PIANC

The World Association for Waterborne Transport Infrastructure

PROCEEDINGS PIANC-SMART Rivers '17

2017

PIANC-SMART Rivers Conference

18-21 September 2017

Pittsburgh, USA

PIANC

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Pittsburgh, USA

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I. PLENARY SESSION

SMART RIVERS: YESTERDAY, TODAY AND TOMORROW

by

James McCarville, Chairman

Welcome to the world of SMART Rivers and welcome to Pittsburgh, site of the first SMART Rivers conference in 2004. It is my task to give an historical perspective and frame the SMART Rivers challenges: yesterday, today and tomorrow.

If there is something special about SMART Rivers, I think it's all about the connections that we make. I like to tell the story that, like a lot of good ideas, my first connection to SMART Rivers all started over a beer. This particular beer was taken at a Transportation Research Board (TRB) meeting early in the 21st century. Reinhard Pfliegl had just made a presentation on Via Donau's plan for a River Information Services for the Danube. He was talking about telecommunications, but what he was really explaining was technology-driven economic development. He spoke in English, but it was a whole new language. I realised – I had a lot to learn.

A year later, the Port of Pittsburgh signed a compact with TINA-Vienna Corridor Planners and the European Federation of Inland Ports, to jointly host conferences on alternating sides of the Atlantic exploring what appeared to be unique, cutting edge solutions to commonly shared problems. SMART Rivers was born.

Attending that first conference, here in Pittsburgh in 2004, was something like reading Jules Verne's classic, '20,000 Leagues Under the Sea', a mixture of great vision, imagination and a little Science Fiction. But just like Verne's classic, much of that vision soon came true. While technology was in the forefront, cultural context also played a big part. We, on the two sides of the Atlantic, were just starting to learn about each other.

In 2005, the European Federation of Inland Ports (EFIP) hosted the conference in Brussels. We, North Americans, were envious of the European Container on Barge and rail passenger transportation networks. We were surprised to learn that the Europeans envied our bulk barge and freight rail transportation systems. For many Americans, it was a first exposure to multi-modal corridor, non-siloed, congestion-mitigating transportation planning.

In 2007, in Louisville, KY, SMART Rivers was coordinated by PIANC USA. Short courses were added and the USACE became a very active part of the programme. In 2009, Otto Schwetz at the City of Vienna, partnering with Via Donau, elevated the SMART Rivers bar a good bit. Since then, conferences have been held in New Orleans, Liège-Maastricht and Buenos Aires. After New Orleans, PIANC International became the sponsor of future conferences with the intent to make it a global initiative.

Today, the conference is fully integrated into PIANC's planning and activities. This is evidenced by the PIANC Council, Executive Committee and Commissioners and PIANC's Inland, Recreational, Financial and Environmental Committees and multiple PIANC Working Groups and Young Professionals (YPs) choosing to meet here during PIANC-SMART Rivers. In addition, several non-PIANC groups, such as such as USACE, COPRI and others are holding related meetings. Today also, for the first time, we are very pleased to add presentations on PIANC-SMART Rivers' topics coming from China. You can see how this has grown.

When I earlier mentioned the Vienna conference, I wanted to use that as an example of how the SMART Rivers conferences have had a lasting impact on the way business is done, at least in the US. Jeff Lillycrop, of USACE, who you will hear from later, provided me with a timeline of the River Information Services (RIS) planning in the US and tied it specifically to the impact of these conferences. While Jeff and Rich Lockwood at USACE, and Helen Brohl, at the US Committee on Marine Transportation (CMTS), had already grasped the potential for RIS for the US, it was not until the 2009 Vienna

conference that our friend ‘Rock’ Salt, representing the Assistant Secretary of the Army, got to see first-hand the benefits of SMART planning for the Rivers. In a short time USACE was working with Via Donau to prepare a system for the US, resulting in a new Lock Operating Management Application (LOMA), integrating communication and data transmission for inland waterway operations. The CMTS coordinated with over 20 US Agencies to build an ‘eNavigation Integrated Action Team’ structure and developed an ‘eNavigation Strategic Action Plan’, including LOMA and RIS. It is still in use today.

LOMA was funded, designed, tested, certified, and deployed with great help from and coordination with the US Coast Guard (USCG). It symbiotically leveraged and borrowed from the USCG National Automatic Identification System (NAIS) to gather, transmit and display data for vessel operators. It increased situational awareness for lock operators, vessel pilots, USACE management and other users of the US inland waterway system. It improved waterway safety, efficiency and reliability.

Jeff credits this to the SMART Rivers process and the connections we all have made coming together. He calls us “a venue to obtain new ideas, seek peer review of our decisions and to evolve our vision based on worldwide experiences and best practices”.

Today we are gathered again in Pittsburgh as our common cultures are racing forward with advances in autonomous transportation and algorithmic thinking. Who knew back in 2004, that Pittsburgh would emerge as a nexus of all this. But being SMART is more than thinking in algorithmic siloes. It has to be broader! It is about making connections of systems of systems. That is why we are here today.

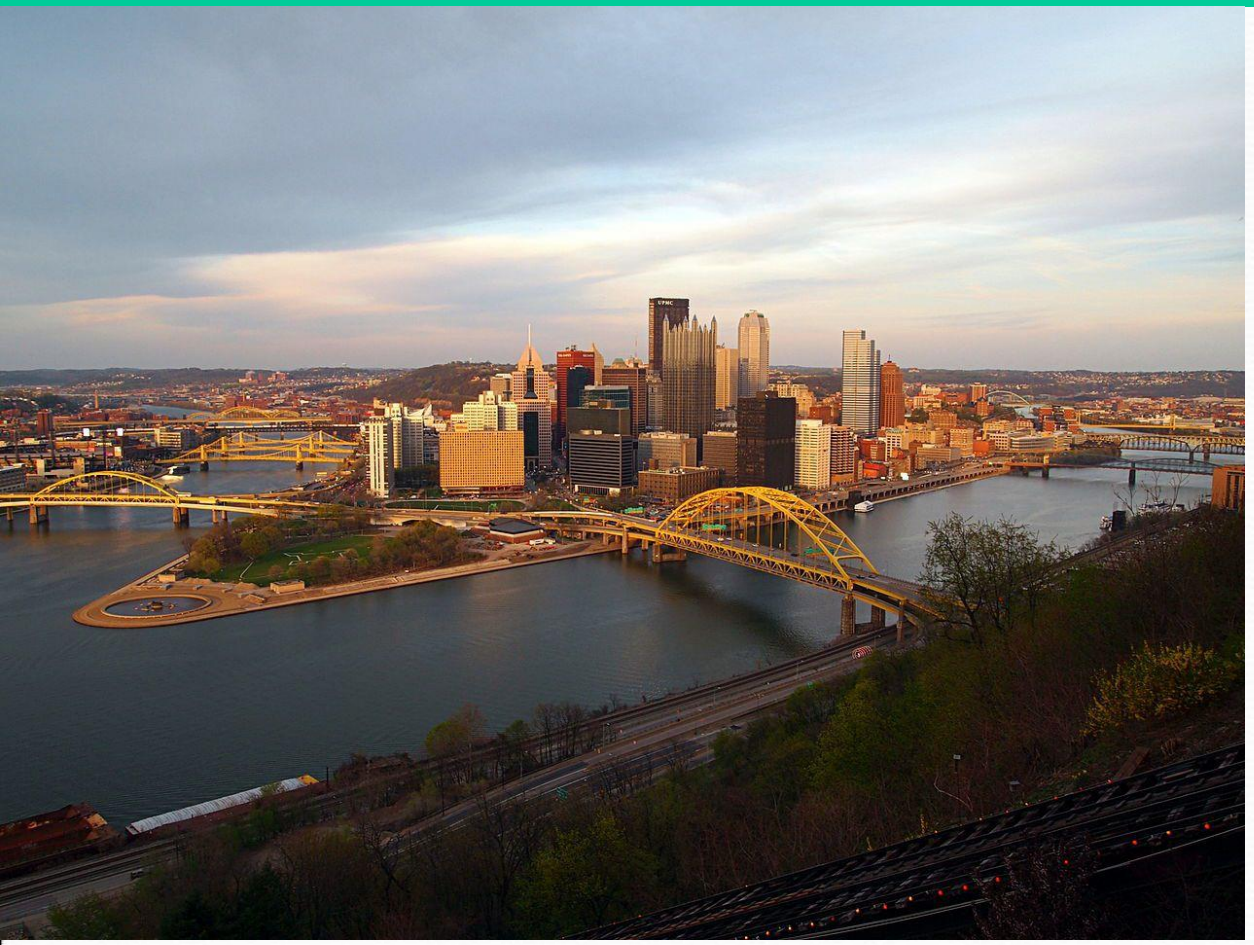
So, what was it that Reinhard said that so impressed me over that beer? He drew it out on a napkin: “Better technology and better data equal better decision-making”. I still have the napkin. This is your charge today. Good luck, go forth, make new connections and learn new ways to make better decisions. Happy PIANC-SMART Rivers!

INTRODUCTION TO PIANC-SMART RIVERS

by

Geert Van Cappellen, Secretary-General of PIANC

The World Association for Waterborne Transport Infrastructure



Introductory speech
for the opening session
of Mr Geoffroy CAUDE
President of PIANC

Delivered by
Geert Van Cappellen
Secretary-General of PIANC

Summary of the presentation

1 PIANC and Smart Rivers Conference

2 PIANC expansion with countries with large navigable rivers or waterways

3 PIANC reports on Smart waterborne infrastructures

1. PIANC and Smart Rivers Conference

- US and Austria set up the Smart Rivers as THE conference for Inland Navigation.
- Smart Rivers has been alternating between Europe and the Americas
- In 2011 Smart Rivers came under the umbrella of PIANC

  - 2011 : New Orleans (USA)
  - 2013 : Liège (Belgium) and Maastricht(The Netherlands)
  - 2015 : Buenos-Aires (Argentina)
  - 2017 : Pittsburgh

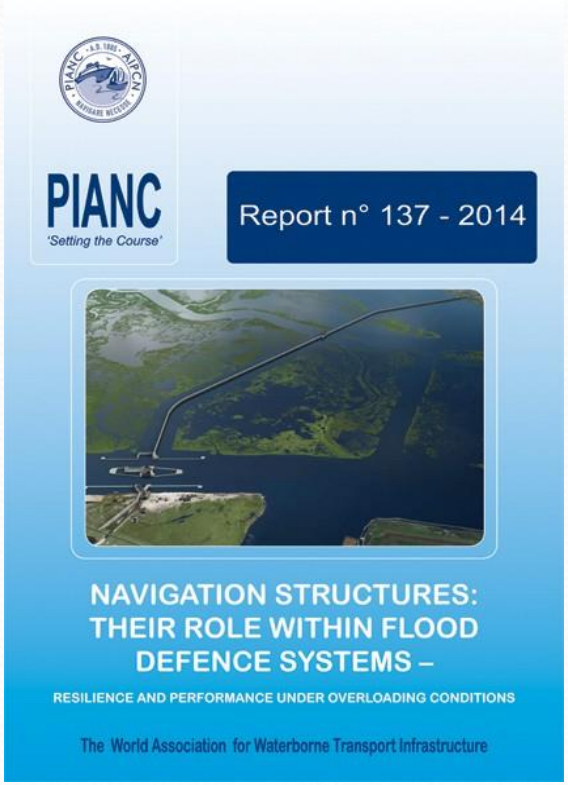
Next destinations : Lyon 2019 and perhaps in Asia later on…

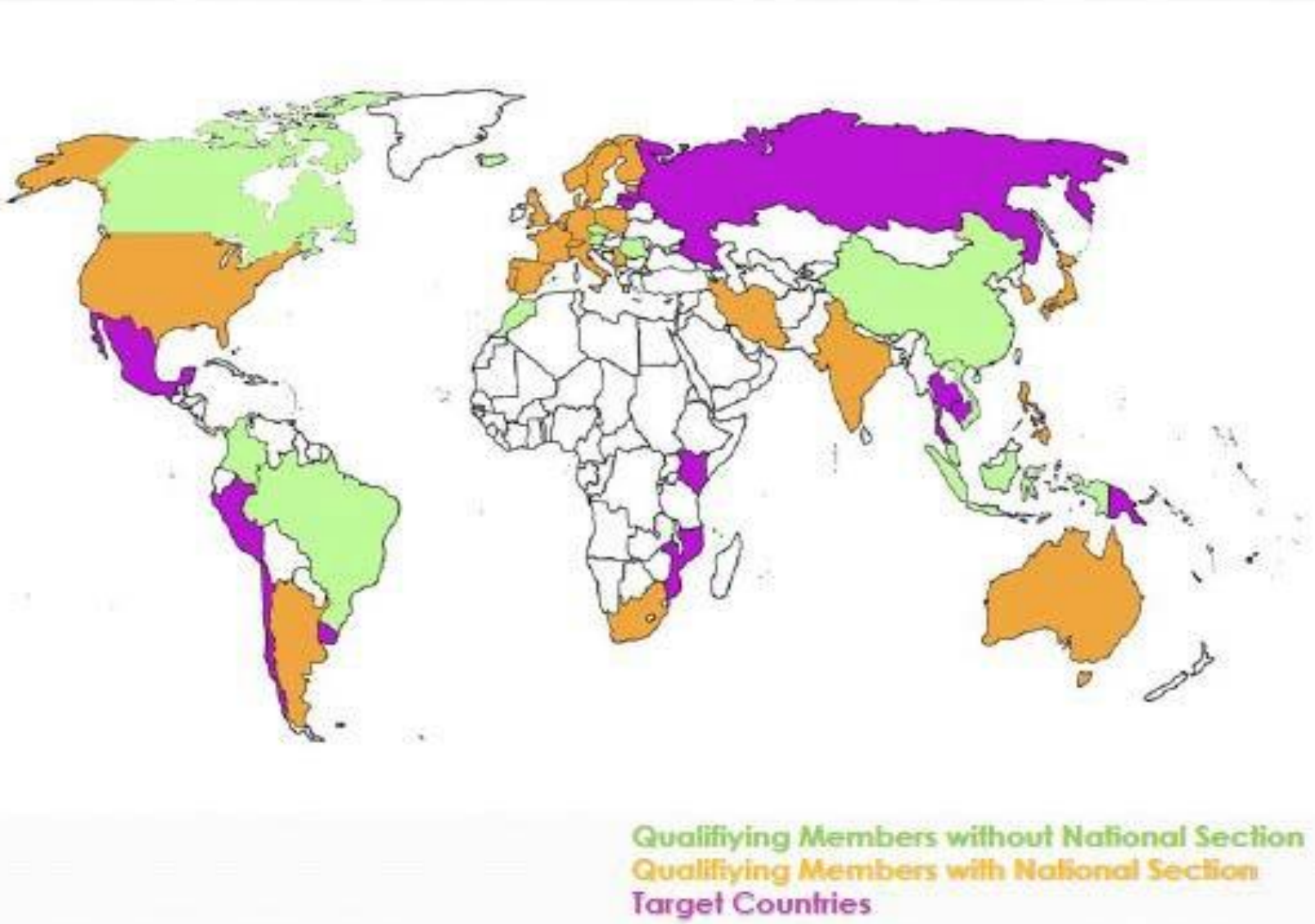
1. PIANC and Smart Rivers Conference

PIANC Smart Rivers 2011 in New Orleans 2011 resulted in:

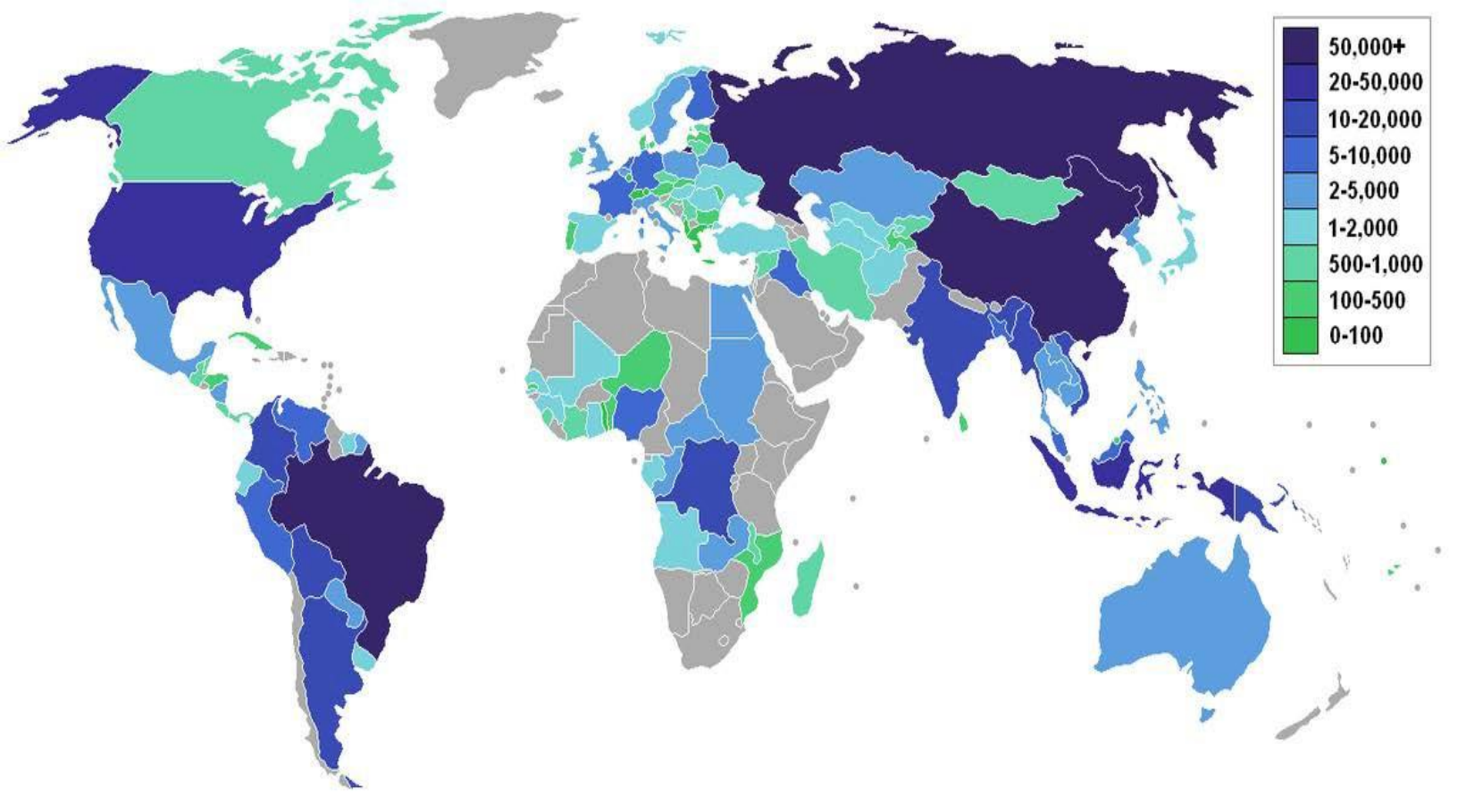
InCOM 137

on resilience and performance of navigation Structures in case of major floods

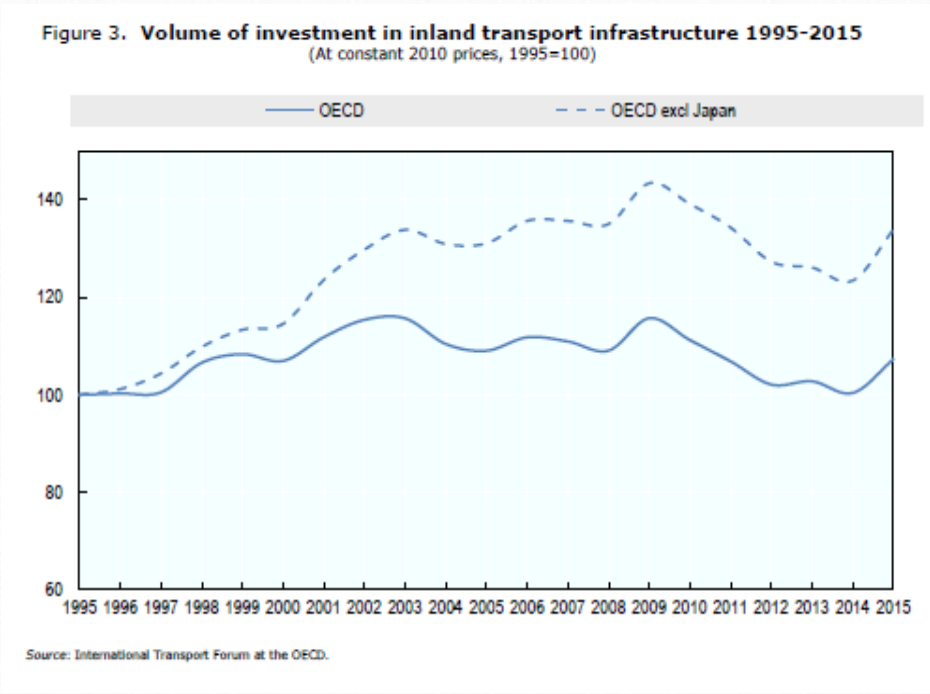



Qualifiying Members without National Section
Qualifiying Members with National Section
Target Countries

2. PIANC expansion in countries with large navigable rivers or waterways



TG 181 : ongoing developments



PIANC-ECLAC classification of rivers for navigation in South America

Pre-meeting questionnaire - to Prepare Kick Off Meeting on 19th Sept 2017

Survey Results

WG 201 – Development for Inland Waterway Classification for South America. 1st Meeting

Smart Rivers 2017, 19 September, Pittsburgh, USA

3. PIANC reports on Smart waterborne infrastructures

InCom

1. Incom 156-2017 : E-navigation for inland waterways
2. InCom 125 -2012 Part I: The implementation status of river information
3. InCom 125-2012 Part II: RIS related definitions
4. InCom 125-2012 Part III: Guidelines and recommendations for RIS 5- InCom 106 – 2009: innovations in lock design
5. InCom 96 – 2008: developments in the automation and remote operations of locks and bridges
6. InCom 24-2004: Guidelines and recommendations for RIS
7. Incom 24-2002 : Vessel traffic and transport management in the inland waterways and modern information systems

MarCom

1. MarCom 196-2016 : Criteria for the Selection of Breakwater Types and their Related Optimum Safety Levels MarCom
2. MarCom 117-2012 Use of Hydro/Meteo Information for Port Access and Operations

3. PIANC reports on Smart waterborne infrastructures

RecCom

1. RecCom 132-2013 Dry Stack Storage

EnviCom

1. EnviCom 150-2014 'Sustainable Ports' - *A Guide for Port Authorities*
2. Sustainable Maritime NavigationEnviCom report of WG 136 – 2013
3. EnviCom TG2-2011 : Towards a Sustainable Waterborne Transportation Industry
4. EnviCom 107-2009 : sustainable waterways within the context of navigation and flood management
5. EnviCom TG3-2008 Climate Change and Navigation - Waterborne transport, ports and waterways: A review of climate change drivers, impacts, responses and mitigation

See you at our next PIANC World Congress

34rd PIANC WORLD CONGRESS
Panama in May 2018

See you at our next PIANC-SMART Rivers Conference

5th PIANC-SMART Rivers Conference
Lyon, France in September 2019

See you at the next PIANC-COPEDEC Conference

PIANC-COPEDEC X
Kish Island, *Iran in November 2020*

4th PIANC-Smart Rivers Conference Pittsburgh-USA September,19 2017

Thank you for attention

Merci de votre attention

Luncheon Keynote Address

THE INTER-AMERICAN COMMITTEE ON PORTS AND A DISCUSSION ON COMPETITIVENESS, AND PORT INFRASTRUCTURE OF LATIN AMERICA AND THE CARIBBEAN

by

Jorge Duran, Chief of The Secretariat, Inter-American Committee On Ports (Cip), Organisation of American States

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CIP Inter-American Committee on Ports

PORT MODELS IN LATIN AMERICA AND THE CARIBBEAN: COMPETITIVENESS, LOGISTICS, PORT INFRASTRUCTURE AND SECURITY

PIANC SMART RIVERS CONFERENCE, PITTSBURG, SEPT. 18-20, 2017

Jorge Durán
Secretary
Inter-American Committee on Ports (CIP)
jduran@oas.org

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Member States

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National Port Authorities

1. Antigua and Barbuda
2. Argentina
3. Bahamas
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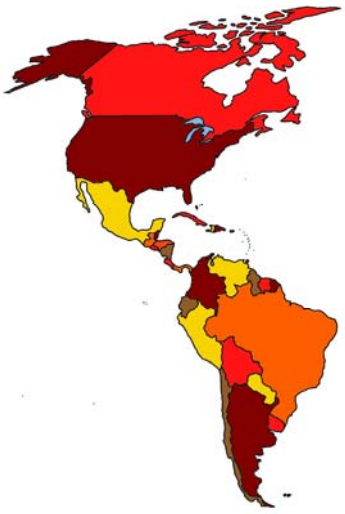
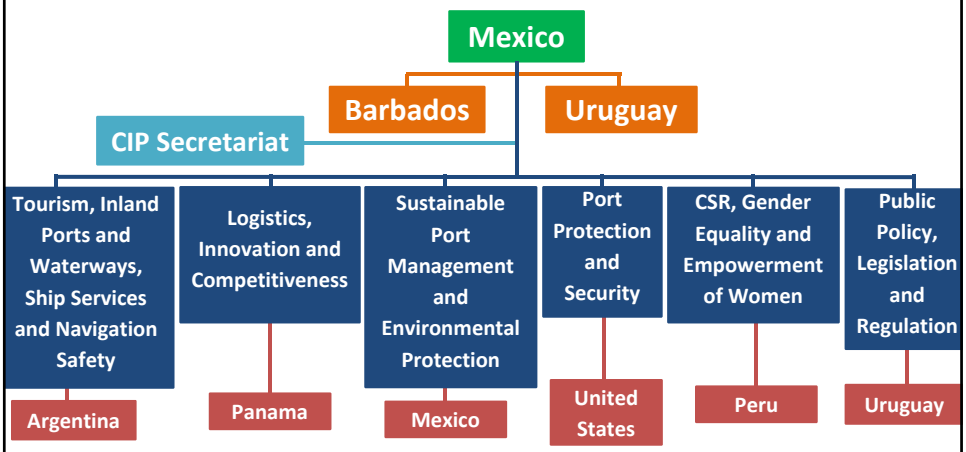
5. Belize
6. Bolivia
7. Brazil
8. Canada
9. Chile
10. Colombia
11. Costa Rica
12. Cuba
13. Dominica
14. Ecuador
15. El Salvador
16. Grenada
17. Guatemala
18. Guyana



19. Haiti
20. Honduras
21. Jamaica
22. Mexico
23. Nicaragua
24. Panama
25. Paraguay
26. Peru
27. Dominican Republic
28. St. Kitts and Nevis
29. St. Vincent and the Grenadines
30. St. Lucia
31. Suriname
32. Trinidad and Tobago
33. United States
34. Uruguay
35. Venezuela

CIP Structure



Inter-American Committee on Ports(CIP)

1. **Political Dialogue**
   - Only permanent inter-governmental forum at the highest level to promote the development of the maritime sector in the region.
2. **Capacity Building**
   - Promote and improve management and technical capabilities of port officials.
3. **Technical Assistance**
   - Assist Member States on issues or specific projects upon request.
4. **Active Collaboration with the Private Sector**
   - Promote win - win partnerships with private sector in the maritime industry to develop projects.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Associate Members
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ENSENADA
LÁZARO CÁRDENAS
MAZATLÁN
APIQROO
TUXPAN
AAPA
American Association of Port Authorities
AMERICAN SALVAGE ASSOCIATION
ADAU
IRU
International Road Transport Union
E&M
CENTRO DE NAVEGACIÓN
Por un país de cara al mar
COMPAS
Carnival
CLIA
CRUISE LINES INTERNATIONAL ASSOCIATION
NCL
NORWEGIAN CRUISE LINE
HudsonAnalytix
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SEMARMEX
MT
MANZANILLO INTERNATIONAL TERMINAL
North American Marine Environment Protection Association
NAMEPA
THE MARITIME ALLIANCE
Uruguay
Hub Logístico
MONTECON
PuertoValparaíso
PERU LNG
GTO PUERTO INTERIOR
RIGHTSHIP
Stericycle
GREEN MARINE
IADC
INTERNATIONAL ASSOCIATION OF DREDGING COMPANIES
Gnostech Inc.


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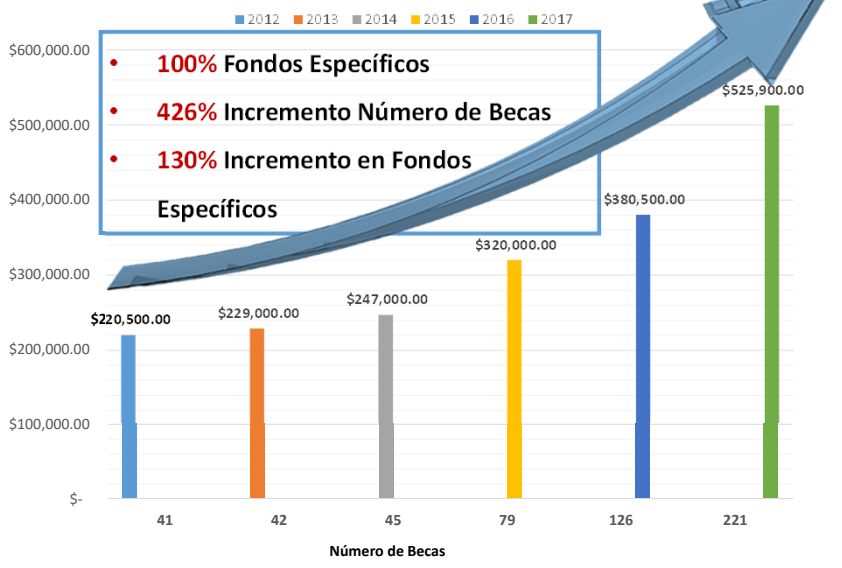
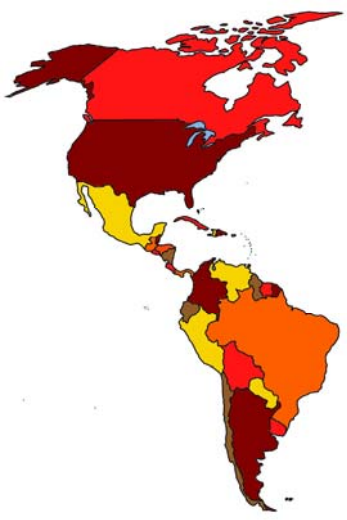
Puertos del Estado
NACIONES UNIDAS
CEPAL
PUERTOARICA
EMPRESA PORTUARIA ARICA
SLOM
Sociedad Latinoamericana de Operadores de Terminales Marítimo Petroleros y Monoboyas
ENAPRO
ENTE ADMINISTRADOR PUERTO ROSARIO
MÉXICO
PREFECTURA NAVAL ARGENTINA
BPA
부산항만공사
BUSAN PORT AUTHORITY
IMO
INTERNATIONAL MARITIME ORGANIZATION
PUERTO BAHÍA BLANCA
caribbean shipping association
PORTMIAMI
CENTER for INTERNATIONAL BUSINESS EDUCATION & RESEARCH
SOGET

Programas Creación de Capacidad CIP





Competitiveness Logistics, Infrastructure and Waterways

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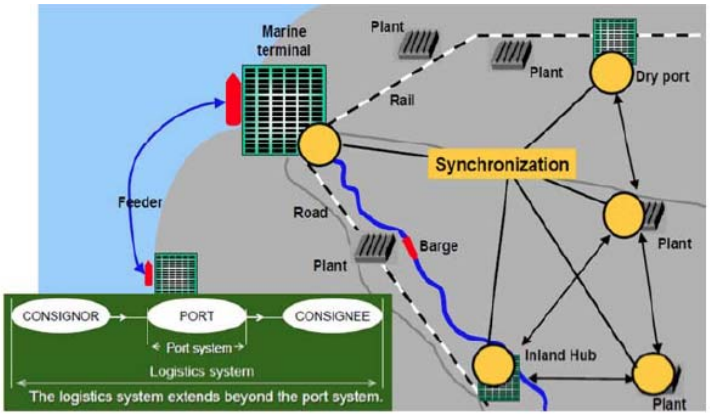
In Ports, what is Competitiveness?



It is determined by the cost, speed and efficiency of each one of the factors and processes that are used by trading in the logistics corridor.

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Member States

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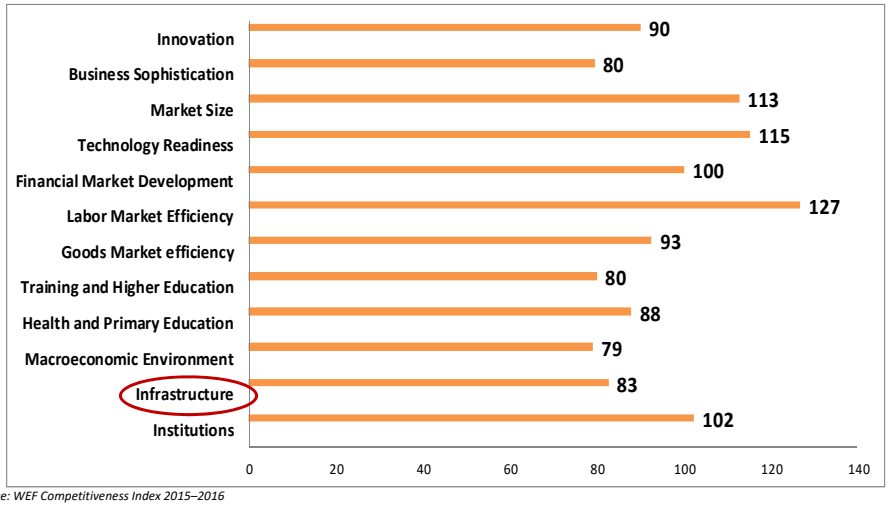
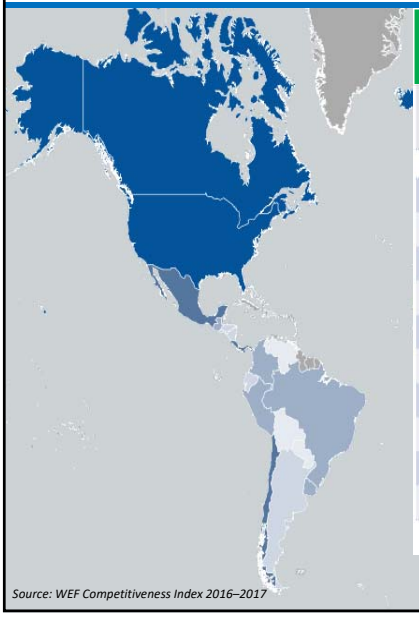
*"Competitiveness is the set of **institutions, policies** and factors that determine the level of **productivity of a country**".*



Source: WEF Competitiveness Index 2015–2016

Global Competitiveness Map 2016-2017



The 10 most competitive Latin American and Caribbean economies

Global Competitiveness Report 2016-2017 — Global rank*

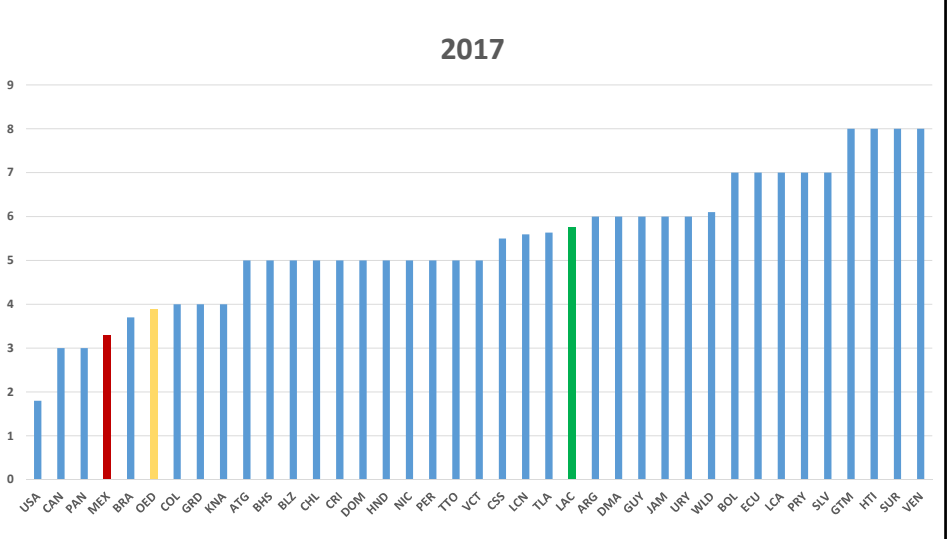
Who is the fastest riser ?

