LAMBERTO BRISEGHELLA

MOSE: INFRASTRUTTURA DI RICERCA PER L' IDRODINAMICA E LA CORROSIONE

COLLEGIO INGEGNERI DI VENEZIA
VENEZIA 26 MARZO 2022

PROGRAMMA (TENTATIVO)

40+20 MINUTI

1. MODELLI NUMERICI (4 VIDEO)
2. MODELLI FISICI IN SCALA (MOSE E COB)
3. DINAMICA DELLE BARRIERE
4. CORROSIONE DEI MATERIALI
5. ISOLE OFFSHORE
6. DISCUSSIONE (20 MINUTI)
7. CONCLUSIONI

SCUOLA DI FRIBURGO COMPUTER GRAPHICS

PROFF. MATTHIAS TESCHNER

JAN BENDER AACHEN

MARKUS IHBSEN PREONLAB

BARBARA SOLENTHALER ETHZ

FRAUNHOFER simPARTIX

………

METODO: SPH

CODICE: SPlisHSPlasH

[redacted]


Valley
up to 38M fluid particles interacting with more than
650 rigid bricks, highly viscous mud and an elastic tree

SCUOLA DI VIGO - BARCELLONA

PROFF: ALEJANDRO CRESPO
JOSE DOMINGUEZ
CORRADO ALTOMARE BARCELONA
....

METODO: SPH, MESHLESS
CODICE: DUALSPHYSICS

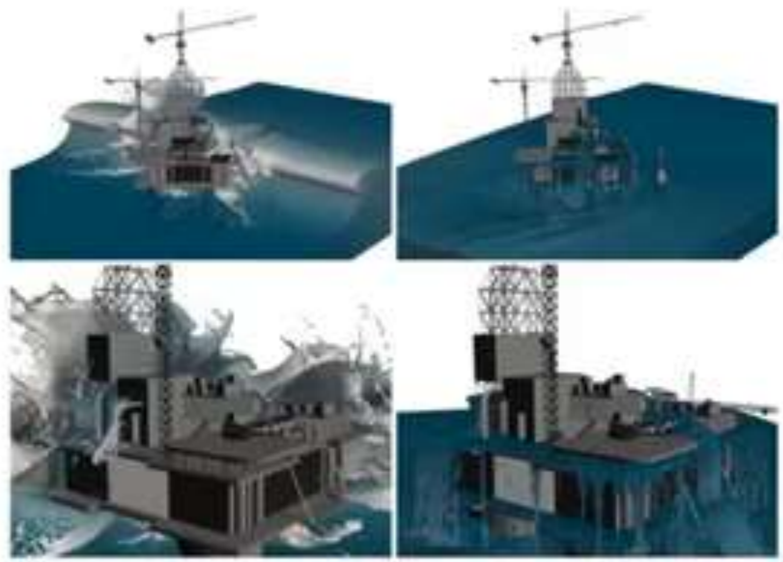
DualSPHysics

High Performance Computing (HPC) + Smoothed Particle Hydrodynamics (SPH)

for engineering problems and realistic simulations

DualSPHysics

EPhysLab



Universida de Vigo

MODELLI FISICI A VOLTABAROZZO

OSTENDA HANNOVER

PROF. ATTILIO ADAMI SCALA 1:30

ING. MAURIZIO POZZATO


Modello Fisico della Bocca di Chioggia - scala 1:60

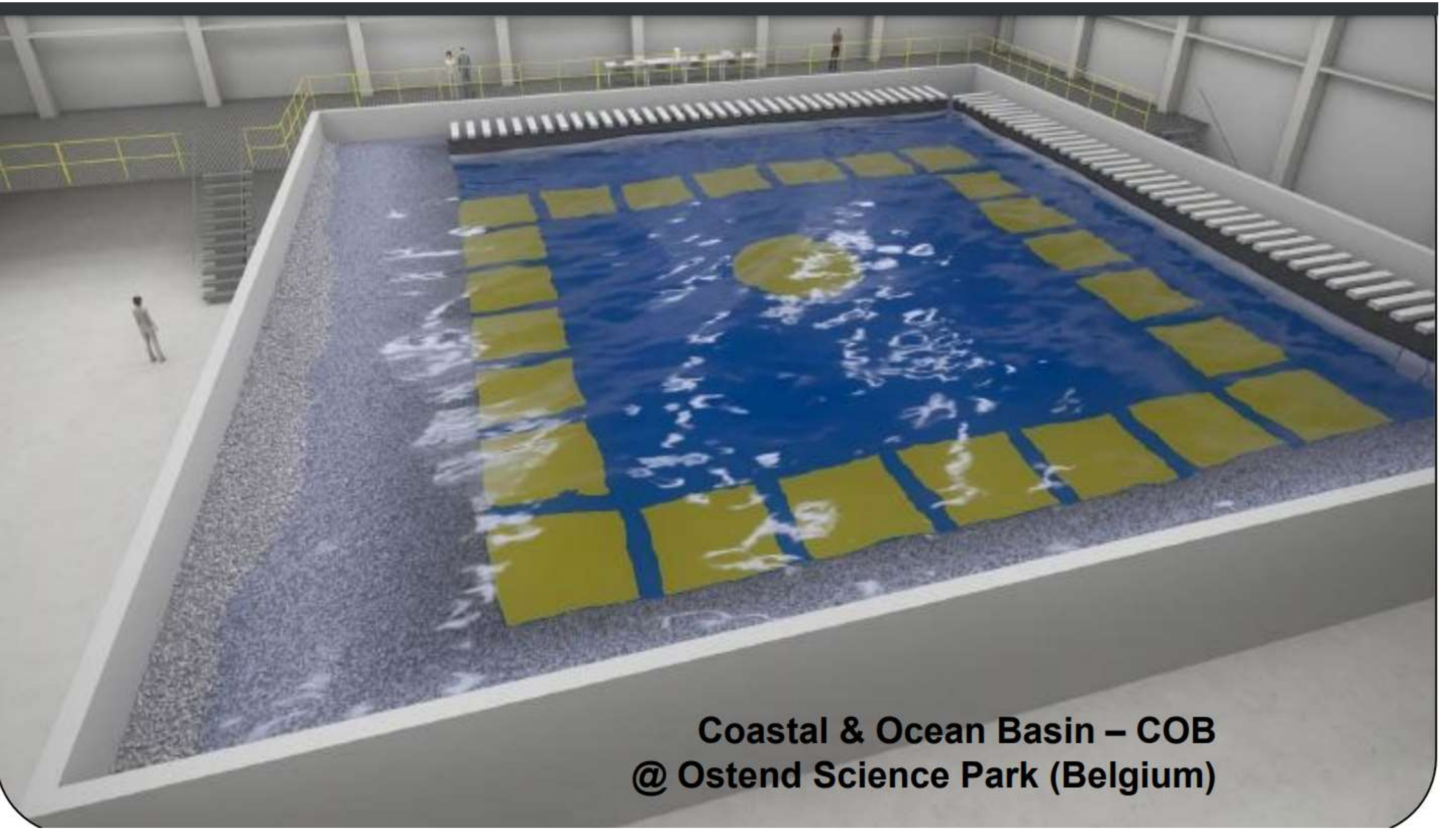
VOLTABAROZZO MODELLI FISICI

SCALA 1:64

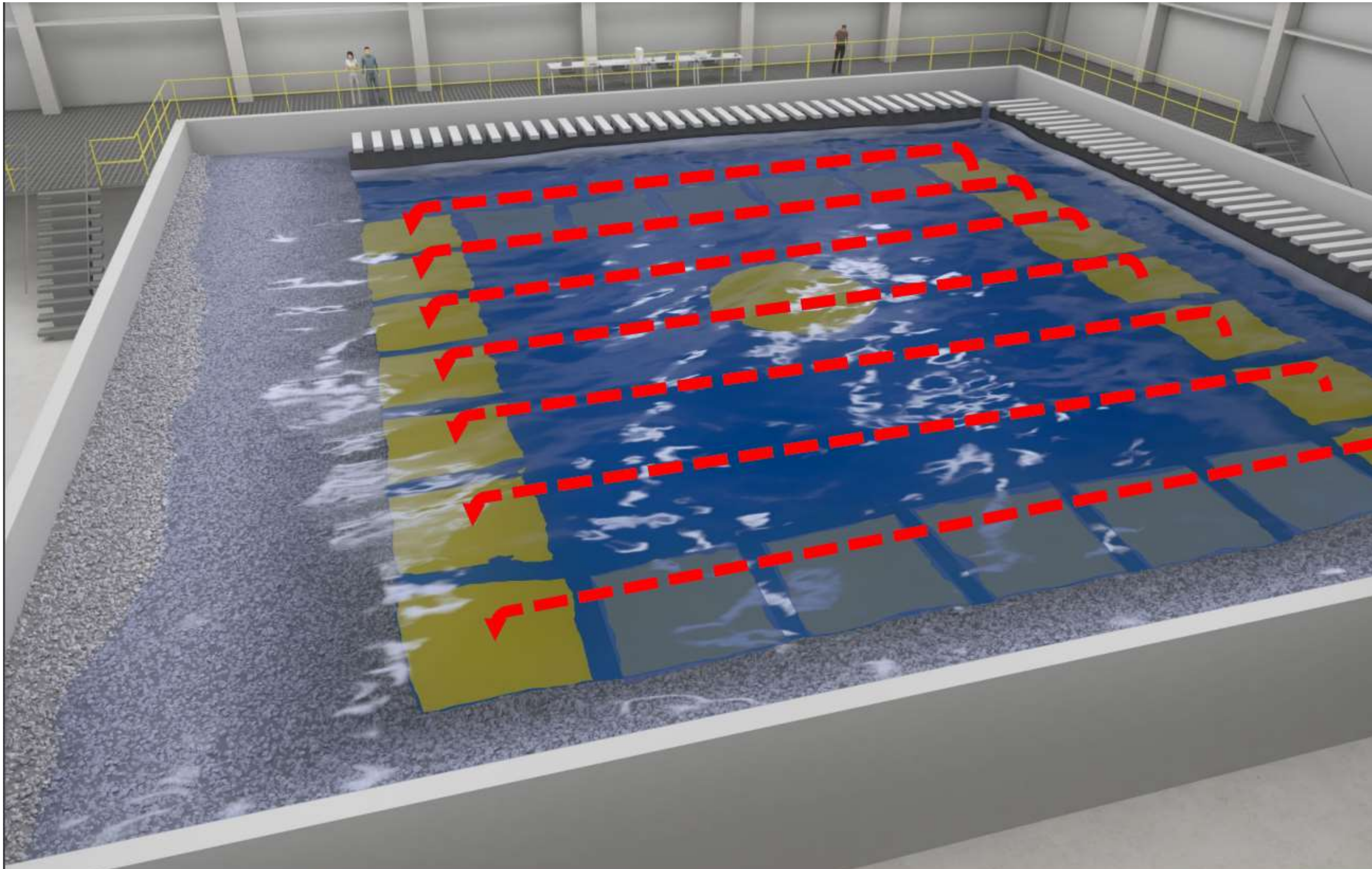
SIMILITUDINE FROUDE (LUNGHEZZE)

BARRIERA	400 M / 64	6.25 M
PARATOIA	26 M / 64	0.40 M
ONDA Hs	3.5 M / 64	0.055 M

COB COASTAL & OCEAN BASIN OSTEND



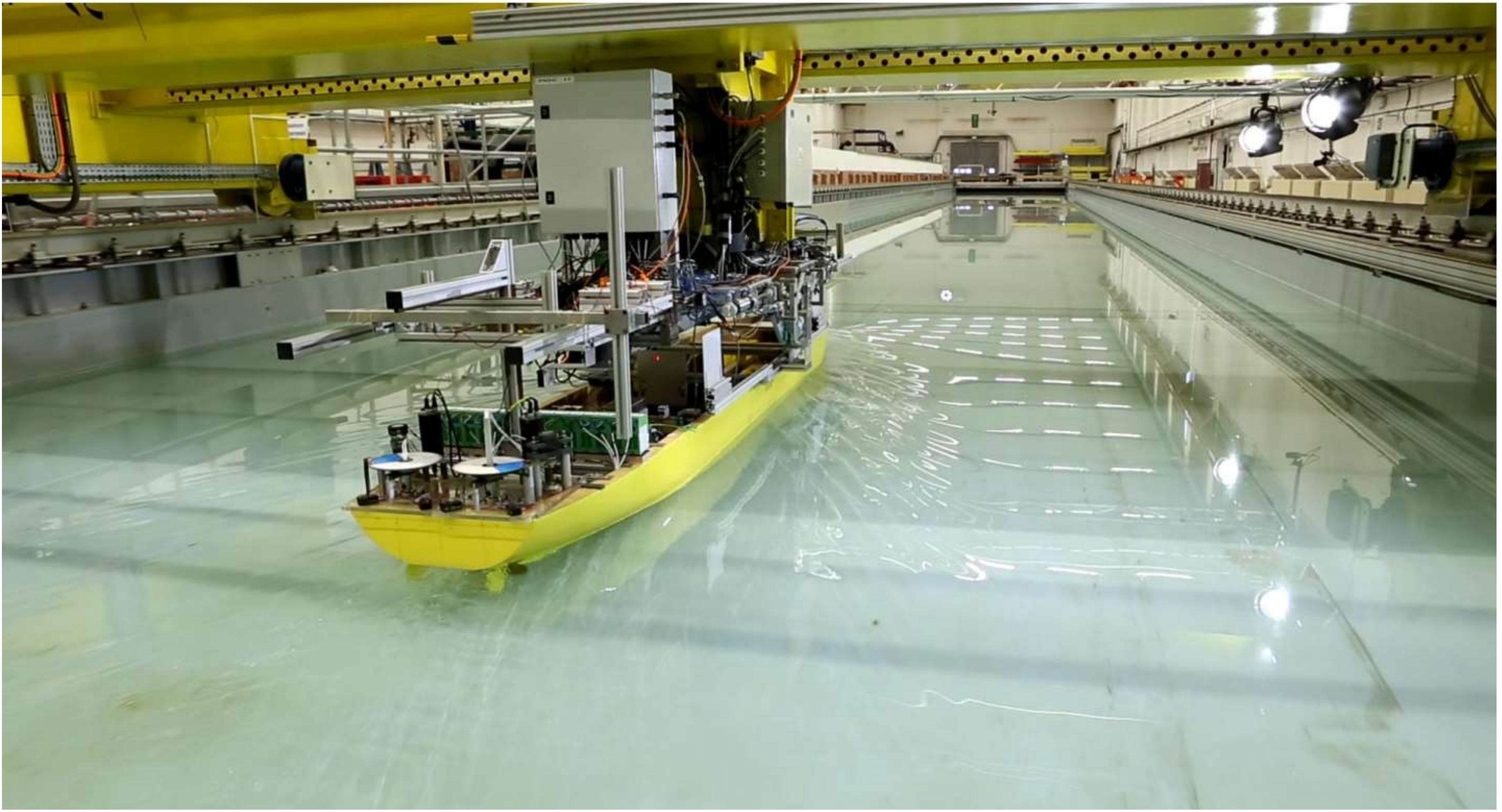
ONDA CORRENTE VENTO

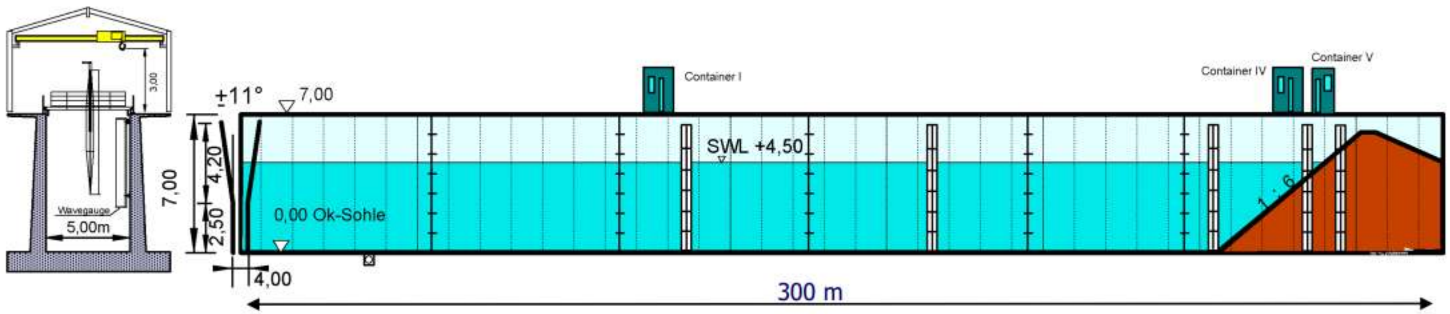


BACINO COB E VASCA DI TIRO 10X200

VASCA DI TIRO MODELLI E BACINO COB

MODELLO DI BARCA IN TIRO (DISEGNO)





