Prof. Ph. RIGO,
University of Liege, Belgium
Optimisation of Ship and Offshore Structures &
Effective Waterway Infrastructures to support
the Global Economic Growth of a Country/Region

Prof. Philippe RIGO,
University of Liege, Belgium
Main research activities at ULG

- Ship Structure Optimization;
- Ship impacts (Collision), with application on IW infrastructures as navigation lock gates;
- Inland waterway navigation and the development in South America of Inland Waterway Classifications;
- The European EMSHIP education program in Naval Architecture - www.EMSHIP.eu
We combine:
- naval architecture, ocean engineering, ship and offshore structure
- expertise’s in inland waterway as well as in transport system analysis and logistics.

So all the aspects related to marine and inland waterways aspects are covered:
- ship design and operation,
- waterway infrastructure
- transportation economical analysis.
PIANC is a reference international association in which Prof. Ph. RIGO disseminates his expertise.

Now PIANC National Columbian Section

Prof. Ph. Rigo is the chairman of the PIANC InCom (Inland Navigation Commission) and is the main author of several PIANC Reports on Inland Waterway infrastructures (PIANC WG106 - 2009, PIANC WG26 - 2016).
PIANC - Navigation Locks

- PIANC WG106 - 2009

- Design of new Panama locks

- Flood Protection barriers(New Orleans- Catherina),...

- Major navigation locks in Europe, ...
PIANC & South America

Joint WG between PIANC and ECLAC (CEPAL)

SOUTH AMERICA

Brazil
Columbia,
Argentina,
...

UNited Nations

ECLAC
A Workshop - PIANC - ECLAC (CEPAL) - ANTAQ

Seminar on Inland navigation in South America
October 2016
Rio de Janeiro, Brazil
PIANC & South America

A Workshop - PIANC - ECLAC (CEPAL) - ANTAQ

- Seminar on Inland navigation in South America
  In October 2016 (Rio de Janeiro, Brazil),

- With representatives of the South American countries (including Columbia)

- WHY?
A Proposal of Inland Waterway Classification(s) for South America

As CEMT 1992 in Europe (Rhin, Danube, ....)
The objective is to develop and implement a strategy for a common supra-national inland waterway classification for South America, combining the knowledge of ECLAC (CEPAL) and PIANC and drawing on the experience of other regions of the world.
Why Inland Waterway Classification(s) for South America?

- Lack of standardization of fleets, vessel, and control procedures.
- Lack or absence of investment in the construction and maintenance of waterway infrastructure and inland ports;
- Delay and lack of administrative structures (capacity in this case refers to human and financial capital);
- Lack or absence of navigation aids, including updated maps, electronic charts, signals, and other navigational services as RIS;
1-2 students **Columbia** each year

P. Rigo - Cartagena, March 207
Starting in Sept 2017

• 2 YEARS MASTER
• 2 MASTER DEGREES
• 2-3 MOBILITIES
• 2 or 3 Languages
• 1 INTERNSHIP in INDUSTRY
ELIGIBILITY

► From 2017: Bachelor Level
(3 years, 180 credits)
Unique International Programme

- 3 Countries
- 3 Cultures / Languages
- 24 months → full time education

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Double Master Degree awarded

► University of Liège (Belgium)
► Ecole Centrale de Nantes (France)
► URO (Rostock, Germany), or ZUT (Poland)
LIST of INTERNSHIP
& AWARDED MASTER THESIS
by DnV-GL, LR, BV, RINA

Hydrodynamic Analysis of a Heavy Lift Vessel during Offshore Installation Operations

Heavy Lift, Germany
INTERNSHIP & AWARDED MASTER THESIS by DnV-GL, LR, BV, RINA

Analytical Formulations for Ship-Offshore Wind Turbine Collisions

STX, France
INTERNSHIP & AWARDED MASTER THESIS
by DnV-GL, LR, BV, RINA

Analysis of Classification Societies Rules for Yacht Superstructure Scantlings – Application to a Light Alloy Superstructure

BENETTI, Italy
Ship Structure Optimisation
LBR5- Ship Structure Optimisation

**Model GUI**

**Design Variables**
- Sea pressures
- Deck pressures
- Bending moments
- Sloshing loads
- Etc.

**Loads**

**Structural Analysis**
- Deflection
- Stresses
- Yielding Strength
- Buckling Strength
- Ultimate strength

**Optimisation**

**Optimisation Algorithm**

**Objective Function**
- Steel weight
- Production cost
- Flexional inertia

**Constraints**
- Structural constraints
- Geometrical constraints
- Global constraints
- Equality constraints
- Technological constraints