Economy	Rank 2016-2017	Rank 2015-2016	Change
India	39	55	16
Albania	80	93	13
Jamaica	75	86	11
Bhutan	97	105	8
Malta	40	48	8
Panama	42	50	8
Botswana	64	71	7
Georgia	59	66	7
Dominican Republic	92	98	6
Mexico	51	57	6

Source: World Economic Forum, Global Competitiveness Report

Source: WEF Competitiveness Index 2016–2017

Number of Documents Required to Export 2017



Source: World, 2017

Number of Documents Required to Import 2017

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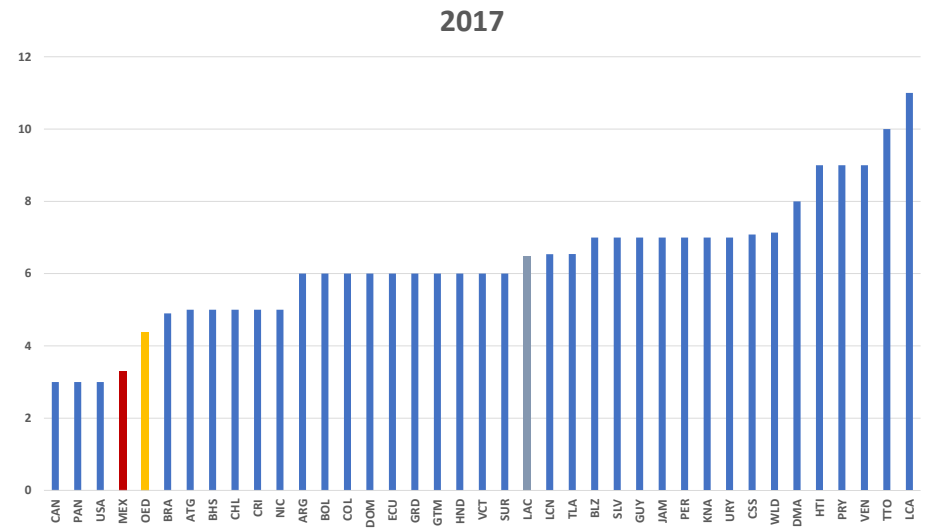

Fuente: Banco Mundial, 2017

Global Logistic Performance 2016

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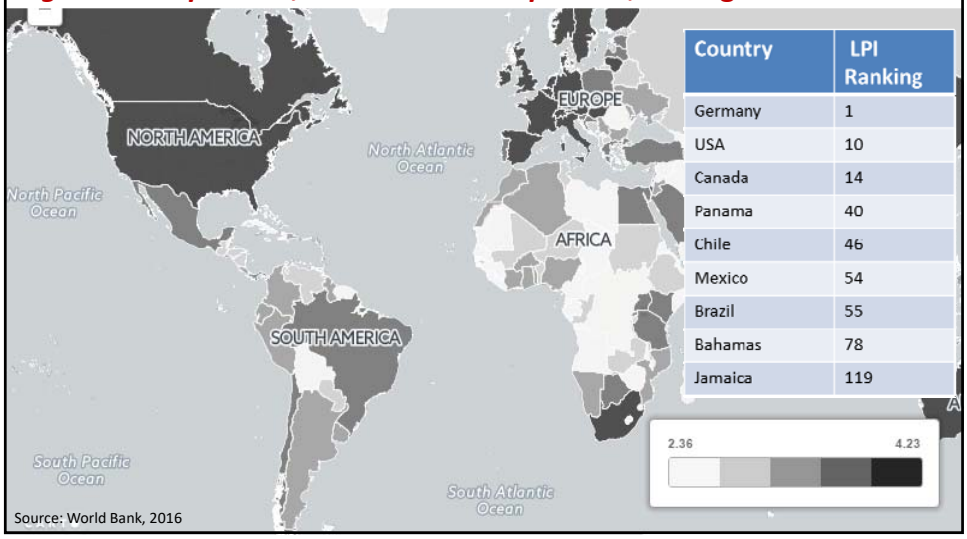
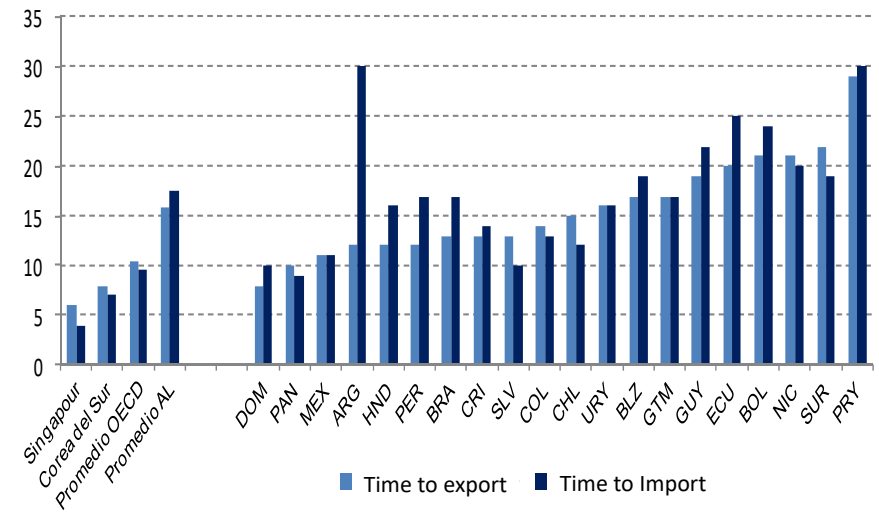
The LPI analyzes 160 Countries in areas such as *Customs, Infrastructure, Logistics Competence, International Shipments*, among others.



Country	LPI Ranking
Germany	1
USA	10
Canada	14
Panama	40
Chile	46
Mexico	54
Brazil	55
Bahamas	78
Jamaica	119

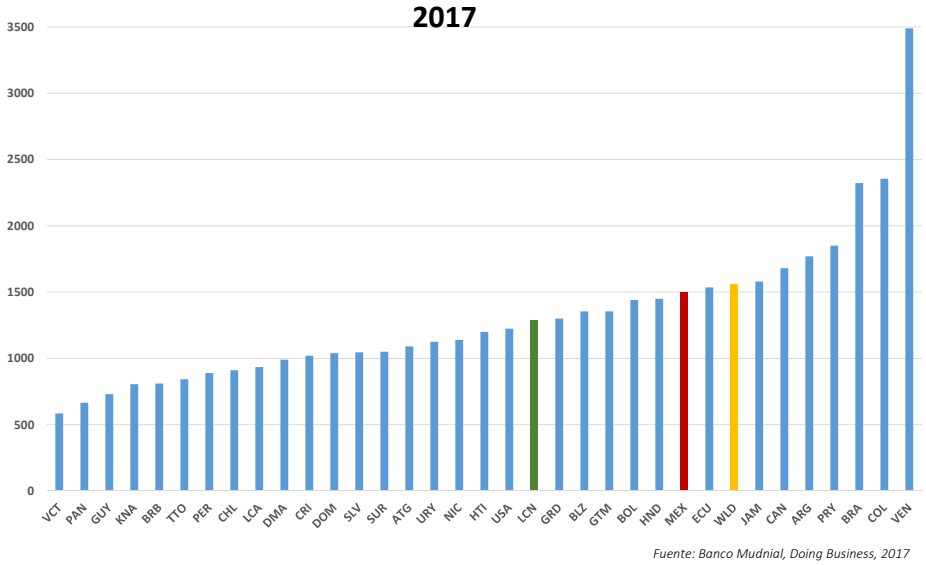
Source: World Bank, 2016

Time to Export and Import in LAC



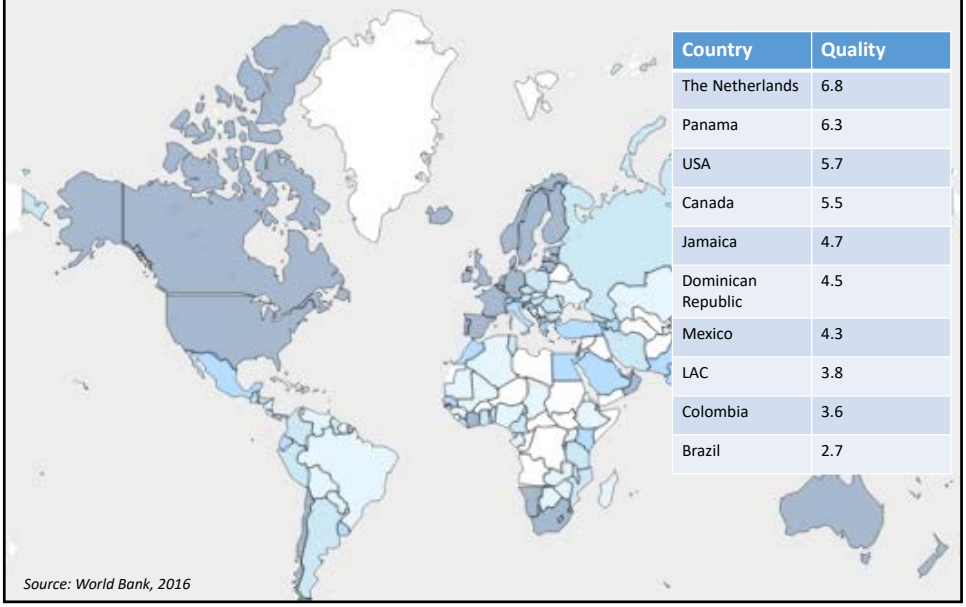
Source: ECLAC, World Bank, 2016.

Cost to Export a Container in LAC



Fuente: Banco Mudnial, Doing Business, 2017

Port Infrastructure Quality 2016



Country	Quality
The Netherlands	6.8
Panama	6.3
USA	5.7
Canada	5.5
Jamaica	4.7
Dominican Republic	4.5
Mexico	4.3
LAC	3.8
Colombia	3.6
Brazil	2.7

Source: World Bank, 2016

Port Ranking in Latin America and the Caribbean

Source: ECLAC, 2016

Maritime Container Traffic

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TOP 50 World Container Ports

Rank	Port	Volume 2015 (Million TEU)	Volume 2014 (Million TEU)
1	Shanghai, China	36.54	35.29
2	Singapore	30.92	33.87
3	Shenzhen, China	24.2	24.03
4	Ningbo-Zhoushan, China	20.63	19.45
5	Hong Kong, S.A.R., China	20.07	22.23
6	Busan, South Korea	19.45	18.65
7	Qingdao, China	17.47	16.62
8	Guangzhou Harbor, China	17.22	16.16
9	Jebel Ali, Dubai, United Arab Emirates	15.6	15.25
10	Tianjin, China	14.11	14.05
11	Rotterdam, Netherlands	12.23	12.3
12	Port Klang, Malaysia	11.89	10.95
13	Kaohsiung, Taiwan, China	10.26	10.59
14	Antwerp, Belgium	9.65	8.98
15	Dalian, China	9.45	10.13
16	Xiamen, China	9.18	8.57
17	Tanjung Pelepas, Malaysia	9.1	8.5
18	Hamburg, Germany	8.82	9.73
19	Los Angeles, U.S.A.	8.16	8.33
20	Keihin Ports, Japan	7.52	7.85
21	Long Beach, U.S.A.	7.19	6.82
22	Laem Chabang, Thailand	6.82	6.58
23	New York-New Jersey, U.S.A.	6.37	5.77
24	Yingkou, China	5.92	5.77
25	Bremen/Bremerhaven, Germany	5.48	5.78
26	Ho Chi Minh, Vietnam	5.31	6.39
27	Tanjung Priok, Jakarta, Indonesia	5.2	5.77
28	Columbo, Sri Lanka	5.19	4.91
29	Suzhou, China	5.1	4.45
30	Lianyungun, China	5.01	5.01
31	Hanshin Ports, Japan	4.93	5.32
32	Valencia, Spain	4.62	4.44
33	Algerciras Bay, Spain	4.52	4.56
34	Jawaharlal Nehru, India	4.49	4.45
35	Manila, Philippines	4.23	3.65
36	Jeddah, Suadi Arabia	4.19	4.2
37	Felixstowe, U.K.	4	4
38	Hainhong, Vietnam	3.87	3.45
39	Santos, Brazil	3.78	3.68
40	Georgia Ports, U.S.A.	3.74	3.35
41	Port Said East, Egypt	3.6	3.4
42	Colon, Panama	3.58	3.29
43	Seattle-Tacoma NW Seaport Alliance, U.S.A.	3.53	3.43
44	Sharjah, United Arab Emirates	3.4	4.12
45	Piraeus, Greece	3.37	3.59
46	Balboa, Panama	3.29	3.47
47	Tanjung Perak, Surabaya, Indonesia	3.12	3.13
48	Ambarli, Turkey	3.09	3.38
49	Marsaxlokk, Malta	3.06	2.9
50	Vancouver, Canada	3.05	2.91

Panama Canal Expansion

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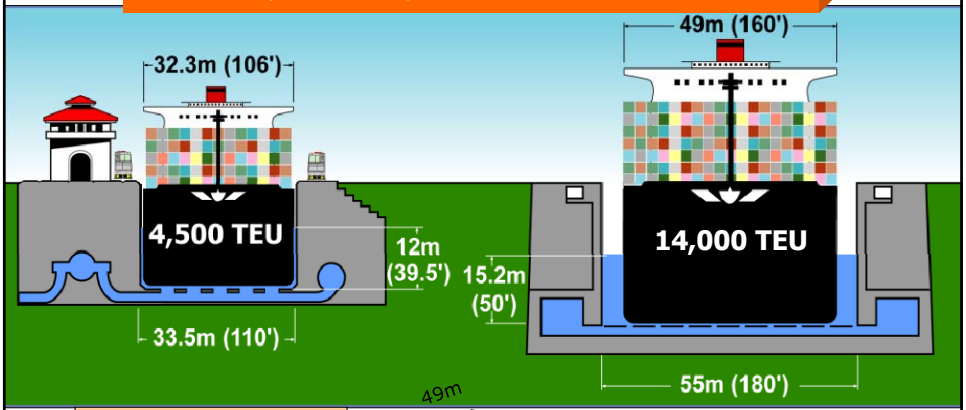
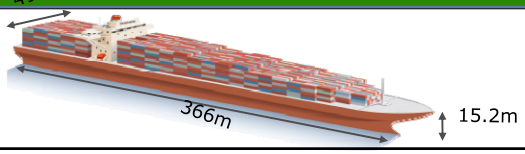
However , vessels of 16, 18 and 20 thousand TEUs do not fit



Vessel Design:

Capacity: 14.000 TEU
Tonnage: 157.000 DWT
Total Longitude: 365.8 m
Bao: 48.8 m
Draft: 15.2 m



Panama Canal Expansión

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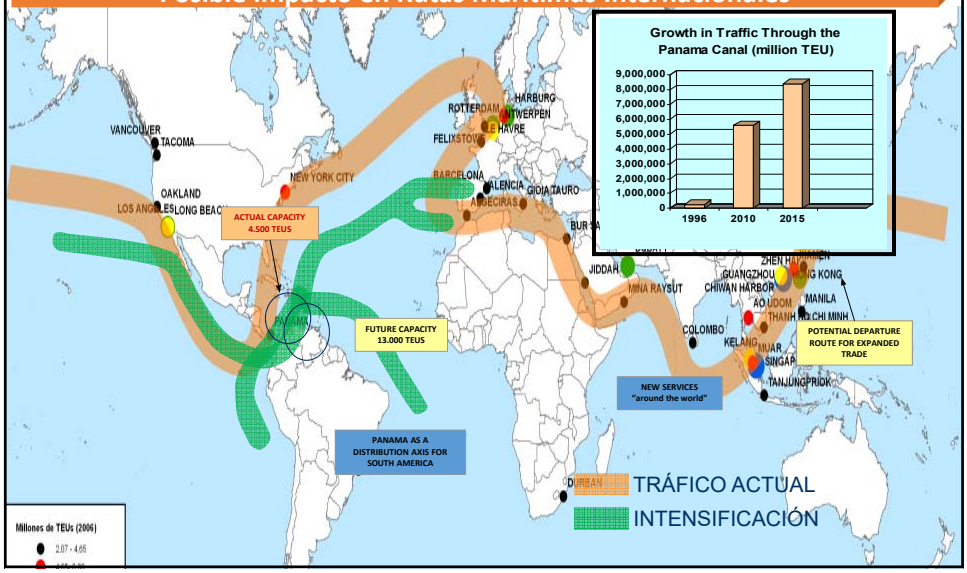
Posible impacto en Rutas Marítimas Internacionales



Investment in Modernization

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Bahamas Freeport Expansion US$ 250 million

Jamaica investing US$ 660 million to become a Regional Logistics Hub

Mexico National Infrastructure Program

- 52 Highways
- 80 Roads
- 3 Passenger Trains
- 1 New Airport in CDMX
- 1 Telecom Network
- 25 Port Projects

$83 Billion USD

US $ 5 Billion for Ports

Investment in Modernization

Colombia Intermodal Master Plan

Brazil: Institutional reform
Reducing logistics costs → Improve competitiveness
→ US $2.5 billion in port infrastructure


Investment in Modernization
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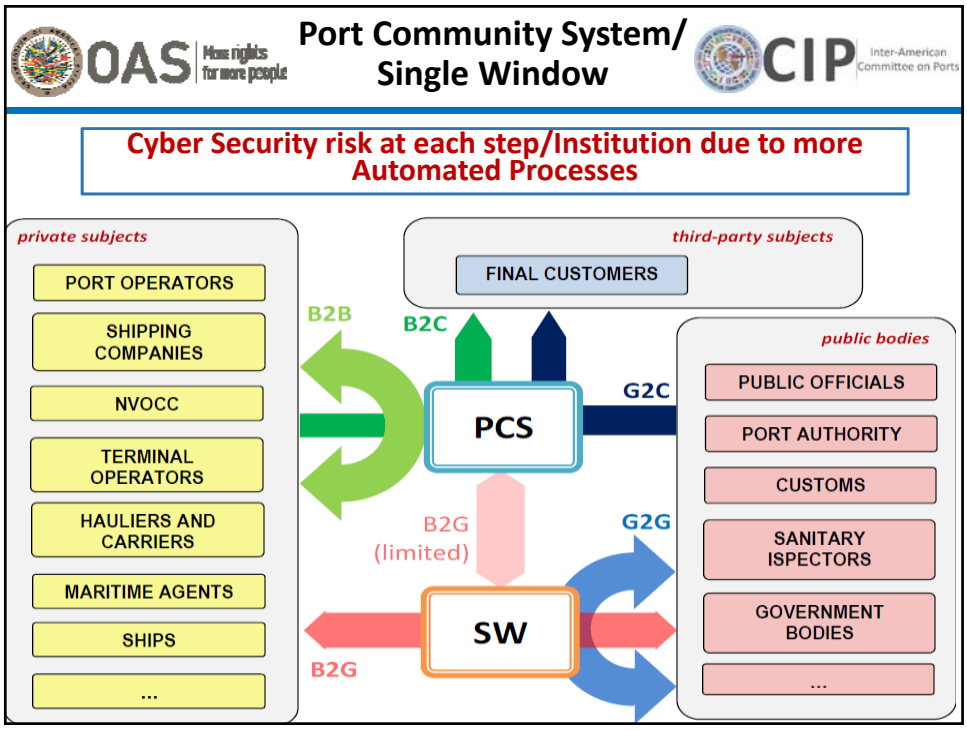
BOLIVIA
BRASIL
PARAGUAY
ARGENTINA
URUGUAY
Cuiabá
Campo Grande
Murtinho
Concepción
Asunción
Villeta
Ciudad del Este
Puerto Toro-Cuá
Puerto Paloma
Encarnación
Corrientes
Exclusa de Yacireta
Uruguayana
Artigas
Rivera
Concordia
Salto
Tacuarembó
Paysandú
Fray Bentos
Treinta y Tres
Nueva Palmira
Colonia
Montevideo
La Paloma
Punta del Este
Curitiba
Argentina
$33.2 Billion
REFERENCIAS
Puertos fluviales y fluviomaritimos
Ciudades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Port Community System/ Single Window
CIP Inter-American Committee on Ports
Cyber Security risk at each step/Institution due to more Automated Processes
private subjects
PORT OPERATORS
SHIPPING COMPANIES
NVOCC
TERMINAL OPERATORS
HAULIERS AND CARRIERS
MARITIME AGENTS
SHIPS
...
third-party subjects
FINAL CUSTOMERS
B2B
B2C
G2C
PCS
B2G (limited)
G2G
SW
B2G
public bodies
PUBLIC OFFICIALS
PORT AUTHORITY
CUSTOMS
SANITARY ISPECTORS
GOVERNMENT BODIES
...

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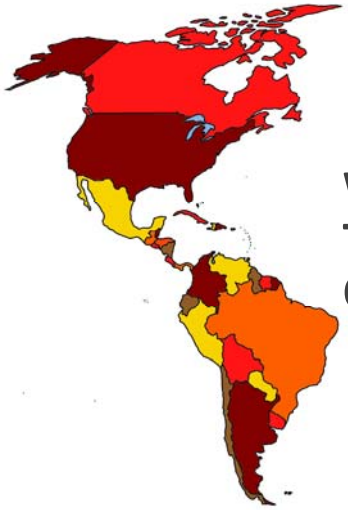

Waterways and River Transport in the Southern Cone

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Main Watersheds

1. Amazonas
2. Río de la Plata
3. Orinoco
4. San Francisco
5. Magdalena

A. Orinoco
B. Casiquiare
C. Río Negro
D. Amazonas
E. Madeira
F. Mamoré
G. Guaporé
H. Paraguay
I. Paraná

Almost 70% of the territory is formed by watersheds with naturally navigable rivers.

75% of the "superficial water resources" of the region correspond to basins shared by two or more countries

Source: CAF, 2016

Density of Waterways in South America

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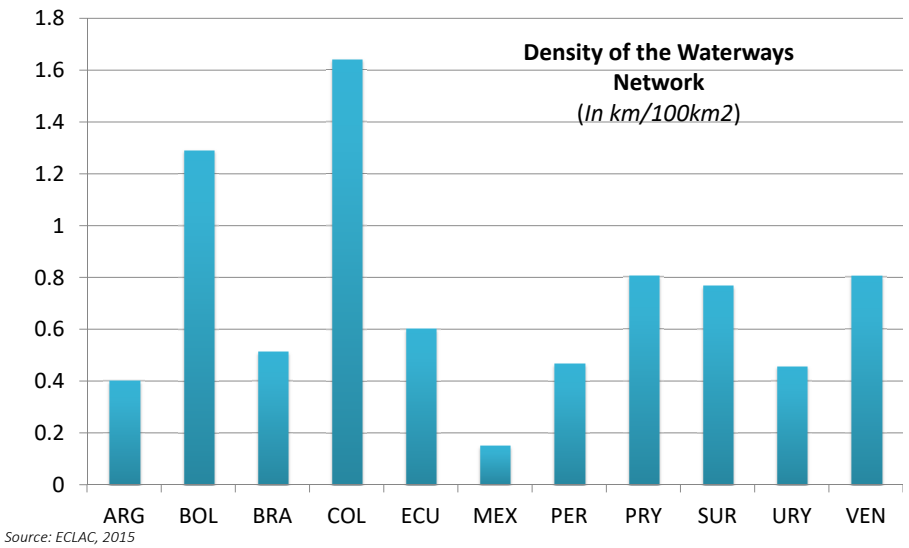

Source: ECLAC, 2015

Advantages of river transport

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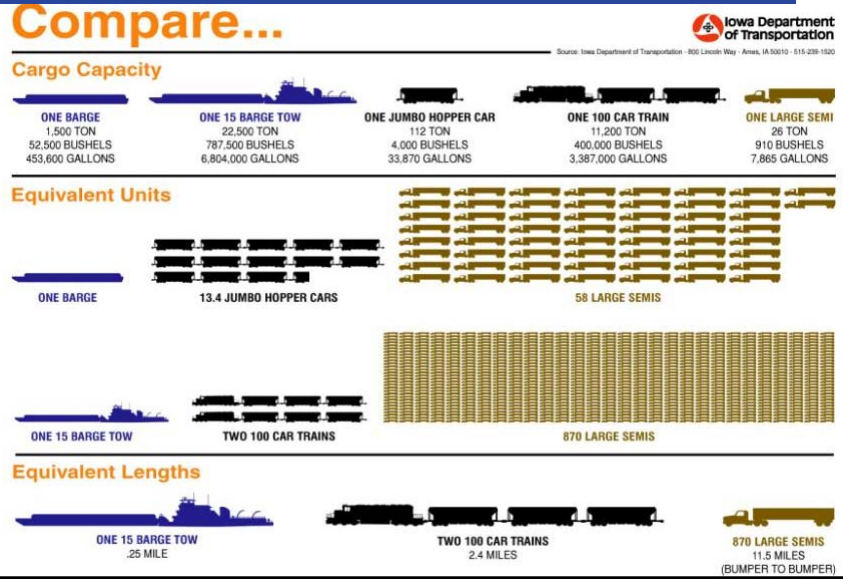
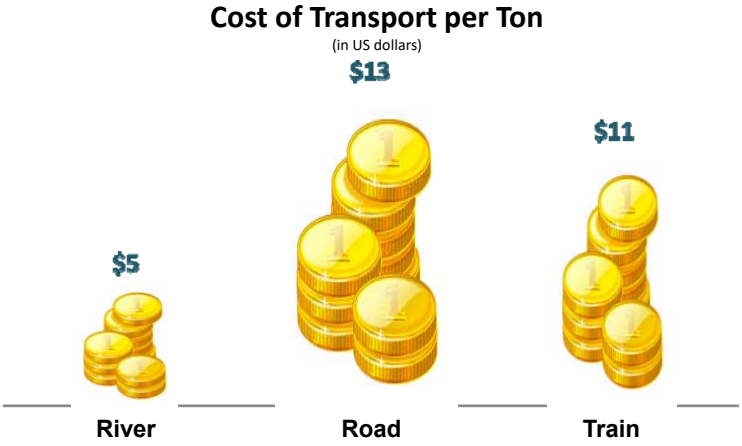


Argentina – Cost of transport by river per ton



In spite of:

- Lack of maintenance dredging
- Lack of waterway buoying – 24 hours use

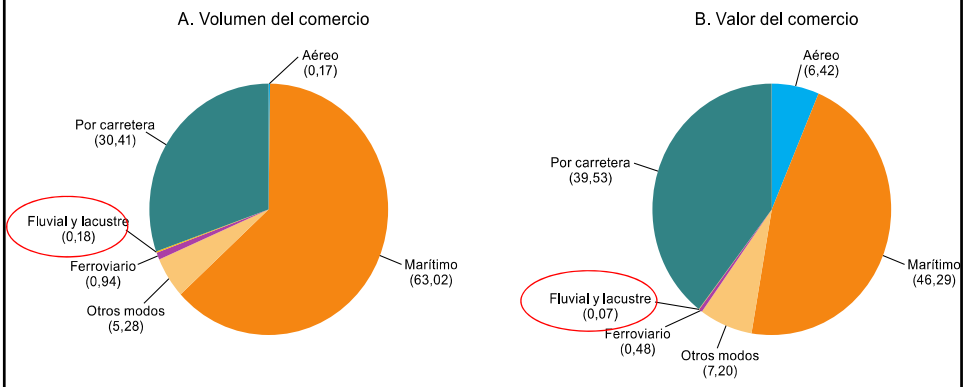
Source: FONPLATA

Cost of Cargo per Ton – from Cuiaba, Brazil to ports in the region

To Port of Paranaguá by Train: $ 24,607
To Port of Paranaguá by Road: $ 23,322
To Port Nueva Palmira by Road – Barge: $ 17,210

Waterways Competitive Advantages Underutilized

Modal Distribution of the Intra-Regional Trade by Volume and Value
(In percentages)



Source: ECLAC, 2015

33

Challenges

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Waterways

Greater Development	**Waterways Operating**	Program and TL Functioning Logistic Integration
Advanced Development	**Improved River**	Program and TL in Development Process
Incipient Development	**Navigable River with Difficulty**	Start of the Program Implementations Weak TL

River

Improvement of:
- Navigability
- Ports
- Institutionalism
- Norms
- Management Model

TL: Transport and Logistic

Source: CAF, 2016

Waterways Classification

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Criteria:

- Horizontal dimensions of the Vessel:
  - Maximum length
  - Maximum Beam
  - Tonnage
- Vertical dimensions:
  - Draught
  - Maximum height under bridges
- Connectivity

Local Importance: Waterways where the transport of goods or people is important for local development;

National Importance: Waterways where the transport of goods or people is important for national development;

Regional and International Importance: Waterways that meet the minimal technical and operating criteria for international traffic.

- Able to adapt to the evolution of inland navigation;
- Capable of accommodating most important freight flows;
- Sufficiently dynamic and flexible to accommodate hydrography and climate diversity;
- Able to incorporate waterways and integrated to other links in the logistics chain and transport modes.

Source: ECLAC, 2017.
http://repositorio.cepal.org/bitstream/handle/11362/41133/1/S1700019_en.pdf

Challenges

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Identify

- **Basic bottlenecks** (sections that do not comply with the requirements of regional or international waterways).
- **Strategic bottlenecks** (sections that meet the requirements of regional and international waterways but need further work to improve the structure of the network or to increase their economic capacity).
- **Missing Link** (necessary sections to complete the network).

Strategic planning for the development of the waterways under a comprehensive vision.

Improvements in Inland Ports Parana/Paraguay Waterways

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"Port must be the facilitators of foreign trade"

- 35 private ports / **they handled 70% of exports** –mainly commodities (low cost)
- US$4 billion investment in private terminals in Argentina
- Rosario Port is investing to improve the access to inland ports and terminals
- In 2016 TEUs operations increased by 30%
- Bilateral agreement between Paraguay and Argentina to established a Free Zone in Rosario Port for Paraguayan exports
- International Cooperation in dredging and navigation control in waterways - Paraguay – United States

Final Considerations

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LAC ports are investing in infrastructure for modernization, updating legislation and policies to cope with new global trends and demands.

- Improve competitiveness, reduce costs and secure operations.
- Security and protection concerns are paramount (ISPS and Cyber).
- Ports investing in soft and hard infrastructure.
- There is a need of an integrated intermodal network sea-land and to increase use of waterways for trade.
- The private sector as catalyst for change, important to promote PPP.

Final Considerations

Public and Private Ports improving logistics to become more competitive

- LAC countries should prepare for the challenges of larger ships and the expansion of the Panama Canal.
- Regional navigation agreements: dialogue and coordination to define navigation policy
- South American countries actively building inter-modal network (road, railway, waterways and maritime).

Thank You!

Jorge Durán

Secretary

Inter-American Committee on Ports (CIP)

jduran@oas.org

Inter-American Committee on Ports (CIP)

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Closing Keynote Address

INLAND RIVER TRANSPORTATION IN CHINA: CURRENT AND FUTURE TRENDS

by

Dr. Ying-En Ge, Professor and Dean of the College of Transport & Communications, Shanghai Maritime University, P.R. China

Inland River Transport in China: Current and Future Trends

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Shanghai Maritime University
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Phone: +21 3828 2301

Outline

- Introduction
- The planned and (or) ongoing tasks
- Challenges or Constraints in Promoting Inland River Transport in China
- Recommendations for development of Inland Water Transport in China
- Concluding Remarks

Introduction
I. River Systems in China

- In China, there are 5,800 natural rivers and about 900 lakes. The three longest rivers in the PRC are the Yangtze (6,300 km), Yellow (5,464 km), and Lancang (4,350 km) rivers.
- The rivers provide huge support for the economic development of the area along them. The total gross domestic product (GDP) of the seven provinces and two cities the Yangtze River corridor covers takes up about 40% of the GDP of China.

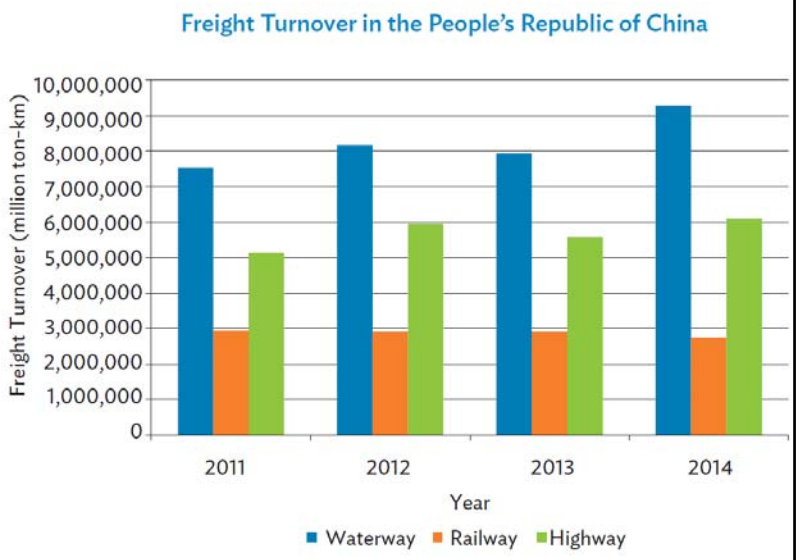
Introduction
I. River Systems in China (Cont.)

River	Length (km)	Catchment (km2)
Yangtze River	6,300	1,808,5
Yellow River	5,464	752,0
Heilong River	3,420	900,0
Songhua River	2,308	557,1
Liao River	1,390	228,9
Pearl River	2,214	453,6
Hai River	1,329	318,2
Yarlung River	2,840	912,0
Lancang River	4,350	795,0
Nujiang River	2,816	324,0

Source: Ministry of Transport, People's Republ

Introduction
II. Market Share

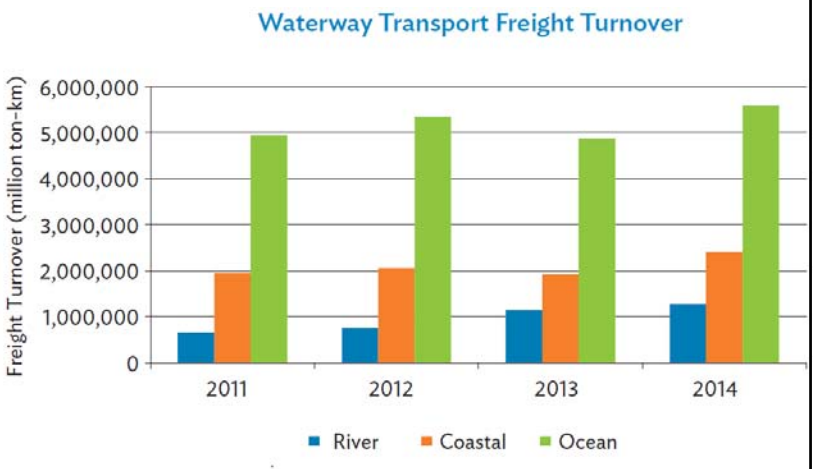
- In terms of freight, waterway transport accounted for 51% of the total freight turnover in 2014, while highways was 34%, and railways, 15%.



Source: National Bureau of Statistics, People's Republic of China, 2015.

Introduction
II. Market Share (Cont.)

- In 2014, among the waterway transport freight turnover,
  - ➢Ocean: 60%;
  - ➢Coastal: 26%;
  - ➢Inland waterway: 14%

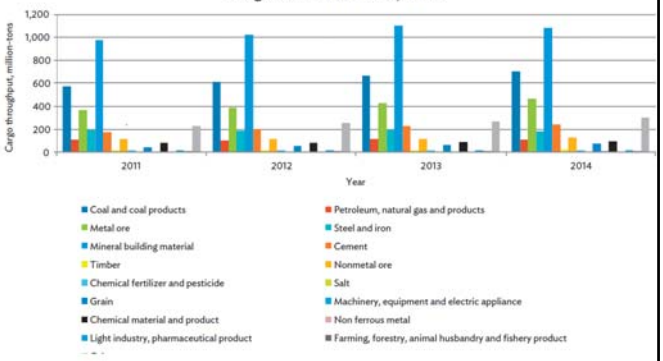


Source: National Bureau of Statistics, People's Republic of China, 2015.

Introduction
II. Market Share (Cont.)

- In 2014, river ports handled 3.5 billion tons of cargo.
  - About 51% of all cargo through the river ports is mineral building materials (31%) and coal & coal products (20%).
  - Container shipping is slowly gaining importance.

Cargo in River Ports, People's Republic of China

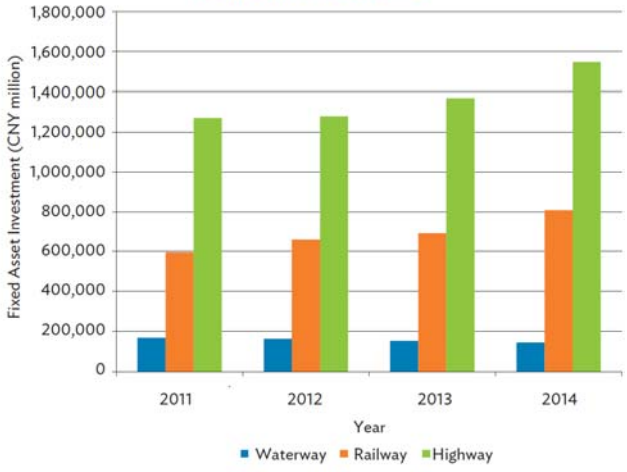


Source: National Bureau of Statistics, People's Republic of China, 2015.

Introduction
II. Investment

- Investment in water transport has not been commensurate with its contribution to the freight transport.
  - Roads: 62%
  - Railways: 32%; and
  - Waterways: 6%.

Investment in Different Modes of Transport, People's Republic of China



Source: National Bureau of Statistics, People's Republic of China, 2015.

Introduction
III. Inland River Transport Management Structure in China

- The Ministry of Transport (MOT) has the overall responsibility for policy and administration of inland waterways.
- The MOT has decentralized responsibility for day-to-day administration and management of the main waterways of national importance to the Changjiang River Administration of Navigational Affairs and Pearl River Administration of Navigational Affairs.

Introduction
III. Inland River Transport Management Structure in China (Cont.)

- Provincial governments are responsible for most other waterways, and indeed for most of the total network, which they administer through provincial departments of transport. Provincial water transport administration bureaus are usually established under provincial departments of transport. The provincial authorities are required to submit annual reports to the MOT.