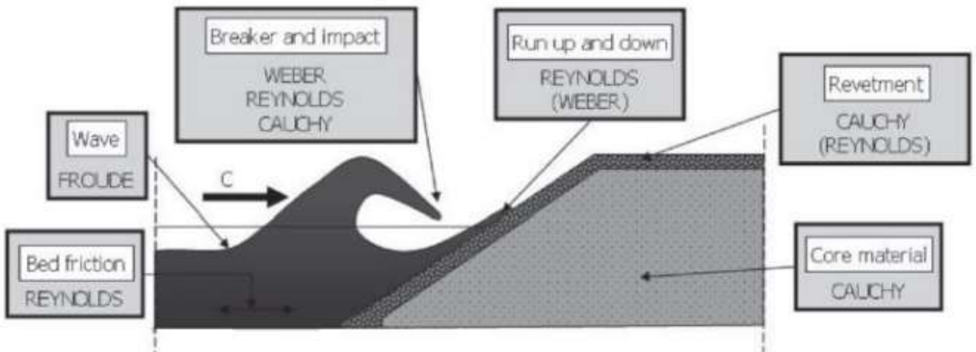
- Physical model tests in the laboratory have been and will be an invaluable tool for coastal and offshore engineering
- **New materials and design concepts** for "traditional" coastal protection will always require new investigations and physical model tests.
- **Emerging technologies** (e.g. marine energy) and **ecological awareness** (Nature-based Solutions) require model tests as design basis.
- **New measurement techniques** (e.g. video analysis, laser scans, ABS) provide better results and insights for future basic and applied research.
- Further improvement and validation of **numerical models** rely on data from (large scale) laboratory experiments.

PROF.SKIMMELS HANNHOVER LARGE FLUME

➔ Strong need for new and improved laboratory facilities

Forschungszentrum Küste

Why large scale models?



Type of Force	Scaling Law	Scale		
		1:1	1:10	1:100
Gravity	FROUDE	1	1	1
Friction	REYNOLDS	1	1:31,6	1:1000
Compressibility	CAUCHY	1	1:10	1:100
Surface Tension	WEBER	1	1:100	1:10000

Scale effects in FROUDE-model

"Users Guide to Physical Modelling and Experimentation: Experience of the HYDRALAB Network"
CRC Press/Balkema, Leiden, The Netherlands, ISBN: 978-0-415-

A large scale is necessary for e.g.:

- Wave breaking
- Wave impact
- Sediment transport
- Soil dynamics
- Wave run-up
- Wave overtopping
- Wave transmission
- ...

PROGETTO GENERATORE D' ONDA HANNOVER

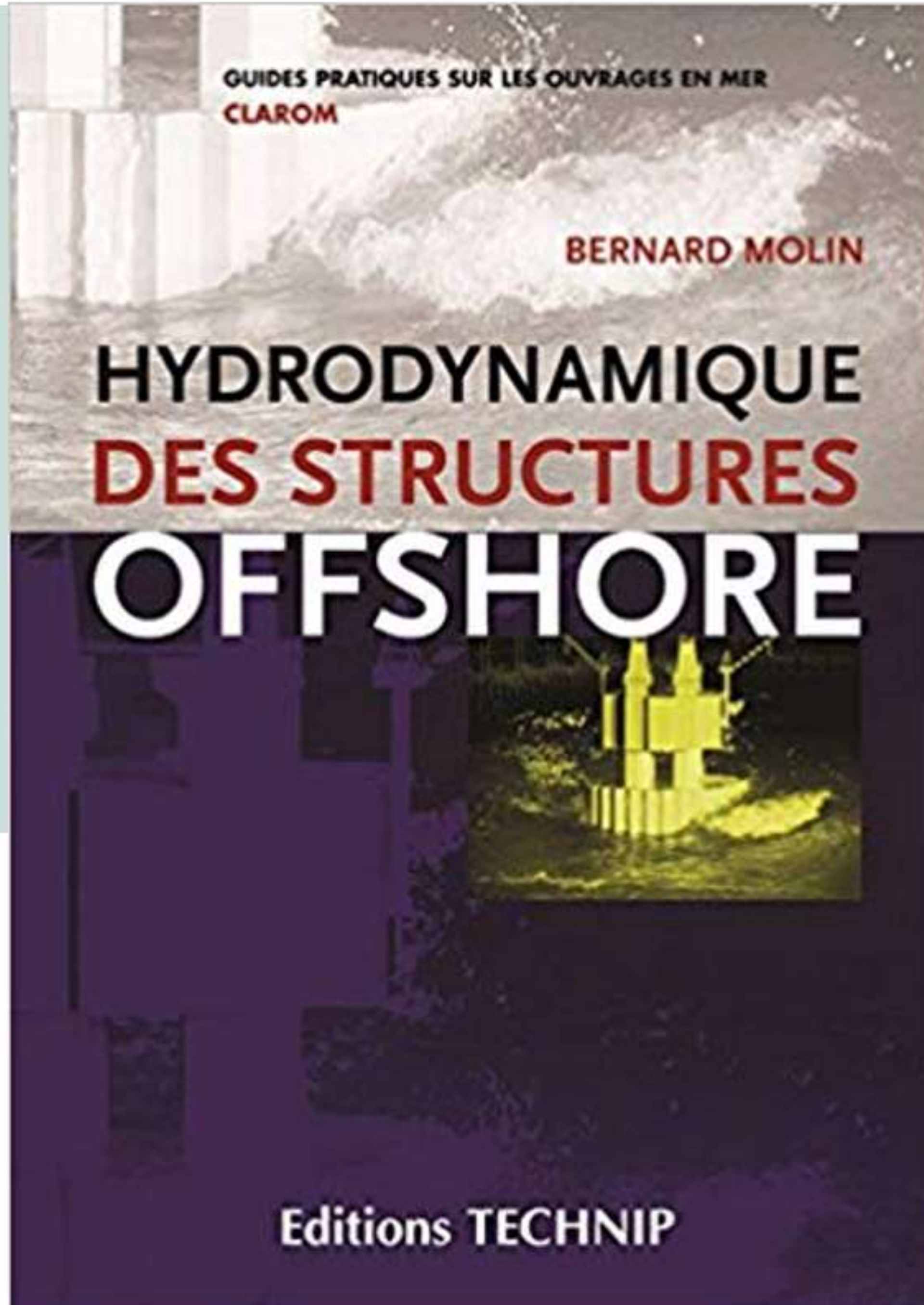
TAKE HOME MESSAGES

Experimental modelling is fundamental to deepen our understanding of the governing physics

Overtopping metrics, other than discharge and volume, are necessary for coastal safety assessment

RECOMMENDATIONS

- Keep investing in monitoring
- Make data available & ensure quality of data
- Keep improving models and model physics
- Keep investing in people
- Invest in interaction with other disciplines
- ….



BERNARD MOLIN
INSTITUTE DE RECHERCHE SUR LE
PHENOMENES HORS
EQUILIBRE MARSEILLE

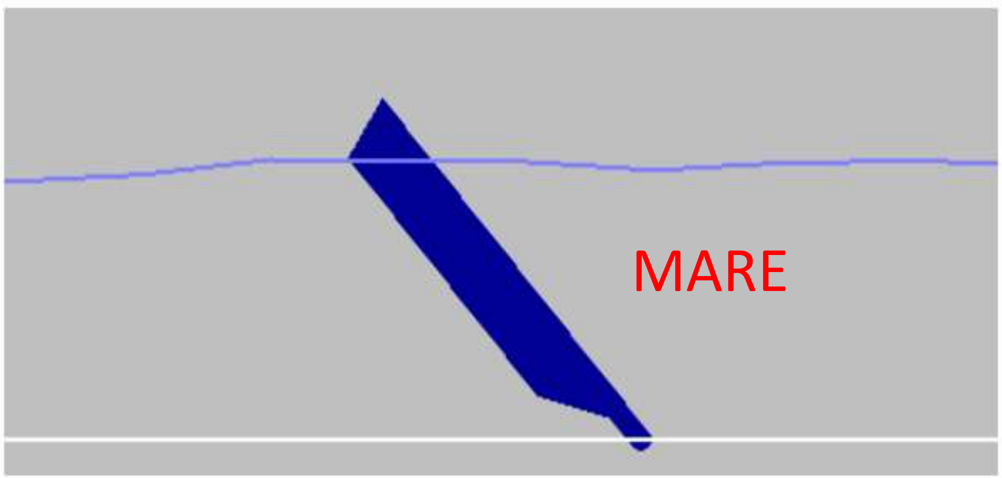
Client : **COMUNE DI VENEZIA**
CA' FARSETTI
SAN MARCO 4136
30124 VENEZIA

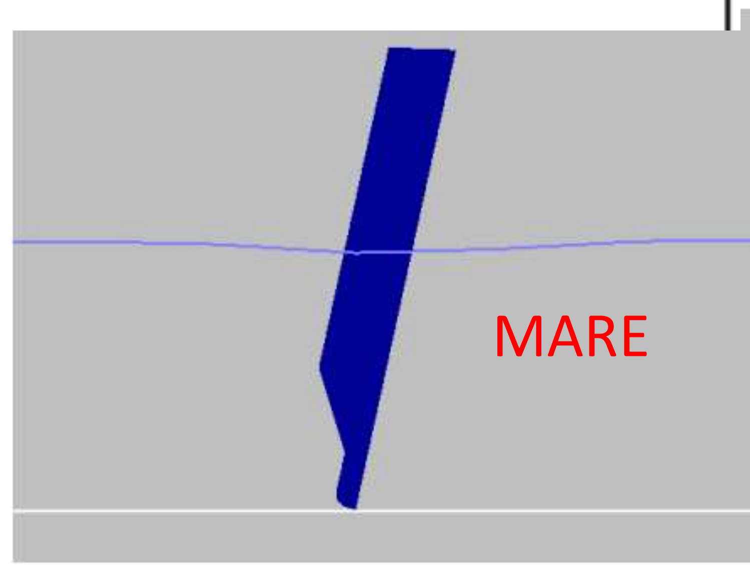
Contract Number :

Contractor : **PRINCIPIA R.D.**
Z.A.C. Athélia 1 – 215 Voie Ariane
13705 LA CIOTAT cedex
☎ +33 (0)4.42.98.11.80 - +33 (0)4.42.98.11.89
www.principia.fr / commercial@principia.fr

PRINCIPIA

Project : **Venice gates system**





PROF BERNARD MOLIN MARSIGLIA

Mean inclination of the Mose gate – Tp=8.0s
left: Hs=2.0m, right: Hs=2.2m

RIFLESSIONE SISTEMI DINAMICI NON LINEARI

$$d(u(t))/dt = F(u(t))$$

$u(0) = u0$ condizioni iniziali

comportamento per t verso infinito

Soluzioni al crescere dell' onda:

Step 1 unica, stazionaria, attrae tutte le orbite

Step 2 altre soluzioni, bacini di attrazione

Step 3 biforcazione di Hopf, non stazionario

Step 4 soluzione quasi periodica

Step 5 soluzione completamente randon, caos

ROGER TEMAM 1965

MOSE DINAMICA PARATOIE

DINAMICA NON LINEARE, CON CONTROLLO
DIFFICOLTA' CALCOLO MASSA AGGIUNTA
DIPENDENZA DALLA FREQUENZA
DIVERSITA' SOLLEVAMENTO E
AFFONDAMENTO DA GALLEGGIAMENTO

MODELLO 1 GRADO DI LIBERTA', ROTAZIONE
20 SINGOLE PARATOIE
MODELLO CONTINUO, IDRODINAMICA
BACINO + SISTEMA CORPI RIGIDI

OSCILLATORE SEMPLICE SDOF

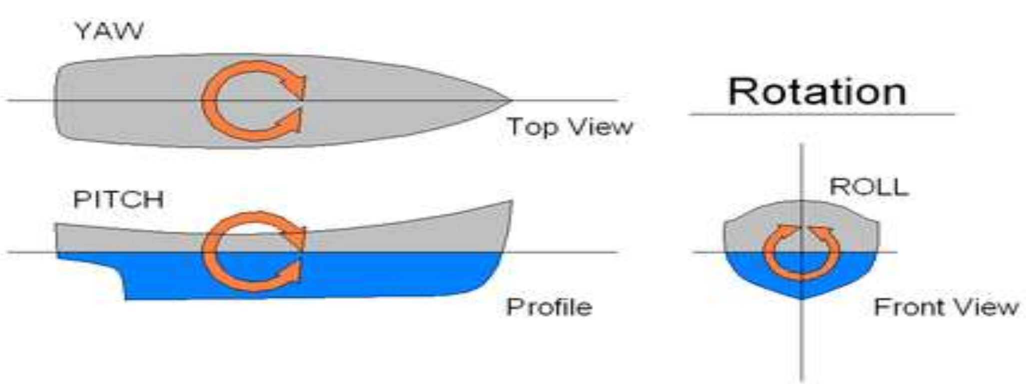
$$[M + A(\omega)]\ddot{x} + B(\omega)\dot{x} + Cx = F(\omega)$$

