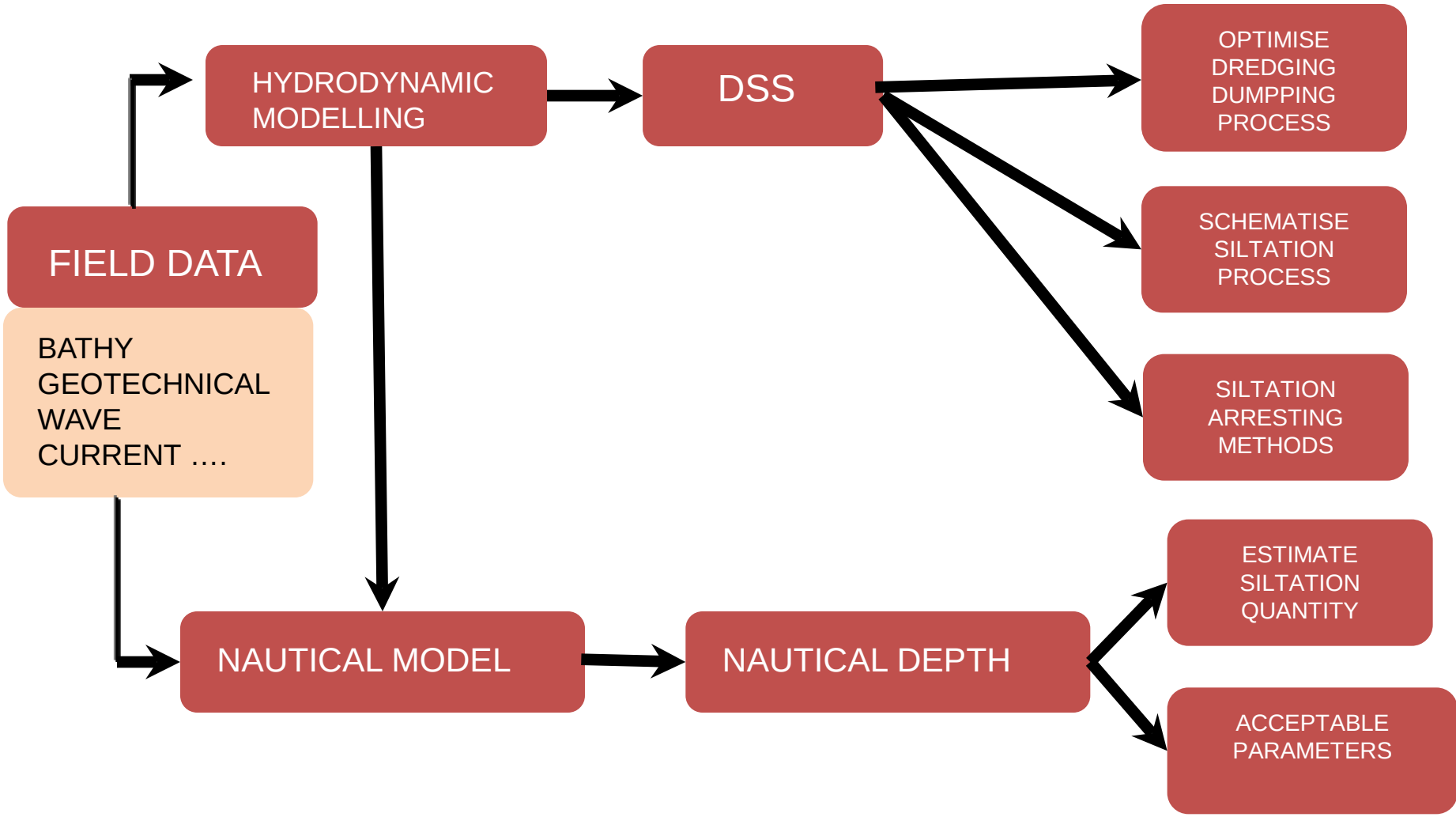
STUDY OF SILTATION & ESTABLISHING NAUTICAL DEPTH IN

COCHIN PORT

13-Oct-17

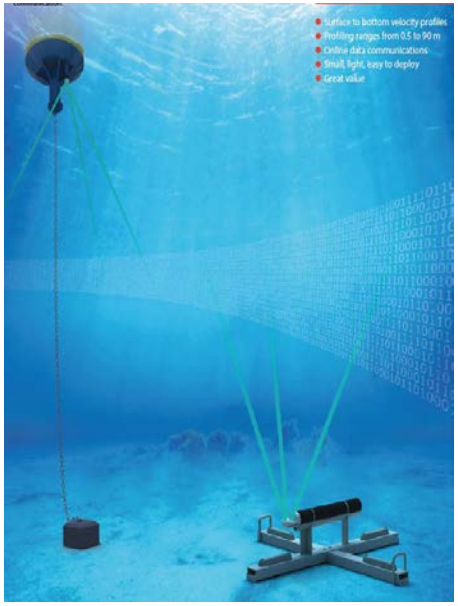
PROJECT METHODOLOGY

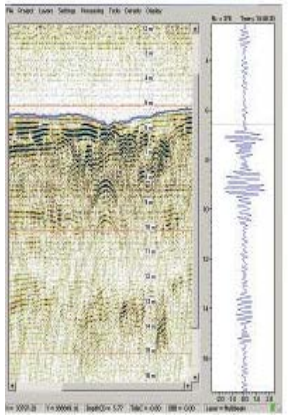
1. Collection of **field data**
2. Hydrodynamic and empirical numerical **model studies** to research the siltation causes and remedies
3. Set up and validate a **nautical simulation model**
4. Operational measurement practice to implement the **nautical depth concept** and derive dredging volumes


HYDRODYNAMIC MODELLING
DSS
OPTIMISE DREDGING DUMPPING PROCESS
SCHEMATISE SILTATION PROCESS
SILTATION ARRESTING METHODS
FIELD DATA
BATHY
GEOTECHNICAL
WAVE
CURRENT ….
NAUTICAL MODEL
NAUTICAL DEPTH
ESTIMATE SILTATION QUANTITY
ACCEPTABLE PARAMETERS

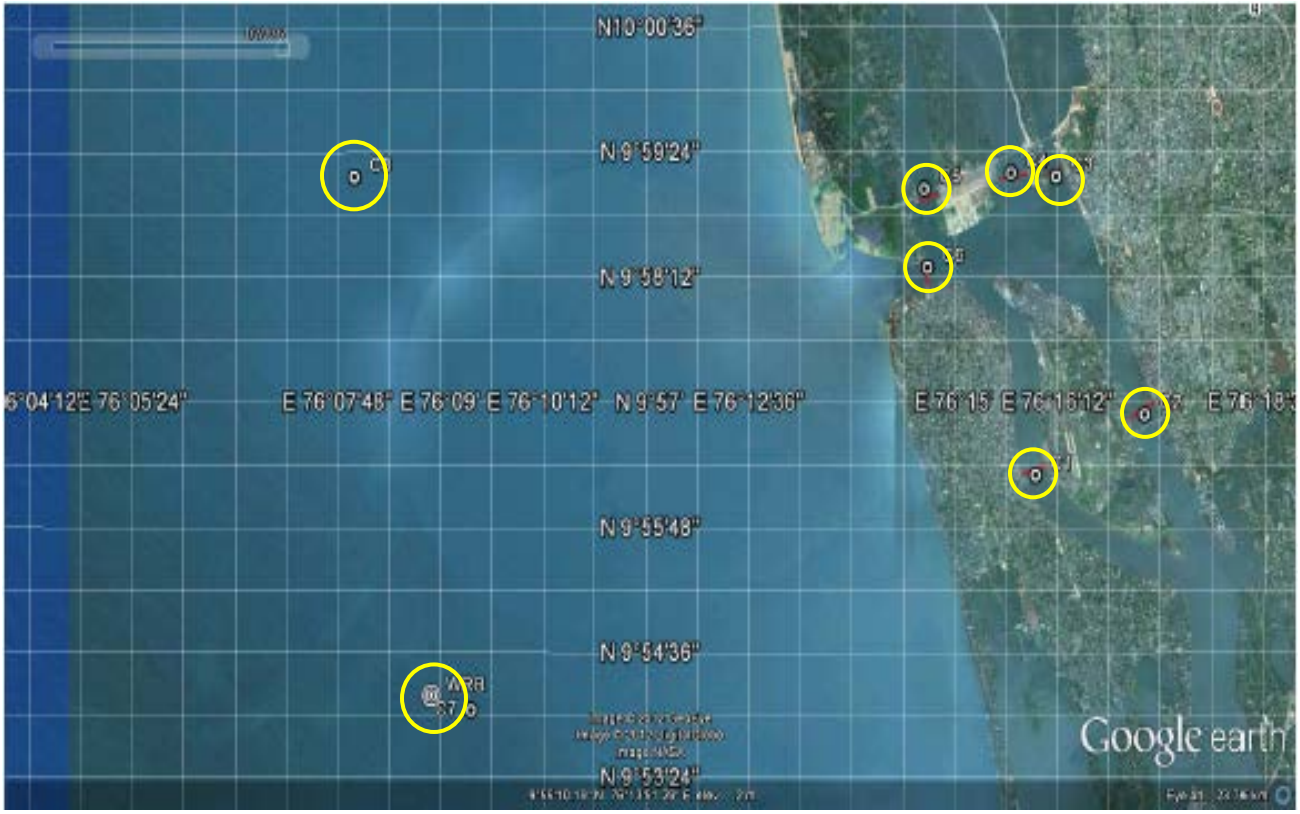
1. Field data collection:

