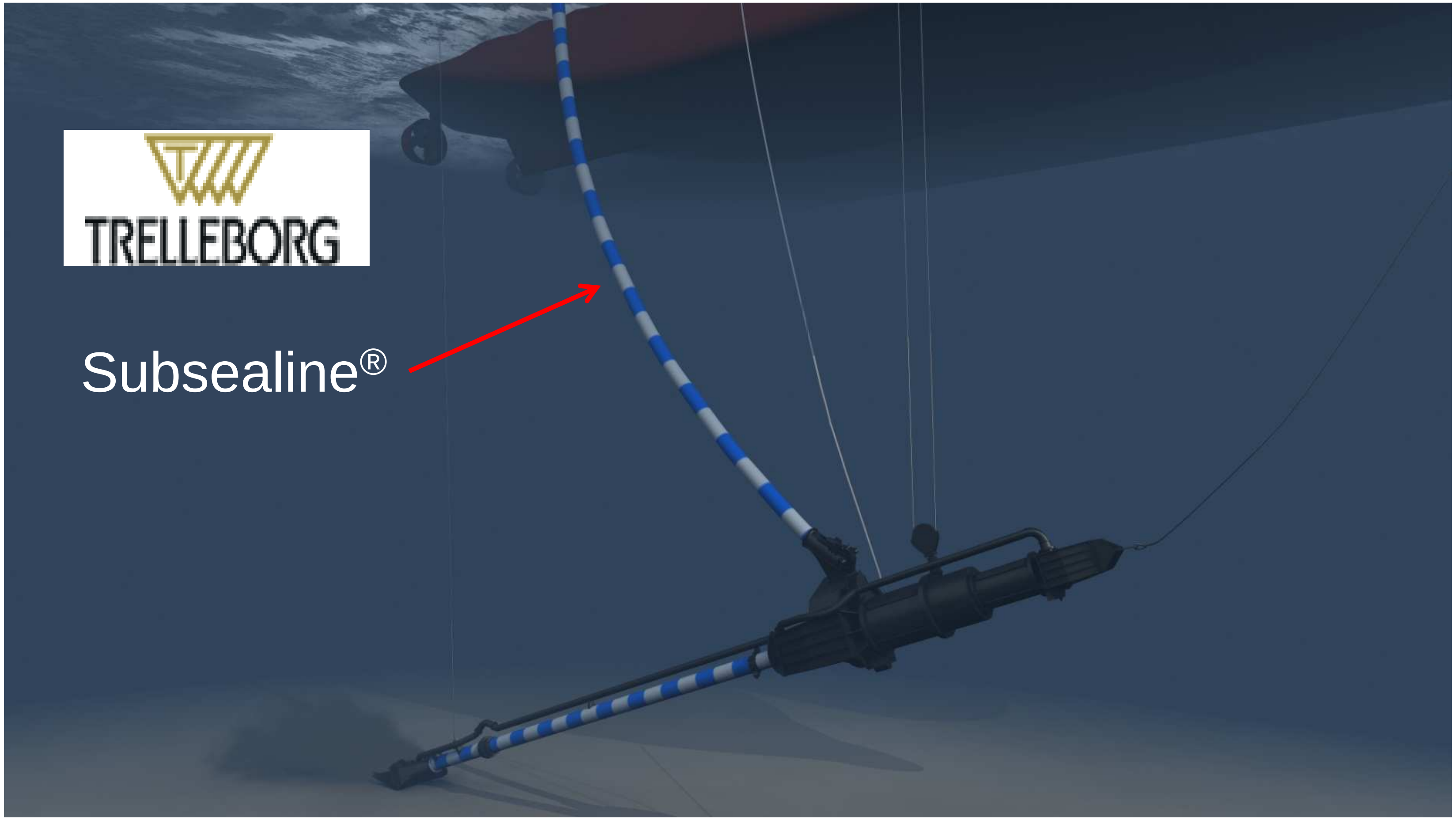
PRINCIPAL COMPONENTS OF THE RORO DEEP DREDGE SYSTEM



New Approach to Deep Sea Dredging

Dredging Equipment

DEDICATED NEW PRODUCT



New Approach to Deep Sea Dredging

Dredging Equipment

PROTOTYPE PRODUCTION TRELLEBORG

New Approach to Deep Sea Dredging

Dredging Equipment

PRINCIPAL SPECIFICATIONS

Nominal diameter	Ø600mm
Maximum dredging depth	200m
Pump type	BP6055HD
Installed power	5000kW
Reel drum diameter	8m
Storage on drum	225m
Possible sand capacity	2500m^3/h

New Approach to Deep Sea Dredging

ADVANTAGES

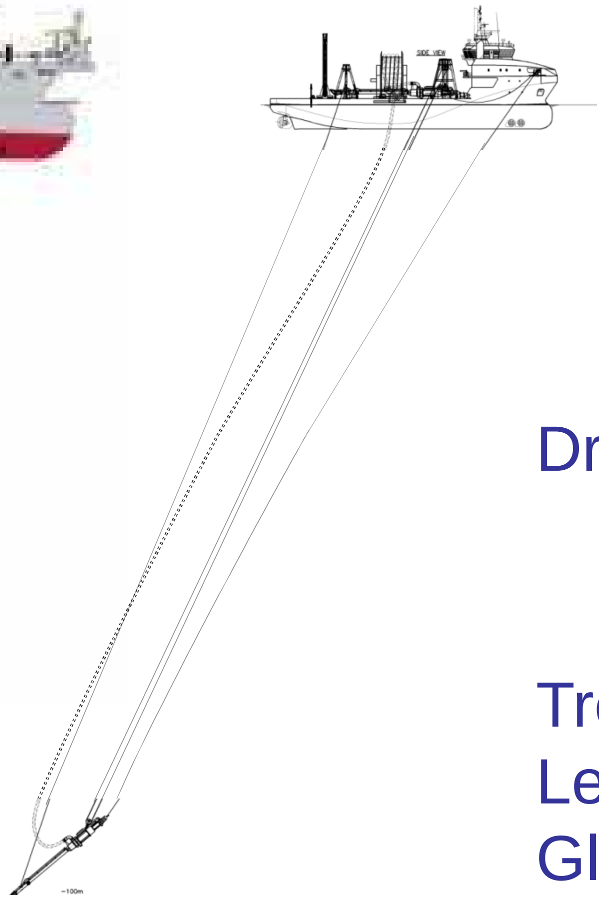
- Dredging depth up to 200 mtr
- Modulair dredging equipment, can be installed on several platforms
- Well known system elements, minimal adaptation
- Segregation of dredging & transport cycle, resulting in less costs/m^3
- Continues cycle, no interuption in the dredging process, no sailing time
- Low investment costs (Platform, Barge & tugs for rental: no direct investment costs)
- Optimum use of invested capital

SELL THE IDEA

New Approach of Deep Sea Dredging

Dredging Equipment

COMPARE THESE PICTURES



Dredging

↓

Trenching
Leveling
Glory holes
Sampling

AVAILABLE ANIMATION

DAMEN

www.damendredging.com

Or

YouTube

Youtube: damendredgingcom

http://www.youtube.com/watch?v=cG6DfjXNoeE

New Approach to Deep Sea Dredging

Dredging Equipment

DAMEN RORO DEEP DREDGE SYSTEM COMBINATION

KIVI, Delft, 2011

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YOUR JOB, OUR TOOLS

New Approach to Deep Sea Dredging

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