MASSE SMORZAMENTO RESTORING

MASSA PARATOIA (MOMENTO INERZIA POLARE)
MASSA AGGIUNTA DIPENDENTE DALLA FREQUENZA

SMORZAMENTO (VISCOSITA') DIPENDENTE DALLA FREQUENZA

RESTORING FORZA DI RITORNO DIPENDENTE DALLA FORMA DELLO SCAFO E DELL' ACQUA SPOSTATA NEL MOTO PITCH



SPH SMOORED PARTICLE HYDRODYNAMICS

$$\underbrace{\frac{D\mathbf{v}_i}{Dt}}_{\text{acceleration}} = \underbrace{-\frac{\nabla p_i}{\rho_{i,0}}}_{\text{pressure term}} + \underbrace{\nu_i \nabla^2 \mathbf{v}_i}_{\text{viscosity term}} + \underbrace{\nabla \Phi_i}_{\text{surface tension}} + \underbrace{\mathbf{f}_i^{\mathrm{b}}}_{\text{body forces}}$$

1. Explicit calculation of all terms except the pressure term

$$\mathbf{v}_i^* = \mathbf{v}_i + \Delta t \left(\underbrace{\nu_i \nabla^2 \mathbf{v}_i}_{\text{viscosity term}} + \underbrace{\nabla \Phi_i}_{\text{surface tension}} + \underbrace{\mathbf{f}_i^{\mathrm{b}}}_{\text{body forces}} \right)$$

2. Implicit computation of the pressure field

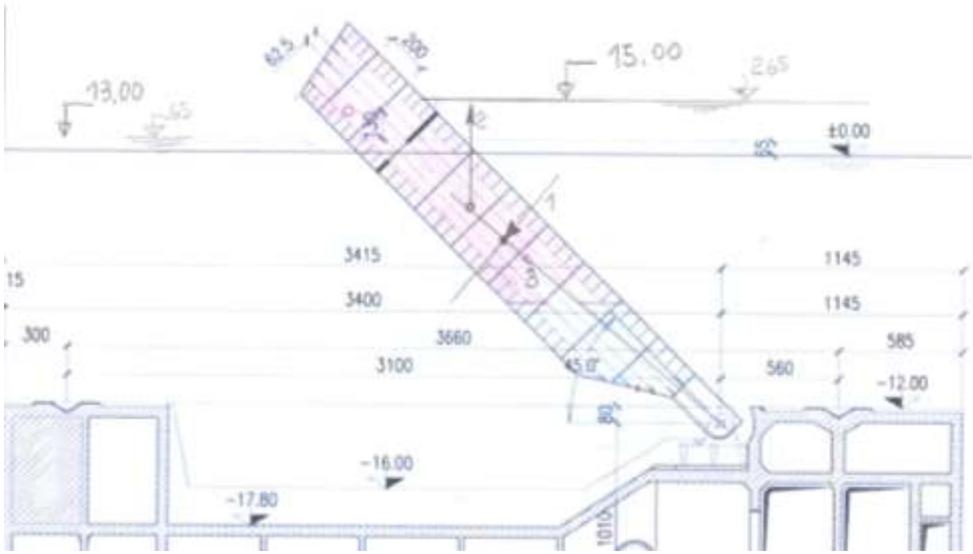
$$\nabla^2 p_i = \frac{\rho_{i,0} - \rho_i^*}{\Delta t^2} \leftarrow \rho_i^* = \rho_i - \Delta t \rho_{i,0} \nabla \cdot (\mathbf{v}_i^*)$$

$$\mathbf{v}_{i,t+\Delta t} = \mathbf{v}_i^* - \Delta t \frac{\nabla p_i}{\rho_{i,0}}$$

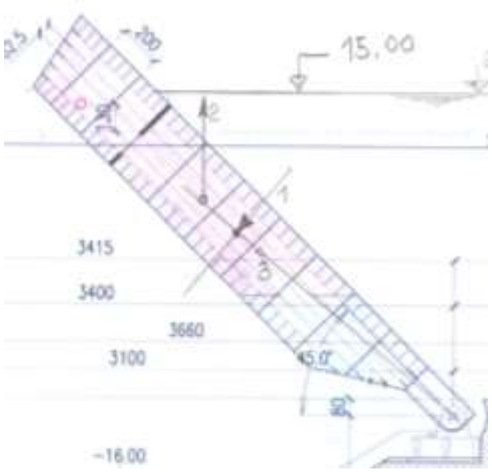
$$\mathbf{x}_{i,t+\Delta t} = \mathbf{x}_i + \Delta t \mathbf{v}_{i,t+\Delta t}$$