The planned and (or) ongoing tasks
I. Inland river Transport Development goals and tasks

- China has adopted a National Plan for Inland Waterways and Ports with a planning horizon from 2007 to 2020.
- The plan details improvements to each of the main (Inland Water Transport (IWT) systems in China (those based in the Yangtze River, Pearl River, Grand Canal and Huaihe River, Heilongjiang and Songliao Rivers, and the Minjiang River).

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- The plan acknowledged the importance of supporting policies which

  (i) seek a stable long-term financing model and external sources of finance;

  (ii) enhance cooperation with other relevant departments in the areas of shipping services, power supply, flood control, irrigation, and water supply;

  (iii) enhance the planning of ports;

  (iv) strengthen measures to standardize and modernize vessel fleets;

  (v) increase & improve applications of IT to inland river transport management;

  (vi) ensure safety and environmental performance; and attain a sustainable development of the system.

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- In February 2006, the MOT published the "National Outline for the Development of Ship-Class Standardization on Inland Waterways", which requires:
  - Provincial transport authorities develop the navigation industry by relying on technological innovations and progress.

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- In January 2011, the State Council issued "Opinions on Accelerating the Development of Water Transport on the Yangtze River", which requires
  - governments at all levels shall be devoted to integrating water transport with other modes of transport involving highways, railways, aviation, and pipelines, developing multimodal transport; and strengthening comparative advantages and combination efficiency of various transportation means.
- It acknowledges that the fast economic and social development, resource and environment constraints are becoming increasingly stringent and that the contradiction between transport development, energy conservation, and environment protection has become increasingly acute. mic development.

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- In May 2013, the Ministry of Transport issued the "Guiding Opinions on Promoting the Development of Green, Recycling-Oriented, and Low-Carbon Transportation."
  - The Opinions mandated provincial transport authorities to (i) strengthen technological research and development on green, recycling-oriented, and low-carbon transportation; (ii) promote scientific and technological breakthroughs including R&D and application of key technology for intelligent transportation, and the research and demonstration of the key technology for emergency response to transportation pollution and pollution control.

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- In August 2013, MOT issued the "Notice on Issuing the Action Programs (Year 2013–2020) on Accelerating the Development of Water Transport on the Yangtze River and Other Inland Waters," in which
  - Governments were required to strengthen planning and construction of inland waterways which connect with coastal ports. Furthermore, governments at alllevels shall make efforts to (i) speed up development of large-scale port areas for special purpose at major ports and part of the key ports along inland rivers, especially terminals for handling containers, automobile ro-ro handling, and bulk commodities; and (ii) develop multimodal transport and port logistics.

The planned and (or) ongoing tasks
I. Inland River Transport Development goals and tasks (Cont.)

- In April 2014, the Ministry of Finance and the MOT promulgated the "Management Measures for Subsidy on Ship-Class Standardization on Inland Waters."
- The policy encourages cargo vessel replacement by providing subsidies.
- It also provides subsidies for vessels to install sewage cabin.

Constraints in Promoting Inland River Transport in China

1) Market Constraints:

① Unbalanced cargo flows caused by the disparity in economic development;

② Penetration because of geographical and topographical situation; and

③ Sophisticated and expensive organization of intermodal inland waterway transport.

Constraints in Promoting Inland River Transport in China

2) Funding Constraints:

- Disproportionate public financing of Inland Water Transport; and
- Restricted access to commercial bank loans.

Constraints in Promoting Inland River Transport in China

3) Inadequate inland ports and logistics system:

- An inherent disadvantage of IWT is the need for double handling. Inland ports play an important role in facilitating supply chain flows through efficient logistics. Interfaces with other transport modes, such as roads and railways, are crucial to overcome the disadvantage. There is evidence that the inland ports in China are not rationally developed and that port administration is cumbersome. The transport system is organized by transport mode, and no single mode is focused on creating multimodal chains and seamless transfers at nodes that are needed to lower transport costs.

Constraints in Promoting Inland River Transport in China

- 4) Information Constraints:
- Communication channels among shipping lines, forwarders, and government are few. There is no institutionalized communication among these IWT stakeholders. Many shippers are not aware of the ability and opportunities coming out of the IWT system.

Constraints in Promoting Inland River Transport in China

5) Technical Constraints:

- Limited water depth in the dry season;
- Long waiting time at locks; and
- The lack of port facilities hinder shippers in using Inland Waterway Transport.

Constraints in Promoting Inland River Transport in China

6) Regulatory Constraints:

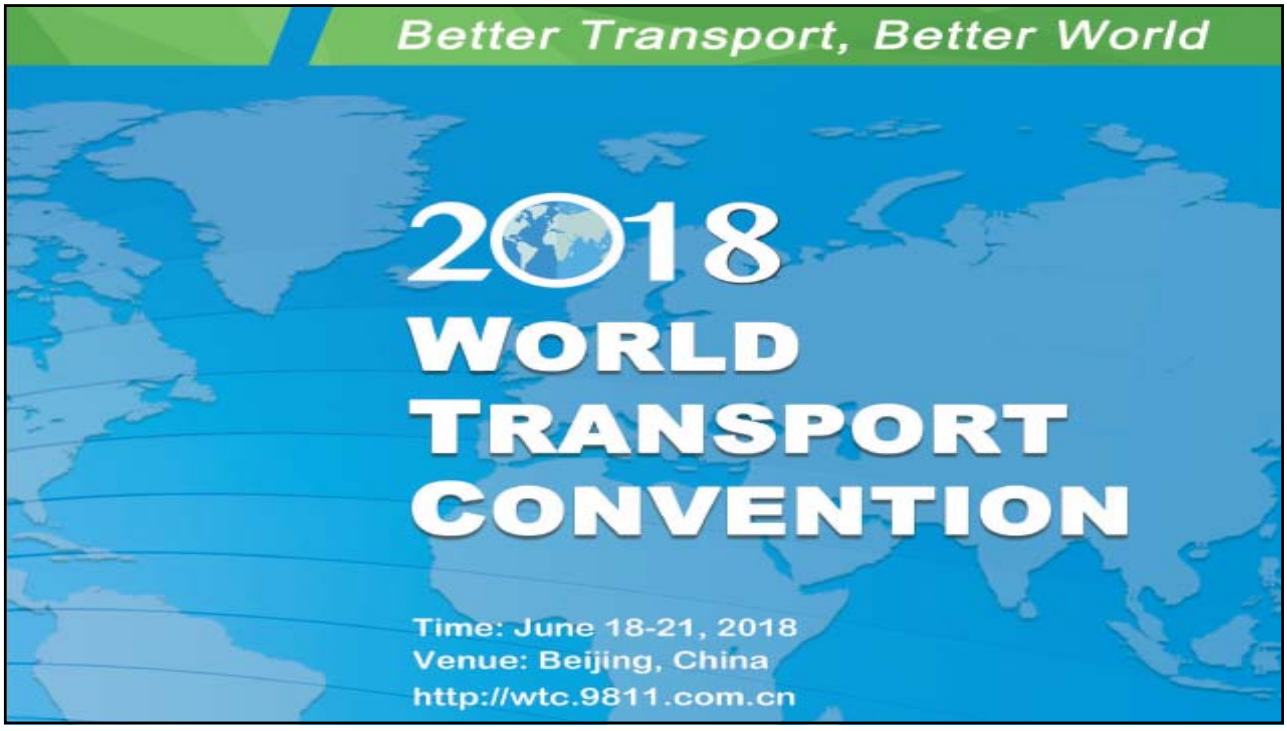
- Many government offices are involved in IWT management, but integrated transport planning to minimize logistics costs and law enforcement capability is weak. The many policy directives to encourage IWT development focus on promotion of infrastructure hardware and give little consideration to market players such as shippers or forwarders, policy instruments, implementation arrangements, and financial support.

Recommendations for development of Inland Water Transport in China

a) Reducing economic disparity within provinces, and coordinating planning and development of transport and land use;
b) Promoting integrated transport planning and intermodality;
c) Developing inland ports;
d) Improving customer service;
e) Directing inland waterway transport incentive programs toward market players;
f) Managing the relationship between government and state-owned enterprises; and
g) Enhancing stakeholder participation.

Concluding remarks

- Safety
- Efficiency
- Environment
- Cost, Revenue, Profit, etc.



Thanks for your attention
Q & A

CONFERENCE SUMMARY

by

Jeff Lillycrop, U.S. Army Corps of Engineers

SMART Rivers 2017

What did we hear?

What are the primary take aways?

PIANC USA

SUMMARY

1. Build sustainable, resilient projects, systems and waterways
    - Use adaptive management & monitoring
    - Engineering With Nature
    - Regional Sediment Management
    - All projects are multi-objective, multi-purpose projects
    - balance between the economic, social and environmental issues
    - Must build in from the start cyber security
    - Innovative materials can be better, faster, cheaper

2. Standards are important
    - Data
    - Infrastructure components & construction methods
    - Information products & services

SUMMARY

3. Everywhere we need to be more transparent, more open about who we are, what we do and why it is important to engage us in all the freight movement.
    - Do a better job of Value Quantification
    - Do a Better job explaining & managing risk
    - Do a better job modeling freight flow
    - Plow the exit ramps

4. We are adopting and applying automation
    - SLS moorings
    - Lock gates & bridges
    - Structural Health Monitoring
    - Vessel operations
    - Water drones for measuring, monitoring & entertaining

5. We've done it, we can do more, we can do better

II. TECHNICAL PROGRAMME ABSTRACTS

Track A

Session A-1 AIS,
Moderator: Patricia DiJoseph, USACE, USA

Inland Waterway Travel Time Atlas via AIS Data Analysis

by

Patricia DiJoseph
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Transportation Systems Researcher, U. S. Army Corps of Engineers, Vicksburg, Mississippi, USA

Waterway system managers need quantitative and statistically robust metrics to evaluate the performance of navigation projects. Waterway system users require accurate travel time predictions for intermodal connectivity. For this research, both of these needs are addressed with a waterway travel time atlas. The atlas includes multi-year statistics, including average and median travel times, along with travel time variability measures such as coefficient of variation and interquartile range, and delay.

Statistics are compiled for time periods ranging from one week to one year and for study areas ranging from a single reach to an origin-destination pair. Waterway system managers can use this information to monitor system performance over time, locate system bottlenecks and areas with most critical needs, and quantify the impacts of different variables such as water levels and restrictions on navigation. Waterway system users can apply this information for voyage planning.

This research developed a methodology to estimate these statistics from Automatic Identification System (AIS) data. AIS data includes historic time stamped discrete position reports of passive probe vessels. Results for the Ohio River and the Upper Mississippi River for 2013 and 2014 are provided. The results quantify the amount of travel time variability locks bring into the system and also suggest voyage planning will need travel time estimates at a disaggregated time period, such as by week, as there is much variation in the travel times year to year and month to month.

Voyage and Traffic Planning Services and the relevancy of AIS

By

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Ensys bv, System Architect, Zevenhuizen, the Netherlands

In the project ‘Traffic Management Centres of the Future’ research has been done on the traffic and voyage planning principles as defined in the RIS guidelines of PIANC and as defined as an essential goal of Corridor Management. The objectives are: (1) Enhance reliability of Expected Time of Arrival (ETA) of the arrival on the terminal to support multimodal transport and (2) Enhance efficiency of lock and bride operations for ships during their voyage to the terminal at fairway network level.

A traffic prediction model has been developed predicting the voyage of all ships in the waterway network. It integrates information of (1) the fairway itself including characteristics of locks and bridges, (2) cargo and voyage information provided by the skippers and (3) AIS positions of all ships. The prediction includes the ETA’s of locations on the fairway network such as difficult corners in the waterway, crossings, VTS areas, arrival on locks and bridges and the arrival on the terminal. Using AIS positions, the prediction model is constantly updated. It was possible to enhance lock and bridge planning. The skipper received information about requested time of arrival (RTA) on locks and bridges, reducing waiting times to a minimum.

Interesting lessons learnt from real-life experiments with 100 ships are: (1) a cooperative system and information exchange concept based on mutual collaboration between the skippers and corridor management provides for the highest added value, (2) Lock and bridge operators used the predictions to enhance their efficiency of operations, (3) Skippers are amenable to provide detailed cargo and voyage information as they benefit from an efficient and reliable voyage. The conclusion is that traffic and voyage planning services are an important part of RIS enabled Corridor Management and is an essential step towards multimodal information services.

Using AIS Data to Support IENC

by

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USACE

Daniel McBride
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USACE - Rock Island District, Navigation Chart Lead

USACE installed AIS receivers at several inland lock sites as part of RIS/e-Navigation, and the AIS messages received at these sites are fed into the USCG NAIS system in real time. In addition to the value of real-time position information to safety and logistics, the cumulative datasets that accrue from the logged messages have tremendous additional value. This high-resolution (spatial and temporal) data presents new opportunities for analysis of traffic along managed waterways.

Traffic patterns, as shown by vessel position density, reveal details of waterway use that are useful for navigation charting, channel maintenance, and other mapping activities. Members of the IENC community have been using this data since 2011 to improve various aspects of navigation chart products but have only just begun to scratch the surface of the potential for analysis of this very rich dataset.

Using Public US Army Corps of Engineers Data for Waterway Performance Indicators

by

Steven Riley
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U.S. Army Corps of Engineers, Institute for Water Resources, Locks and Dredging Program Manager

The US Army Corps of Engineers (USACE) overseas navigation projects in 41 states, operates and maintains 236 lock chambers at 191 lock sites on 41 waterways involved in transporting commercial goods. In order to help manage in near real-time the Inland Marine Transportation System (IMTS), the USACE utilises several information systems to manage its infrastructure of which locks serve as a major component.

The USACE uses the Lock Performance Monitoring System (LPMS) to record data and characteristics of locks that are used to help manage operational and budgetary decisions. LPMS data contains information on lock queues, transit times, barge and commodity information and equipment availability.

Where possible, this data is made publicly available through the Navigation and Civil Works Decision Support Center and Corps Locks websites. Participants will learn the data available via these outlets and about future enhancements to the system, including changes to the public site and migrating to the cloud. These enhancements will strive to provide data to the public and other agencies more readily and in a more easily consumable manner.

Session A-2 River Information Systems,
Moderator: Brian Tetreault, USACE, USA

Providing e-Navigation on Inland Rivers with AIS

by

Gregory Johnson
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Alion Science and technology, Sr. Program Manager, New London, CT

Brian Tetreault
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U.S. Army Corps of Engineers, Navigation Systems Specialist, Baltimore, MD

The Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. Since its inception there have been provisions in the AIS protocols for the use of AIS as a 2-way information transfer system.

However, many of the functions required to effectively implement an AIS transmit service are missing or lacking in existing standards, recommendations and guidelines. Since 2007 the United States Coast Guard (USCG) Research and Development Center (RDC) and the US Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) have been working on identifying the gaps in the architecture and working on solutions to enable a full two-way data transfer or transmit service.

This system was prototyped in Louisville and then extended to a broader eNavigation testbed on the Ohio River starting in late 2015. This presentation will describe the testbed and the processes that enable the distribution of the electronic Marine Safety Information (eMSI) from the data sources to the mariner via AIS. This information is then displayed as overlays on an Electronic Charting System (ECS).

Electronic Reporting and Advanced River Information Services

by

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The introduction of River Information Services (RIS) was a major development in Inland Waterway Transport (IWT). Standards have been defined and were first implemented in Europe based on the European Union's Directive 2005/44/EC. River Information Services are based on four enabling technologies namely the Automatic Identification System (Inland AIS), Electronic Navigational Charts (Inland ECDIS), Notices to Skippers (NtS) and the system for Electronic Reporting of voyages, cargo and persons on board (ERI).

This conference contribution will first give an insight how River Information Services are currently used and will highlight the benefits of transmitting information by electronic means resulting in new opportunities for all stakeholders involved in Inland Waterway Transport.

Practical examples and showcases will be presented, focusing on the holistic use of electronic reporting of voyages and cargo, going beyond the traditional usage scenarios and by rethinking the communication process resulting in a bidirectional dialogue between authorities and commercial parties purely based on electronic messages. Combining the four RIS enabling technologies and exchanging RIS data across systems and countries in a RIS-enabled corridor approach, allows for improved traffic management by authorities and more efficient transport management by the logistics sector.

The presentation will finally address operational and legal aspects which need special attention in those future usage scenarios, where governmentally collected data is shared with the logistics sector.

RIS Development in the United States

by

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The implementation of River Information Services (RIS) in the US has progressed substantially since 2010. Government agencies, such as the US Army Corps of Engineers (USACE), the US Coast Guard (USCG) and the National Oceanic and Atmospheric Administration (NOAA), have introduced several services which are building a strong foundation for RIS. However, there are several critical areas where the US should focus their RIS implementation efforts, and developing concepts that may provide substantial benefits for waterways operations if developed and adopted in the US.

Subsequent to an initial review of US RIS implementation conducted in 2012, and following the introduction of the concept of RIS-Corridor Management in Europe, the USACE and via-Donau have completed a joint effort to analyse the technical and organizational status of RIS in the US and the potential for the introduction of advanced RIS-Corridor Services. The presentation will reflect the results of this study. It will first provide an overview of the numerous services and initiatives which are already operational or still in development. The presentation will then address current challenges and the potential for technical and organisational improvement of the existing RIS capabilities.

Finally, the presentation will review potential scenarios for the introduction of advanced RIS-Corridor services together with a proposed roadmap of prioritised measures to proceed in a structured way. This approach will provide harmonised services for waterway users while ensuring all underlying systems can be operated and maintained effectively.

VisuRIS – Visualisation of RIS Related Information

by

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Since 2004, the Flemish waterway authorities DS and W&Z are developing applications according to the PIANC RIS guidelines and the European RIS standards to make Inland Navigation more safe and efficient. To maximise the benefits of these developments, both authorities decided to combine and enrich all available data and make this information available for their customers, based on defined access rights.

The functional requirements and the communications channels were defined on basis of the feedback of their inland waterway customers, like skippers, shippers, logistic partners, authorities, rescue services. This session will illustrate the approach, i.e. evolving from historical monolithic developments to a single window, called VisuRIS, offering a lot of new services to customers and putting Inland Navigation to a next information level. During these sessions, some services will also be live demonstrated.

Session A3 – MTS Performance,
Moderator: Marin Kress

Storytelling Big Data with Information Technologies

by

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Data organisation and availability, coupled with progress in web site development and social media, is significantly changing the landscape of display tools, dashboards, and viewers of navigation data. This presentation will provide an overview of the US Army Corps of Engineers (USACE) progress at aligning waterborne data with different options to view data and deliver decision support tools to internal and external customers.

Existing data sources of Corps navigation data from the Lock Performance Monitoring System (LPMS) and Waterborne Commerce Statistics data are being integrated and organized using modern IT tools to deliver data that can be consumed by a variety of sources to help end users whether that be within USACE, other federal agencies, and industry to manage the inland navigation system. These tools include easy to use web sites that incorporate user driven data queries, automatically refreshing dashboards using near real time data from the field, that provide USACE leaders the ability to monitor critical inland navigation systems managed by the USACE.

Also, these tools serve as strategic communication tools that are being used by industry and the public to understand USACE projects and operations. Data within these systems include both real-time and historic information. This presentation will also include a brief demonstration of the actual operational website, providing conference participants with a clear example of the benefits of this process and how the USACE has modernised its data systems within a relatively short period of time. This presentation provides both a path forward and operational example of how historic navigation data can be integrated and formatted for use in today's dashboards and viewers along with the latest social media tools, all with the purpose to make more data available.

Indicators for Port Response and Recovery: A Case Study on Hurricane Matthew in the Southeast

by

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This presentation will discuss an effort to measure port resilience through focused case studies intended to identify feasible and meaningful metrics for tracking port performance before, during, and after disasters. Federal datasets provide a depth of knowledge about the baseline functions of our waterways. Cultivating informed resilience metrics from these datasets can allow managers and decision makers to track the potential for elevated performance after improvements or investments. Case studies are integral in identifying meaningful metrics because they gather empirical data to validate theories about the behaviour of complex systems like the Marine and Inland Waterways Transportation System.

Tools like the Automatic Identification System Analysis Package (AISAP), developed by researchers at the US the Army Corps of Engineers Engineer Research and Development Center, utilise the US Coast Guard Nationwide Automatic Identification System dataset and allow for empirical data to be

collected and analysed throughout an event. The capabilities of AISAP and other tools are outlined in a case study on the effects of Hurricane Matthew across three ports in the Southeastern Seaboard.

Evaluation of Supervised Learning to Identify Trends in River Water Quality

by

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Infrastructure and retrofits alter the type and magnitude of the run-off that infiltrates urban river systems. Furthermore, the design and state of the infrastructure is unique for each municipality. However, there exists a lack of systems to provide real-time water quality monitoring in these urban environments, resulting in uncertainty of the effects of these various contaminants from different sources. The purpose of this project is to evaluate the ability of supervised learning algorithms to identify and monitor trends in river water quality, using historical data and real-time measurements in Pittsburgh's rivers.

Different environmental parameters (e.g. dissolved oxygen, nitrate and chlorides) for the Monongahela River in Pittsburgh, PA can be examined throughout their historical record. Through supervised learning algorithms in combination with dynamic spatial-analysis (GIS) relationships between these parameters, river geomorphology and water infrastructure can be identified. The potential for improving the resolution of these relationships can be improved using real-time monitoring.

With real-time water quality data, one can begin to better analyse the response of an urban watershed to wet weather events. Furthermore, when comparing the sampled data with measurements from point sources, one can begin to understand the effects of non-point sources on the urban river environment. This presentation will be of interest and benefit to conference attendees because it will demonstrate the importance of strategic placement of sensors in wireless monitoring networks. The data from these measurements will provide insight into contaminant dynamics in urban river systems, and can potentially guide regulations and designs for urban water infrastructure.

Framework for a Port Activities Scoring System

by

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There is significant literature on measuring port performance and effectiveness based on varying measures of the activities at maritime ports and waterways. Various analytical methods for measuring port activities used in the literature focus on cargo movement activities. Primary examples of these sources for the U.S. are tonnage and container data published annually by the Navigation Data Center, U.S. Army Corps of Engineers.

The U.S. Coast Guard's (USCG) scope of responsibility for ports and waterways includes freight traffic, passenger and ferry vessels, and recreational vessels. While activity other than freight remains sizeable for many major ports, current methodologies do not reflect the extent of such activities. As a result, the USCG is unable to compare maritime activities across ports and waterways at a given time or analyse

changes in the specific components of maritime activities across time.

To remedy this data gap, the USCG recently completed a research project that developed a framework to estimate the intensity of port activities. The framework combines data on cargo, passenger and recreational vessel activities. The initial USCG application included both inland and coastal ports.
This presentation describes the: data sources for the inputs, methodologies used to prepare ferry and recreational data, the port intensity scoring system, and an alternative for weighting the inputs. As the inputs are publicly available data and the initial application was developed on a spreadsheet, the framework can be readily adopted, modified, and used by port managers and researchers. Potential uses of this framework include: a basis to fill gaps in port maritime data, analyses of port performances both as a comparison across ports at a given time and to investigate changes in port activities across time, and extension of the framework to use 'big data' techniques.

Session A4 – Future eNav Directions

Moderator, Craig Philip

Electronic Navigation: the Future of Waterborne Shipping

by

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The objective of this research is to determine an implementation strategy for more effectively moving E-Navigation (E-Nav) technology platforms forward. We recount the history of the development of the E-Nav concept, including attempts to implement these strategies globally and the various roadblocks they have encountered. Then, we discuss the maritime community's main conceptual barriers to the fullest implementation of this technology as it relates to safety, security, and environmental concerns. A content analysis of survey responses was conducted to uncover the dominant themes.

Our findings indicate that the primary concerns are: 1) the technology may be oversold to a younger generation of mariners, leading to the unintended consequence of an increase in maritime accidents related to the mariner's failure to sufficiently blend the technology with traditional seafaring and 2) that E-Nav technologies are being cultivated with the purpose of implementing 'drone' or pilotless shipping, which mariners are resistant to because of safety and labour concerns. We conclude with the implementation strategy and a general outlook for E-Navigation in the short and long term.

USACE IENC – An Overview of the IENC Program and Future Technical Directions

by

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Join us for a session presented jointly by the Pittsburgh District and Army Geospatial Center to learn more about the USACE Inland Electronic Navigation Chart (IENC) Programme. The USACE IENC are built upon international standards and are now authorised for navigation use, in lieu of paper charts, by the USCG. Mr. Dodson will discuss the Programme's inception, discuss current state of affairs, introduce

some IHO standards, and show where to download IENC data. Mr Jalbrzikowski will walk you through some LiDAR and multibeam datasets collected for charting purposes and explain how they are used to verify such things as vertical clearances. We will wrap up with a discussion of some cutting-edge and future possibilities for the IENC such as real-time updates via AIS.

Results of PIANC Working Group 156 on 'e-Navigation for Inland Waterways'

by

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In 2011 the PIANC Working Group 125 finished its report on the update of River Information Services (RIS) Guidelines and came to conclusion that RIS might benefit from concepts in the maritime world such as e-Navigation and e Maritime. In addition, it turned out that in several regions (e.g. the Westerscheldt River) the interaction between seagoing and inland transport was increasing.

The number of mixed traffic areas (inland barges and seagoing vessels) as well as the traffic density itself was constantly increasing and calls for a harmonisation of the services and information used for traffic management together with harmonised information exchange between maritime and inland waterborne transport.

Therefore, it was the task of the PIANC Working Group 156 to investigate if Inland Waterway Transport (IWT) could learn/benefit as in the initial development phase of RIS from the maritime transport world, specifically from the maritime e-Navigation concept for the above-mentioned themes. The session will describe the approach of WG156 together with the definition of 'e-Navigation for Inland Waterways', the conclusions and a large set of recommendations and foreseen next steps.

The Next Generation of the Guidelines for River Information Services (RIS) PIANC Working Group 125

by

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Subtitle: 'RIS Enabled Corridor Management as Cornerstone for Smart Transport Management Solutions in Inland Waterborne Transport'

Already in 1999, PIANC recognised the importance of the development of River Information Services (RIS) and installed a working group on this topic with the task to develop the first edition of the 'Guidelines for River Information Services'. These RIS Guidelines were published in 2002. The PIANC RIS Guidelines were an important cornerstone of the Directive on River Information Services of the European Commission that came into force in 2005. Since the first publication of the PIANC RIS Guidelines, developments on traffic and transport services and standards, as well as technical and practical experience, have taken place. At the same time River Information Services, has found its way through the world. This led to the update of the RIS guidelines in 2011, when edition 3 of the Guidelines was published.

In recent years the concept of RIS enabled Corridor Management is recognised as an important next step in the deployment of RIS services. In the context of RIS, Corridor Management is defined as information services among waterway authorities mutually and with waterway users and related logistic partners to optimise the use of inland navigation corridors within a network of waterways. RIS-enabled Corridor Management will lead to new developments enabling 'smart transport management solutions with River Information Services as an essential cornerstone'. This will facilitate the integration of inland navigation into intermodal logistics chains.

The PIANC Working Group 125 on RIS analyses the above-mentioned developments but also takes up the lessons that can be learnt from information technologies and services in other transport domains, like there are e-Navigation in the maritime world and Intelligent Transport Systems (ITS) in the road sector. The PIANC working group is preparing 'the next generation of RIS Guidelines' that will be published by PIANC in 2018. The contribution to the Smart River Conference 2017 provides insights into the recent developments of RIS in Europe, the uptake of RIS worldwide and the important role of PIANC WG 125 in transforming the concept of Corridor Management into a practical guideline for the application of RIS in smart transport management solutions in the inland waterborne transport domain.

Session A5 – Data Collection & Dissemination Frameworks

Moderator, Eddie Wiggins

Analysis and Dissemination of Information in Support of e-Navigation

by

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This presentation will provide an overview of advances in the collection, structuring and organisation of maritime data as the foundation for extracting client driven information from large data repositories ('biggish' data). The focus of the presentation is on the analysis of the data and the dissemination of information in support of e-Navigation.

With improved sensor suites and more robust and affordable communication links, large volumes of data are being collected on daily basis. This data must be structured and organised to support sophisticated analysis resulting in the provision of information to the stakeholder. For stakeholders to effectively use the information, it is critical that it be provided in a standardised, non-proprietary fashion. With information being readily available, stakeholders can determine its value, and if appropriate, utilise it to support their decision making processes.

The presentation will provide examples of data analysis resulting in information and how this information can be disseminated for efficient utilisation.

eHydro: A USACE Enterprise GIS Navigation Support Program for Standardising and Processing Hydrographic Surveys

by

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A session presented jointly by the Louisville District and Army Geospatial Center that will demonstrate some of the capabilities of the USACE eHydro Program. The eHydro Program is an Enterprise Navigation GIS which is built to ensure USACE standardisation in processing and outputting navigation support products. The Hydrographic Survey Overlay Output Module of eHydro produces an Inland Electronic Navigation Chart (IENC) Standard compliant survey overlay.

The overlay will consist of contours and spot depths and will be provided to the US Coast Guard (USCG) to enable them to better place buoys on the inland waterway system. The USCG has an Electronic Chart Display System (Vega) with a Western Rivers Module which allows the USCG to vary river level conditions highlighting appropriate contours while monitoring or placing buoys. By using the eHydro produced IENC Survey Overlay, the USCG is able to better evaluate existing buoy locations and save a great deal of time planning and physically moving the buoys, resulting in a more efficient process and a safer waterways system.

Aiding Navigation through Centralising Information Dissemination

by

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The US Army Corps of Engineers (USACE) is charged with providing bulletins or notices by our 'District Engineers' on information relative to the improvement of harbours and waterways such as dredging operations, and precautions due to the presence of dredging or other vessels be brought to the attention of commercial, recreational, or governmental vessel owners or operators regularly using the waterways. The Notices To Navigation Interests (NTNI Notices) process and website, stood up in 2015, contains navigation notices and operational policies by the USACE districts with a navigation mission.

This single point of access informs mariners of events that affect waterway navigation such as maintenance projects, hazards to navigation, closures or restrictions, and other pertinent information and is a piece of the companion mariner information provided by the U.S. Coast Guard's (USCG) Local Notices to Mariners and the National Oceanic and Atmospheric Administration's (NOAA) Notice to Mariners Chart updates. This presentation will touch on collaborative efforts among the Corps, the USCG, NOAA and other entities to improve one-point data entry and maximise system operability through collaborative efforts such as the US Committee on Marine Transportation interagency action teams.

This presentation will also describe real-time dissemination of navigation information to users in a centralised system, which is important for mariners utilising the nation's waterways to identify current or planned performance and/or safety changes in waterways, and future improvements to the Corps notice system.

River Information Services Enterprise (RISE) – A Framework that Harmonises the Collection, Integration, Exchange, Presentation and Analysis of River Information Services within the U.S. Inland Waterways

by

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The River Information Services Enterprise (RISE) is a framework that harmonises the collection, integration, exchange, presentation and analysis of River Information Services (RIS) within the US Inland Waterways. RISE will improve the information services between the Marine Industry and Government to enhance navigation, safety, and security, as well as protect the marine environment.

RISE utilises an open architecture employing cloud services, sophisticated data schemas and leverages existing presentation formats, to allow scalability to accommodate growing communities of interest. RISE leverages existing RIS data resources to conduct machine to machine data exchange and performs the data analytics to correlate and fuse key information.

Government benefits include reduced error rates for barge, cargo type, and tonnage reporting; customised analysis of river commerce; optimised lock utilisation by Marine Industry; and improved

response to natural disasters. The Marine Industry benefits through improved voyage planning, reduced lock and terminal wait times; reduced costly manual reporting; improved notification of navigation hazards; optimised scheduling of tow and barge utilisation.

RISE development is sponsored by Coastal and Hydraulics Laboratory (CHL) at the Engineer Research and Development Center (ERDC) of the US Army Corps of Engineers ((USACE). Trabus Technologies (TRABUS), a Service-Disabled Veteran-Owned Small Business (SDVOSB) of San Diego, CA, is the industry developer.

Session A6 – Cooperation and Regulations

Moderator, Kevin Knight

Incentivising Contractors to Deliver Value for Money and Long-term Performance Leads to Optimised Designs for Waterways

by

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The Dutch Government is currently implementing a programme consisting of five Public-Private Partnership (PPP) waterway projects: Lock Limmel, Sealock IJmond, 3rd Beatrix lock, Lock Eefde and Afsluitdijk.

Main objective is to improve flood protection, inland navigation and water (level) management by widening existing waterways, renovating existing locks and building new locks and flood barriers.

The projects are structured in 25- to 35-year Design-Build-Finance-Maintain (DBFM) contracts. The contract specifies the minimum performance requirements, leaving substantial room for the contractor to optimise its own design and life-cycle approach. Performance-based availability payments constantly incentivise the contractor to deliver the required performance.

The Government uses the ‘competitive dialogue’ procedure to allow bidders and contracting authority to explore improvements to the project, before the bids are submitted. In addition to the price, bidders can receive a qualitative score when added value is offered for the project owner, users and other key stakeholders. As such, the contractor is selected on the basis of the best value for money.

Case study

The Beatrix Lock project required the contractor to build a third lock in order to increase capacity for locking of ships. The lock complex is also used as flood barrier and to regulate water levels in the rivers on both sides of the complex.

The winning bidder proposed a 297-m long lock and double sliding doors in each lock head, whereas the minimum performance requirements could also be met with a 270-m long lock and single sliding doors. Double versus single door offers redundancy and allows the contactor to perform preventive and corrective maintenance on the doors while being fully operational. The return on this investment is superior capacity, availability and reliability of all three abovementioned primary functions offering added value for the project owner, users and other key stakeholders.

Why Doesn't Anyone Compare Navigation Benefit/Cost Analysis Strategies?

by

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America enjoys an abundance of coastlines and inland waterways; and where previous investment in water projects sustains economic activity and national security. Navigation projects especially contribute to nation's growth, through its linkages to road and rail modes. However, these previously generated benefits will not last indefinitely. Today, governmental decision makers must define and rank the relative merits of both new navigation construction and ongoing maintenance projects.

This linkage between national modal investments, both within a single mode, but also across modes, represents a rich field for additional research; the presenters call for such sustained action in the subject through this paper demonstrating both the problem and some areas where additional research is required.

Various agencies share responsibility for components of the waterway navigation system. Eventually, legislative and regulatory policies codified different evaluation approaches when examining investments in waterways. For example, the Corps of Engineers, state and federal DOTs and the US Office of Management and Budget each rely upon different Benefit/Cost Analysis and multipliers (BCA), sometimes in analysing the same project.

The presenters will identify established ways that BCA approaches are used in navigation related projects. The presenters call for research on how investment decisions and prioritisation of inland waterway navigation projects would improve by reconciling inconsistencies between BCA strategies and requirements.

The presenters call on researchers to expand work on maritime transportation subjects, such as to identify how to use BCA to account for different agencies requirements; to identify the common areas of consideration; identify false differences between BCA strategies; to demonstrate how these valuations could be expanded to include the true economic alternatives of not only a discreet project, but to also facilitate comparison between alternative projects across a geographic region proposed to meet a transportation requirement.

Keeper of the Danube: the Facilitating Role of the ICPDR – From Joint Statement on Navigation to 'MEETET'

by

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With a total area of 801,463 km^2 – 10 % of continental Europe – the Danube River Basin is Europe's second largest river basin in the world. Including the territories of 19 countries, and home to 81 million people with a variety of languages and historical backgrounds. The River Danube itself, stretches over 2,780 km between its spring in Germany's Black Forest and the Danube Delta. The Danube River Basin shows a tremendous diversity of habitats and ecosystems to be preserved. To commit to transboundary cooperation in protecting the Danube, the main Danube countries signed the Danube River Protection Convention (DRPC) in 1994.

Today, 14 Danube Basin countries and the European Union are so-called contracting parties of the International Commission for the Danube River (ICPDR). They work jointly towards the sustainable management of the Danube basin`s waters. In 2000, the EU Water Framework Directive (WFD) came into force, establishing a legal framework to protect and enhance the status of aquatic ecosystems, prevent their deterioration, and ensure the long-term, sustainable use of water resources throughout the EU. The contracting parties made the ICPDR the facilitating platform to coordinate WFD-related work.

Navigation of the Danube has always been of great importance; the first navigation Treaty dates back to 1616. Historically, the Danube and some of its tributaries have formed important trade routes across Europe. The harnessing of these rivers to facilitate navigation has radically changed their physical and ecological characteristics, while pollution from ships and boats is also a problem. In order to address this problem, the ICPDR is undertaking various activities. Through its 'Integrated river basin management' approach of the ICPDR foresees cross-sectoral discussion processes.

Such a process has led to the Joint Statement on Inland Navigation and Environmental Sustainability in the Danube River Basin. Launched in 2007 by the ICPDR in cooperation with the Danube Commission and the International Sava Commission.

Inland navigation can contribute to making transport more environmentally sustainable, particularly where it substitutes for road transport. It can, however, also have significant influence on river ecosystems and jeopardise the goals of the EU Water Framework Directive. The Joint Statement summarises principles and criteria for environmentally sustainable inland navigation on the Danube and its tributaries, including the maintenance of existing waterways and the development of future waterway infrastructure. It does however does not cover the entire scope of problems. The ICPDR realised that more initiatives and work are required and the inland navigation activity METEET came to fruition.