**Optimum Scantling**
Multi Objective Optimisation

<table>
<thead>
<tr>
<th></th>
<th>Weight Optimization</th>
<th>Cost Optimization</th>
<th>Min-Max Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel weight</td>
<td>-12.72%</td>
<td>+5.1%</td>
<td>-11.3%</td>
</tr>
<tr>
<td>Material cost</td>
<td>-8.5%</td>
<td>+0.89%</td>
<td>-8.38%</td>
</tr>
<tr>
<td>Labour cost</td>
<td>+4.22%</td>
<td>-8.8%</td>
<td>+2.96%</td>
</tr>
</tbody>
</table>

PARETO SOLUTIONS
Towards a Ship Structural Optimization Methodology at Contract Design Stage

**BESST – EU Project**
- CAD tool (AVEVA),
- FEA (ANSYS),
- Optimizer Platform (ModeFrontier)

BESST "Breakthrough in European Ship and Shipbuilding Technologies"
Ship Structural Optimization at Contract Design Stage (BESST)

BESST "Breakthrough in European Ship and Shipbuilding Technologies"
Holistic Ship Design Optimisation - Generic Problem

**Input Data**
- Deadweight, payload
- Speed
- Maximum Draft
- Initial Arrangement
- etc...

**Variation of Design Parameters**
- Hull form
- Arrangement of spaces
- Arrangements of (main) outfitting
- Structural arrangements
- Network arrangements (piping, electrical, etc)
- etc...

**Parametric Model of Ship Geometry and Outfitting**

**Optimisation Criteria**
- Maximisation of Performance/Efficiency Indicators
- Minimisation of Environmental Impact Indicators
- Minimisation of Building and Operational Costs
- Maximisation of investment profit
- Minimisation of investment risk
- etc...

**Constraints**
- Regulations set by society
- Market demand/supply
- Cost for major materials, fuel and workmanship
- Other, case dependent constraints

**Output**
HOLISHIP Objectives

Adapting/developing methods/modules/tools, specific to initial and contract design phases, so that;

- the DESIGN can comprehensively and systematically fits to the owner/yard/operator requirements,
- Designer has a thorough capability within ships & maritime structures design software platforms to conduct structural and functional design/assessment/optimization
HOLISHIP – WP4 Structure and production

- Structural strength assessment & optimisation
- Producibility assessment/simulation
- Rule-based design & assessment
- Load assessment & implementation
- Tools-Rule Interfacing
- 3D CAD modelling
- Requirements and specification
- 'Structures, Materials and Producibility'

- S.M.I.L.E.-FEM GmbH
  FEM Simulation (Vibration, Loads, Strength)
- Fraunhofer
  Producibility assessment/simulation
- TNO
  Noise & Vibration assessment/simulation
ULG is WP leader for Structural Optimisation

Concept Design

"Structures, Materials and Producibility"
Impact on Navigation lock

- Local crushing then global bending
- Global Deformation (Bending + membrane) mainly of the plates and the horizontal beams
IMPACT ON LOCK GATE
SUPER ELEMENT METHOD
Ship impact - Validation
VIDEOS

IMPACT / COLLISION
We NEED of an Effective Waterway Infrastructures to Support the Global Economic Growth in SOUTH AMERICA

HOW?

Rivers and waterways are natural transportation modes and we should use them more extensively to sustain the future world economic development, and particularly in South America.
• The economic development of a country always requires effective transportation modes.
• Our purpose is not to promote Inland Waterways (IW) versus road or train, but to claim that a sustainable future development requires sustainable transportation.
• This can only occur by using multi modal transportation (sea transport, Inland navigation, road, train and air(?)).
• To reach such sustainable development, the share of the inland navigation must be increased, as it is much more environmental friendly that than other modes.
Inland navigation and waterways infrastructures (port, quay, navigation lock, flow regulation weirs, dredging, etc.) are important for transportation but also for:

- Hydro-electricity → power plant;
- Environment protection (fishes, plants, etc.) → fish passes and bank protection;
- Tourism (along the rivers, and on the river, yachting), walk pad along rivers and parks, ports and marinas, etc.;
- Fishing activities (quay, port, etc.);
- and flood protection (dredging, flooding areas, etc.).
In the modern cities, all these activities relating to waterways must be considered,

none can be neglected,

otherwise the “public, media, and lobbies” will not accept it.

What about Columbia?
Inland navigation requires multidisciplinary knowledges and expertise’s [technical (for ship and infrastructures), economical (transport model), social and environmental].

Alone ship designers and ship owners cannot improve the navigation (and economic growth), they should collaborate with waterway managers responsible of infrastructures and with the persons/companies/associations who are living, using and working along/on the waterways.
Thanks for your attention

Questions ?