SIMULAZIONE NUMERICA

MARE + LAGUNA + PARATOIE MOBILI



SOLO PARATOIA

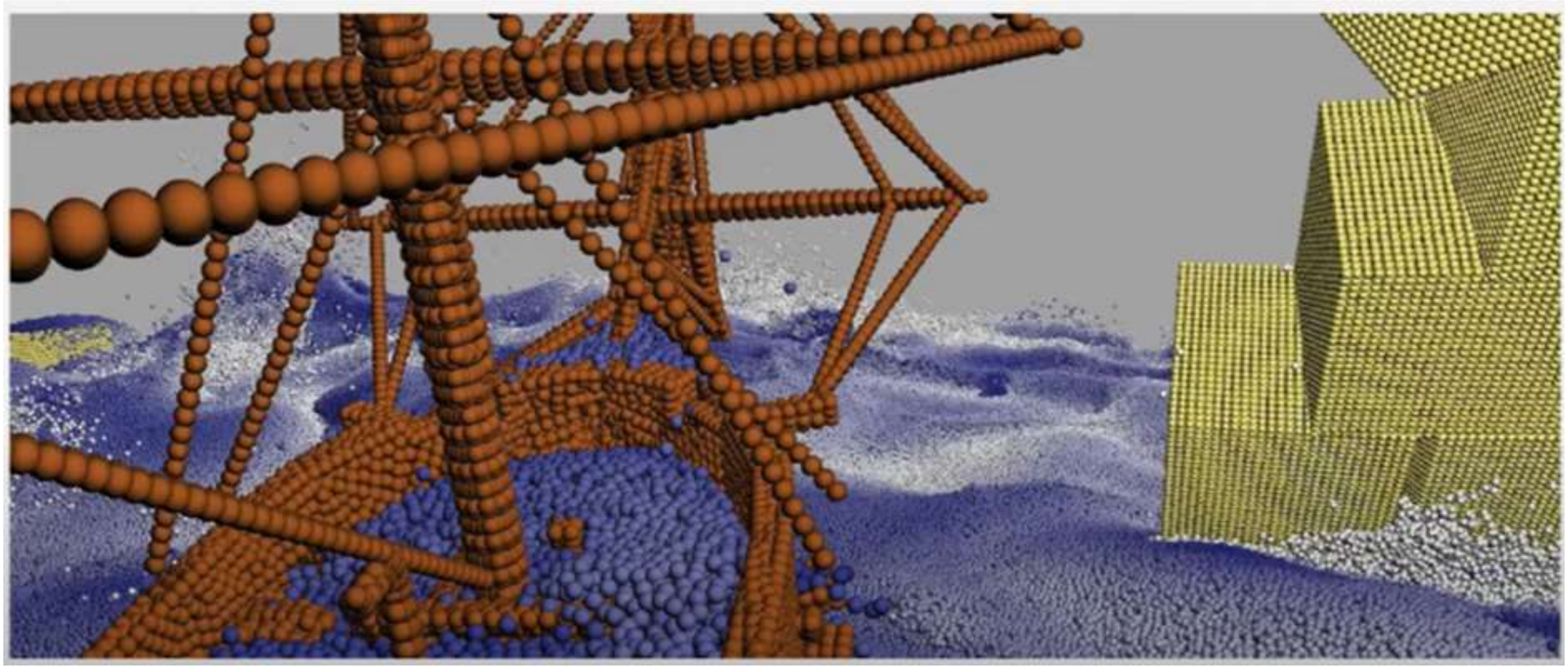


DOMINIO 3D
EULER FEM MESH
ANCHE 1000 ELEMENTI FINITI

LAGRANGE SPH MESHLESS 2 CM
ANCHE 1000 MILIONI PARTICELLE

OSCILLATORE SEMPLICE
1 GRADO DI LIBERTA'
SDOF

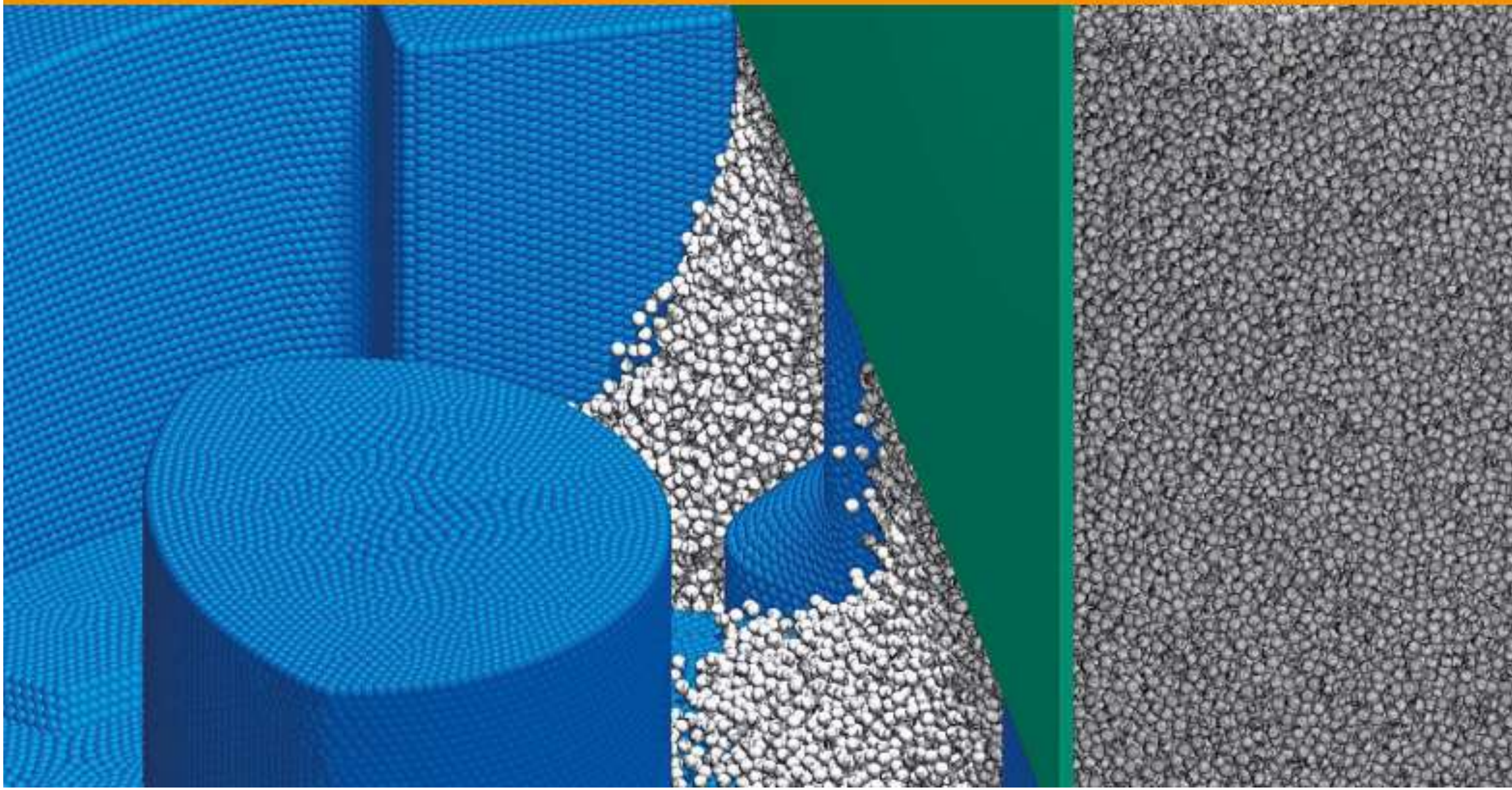
SPH MESHLESS SIMULATION



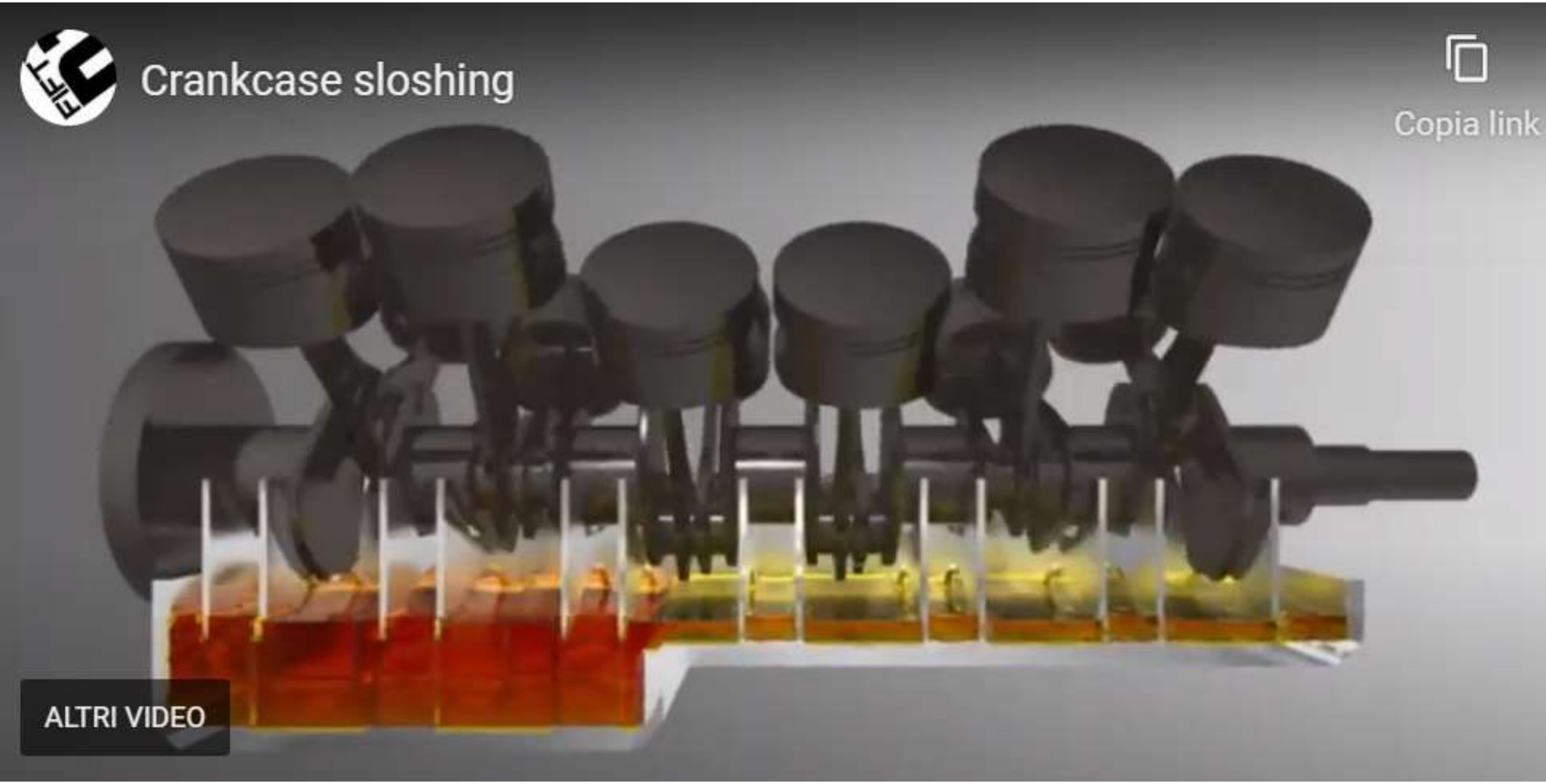
MODELLING SIMULATION RENDERING

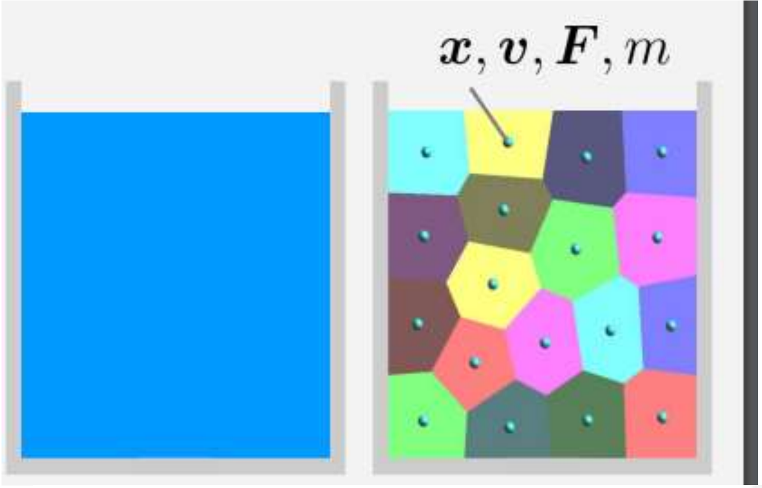
SimPARTIX®

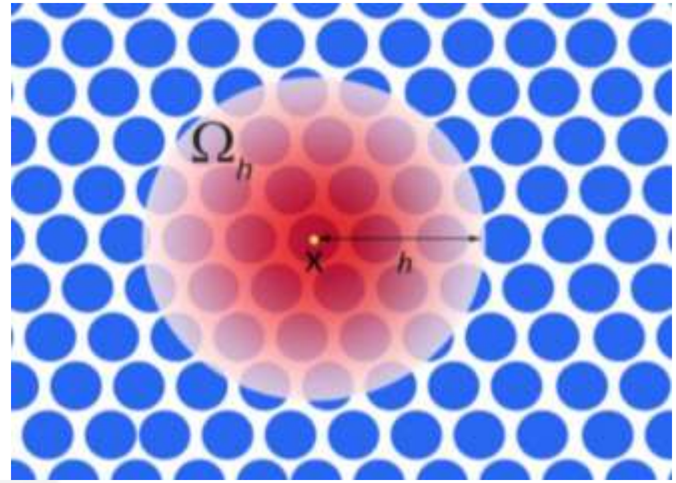
PARTICLE-BASED SIMULATIONS OF FLUIDS AND GRANULAR MATERIALS

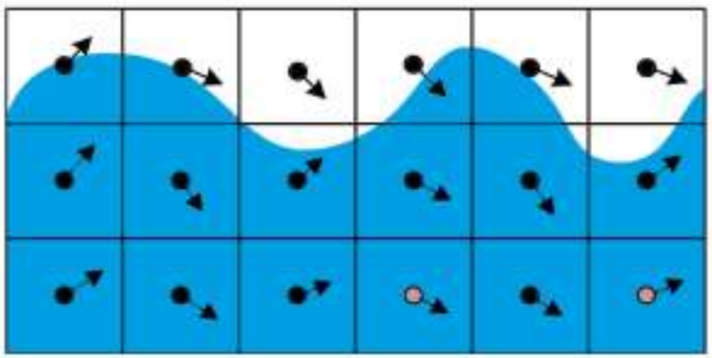



ion: 5x


Crankcase sloshing
Copia link
ALTRI VIDEO

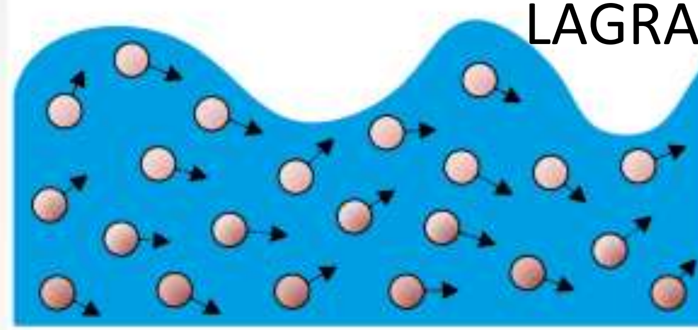


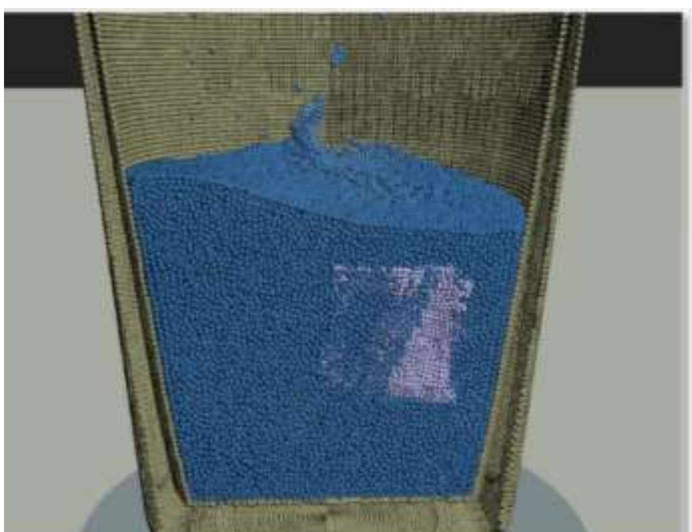




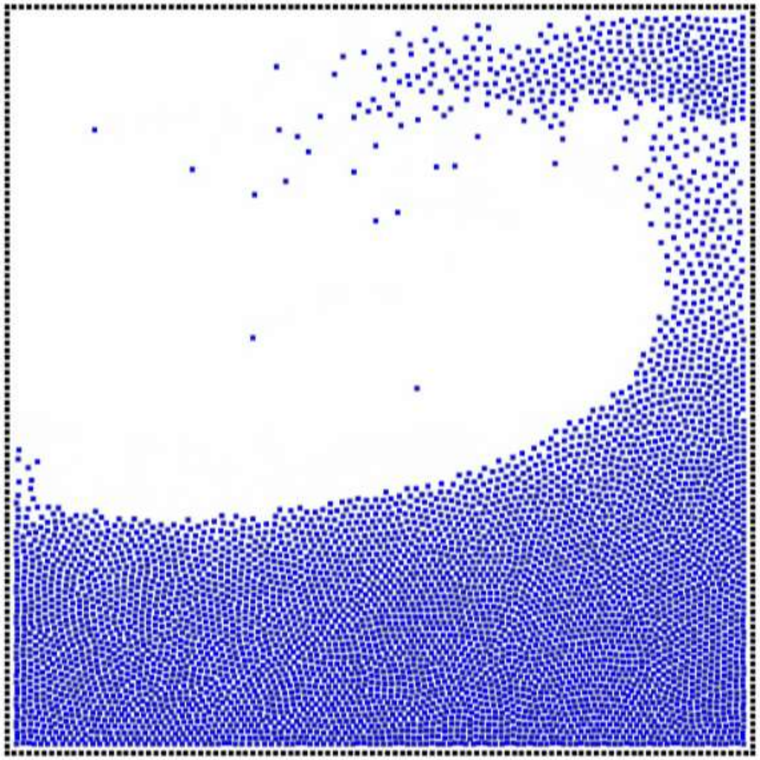
EULER

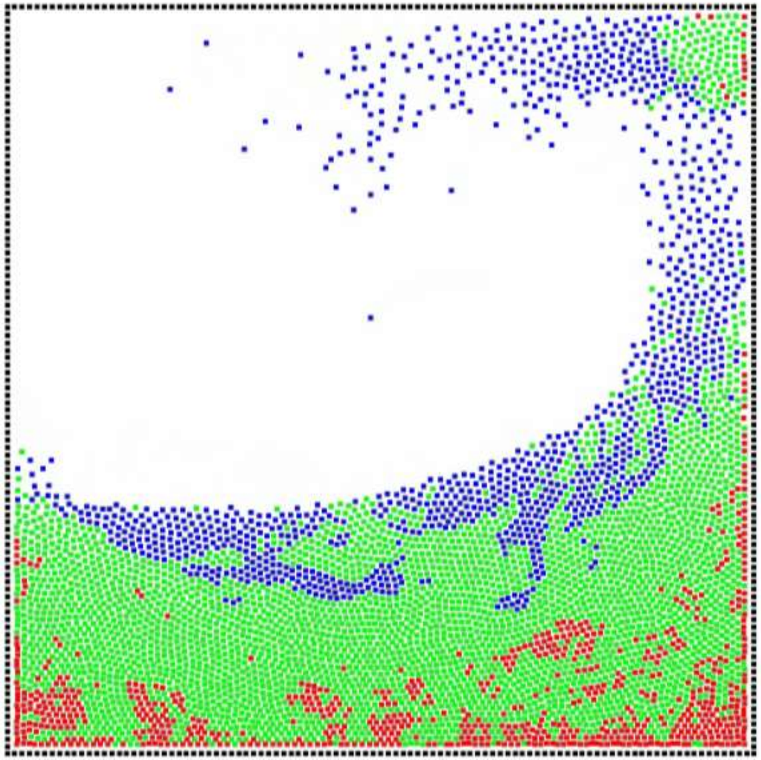
LAGRANGE

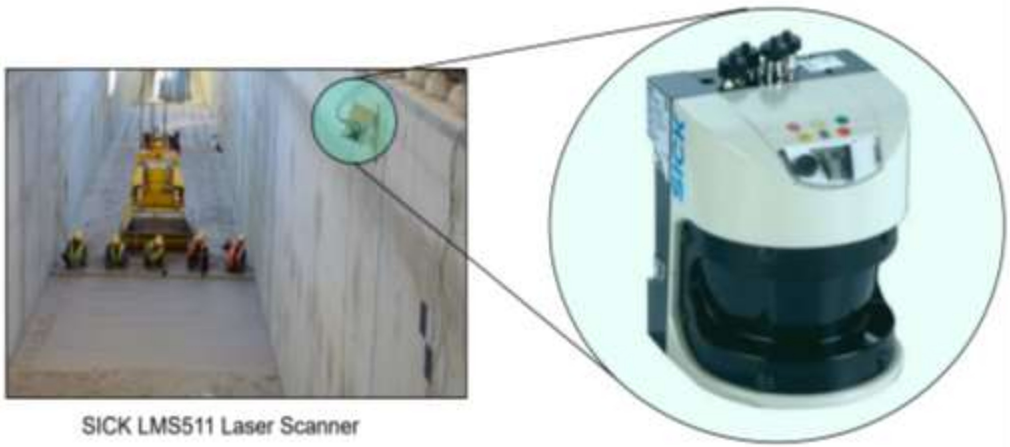




RENDERING







SICK LMS511 Laser Scanner

LASER SCANNER
STEREO VIDEO 3D

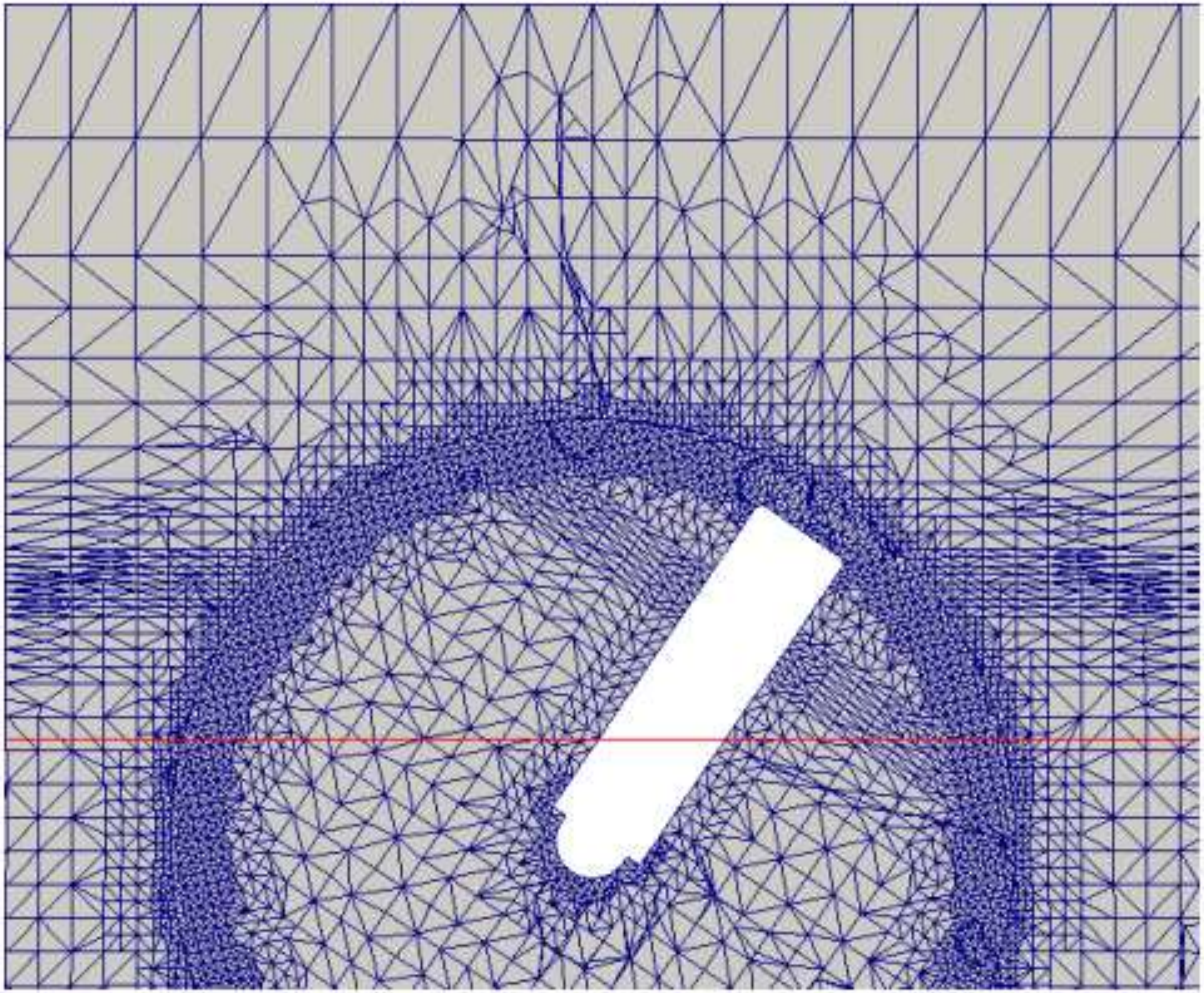


Fig. 7 Side view of the center plane of flap and moving mesh

DATABASE - HINDCAST (PUBBLICO?)