- Wave measurement
- Tide measurements
- Current / velocity measurements
- Discharge measurements
- Wind measurements
- Suspended sediment & salinity measurements
- Bed sediments
- Longshore sediment transport



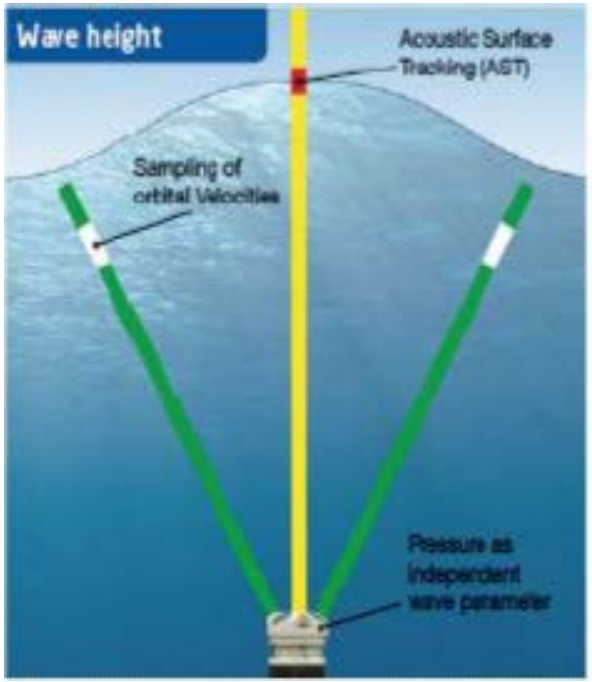


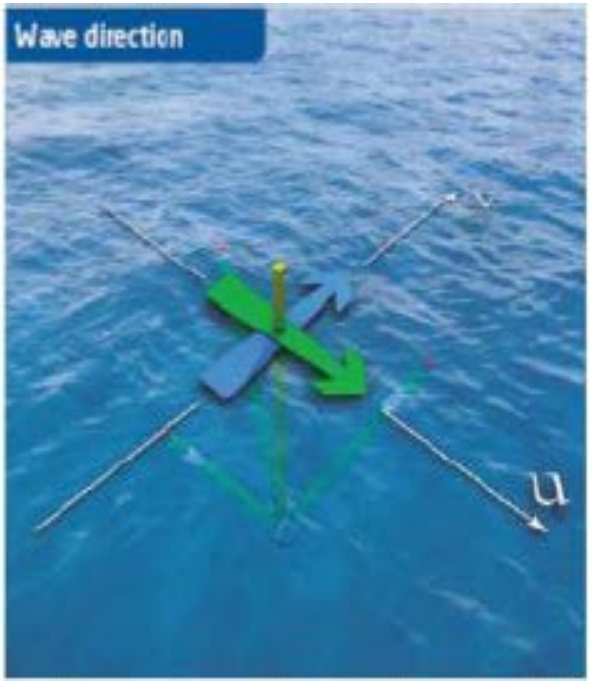
- Gain understanding of processes in study area
  + feed hydrodynamic/sediment/nautical models
- 8 monitoring locations: 2 offshore, 1 in entrance channel and 5 in harbor



1.1 Wave measurements

- *What*: wave height, direction and period
- *How*: bottom mounted Acoustic Wave and Current Profiler
- *Where*: Offshore C7
- *When*: 1 year





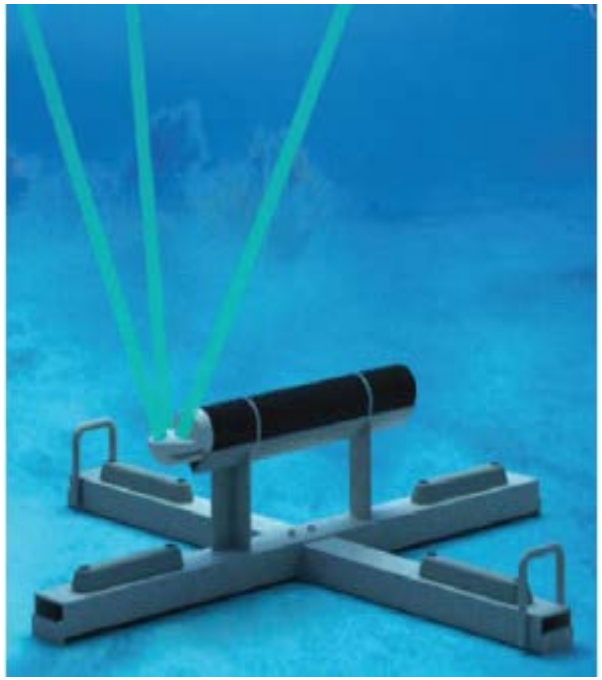
- *Advantages*: less visibility and vulnerability, 1 sensor for wave, current and tide measurements, measures temperature, tilt and compass

1.2 Tide measurements

- *What*: water level
- *How*: Wave sensor / pressure based tide gauge
- *Where*: Offshore C7 and inside harbour (e.g. C4)
- *When*: 1 year

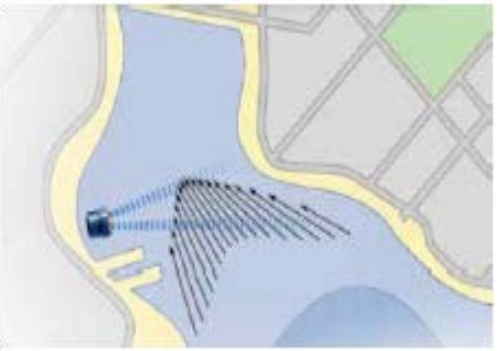
1.3 Current and velocity measurements

- *What*: current velocity & direction
- *Where*: inside harbour (C1 to C5) at 0.2D, 0.6D and 0.8D
- *How*: bottom mounted ADCP (+ pressure, temperature, tilt & compass)
- *When*: 1 month x 3 seasons