The Mixed Environment Transport External Expert Team (METEET) activity on Integrated Planning of Inland Waterways Transport (IWT) Projects, led by the ICPDR, the Sava Commission and the Danube Commission is aims to provide advice to competent authorities about developing sustainable strategies, plans and projects in the field of inland navigation along the Danube. In order to analyse impact, constraints and possible mitigation and compensation measures at a very early stage, these actions will also take European Environmental Legislation from the beginning of the drafting process into account. The work of METEET will be guided, supervised and managed by a Steering Committee composed of representatives from the DC Secretariat, ICPDR Secretariat and the European Commission services (DG MOVE, DG ENV and DG REGIO).

Who Should Pay for Sediment Cleanup?

by

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In the next decade or so, various entities are expected to spend several billion dollars to clean up contaminated sediments in rivers throughout the country. One commonly repeated question in the cleanup process has been: 'who will pay the cost?'. The analysis of this question is convoluted, involving primarily legal and technical issues but also social and economic aspects. The typical response has been 'the polluter should pay'! For the most part, this is true but the premise of 'polluter pays' reaches practical limits.

The fact that most sediment contamination is derived from discharges associated with the industrial activity of the mid-twentieth century can add to the complexity of the 'polluter pays' principle. At several sites in the U.S., cleanup costs are being allocated using an alternative dispute resolution format consisting of both technical and legal elements.

The approach is predicated on the belief that distributing the cost of cleanup beyond a single polluter to a wider group of stakeholders will result in better incentives to proceed with cleanups. The methods used include careful analysis of facts surrounding industrial and municipal discharge points and sediment deposits. Cases can be developed to support the relationship between sources and deposits of pollution using modern physical and chemical investigative and forensic techniques. Careful economic analysis can reveal both profit and tax incentives that will appeal to developers and municipalities alike. Social benefits, such as better access to the waterfront and advancement of public trust values, will appeal to communities.

Thus, the cost of cleanup can be allocated to a wider spectrum of interests including industry, commercial development, government, and the public. Using this approach, it may be possible to bring parties together and break at least some of the gridlock currently typical at many of the large contaminated river sediment sites in the U.S.

Session A7 – Recreational Navigation

Moderator, Denise Soisson, PennPorts, USA

Making the Nation's Largest Waterfront Redevelopment Real – The Trials and Tribulations of The District Wharf Project

by

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The Nation's largest waterfront redevelopment 'The District Wharf' – the historic waterfront in the District of Columbia – was snarled in the regulatory jurisdiction of over 30 agencies, disconnected from the city by urban renewal, and left in a derelict and neglected state. Historically a thriving commercial port, this function was long forgotten as the waterfront became a series of small, private marinas, fenced off from the promenade, with no public access.

The District has 26 miles of waterfront, however, is not thought of as a waterfront city. In 2003, the District realised the site's potential as a catalyst for improving city's waterfront creating the Anacostia Waterfront Corporation charged with enacting change along the waterfront. The scope and breadth of the effort exhausted public financing capacity and the corporation put the project out to bid in 2006. The project received submissions from 17 developers; following selection of the PN Hoffman and Madison-Marquette team, negotiations began on the largest public-private partnership in DC's history. The development team formulated a waterside plan incorporating waterborne transportation, public access, urban living, tourism, commerce, art and waterfront activity.

In an area with significant portions of the waterfront under federal control, this project was subject to intense regulatory approvals, requiring three acts of Congress and approvals from agencies as far-flung as the US Commission for Fine Arts.

Deauthorisation of the federal navigational channel unlocked the project's potential and allowed for an innovative approach to remove the project from the National Parks Service jurisdiction through the extension of a historic pier head line. In addition to the extensive regulatory agency reviews, over 350 stakeholder meetings were held to get community buy-in, including the site's residents of over 100 live-aboard vessels.

The project is presently under construction and Phase 1 was scheduled to be opened on 12 October 2017.

Risk, Reward and Resilience: Engineering Community Waterfronts for Extreme Events and Everyday Success

by

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Extreme weather can wreak havoc on riverine communities, their infrastructure and their redevelopment efforts. Historically, the response has been to create high flood barriers that make the river's edge less accessible, cutting off the public from the water. As the desirability and value of waterfront cities and properties continue to rise, communities are also faced with redeveloping neglected, former industrial waterfront sites that are in increasingly vulnerable locations. While redevelopment of these underutilised lands to mixed-use, community spaces has been shown to have significant economic impact, extreme weather events can quickly wipe away a community's investment.

Creating vibrant and successful community waterfronts requires more than hard, structural solutions. The most valued waterfront spaces provide opportunities for direct public access and a myriad of water-based uses. This presentation will focus on forecasting for extreme weather and flood events, and the ways that waterfront infrastructure can be engineered to be more resilient against damaging events while also creating an appealing waterfront environment.

Case study examples will explore a range of design approaches and opportunities, including new tools for modelling and risk assessment, the integration of green infrastructure and living shoreline design, and the utilisation of flexible and movable infrastructure. Participants will learn how these approaches can be utilised to anticipate and mitigate the impacts of flooding, variable water levels and hydraulic flows, high winds, and sedimentation, as well as provide economic, recreational and ecological benefits.

Working with Nature: Planning Sustainable Marinas

By

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The 'Working with Nature' (WwN) philosophy is a general approach proposed by PIANC for a broad range of types of projects. This paper explores detailed interpretations to the WwN principles, specifically applied to recreational navigation infrastructure.

The analysis is based on consulting experience with design and permitting of marinas in a variety of conditions and countries. This review unveils practical recommendations for marina design based on the WwN principles, which are based on demonstrating the added value to the project (and potential increased return on investment). Specific examples of sustainable marina project elements that meet these recommendations are illustrated.

The underlying justifications of WwN have existed for many years before WwN was published and many projects were developed based on those principles. This paper intends to show how WwN provides a simple framework that – if used adequately – can facilitate the timely consideration of environmental issues to achieve sustainable and resilient design of recreational navigation infrastructure.

Session A8 – Freight Flow
Moderator, Jeff Lillycrop

The Nautical Network Puzzle – How to Build the (European) Waterway Network for RIS Corridor Management

by

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River Information Services (RIS) have been deployed in several countries and are usually operated and provided regionally. In order to better suit the needs of the users of the waterway it is important to overcome the borders of the area of competence of respective authorities and service providers and to offer enhanced services for route and voyage planning on wider geographical scale.

For route planning it is essential to know where objects of relevance for inland navigation are located and how these objects are connected with each other within the network. In Europe, the so-called RIS Index was established as repository for object reference data in the RIS environment. Unique Object IDs out of the RIS Index are used to enable linking of the key-RIS-technologies like displaying Notices to Skippers (NtS) or AIS information in Inland Electronic Navigational Charts (IENCS). Nevertheless, the RIS Index does not include a specification of the links between the objects.

With respect to the waterway links, different national authorities have their own definition of relevant basis data or even lack of the required information needed for RIS Corridor Management. Therefore, a uniform digital Nautical Network Data Service (NNDS) is to be developed facilitating provision of information about objects and possible routes. The NNDS has to include static data, such as the RIS Index (e.g. location and dimensions of a lock chamber), as well as dynamic data provided by fairway- and traffic information services (e.g. operational status of the lock chamber, limitations, schedules).

The conference contribution will show the results of NNDS studies and pilots elaborated in European projects and will give an outlook of the challenges ahead and a possible concept how to meet them in the European project RIS Corridor Management Execution (RIS COMEX).

Modernisation of Navigation Statistics Publishing

by

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The Waterborne Commerce Statistics Center (WCSC) of the U.S. Army Corps of Engineers (USACE) produces commercial usage statistics for all navigable waterways within the United States. These statistics are used by the USACE as a factor in determining project budget allocation, and are also used by other governmental agencies to support funding decisions and provide performance indicators. Also, they are used by the industry, governmental agencies, economists, and academia as foundational data for understanding the flow of waterborne commerce in the United States. In response to stakeholders, WCSC is driving to produce these same high-quality statistics more rapidly and more frequently. In this presentation WCSC's recent movement and plan to reach this goal will be introduced.

The presentation will also touch upon suggested vessel operator practices that would help WCSC achieve these goals. Also, it will familiarise conference attendees with WCSC data that is available, and how it is relevant to all stages of the planning process. It will demonstrate how our processes are improving, and how new development tools are being used that may be helpful to other government owned technologies process improvement projects.

Suggestions will also be made on how to interact with the waterborne operators' community of practice and invite valuable feedback from them. WCSC feels that those motivated to attend the sessions related to smart IT infrastructure would benefit from this presentation.

Fluidity Analysis of Major Inland River Freight Corridors

by

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The U.S. Inland Marine Transportation System (IMTS) handles nearly 600M tons of waterborne cargo annually. Bulk commodities such as coal, grain, fuels, and aggregates move throughout the network comprised of free-flowing rivers, navigation locks and associated pools, and maintained canals and waterways. The cost-effective, efficient and reliable movement of these goods throughout the IMTS is essential to the health and stability of the national economy. So as to monitor the performance of the IMTS in these terms, this work utilises two capabilities developed by the U.S. Army Corps of Engineers (USACE) Navigation R&D program to 1) identify the largest commodity-specific corridors utilising the IMTS, and 2) determine the travel time reliability, or fluidity, for vessels transporting goods along these primary corridors.

The Channel Portfolio Tool (CPT) is used to find the largest unique origin-destination pairs and associated routes for select commodity groupings. The Automatic Identification System Analysis Package (AISAP) is then used to track unique vessels moving between the respective origin and destination zones defining each of the primary corridors. Comparisons of the date-time stamps from the AIS vessel position reports observed within the origin and destination regions allows for a statistically meaningful sample of travel time observations. Corridor travel time parameters such as mean, median, and standard deviation can then be established to set baseline performance thresholds, but these and other measures can also be tracked through time.
This temporal analysis allows for the impact from waterway closure events, weather delays, marine casualty events, and other disruptions to be evaluated in terms of the effect on IMTS travel times. It is important that a robust, quantitative understanding of these relationships be used to inform the policy trade-off decisions that much be confronted as the nation seeks out an investment strategy for its aging inventory of navigation locks and dams.

Track B

Session B1 – Climate Change
Moderator, Anne Cann

Global Climate Change Action and the Transportation Sector: What is Happening Now and What to Expect

by

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In 2015, the first truly international agreement to reduce carbon emissions worldwide was entered into by the nearly 200 parties to the 1992 treaty known as the United Nations Framework Convention on Climate Change (UNFCCC). Work on implementing that 2015 agreement has begun. The IPCC reports that in 2010 the transportation sector contributed about 14 % of total global greenhouse gas emissions,

with the marine industry responsible for a substantial portion. The transportation sector will continue to be a target of the many ongoing efforts worldwide to reduce emissions. For example, at the recent 22nd meeting of the UNFCCC parties in 2016 the International Maritime Organisation announced adoption of mandatory rules for ships to record and report data regarding fuel consumption in international shipping that is expected to lead to further debates on whether additional rules are required to reduce emissions.

In the U.S., studies have shown that inland waterway transport is one of the lowest emitters (CO_2 emitted per tonne-mile) in the freight transportation sector, providing incentives to those concerned about greenhouse gas emissions to increase freight movement by barge. In Europe, the Central Commission for the Navigation of the Rhine (CCNR) has recognised that other modes of transportation are decreasing emissions in response to climate change initiatives, and inland waterway navigation must also do so in order to remain environmentally competitive. This presentation will focus on the status of international climate change negotiations and their current and potential impact on the transportation sector with a focus on shipping. Action is being taken by many nations across the globe, but also (especially in the United States) by the private sector, states, local governments, and cities that impact (or may soon impact) the transportation sector. Anyone who operates in the freight transport sector should be aware of current developments.

Climate Change Adaptation: Why, What, and When?

by

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Climate scientists are in agreement that the climate is changing. Recent changes have already had widespread impacts on human and natural systems, and the world is now locked in to further change in some key climate parameters.

Even if the Paris Agreement succeeds in limiting global warming to no more than 2°C, adaptation will therefore be critical. We need to guard against complacency.

But what to adapt, and how, and when? The answers to these questions can be far from straightforward. Climate science remains riddled with uncertainties.

The Navigating a Changing Climate Action Plan prepared by the partners in the PIANC-led Think Climate coalition stresses that it is time to stop using this uncertainty as a reason for inaction. If navigational safety is to be ensured, downtime reduced, and business continuity protected, the waterborne transport infrastructure sector must act to adapt waterborne transport infrastructure and the operations that depend on it; and to strengthen resilience to reduce the vulnerability of the sector to more frequent extreme events.

PIANC's Working Group 178 on climate change adaptation for ports and inland waterways is addressing this challenge through the development of technical guidance. The guidance sets out a series of steps towards determining a locally-appropriate course of action, including sections on:

- setting goals
- identifying and engaging stakeholders
- preparing an inventory of infrastructure assets and operations
- understanding and interpreting the climate science
- identifying and assessing the risks
- understanding what matters (e.g. when retrofitting, developing new infrastructure, or improving the resilience of existing infrastructure)
- understanding the generic options: structural, operational and institutional
- identifying and selecting potentially feasible measures
- evaluating options and implementing a preferred option.

The presentation will elaborate on the contents of the WG 178 guidance, highlighting the key messages and encouraging the owners, operators and users of waterborne transport infrastructure to take action.

Transboundary Climate Change Adaptation of the Largest European Inland Port Area

by

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Over a length of 46 km the river Meuse forms the border between Belgium and the Netherlands. With more than 3,000 berths, the northern part of this river section houses the largest inland port of Europe. The governmental authorities De Vlaamse Waterweg in Belgium and Rijkswaterstaat in the Netherlands are both responsible for the water management of this area. In order to protect this area against floods and taking into account the possible effects of climate change, both authorities have joined forces and set up a transboundary plan. The plan aims to enlarge the river bed as much as possible and thereby avoiding a further raise of the dykes. The latter would lead to higher water levels and higher water velocity and thus demanding large adaptations to the current infrastructure.

Therefore 14 different measures are defined and tested in a hydraulic study. The measures are various like: lowering the winter bed, relocating dykes, activating flows through former gravel excavation pits, relocating harbour entrances, etc. Each measure is linked with a realistic execution date. Taking into account the possible increase in discharge for the same return period due to climate change, the results of the study show that for the year 2030 a decrease of 1,10 m of the water level, compared to the current situation, can be achieved. For the year 2050, when all measures are planned to be executed, a total decrease up to 1,35 m was noted. These results show that by developing an adaptive strategy to increase the protection against floods of this area, the economical, recreational and ecological attraction of this area could be secured for the future.

Carbon Management for Port and Navigation Infrastructure

by

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There is international scientific consensus that anthropogenic emissions of greenhouse gases (GHGs) have and will continue to contribute to changes in the global climate.

Although there is uncertainty concerning the magnitude, rate, and ultimate effects of this change, it is generally accepted that climate change will result in a number of substantial adverse environmental impacts. In 2013, the Intergovernmental Panel on Climate Change (IPCC) began releasing components of its Fifth Assessment Report, providing a comprehensive assessment of climate change science. The Fifth Assessment Report states that there is a scientific consensus that the global increases in GHGs since 1750 are mainly due to human activities such as fossil fuel use, land use change (e.g. deforestation), and agriculture. In addition, the report states that it is likely that these changes in GHG concentrations have contributed to global warming.

The Paris Agreement, developed at COP21 in December 2015, is an international agreement among parties in the United Nations Framework Convention on Climate Change (UNFCCC). The central aim of the Paris Agreement is to maintain the global temperature rise in the 21st century below 2 degrees Celsius above pre-industrial levels. Furthermore, the Paris Agreement provides for increased transparency, requires all Parties to maintain and communicate 'nationally determined contributions' that they intend to achieve, and aims to erect financial and technology frameworks for reaching the climate goals it puts forth. The agreement addresses a range of areas necessary to combat climate change, including a long-term temperature goal, global peaking of GHG emissions, mitigation, and a 'global stocktake' every five years.

Given this context, there is growing regulatory interest globally in managing the GHG emissions, or 'carbon footprint', of industrial activities to respond to climate change. Effective carbon management involves steps to reduce and offset GHG emissions and sequester carbon. While the International Maritime Organisation (IMO) under the UNFCCC has recently spent efforts to reach agreement on a global approach to reduce international shipping GHG emissions, there has been much less focus on the infrastructure that supports waterborne transport. PIANC and its partners in the Think Climate coalition are working to fill this gap.

Taking proactive steps to effectively manage carbon will help the navigation sector: 1) comply with emerging regulatory requirements, 2) respond to general stakeholder and public pressure to reduce environmental burdens, 3) take a leadership role in carbon management practices, and 4) drive innovation and investment while influencing future practice and regulation. In addition, there are unique opportunities to reduce and offset emissions from waterways navigation infrastructure development, including dredging and the beneficial use of dredged sediments, which need to be addressed in any carbon management framework.

PIANC's Work Group (WG) 188 on Carbon Management for Port and Navigation Infrastructure is tasked by PIANC to review and report on the technical literature related to the carbon footprint of navigation infrastructure and supporting activities, provide guidance on applying life cycle analysis and related assessment tools and techniques, and investigate opportunities for reducing atmospheric GHGs through operational practices, Working with Nature, land use management, blue carbon projects, and related environmental management.

WG 188 was established in February 2016 and is now beginning its process to develop draft text for its eventual guidance document. In this talk, WG 188 progress will be discussed as well as carbon management framework considerations for navigation infrastructure and example case studies.

Session B2 – Engineering With Nature

Moderator, Todd Bridges

Engineering with Nature for Rivers

by

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Engineering With Nature (EWN) is defined as the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes. The principles and practices comprising EWN lead to a range of important opportunities to create operational efficiency, make use of natural processes, produce expanded (and more diverse) project benefits (i.e. economic, environmental and social), and reduce conflicts that interfere with and/or impair project development and execution. There is a growing interest, internationally, in making more deliberate use of natural systems and processes to support engineering outcomes, and vice versa. Examples of such approaches span decades in both coastal and riverine systems.

Our objective here is to discuss the realized and expected outcomes of past, current, and future projects in river systems and how EWN principles and practices can be used to enhance the value of both restoration and infrastructure projects. By giving more attention to the principles and practices that enable the production of expanded benefits, more project value and social support will be created. This paper will highlight the principles and practices that are critical to creating project value through engineering with nature and will illustrate the approach by referring to a range of international examples. Overarching lessons will include 1) identifying opportunities to create added value, 2) project partnering and proponency and 3) innovation.

Coping with Changing River Morphology and its Effect on Navigation and the Environment

by

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Waterborne transport is an important driver for the Dutch economic sector. The Waal River is part of the Rhine Delta and as such the most important navigation route within Europe, as illustrated by its annual transport of 1.6 million TEU at the German-Dutch border. For the transport industry it is very important to have accurate predictions about changing boundary conditions like sea level rise, discharge and sediment budget, as this determines the future changes in the equilibrium profile of the river, hence navigation depth and thus future investment.

Shipping is often at odds with river restoration measures because these measures may result in more irregular sedimentation and erosion patterns on a short term. As a result, increased dredging is necessary, although this decreases the overall bed level unless dredged material is relocated in upstream positions. Therefore, river managers need to study alternative measures for flood mitigation which still ensure a navigable channel, even at periods of low river discharge. On the long term, the predicted effects of climate change point in the direction of more extreme river discharges (both high and low) and the possible effects on the transport industry might be considerable.

Therefore, a long-term research programme is currently being set up to study the changes in equilibrium profile of lowland rivers under external drivers like climate change (and also anthropogenic) changes. Very important input for this research is a proper insight in the (changes of) the sediment budget of the major river branches. For that reason, the Netherlands is considering an intensive campaign to monitor and analyse the sediment distribution budgets for the Rhine delta, in order to further improve existing models and our associated long term hydromorphological, physical and economic predictions. In our presentation we will present the outline of the research programme focusing on the equilibrium profile and present the first results based on several cases studies.

Creating River Island Habitat in the Lower Atchafalaya River Using Engineering With Nature Concepts

by

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The US Army Corps of Engineers (USACE) New Orleans District utilised dredged material to nourish and increase the size of a sand bar that had naturally formed in the Atchafalaya River, LA. Over a 12-year period, dredged material was placed upriver of the island using shoal material removed from an adjacent Federal navigation channel during routine channel maintenance. The dredged material was dispersed downstream by river currents, thereby nourishing and self-designing the island. This project demonstrates USACE Engineering With Nature concepts, where environmental and other benefits are being documented, enabling more sustainable delivery of economic, social and environmental benefits associated with river infrastructure. Monitoring studies were performed to determine the river hydrology necessary to create the island via transport from dredged material strategically placed upstream.

This beneficial use of dredged material has created nearly 100 acres of river island habitat. Ecological surveys of the island identified over 80 species of plants and over 20 faunal species, many native to the region. The enlarged island has reduced the overall cross section of the river, increasing flow through the navigation channel to velocities that were sufficient to reduce shoaling and maintenance dredging requirements. This narrowing of the channel profile is yielding quantifiable economic benefits, as maintenance dredging frequency and material volume has been reduced due to the island's growth. Understanding the hydrodynamic and environmental processes that led to the island's growth through monitoring activities will allow the USACE to apply this approach at other riverine sites where currents

could be advantageously used to naturally deliver dredged material to areas of need. Demonstration of this approach, and fostering its integration into USACE business practices of project design, is intended both to increase project value and to more effectively manage the nation's waterways.

Hydraulic Regulation of Canal Del Dique, a Proposal of Integral Environmental Restoration

by

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In the Caribbean coast of Colombia, the project for the restoration of degraded ecosystems of the Canal del Dique is underway, led by the Fondo Adaptacian of the Colombian Government. As a response to the effects evidenced that have directly altered the dynamics and structure of the lotic and lentic water bodies of the system, and modified the marine ecosystem bringing estuarine functions to bays of Cartagena and Barbacoas.

As a result of the 2010-2011 Niña phenomena, water levels within the Canal del Dique increased, causing a breach (km^3), flooding the south of the Atlántico Department and from there downstream to Gambote village in Bolivar Department (km66), and affecting the ecosystems associated to the channel. In order to prevent, mitigate, correct and/or compensate for the effects of degradation in the system, the implementation of engineering works was organized to control the water discharge entering the Canal from the Magdalena River, and to diminish the sedimentary contributions to the associated bodies of lotic and lentic type along the channel. Activities to increase water levels in the Ciénagas (lentic) have been developed, guaranteeing the supply of the fish resource and the preservation of strategic ecosystems.

The project incorporates the effects of climate change, which allows projecting the interaction of the sea with the coastal zone. This strategy integrates the degraded ecosystems of the terrestrial and marine protected areas and the lotic and lentic water bodies. Cushioning the effects of future extreme climatic events such as El Niño and La Niña phenomena, and to prevent future floods, maintaining the dynamics of the Canal del Dique, navigability and stabilising the elasticity in the Ciénagas, with a decrease of tensors on the Marine ecosystems, a condition that will allow grassland, mangrove, corchales, coral reef and littoral ecosystems to restore their environmental services through resilience mechanisms.

Session B3 – Engineering with Nature

Moderator, Todd Bridges

Building a Smart River Solution for Climate Adaptation: The Room for the River Programme & Noordwaard Case

by

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The Noordwaard polder is an area of 4,450 hectares – around 6,000 football pitches – that borders on the Biesbosch National Park and the Nieuwe Merwede river in the Netherlands. In the area's history,

nature, water and humans alternated in determining the appearance of the landscape. As part of the Room for the River flood safety program the classical agricultural function of the Noordwaard polder was eliminated in order to increase the safety situation of the upstream river area. Since January 2016 the river is allowed to flow through new flood channels created in the Noordwaard during periods of high water. 70 km of new dikes and quays and 33 bridges have been build, some dikes including innovative hybrid engineering with nature solutions. New agriculture businesses had to be developed, residents remaining in the now flood prone area required new flood safe housing and flood early warning systems. New natural areas were established. This project is valued at approx. $ 200 million and can be seen as one of the largest scale climate adaptation projects of the Netherlands and probably of the world.

Applying Working with Nature to Navigation Infrastructure Projects

by

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The PIANC Working Group 176 is developing guidance to support ports and other public and commercial maritime interests apply a 'Working with Nature' paradigm to navigation and infrastructure projects. The guidance will provide a basis for maximising opportunities for working with natural processes delivering environmental restoration and enhancement outcomes that go beyond merely avoiding or just compensating environmental impacts.

In addition to providing guidance on how to apply the Working with Nature paradigm, the guidance will raise awareness and promote expanded acceptance of Working with Nature as applied to navigation infrastructure projects. Working with Nature is defined as an integrated approach which involves working to identify and exploit win-win solutions which respect nature and are acceptable to project proponents and environmental stakeholders [PIANC, 2008, 2011]. Working with Nature provides an opportunity to:

a) Reduce demands on limited resources by way of using natural processes to maximise project benefits, thus minimising the environmental footprint of projects while enhancing project benefits.
b) Reduce social friction and resistance by applying science-based collaborative processes to organise and focus interests, stakeholders and partners.

The guidance will draw from existing approaches and best practices worldwide. We will present various case studies that exemplify the WwN philosophy. By focusing on case studies, we hope to provide tangible examples of how WwN can be integrated into standard practice for navigation infrastructure projects. The presentation will discuss:

- The Working with Nature philosophy
- Available methods that support alignment of natural and engineering processes
- Present Working with Nature as a process of shifting toward more sustainable practices for achieving multiple project benefits (i.e. environmental, social and economic)
- Incorporate adaptive management principles and practices, as appropriate

The primary audience in both developed and emerging economies is project engineers, contractors, ecologists, planners, and environmental stakeholders who have an influence on the decision making responsibility pertaining to navigation infrastructure projects. This paper will provide an overview of the Working with Nature process and the guidance document under development. Concepts and approaches are illustrated through representative case studies.

Environmental Pool Management in the Upper Mississippi River: Managing Water Levels to the Benefit of both Navigation and the Environment

by

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For over 20 years the U.S. Army Corps of Engineers, St. Louis District, has effectively managed water levels within three lock and dam navigation pools on the Upper Mississippi River to the benefit of the environment while allowing for the continuity of navigation operation. The practice, known as Environmental Pool Management (EPM), adaptively regulates water levels to allow for the exposure of mud flats and shallow areas during the growing season for vegetation, while sustaining the 9-ft. navigation channel. Past practices in these three pools produced a growing period occurring somewhere between May and August for periods of approximately 30-45 days.

EPM exposes approximately 1,000 acres per navigation pool, creating a variety of ecosystem benefits including emergent aquatic vegetation growth, sediment consolidation, increased floodplain habitat diversity, and food production for fish and wildlife. In 2016, The Nature Conservancy and the Corps collaborated to further improve EPM and increase benefits by targeting a period of exposure of at least 60 consecutive days.

Hydrologic conditions that year allowed EPM to be implemented for over 100 days in each of the three navigation pools. Substantial benefits were observed including additional vegetation growth and seed production, higher rates of sediment consolidation, and reappearance of historically prevalent but now scarce ecological communities. Success of the 2016 season has increased the call to have the Corps look at implementing Environmental Pool Management throughout the entire Upper Mississippi River navigation system.

Capturing the Socio-Economic Payoff from Managing Rivers for Environmental Objectives

by

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The economic, social and ecological imperative for sound management of limited freshwater is undeniable. River management often requires trade-offs among these crucial objectives and a decision framework should be transparent, fair, repeatable, and capable of demonstrating the costs and benefits of alternative management strategies. The quantity, timing, and quality of water flows affects the integrity and long-term resilience of river ecosystems and the human populations dependent these systems.

Although the importance of flow management is widely acknowledged, challenges arise in specifically

identifying the quantity, timing, and quality of water flows needed to obtain a desirable and sustainable socio-economic and ecological state.

This case study examines competing outcomes associated with water management in the Middle Oconee River near Athens, Georgia. Operated by a four-county authority, Bear Creek Reservoir is an off-channel, pump-storage reservoir, which withdraws water from the Middle Oconee River for municipal water supply. This project uses structured decision making to examine some of the economic and ecological trade-offs associated with alternative pumping schemes. In particular, we focus on developing a scientific basis for informing flow management in the Middle Oconee River.

Outcomes of river management actions are presented relative to socio-economic endpoints of municipal water supply and recreational kayaking as well as ecological outcomes of hydrologic change, fisheries production, and sediment and organic matter transport. Each of these 'lines of evidence' contributes to our understanding of how alternative management actions affect the system as a whole and inform decision making. Contrary to common assumptions, ecological and socio-economic outcomes are both shown to benefit from novel flow management schemes.

This case study provides a variety of transferrable tools to examine the trade-offs and synergies associated with managing water for multiple objectives.

Session B4 – Regional Sediment Management Session

Moderator, Linda Lillycrop

Regional Sediment Management on Riverine and Reservoir Systems

by

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USACE.

The U.S. Army Corps of Engineers Regional Sediment Management (RSM) Program was initiated in 1999 to change the USACE focus from managing sediments on a project-by-project scale, to taking a regional approach to implement sustainable solutions for managing sediments across multiple projects and business lines. Benefits of managing sediments within a regional context are added value and reduced lifecycle costs, environmental/ecosystem benefits, and improved communication and collaboration within the Corps and with stakeholders, partners, and resource agencies.

A key component to the implementation of RSM is the application of tools and technologies to identify and evaluate opportunities to improve the management of sediments, as well as using science based data and information in making decisions and overcoming challenges. The RSM programme initially focused on coastal systems and beneficially using sediments dredged from navigation channels to reduce coastal shoreline erosion or for habitat creation.

The RSM focus later broadened to integrate RSM principles into riverine and reservoir systems, providing a comprehensive approach to managing sediments across watersheds. This presentation will review enhancements to tools and case studies demonstrating the application of RSM principles to improve the management and use of sediments in riverine and reservoir systems.

Integrating Channel Maintenance Planning in the Lower Columbia River

by

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This presentation will introduce the alignment of the 20-year Lower Columbia River Channel Maintenance Plan (LCR CMP (also referred to as a Dredged Material Management Plan or DMMP)), with the development of a Regional Sediment Management Plan (RSMP). The U.S. Army Corps of Engineers (USACE), Portland District, is charged with maintaining a 43-foot deep-draft navigation channel spanning 102.5 miles between the states of Oregon and Washington.

The channel supports 40,000 local jobs, economic interests over $ 24B, and is the largest wheat and barley export gateway in the nation. Contrasting the economic benefits are dozens of other concerns stemming from maintaining the deep-draft channel, namely environmental concerns over ESA-listed species. Coordination of channel maintenance activities is done with a number of agencies from both states, as well as a number of stakeholders and partner organisations.

Through the development of a new CMP, the Portland District will look to marry the principles of RSM with annual channel maintenance dredging and passive channel training. Main themes of this integration will be beneficial uses of dredged material for habitat creation, beach nourishment, and other projects that can benefit from channel maintenance activities. The Corps will also seek opportunities to partner and cost-share projects with interested parties through existing federal authorities. Stakeholder outreach and public coordination is critical in aligning the need for maintaining the 43-foot channel with the beneficial use of material.

Strategic Shoreline Placement from Coast to Coast: Comparing the Kings Bay Entrance Channel, Florida and Georgia with the Columbia River, Oregon and Washington

by

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The US Army Corps of Engineers commonly places sediments dredged from federally authorized navigational channels along coastal and riverine shorelines during routine operation and maintenance (O&M). Comparisons can be drawn when reviewing strategic placement along coastal and riverine shorelines. On the east coast, O&M sediments from Kings Bay Entrance Channel (KBEC), Nassau County FL and Camden County GA are placed by agreement along the shoreline to protect historical sites, reduce renourishment intervals for federal shore protection projects and to mitigate down drift inlet impacts. The KBEC is maintained to -49’ mean lower low water with tidal ranges of 8’ and volumes from 50K-400K cubic yards (cy).

Sediments are placed at Fort Clinch State park or along a ~1.5-mile coast of Nassau County. Berms are constructed to 13’ with 1V:15H slopes seaward to MLW and 1V:25H slopes to the bottom. Shore face scarping is common, likely from winter construction when the beach is erosive. Longshore sediment transport is southward. The Columbia River is maintained to -48’ Columbia River Datum. Shoreline placement is a least cost option producing environmental and engineering benefits including pile dyke efficiency and creating habitat. Equilibrated shore face slopes average 1V:5H with 20’+ berm elevations and volumes from 350K-500K cy over island segments are typically less than one mile long. With river level change, scarping on the back berm occurs but is uncommon along the shore face. Islands in the lower Columbia River experience 6.5’ tidal range creating bi-directional flow along shore with preference downstream.

Sediments eroded from islands migrate as spits to back marshes or into the channel as sand waves. Sediment grain sizes are similar with a d50 range of 0.20 mm to 0.56 mm but the NW consists of volcanoclastics where quartz/carbonates dominate the SE. Beach construction techniques are similar where longitudinal dykes aid turbidity control.

Session B5 – Waterway Sustainability

Moderator, Emily Vuxton

Sustainable Management of the Upper Sea Scheldt, Self-Dredging: Tidal River Training and Nature Conservation Put in Practice

by

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The Upper Sea Scheldt is a tidal river in Flanders Belgium, with important navigation and nature functions. Conflicts arose between river maintenance to preserve the navigation function, and nature conservation. Up to 2016, dredging was executed on an ad hoc basis, based on visual inspections, indications of bottom contacts from skippers. Sand mining was allowed outside the navigation channel, with questionable impact on tidal nature.

Cooperation between the waterway manager, skippers and nature agencies led to the drafting of a maintenance plan, separating a maintained navigation channel from tidal nature areas. Sand mining is allowed only in the navigation channel.

Some river training methods are also tested in selected areas, investigating the potential of a 'self-dredging' river. In two inner bends sediments are relocated to the outer bend to reshape the section to slow down deposition in the inner bend. Willow mattresses and geotextile containers are used to retain the disposed sediment in two pilots. A third pilot project concerns the dredging of a riffle, with deposition in an adjacent low velocity lee, to incite the development of a shoal, but also to reduce the section and favour erosion in the dredged area. Government and the Rhone's territories and local authorities, allowing economic and tourism development in connection with the river.

Based on these requirements, CNR designed and built two double ship locks on Chautagne and Belley hydroelectric facilities. These navigation infrastructures, commissioned in 2010, are now operated and maintained by CNR.

The site of Chautagne ship lock is included in a particularly rich and diversified environment, enjoying preservation status under Natura 2000 and a Biotope Protection Order which underlines the very high biodiversity of this section, which is also an important constraint and a major challenge for the creation of a new navigation structure.

Considering these environmental issues, CNR has designed and built a navigation structure that is fully integrated into this sensitive natural environment. The 18-metre drop can be crossed by two locks (10 m and 8 m) linked by an ecological pound, integrating aquatic and wet habitats of high qualities for breeding, feeding and development of particularly rich fauna and flora.

During the 2 years of construction, CNR and contractors took account of this environment on a day-to-day basis, so as to ensure that the ecological stakes present throughout the construction period were preserved. Ecological monitoring after work has shown very good functionalities with respect to birds, batrachians, invertebrates and fishes. Beaver is also present on the pound for its feeding. Beyond the

ecological treatment of the pound, the development of the surrounding areas had also integrated the consideration of the vulnerability of the habitats and reinforced the ecological interest of the site by creating new natural environments complementary to those pre-existing.

Sustainability and Resilience Analysis: Methodology to Reduce Service Vulnerability on Inland Waterways

by

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Recently, the qualities of 'sustainability' and 'resilience' have become project objectives in the development process for new transportation facilities. These qualities are also important aspirations for facility rehabilitation activities. With climate change and the increasing number of extreme weather events and other disruptions, inland waterway infrastructure and its daily operation face both sustainability and resilience challenges for maintaining navigational functionality and transport services. Waterway infrastructure owners must ensure that their facilities continue to perform adequately whether subjected to long-term impacts (e.g. flooding vs. drought conditions or extreme temperatures) or high-impact short-term events (e.g. tornadoes or unscheduled lock outages).

Changing weather conditions can not only cause catastrophic destruction to facilities, but they also may increase the costs of maintenance and facility rehabilitation overtime. A major concern for new built assets is that it must be planned and constructed without knowing what design specifications will be adequate to address tomorrow's hazards. These hazards may cause progressive deterioration of facilities or abrupt failures resulting in service disruptions. Climate change creates both long and short-term risks of failure.

On top of the yearly bathymetric surveys, the pilot areas are closely monitored (bathymetry, current, benthic development) to evaluate success, and draw lessons for future projects.

The presentation is focusing on the design principles of the channel, the installation techniques used in the pilot areas, the results of the monitoring and first conclusions on effect of the maintenance operations on preservation of the navigation channel and nature restoration, and the potential of future use of the training techniques.

City-Wide Green Stormwater Infrastructure Sizing, Siting and Cost-Effectiveness Analysis

by

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Green infrastructure is becoming an increasingly important strategy for managing urban wet weather given its potential cost efficiencies and social benefits. However, sewershed or watershed hydrologic models do not align with the scale and decision context for green infrastructure, making project prioritisation and site selection particularly challenging. Using several land use representations, proximity to the right of way, and site topography, we identify approximately 130,000 feasible locations of green roofs, rain gardens, downspout disconnects, and pervious pavement for all parcels in the City of Pittsburgh, PA.

We then estimate the installation cost, reduced run-off, and thus cost effectiveness (in dollars per volume reduced) for each installation. The results of the green infrastructure project site identification and cost effectiveness analysis are published openly in the format of an interactive map at:

http://sb.ucsur.pitt.edu/green-infrastructure, where projects resources (including model results) can be freely explored and downloaded.