OGNI MAREGGIATA CLASSIFICATA CON:

ALTEZZA SIGNIFICATIVA Hs

PERIODO SIGNIFICATIVO Ts

ALTEZZA MASSIMA MAREA ……….

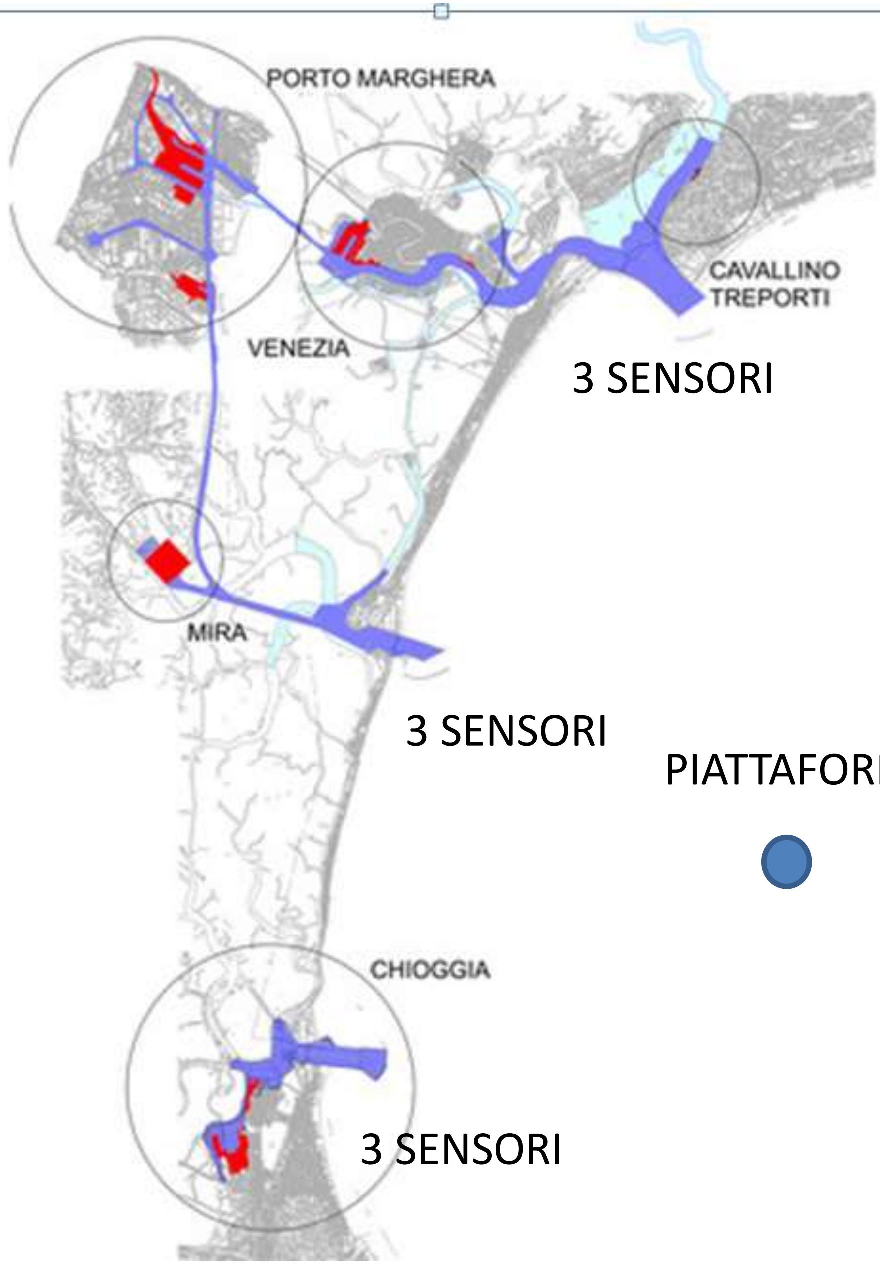
E STORIE TEMPORALI PASSO 1.0 S IN

MARE

BACINO

LAGUNA

SINGOLA PARATOIA DELLE BARRIERE



PIATTAFORMA ACQUA ALTA

SENSORE LATO LAGUNA

MONITORAGGIO E CONTROLLO ATTIVO

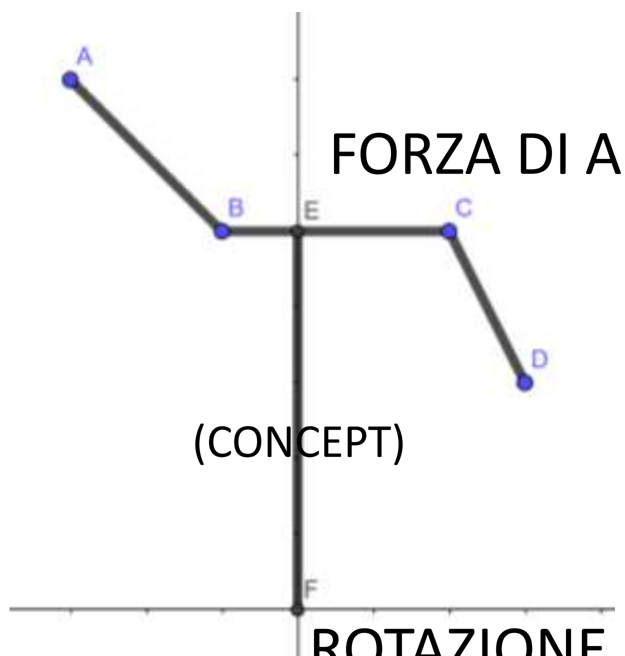
SENSORE
PIATTAFORMA
ACQUA ALTA

SENSORE
BACINO

SENSORE
BARRIERA
OGNI PARATOIA
CONTROLLO

SENSORE
LAGUNA

CONTROLLO PARATOIA
LIMITA LA ROTAZIONE
IN MODO ATTIVO

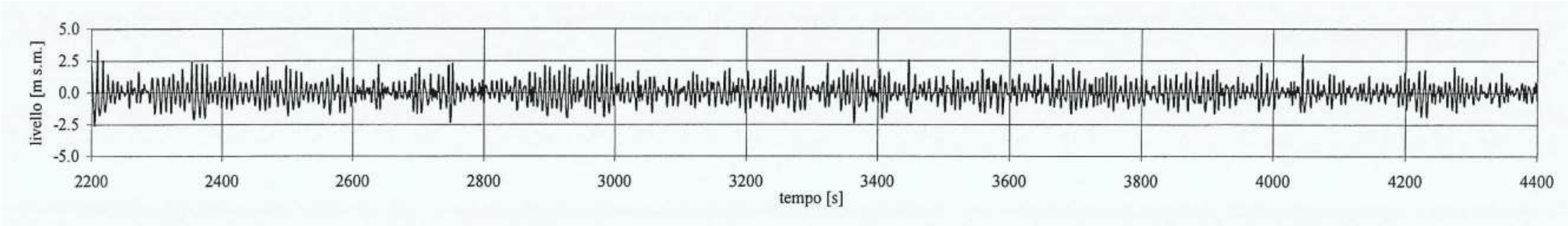


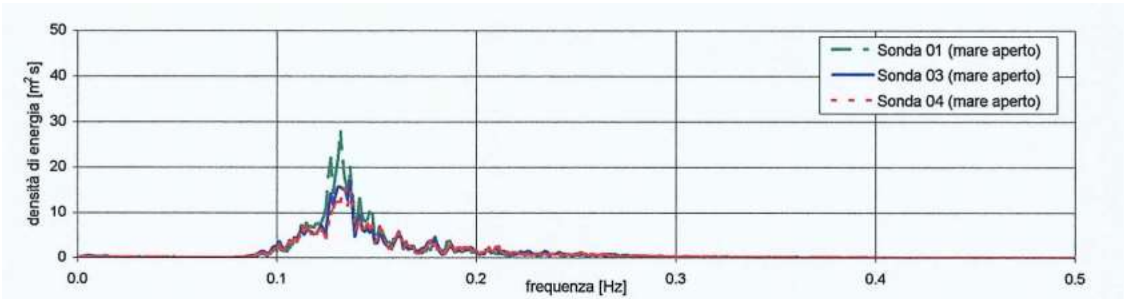
FORZA DI ARCHIMEDE

(CONCEPT)

ROTAZIONE

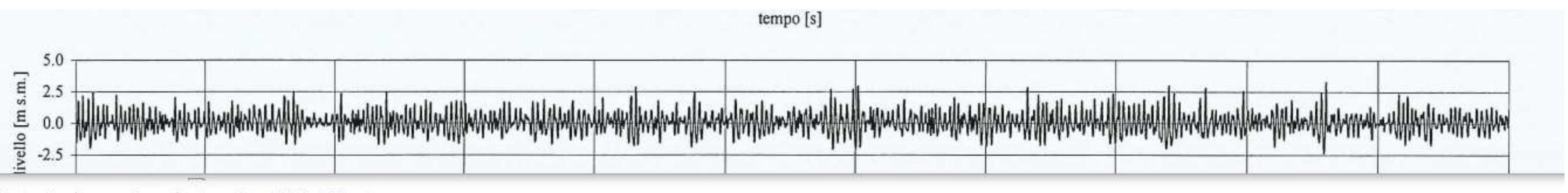
MOTO ONDOSO IN BACINO





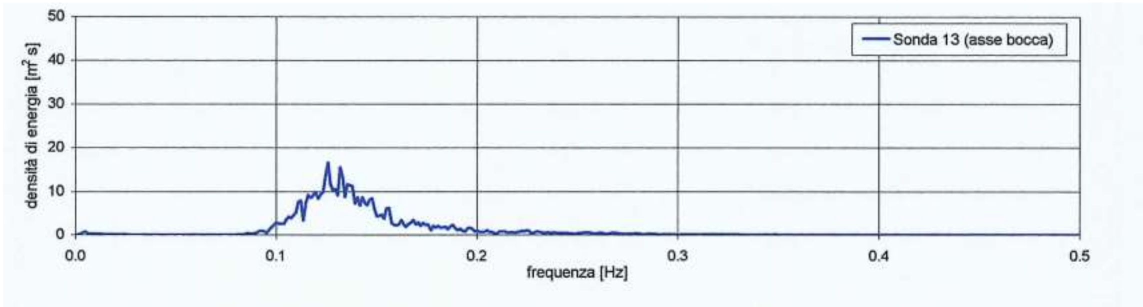
SPETTRO MOTO ONDOSO

LEGAME ONDA ROTAZIONE



ROTAZIONE PARATOIA

SPETTRO PARATOIA



OpenFOAM

- Mesh-based (fixed grid points)

DualSPHysics

- Mesh-less (moving grid points)

(OpenFOAM and DualSPHysics):

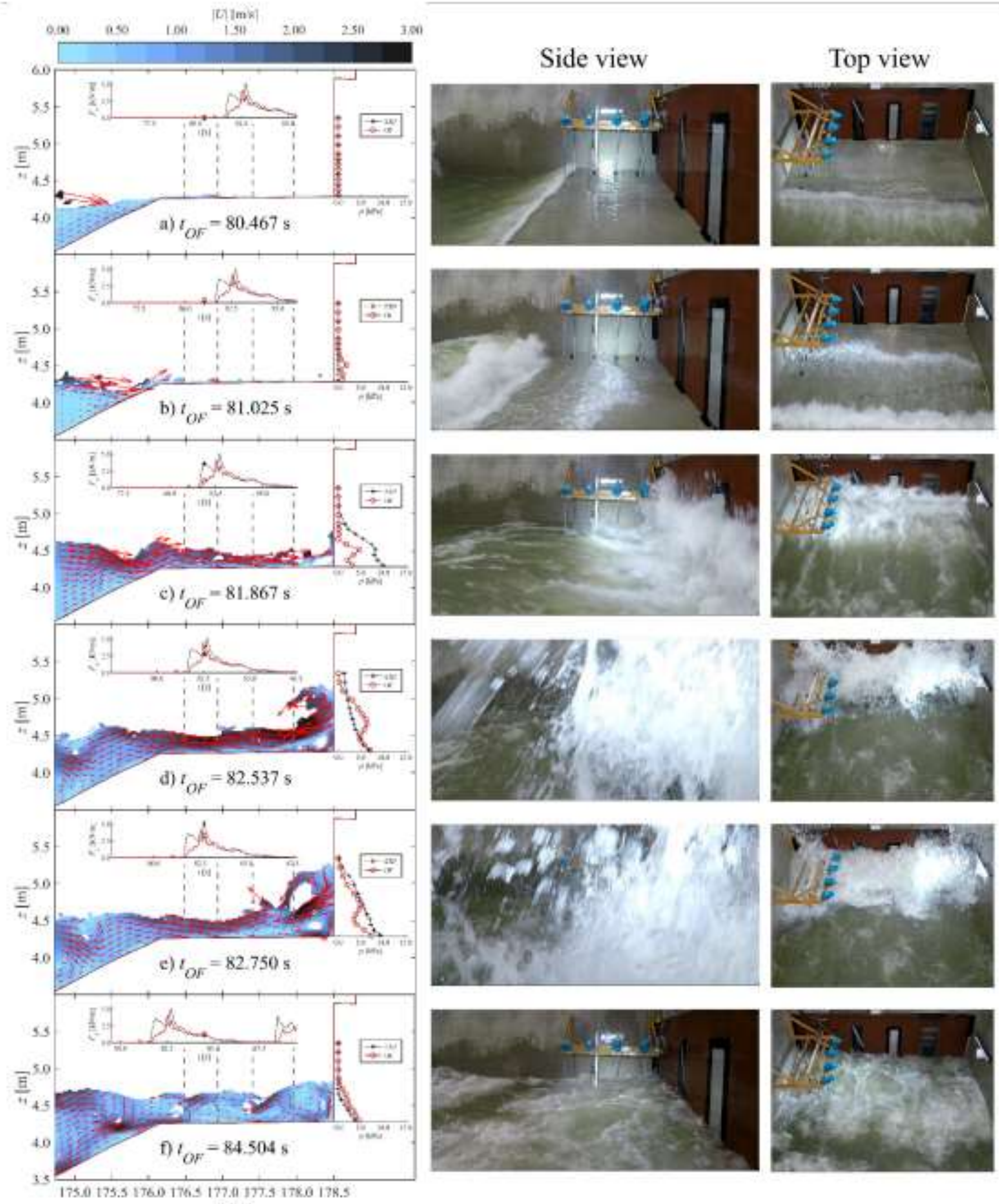
- Based on <u>most complete</u> mathematical description of fluid flow
- Open source!