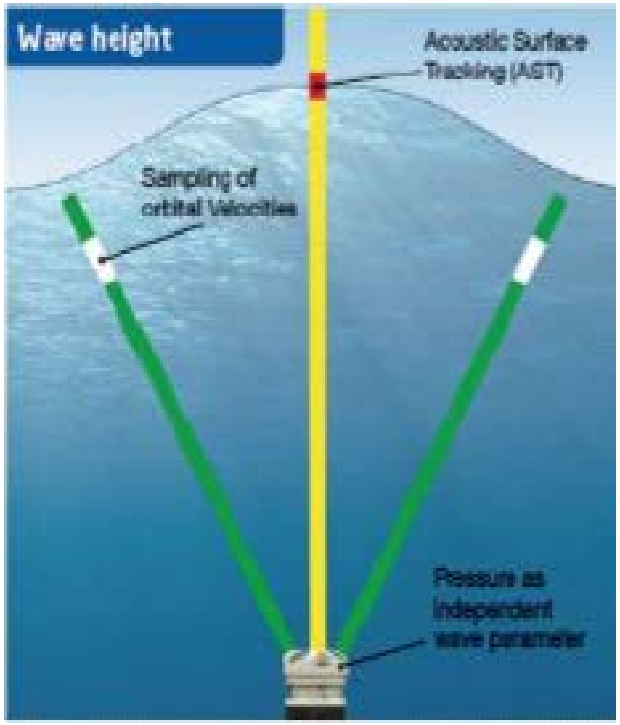
1.3 Current and velocity measurements (continued)

- *What*: current velocity & direction
- *Where*: entrance channel (C6)
- *How*: Horizontal ADCP (+ pressure, temperature, tilt & compass)
  - Location avoided hindrance to and interference with ship traffic
  - At both banks, collecting multiple discharge measurements
- *When*: 1 month x 3 seasons



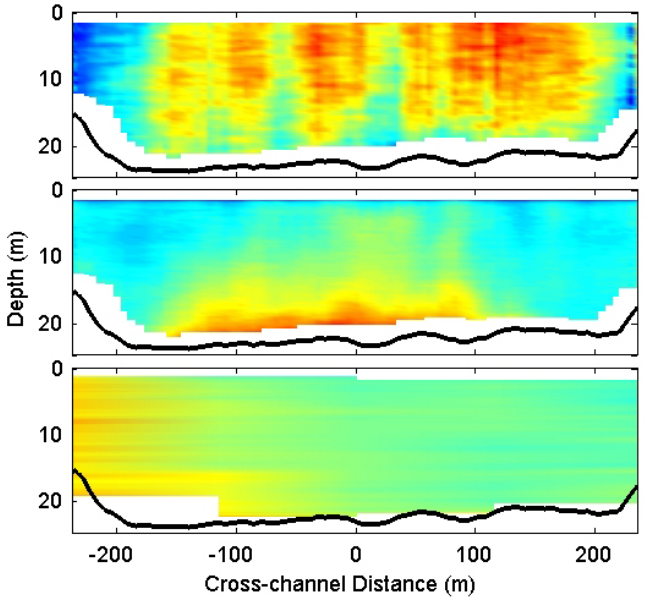
1.3 Current and velocity measurements (continued)

- *What*: current velocity & direction
- *Where*: offshore (C7 & C8)
- *How*: bottom wave sensor (+ pressure, temperature, tilt & compass)
  - Combination of continuous wave/current/tide data at C7
  - Short deployment periods at C8 -> spare sensor
- *When*:
  - Required: 1 month x 2 seasons
  - Completed: 1 year at C7; C8 as required



1.4 Discharge measurements

- *What*: cross section discharge via vertical profiles of current velocity and direction
- *Where*: harbor “boundaries” (C1 to C6)
- *How*: vessel mounted ADCP (with bottom tracking)
- *When*: 1 neap & 1 spring tidal cycle x 3 seasons
- Upstream rivers: approx. 10 locations, during monsoon, + tide measurements



1.5 Wind measurements

- *What*: wind speed and direction
- *Where*: offshore (C7) and inside harbor
- *How*:
  - C7: data buoy with ultrasonic wind sensor and compass (+ air temperature, humidity and pressure)
  - Inside harbor: weather station with ultrasonic wind sensor (+ air temperature, humidity and pressure)
- *When*: 1 year

1.6 Suspended sediment concentration (SSC) and salinity

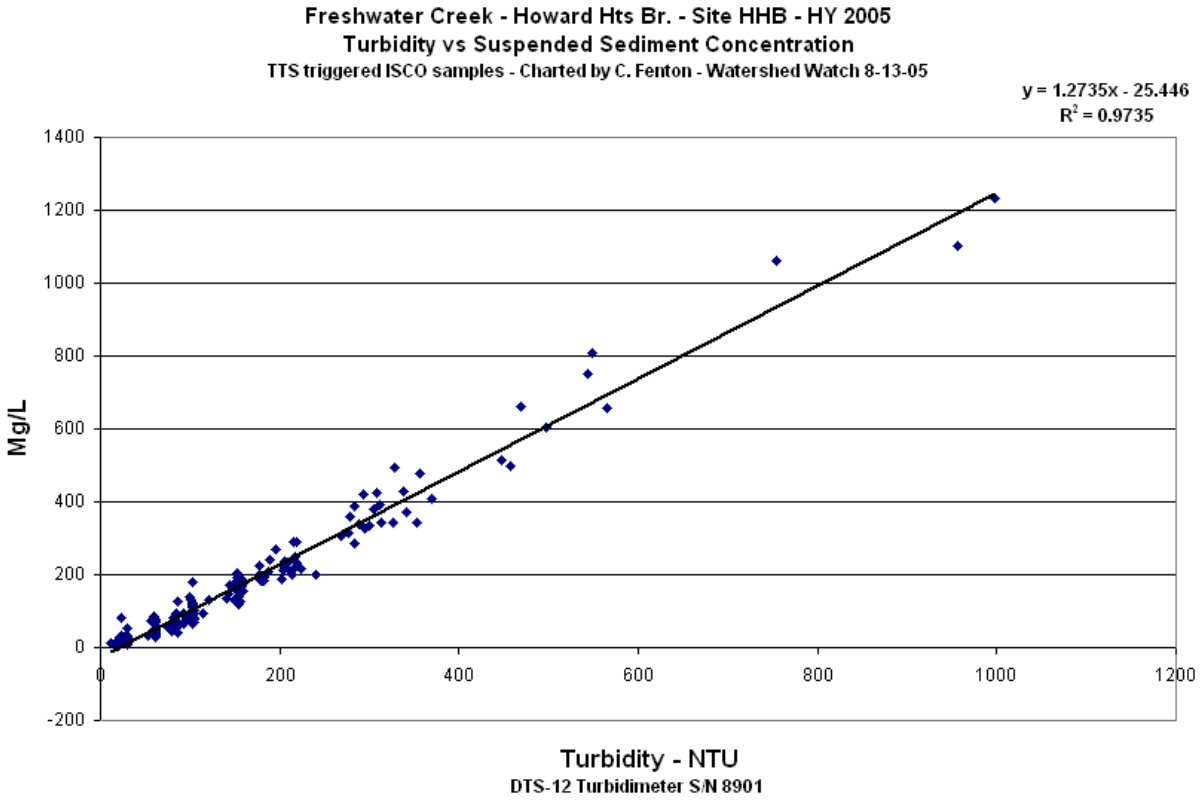
- *What*: SSC and salinity of water samples + vertical SSC profile
- *Where*: C1 to C8 at surface, mid-depth and bottom
- *How*:
  - **Niskin bottle** and laboratory analysis (SSC, salinity, grain size distribution)
  - Optical Backscatter Sensor for vertical profile -> **OBS3A**: turbidity, salinity (conductivity and temperature) and pressure
- *When*: during high, mid and low tide

  over 1 neap and 1 spring tide

  for 3 seasons

1.6 Suspended sediment concentration (SSC) and salinity (continued)

- Regression analysis between SSC and Turbidity
- Sub-periods if indicated by (i.a.) grain size data