We then demonstrate how models aligned with the scale of green infrastructure projects could be integrated with geographically broader sewershed (or watershed) models by leveraging runoff (or inflow) as a common output from both models. In doing so, we propose an approach that can jointly model the costs of gray and green infrastructure in a manner that minimises the total cost of wet weather management solutions. Attendees will learn how to utilise publicly available geographic data to estimate feasible green infrastructure project locations and how to jointly model the estimated costs of green and gray infrastructure strategies. Attendees will also be encouraged to explore the project results mapped at the project website.

French Upper Rhone River Chautagne's Double Navigation Ship Lock: An Essential Ecological Integration

by

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Compagnie Nationale du Rhone (CNR), as a concession holder for the Rhone River, is responsible for the production of hydroelectricity, navigation and agriculture since 1934 on a 550-km long river line, extending from the Alps (Swiss border) to the Mediterranean Sea in the south of France.

The development of boating on the French upper Rhone is a strong ambition of the precipitation, then as rainfall intensity increases overtime, actions will be needed to ensure that waterborne transport can be sustained during high water and flooding. On the other hand, if a lock is damaged by a vessel strike, then the resilience of the facility and its operators will be challenged.

Today's rapidly changing business and unstable environmental conditions demand new planning and engineering design practices for infrastructure construction and maintenance that recognise the risk. Risk analyses can be used to characterise infrastructure vulnerabilities as either long-term, short-termed, or some combination.

Long-term concerns require a sustainability-centric strategy to address and respond to shifting long-term environmental or social conditions. Short-term system shocks need a resilience-centric strategy to meet the immediate concerns caused by the disruption and guide necessary actions to respond and recover navigational service. Advanced planning for meeting climate change or other hazards to navigation services will require identifying mitigation and adaptive measures for countering hazards and system vulnerabilities. Such preparations for inland waterway navigation are essential to the user community's business continuity plans.

Session B6 – Environment
Moderator, Leah Dundon

Marine and Inland Waterborne Transportation System Resiliency: Status and Needs

by

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Waterborne transportation systems are inherently vulnerable to a range of environmental and human-related hazards and constraints, and can impact local and national economies, environments, as well as safety and security. Approaches to reduce disruptions to this system and increase speed of recovery are of keen interest to waterway owners, operators, and other beneficiaries. The concept of resilience recognises that short- and long-term disruptions can be partially addressed through proactive planning, mitigation, and adaptation. Resilience of the waterborne transport system means continuing an

acceptable level of operation with minimal disruption in service through short- and long-term environmental and human-related disturbances.

Increasing resilience of a particular system can be achieved in many ways depending on the scale of the component or system and focus. Many maritime and inland waterborne transportation systems have activities to increase resilience, but these vary widely in scope, intent, and outcomes. In May 2016, PIANC initiated Task Group (TG) 193 to summarise international knowledge and provide recommendations for advancing the concept of resilience of marine and inland waterborne transportation system. This presentation will summarise findings of PIANC TG 193, presenting state-of-knowledge for resilience of the waterborne transport system and synthesising gaps in data, understanding, and applications.

Natural Infrastructure: Take Me to the River

by

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People often forget that Manhattan is an island, mostly because of its extraordinary network of subways, trains, bridges, and roads. But when hard, man-made infrastructure is no longer available, whether due to extreme weather events or a terrorist attack, waterborne transportation becomes a necessity, and intrinsically more valuable.

As climate change increases the frequency and intensity of extreme weather events and as sea levels rise, cities must be prepared to adapt efficiently and embrace nature as the most resilient infrastructure of our communities. Ferries, public and private, as a mode of transportation, have proven to relieve the need for transportation by hard infrastructure when needed.

This presentation will explore how New York City and the surrounding metropolitan area have employed watercraft during times of emergency, including the repercussions from Hurricane Sandy in 2012 and the September 11, 2001 attack.

Connecting the Public to Big Data with Storytelling

by

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The U.S. Army Corps of Engineers faces many challenges now and into the future that require user experience solutions to integrate Navigation Data Center (NDC) legacy systems into open, accessible, and visually compelling websites. Attendees will learn how NDC developed a communications strategy with storytelling mechanisms utilising visual design. In addition, NDC established a distinct and aspirational voice through performance goals on the open data platform Socrata, social media, and an alternative to the American Forces Public Information Management System prototype website.

By designing and structuring the NDC website for desktop, tablet, and smartphone users, the previously difficult to locate data became readily available for internal and external users. The story of NDC integrating legacy systems to create engaging and relevant government data lays the groundwork for future partnerships with the public in challenge and prize community opportunities.

Waterborne Transport, Ports and Waterways: A review of Climate Change Drivers, Impacts, Responses and Mitigation

by

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The original PIANC TG3 Climate Change and Navigation Report (2012) was based on the Intergovernmental Panel on Climate Change IPCC 4th Assessment report (AR4). This paper presents a summary of the new Updated PIANC report which incorporates the assumptions, definitions and findings of the IPCC 5th assessment report (AR5).

Projections for 2100 suggest a global mean sea level rise of 0.4 to 0.8 m and a greater frequency and intensity of extreme weather events. Even if emissions of greenhouse gases (especially carbon dioxide CO_2) stop today, these changes would continue for many decades and in the case of the sea level for centuries.

This paper summarises the expected climate change impacts on maritime and inland navigation including sea level rise, wind conditions, wave action, tidal and surge propagation and range, ocean circulation, storms, coastal hydrodynamics, sea chemistry, environmentally protected areas, ice conditions, icing, water supply and quality in inland rivers, extreme hydrological conditions, and coastal, estuarine and river morphology. Potential adaptation and mitigation responses are identified.

Navigation contributions to greenhouse gas (GHG) emissions are discussed, along with opportunities for navigation to contribute both to overall decreases in anthropogenic GHG, and, through use of alternative fuels, to decreases in other pollutants.

Session B7 – Environment

Moderator, Ali Mitchell

Smarter River Management With Natural Decadal Climate Variability (Not Climate Change)

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An important emerging area of atmospheric research is the study of natural global oceanic/atmospheric processes that persist for many years to decades. These physical processes are referred to as Decadal Climate Variability (DCV) and like the better known seasonal process known as El Nino/Southern Oscillation (ENSO) are naturally occurring and are not to be confused with anthropogenic climate change.

The relevance for participants in the Smart River Communities of Practice is that these drivers can potentially provide valuable information for managing economic, social and environmental risk and also help identify conditions that will increase the chances of achieving success with riverine investments and activities vulnerable to drought or flood.

This presentation will describe how DCV processes have been observed to affect the Mississippi and Missouri River Systems water volumes. Secondly, it will describe recent research that has estimated the value of DCV information for reducing economic, environmental and social risks and capitalising on opportunities in the Missouri River system. Finally, the presentation will describe current research underway at the U.S. Army Corps of Engineers Institute for Water Resources and a NOAA Sectoral Applications and Research Programme funded project led by Dr. Vikram Mehta of the Centre for Research on the Changing Earth System that is exploring the potential value DCV information reducing transportation and river transportation infrastructure budgeting, operations and maintenance risks on the Mississippi River.

This presentation is of interest to a wide range of individuals. Examples include the members of the agricultural, financial, public sector, urban, river transportation, river infrastructure management and disaster management sectors.

The preceding list is not comprehensive but only provided to illustrate a sense of the relevance this information can have for all individuals interested in Smart River issues.

Asian Carp Establishment in the Great Lakes: Challenges with Evaluating the Full Impacts

by

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Invasive species can potentially wreak havoc on the natural environments resources and hinder the nation's navigation system. In the Mississippi River System, for example, Asian carp have quickly become the dominant fish species as they do not have natural predators, grow quickly, reproduce at high rates, and adversely affect the biomass of resident fish species. In addition to disrupting the aquatic ecosystem, Asian carp cause problems to users of the river system given their considerable size and distinctive jumping behaviour.

Over the past several years, this invader has multiplied and migrated significantly along the river system. Many of the options to limit their progression are extremely costly and/or difficult to implement. When evaluating control alternatives, decision makers have to consider criteria such as the economic and environmental consequences of Asian carp gaining a foothold in the Great Lakes. However, uncertainty about the types and extent of ecological changes plus the possibility that 5 Lakes and over 5,000 tributaries could be affected, make it difficult to develop a comprehensive and defensible estimate of their full economic impacts.

As the concept of 'ecosystem services' continues to grow in the US, economists have been linking ecosystem changes to economic changes. This process is delineated into several additional components, including but not limited to: ecological change (e.g., effects on food web) and the magnitude of change (e.g. declining fish populations); array and magnitude of ecosystem uses (commercial and recreational); factors influencing uses (e.g. catch rates); and how economic values and activity are affected. The Corps of Engineers' Great Lakes and Mississippi River Interbasin Study –

Brandon Road Report highlights this complex but often-overlooked interplay along with the many challenges of capturing the full economic impacts. The lessons learnt from this study can also be applied to other invasive impact studies on navigable river systems.

River Restoration Combined with Climate Adaptation in Denmark

by

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Old water mills and hydroelectric power plants are often an obstacle for restoration of free passage for fish and fauna in streams and rivers (connectivity). In these years much work is going on to remove obstructions and establish fauna passages in streams and rivers. In this connection, it is sometimes found that the fish and fauna in rivers and streams have 'low' priority and there is not sufficient focus on both upstream and downstream passage.

In very few cases fish and fauna passage is ensured by fully removing obstructions and barriers, and it is instead sought ensured with 'technical solutions'. Furthermore, the solutions are often only for strong swimmers, such as salmon and trout. It is important at an early stage in the process to achieve clarity of which requirements the given fish and fauna in the stream have to the passage.

In this way it can be avoided working with solutions that do not provide the desired results, which eventually may have to be changed. The construction of fish and fauna passages has been done in the last 20-30 years in Denmark with a variety of different solutions. Therefore, considerable experience in the functionality and effects of these different solutions has been gained. Moreover, knowledge has been achieved about which solutions function optimally in relation to the actual purpose of the passage to ensure a completely free passage for the respective species of fish in both up- and downstream directions of the dam in the stream.

For the last 10 years climate adaptation has been implemented in river restoration projects in Denmark. Typically, low areas along the rivers are used as reservoirs to store water in case of cloudburst. These low areas are integrated in the projects as an asset for recreation for people and for biodiversity.

Inundation impacts of Local Sea Level Rise on the Lower Columbia River Estuary

by

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The Adaptive Hydraulics (AdH) numerical code was applied to investigate the effects of local sea level rise (LSLR) on the inundation and subsequent wetland impacts in the Columbia River Estuary. Three National Oceanic and Atmospheric Administration determined LSLR scenarios (low. medium and high) were simulated. It was found that the lower coastal wetlands are impacted the most by the LSLR in terms of wetland and beach loss; it was also found that the increased inundation might be beneficial to juvenile salmon migration.

Session B8 – Technology Improvements
Moderator, Fred Joers

Systems Analysis of the Behaviour and Economic Impacts from the McClellan-Kerr Arkansas River Navigation System

by

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The inland waterway transportation system, an integrated part of society, economy, and the environment, provides a variety of ancillary benefits including flood protection, power generation, recreation, water supply, and habitats for fish and wildlife. The system, however, is vulnerable to natural disruptions, system component failures, and man-made attacks. Consequently, it is important to understand inland waterway transportation system behaviours to reduce associated risks and mitigate economic losses. It is challenging to study the behaviour and economic impacts of the inland waterway transportation system due to high degrees of complexity and uncertainty.

Therefore, comprehensive modelling techniques are required to accurately represent the complex relationships among system components and how these relationships influence economic impacts. In this presentation, we present the maritime transportation simulation decision support tool (MarTranS) that integrates agent-based modelling, discrete-event simulation and system dynamics along with a multiregional input-output model is developed to better understand the relationships between inland waterway transportation system components and economic impact factors.

To demonstrate these relationships through our model, the McClellan-Kerr Arkansas River Navigation System is presented as the case study region. MarTranS is generalisable to any inland waterway transportation system to enable maritime transportation stakeholders to better allocate investment budgets and increase economic benefits.

Robust Snapshot Positioning in Multi-Antenna Systems for Inland Water Applications

by

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Global Navigation Satellite Systems (GNSS) are increasingly used as the main source of Positioning, Navigation and Timing (PNT) information for inland water navigation.

Therefore, it becomes of crucial importance to ensure reliability and accuracy of the GNSS-based navigation solution for challenging inland waterway environments like locks or bridges where effects such as multipath and non-line-of-sight (NLOS) can occur. This work extends the single-antenna snapshot positioning solver to a multi-antenna snapshot positioning and orientation solver. In contrast to a single position calculation for each individual antenna, this combined approach allows position and orientation calculation even in the case that each antenna has less than four observations. Any additional observation can be used in a robust estimation framework, for instance by applying the S-estimator, to lessen the impact of NLOS effects.

Moreover, different weighting options for the satellite signals are considered where the elevation angle of the satellites, as well as the signal-to-noise ratio measured by the receiver, is taken into account.

The presented scheme is evaluated using real measurement data from an inland water scenario with multiple bridges and a waterway lock. With regard to single-antenna algorithms the initial results are encouraging and clearly indicate the advantage of the combined position and orientation calculation with multiple GNSS antennas, especially in scenarios where direct GNSS signals are obstructed. Also, the multi-antenna scheme in combination with a robust estimation framework shows the potential to be used in advanced driver assistance systems for integrated navigation as well as autonomous shipping.

Electronic Nautical Chart (ENC) Adaption in Pilot's Display in Order to Optimise River Navigation Safety and Efficiency

by

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In the era of technology, IT and big data, hydrographic services worldwide have made many improvements on the Electronic Nautical Charts (ENCs) display. However, the more detailed features that ENCs can offer, the bigger challenges an e-Piloting solution provider comes to face. The challenge is to keep balance between the intuitiveness to use of a piloting system and the proper display of the ENC features. Particularly in river piloting jobs that a pilot has to manoeuvre a vessel along long and narrow waterway. The pilot would need to see enough chart details around the current position of the vessel, in the meantime, he/she needs a good overview along the route further distance away for obtaining good situational awareness. In SafePilot, we have improved our ENC adaptation in Pilot's display to optimise navigation safety and efficiency.

Low Head Hydro Power: A UK Perspective

by

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This presentation will look at the new opportunities for generating hydroelectricity at low head hydro sites alongside existing navigation structures. It will present details of the latest developments in the UK using Archimedean Screws, turbines and embedded grid generation.

The relationship between hydro developers and navigation authorities will be considered especially the need to maintain navigational levels being a priority as against maximising energy output. The issues associated with the economic sustainability of hydro plants utilising environmental subsidies will be examined and compared with other sources of green energy such as wind power and photo voltaic.

The very positive impact on, and the improvements in bio-diversity in rivers previously blocked to fish migration, will be discussed giving examples of fish pass developments in the UK. The obvious benefits in the reduction of CO_2 emissions and the financial benefits of being fully sustainable in terms of producing electricity will be discussed. Reference will be made to the types of environmental control imposed upon proposed developments including water abstraction /impoundment licensing, planning and heritage protection by the UK regulatory authorities.

The challenges faced over the last five years of hydro development will be reviewed as well as the lessons learnt in the process. Reference will be made to a number of completed sites and examine the additional benefits that have arisen from allowing the development and operation of low head hydro electricity generation.

The current need to deal with cyber security will also be examined.

Track C

Session C1 – Inland Waterway Transport

Moderator, Juergen Trögl

The Rhone Traffic Management Centre: 6 Years of Feedback

by

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The Compagnie Nationale du Rhone (CNR) designed and now operates the hydroelectricity power stations, barrages and locks on the Rhone.

Downstream of Lyon, CNR has developed 330 km of waterway, from the confluence of the Rhone and the Saone down to the Barcarin and Port-Saint-Louis locks. This waterway comprises 14 locks for crossing the hydroelectricity power stations. The drop-in level between Lyon and the sea is 162 m and the drop of the locks ranges from 6.70 m to 23 m.

Since 2010, the operating and monitoring of the 14 locks have been carried out remotely 24/7, from the Rhone traffic management centre based in Chateauneuf-du- Rhone (150 km south of Lyon). From this control centre, the management of river traffic is optimised, the safety of the lockage operations is reinforced, the traceability of transport is ensured and the level of service to navigators is improved.

In 2016, CNR put in place an AIS (Automatic Identification System) on the Rhone. All AIS datas are recovered on the CNR information system with several objectives:

1. To improve the efficiency of the navigation management by perfect knowledge of the traffic on Rhone.
2. To reinforce the security of people by better knowledge of the exact position of boats at any moment.

The AIS data transmitted are used in the Rhone traffic management application (GTR) and allow the exact positioning and calculation (from position, speed and course data) of the estimated arrival times of boats at the locks. This significantly improves the management and the prioritisation of the lockage operations to be carried out.

At the Rhone traffic management centre, 36 technicians work in shift works. During the daytime, 7 technicians are on duty: the room manager and 6 operation officers. Each control workstation allows each operator to monitor and to operate any of the 14 locks.

The room manager allocates to the operators the locks to be managed. He has a complete view of all the boats present on the Rhone, with for each one: the location, size, load, speed and estimated time of arrival at the lock. These factors facilitate the real-time dispatching of the locks to the operators on duty, based on the lockage operations to be carried out.

Once a lockage operation has been completed, the room manager can recover the lock on his workstation, put it under surveillance and allocate a new lock (the one with the boat closest to it) to any available operator. A better quality of service is provided to navigators, in particular during peak traffic periods but also in the event of under-staffing at the management centre. Since summer 2016, we have had to manage various under-staffing situations (absence due to sickness, strike etc.). The AIS system together with the possibility of dispatching any lock to any workstation have allowed the negative impact of this situation on the service provided to navigators to be limited (the waiting times normally encountered at locks in such cases have been partially eliminated). Outside the summer period (traffic peak with 14 locks to be operated simultaneously), the traffic management on the Rhone can be carried out, in degraded mode, by 70 % of the workforce without disrupting the service provided to navigators.

Sulina Channel – Danube European Waterway Link to Black Sea

by

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Sulina Channel (73 km long) ensures ship traffic between the Black Sea and the Danube maritime ports of Tulcea, Galati and Braila in Romania plus the European Corridor 7 Rhine-Main-Danube inland ports having a navigable depth of 24' (7.32 m). The Channel is also the main communication link for the local population in the region. Sulina Channel divides the Danube Delta in two almost equal parts. The Danube Delta is a national reserve protected by law, a World Heritage Site and in 1992 recognised as a Biosphere Reserve by UNESCO. It consists of wetlands, rivers, lakes, reed swamps,meadows, sand dunes and forests and is a rich economic resource for fish, timber and reed.

The development of navigation, the action of waves, currents, massive ice flows and winds that have occurred in time, have intensified the erosion processes of the channel's banks and the partial destruction of the land strip between the channel and the existing enclosure dykes for the protection of adjacent localities, forests, fish farms and agricultural arrangements.

In the last decade based on technical, economic and environmental justification a lot of hydrotechnical works have been performed in order to improve navigation conditions for up to 25,000 DWT partly loaded vessels till a max. draught of 7 metres.

Maintaining the fragile balance between influx of water and sediment by Sulina Channel to the Danube Delta demand an adequately designed bank protection and inlet points. Also, the sedimentation in the entrance channel through Sulina Bar has to be evaluated. The paper will present some historical facts about navigation starting on Sulina Channel with the inaugaration of CED (Danube European Comission 1856 Sir Charley A. Hartley) and will continue with the actual vision of designing banks protections and rehabilitation works on the sectors of Sulina Channel for the final stage as well as other needed river works to achieve overall safe navigation and environmental benefits of Sulina Channel within the next years.

The design philosophy was connected with environmental impact assessment, physical analysis, present embankments hydraulic verifications and morphological modelling.

Technical solutions to repair/rehabilitate the existing quays structures for passenger vessels along the Sulina Channel will also be presented.

Assistance Systems for Close Range Navigation on Inland Waterways

by

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Navigating within limited space is a common situation for inland vessels. While mooring or when entering a lock, the ship has to be guided with a tolerance of some decimetres or even centimetres. To support the skipper in these situations driver assistance functions are developed in the research project LAESSI in Germany. Basis for the functions is a GNSS based high precision position and heading solution. As

a malfunction of the GNSS solution is critical when operating in confined waters, special attention is put on monitoring of the integrity of the GNSS results. Correction data are checked for their integrity before they are sent out. On board of the vessel, integrity checks of the GNSS measurements are well as with additional sensors are performed. Correction data are transmitted by a new service based on AIS-VDES from the shore to the vessel.

Based on the integrity checked GNSS measurements a mooring assistant is developed. On the one hand distances between the hull of the vessel and contours of the chart are computed. On the other hand, the system is equipped with a laser scanner for monitoring the close neighbourhood of the vessel. Another assistance function is a conning display, supporting the skipper during manoeuvres, e.g. when turning the vessel in harbour basins or waiting in front of a look with very low velocities.

GNSS results will also be the basis for automatic guidance of the vessel along a given track on canals and other narrow waterways.

Finally, the height of the vessel is monitored to check for a save passage of the bridges on the waterway. The presentation will give first results of the implementation of these functions and show data from practical trial on board of vessels.

Linking Modal Shift to Inland Ports

by

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There has been considerable interest in developing container on barge services in the United States. Several containers on barge services have been attempted within the United States, but with various degrees of success. The role of inland navigation and the importance of ports to attract and retain cargos remain remains just as important to supporting these services.

This presentation will seek to identify some of the common elements that have been shown to be successful in developing inland navigation services, while also identifying possible cargos that could be divertible to inland waterways, with a focus on divertible/containerisable and oversized/overweight cargos. The presentation will examine the relative costs of moving various cargos through the United States, including discussions on inventory carrying costs and other related supply chain considerations. At the same time, the presentation will review what types of cargos could potentially be attractive to waterways, based on linkages to global and/or specific domestic markets.

Finally, the study will discuss the role of inland ports in approaching governments, shippers/carriers to understand the relative benefits of waterway traffic.

This final point, that decision makers may not understand the commitment required to support modal shifts to waterways, should reflect such these commitments require a long-term view concerning the role of the port, and its related cargos, as they may potentially benefit their local communities. Oftentimes, these decisions are treated as simply a ‘quick fix’, so focusing on what has worked, and not worked, in the past should provide some areas of discussion when examining the potential for the nation’s waterways.

Session C2 – Latin American Waterways
Moderator, Ron Coles

Extreme Increase in Water Levels. Effects on the Paraguay – Paranã Inland Waterway

by

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Towards the end of 2015, and as a consequence of the 'El Nino' phenomenon, the effects of high precipitations in the south region of South America began to be noticed. Hydrometric levels registered in the Parana River surpassed by far the alert and evacuation values.

The consequences were highly significant on different aspects of the Paraguay-Parana Waterway: the aids to navigation facilities and the channel depth were highly threatened. The high water level brought a high volume of suspended vegetation, which cause severe damage to buoys and beacons. An important number of them were displaced, even lost. The extreme water levels also generated a high sedimentation rate, which reached its peak when the water levels started to descend; additional dredgers were needed (specially brought to mitigate the situation).

As a consequence, an emergency program was developed. It allowed to regularise and reset the aids to navigation facilities and to guarantee the required channel depth.

Multiple buoys and beaconing elements had to be re-installed, which entailed a significant use of buoy tenders and other support vessels as well as an outstanding work by the dredging team.

The auditorium will find out the key factors/steps that helped to sort out this extreme and severe situation:

- Predict the event, based on reliable forecast service
- Planning the equipment and AtoN facilities requirement in advance
- Establish a crisis committee, consisting of the IW National Authorities, skippers, the concession holder
- company and the Coast Guard
- Consult emergency response documents / guidelines

These key factors allowed guaranteeing the navigability in such extreme conditions. The Paraguay-Parana Inland Waterway is very important for the national and international trade, and hasn't suffered from traffic interruptions during this extraordinary and severe phenomenon which, even worse, coincided in time with the harvest season.

Inland Waterways Master Plan for Colombia

by

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Colombia has 18,000 km of rivers, of which 6,500 km are navigable. At the time of the study, Colombia mobilised 3.4 MTY (1.8 % of the national total) per waterways, mainly through the Magdalena and Leon rivers, with a projection of 5 to 20 MTY by 2035. The transportation of passengers was of 3.7 million people per year, mainly through Magdalena, Cauca, Sinu, Leon, Putumayo and Caguan rivers, with an estimated of 4.5 million people per year by 2035.

The Fluvial Master Plan – FMP – of Colombia was developed with the purpose of making the fluvial transport more competitive, sustainable, safe and social within a plan for the next 20 years, taking into account several key components: river infrastructure and connection with other modes of transport, institutional ordering, operational regulation, promotion and financing.

The FMP approach to cargo and passenger river transport focused on commercial interest and social interest. Commercial interest rivers were selected according to the following criteria: navigation of vessels of more than 25 tonnes, transport volume by 2035 of more than 50,000 tonnes per year and existence of an intermodal connection.

Social interest rivers were selected according to the following criteria: waterway with public transport, transport volume estimated by 2035 of more than 50,000 passengers per year and integration of isolated and remote territories. In addition, navigation was considered in reservoirs and lakes that met the criteria.

The recommendations of the study proposed a set of projects for the improvement of the infrastructure for the waterways transportation. The estimated final value of all FMP projects was estimated at US $ 3 billion. The project categories are: (i) connection of remote state capitals removing bad crossings; (ii) connection of rivers with second- and third-class roads, (iii) connection between watersheds; and (iv) tourist circuits.

The Human Factor Relevance in the Decision Making Process for Manoeuvring a Vessel when Navigating in Inland Waters

by

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The reduction of costs in maritime transport has imposed the construction of ships larger than those initially established for the ports, causing modification of its operational parameters. Any modification to be authorised by the Competent Authority demands several technical studies of navigation and manoeuvre under various conditions and scenarios. However, they do not usually consider the time needed in the decision making process by whoever manoeuvres the ship. It is necessary to take in mind that restricted water navigation is a complex navigation that imposes fast and correct decisions to the pilot or to the Captain, which explicitly represent the Human Factor in the success of the manoeuvres. By means of Monte Carlo simulation, the critical reaction time to maintain the vessel within the navigation channel can be estimated, considering the rudder angle variations used for the normally used speed ranges. On the other hand, the reaction times of the person who navigates and usually perform manoeuvres in the port area can also be estimated by interviewing harbour pilots.

Usually aids to navigation tools and key navigational points along sea coasts, channels and harbour and also river entrances contribute to the better perception of the scenario and greater awareness of the real situation. However, such features do not enter into autopilot simulations. Herein we consider that a comparative analysis of simulations using an autopilot and a critical analysis of that simulations conducted by different pilots may introduce the person feeling. This analysis will allow us to establish a criterion to introduce the human reaction time in the manoeuvres of a ship navigating in a channel (or harbour). So, the relevance of this study is the introduction of the Human Factor in the operational limits of ports, contributing to the safety of navigation.

Taming the Magdalena River: How a State-of-the-Art Model Can Take Common River Engineering Practices to the Next Level

by

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For a long time already, the governmental manager of the Magdalena River in Colombia (CORMAGDALENA) has shown interest in upgrading the Magdalena River to a key fluvial transport artery, by recovering navigability and subsequently reducing land transport freight costs. In 2014, CORMAGDALENA awarded a 13-year concession to NAVELENA to restore and maintain the navigability along the 908 km long stretch between Puerto Salgar and the mouth at Barranquilla, through a combination of dredging and river training works.

IMDC offered technical assistance to NAVELENA, including evaluating existing studies, reviewing the design documents, and executing specific inspections, e.g. of dredging equipment or geotextile manufactories. Also, a 2-D hydrodynamic and sediment transport model was developed in the TELEMAC software. The presentation will focus on how the model proved to be a valuable tool for many aspects in the engineering process.

A first application of the model was in the functional design of the river training works. While this design was based on empirical formulae, offering a good starting point for the layout of the training works, the 2-D model provided complementary results enabling a more thorough optimisation. Secondly, the results were used in identifying which spur dikes are sensitive to scour. The model results provided a clearer view on the governing flow over and around a structure, decreasing the uncertainty in the scour depth estimations. In a next step, a scour monitoring plan could be drafted.

Results were applied in analysing the workability in the river, helping the contractor in the phasing of the works. Furthermore, 2-D flow fields could be used as input for fast-time navigation simulations (SHIPMA software) to assess navigation conditions. In conclusion, the presentation shows how a 2-D model can extend – not replace – common river engineering practices, especially in a complex and braided system as is the Magdalena River.

Session C3 – Latin American Waterways
Moderator, Pablo Arecco

Incidence of the New Bridge Construction over the Magdalena River in Barranquilla, Colombia, on the Hydraulic Conditions

by

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The objective was evaluating the influence of the new bridge construction on the river hydraulics near the crossing. New bridge will be located parallel to the existing bridge. Magdalena River is 1,150 m wide at the crossing and its mean stream flow is 7,200 m^3/sec.

The current bridge is characterized by having piles arranged in pairs with 2.5 m diameter each and 5 m diameter for the central piers; these are 140 m apart and define the navigable channel. The new bridge is much larger, with a span of 380 m between central piers, each one supported on a dice with 20 piles of 2.8 m diameter.

On the other hand, there are temporary jetties used for the construction of the new bridge, next to the main piers. These are platforms supported on piles of 0.9 m separated each 5 m; they leave from the river banks and from the island located in the middle of the river.

The above-mentioned structures represent 189 piers and piles that are close to the navigable channel. As this condition will be maintained for approximately 3 years, it was considered important to carry out an assessment of the influence of all structures on the river hydraulics.

Hydraulic parameters were evaluated for the most critical condition, which is the simultaneous presence of the old bridge, the new bridge and the jetties. HEC RAS modelling allowed to analyse the different situations to obtain water levels, velocities and scouring, to evaluate the incidence on the camp site, on the channel outlet from the water treatment plant at the left bank, on the grounds of a primary school at the right bank, and on the general layout of the roads near the approaches.

Adaptive Port Planning for a new Multipurpose Terminal on the Paraná River, Campana, Argentina

by

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The Paraná-Paraguay river system is an important inland waterway transport corridor with a significant amount of sea going vessels and inland barges navigating throughout stretches of more than 3,000 km. Consequently, there are numerous port complexes and terminals along the river banks, especially in the Argentine part of the Paraná waterway. The wet infrastructure of these port complexes and terminals is usually composed by jetties and quay walls, and occasionally with side or lateral basins. Whereas, the case included within this study presents all these components.

This case study refers to the planning, design and construction of a new multipurpose terminal located on the right bank of the Paraná de las Palmas river, near the city of Campana, 92 km north of Buenos Aires city. The development of this is new terminal responds to the needs of expansion for a private owned port complex which already has two operating terminals in the same region. However, due to the limited river front of the acquired plot for developing the new terminal, the creation of a lateral basin accessible for sea going vessels and inland barges has been planned and designed to maximise the

berthing positions. Consequently, it is becoming a very special case in the Parana River where most of the berths are placed along the river banks.

Furthermore, the planning and design of this new multipurpose terminal follows The Flexible Port [Taneja, 2013] approach for the very first time in South America, and especially for an inland terminal. Finally, and to conclude, this methodology allowed to create a robust Masterplan following the Adaptive Port Planning framework, and dealing with future uncertainties towards a sustainable growth.

Session C4 – InCom Working Groups

Moderator, Phillipe Rigo

PIANC Inland Navigation Commission: Presentation of New Working Groups

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The PIANC's Inland Navigation Commission (InCom) is currently composed of more than 20 active members, professionals involved in inland navigation activities in Europe, Americas and Asia. In the last two years, the number of active members has been increased substantially.

In October 2016, PIANC InCom organised with ANTAQ (Brasil) and ECLAC (UN) a workshop 'Inland Navigation and a More Sustainable Use of Natural Resources: Networks, Challenges and Opportunities for South America' during the Copedec Conference in Rio de Janeiro, Brazil. It was an important starting point for new discussions and projects in Latin America.

Based on that event PIANC and ECLAC have launched a specialised WG 'Development of a Proposal of Inland Waterway Classification for South America' with experts from USA, Europe, UN, and of course South American countries.

Why do we need such international WG?

In South America, there are several independent inland waterway systems, with different levels of development and varying navigation conditions, whose potential in terms of sustainable freight and passenger transport remains unexploited. A harmonised classification system for the region would bring direct and indirect benefits for policy makers as well the industry and the end users of the transport services.

In particular, this work is necessary to harmonize the functioning of services, information exchange and infrastructure. This includes updated and new (where non-are existing) national and regionally harmonised regulatory frameworks, harmonised methodologies and data management of inland shipping data, statistics and indicators.

The goal of the paper and the presentation is to present InCom activities and to introduce some new challenging Working Groups for which the audience will receive a complete overview, such as:

- WG 197: Small Hydropower Plant in Waterways
- WG 198: Saltwater Intrusion Mitigations and Technologies
- WG 199: Health Monitoring for Port and Waterway Structures (with MarCom)
- WG 201: Development of a Proposal of Inland Waterway Classification for South America
- WG XX: Multifunction of Inland Waterways – Social and Environmental Awareness of IW Managers (WG to be confirmed)

PIANC WG 173

by

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This presentation will discuss the conclusions and provide a summary of the PIANC WG 173 report. The aim and purpose of this report is to determine technological guidelines for design, fabrication, construction, operation and maintenance of both rolling gates and movable bridges. The focus of the report will be on mechanical and electrical design features of rolling gates and movable bridges. However, structural design features often overlap with mechanical design and will be discussed in the report as appropriate. Another primary objective of the Working Group is gathering the experiences of the Working Group members and providing lessons learned and best practice in the design and operation and maintenance for both rolling gates and movable bridges. These lessons learned are captured in the various chapters of the report.

All About Mitre Gates – PIANC Report No. 154 Overview

by

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Mitre gates are by far the most common navigation lock gate type in the world. They have a long and reliable history dating back to 15th century Italy and Leonardo Da Vinci. Despite good performance, there have been a number of problems which have plagued mitre gates leading to occasional failures. Since mitre gates are an essential component of lock operation, long-term successful operation of these gates isvery important to the reliability of the navigational system. Therefore, there is a critical need to identify these problems and provide improved designs and practices from around the world.

Matters investigated and reported on include mitre gate systems, components, design, materials, ancillary components, operations, and maintenance. Since the performance of a mitre gate is dependent on how it receives and transfers loads to the lock walls, a detailed look into various gate framing and support conditions is explored. Often operational problems arise at the top and bottom hinges where unintended loads or geometrical performance can lead to component and gate failure. Improved designs and best practices for these components are discussed. In addition to components, the materials used to construct the gate components can have a significant impact on performance and longevity.

Recent advances in bearing and composite materials have led the way to better performance self-lubricating hinges as well as corrosion-resistant and lighter gates made of fibre reinforced polymers (FRP). An overview of design practices and load conditions used across various PIANC member organisations is provided. There are many ancillary components attached to mitre gates such as seals that affect performance – many varieties are presented with recommendations. Finally, there are many operation and maintenance issues and practices that must be considered for a long successful operational life. Such issues include repair methods and structural health monitoring.

PIANC Working Group 192 – 'Developments in the Automation and Remote Operation of Locks and Bridges'

by

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Since the publication of the 2008 PIANC WG 96 report on the developments in the automation and remote operation of locks and bridges, technology has significantly advanced providing us with the mature and reliable state-of-the-art technologies we have today. Nowadays, an increasing number of Port and Waterway Authorities have implemented remote operation, or are planning this evolution through their strategic goals.

The activities and work of the PIANC Working Group 192 – 'Developments in the Automation and Remote Operation of Locks and Bridges', will be presented, giving an insight into recent developments and case studies from different countries covering automation and remote control of locks and movable bridges. The strategic, operational and technological constraints, requirements, evolutions and opportunities in remote operation of locks and bridges will be presented based on the 'Why/How/What' questions in order to build a business case around remote operation.

Some countries have not yet implemented remote operation, so the first part will be of interest as it will cover 'whether and why' they would start implementing automation and remote operation of their lock and bridge assets. An important topic relates to the 'Why' part of the presentation which covers vessel traffic and corridor management, presents user references by operators and skippers and provides an analysis of a strategic implementation. The 'how' and 'what' part of the presentation will include lessons learnt and best practices in this field. Technological developments, reliable and state-of-the-art electromechanical automation and control equipment, the organization of the total chain of command, human factor engineering, and safety requirements in remote operation of locks and bridges will also be covered.

Session C5 – Inland Waterway Transport

Moderator, Rich Lockwood

Potentials and Barriers of Inland Waterway Transport in the Baltic Sea Region

by

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Political supported measures for a sustainable future have received considerable attention within the European Union. A reduction of greenhouse gas emissions is fundamental for a sustainable future. One measure to reduce greenhouse gas emissions is to enhance the usage of eco-friendly transport modes in the supply chain. The integration of inland navigation in supply chains is a challenge which has been addressed by various ongoing projects and initiatives in continental Europe and in the Baltic Region. However, continental Europe and the Baltic region have distinct potentials and barriers concerning the use of inland navigation which have to be investigated.

The aim of this paper is to analyse potentials and barriers of inland waterway transport (IWT) in the Baltic Region in order to develop measures to increase the use of IWT in supply chains. In addition, differences and similarities in the Baltic Region and continental Europe will be investigated.

In order to investigate the potentials and barriers of inland waterway transport in the Baltic Region, after a literature review, qualitative interviews will be conducted from January to March 2017. The interview partners are political representatives and shipping companies from the Baltic Region. The research method follows the action research attempt with semi-structured questionnaires. Those questionnaires were developed by five European experts from politics, industry and R&D. Results of the study can be presented at the conference, since the data collection and analysis will be finalised in summer 2017.