SWASH

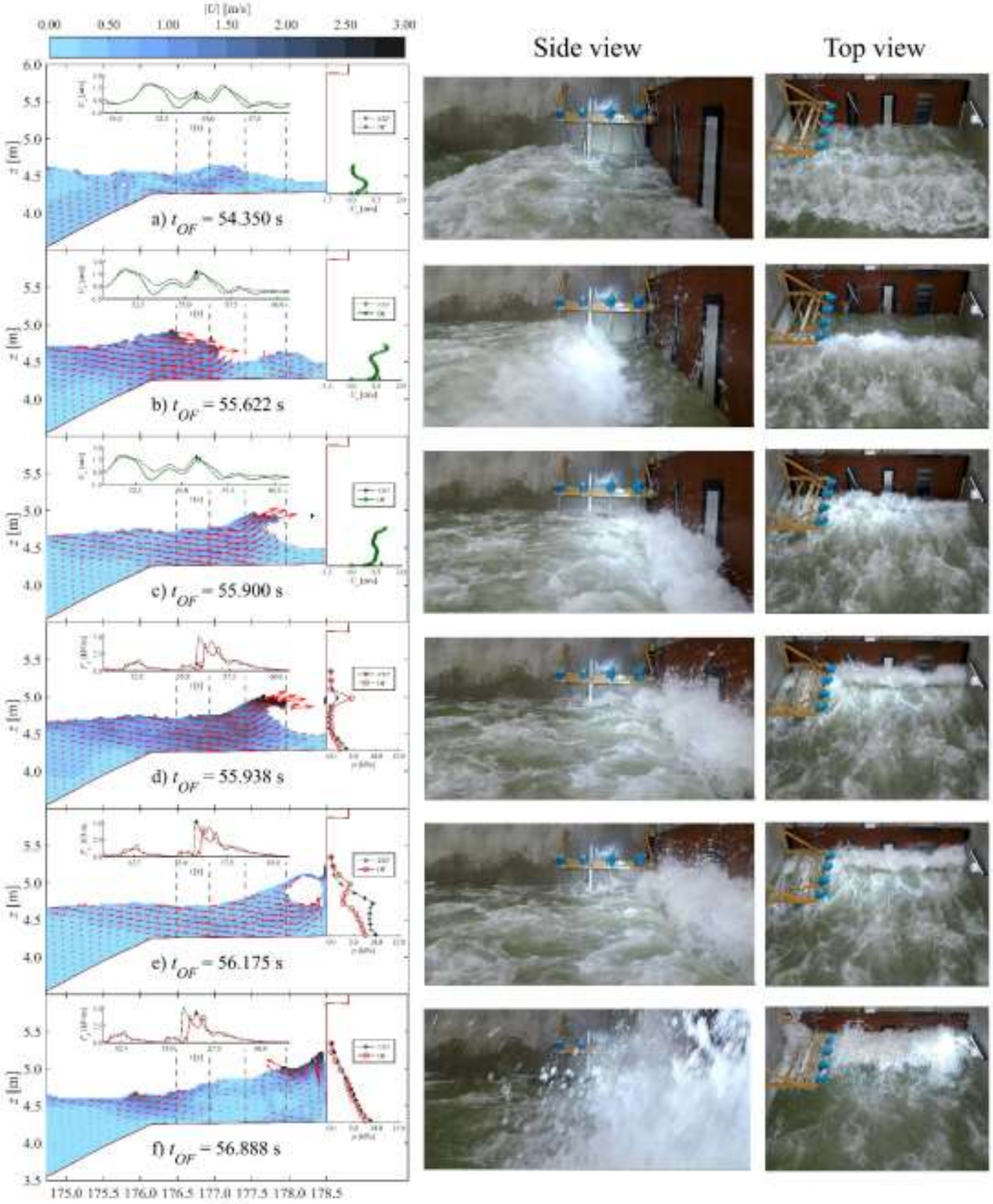
- Mesh-based (fixed grid points)
- Based on <u>more simplified</u> mathematical description of fluid flow
- Open source!

How accurate are these models?

What about the computational efficiency?

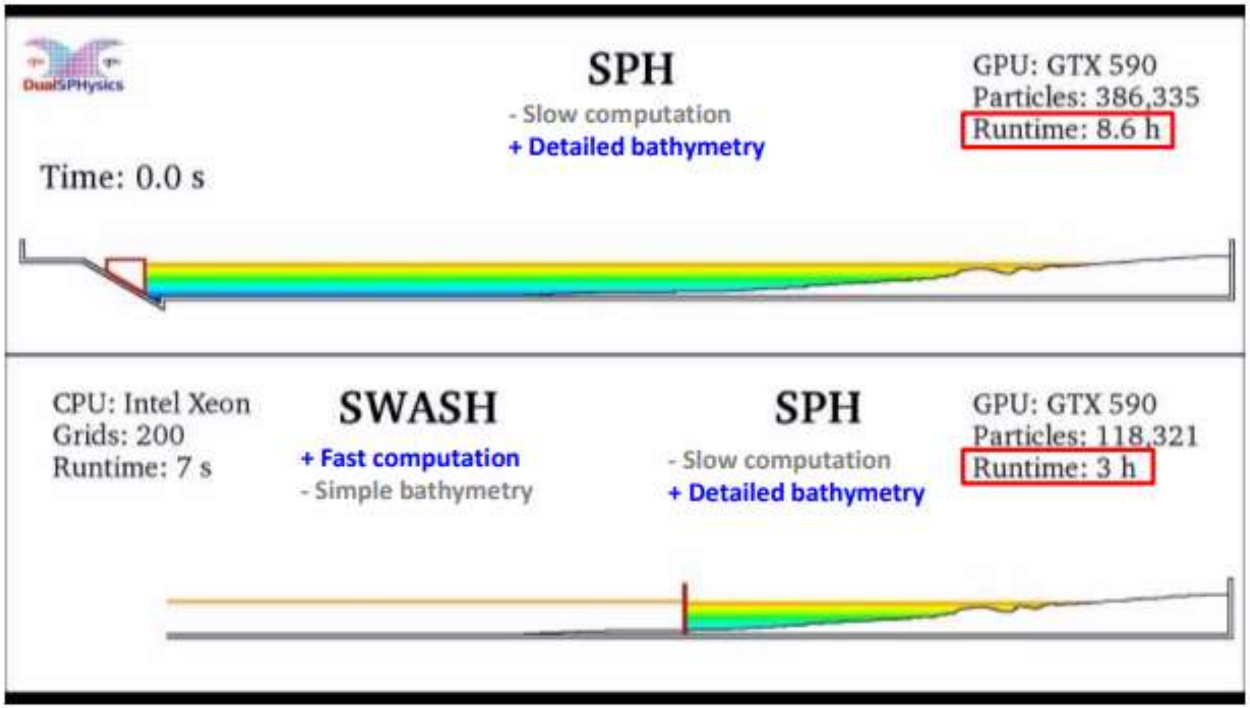


|U| [m/s]
0.00 0.50 1.00 1.50 2.00 2.50 3.00
Side view
Top view
z [m]
a) t_{OF} = 80.467 s
b) t_{OF} = 81.025 s
c) t_{OF} = 81.867 s
d) t_{OF} = 82.537 s
e) t_{OF} = 82.750 s
f) t_{OF} = 84.504 s
175.0 175.5 176.0 176.5 177.0 177.5 178.0 178.5
x [m]


|U| [m/s]
0.00 0.50 1.00 1.50 2.00 2.50 3.00
Side view
Top view
a) t_{OF} = 54.350 s
b) t_{OF} = 55.622 s
c) t_{OF} = 55.900 s
d) t_{OF} = 55.938 s
e) t_{OF} = 56.175 s
f) t_{OF} = 56.888 s
z [m]
x [m]
175.0 175.5 176.0 176.5 177.0 177.5 178.0 178.5

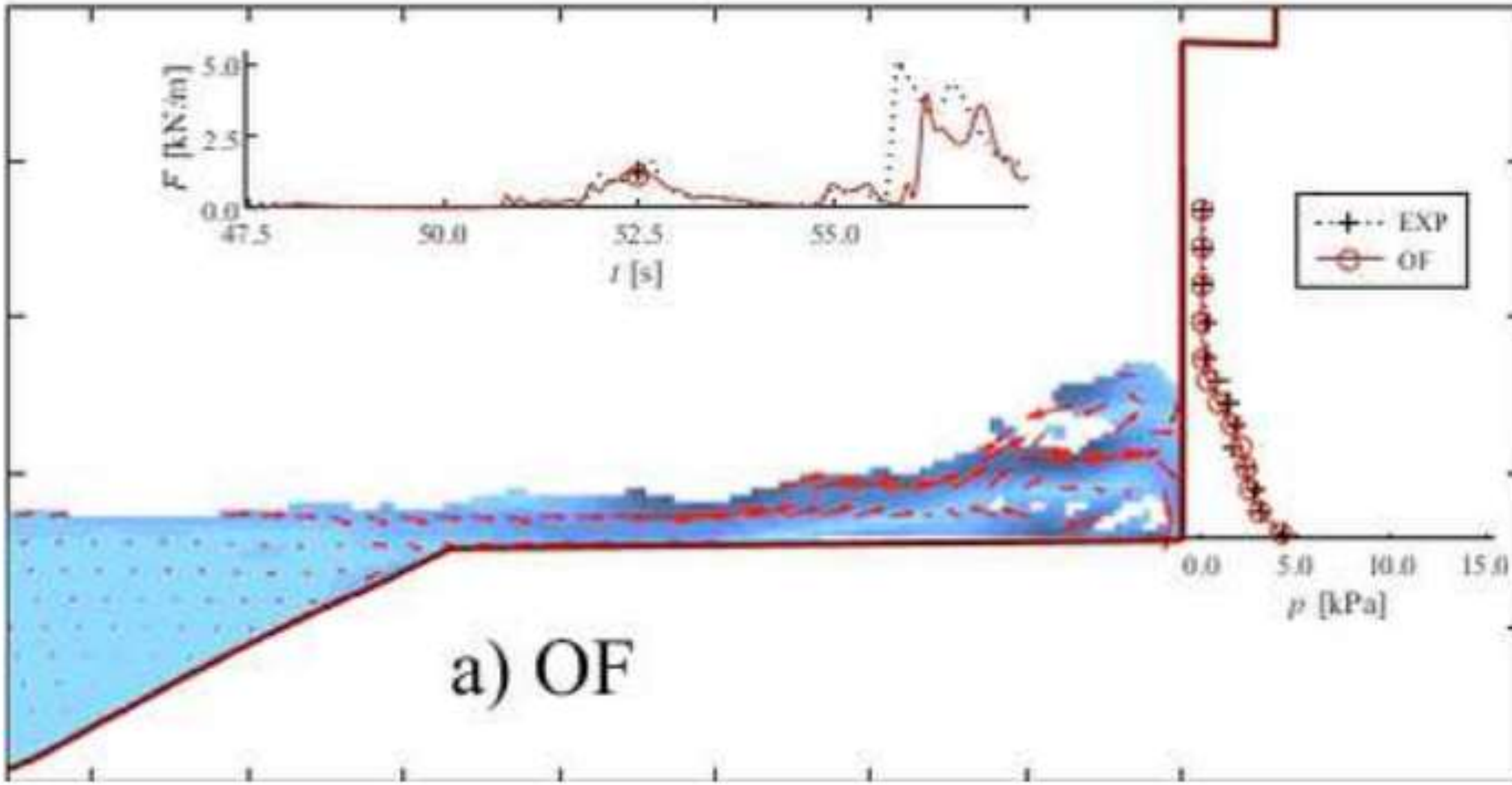
Innovation in coupling of numerical models

Tomohiro Suzuki (Flanders Hydraulics Research)

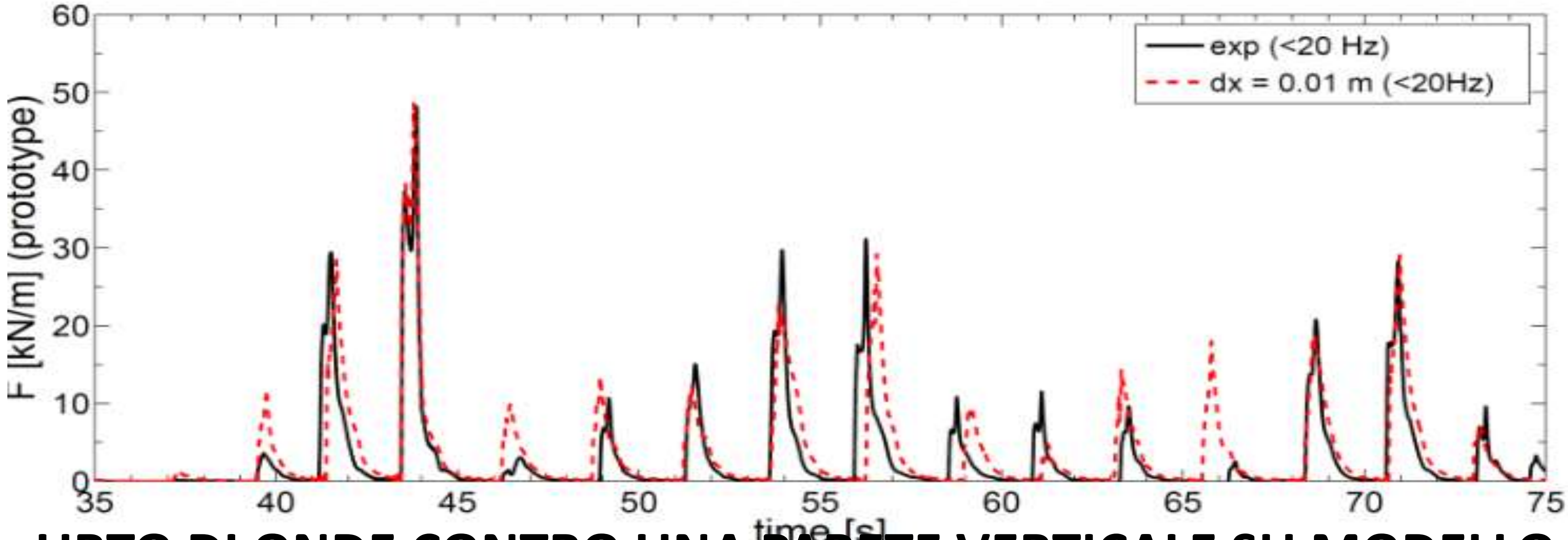


Take home message: The road to efficient and accurate design of the optimised coastal defence systems of tomorrow ➔ ***Coupling numerical models*** *enables complex modelling only where necessary: advantages of each model are preserved without suffering their individual downsides.*

OpenFOAM

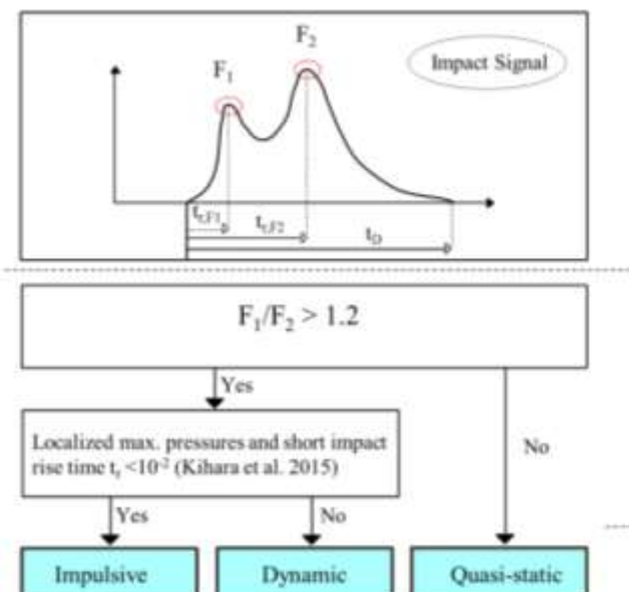


(a)



URTO DI ONDE CONTRO UNA PARETE VERTICALE SU MODELLO

(b)



URTO
IMPULSIVO
DINAMICO
QUASI STATICO

GRUWEZ ET AL.