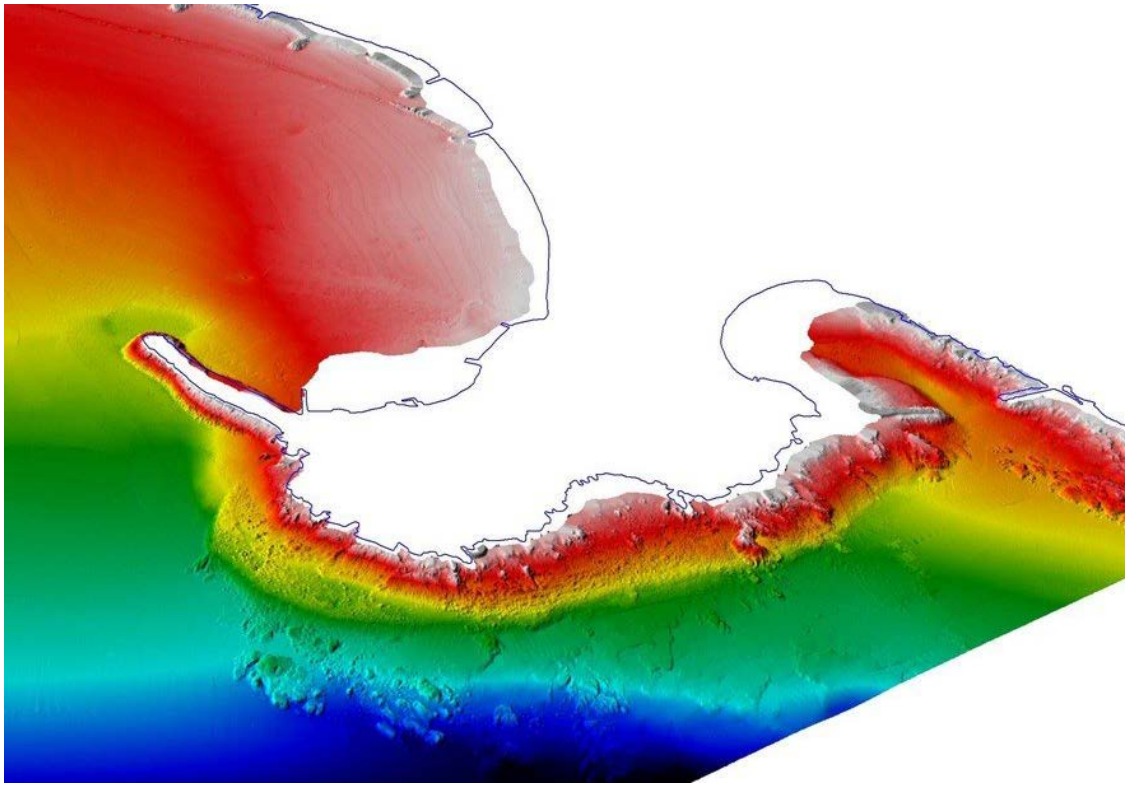


1.7 Bed sediments

- *What*: grain size distribution of bed sediment
- *Where*:
  - Entrance channel and main shipping channels: 500x500m grid
  - Other areas inside the harbour: 1x1km grid
  - 25 km² zone outside harbour: 1x1km grid
  - 10 upstream rivers: 2 samples each
- *How*: Van Veen grab and laboratory analysis
- *When*: 2 seasons

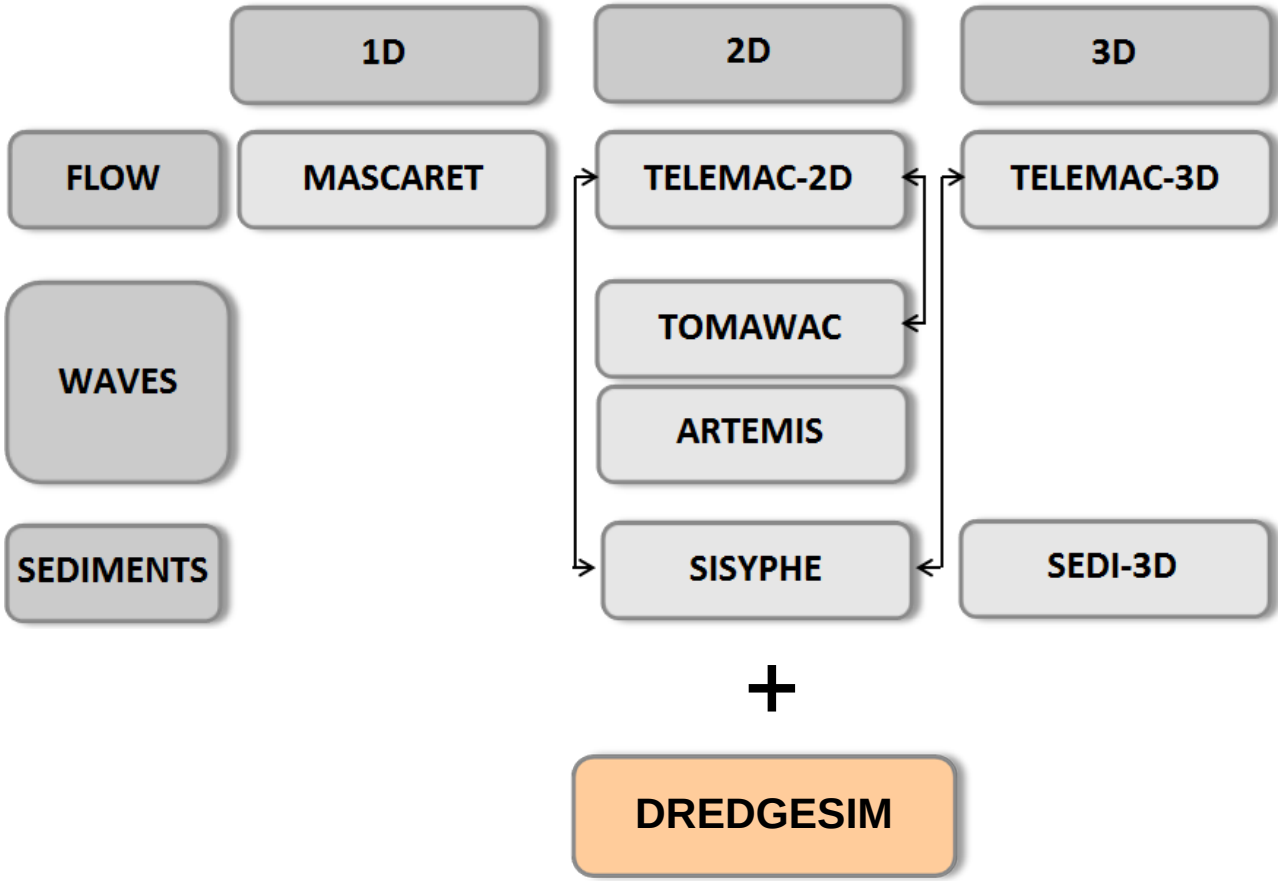
1.8 Longshore sediment transport

- *What*: beach profile analysis
- *Where*: >2 locations each north and south of the entrance channel
- *How*: hydrographic surveys by Port Authorities
- *When*: 2 times x 3 seasons (during spring tide)