Preliminary results suggest that an improvement and enhancement of infrastructure (e.g. ITS, River Information Services) and the consideration of ongoing trends (i.e. LNG as a fuel and synchromodality as a new transport concept) is needed to strengthen inland waterway transport in the Baltic Region. Moreover, the political cooperation between the Baltic Region and the rest of Europe and Russia is a crucial issue. Another barrier which was addressed of the experts is the awareness and knowledge of people about IWT: current logistics education does hardly include IWT.

Ohio River Basin Energy Commodity Trends

by

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Flowing roughly from northeast to southwest, the Ohio River in the eastern United States is an important marine transportation corridor for energy commodities, primarily coal. We used annual vessel trip records archived by the U.S. Army Corps of Engineers Waterborne Commerce Statistics Center to identify the coal tonnage flowing between reach-level Origin-Destination (OD) pairs during the years 2008 to 2015.

The distribution of total coal tonnage exchanged between OD pairs approximates a power law (or Zipf's law) distribution (where a few highly ranked pairs far exceed most others, followed by a long tail of the distribution). This distribution has been found to describe other natural phenomenon from word frequency to city sizes. OD pairs exchanging more than 250,000 tonnes of coal each year more closely follow this power law distribution.

Over $ 5 billion worth of coal shipments originated from the Ohio River in 2015, with many of the top 20 reach pairs by tonnage consisting of origin and destination reaches along the Ohio River. Mapping the size and variety of OD flows through time may reveal the impacts of national policies on regional and national coal commodity trade flows.

CoVadem: What you Don't Measure, you Won't Improve

by

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CoVadem connects and individual depth and performance observations and turns them into information serving a smarter IWT. IWT is constantly being challenged to improve both economic and environmental performance. From a hydrodynamic and operational perspective, a large improvement potential remains merely unused. A cooperation between 50+ ship owners, research institutes Deltares and MARIN, branche organisations and government allows for further exploitation of this potential: the CoVadem initiative.

This presentation gives an updated insight in the developments of the CoVadem initiative. CoVadem introduces a big data solution that will add significant value to both the (inland) shipping industry, fairway monitoring and maintenance as well as societal benefits.

Cooperatively sourced big data from a growing pool of vessels all over Europe (each vessel providing over 350 million measured values per year) is used to provide effective key performance indicators (KPI's) to judge actual performance and cater for the necessary metrics to analyse, interpret and decide upon improvement measures. With the right technical and organisational implementation a revolutionary basis is introduced that allows for effective, continuous and holistic improvement.

By using these data, individual ships gain access to actual and future river depth information. With this information, the ship operator is capable to optimise his voyage in terms of cargo, reliability and fuel economy. The first added value for ship owners is the provision of the maximum allowable loading

condition for a given route, in such a way that critical points on the route can be passed. Secondly, a performance application is implemented, giving skippers insight in their ship performance related to actual fairway conditions.

At the same time, benefits have been identified for other stakeholders. These include dredging companies, fairway authorities and water managers. The presentation will address these with results of Proof of Concept studies.

LNG, a New Fuel for Inland Waterway Transport – Unmet Expectations and Lessons Learnt

by

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Liquefied natural gas (LNG) is being promoted as an environmentally friendly fuel capable of playing a vital role in supporting innovation, sustainable development and competitiveness of inland waterway transport (IWT). In Europe, the European Union (EU) and national governments strongly support the introduction of this alternative fuel with legislative measures as well as financing of development and pilot projects. In 2015, the Central Commission for the Navigation of the Rhine (CCNR) created the regulatory framework necessary for establishing LNG as 'regular' fuel in IWT.

Experience gained with pilot projects and from the development of gas engines for inland waterway vessels shows that the environmental, climate and economic benefits associated with the use of LNG as fuel in inland navigation are much smaller than initially suggested. Regarding the reduction of air pollutants as well as those of greenhouse gases (GHG), benefits were overestimated, because important specificities of inland navigation were not taken into account. Promoters of LNG established too quickly an analogy with the maritime sector, which indeed has a very different environmental baseline.

As the use of LNG as fuel can 'at best' only marginally contribute to the reduction GHG emissions from IWT, the need for consistent public policies aiming at reduction of GHG emissions from IWT is growing. This presentation sets out to explain how LNG is being established as a fuel for IWT in Europe, to compare the initially suggested benefits with those derived in practice, and to draw lessons on how to keep IWT in the race for the greening of transport.

Session C6 – Waterway Transportation
Moderator, Jessica McIntyre

Water Depth Prediction for Optimizing the IWT Sector

by

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As a distribution country, the transportation sector is a crucial pillar for the Netherlands. The transport and transfer of goods covers about 10 % of our economy, with a yearly turnover of € 50 billion (CBS, 2015). About 35 % of the transport takes place over water. The ambition is to adapt the current modal split in favour of transport over water, since the expected cargo volumes (e.g. due to Maasvlakte 2) would lead to a congested road system. Therefore, it is needed to make better use of the waterway system and to make the transport over water more attractive, smarter and cleaner. The so-called CoVadem initiative aims to do so by gathering echo sounder data from inland vessels.

One of the projects we are working on in this context is developing and testing two information services for the benefit of IWT: (1) a water depth & bridge clearance predictor and (2) a fuel consumption monitor.

We do this in a joint project with shipping companies, research institutes MARIN and Deltares, ICT supplier Autena Marine, the Bureau for Telematics application in IWT, the branch organisation BLN Schuttevaer, the Delft University of Technology, and the waterway manager Rijkswaterstaat.

The applications will be used as additional tools in determining optimal navigation schemes and loading depths. More transported goods per trip and sailing more economically will be the result. During the presentation we will elaborate on the development of the water depth predictor. It is shown how we process and combine echo sounder data with a prediction system for water levels in the Rhine to determine water depths for the coming days.

Please note that the abstract/presentation by Mr van Wirdum will address the overall CoVadem initiative, of which this project is a part.

RAMS Analysis for the Next Generation of Waterways

by

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Pedro S. Vila

The aim of this paper is to evaluate how a design methodology based in RAMS analysis (Reliability, Availability, Maintainability, and Safety), commonly used in other land transport ITS (Traffic Information Systems) infrastructures design (railways, highways, ports), can also be applied to inland waterway RIS (River Information Systems) environment, taking profit of its holistic scope for dimensioning operation and maintenance procedures taking into account not only functional and operational requirement, but also construction and design constraints.

The analyses are based on the use of the International Standard for Electrical, Electronic and Programmable Electronic Safety related systems (IEC 61508) as framework for the fully risk based approach for determining SIL (Safety Integrity Level) (SIL) requirements for those functions that are involved in the safety of the operations or in the achievement of the availability targets. This international standard uses a systems engineering approach the safety lifecycle as a framework in order to structure requirements relating to specification, design, integration, operation, maintenance, modification and decommissioning of the specific system.

The complexity of RIS infrastructure, the huge amount of input and output signals, the wide variety of failure functions of system's components, the complexity of functions relating SIL and failure probability, the restrictions on design based on the safe failure fraction, safety specification for different elements and the control of system failures as well as the own probabilistic nature of waterborne transport makes the RAMS analysis quite unaffordable unless software based simulation tools were considered.

This paper shows the results of a sample application of Discrete Events type simulation tools for evaluating failure probabilities of waterway's systems, providing as a main conclusion an initial set of recommendations for evaluating the effectiveness of RAMS analyses for the functional and operational risk assessment of RIS through these tools.

Utilisation of Marine Highway 95 for Integrated Marine Transportation on the U.S. Atlantic Coast

by

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Running along the eastern seaboard of the United States for approximately 1,100 miles, the Atlantic Intracoastal Waterway (AIWW) is an example of a large-scale, federally maintained, marine

infrastructure project. It is also designated as Marine Highway 95 (M-95) by the Maritime Administration of the U.S. Department of Transportation (U.S. DOT). M-95 mirrors one of the most heavily congested U.S. transportation routes – Interstate 95 and connects three of the ten largest ports by cargo value in the U.S. In addition, five ports along the AIWW are currently pursuing harbour deepening projects including Hampton Roads, VA, Charleston, SC, Savannah, GA, Jacksonville, FL and Miami, FL to better accommodate larger vessels that are expected to arrive in larger numbers since the expansion of the Panama Canal. These ports are the exit ramps to the world. However, the AIWW is not typically maintained to its authorised width and depth which is limiting the possibility for full utilisation.

In their Beyond Traffic 2045 report, the U.S. DOT estimated that U.S. freight volume will increase by 45 % by 2040. Of this 45 %, they estimated that freight movement would increase by 43 % by road and 37 % by rail, but only 10 % by waterborne vessels, a mere 125 million tonnes. We believe there is an opportunity to move additional freight from road and rail and free those methods to move items that are more time dependent, and connect larger ports with existing smaller ports where there may be additional handling capacity through short sea shipping. By better planning and smart investments into existing marine highways today, we have an opportunity to create an integrated Marine Transportation System to maximise freight movement before we reach capacity on existing modes.

Red River Delta Waterway Modernisation (Vietnam), From Conception to Supervision: Feedback on 5 Years of Environmental, Social and Safety Supervision

by

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CNR (Compagnie Nationale du Rhone) is in charge of the design and supervision of the improvement and modernisation of the inland waterway on the Red River Delta (Vietnam). This project, led by the Project Management Unit (PMU) of the Vietnamese Ministry of Transport, is divided in 2 sections (Corridor 1 and Corridor 2) of 160 km each, linking for Corridor 1, the capital (Ha Noi) to the port of Hai Phong and the Ha Long Bay, and for Corridor 3, The Port of Viet Tri (70 km North of Ha Noi) to the 'East' Sea.

This project includes the construction of a seawall access structure in the Ninh Co River estuary, the construction of a connecting canal and a lock between two branches of the delta, and the modernisation of the industrial port Viet Tri plus the construction of a new commercial port on the River Day.
Consideration of social and environmental issues was a major challenge from the design stage to the construction phase. Preserving agricultural land, reducing impacts on buildings and infrastructures, as preserving religious buildings and the environment have been made possible by a common desire for dialogue between local communities, authorities and the project team.

This project, beyond the necessary environmental and social impact studies, was also an opportunity to forge strong links with some Vietnamese educational structures such as the University of Science and Technology of Hanoi (USTH) or to develop a plan for the prevention and fight against VIH for the workers but also voluntarily opened to the residents living near the projects.

CNR and its local partner VIPO mobilized for 5 years French and Vietnamese experts who were able to construct over the long term a cooperative and dynamic partnership with the team in charge of the project (PMU) with the Ministry of Transport as well as with the teams Of the World Bank, thus leading to an exemplary and ambitious project on environmental and social aspects.

Session C7 – IWRM

Moderator, Rex Woodward

Computations of Economic Impacts of Coastal Navigation

by

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The US Army Corps of Engineers (USACE) developed the National Navigation Operation and Maintenance Performance Evaluation Assessment System (NNOMPEAS) as a budgeting tool and general project evaluation tool analysis of Operation and Maintenance (O&M) and new work for deep draft environments. USACE is charged with maintaining the Nation's Federal navigable coastal and inland waterways, nearly 200 million cubic yards of material are dredged in the U.S. annually. In addition, these quantities are likely to increase under proposals for deeper and wider channels to support emerging commercial cargo vessel designs. NNOMPEAS helps enable USACE to provide a more credible and informed evaluation of maintenance requirements, based on the economic return. In addition, USACE is developing metrics that would help demonstrate the incremental return-on-investment from an increase or decrease of dredging funds and associated maintenance at any specific location.

NNOMPEAS is being further developed to demonstrate whether such a metric can be provided across all coastal shallow- and deep-draft harbours and waterways. This tool uses domestic and foreign trade data to determine and analyse the loaded or immersed drafts and related utilisation of vessel cargo-carrying capacity for all recorded cargo vessel calls for individual harbours and channels. The system in turn can provide for the estimation of incremental transportation cost benefits foregone with reduction or absence of maintenance for waterway depth, and of the transportation cost savings with a limited increase in depth.

This could offer the potential to optimise maintenance dredging requirements for individual channel reaches and across much a company or agencies dredging program.

Watertruck – The Future of Small Inland Navigation

by

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Watertruck+ is a TEN-T/CEF-project that aims to provide a long-term solution for the future of small inland navigation. With a continuous decline in volumes and vessels during the past decades, without immediate action, cargo transport on Europe's smaller waterways will disappear.

Watertruck+ is a concept that addresses the main threats to the sector, as identified in the Watertruck Interreg project (2010-2014): an ageing workforce, a shortage of available vessels, high design and construction costs and financing issues. The concept focuses on modular, multi-purpose barges, which are designed with a focus on standardisation, maximisation of payload and simplicity in design. With a modular propulsion, these barges can be self-propelled on the smaller waterways. On the larger waterways of the TEN-T core network, they form a convoy as to benefit from economies of scale.

As a proof of concept, a small fleet shall be built and deployed in a trial phase, in which dedicated volumes, new to inland navigation, shall be transported. An additional obligation during this phase is to

reduce CO_2 emissions by at least 25 % and to use clean propulsion systems which meet the emission levels of the EURO VI norm for road transport.

The trial phase shall provide us with more information about the investment costs and operational costs. These parameters shall be combined with a financial toolbox, containing financial institutions and instruments, to support business cases for the construction and financing of a European fleet of Watertrucks, securing the future of small inland navigation.

Economical Model of Inland Waterways in European Multimodal Corridors

by

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Multimodal European corridors decided in Tallinn in October 2013 will be fully implemented by 2030 to guarantee sustainable mobility within Europe and also efficient exchange of goods at international level.

Seine-Scheldt, a new gate to Europe, connecting inland and maritime ports in France, Belgium and the Netherlands, offers to shippers a modern logistic way to integrate within their own production and consumption processes.

The model developed for Seine-Scheldt involves widely the users for the estimation of the wider economic benefit, and the implementation requirements in terms of transport services. It develops also the multipurpose benefits of Inland Waterways at international, European, national and regional levels.

It creates a reference for contribution of all stakeholders to the development of the IWT transport system, and for multimodal services Road/IWT, Rail/Road and IWT/Rail to deliver solutions for transit, long distance and port access to reduce costs and environmental impacts.

Implementation of solutions will be operational on existing network and during the construction of the missing Link, Seine-Nord Europe.

Coping with Changing River Morphology and its Effects on Navigation and the Environment – Introduction of Longitudinal Training Dams River Waal

by

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As part of the ‘Room for the River’ programme Rijkswaterstaat completed the construction of a unique 10 km long longitudinal training dam (LTD) on the river Waal (the Netherlands), complementary to the lowering of 462 groynes. The LTD is a pilot project as alternative for lowering groynes. Both water works increase the rivers discharge capacity and lower flood levels. The choice for a LTD to train part of the river is to mitigate the side-effects of groynes (bed incision and the impact of navigation on the unprotected river bank) and to increase navigable depth during low river discharge. The new LTD divides the Waal river into two parts: a main channel (230 m wide) for ship navigation and a side channel (90 m). It regulates flow velocities, discharge and sediment distribution between both channels using a weir at the inflow of, and lateral openings in the LTD.

These openings are adaptable in width and depth and will be adjusted based on intensive monitoring. Besides increased navigable depth, other beneficial side effects of the longitudinal dams are expected.

In the side channel and along the river banks ecological values are expected to improve. Waves from the large commercial ships will no longer reach the banks, providing a quiet zone. Furthermore, it is expected that the main channel will aggrade less and hence, less maintenance dredging is needed. Total constructions costs of the LTD are approximately € 50 million, including the removal of the groynes and the dredging of the side channel.

The LTD is closely monitored on these aspects for the coming years. This monitoring is part of a large research project within the RiverCare programme (www.ncr- web.org/rivercare/about) involving the universities of Wageningen, Nijmegen and Delft, Rijkswaterstaat and the research institute Deltares.

Session C8 – Lock Maintenance

Moderator, Helene Masliah-Gilkarov

Analysing Lock Maintenance Needs

by

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The US Army Corps of Engineers (USACE) utilises several information systems to manage its infrastructure on the Inland Marine Transportation Systems (IMTS), of which locks serve as a major component. USACE requires the use of the Lock Performance Monitoring System (LPMS) to record characteristics of locks and lockage data such as barge direction, commodities, and number of recreational vessels. That information is used to help manage operational and budgetary decisions. Utilizing this data found with LPMS, it is possible to explore the relationships between equipment age and its cost, efficacy and availability. The presentation will be of interest to participants by highlighting key bottlenecks to performance on the IMTS as related to lock infrastructure. By better understanding the causes of declines in performance, USACE can integrate that information into their asset management processes.

Extended System Wide Lock Maintenance that Users Can Support

by

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Problem: system reliability and safety is key to the economic success of shippers using the inland waterways. Any lock outage causes impacts to profitability. But, as our navigation system infrastructure ages, major upgrades are required for system reliability. Achieving reliability while minimising shipper impacts is a difficult balancing act.

Approach: To minimise impacts to shippers, the Corps of Engineers Portland and Walla Walla Districts coordinate for simultaneous extended outage to accomplish major maintenance on the eight locks on the Columbia and Snake Rivers.

System wide repair priorities are set based on standardised component condition assessments, coordination between the engineering teams of two Corps Districts, budgetary coordination between the Districts, the Northwestern Division and USACE HQ. To be successful, this approach requires extensive coordination of planning, budgeting, engineering and construction to bring a system wide outage to timely completion. Just as important as the engineering and project management aspects of the work, is the advanced and open communication with the shippers and other stakeholders on the system. Simultaneous construction at multiple projects during project execution requires multiple successful

contract acquisitions with a relatively narrow field of experienced contractors. Contracts must be awarded with enough lead time to allow for completion of fabrication and river shipment of large items prior to the start of the lock outage. Corps partnering efforts with the contractors have been a great contributor to project success.

Result: In the Pacific Northwest, the entire system of the locks on the Columbia and Snake River Inland system have been taken out of service for extended repairs twice in the last ten years, greatly improving system reliability. Despite the disruption to service, our stakeholders have supported this approach to the work and been active participants in the process.

Effects of Quoin Block Deterioration on Quoin Post and Thrust Diaphragm on Horizontally Framed Mitre Gates

by

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This article presents the effects of quoin block deterioration on the quoin post and thrust diaphragm of horizontally framed mitre gates. The study uses three-dimensional (3-D) numerical simulation of mitre gates that includes all the geometrical details of the most commonly used mitre gates. The simulation is used to evaluate the effects developed by the quoin block deterioration on the quoin post and thrust diaphragm. The results show a change in stresses from a full compression state to a combine bending and axial load for 30 % of deterioration. For the thrust diaphragm. The numerical models where calibrated analytically against the bending theory on the horizontal girders and skin plate. The results show that a 10 % of quoin block deterioration may be acceptable.

Optihubs – Optimisation of Container Terminals through Simulation

by

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Port optimisation has become a very complex task due to numerous parallel and consecutive running processes that need to be taken into account during the optimisation process. So far, existing modelling solutions mainly focused on single aspects of the supply chains for dedicated stakeholder processes. Optihubs went a step further and introduces an advanced and innovative approach on a very detailed level with vehicles and loading units that simulates and optimises administrative, operational and logistic processes at multimodal hubs and freight terminals among with their interactions and interdependences. Micro simulation technologies are used based on a realistic 3-D image of a port and its surrounding environment. The image is used as a basis for modelling processes such as multimodal terminal entries and exits, checking, loading and unloading of vehicles among other processes of terminal management systems. Units interact with events in the surrounding traffic environment such as delays, traffic lights and railway crossings in accordance with defined settings, technical parameters and transport flows. The existing terminal data, workflows and routines of individual ports are imported into the modelling system and simulated in order to validate them against optimized process flows of the Optihubs modelling system which are established through means of observations, terminal data analysis and interviews.

For validation purposes key performance indicators are used.

The Optihubs modelling system consists of several processing modules that allow alterations of parameters such as transport flows, handling volumes/processes and process/time restrictions. The surrounding road and railway network as well as inland waterways are simulated in addition to the specific terminal environment in order to be able to analyse interdependencies and capacity restrictions. Administrative processes such as pre-registrations and agent communication also take place during simulations. Most processes can be traced during and after the simulation in 3-D among realistic vehicle manoeuvres. In the framework of a pilot the optimised process flows were already introduced at the premises of the Port of Vienna, Austria. The modelling results were taken into account by the Port of Vienna to optimise the layout of the new container terminal, which is being constructed in 2017. Members of PIANC could use Optihubs based consultancy services as a very flexible and forward decision making support for investments and as an analysis tool for measures and proposed system/process changes.

Track D

Session D1 – Structural Health Monitoring

Moderator, Matt Smith

USACE SMART Gate: Toward an Automated Damage Detection System for Navigation Locks

by

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Since 2007, the US Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) has begun deploying structural health monitoring (SHM) systems on several of the lock gates under USACE jurisdiction. Labelled the Structural Monitoring and Assessment in Real Time of Lock Gates (SMART Gate), these SHM systems have been installed at six such sites to date. The systems consist of arrays of hundreds of sensors that measure strain, temperature, water levels, etc., and sample data every ten to fifteen seconds.

Thus, since SMART Gate's inception, ERDC researchers have amassed terabytes of data with which to investigate the normal operating behaviour of lock gates. In tandem with the SHM systems, finite element models (FEM) are used to simulate damage which then allows researchers to quantitatively describe changes in gate behaviour due to the presence of typical damage to lock gates. Through the use of statistical pattern recognition and decision making algorithms (i.e. machine learning), the data obtained from the SMART Gate system and the FEM simulations is analysed and the results are used to develop algorithms that will be implemented in ERDC's ultimate goal: a user dashboard providing lock operators information on critical maintenance needs.

This presentation focuses on recent advances made by ERDC as pertains to the damage detection algorithms. Successful frameworks for detecting quoin gaps, gate impact, and dragging debris are presented. Challenges, such as the effects of environmental and operational variables, and promising solutions to those challenges are discussed. Finally, future steps required for system deployment, and promising technologies such as computer vision, are discussed and reviewed.

Non-Destructive Evaluation of Aging Lock Monoliths

by

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In service since 1959, the concrete lock monoliths at the U.S. Army Corps of Engineers (USACE) Greenup Locks and Dam in Greenup, KY, comprise a critical and busy link in the Ohio River waterway. Regular visual inspections of the locks and dam identified cracking in several of the lock monoliths that had the potential to impact long-term structural performance. A Non-Destructive Evaluation (NDE) programme – incorporating seismic impact-echo testing – was developed and implemented to identify the extent of internal cracking in ten (10) of the 20-ft long x 40-ft wide x 50-ft (depth to waterline) monoliths. The results of this NDE programme were used by USACE and consulting engineers to determine the effect of the crack on long-term structural health, and plan for reinforcement and structural enhancement where needed. This presentation will cover the NDE programme, including the testing and analysis methods, and typical results observed.

Utilisation of SHM Methodologies to Detect Trunnion Friction in Tainter Gates

by

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Failure of the Folsom Dam spillway Tainter gate is often cited as a landmark example of the sudden failure that can occur when trunnion friction goes undetected during gate operation. The consequences of a sudden failure of this magnitude have the potential to be catastrophic, and could include loss of life, flooding of homes and businesses, significant ecological impacts, unscheduled repair/replacement at premium cost, and a temporary halt on recreational and commercial activities until repairs are made.

The positive that resulted from this particular incident, however, is that it raised awareness regarding the need to advance the state of design, inspection, and maintenance planning related to trunnion friction. In direct response to concern expressed by numerous US Army Corps of Engineers (USACE) districts, the Engineer Research and Development Center (ERDC) initiated a research project to develop an automated detection system that uses real-time structural data collected utilising a minimal number of strategically placed sensors to indicate the presence and magnitude of trunnion friction.

As part of this effort, ERDC designed, analysed, fabricated, and instrumented a one-fifth scale Tainter gate structure to study. The scaled structure was designed to accommodate a simulated head load, while being raised with and without induced trunnion friction. The Structural Health Monitoring (SHM) strategy was successfully demonstrated on the scaled physical model in a lab setting and has strong potential for real-world application. This paper provides a case study of the lab test and field deployment, including a full description of the setup, instrumentation strategy, and conclusions. The results of this research would be of interest to the structural health monitoring community, and to design and maintenance engineers responsible for large civil infrastructure.

Medium Range Underwater Wireless Communication for USACE Infrastructure

by

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U.S. Army Corps of Engineers (USACE) maintains and operates more than 600 dams and 12,000 miles of commercial inland navigation channels while also dredging more than 200 million cubic yards of material. These operations often require the use of control and sensing equipment that operates under water. Current implementations of underwater wireless communications (UWC) present limitations in shallow turbid waters around manmade structures. The Engineer Research and Development Center (ERDC) has developed a system for evaluating various UWC techniques to discover which would be best suited for the unique needs of USACE.

Our initial test case of river locks presents a highly challenging environment for traditional UWC systems. The concrete structure produces multipath effects for acoustic methods, and the inherent turbidity of river water, along with debris, are prohibitive to optical techniques. Electromagnetic waves, however, are not affected by these conditions. With the use of radio frequency electromagnetic waves, the ERDC has achieved wireless transmissions underwater up to a distance of 25 m with minimal data loss and power consumption. Underwater wireless modems can greatly increase capabilities of USACE by reducing deployment cost of monitoring and control systems in US fresh water infrastructure. Results from the initial test case are discussed in this presentation.

Session D2 – IWRM
Moderator, Helen Brohl

Sedimentation Control behind a Multipurpose Tidal Hydropower Dam on the Rance River Estuary

by

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The river Rance is a river in Britanny (France), which has been channelised in the early years of the 19th century with the building of a channel named canal d'Ille et Rance and its estuary due to the high tidal range which reaches up to 13, 50 metres has been closed by a prototype tidal hydropower dam producing electricity since 1966, prolonged by a lock which gives way to recreational navigation and allows navigation between the estuary mouth and the canal d'Ille et Rance.

After more than twenty years of operation the sedimentation process increased due to very low waters on the river Rance and a mixed way of flushing and dredging operations occurred. Today some environmental associations and the elected representatives have estimated the amount sediment to be dredged to nearly 3 millions of cubic metres.

The aim of the presentation will be to see how the sedimentation process has been analysed, why it hasn't been possible to compare the situation with and without the dam and to make a review of the different solutions derived to tackle this sedimentation issue.

Task Group 181: The State of the World's Waterborne Transport Infrastructure

by

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PIANC's Task Group 181, on the State and Perspectives of Waterborne Transport Infrastructure Worldwide, has identified opportunities to deploy the association's resources to be more relevant and impactful in global development, which relies so heavily on waterborne transport infrastructure.

Major findings of the Task Group are: 1) Intermodal connectivity to both maritime and inland ports is a major global challenge; 2) Funding for waterborne transport infrastructure lags significantly behind that of alternative modes (e.g. road and rail) and innovation is needed to bridge the gap; 3) Outreach to developing- and emerging-market countries for whom waterborne transport is game-changing is critical to strengthen the sector; and 4) there is a need for a cross-cutting, ongoing dialogue both within PIANC and with a larger stakeholder group to inform, communicate, and achieve PIANC's vision, mission, and goals for the sector.

Following up on finding 4, an international panel discussion was held at the 2017 Annual General Assembly in Cairns, Australia in June. This presentation will summarise and build on that discussion and review the latest in emerging trends impacting waterborne transport worldwide.

The Florida Inland Navigation District: Sustainable Statewide Waterway Management

by

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In 1927 the U.S. Congress acquired rights-of-way from the Florida Coastline Canal and Transportation Company and authorised the Jacksonville District U.S. Army Corps of Engineers (USACE) to widen, deepen, and maintain the Intracoastal Waterway (ICW), now a 404-mile long continuous coastal waterway stretching from the mouth of the St. Johns River in Jacksonville to Biscayne Bay, Florida. Since its initial construction, this Florida portion of the Atlantic Intracoastal Waterway (AIWW) has required frequent dredging and increasingly complex dredged material handling to maintain commercial and recreational use. To assist the USACE with management of this waterway, the Florida Legislature created the Florida Inland Navigation District (FIND) as a special taxing district and local sponsor to locate, obtain, design, permit, and construct dredged material management sites capable of handling projected 50-year maintenance dredging requirements.

Since 1986, Taylor Engineering has assisted the FIND in planning a programme to ensure the ICW's continued viability over its 404-channel mile length and 98 miles of the Okeechobee Waterway that fall within FIND's geographic limits. This work has involved strategic development of site acquisitions, construction, and dredging projects in conjunction with FIND's annual funding and grant cycles. When complete, the program will comprise a permanent infrastructure of 52 upland facilities designed to manage over 41.5 million cubic yards of dredged material over the next 50 years and beyond. Attendees of this session will learn about the initial development and planning of the state-wide dredged material management plan for the ICW as well as current strategic management issues such as an ongoing 5-year plan for the waterway, development and operation of dredged material disposal sites, and successfully working with regulatory agencies to efficiently manage the waterway.

Strategies for Waterway Management in Highly Protected Areas

by

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Most problematic river stretches for inland navigation are frequently located in areas of high ecological value. In free-flowing sections – not impaired by dams or weirs – erosion or sedimentation processes often lead to restrictions, such as limited fairway widths and depths. At the same time, stricter environmental legislation protecting the ecologic wealth of such areas has become a challenge for infrastructure providers.

The Danube east of Vienna is the last remaining major wetland in central Europe and is protected by the Donau-Auen National Park. It is not only the lifeline of a very sensitive eco-system, but also part of a main transport corridor of European significance. Thus, an integrative waterway management must serve both the needs of inland navigation and the protected eco-system.

Involving of experts for navigation, environmental protection and river engineering since the early planning phases was a key to success. With the completion of a pilot-phase and the implementation of fist measures the compatibility of inland waterway infrastructure with highly protected areas was clearly demonstrated.

For the years to come, a combination of adapted maintenance works and small-scale river engineering measures was given preference over a large-scale project. This new approach is easier to be aligned with the management of the protected area.

Sediment management (e.g. dredging), the design of regulation structures and even instruments for traffic management were optimised to serve ecological goals too.

Restoration measures will improve habitat quality and reduce riverbed degradation. All the solutions implemented and planned wouldn't have been possible without the active involvement of stakeholders, voicing the interests of inland navigation and environmental aspects. To fuel the discussions, scientists investigated the impacts of the river engineering measures. All involved parties have been and still are part of a 'learning system'.

Session D3 – Structural Health Monitoring

Moderator, Quincy Alexander

Structural Health Monitoring for Water Resources Infrastructure

by

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The U.S. Army Corps of Engineers (USACE) has an extensive portfolio of water resources infrastructure. The performance of this portfolio of infrastructure is declining, with some components presently being used well beyond their design life, and many components operating in only fair, poor, or failed condition. To return the greatest value to the U.S. for its given investments, the USACE must strive to maximise the performance of these aging resources by optimally operating, maintaining, and repairing its asset portfolio. To that end, the U.S. Army Engineer Research and Development Center (ERDC) is developing structural health monitoring (SHM) and damage prognosis (DP) techniques to provide decision-support information for facility operation, engineering, maintenance, and budget prioritisation by senior

leadership. The underlying SHM framework, used by ERDC, consists of interpreting inspection and sensor data with multi-physics, data driven and statistical models. Tools and techniques are being developed with varying levels of complexity, ranging from simple strain time-history plots to probabilistically calibrated finite element models.

Combining these tools with the principles of decision analysis will allow service-life and reliability models to be incorporated into the USACE asset management processes and provide consistent and defensible performance assessments for prioritising funding for the infrastructure assets. This presentation will describe the ERDC approach to SHM, provide some illustrative examples of tools and techniques, and describe the current goals for incorporating these principles into the USACE business processes.

The Internet of Big Things: Acquiring Data from Vital Infrastructural Assets in a Safe and Uniform Way

by

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The presentation will provide insight in a safe and uniform way of acquiring data from infrastructural assets (locks, bridges) and the subsequent use of this data to provide enhanced information services to fairway users and fairway authorities improving traffic planning reliability, RIS enabled corridor management and inland waterborne transport cyber security.

All of the 300 major infrastructural assets (bridges, weirs, locks, water barriers and pumping stations) in the Netherlands continuously generate data.

This data can be used as valuable input by fairway authorities for predictive maintenance, early detection of malfunctions, water level control and automated performance monitoring. Real-time lock and bridge data can also be provided to skippers and inland waterborne transport service providers for improved traffic planning in a multi-modal environment. Availability of up-to-date status information of all locks and bridges in the transport network contributes to traffic planning reliability and constitutes an important step towards River Information Services enabled corridor management.

Until recently however, acquiring this data was cumbersome due to the large diversity in automation solutions and maintenance contracts that do not encourage data sharing. To overcome these difficulties Rijkswaterstaat developed a configurable data service which connects to an assets' Supervisory Control And Data Acquisition (SCADA) system, reads the sensor and machine state values and forwards the data to a central service.

Special measures have been taken to ensure one-way data traffic, preventing cybercriminals attacking the asset through this connection. Additional advantages of this data service are enhanced vital asset monitoring possibilities for the cyber security department and the safe delivery of data to contracted maintenance parties. Unmonitored and possibly unsafe digital access to control systems for external parties is no longer necessary for provision of asset maintenance services.

After the first successful trials with this technology Rijkswaterstaat decided to make a big step forward towards centralised real-time monitoring and control of the operation of all infrastructural assets in the entire national transport network.

How do Riverports Align Actions with Goals? A Smart Approach to River Port Asset Management

by

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Large deep water ports throughout the world are developing and implementing comprehensive risk-based asset management programmes for their physical assets. Many of these programmes have been beneficial in managing portfolios of several different asset categories containing tens or hundreds of similar assets. Resources necessary to establish and execute these large programs are typically cost-prohibitive to all but the largest ports.

A different approach for river ports is typically more appropriate. Most river ports do not manage asset inventories of the size and breadth of their coastal colleagues. An effective approach offers quicker implementation, lower initial and execution costs, and simplified data collection to capture benefits relative to the size and scale of operations at most river ports. Additionally, with many ports regularly competing for public grant funding, capturing information which correlates to grant application requirements carries increased importance.

This presentation discusses an approach to developing a useful asset management programme at a diverse river port. The programme incorporates the inventory, maintenance, and capital programming needs of the port's physical assets. Although it has been customised for one port's specific needs, it is built on a platform that can be implemented in other facilities of similar size and complexity. It relies on simplified record-keeping and easily-taught best practices. It also prioritises the port's next steps appropriately for the port's many competing priorities, which include ensuring the port's resilience to several types of events, maintaining a consistent level of responsiveness to client needs, retaining and growing industry in the region, and competitiveness for public grants.

Smart Waterway Infrastructure – Structural Health Monitoring

by

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Pilot project 'The Smart Lock': smart maintenance by using energy sensors as indicator for structural health monitoring Rijkswaterstaat has high costs of failure, due to untimely maintenance: too early with fixed intervals or sometimes too late, instead of condition based. Electricity consumption can provide valuable information as an indicator for the health of our installations.

Normal use results in a known level of electricity consumption. In a lock complex, for example, the number of passages, the temperature, the time of day and the water level are all factors in determining consumption. The combination of electricity consumption data with other information makes it possible to identify non-conformities. In this way we can prevent damage and even greater consequential damage.

The different users such as contractors, suppliers and asset managers at Rijkswaterstaat all have different information needs. In this and future pilots, we will be testing the required level of detail, frequency and methods used for reporting. This pilot project also provides us with insight into the benefits for the various stakeholders. Those benefits are considerable, making a continuation of the pilot programme more than worthwhile!

Values:

- Lower maintenance costs for maintenance and for extended lifetime of the infrastructural components.
- Lower costs of process disturbance by maintenance. Higher reliability for use and availability of networks.
- Enhanced environmental durability due to reduced use of materials and lower energy consumption.
- Lower energy consumption of infrastructure users through reduction of their detour mileage.

Additionally, this pilot is part of the European Program BE-GOOD: a pioneering project which aims to unlock, re-use and extract value from Public Sector Information (PSI) to develop innovative data-driven services in the area of infrastructure &environment.

Session D4 – Infrastructure and Vessel Interation

Moderator, Liz Burkhart

Intelligent Hands-Free Mooring On the Saint Lawrence Seaway

by

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A presentation on the current status of recently installed, and being installed Hands-Free Mooring (HFM) systems for the St. Lawrence Seaway Management Corporation for the Welland Canal's Locks 1 through 7, and for the St. Lawrence Seaway Development Corporation for the Eisenhower and Snell Locks.

The proprietary, Cavotec Hands-Free Mooring devices are capable of identifying common shipping vessels traversing the St. Lawrence Seaway. With the software applications being used the vessels are properly aligned downstream/upstream and their proximity to the lock wall for the HFM equipment to properly attach to the vessels and guide them vertically through lockages enhances the ability to lock through vessels quicker. This innovative, modernisation will help advance cargo and vessel transport to and from the Great Lakes along the St. Lawrence Seaway.

The presentation will show some of the construction necessary to install the HFM equipment, and the current status of construction performed the 2016/2017 Navigation Season, and Construction yet to be performed. Also, some information regarding the operation of the HFM system will be presented.

The presentation will give the conference attendees a better understanding of how the HFM system works, the benefits, and an update of the current status of the construction progress.

Improving Performance of Inland Ships with Hull Optimisations

by

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Inland shipping provides an environmental friendly alternative in those areas where an inland waterway infrastructure is present. Western Europe has such a network, with the river Rhine as an important backbone. The Maritime Research Institute Netherlands, MARIN, was and is involved in different projects to improve inland ship design performance on both a design for service approach and in specific situations.