SCENARIO STANDARD DI VALIDAZIONE

SIMULAZIONE NUMERICA CON SPH SPLISHSPLASH

S. Band & C. Gissler & M. Teschner / Compressed Neighbor Lists for SPH 7

Figure 6: The dam break scenario at $t = 0\,s$ (left), $t = 1.5\,s$ (middle) and $t = 3\,s$ (right).

NECESSARIA VALIDAZIONE DELLE SOLUZIONI NUMERICHE ATTRAVERSO CONFRONTO CON PROVE SU MODELLO O REALI (MOSE)

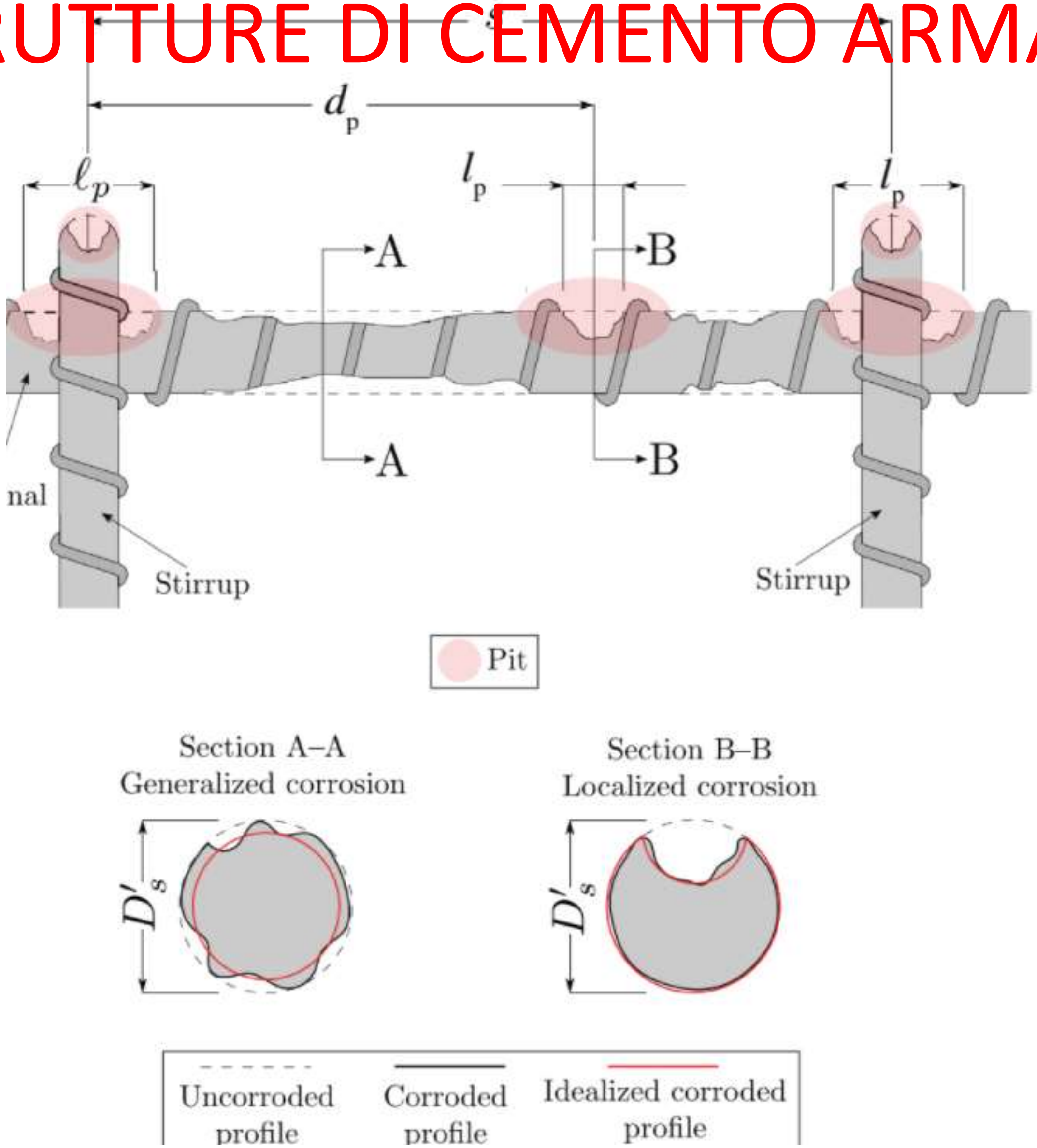

2021-11-01 20:02:42
Treporti_02 UTC + 1

CORROSIONE E BIOCORROSIONE

ASSETS EXPOSURES	HAZARD
PALANCOLE 50KM	PROBABILISTIC MAP
PARATOIE	DENSITA' CORRENTE
IN ACQUA	CLORURI
IN ARIA	MICRORGANISMI
CASSONI	

B. BRISEGHELLA C. NUTI ET AL

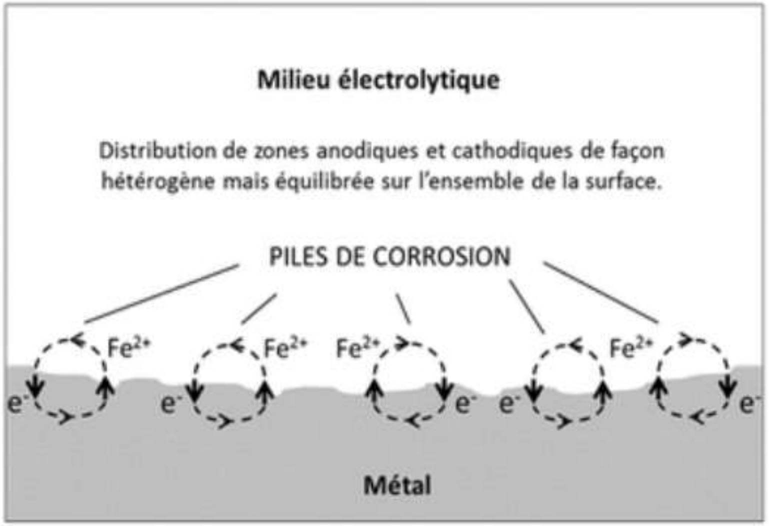
STRUTTURE DI CEMENTO ARMATO



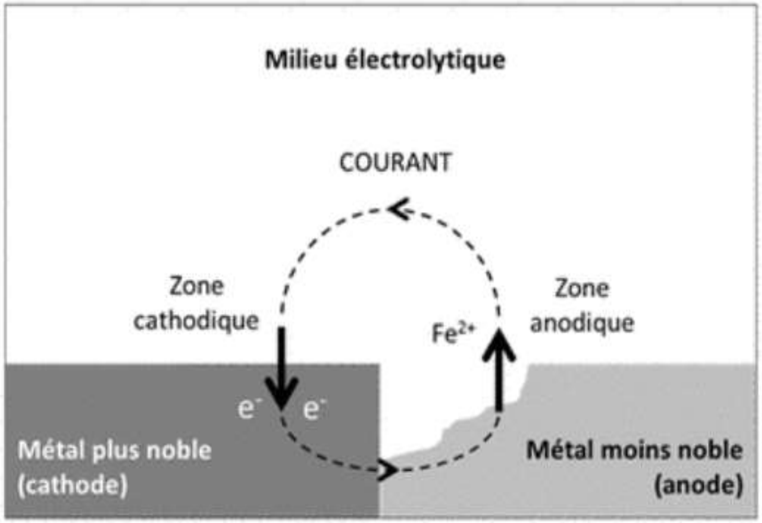
B. BRISEGHELLA ET AL.

ISO 8044 8 FORME DI CORROSIONE

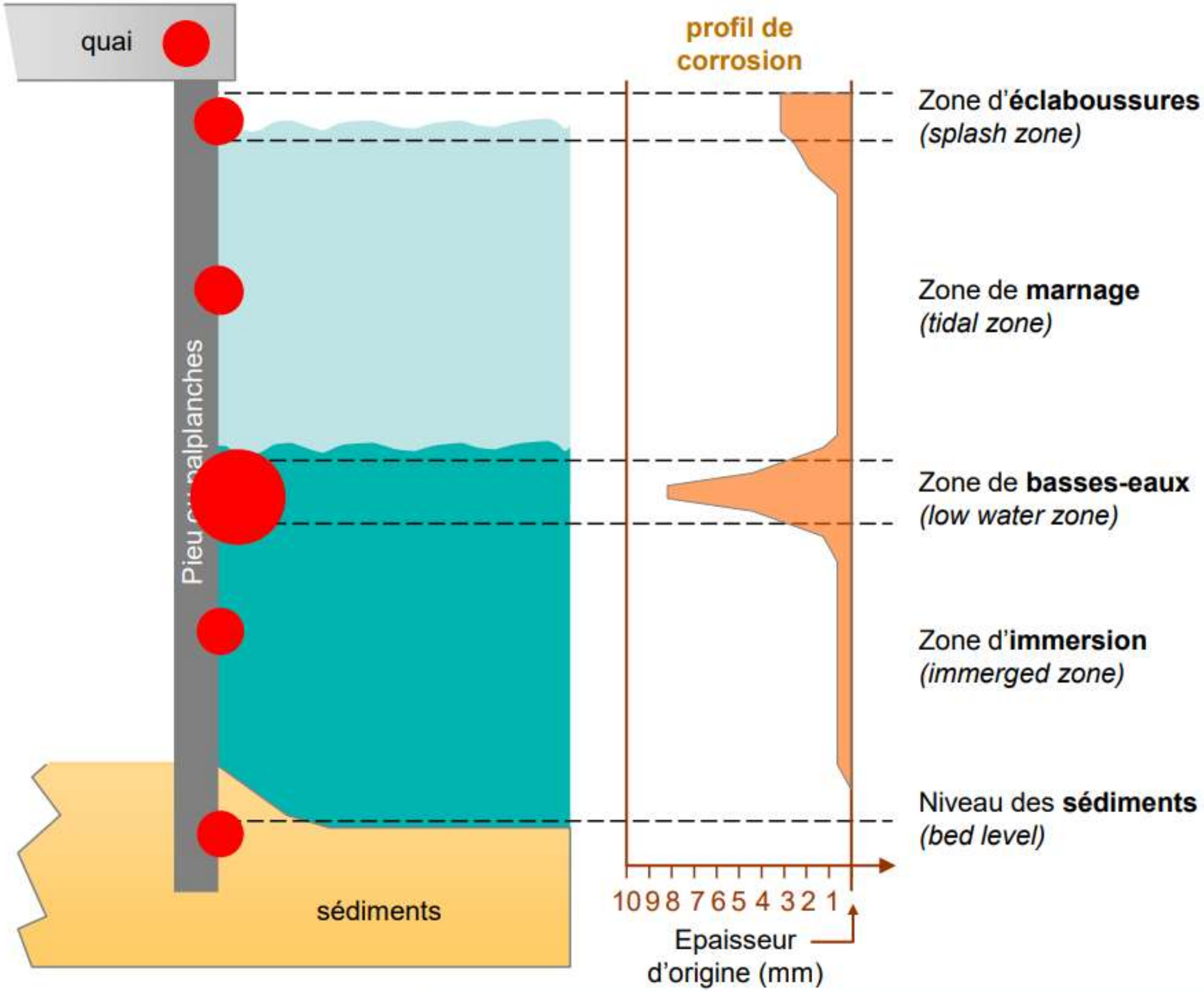
❶ La corrosion généralisée ou uniforme

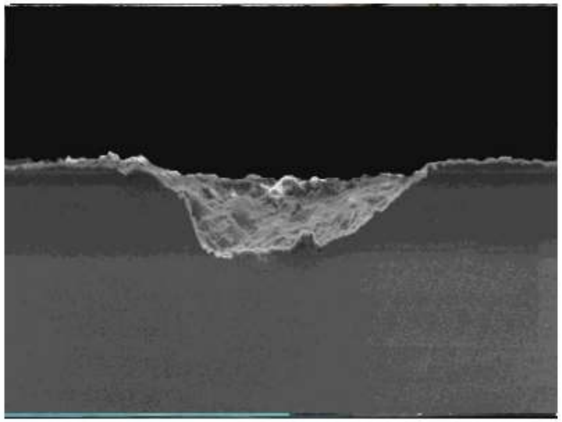


❷ La corrosion galvanique



VELOCITA' DI CORROSIONE





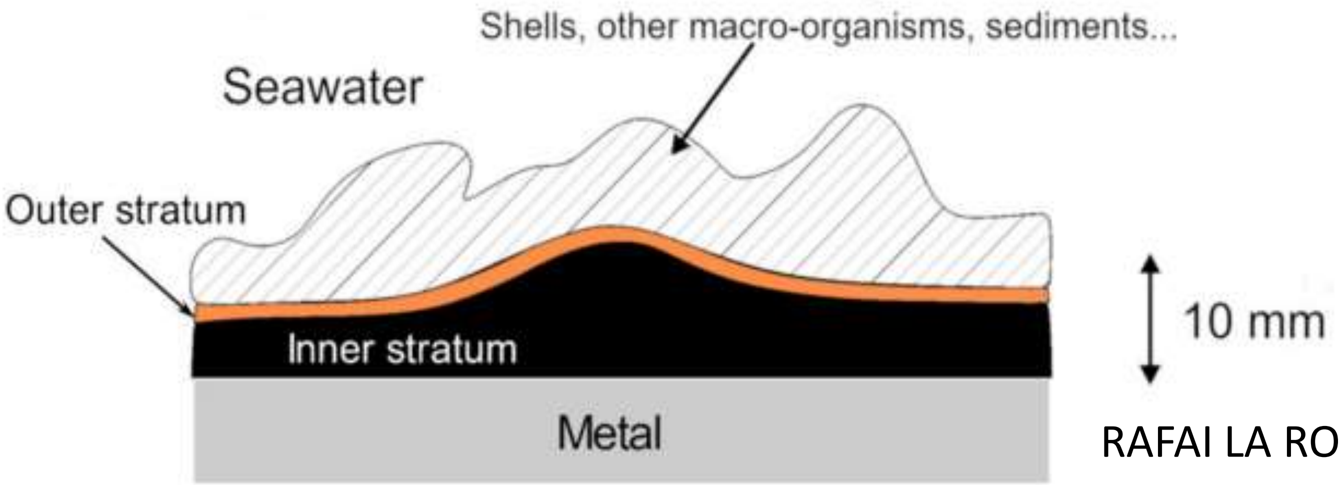
Corrosion
Corrosion
généralisée
classique
béton

Vitesse de corrosion

« accélérée » : **> 0,1 mm.an^{-1}**

« normale » : **≈ 0,01 mm.an^{-1}**

FOTO PINEAU



RAFAI LA ROCHELLE UNI

Figure 1. Schematic representation (cross-section) of the layer covering a carbon steel coupon after 6–11 years of permanent immersion in natural seawater.