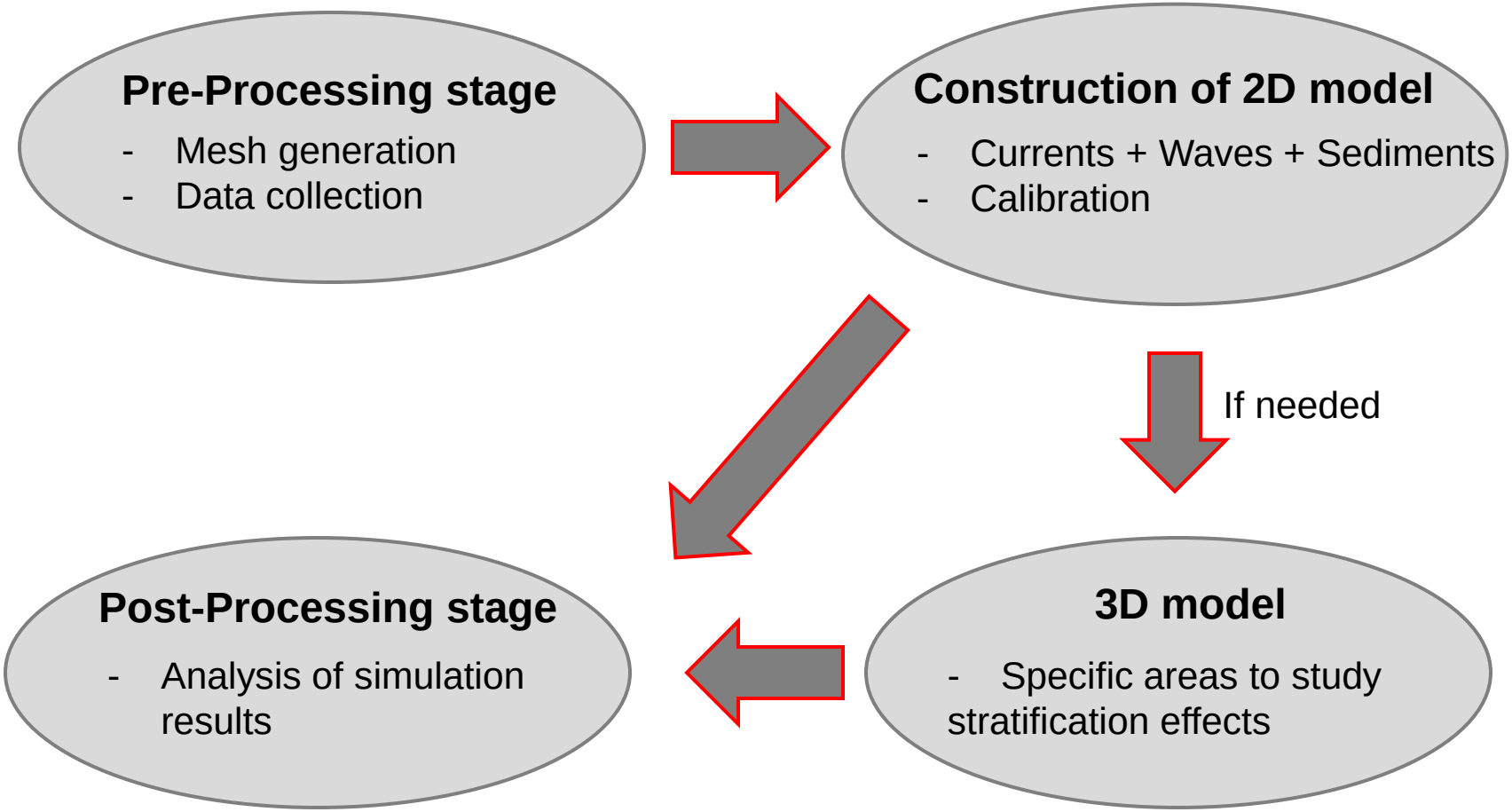


2. Model studies: TELEMAC-MASCARET numerical platform

- Free surface flows modellling
- Different modules communicate between each other
- Unstructured grids
- Finite elements method
- Open source