The following topics will be dealt with: the optimisation of the ship design (hull, powering) to minimise fuel consumption, comparing different designs based on 'total costs of ownership' and the impact of

rudder design on powering. This will be illustrated with concrete examples taken from projects realised by MARIN, among others;

- A comparison of existing inlands ships on wave making resistance and stern configurations. A project performed in cooperation with six ship owners of inlandships.
- A study on container transport from Rotterdam to Berlin via inland waterways: what ship concepts are feasible and economically viable. From the impact of 45-feet continental containers, via ship barge optimisation to the total cost of ownership of the different ship/barge options. A comparison based on the Net Present Value.
- The optimisation of a 90-m inland container ship. A project commissioned by a logistic service provider, in order to fulfil the requirements of their client to reduce the emissions of the transport of their cargo.

Olmsted Dam Construction Project, Innovative Design: Heavy Lift Catamaran Bridge

by

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Since the 1990s, the United States Army Corps of Engineering (USACE) has been engaged in the construction of the Olmsted Lock and Dam on the Ohio River. To maintain navigation during the construction, USACE developed an 'in-the-wet' construction method, whereby the dam is constructed sequentially, from a set of prefabricated modules ('shells').

Installation of these shells required a heavy lift vessel capable of lifting, transiting, and lowering a range of shell types. The shell weights range from 365 to 4,080 MT, with a correspondingly wide range of pick point locations. The shells must be set within approximately 1 cm tolerance, in water depths up to 21 m, winds up to 13.4 m/s and currents up to 1.8 m/sec.

Glosten was contracted to design an installation barge meeting these criteria. The resulting design is a 61m long x 95m wide catamaran barge. Towers on each hull support 15 cross beams, which support two longitudinal gantry beams that shift transversely to accommodate different sized shells. Up to 12 strand jacks are installed on the gantry beams for lifting and lowering the shells.

The barge superstructure required careful structural design, supplemented by global and detailed finite element analyses. An active ballasting system is used to maintain level heel and trim during the lifts. The details of the mooring arrangements and installation procedures evolved with the barge design. Four double-drum mooring winches were installed on deck to maintain the barge's position in the river, utilising plate anchors installed upstream and downstream of the dam axis. Eight snubbing winches were installed to maintain shell position between the hulls.

Prior to each construction season, the lifting sequences are planned, and the required mooring, snubbing and ballasting procedures are determined. The mooring and snubbing analyses use a combination of the static and dynamic mooring simulation tools.

Real-Time Mooring Line Tension Monitoring at High Current Sites

by

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Several marine oil terminals in California have upgraded their mooring systems over the last years due to regulatory requirements. The design of the mooring systems has been driven by considerations of both the vessels calling at the terminal as well as the capacities of the existing supporting structures. As a part of the upgrades the mooring hook installations have been fitted with monitoring systems, allowing real-time monitoring as well as recording of mooring line tensions and vessel movements.

The recordings of load tension values provide a unique data set that can be compared with and possibly verify mooring system design methodologies currently in use. Many factors that are difficult to account for in an analysis due to the sheer volume of possible scenarios now have the possibility to be captured in the measured tension data from the mooring hooks. Some of these factors are pre-tension of mooring lines, actual line tending procedures on the moored vessels, and deviations from assumed design conditions in environmental and other loading cases on the moored vessel.

Two sites that regularly experience both high currents and relatively large tidal variations have been selected for this study. These sites not only record data from vessel monitoring, but are also located in close proximity to NOAA Stations that provide a full range of environmental data such as tides, currents, and wind. The presentation will give an overview of the sites, design procedures for the mooring hook installations, and the available mooring line tension data. Cases exhibiting high line tensions or vessel movements will be selected for a more detailed study, including environmental data, vessel loading conditions, as well as possible passing vessel effects. Both line tension data and environmental data will be compared to the values used in the design and analysis of the mooring systems.

Session D5 – Infrastructure Lock Design Innovations

Moderator, John Clarkson

Use of a Navigation Lock as a Barrier against the Spread of Invasive Species

by

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Invasive species in the Mississippi River are causing major environmental concerns to the United States. In particular, the spread of Asian Carp toward the Great Lakes would be catastrophic too much of the eastern United States and Canada.

To protect the Great Lakes, many different methods across multiple engineering and scientific disciplines are being explored as ways to restrict the migration of Asian Carp northward. One of these methods is the use of a navigation lock to act as a barrier to prevent the transport of juvenile fish, roe, and DNA through lock flushing. This talk would focus on different lock flushing concepts that have been developed and evaluated. These lock flushing concepts have been evaluated using three-dimensional, Reynolds-averaged Navier-Stokes numerical modelling simulations to understand the flow behaviour during a flushing operation.

Details of the lock flushing concepts and results of these numerical model simulations are presented in this talk.

Evaluation of Different Construction Types for Lock Chambers

by

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In the German waterway system, similar to the European waterway system, about 70 % of all locks have a fall of below 10 metres. In case of replacement three main types of construction for the lock chamber are suited for this range of falls. These construction types are:

- a reinforced concrete U-frame
- sheet pile walls with concrete base slab
- large-diameter cast-in place bored piles, adherent thin concrete shells and a concrete base slab

The heads are constructed in traditional way as a massive concrete structure. The filling and emptying is generally managed through the gates or in some cases by short hydraulic circuits in the heads. Examples of the mentioned lock chamber types will be given.

Whereas the two former construction types are well-experienced the last mentioned is a new type with only few experiences which provoked an evaluation process described in here. All three construction types have different shapes, cubing, safety fulfilments, construction costs and maintenance aspects. By a multi-aspect criteria catalogue different structural requirements such as bearing capacity, usability and durability are judged and weighted by numerical values. Aspects are the safety, technical lifetime, expected deformations, dimensional accuracy, installation of equipment, easiness for the ship passage, degradation, environmental actions, accessibility for inspections and repairs, but also extensibility and variability. Additionally, robustness criteria like redundancy, stability, ductility, compactness and fault tolerance, some of them are quantified by a numerical value, are considered supporting the decision for the most suitable construction type. For a set of given circumstances, the reinforced U-frame lock chamber shows the best ranking order.

Renovation of Weirs in the Lower Rhine and Lek Computational Models as Support for Weir Operations in Off-Design Conditions

by

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The weirs in the lower Rhine, at Hagestein, Amerongen and Driel, each with 2 visor gates spanning 54 m each, are to be renovated after approximately 50 years of operations. During the renovations one gate at a time will be removed and replaced. In the temporary situation that one gate is inactive the other gate fulfils the function of the weir. All discharge and water level control will be conducted by a single gate, a situation for which the structure was never designed. The design of these weirs was supported in the 1960s with scale model research of the scour protection, discharge characteristics and vibration analysis. Repeating this for the temporary situation during renovation is not feasible. However, with the help of modern high fidelity computational models, the off-design condition described here can be analysed in a time efficient manner.

In this presentation the discharge characteristics of the existing weirs from the field data are used to develop a temporary weir programme. A detailed 3-D CFD simulation has been used to study 5 operating conditions of the temporary situation of the Hagestein weir to calculate the adjusted discharge characteristics owing to the contraction of the flow through one opening, here limited, and the higher velocities of the flow downstream as all the discharge is directed through half of the flow area. Using

these tools an estimate can be made of the required extra bed protection during the renovations. The results show that these models will also be useful tools for the design of bed protection for new structures and recommendations are made for what is required to develop them further for more accurate results.

Numerical Investigation of Salinity Effects in Locks

by

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At the interface between inland and maritime navigation areas one may observe the effects of density differences on the flow field. This is an effect which is prominent at navigation locks, as high salinity gradients can be observed here. At locks, vessels are very vulnerable to external forces when driving slow or being moored.

During the locking process, controlling the hydrodynamic forces which act on a vessel is of utmost importance for the safety of the transit. Typically, surge and sink waves, jets and flow deceleration are the dominating effects. If furthermore density gradients occur, this can have an additional effect which is often underestimated.

In an ongoing study the effects of salinity gradients on the locking process in the Kiel-Canal locks are being investigated. In a primary phase physical model tests for two different locks were conducted with fresh water. Later, additional studies with a three-dimensional numerical model based on OpenFOAM® with free water surface, moving valves and a moving vessel were conducted for validation purposes. Recently, this numerical model was enhanced by adding density effects in order to check whether these effects are relevant at the Kiel-Canal.

In the presentation the numerical background, the basic assumptions and the current results of the model will be presented for two locks with different through-the-head filling systems. This will be the basis for pointing out some hydrodynamic effects triggered by the density differences. The results clearly show the importance for designers or operators to take density differences into account, as the forces on the vessels are larger than commonly expected. Furthermore, the current drawbacks and known limitations of the model will be pointed out in order to stimulate discussions about future enhancements.

Session D6 – Infrastructure Design Innovations

Moderator, Denise Soisson

FRP Composite Structures in the U.S. Inland Waterways

by

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The US inland waterways infrastructure serves as a backbone to the nation's economy by carrying an equivalent of 51 million truck trips each year. Its importance has been neglected by not thinking towards its update since 1950s, and as a result the nation's inland waterways infrastructure obtained a rating of D^- from the American Society of Civil Engineers in 2013. The US Army Corps of Engineers (USACE), who owns the nation's Inland navigational lock and dams, are obligated to spend 73 % of their annual budget in repair and maintenance, to keep them functioning. Due to massive budget cuts and the regular

repair works associated with the use of conventional materials, the USACE has started exploring the use of durable fibre reinforced polymer (FRP) composites. Lightweight and non-corrosive FRP composites pose as the most viable solution to the problems of corrosion and deterioration faced by USACE in their waterway structures. In this work, FRP composites have been utilised to replace some of the traditional waterway structural components such as wicket gates, recess protection panels, and mitre blocks, which were built of steel and timber in the past. In addition to several facets of the design, manufacturing, testing and analysis, field implementation of these structures has also been discussed in this work.

Glass Fibre-Reinforced Polymer (GFRP) Composite Wicket Gates for Chanoine Type Wicket Dams

by

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A novel fibre reinforce polymer (FRP) composite material product was developed and proven to be a successful replacement for standard white oak timber chanoine-type wicket gates. This is the first FRP composite material-made navigational structure to be used by the U.S. Army Corps of Engineers (USACE). Wicket gates are an adjustable dam that can be raised during low water to maintain pool levels for navigation. During high water, the gates are lowered to the river bottom, creating a navigable pass which allows river traffic to flow without using the lock chamber.

Innovation was required in three areas: development of FRP composite material configuration, development of a new gate manufacturing process, and optimisation of structural design. The new product works the same as timber wickets, but exceeds their performance in cost, manufacture, environment, maintenance, and safety.

The new gates cost 40 % less on a first-cost basis, provide an environmentally conscious alternative to timber, and increase the lifespan of each gate from 15 to 50 years. A longer lifespan saves installation costs, increases diver safety, and projects virtually no maintenance costs.

Research, design, and testing spanned the years 2014 and 2015, with 3 gates installed at one location on the Illinois River during August 2015. Thorough inspections in November 2016 validated the product as superior to its predecessor. A budget request has been submitted by USACE's Rock Island District to replace all of the existing timber gates to composite, which will save $18.6 million in materials and labour over 50 years at two Illinois River sites. This product's innovation paves the way for the design and use of FRP composites for other gate types on navigation structures that have more demanding performance requirements, such as mitre gates and lock culvert valves.

USACE Standardisation of Navigation Infrastructure

by

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Simply stated, the network of inland navigation infrastructure owned and operated by the US Army Corps of Engineers (USACE) is burdened by a lack of interchangeable parts and major components resulting in operational and financial inefficiencies. A national view is needed to build an overarching strategy to move from unique site-specific designs to universal standard designs for items such as lock configuration, construction methods, standardised gate systems that are deployed for easy adaptation to many sites on the system, and consistent strategies for maintenance and repair on high value areas such as lock wall rehabilitation, gate sill renewal, hydraulic systems, maintenance closures, and others.

The Inland Navigation Design Center (INDC) is a new centre of the USACE with responsibility to standardise design of components for navigation locks and dams. The development of standard designs

and repair strategies for implementation throughout the USACE portfolio has been initiated by HQ and is currently being executed by the INDC in close coordination with engineering and maintenance and operations teams to maximise life cycle value and savings potential. A joint integrated team using the Inland Navigation Design Community of Practice resources as the base, with oversight provided by the INDC and strategic direction provided by the Inland Navigation Design Oversight Committee has been formed to study and effect change.

This team will develop a path forward to implement national standardization criteria for the design of new locks and the replacement of major components of existing facilities. Solutions for interchangeable components will be built around cost savings from design, quality improvements, reduced outage durations, storage yard requirements, best practices, lessons learnt, and other guiding principles. This presentation will provide a snap shot on this new USACE focus area.

Current Research with Navigation Lock Culvert Valves

by

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Navigation locks are used throughout the world as the means to navigate past dams. The flows through navigation locks are controlled by unique valves that can experience complex flows and are often plagued by many different problems ranging from cavitation, to vibration, to excessive hydrodynamic loads. The research presented in this talk focuses on the details of the flows near the valve and some design modifications that have been employed to mitigate these problems. Particle image velocimetry has been used to map the flow fields in the turbulent flow zone immediately downstream of the valve. These results are described in detail. Further, some features of valve design which have been found to cause the valve to perform poorly are described. These design improvements are being used throughout the United States as lock culvert valves are being redesigned to replace existing valves that have exceeded their design life.

Session D7 – Infrastructure Design Innovations

Moderator, Andy Harkness

New Lock of IJmuiden – Physical Scale Model of the World's Largest lock

by

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After almost 100 years the Noordersluis (Northern lock) in IJmuiden needs replacement. A new, bigger lock will provide access to the harbour of Amsterdam for larger sea going vessels and will thereby stimulate the economy in the region. Building of the lock commenced in 2016 and the new lock is expected to be completed in 2019. With a width of 70 m, a length of 500 m, and a depth of 18 m the new lock will the largest in the world!

In the period 2014-2016, Deltares carried out extensive hydraulic research for the design of the levelling system of the new lock of IJmuiden. The main objective of the study was to determine achievable levelling times, on condition that the forces on the vessel remained within limits. A central research question was whether a levelling system with gate openings was feasible or that a (more expensive) levelling system with culverts was required.

The hydraulic design of the levelling systems is investigated in a scale model, on scale 1:40. The complete levelling process is simulated in the scale model, including the lock exchange process after opening of the gate. One of the most important boundary conditions is the density difference over the lock, since the lock is located between salt water on one side (Noordzee) and fresh water on the other

side (Noordzeekanaal). Levelling tests with a density difference showed that the forces due to these differences in density were significant and could exceed allowable force criteria.

Besides providing valuable insights in the process of the complete locking cycle, the measurements were also used to validate various numerical models. On basis of the results of the scale model study and the validated numerical simulations, contractual requirements for levelling times have been adjusted and the final design has been verified.

Infrastructure, Innovation and Standardisation: A Look at How One Lock Closure at Montgomery L&D Led to an Innovation in Standardisation of Critical Lock Closure Components

by

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The vision of the Corps is 'Engineering Solutions for our Nation's Toughest Challenges'. The challenge for getting the Montgomery auxiliary chamber operational where critical systems necessary for lock operation were extensively damaged with mechanism in place to dewater the lock to repair the system was without question one of the toughest challenges LRP USACE was recently faced with solving.

The sill designed for installation at the Montgomery Locks in the downstream auxiliary chamber was a design driven by necessity that incorporated highly innovative techniques pushing LRP USACE to respond and answer to increasing complex and dynamic problems we face from both an engineering and operations perspective. The local site conditions and geometry of previous sills that had been installed and replaced multiple times over the years were not totally known and the chamber could not be dewatered to replace the damaged sill. Since the chamber could not be dewatered, a replacement had to be designed such that it could be installed in the wet by divers.

Therefore, the design had to be simple, yet highly accommodating to the unknown site conditions. This design not only streamlined this emergency repair, but it took into account that our old way of doing business, using single site-specific designs needed to be re-evaluated and greatly improved upon. This innovative way of thinking will allow LRP USACE to greatly minimise lock delays on any lock emergencies where mitre sill damage has incurred utilising this new standardised design for lock chamber mitre gate sills.

The new LRP replacement sill was designed to be site adaptable, incorporating design features that would make it universally adaptable to all LRP USACE complex mitre sills. Therefore, with this standardisation, LRP USACE can now more effectively and efficiently replace old sills across the district utilising either an in the wet or an in the dry installation method depending on the complex situation and variables. Additionally, this design incorporated replaceable wearing features that accommodate easy replacement of the critical sealing systems should they become worn or damaged beyond repair.

Furthermore, should excessive damage be incurred to the sill and render it unusable and beyond repair, LRP USACE will have a quicker response and increased efficiency by accessing a localised area replacing only the actual modular section (standard member), that can be pre-fabricated, stored for emergencies, and is accommodating to all LRP USACE sites with this system in place.

Key Technologies for Reconstruction of Navigation Obstruction Structures – Design Overview of Reconstruction Project of Fuchunjiang Ship Lock

by

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Some existing navigation and hydropower junctions in China may cause obstruction or interruption to navigation due to low standards and insufficient size of navigation structures. With the increasing demand for inland waterway transport, it is of urgent need to solve the bottleneck problems of navigation. The paper focuses on the reconstruction of a 100-t lock into a 1,000-t lock at the Fuchunjiang Hydropower Junction in Zhejiang Province, and presents research results on how to meet the requirements of navigation, safety of the power plant and dam, power generation and flood prevention etc. while considering various factors like the general layout, strengthening of existing structures and construction scheme, etc. of navigation structures.

WG166 – 'Inflatable Structures in Hydraulic Engineering' – A Successful Application of Inflatable Gates at Waterways

by

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Inflatable gates are a relatively new gate type, in particular at waterways, and are considered to be innovative hydraulic structures. Generally, it can be distinguished between rubber gates and steel-rubber gates. The rubber gate is inflated by pumping air or water inside the rubber body or membrane until the design height or pressure is reached. It is deflated by allowing the air or water inside the rubber body to escape. A steel-rubber gate can be described as a row of steel gate panels supported on their downstream side by inflatable air bladders. By controlling the pressure in the bladders, the upstream water level maintained by the gates can be adjusted within a required tolerance. Inflatable gates have a number of advantages when compared with standard steel gates due to the simplicity and flexibility of the structure. Generally, capital and maintenance costs are supposed to be lower than steel gates.

Rubber is a complex product requiring special attention to the jointing process or the rubber recipe. Insight in the manufacturing processes is helpful in order to sensitise the engineer for possibly weak points of the membrane structure. Points of attention in this contribution are the structural and the hydraulic design. Therefore, existing design approaches will be presented to give some guidance. Additional considerations and recommendations are given with regard to material testing, design approach and deviations from the only existing standard in Japan. The updating of the standard for rubber gates and steel-rubber-gates, which is already published in a forth version since 1978, had a great influence on the work.

Due to the elasticity of the structure, an inflatable gate has some hydraulic characteristics which will be described. Mechanical and electrical systems provide the means to inflate and deflate inflatable gates which will be discussed. An outline of the main points of attention will be given during for the on-site construction phase.

Operational requirements include operating modes, inspection, maintenance, repair techniques, monitoring and replacement. Finally, multiple case studies are summarised and will detail some of the operation and maintenance concerns of rubber gates and steel-rubber gates. This includes sites where inflatable gates have worked well and other sites where they have not. The aim is to give insight to several years of operating experiences in order to distinguish between teething in the early years and characteristics of the technology which have to be taken into account during the design.

PIANC InCom Working Group (WG) 166 – 'Inflatable Structures in Hydraulic Engineering' held its kick-off meeting on September 2013 in Maastricht, the Netherlands. The work was influenced by current projects in Belgium, France and Germany, where inflatable structures will be applied to waterways. Therefore, guest experts were regularly invited and on-site visits at existing weirs and meetings with operators and administrations were consequently arranged. The aim of this contribution is to give a summary at the end of the Working Group lifecycle.

Session D8 – Infrastructure

Moderator, Jim Athanasiou

Simple Lock Operations Improvements

by

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USACE navigation locks have very good safety and reliability records but there are numerous relatively simple and inexpensive ways they could be made safer and more reliable. These include but are not limited to redundancies, sensor alternatives, interlocks, operator issues, policies and cameras. The presenter and a lock maintenance mechanic have complied numerous examples to share with the session attendees.

Expert System for Automatically Managing High Water Levels with Smart Infrastructure

by

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Voies Navigables de France began to look into the possibility of using its summit level transport network to reduce the sector's exposure to flood risks. By increasing the resilience of the hydraulic infrastructures and the forecasting and emergency systems, the network can be used to store and draw off part of the flood waters from the surrounding watercourses with a noticeable reduction of the effects of the high water levels on the network as well as on goods and people.

The so-called expert-system is made up of three complementary and indivisible segments:

- The real-time acquisition of meteorological data and water height and flow data. This data is then processed by a 1-D real-time propagation model to extrapolate the results for the entire network and allow a preventive action based on the forecasts. This model will be a data assimilation model: it will evolve with each iteration according to the measurements made.
- The deployment of infrastructures to reduce the effects of the high water levels: by trapping as much water as possible upstream of the drainage basins using dams, by diverting as much water as possible from the flooded rivers to inert sectors and by preventing the watercourses from making the canals burst their banks, which could lead to a weakening of the embankments and a domino effect.
- The speed at which the infrastructures can react to events with a secure remote management system that translates the hydraulic data of the data assimilation model into operational instructions which can then be remotely and automatically applied.

In this way, the entire system works together to take instant and highly optimised actions within the sector, providing hence safety and insuring best hydraulic management.

Miter Gate Embedded Anchorage Soo Locks, Sault Ste. Marie, MI

by

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The Inland Navigation Design Center (INDC) is a new center of the US Army Corps of Engineers (USACE). The INDC was performing a Major Rehabilitation study on the SOO Locks, during this effort it was determined that a Potential Failure Mode was actually an existing real time active failure state. The mode was an Embedded Anchorage structural failure resulting from fatigue and fracture issues leading to catastrophic failure of a Mitre Gate Leaf. The INDC in collaboration with the USACE Detroit District and Risk Management Center, and Consulting Engineers evaluated the embedded anchorage fit for service state. This process consisted of gathering as built information thru inspections and testing, performing advanced finite element, fatigue, fracture, and Risk Analysis.

The Analytical conclusions were the probability of catastrophic failure from a gate embedded anchorage was 7 % in a one-year period and 35 % over a five-year period. The consequences were $ 360 million in direct shipper cost over 180 days with secondary cost escalating significantly larger. Non-Destructive Testing (NDT) of exposed upper portions of the embedded anchorages verified that significant cracks existed in welds and base metals similar to theoretical projection.

Immediate risk reduction measures were implement while a permanent solution was developed through an INDC facilitated ‘Design Charrette’. The solution was a shallow depth, bolt down, embedded anchor frame system installed in a two steps process. Installation of the embedded anchorage main frame was installed during the locks normal 9-month operation period with final connection plates installed during the normal winter shutdown period. Installation of the upper and lower Mitre Gate Embedded Anchorage was completed in 2017.

RC Byrd Lock and Dam Sedimentation Study

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The navigation channel just downstream of RC Byrd Lock and Dam on the Ohio River continues to have a sedimentation issue. Fine sediments deposit directly in the channel just downstream of the lock guide wall, especially after higher flows. Extensive dredging is required to remove these sediments to keep the channel open to barge traffic. A two-dimensional numerical sedimentation model was developed for the problem reach in order to test river training structure configurations that might prevent or reduce the amount of sediments depositing in the channel. A six-month hydrograph of actual flows for the period of September 2011 to March of 2012 was used for the simulation period. It was chosen because there were several very high flows during that time which resulted in large dredging volumes that were required to keep the channel in operation. The results show at least two configurations that could reduce the quantity of deposited sediments by at least 50 % or more. If the structure(s) were built, this would represent a large cost savings for required dredging.

III TECHNICAL PAPERS

CARGORIDER – A BOAT TRIP ON A CARGO SHIP

by

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ABSTRACT

Are young people interested in going on a cruise? Yes, they are for sure!

In the research project CargoRider we conceptualised a platform that offers route finding and booking for cargo ships in Europe. For cargo? No, for passenger travel on cargo ships! Traveling by ship doesn't have to be a classic cruise, it can be especially interesting to an adventurous audience on a small budget.

The CargoRider service as laid out is not only an affordable but also a sustainable alternative to air travel. The platform would also include an interface for interchanges. Travelling from Italy to the Northern Sea, from Serbia to the Netherlands and from France to Poland, changing from train to ship and back – the idea is to offer a platform for ships comparable to InterRail travel.

In our research project, we were able to show that all that is feasible. Even more important though, is the public acclaim that our project received. Although operating on a modest budget, we attracted public attention nationwide in Austria and up to the North Sea to the ports of Germany. At research events, our presentation evoked lively discussions among friends who started to plan their route, meticulously deliberating on the stops and interchanges on their way. Young people who have never been on a cruise or any boat trip before studied our map carefully and were surprised how closely cities and nations are interlinked via waterways. We found that a trip on a cargo ship is conceived as adventurous and distinctive, desirable because of its sense of remoteness yet proximity to important cities and sights.

Our presentation will offer food for thought to all conference attendees to open up their businesses to new target groups and to work together with the aim of growth and attractiveness.

Topic: Smart Inland Waterway Transport (IWT), Education and training, including social changes and attracting young people to waterway careers, and reaching new audiences.

1. INTRODUCTION

In the CargoRider project, we conceptualised a booking platform for passenger travel on cargo ships in Europe. The aim of this paper is to present the platform and thereby showing a means of making cargo transport on waterways more attractive in the public eye.

First, our paper will describe the situation of waterborne passenger transport in Europe with focus on cruises, freight transport and freighter travel, second, the booking platform itself with its conceptual design and user needs on which it is based. Third, the potentials of such a platform to attract new audiences for cargo transport will be discussed. Finally, the main outcomes of our project will be summarised.

2. CRUISE AND FREIGHTER TRAVEL – AN OVERVIEW

2.1 The Cruise Market in Europe

From the 1990s on, the global cruise sector has been steadily growing. Likewise, the size of vessels and the ship occupancy rate has increased [Soriano, 2009]. According to the Cruise Lines International Association, which represents 58 major cruise lines, the global cruise fleet will be growing by at least a third over the next ten years [CLIA, 2017].

Within Europe, during the period 2012 to 2016 the numbers of passengers from the Mediterranean countries have decreased while from countries like France or Germany increased. From Germany, UK and Ireland, France, Austria, Belgium and Luxembourg, more passengers have gone on a cruise, while fewer passengers from Italy, Spain and the Netherlands have been counted, though Spain has seen an upward trend again in the period 2014-16 after years of economic recession [CLIA, 2017].

Overall, the European Cruise Market is growing. In 2016, approximately 6,674,000 passengers have been on a cruise. Half of them, that is 50 %, have made a cruise to the Mediterranean or to the Atlantic Islands, 20 % to Northern Europe and about 30 % to the Caribbean or other destinations [CLIA, 2017].

30 % of European passengers come from Germany and 28 % from UK and Ireland. Thus, these two countries constitute 58 % of the market share. On ranks 3 to 5, there is Italy with 11 %, France with 9 % and Spain with 7 %.

The cruise market has become more diversified – in addition to luxury cruises there are club cruises that offer an entertainment programme, targeting a middle-aged audience (the 'babyboom' generation) and adventure and cultural cruises that offer routes off the beaten track [Schulz, 2010]. In Germany, there are cruises for an even younger clientele with electronic music or heavy metal music live on board.

2.2 The Freight Market in Europe

Looking at the 28 countries that are part of the European Union and freight transport within the European Union, road transport is by far the most important means to transport freight: It currently has a share of 49 % of the modal split (2015) with an upward trend. The share of rail transport is slightly decreasing with a share of 11.9 % in 2015. Freight transport on European inland waterways has a stable share of 4.2 %, not having changed much since 1995 (4.3 %). Domestic and intra-EU-28 transport on the sea has a slightly decreasing but major share, currently at 31.6 % (2015). Intra-EU-28 air transport has a constant share of 0.1 % [Eurostat, 2017].

Displayed as a pie chart, the modal split in 2015 is given in Fig. 1.

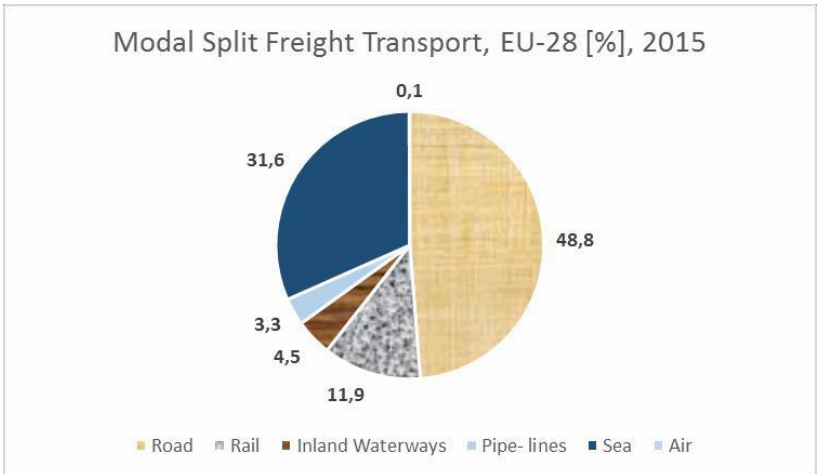

Figure 1: Modal Split Freight Transport EU-28, 2015

2.3 Inland Waterway Transport in Europe

Inland waterways connect Europe. Within the European Union, 13 of 28 member states are part of an interconnected network [EC, 2017]. Of the 40,000-km network, 20,000 km are accessible to 1,000-tonne vessels.

In 2015, almost 544 million tonnes of freight were shipped on inland waterways in Europe, the largest amounts of these in the Netherlands, Germany, Belgium and France. Almost 84 % of the overall volume is transported in these countries [INE, 2017].

Goods that are shipped are mainly metal ores, coke, refined petroleum and agribulk. They represent about half of the transport performance [INE, 2017].

With a modal share of 4.2 % of intra-EU-28-freight-transport, inland waterway transport within Europe clearly has the ability to expand. Promotion of inland waterway transport is also an aim of the European Commission in order to support a climate-friendly and energy-efficient means of transport.

With the CargoRider project, we want to show one way of making inland waterway transport more popular, especially to a younger audience. In doing so, we suggest that inland waterway cargo ships should promote more intensely that they take passengers on board.

2.4 Freighter Travel

The number of passengers on a cargo vessel is strictly limited. A cargo ship can carry up to 12 fare paying passengers, according to the International Classification of Ships by Type (ICST (94)) [ISL, 2016]. Freighters that carry more are defined as combination passenger-cargo ships, regulations for passenger ships apply [Showker, 2007].

Therefore, passenger travel on cargo ships is a minor niche within the passenger transport sector with estimates of 5,000 to 6,000 passengers a year [Schulz, 2010].

Despite the negligible market share, there are travel agencies that are specialised in freighter travel [Wikitravel, 2017] and passenger travel on cargo ships is a successful business model. The major provider in Europe transports about 3,500 passengers a year on freight ships, with the demand, according to their words, being significantly higher. Confronted with limited supply, cabins on popular routes can fill up quickly.

The CMA CGM group reports a number of 874 passengers who have travelled on their containerships in 2013 [CMA CGM, 2017].

In Europe, nine operators are currently active in this business. All of them have their individual platforms on which a trip can be booked. An independent platform does not exist.

Perhaps contrary to common belief, a cargo ship voyage is not the cheapest way to travel, the average payment is between € 90 and € 150 a day [Schulz, 2010], equalling US$ 107 to 178. This is much cheaper than a classic cruise, but luxury on the ship is also limited to basic needs, although some ships on the sea do offer a swimming pool, sauna and a small gym. As cargo ships travel at a slow pace with the average speed not exceeding 25 knots (~46 km/h) and often much lower, air travel is faster and cheaper than the cargo ship alternative, except of relocating being the journey's purpose. Therefore, a cargo ship will hardly ever be the appropriate means of transport when the deciding factors are time and price, and neither with luxury for recreational purpose.

Furthermore, a freighter cruise demands a lot of preparation, namely vaccination, medical checks, insurance and travel visa for all destinations.

Despite these detrimental facts, these journeys are labelled by travel agencies and providers as adventurous, as romantic, as unique experiences off the beaten track while sharing the seafarer's life.

There are no crowds on the ship, no planned activities. 'Passengers can be as active or as lazy as they choose'. [Showker, 2010: p.595].

3. THE CARGORIDER PLATFORM

3.1 Framework

The presence of passengers on cargo ships is characterized by a number of peculiarities. First of all, in maritime navigation the captain's decision always applies. This disclaimer concerns guarantees for booking requests because they cannot be given.

Second, the transport conditions of ship owners and agencies are heterogeneous. This refers to the terms of carriage, the accommodation of passengers on ships, the catering rules and the rights and obligations of passengers on board.

Third, although there are differences, in order to be able to conclude a contract of carriage, the following categories are usually compulsory:

First and foremost, preparations have to include vaccination, insurance, and travel visa for all destinations, plus health certificates from a certain age on.

In further detail, this includes that, before the start of a journey, passengers are required to provide name, first name, age, photo, address, telephone number, email address, a certificate on the safety of the state of health (health certificate as from 65 years), name and age of other fellow travellers, the preferred journey area, the period of the passage, a justification for the application to the cargo trip, and a character description of the person. Travel documents also include carrying ID documents and, where appropriate, visa for the intended destinations. In addition, vaccination regulations must be taken into account prior to travel as well as the preparation of the payment (different currencies).

In addition to the well-known individual insurance options such as health insurance, accident insurance, liability insurance, travel insurance and travel cancellation insurance, the so-called 'deviation insurance' which is specific to the traffic route must be taken into account. In case of an illness, it might happen that the route has to be changed in order to reach the nearest port. The concerned passenger must cover the expenses for changing the route, which can be significant. Therefore, the key aspect of this insurance is the coverage of deviations from the ship route, which can have a serious impact on the business of the shipping company/captain.

3.2 Conceptual Design

The CargoRider platform was developed via a user-centred design process. In order to find out users' needs, a survey was conducted by sending out a questionnaire. Based on these outcomes, personas and scenarios for booking a cargo ship trip were devised, which in turn were the basis for the front-end design and visual interface components of the CargoRider platform. This conceptual design was evaluated again in two test cases and re-designed. After this iterative process, the platform was implemented as an interactive prototype which contains dynamic visualisation elements and demonstrates the possible implementation of such a service.

Based on inland waterway maps, a map showing main inland waterway and sea routes was created. It is shown as one single map on the main page of the platform to give an overview of the rivers and ports at which boarding on ships would be available.

Using a slider on the bottom of the page, the intensity of use, i.e. number of ships in the harbours and on the rivers, is being displayed by the intensity and size of the symbol. With ports, this is visualised by different sizing of red spots. With ships, it is visualised by the line width. This information can be changed according to the respective month. Fig. 2 shows the CargoRider map.

Figure 2: Main page of the CargoRider platform

In order to use the service, it is necessary to create a profile. Optionally, this data can be made public. Additional features are a travel diary, saving of the routes, and an archive function of sent messages. The profile site is shown in Fig. 3.

Figure 3: Personal Profile on the CargoRider platform

In the menu item travel planning (see Fig. 4), different kinds of information can be filtered for every port, like name of the ship, departure, number of free places, travel period and destination.

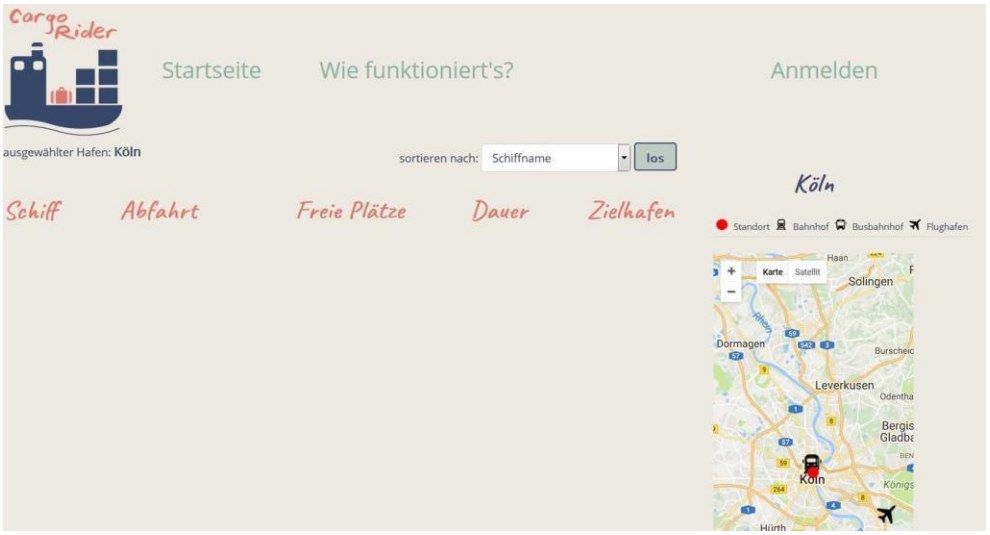

Figure 4: Travel planning on the CargoRider platform

The prototype is publicly available: http://flock-0844.students.fhstp.ac.at/pages/startseite.php

3.3 Exploring Users' Needs

In order to get information about the expectations and needs of potential users on which the prototype platform is based, an online survey was conducted in the period from 18 December 2015 to 31 January 2016. In total, there were 358 participants of whom 258 participants answered all the central questions. A total of 104 respondents were particularly interested in CargoRider's service, their interest in the rating scale from 1 to 5 (1 being 'very interested') was rated 1 or 2. Regarding the age distribution, more than half of the participants were under 30 years. Regarding gross income, about one third declared it was less than € 500 ($ 593) and almost 40 % had an income between € 1,000 and € 3,000 (equalling $ 1,185 to $ 3,556). The higher proportion of the participants were women (57 %). There was no difference between the overall rate of interest in the service and interest among specific groups. In a multiple-choice question, 34 % imagine a trip on a cargo ship being adventurous, 37 % interesting and 'rich in experience' ('erfahrungsreich'). The sample fits very well within the CargoRider's target group,

which is supposed to be younger people who are fond of travelling and adventurous. Both people with high and low income are addressed.