DOPO 6-11 ANNI DI IMMERSIONE IN ACQUA DI MARE

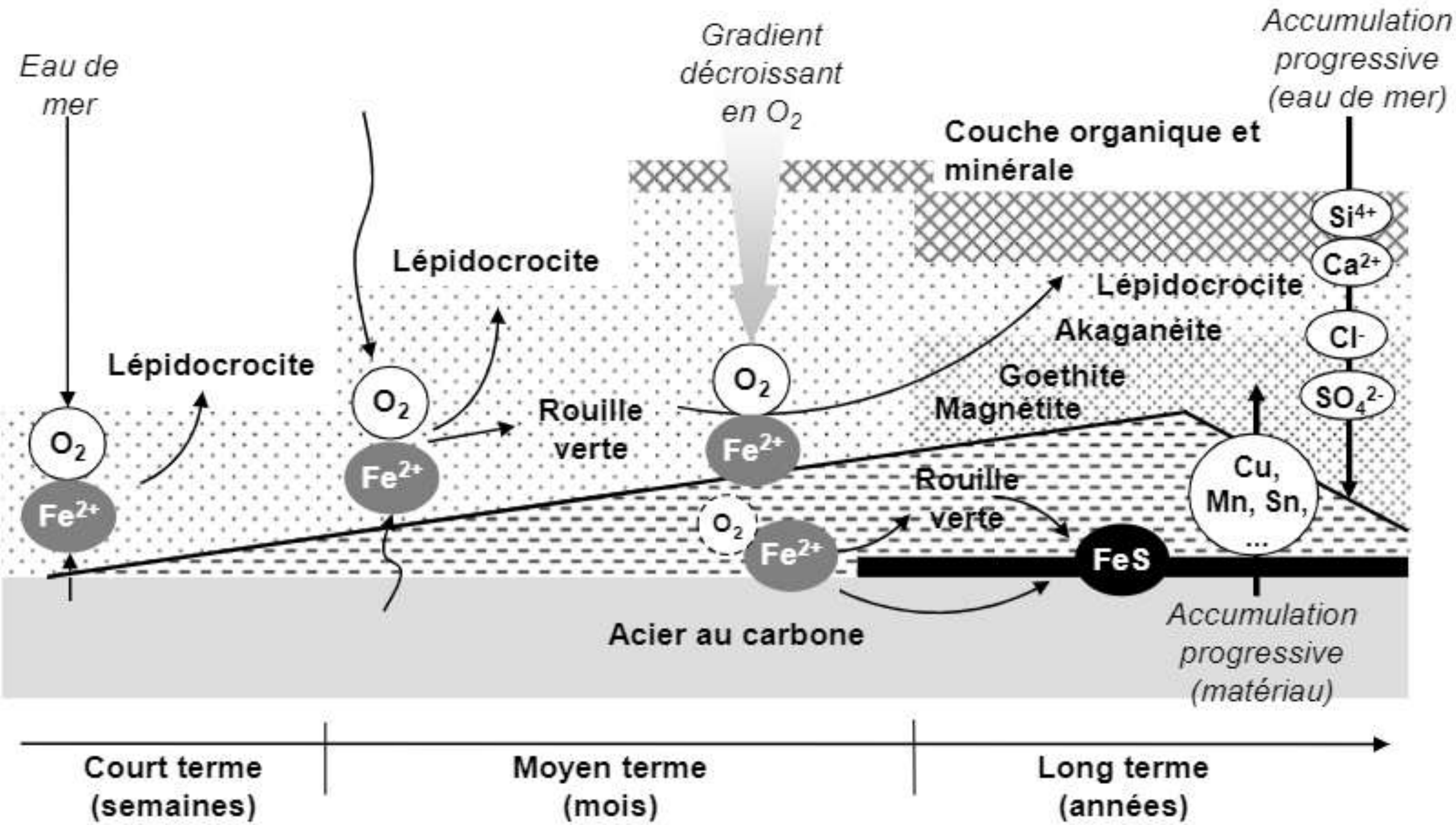
Les produits de corrosion observés au sein d'un dépôt témoignent d'un gradient décroissant en oxygène

Concentration en oxygène ↓

	Degré d'oxydation du fer
Lépidocrocite (γ-FeOOH)	**3**
Goethite (α-FeOOH)	**3**
Magnétite (Fe_3O_4)	**2,67**
Rouille verte ($Fe^{II}_4Fe^{III}_2(OH)_{12}SO_4.nH_2O$)	**2,33**
Sulfures de fer	**2**
acier	

Processus de formation des produits de corrosion (eau de mer)

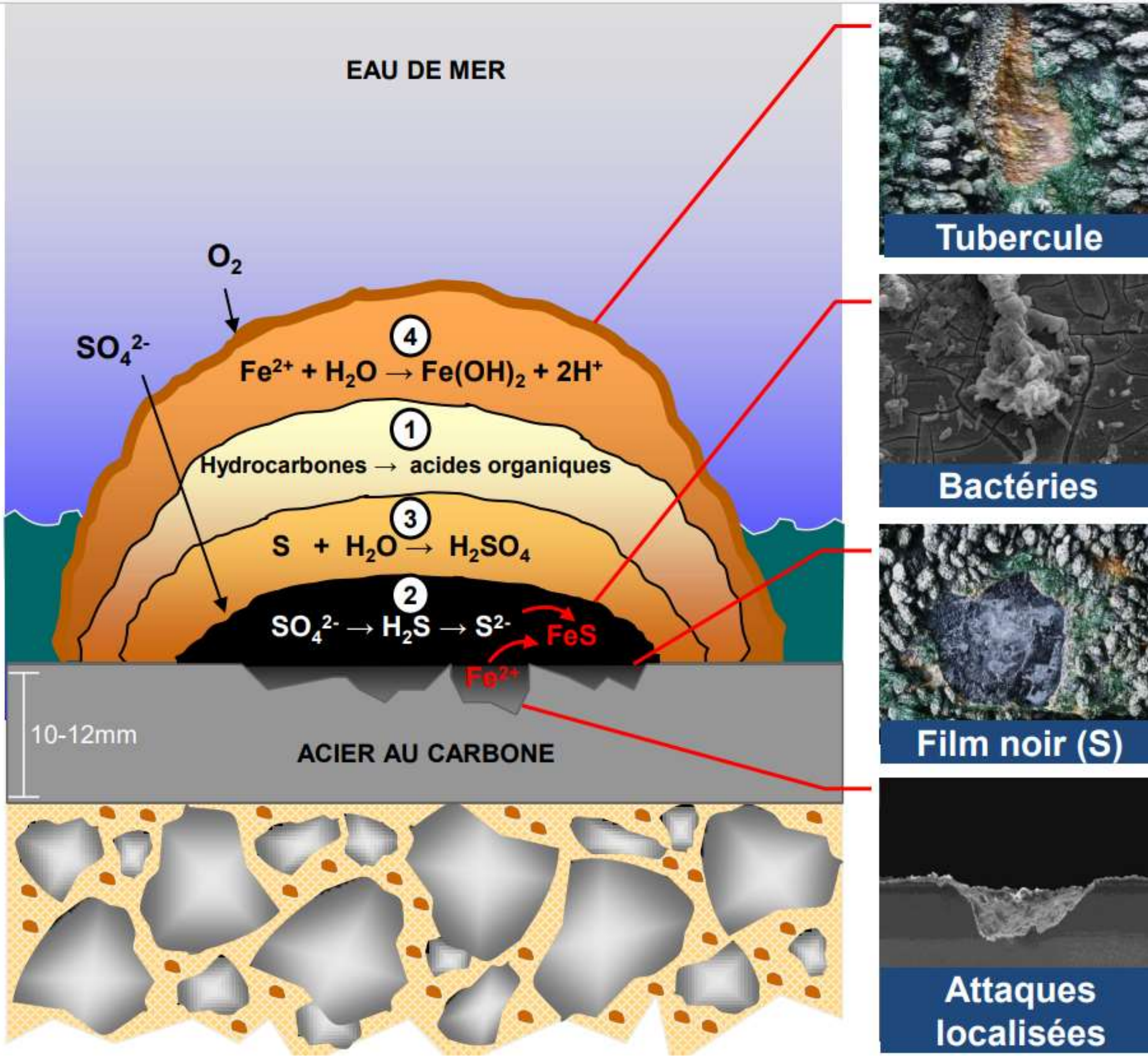
PINEAU ET AL.



Hypothèse de l'association bactérienne

FLORE BACTÉRIENNE :

- Ferro-précipitante ④
- Acidogène ①
- Sulfo-oxydante ③
- Sulfurogène ②



Indices actuels d'identification de la biocorrosion

SEDIMENTI E/O CORROSIONE? ACCIAIO AL CARBONIO CON PROTEZIONE CATODICA, VERNICI IN STRATI EPOSSIDICO ANTIRUGGINE E ANTI FOULING DOPO ANNI XXXXX

PIU’ INQUIETANTE CHE ALLARMANTE

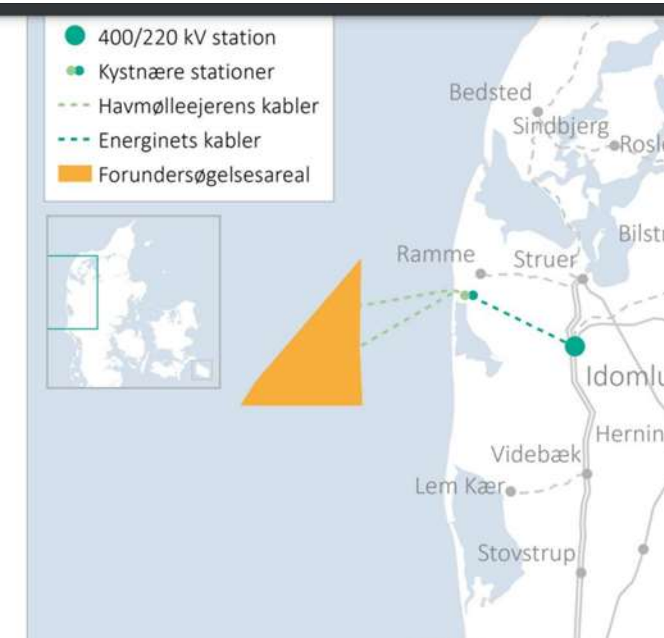
DUE FOTO ARSENALE MURO NORD

ISOLE OFFSHORE

Metocean (EOLOS BOA)
Seabed investigation
Geophysical
Marine archaeology
Geotechnical
Geomodel report
Environmental assessment

MONITORAGGIO CON BOE

EOLOS METOCEAN BUOY



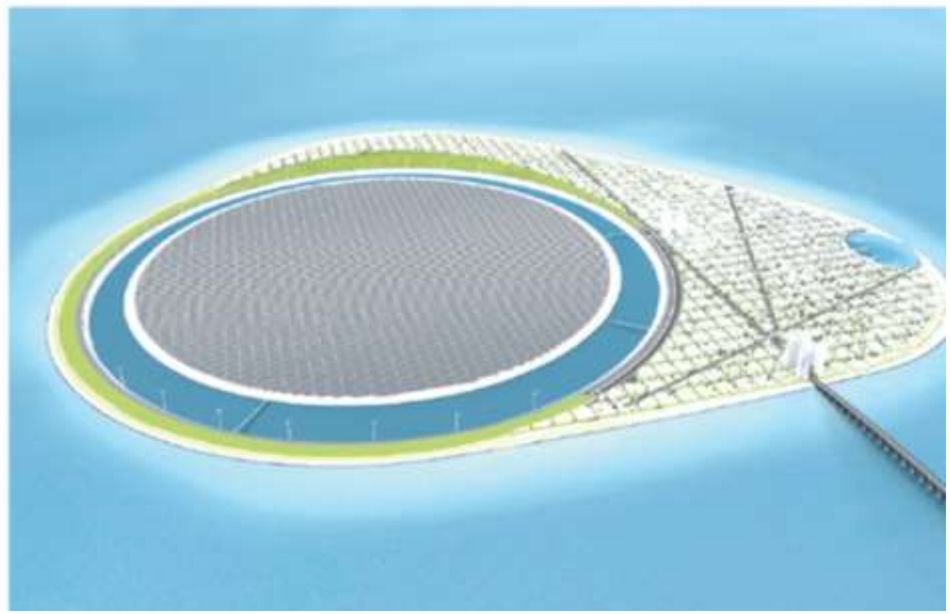
THOR OFFSHORE DENMARK (CONCEPT)

GOTTLIEB PALUDAN ARCHITECTS

CITTA' CONTRO INNALZAMENTO MARE?

JACQUES FRESCO DESIGN



….. ALTINO TORCELLO RIALTO VENEZIA ……………… GRAZIE

DISCUSSIONE
20 MINUTI

1. MODELLI NUMERICI (4 VIDEO)
2. MODELLI FISICI IN SCALA (MOSE E COB)
3. DINAMICA DELLE BARRIERE
4. CORROSIONE DEI MATERIALI
5. ISOLE OFFSHORE
6. DISCUSSIONE (20 MINUTI)
7. CONCLUSIONI