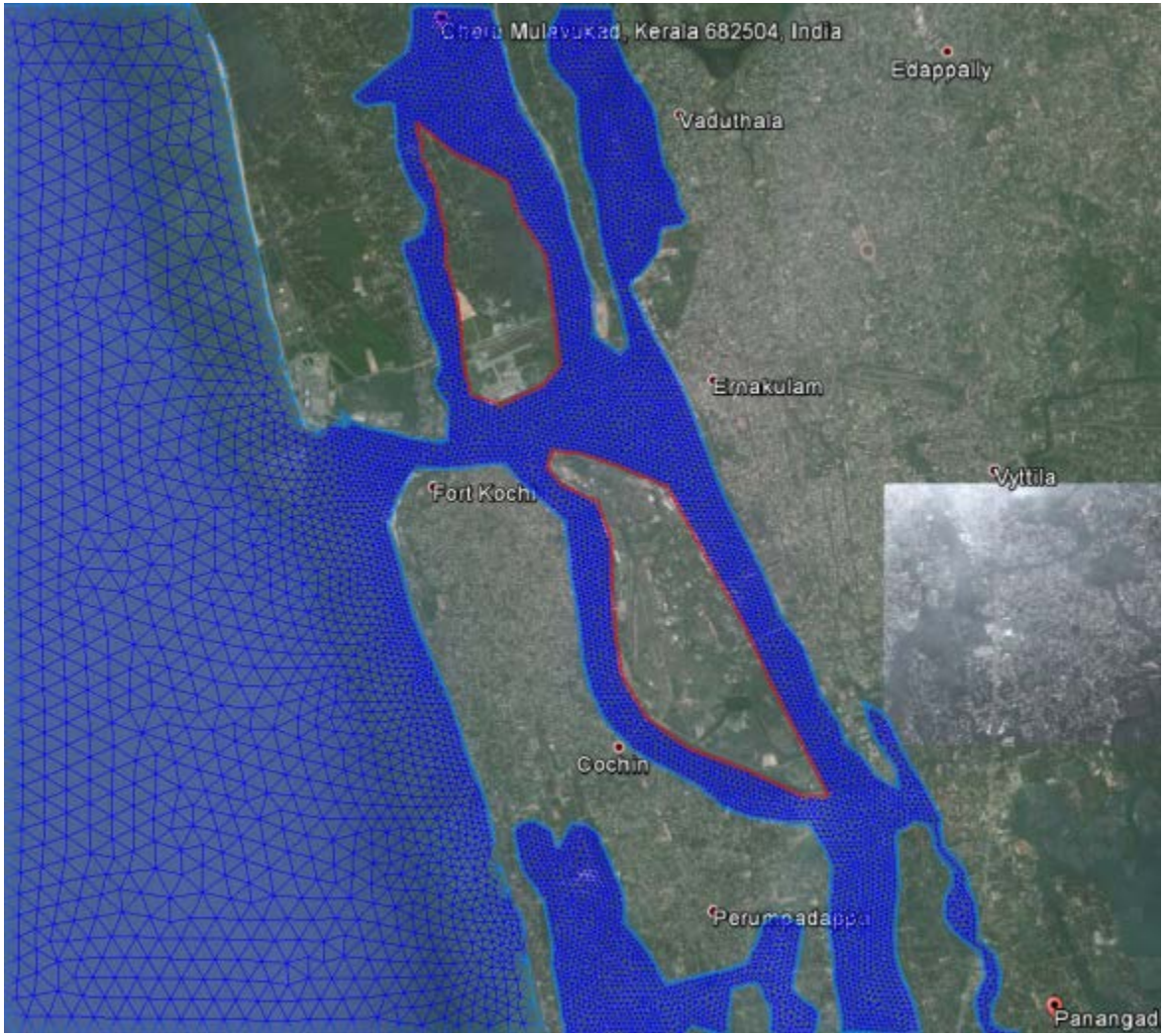


Multi-phase approach

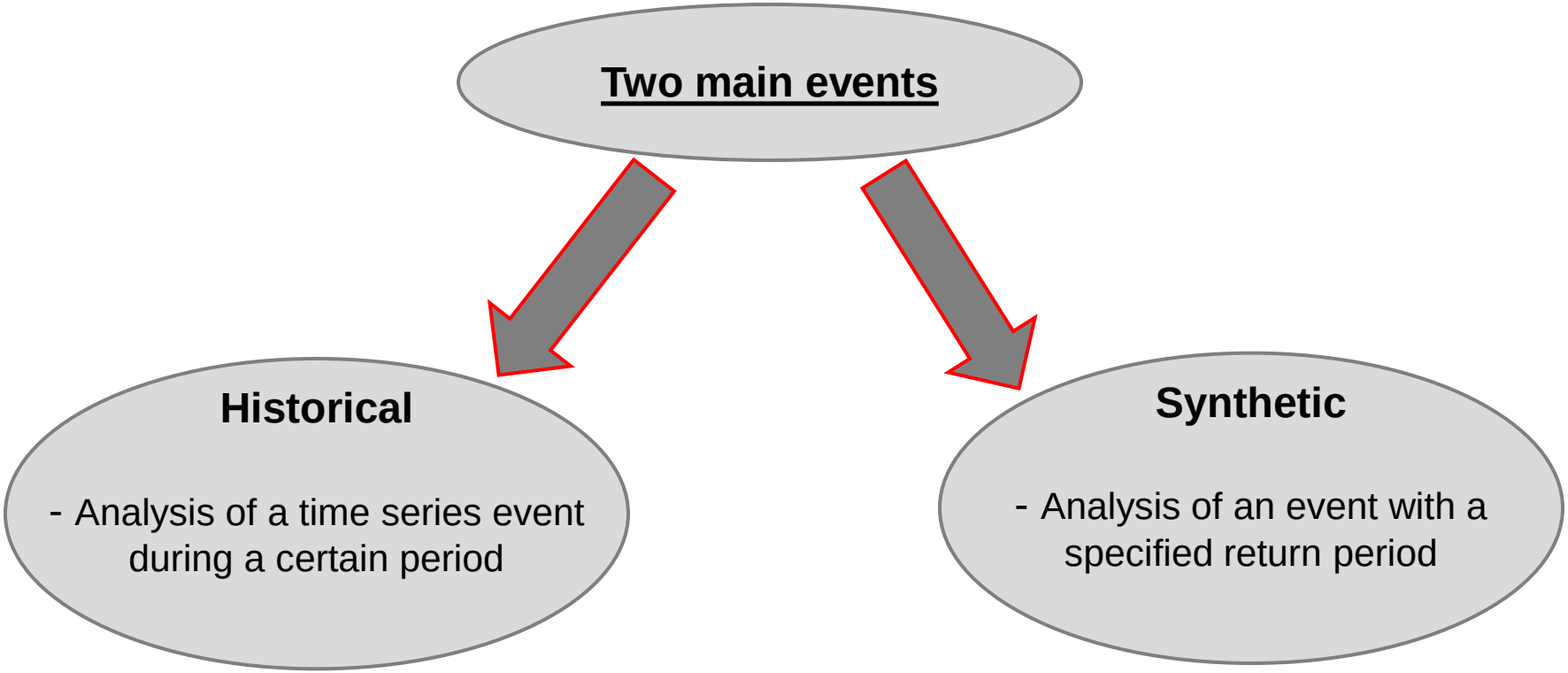


Two-dimensional domain

- Reach between Panangad and Cheru Mulavukad



Simulation results



- •Used for model calibration
- •Selected in agreement with the client
- •Describes current situation

- •Used for scenario analysis
- •Selected in agreement with the client
- •Describes future situation

Modeling schedule

Task\Month (after start measurement campaign)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Models v1																		
Process Annalysis																		
Data Analysis																		
Model design & implementation plan																		
Model Setup																		
Models v2																		
Models v3																		
Sims & Report																		

(*) Schedule will be reviewed during design & implementation plan

3. Nautical Simulation model

- Flanders Hydraulics Research
- Ghent University, Maritime Technology Division

Towing Tank for Manoeuvres in Shallow and Confined Water

Full Mission Bridge Simulators

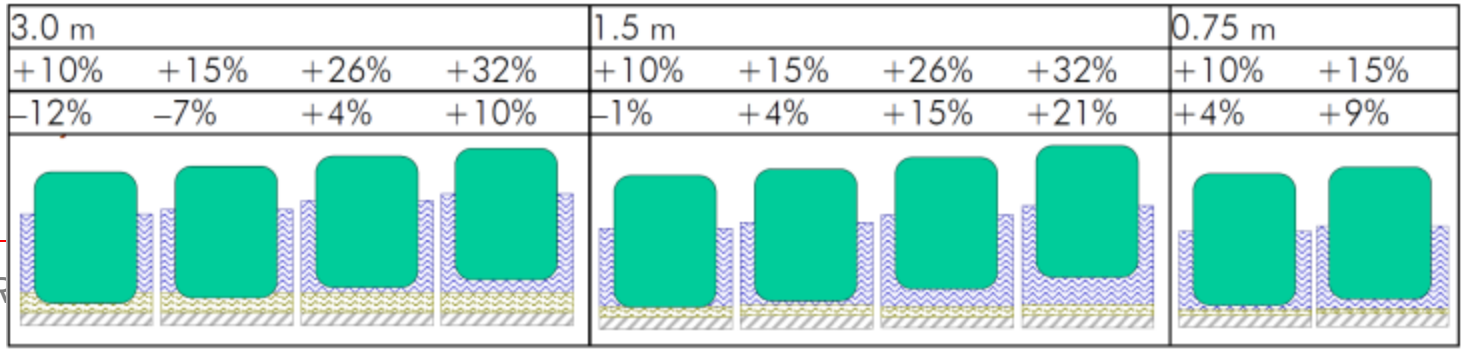
Nautical Manoeuvring Models (1)

6000 TEU CONTAINER VESSEL
(model D scale 1/75)

- > 50 bottom conditions tested in Towing Tank
  - 7 combinations of mud viscosity and density
  - 1 to 3 layer thicknesses
  - 2 to 4 under keel clearances with respect to solid bottom
- Manoeuvring model for positive and negative ship speeds

Mud type	Density	Dynamic viscosity	Layer thickness (m)		
			1	2	3
(-)	(kg/m³)	(Pa s)	0.01	0.02	0.04
d	1100	0.03	D	D	D
c	1150	0.06	D	D	D
b	1180	0.10	D	D	D
f	1200	0.11	-	D	-
h	1210	0.19	D	D	D
e	1260	0.29	-	D	-
g	1250	0.46	-	D	D
S	solid bottom				

MUD LAYER THICKNESS
UKC SOLID BOTTOM
UKC TOP MUD LAYER



Nautical Manoeuvring Models (2)

TANKER 290 m x 47 m x 15.5 m (model E scale 1/75)

- More limited number of test conditions
  - 3 combinations of mud viscosity and density
  - 2 to 3 layer thicknesses
  - 4 under keel clearances with respect to solid bottom
- Manoeuvring model restricted to positive ship speeds

Mud type	Density	Dynamic viscosity	Layer thickness (m)		
			1	2	3
(-)	(kg/m³)	(Pa s)	0.01	0.02	0.04
d	1100	0.03	**E**	**E**	**E**
c	1150	0.06	-	-	-
b	1180	0.10	-	-	-
f	1200	0.11	-	-	-
h	1210	0.19	**E**	**E**	-
e	1260	0.29	-	-	-
g	1250	0.46	-	**E**	**E**
S	solid bottom				

The Manoeuvring Models (MM) required for the **project vessels** will be developed by scaling the MM's from the container vessel D for slender hull forms and from the tanker E for full hull forms for a **maximum number of 12 mud conditions** (combination of layer thickness, density, viscosity and water depth (tide)).

REAL-TIME SIMULATIONS:

Project vessels:

Ship Type	Length	D	E
Container vessel	335 m	X	
General Cargo	250 m	X	
General Cargo	180 m	X	
Tanker	250 m		X

Environmental and External Conditions:

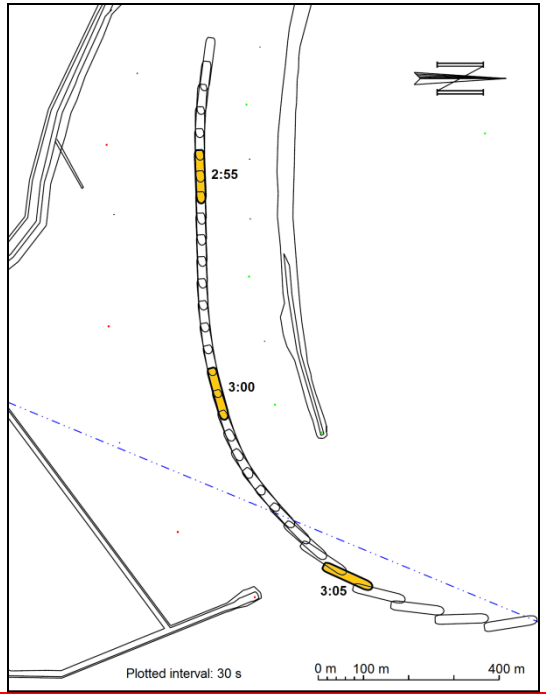
- Tide, Current, Wind, Tug boats
- 3D-model environment

Organization Real-Time Simulations:

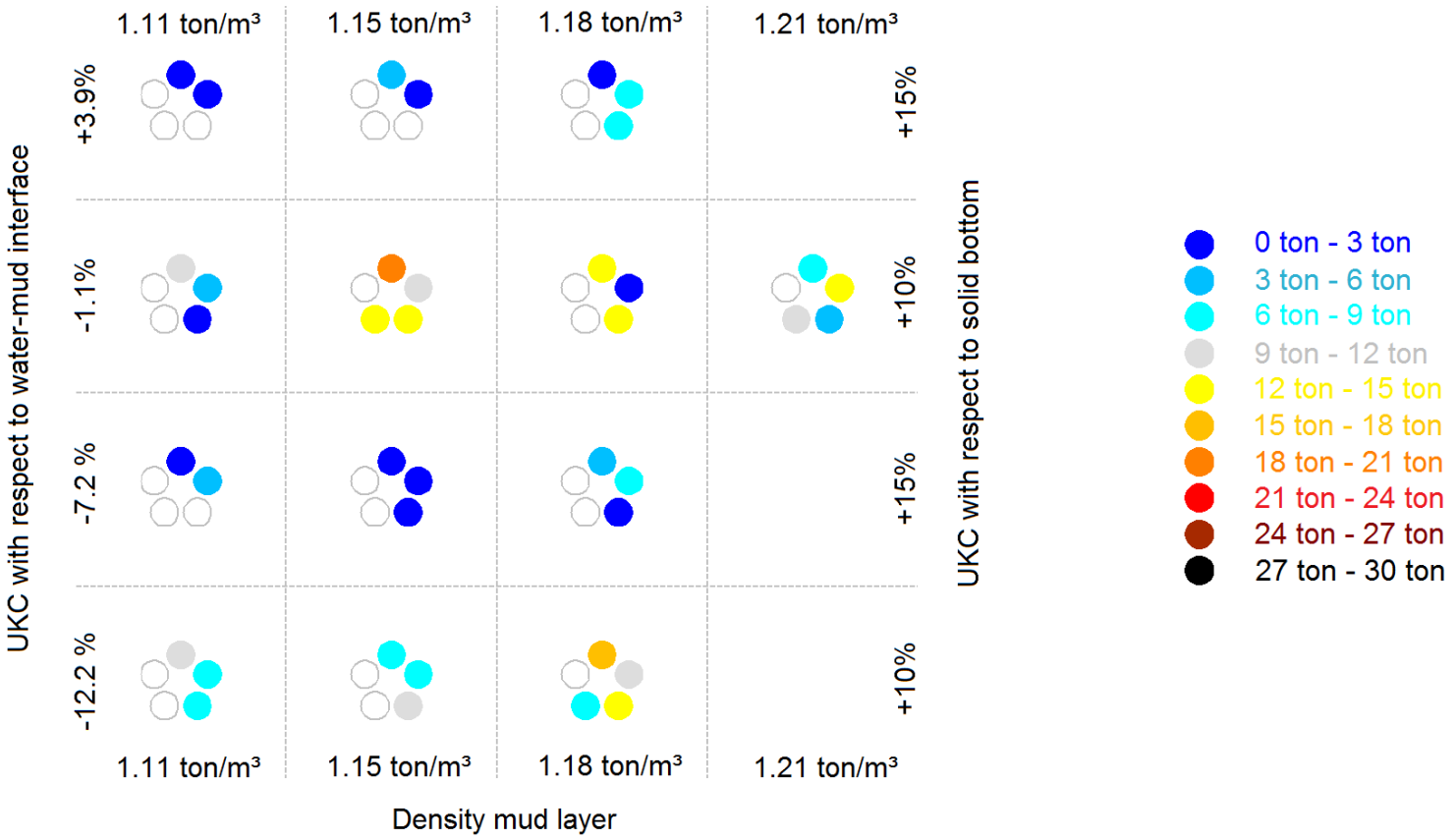
- 2 x 3 days at FHR Antwerp
- Performed by Cochin Pilots
- Assistance by Belgian Coastal Pilots (Zeebrugge)

Reports

- Analysis objective parameters
- Expert judgment by Cochin Pilots and Belgian Pilots

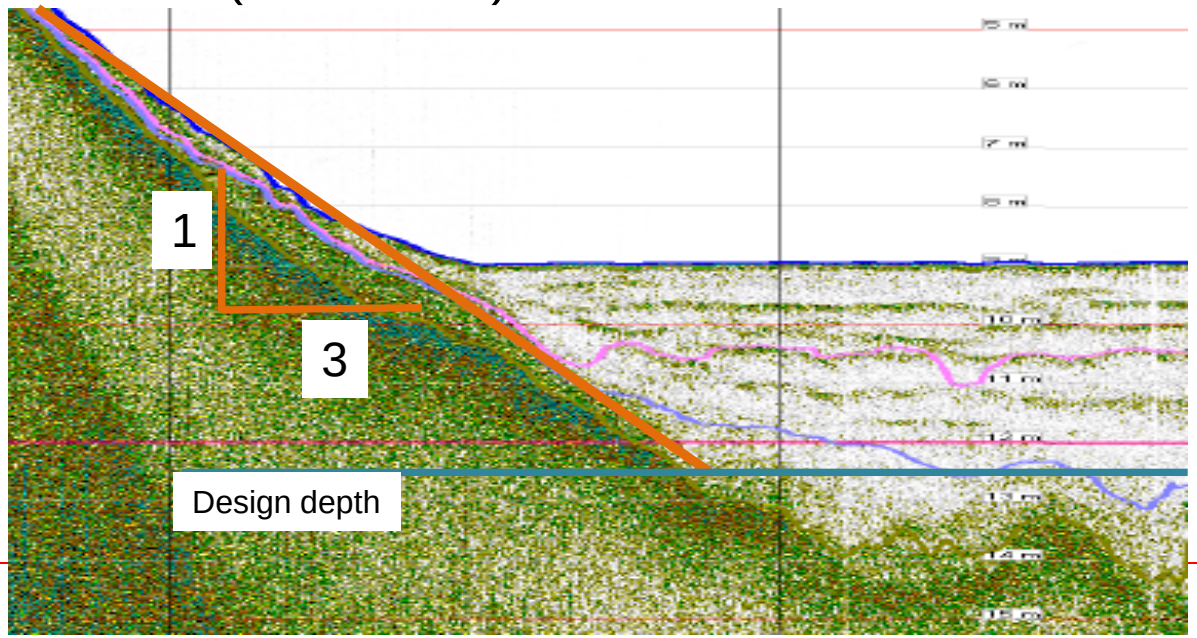


Example of objective analysis of application of aft tug boat at several mud conditions.



4. Nautical depth + Slope stability

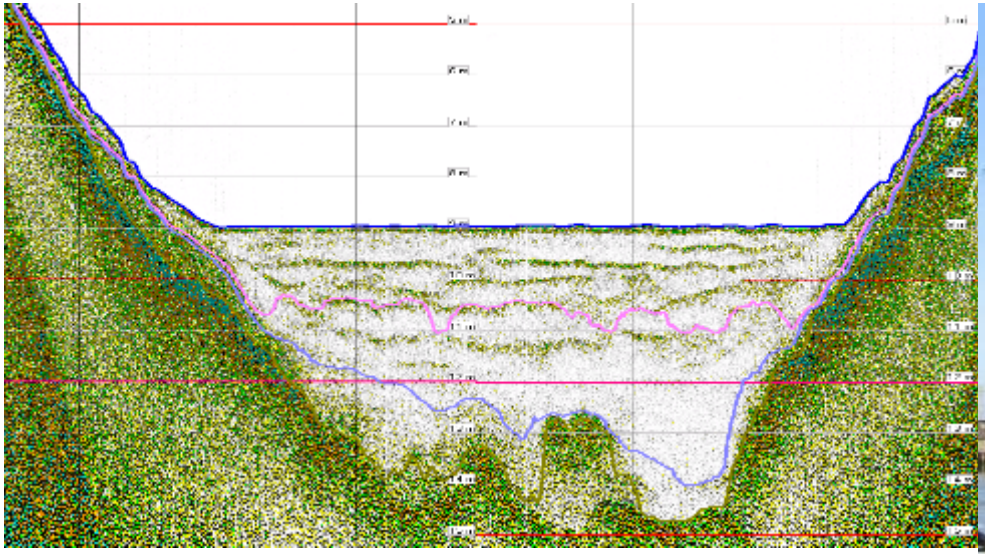
- *What:* Nautical depth and slope stability survey.
- *Where*: Focus on entrance Channel (buoy 5 and 6 to 15 and 16), Ernakulam channel, Mattancherry Channel, ICTT Basin, LNG Basin
- *How*: Survey campaign with:
  - Acoustic profiling (Silas)
  - In-situ rheology measurements (RheoTune)
- *When*: From June till end December



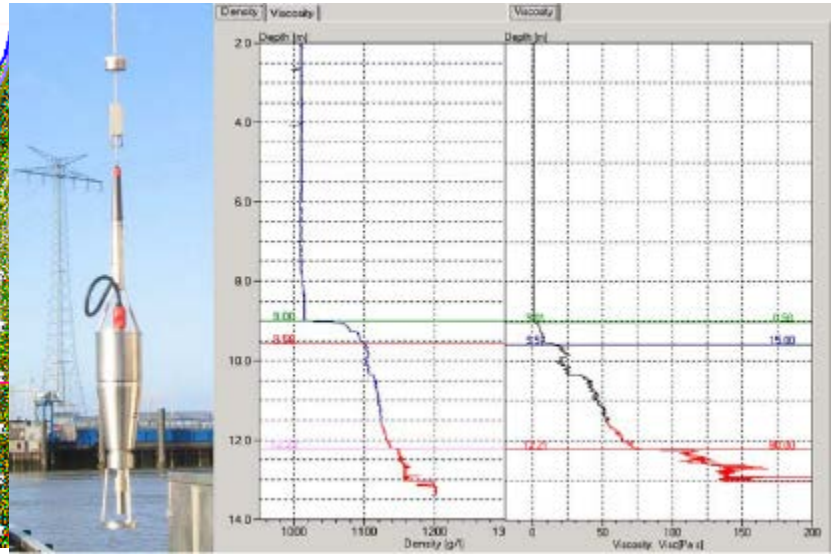
Survey Method Nautical depth

= Combined method

Acoustic profiling



In-Situ rheological measurement



Nautical Depth campaign

Initial Phase:

- Installation
- Training
- Baseline survey

→ Data processing, data comparison

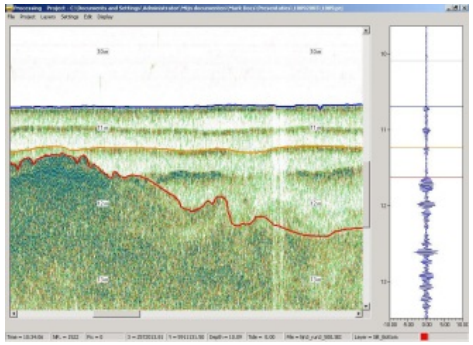
→ Silas density calibration

Second phase:

Survey is repeated by Cochin Port Trust combined with IIC.

Type of equipment Used

Acoustic Profiling
- Silas Software
- CV200
- 24 kHz transducer



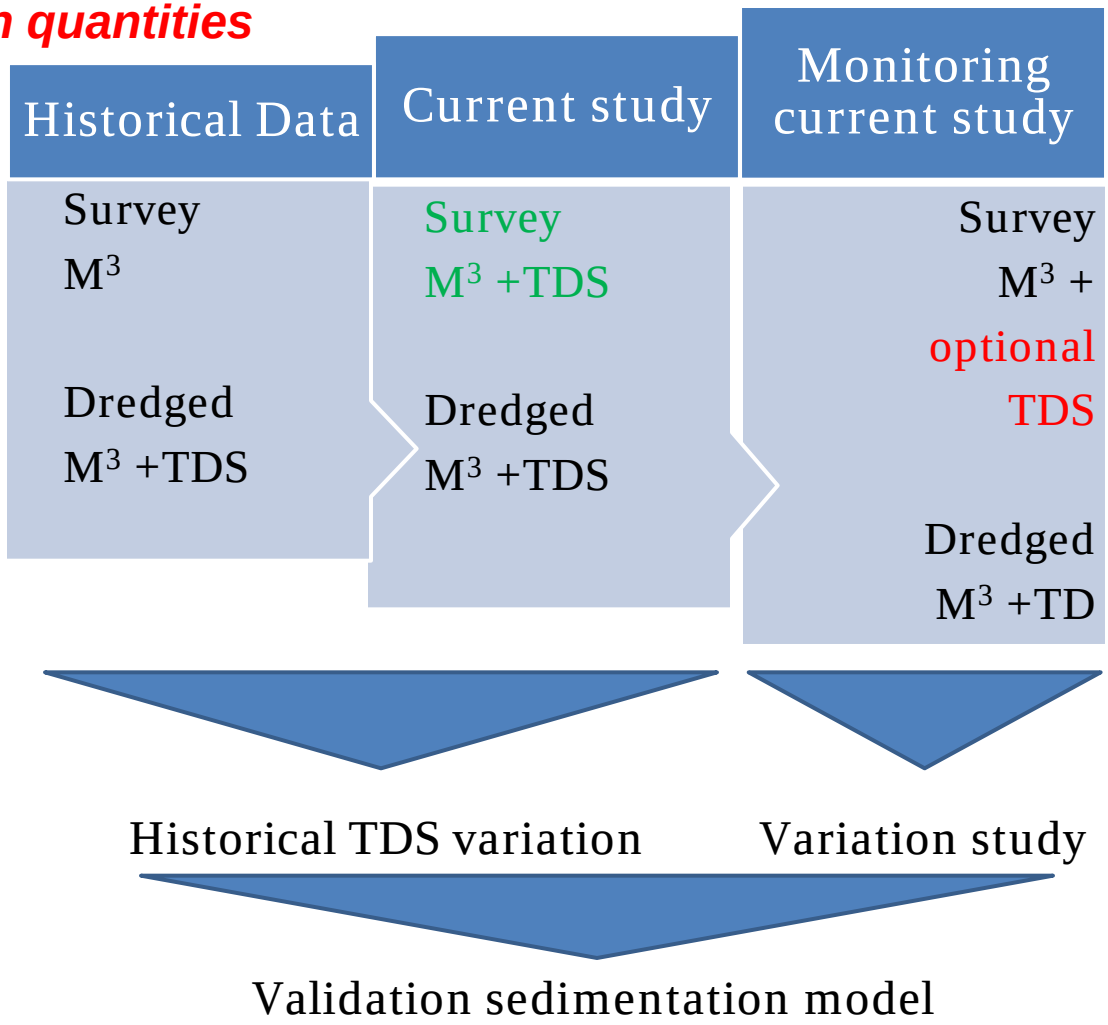
In-situ rheological measurements
- RheoTune / DensiTune Portable
- Optional: Handwinch

Fig 2.1

Equipment was installed on a survey vessel of the port of Cochin.

The equipment interfaced with the installed equipment on the survey vessel (survey software, positioning system, optional heave sensor).

Estimate siltation quantities



Port Support in Implementing

- Permits and Permissions for personnel working on the project
- Permissions to operate the boats in survey area
- NTM (especially for C7 & C8 locations)
- Information to fishing community
- Anchorage in vicinity of C7 & C8

Additional Developments against the Siltation Study

- Dynamic Under Keel Clearance – Planning and Transiting Stages
- Tracking of pollutant migration
- Tracking of Ecological Material – Algae in particular

Dynamic Under Keel Clearance – Planning and Transiting Stages

- Requires special order or A1 bathymetric sea floor collection

- Integrate it with tidal, current, and river stage information.

- Make it vessel independent, fully dynamic
  - Complete Ballast Inputs, along with speed, tie into ECDIS/ECS
- What do you have?

- A system with a completely adjustable sea floor, along with the specific ship's dynamic motion, within a tolerance of (+/- 1.2cm).

THANK YOU