In general, strong willingness to travel on the interviewees' side is recognisable. Concerning the favoured the length of a trip, only 17 % of participants prefer a trip longer than a month. More than 60 % of those who are interested have never made a trip on a ship. The most frequent interest is sailing (55 %), followed by cargo ships (46 %). Furthermore, participants were asked as an open question what they regard as important when planning their journey. Aggregating the data, important issues were price, the cities, and countries to be visited. Concerning the desired service on board, almost three quarters of all interviewees wanted a breakfast. The possibility to go ashore was just behind it, followed by private sanitary facilities (WC and shower). The contact with the crew is important to more than half of the respondents, the contact with the captain is significantly less important with about 30 %.

As the top destinations, London and Hamburg with about 14 % of the nominations were the first to be selected, followed by St. Petersburg and Constanta. Among the top 10 were also large sea harbours such as Marseille, Rotterdam or Gdansk. Furthermore, the popularity of Eastern European destinations such as St. Petersburg and Moscow is striking. With nearly 60 % of the nominations, the visit of cities was ranked equal to traveling on beautiful routes. During the itinerary, it is noticeable that about 60 % prefer a spontaneous organisation from port to port and 40 % detailed planning. Interestingly, the desire for detailed planning compared to a spontaneous trip was much less represented in the segment with a gross income of between € 500 and € 1,000 (less than 25 %) ($ 593 to 1,185). Also, the segment between € 2,000-€ 3,000 gross income ($ 2,370 to $ 3,556) is only half as often interested in planning. There is a slightly larger number of respondents aged 30 to 49 years who are interested in spontaneous trips.

Women's concerns about travelling on purely male-staffed freight ships are present, and more than a quarter of the answers are located on the two outer values of the five-part scale. However, almost as many respondents had absolutely no concerns in this regard. Respondents aged 20-29 years are slightly more positive than the rest of the age groups. Nevertheless, these concerns must be considered and communicated in the service design.

A map has been sketched which, similar to the maps of subways, should be a support for travel planning (see Fig. 5). The map shows the most important cities that can be reached by freight ships. In addition, an approximate travel time is given in days based on the velocity of the ships. This specification also takes into account different speeds in both directions in case there are, i.e. upstream and downstream. This map achieved very high levels of understandability (82 % in the two upper values of the five-part scale). It can thus be assumed that the use and characteristics of the CargoRider service are well-connected.

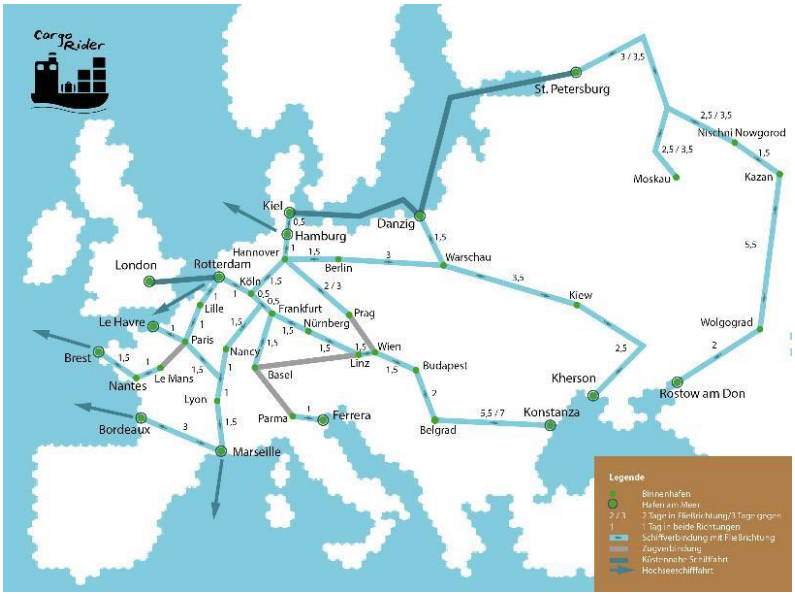

Figure 5: CargoRider map

Possible services of the platform were asked, with the following services as the ones that are mainly

requested:

- Electronic deposit of tickets, e.g. bar codes (so tickets do not have to be printed)
- Electronic deposit of travel documents
- Possibilities for online rescheduling of the trip
- Display of the current location/map
- Navigation function
- Presentation of possible activities and/or sights of the cities
- Communication with other travellers
- Connections with other freight ships/trains including First-Mile/Last-Mile connection

4. POTENTIALS FOR ATTRACTING NEW AUDIENCES

In order to assess the general potential of the concept, a SWOT analysis was carried out. The main results are the following.

Strengths:

- Visualisation of the still largely unknown offer of cargo ship travel
- Simplified access to this service
- Public interest in CargoRider service

Weaknesses:

- High price for cargo ships
- Long travel time
- Niche product

Opportunities:

- Interest in the tourism industry
- General increase in passenger numbers for ship travel
- Increasing interest in ‘decelerated travel’

Threats:

- Special offer for travel insurance is required, provided by external insurance companies
- The legal situation requires the captain to have the final decision in a number of cases (for example, who may come on board)

As shown in the strengths and opportunities, there is interest in this service. This is also reflected by the reactions to this project.

Stimulated by the survey and by a press release which was still carried out midway of the project, the project team was repeatedly contacted with questions about the project and also with specific inquiries about when and where a trip can be booked. We have also become aware of the fact that the topic has become talked about in social networks without our involvement.

Every reaction we got to the project was unanimously positive. This has already led to a positive image of waterborne transport sector among young people, though on a small scale. Travelling on cargo ships has become an interesting option to them although they had not known this form of travel before. Thus, this industry can be made more popular by creating a web platform targeted to a younger audience using a modern front-end design, a way that is possibly more efficient and sustainable than a classic image campaign. For comparison, the costs for this project were under € 50,000 ($ 60,000).

From our point of view, it can be stated that 1) there is a niche market for this service, and 2) the waterborne industry in general can be made more popular among young people by setting up a booking platform for freighter trips.

Comparable to InterRail with trains, it shall include a schedule and booking options for various trips,

covering topics like insurance, information for visa procedures and further. Most importantly, though, it targets a younger audience in the millennial age group (born 1980-2000) which is depicted in the front-end design and the incorporation of social media elements and APIs.

5. CONCLUSION

Traveling on cargo ships is and will be a niche market. However, there is ongoing interest in booking a trip on a cargo ship. At present, the clientele are mainly senior citizens. Therefore, the idea of the CargoRider project is to make freighter travel more interesting to a younger audience and, in doing so, raising the attractiveness of cargo transport, particularly on inland waterways.

Thus, a booking platform for inland waterway journeys on cargo ships in Europe was set up with a front-end design particularly appealing to a younger audience. In order to ensure that, a user-centred design process was performed and testing of the platform involved the specific target group.

Public reactions to our platform and feedback to the questionnaire show positive reactions to our platform and thereby conform our hypothesis.

We therefore recommend that further steps should be taken to check the feasibility of actual bookings on inland waterway cargo ships within Europe via an integrated platform.

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SEDIMENTATION CONTROL BEHIND A MULTIPURPOSE TIDAL HYDROPOWER DAM ON THE RANCE RIVER ESTUARY

by

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The river Rance is a coastal river in the Northern part of Britanny (France), near the port of Saint-Malo, which has been channelised in the early years of the 19th century with the building of a channel named 'Canal d'Ille et Rance', designed to join the two rivers in order to move timber and marine limestone sediments used to treat the very acid agricultural land soils in this watershed. Due to the very high tidal range in this coastal area, which reaches up to 13,60 metres, the estuary has been chosen in the early sixties to build a dam, which closed the estuary of the river Rance, nearly at its mouth by a prototype tidal hydropower dam producing electricity since 1966, when it was inaugurated by the President De Gaulle and prolonged by a lock which gives way to recreational navigation and allows ships to travel between the estuary mouth and the canal d'Ille et Rance. The dam is operated by EDF[1] which benefits of a 75 years long concession from the State lasting until 2043 with the duty to keep the navigation channel throughout the estuary with a depth similar to the allowable one existing in 1966.

After more than twenty years of operation, at the beginning of the 1990s, the former natural sedimentation process increased due to very low water periods on the river Rance and several operations of flushing and dredging operations were launched by EDF, which has the duty to maintain the navigation channel. Since the 1990s, several environmental associations together with the elected representatives have complained about the growing sedimentation amount which occurred within the estuary after the dam was built and they estimated the amount of deposited sediments to nearly 3 million cubic metres. In their views most of the dredged sediments had to be dredged but could be used as agriculture amendments as in the 19th century.

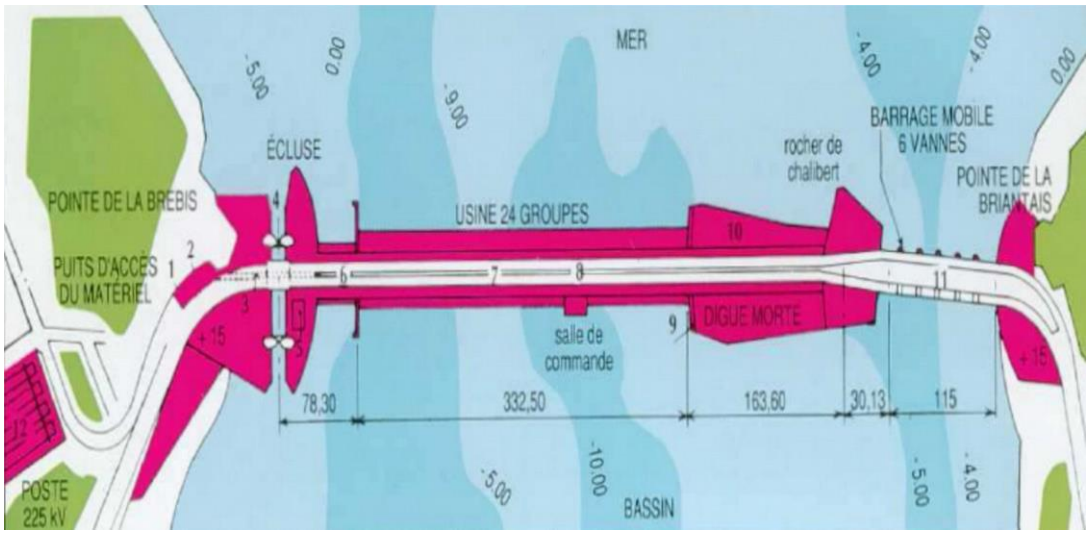
The High Council for Environmental and Sustainable Development and the High Council for Economy were then commissioned by their Ministers and a team of four engineers designated in order to produce recommendations to the Ministers which could be sent to the local authorities to solve the dispute between EDF and the local NGOs and elected representatives within this area.

The presentation will follow three aims: give some clues about the dam and the way it has been operated (part 1); explain how the sedimentation process has been analysed by scientists (part 2) and why it hasn't been possible to compare the situation with and without the dam; and to make a review of the different solutions derived by to tackle this sedimentation issue (part 3).

1. THE RIVER RANCE TIDAL HYDROPOWER DAM AND THE WAY IT HAS BEEN OPERATED

The building of the dam started by the full closure of the estuary for two years (between 1961 and 1963) with two sets of sheet piling gabions (the circular gabions were filled in with sand and measured 20 metres of diameter: they consisted of cylindrical caissons of concrete of about 9 metres diameter, twinly joined by sheet piles). This process allowed to build the powerplant on a dried area in between the sheet piling gabions from 1963 until 1966. The powerplant was covered by a road which avoided the circulation on the perimeter of the whole estuary (a length of nearly 20 kilometres). A lock of 13 metres wide and with a lock chamber of 65 metres long was also built in order to allow a recreational navigation between the sea and the river Rance to the port of Dinan.Two lift bridges took also place above the lock so that road transportation could occur when there is no navigation inside the lock.

[1] EDF or Electricité de France is the main state-owned electricity company in France



The tidal range reaches 13,60 metres at the highest periods and the seawater volume of the dam over the maritime stretch of the Rance estuary is about 180 million cubic metres for a surface of about 22 square kilometres. Of course, both elements (high tidal range and high capacity of the reservoir) were very favourable to launch such a tidal powerplant.

The hydraulic engineers[2] have been able to design turbines which can be used in both directions either with the flow in an upstream move or with the ebb in a downstream move. More, using the produced electricity to pump water and store larger volumes allows to optimize the production as can be seen from the following figure.

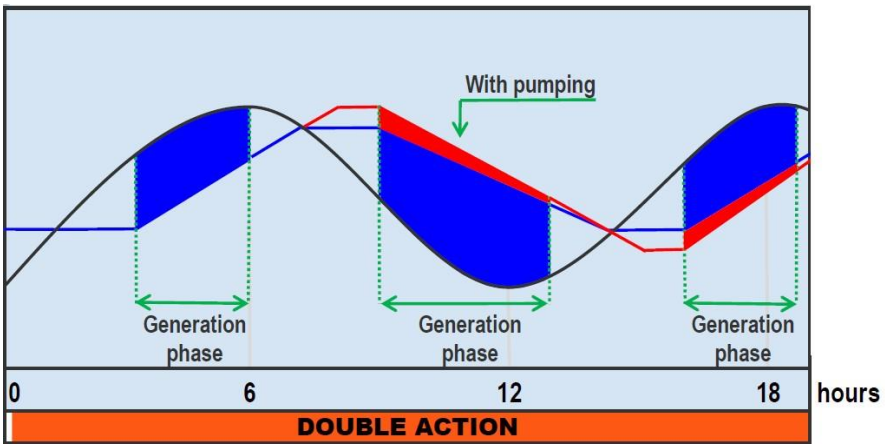


Figure 2: source EDF – Presentation by Denis Aelbrecht and Lénaïk Derlot

The black line gives the tidal height upstream of the dam and the blue line the level of water in the estuary upstream of the dam: the red line shows how the water level in the reservoir is heightened due to the pumping.
The bulbs groups develop a power of 10 MW each so a total of 240 MW [3], for the whole plant.

The overall works include the tidal powerplant inserted into a concrete structure of 350 metres long and 33 metres wide and complemented by a dead dyke seated on the Chalibert rock island. The plant itself shelters the 24 bulbs groups to produce electricity. The design allows to take away easily and to replace each bulb group which requires maintenance or replacement[4].

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[2] Can be mentioned Albert Caquot and Robert Gibrat

[3] In this article we use the word Watt (W) to refer to the power unit and the watt hour (Wh) as a energy unit, as their multiples, such as kilo: k= 1,000, méga : M= 1,000,000 et giga G = 1,000,000,000.

[4] As it occurs now after 50 years of operation

The maximum generation flow is 6,600 m³/s. The mean annual electricity production reaches 500 GW per hour, which corresponds to approximately the residential electricity consumption of a city of the size of Rennes[5] (with 225,000 inhabitants). The remaining part of the dam includes a movable weir of 115 metres length with 6 openings equipped with gates of a wagon type with a height of 10 metres and a width of 15 metres each.

In order to give an overall view of the navigation through the estuary of the river Rance, one should mention that the canal d'Ille et Rance connects to the end of the estuary at a location, called Le Chatelier, where a movable dam and a lock had been built in the 19th century. Since this canal has been transferred from the State to the Region Britanny in the early eighties, the lock and the dam are operated by the staff of the Region Britanny. The main stretch of the canal for the recreational purpose extends between the port of Dinan and the Chatelier lock. It should also be mentioned a significant increase of the recreational navigation: in 1966, 20,000 boats used to cross the lock at the Rance hydropower dam, whereas today 60,000 are now crossing it each year.

2. ANALYSIS OF THE SEDIMENTATION PROCESS

The sedimentation process occurs in nearly all estuaries[6]. It existed before the dam was built, but of course the process increased significantly with the hydropower tidal dam due to the fact that the water level is much higher upstream than before the dam was built, which means lower water velocities and a higher duration where sedimentation can occur. The dam operation means flushing and erosions in the vicinity of the dam and growing sedimentation upstream near the Chatelier lock, as can be seen on the following view taken downstream from the Chatelier dam, lock and bridge system.

Figure 3: low tide in the vicinity of the Chatelier lock (end of the estuary)

Several scientists have been studying the process of sedimentation in this estuary. One of the most famous is Mrs. Chantal Bonnot-Courtois who compared the nature of the sediments at different periods of time:

[5] The main city of the Region Britanny in France

[6] Several other coastal rivers were studied such as the Arguenon river: in 1992 C. Vaucourt and C. Bonnot-Courtois concluded that “the main sedimentation element in this estuary is the increasing mudding from downstream to upstream in the internal part of the estuary”

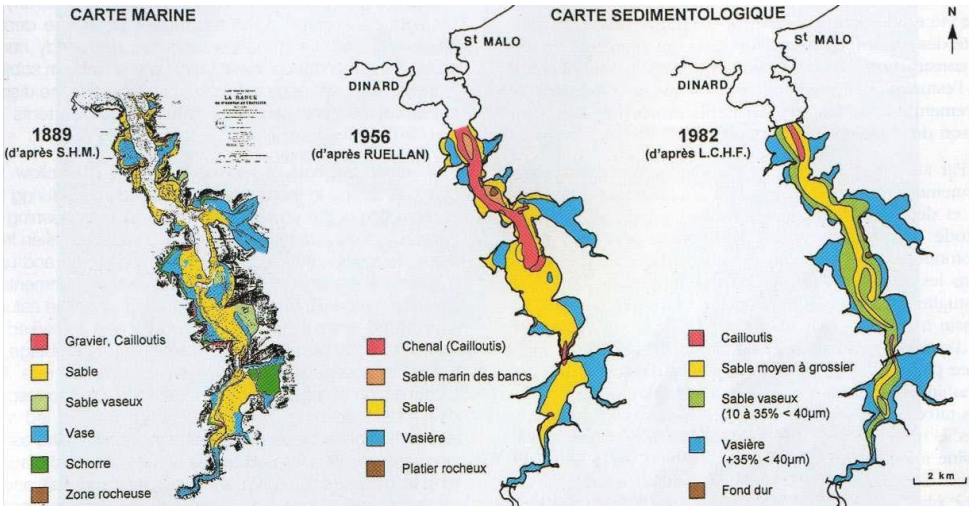

Figure 4: Sea and sedimentation map of 1889, 1956 and 1982 [Bonnot-Courtois et al., 2002]

One can easily observe that in the channel bottom of the downstream part of the estuary sands replaced gravels and that in the upstream part of the estuary the mud progressively increased.

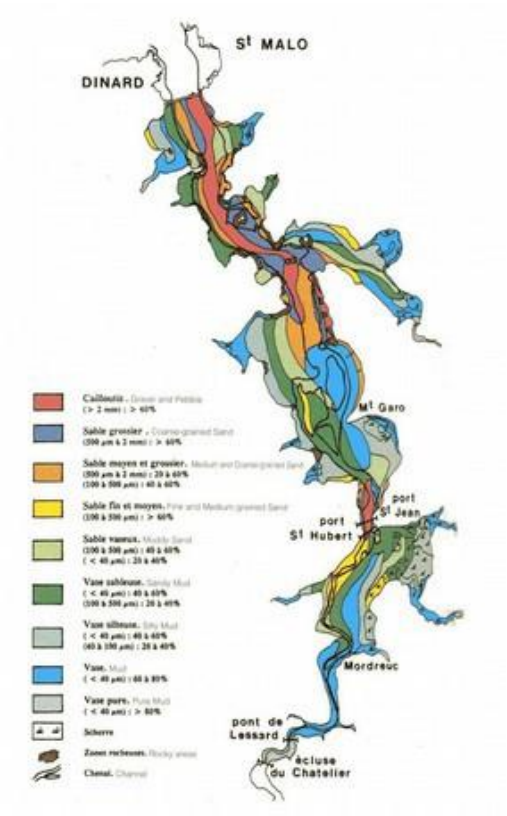

Figure 5: Sedimentation map of 1994 [Bonnot-Courtois et al., 2002]

This more detailed sedimentation map, established ten years later in 1994, shows clearly (in colour light blue) how the mud bottom expands between the Chatelier lock and the Port Saint Jean. It is also the same in nearly all coves.

In a report published recently, the CEREMA[7] stated that the main modifications to the hydraulic regime have been a reduction of the tidal range due to the fact that the dam was operated between the level +4 and +12, whereas the natural tidal range allowed water levels in the range +2.30 m [8] for a tidal coefficient of 20 and 13.60 m for a coefficient of 120. Calculation show that the sea levels behind the dam are 2.50 metres higher than previously.

The sedimentation consequences are twofold: on one hand a reduction of the flow velocity due to the mean elevation of the levels and an increase of the standing sea level of the tide duration which had been already noticed by the LCHF[9] in 1982 as possibly more than two hours, which increases the sedimentation process and on the other hand a reduction of the submersible area of 30 % while it decreased from 70 % to 50 %.

This is explained in this small table:

Niveau (m CM)	Part du temps où le niveau est atteint	
	Avant l'usine	*Après l'usine*
4 m CM	80 %	100 %
6 m CM	57 %	91 %
8 m CM	34 %	68 %
10 m CM	17 %	34 %

At the very beginning of the 1990s, the sedimentation rate in the vicinity of the Le Chatelier lock became so critical that it had to be analysed as already mentioned by Mrs. Bonnot-Courtois[10] from the CNRS of Dinard. The analysis showed a strong increase of sedimentation at the Le Chatelier lock, which had been attributed mainly to the upstream move of the mud cork, with a concentration of sediments of nearly 100 mg/l (compared to the concentration of 10 mg/l which can be observed in the downstream area of Mordreuc). The long periods with very low water discharges of 1989, 1990 et 1991 were considered as the main factor for the acceleration of sediment deposits, which required repeated dredging of 6,000 m³ in en 1990 et of 20,000 m³ the following years. Whatsoever this analysis shows that without the lock-dam system at Le Chatelier the mud cork would have progressed even higher in the upstream reach between the lock of Léhon and the lock of Le Chatelier and may have affected the port of Dinan.

After those facts, a mud trapping trial located at the Lyvet, just downstream the lock of Le Chatelier was proposed: this first trial has been deeply described by Alain Jigorel of the INSA[11] of Rennes [12]. After this work he confirmed that "the sediment intake has been partially treated since 1996 at the Lyvet location with an original concept of sediment trap in a pit", which after 20 months of running stored roughly 50,000 m³ for a capacity of 80,000 m³.

A couple of years later, several attempts were made to appreciate through numerical modelling the amount of the mud deposits. But they failed to arrive to any quantitative conclusion so that locally people felt that EDF was trying to avoid some of its responsibilities.

Therefore, the CEREMA was asked in 2016, to give an overall sedimentation diagnosis which arrived to the following conclusions:

- shear impossibility of reasons of heterogeneity and level of uncertainty from bathymetric measures[13] to derive a global sediment balance in the estuary since the building of the dam;
- shear impossibility to simulate through a numerical model the effects of the dam in order to determine the level of sedimentation increase due to the dam
- the essentially marine origin nature of the deposited sediments themselves, whether their origin is new (sea origin passing through the dam) or stemming from older deposits back in suspension from the bottom of the estuary;

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7 Former CETMEF (Institute for Maritime and Waterways Studies) which merged with many other centres.

8 These are the theoretical sea levels from the astronomical tide independently of the air pressure which can lower or heighten those levels

9 LCHF Laboratoire Central Hydraulique de France: former French national hydraulic laboratory.

10 Bonnot-Courtois, C. et Lafond, L.R. (1992): "Caractérisation et comportement des vases dans l'estuaire de la Rance", EPHE-CNRS.

11 INSA – Institut National des Sciences Agronomique or National Institute for Agronomic Sciences

12 Jigorel, A., INSA Rennes, Lang, F., Melec, D., Cœur, Ledrappier, M. EDF (2003): "Impacts sédimentologique et biologique de la gestion des sédiments dans le bassin maritime de la Rance", Extraits du colloque Barrage et sédimentation en France, pp. 163 à177.

in certain areas the sedimentation creates obstacles to the development of some navigation activities

To complete the understanding, one should also describe what kind of operations were undertaken in order to limit the sedimentation.

Four types of processes have been considered:

3. FLUSHING

The flushing is operated while opening the gates of the Le Chatelier dam and coupling this operation when possible with upstream flow from another dam called the Rophémel dam. The following table gives the flushing durations between 1996 and 2015.

Année	date	Nbre de chasses	Durée de la chasse
1996	26/8 au 30/8	4	2h maxi/chasse
1997	répartie sur tous les mois	38	2 à 3 h maxi /chasse
1998	Janvier à mars 2 août et décembre	20	2 à 3 h maxi /chasse
1999	Février à mai octobre et décembre	9	2h maxi/chasse
2000		0	
2001		0	
2002	mars	1	1h
2003	mars	2	1,5h
2004	mai	2	1h
2005	Février	3	2h maxi/chasse
2006	Janvier à avril	9	1,5h maxi/chasse
2007		0	
2008	Février à mai + décembre	13	1 à 2h maxi /chasse
2009	Décembre	5	1h
2010	Janvier à Mars	5	1,5 à 2h maxi/chasse
2011-2015	Hiver	5	1h

4. DREDGING OPERATIONS

They were undertaken between 1990 and 2016. We collected the following data:

- 6,000 m³ in 1990 and roughly 20,000 m³ the two following years, downstream to the Chatelier lock, according to Mrs. C. Bonnot-Courtois
- 10,000 m³ in 1996 in order to test a first experimental pit to validate the feasibility of the technical process of extracting the mud and using it for agricultural purposes
- 92,000 m³ in 2000-2001 expanding the Lyvet pit created in 1996 in order to limit the sediment progression in the navigation channel
- 91,000 m³ extracted in the central part of the navigation channel at the location of Mordreuc in 2002
- 65,000 m³ in 2014-2015 in the Chatelier area, where 2,250 m³ were taken out of the environment near the navigation channel

[13] The 1953,1981 and 1988 bathymetries have been established while taking into consideration about 20 profiles of the estuary and it is only in 2011 that with a multibeam sounder and with a lidar that one was able to obtain a thorough mapping of the estuary.

In its own analysis of the sediment process, EDF recalls some observations made by Mrs. C. Bonnot-Courtois who tends to consider that if the dredging operations in the downstream vicinity of the Chatelier lock are useful in the short term, they are inefficient in the middle or the long term, because the mud cork occurs in this area and fills all this area inasmuch the low water discharges from the Rance remain very weak. EDF concludes that it is preferable to flush than to dredge.

In our mission, we arrived to the conclusion that if such views can be understood from the viewpoint of the concession owner who needs to maintain the navigation channel, the flushing pushes the sediments downstream and creates therefore other inconveniences.

5. OTHER HYDRAULIC OPERATIONS

From our views EDF has focused its attention to the hydraulic operations optimising the electricity production and in order to reduce several inconveniences which appeared in the vicinity of the dam (vortices for instance).

So in practice the water level upstream of the dam is maintained at more than 4,50 metres which can be seen as the addition of three figures: +2 metres as the level of the bottom of the lock, 2 metres as the maximum navigation draught and 0,50 metres as the under keel clearance.

F of the highest operation level, we observed that it had been reduced to 12 metres instead of 13.60 metres due to the fact that EDF was obliged by the State to do so in the 1990s[14].

6. OTHER POSSIBLE TECHNIQUES

A former environmental inspection from our High Council had been undertaken in 2003[15] , and suggested the following techniques:

- find other siltation pits with associated decantation areas
- sea disposal of the mud: but we considered the cost to be much too heavy and that choosing a site would be sensitive and time-consuming
- use the sediment to rebuild the dune of Ville-Ger: to a certain extent this was used in 2002 when the sandy part of the sediment dredged in the Mordreuc area in 2002 was replaced on certain beaches after separation from the muddy part of it

We also suggested to make use the PIANC report on water injection dredging[16] in order to complement the flushing process or to take its place in case of an important deposit occurring with very low waters impeding the flushing.

From those considerations we arrived to the conclusion, that the sedimentation process in this estuary has attained such an extension that it becomes necessary to reduce it considerably or to stop any further extension of new deposits using several sediment management techniques: trapping sediments with mud pits is one of those, flushing at the Chatelier dam upstream another, a better hydraulic operation at the tidal dam downstream with higher levels than 12 metres, classical dredging operations or water injection dredging or even small devices to concentrate the flows have to be considered.

We disagreed with the proposal to dredge 3,000,000 m³ at a cost of € 55 million considering the effects or such as huge amount of dredging in terms of habitat and biodiversity together with a very high cost and uncertainties about using so much mud for agricultural purposes.

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14 The main reason to do so is because of the ownership of historical a sea mill, authorised in the Middle-age before the so-called « édit de Moulins » taken in 1566

15 Rapport IGE/02/054 « Mission d'expertise sur l'estuaire de la Rance»- André Le Berre-Jean Bourcet

16 Cf for instance « Water injection dredging » PIANC MarCom report 120-2013

7. RECOMMENDATIONS PRODUCED BY THE MISSION TO THE STAKEHOLDERS

Without detailing all our recommendations, we can say that we concluded that a six years programme should be launched quickly in order to obtain a satisfactory sediment management in this estuary.

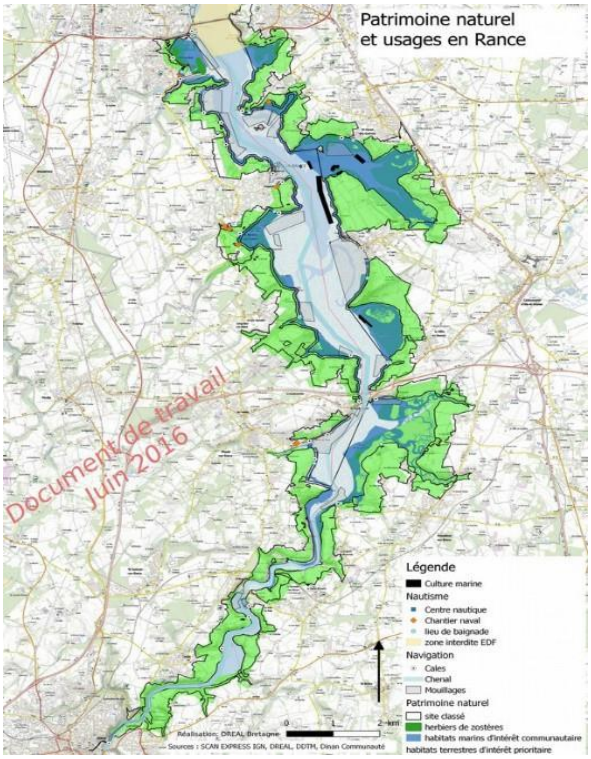
Such a programme could have three coordinated components:

- a short-term mud pit operation called Lyvet 3
- a 5-year experimental programme of sediment management including alternative techniques
- a R and D associated programme to improve numerical modelling with stable bathymetry measures in order to progress in the scientific understanding of the sedimentation process, which would require a scientific committee with international experts

We also suggested to let all the stakeholders build a wider “territory project”, including sedimentation management but also recreation navigation purposes and entrust the contracting authority to a dedicated legal entity, such as the EPTB Rance-Frémur 17.

So, in this suggestion three periods of time could be considered:

- the first next two years between mid-2017 and 2018 in order for all stakeholders involved into the sediment management of the Rance estuary to launch the Lyvet 3 multiple mud pits operation, to build the contracting authority legal entity in order to fulfil the five years experimental programme, to install the scientific committee with international and national experts and for the General Directorate for Energy and Climate to prepare an addendum to the existing concession to take into better account the evolution of the recreation navigation in the estuary since its origin in 1966.
- the next period between mid-2018 and mid-2023 would allow the possibility to realise the five years experimental programme necessary to obtain a zero sediment increase in the following period (between 2024 and the end of the concession in 2043.



17 EPTB Etablissement public territorial Rance Frémur or the existing water basin authority for the watersheds Rance and Frémur

IMPROVING PERFORMANCE OF INLAND SHIPS WITH HULL OPTIMISATIONS, BENEFITS AND PITFALLS

by

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ABSTRACT

Inland waterway transport provides an environmentally friendly alternative for the transport of goods in those areas where an inland waterway infrastructure is present. Western Europe has such a network, with the river Rhine as an important backbone. The Maritime Research Institute Netherlands, MARIN, is involved in different projects to improve inland ship design and/or inland ship performance in specific situations and by a design for service approach. In this paper several aspects of projects are described: A comparison between the performance of existing inland ships, the optimisation of a hull and a case study for transport of 45' containers in a container service on inland waterways.

1. INTRODUCTION

Inland waterway transport plays an important role in the transport of cargo in Western Europe. Some figures for the Netherlands: in 2016 inland ships transported about 365 million tonnes of cargo on the Dutch inland waterways, they realised over 49 billion tonne-km. More and more goods are transported in containers. In 2007, over 3.8 million TEU were transported, in 2016 over 5.3 million TEU. (source CBS: www.cbs.nl))

The inland ship fleet in western Europe consists of about 15,000 ships, about 50 % of them owned by Dutch companies. The majority of these companies owns and operates one ship. In order to maintain competitive and to comply with environmental regulations, reduction of fuel consumption and emissions are important aspects. For existing ships, this could be realised by adjusting/renewal of e.g. existing engines. And in the design of new ships reducing the required power by hydrodynamic optimisation gains importance.

A lot of inland ships have been designed based on the requirements and experience of the owner and/or the ship designer/ship builder. Contrary to seagoing ships, in most cases no requirement is stated in terms of required speed at a given power. The shape and dimensions of the ship are determined by e.g. the sailing area (dimensions of canals, locks, etc.), the required deadweight, hold dimensions and/or number of TEU's and other requirements (accommodation, manoeuvrability, etc.). Very often there is/was no time nor budget for a hydrodynamic optimisation.

The development and application of Computational Fluid Dynamics (CFD) provide the possibility for flow computations in order to compare and optimise different designs in a short timeframe. The application of these tools is described using examples taken from projects realised by MARIN:

1. The SAVE project: a comparison of existing inlands ships on wave making resistance and stern configurations. This project was realised in cooperation with six ship owners.

2. An optimisation of a 90-m inland container ship. A project commissioned by a logistic service provider to fulfil the requirements of their client to reduce the emissions (for the transport of their cargo).

3. A study on container transport from Rotterdam to Berlin via inland waterways; What ship concepts are feasible and economically viable. From the consequences of 45 feet continental containers, via ship barge optimisation to the total cost of ownership of the different ship/barge options. A comparison based on the Net Present Value.

To analyse the different design aspects of inland vessels, various computational tools are used at MARIN. The first tool used in the projects mentioned is the free-surface potential-flow code RAPID, see Raven (1996). This is an efficient method to compute the inviscid flow around a ship hull.

Within very little calculation time it provides an accurate prediction of the wave pattern (except for stern waves that are affected by viscous effects), the pressure distribution on the hull and flow direction over the hull. These calculations provide information to reduce the wave resistance and improve the flow quality by design changes. RAPID is used at MARIN for over 20 years already. The second CFD code applied in these projects is ReFRESCO, which is an RANS solver for predicting the viscous flow over a ship hull, see Vaz, Jaouen and Hoekstra (2009) and Klaij and Vuik (2013). It predicts the velocity field along the hull, streamline pattern and pressure distribution on the hull, it can be used e.g. to visualise and eliminate separation phenomena and it can predict the nominal wake field to support the propulsor design. Complex hull forms and appendages, such as bow thruster tunnels, can be included in the calculations.

2. COMPARING AND ANALYSING EXISTING SHIPS

2.1 The SAVE Joint Industry Project

After exploring different options for analysing inland ships, in 2013 several inland ship owners, a yard, two suppliers and MARIN realized the SAVE project. The project aimed for an analysis of the ship designs and to identify options for improving the existing ships and relevant design aspects for new ship designs.

2.2 Scope and Results of the SAVE Project

The SAVE project consisted of:

1. Analysis of the existing ship by studying the drawings and in some cases full-scale measurements.

2. Analysis and comparison of the designs by computations.
    - Applying potential flow computations for analysis of the wave pattern and pressure distribution
    - Applying viscous flow computations to analyse the flow around the bow thruster tunnels and the aft ship.

3. Additional study on the effect of rudder profiles on the resistance of a ship.

This paper summarises some results of this project. Van der Meij and Raven (2014) give a more extensive description.

2.3 The Impact of Bow Shape on Wave Making Resistance

By comparing the wave system of six inland ships, it became clear that small differences can have a significant impact on the wave system of an inland ship. Table 1 provides the main dimensions of these ships.

Ship:	Length in m	Beam in m	Draught in m	Displacement in m^3
A	182.40	14.20	2.80	6,428
B	109.36	11.40	2.80	3,103
C	110.0	11.36	1.80	1,973
D	110.0	11.40	2.80	3,079
E	110.0	11.36	2.80	3,036
F	110.0	11.40	2.80	3,071

Table 1: Main dimensions ships involve

Ship A is a coupled unit (ship pushing a barge), the length and beam are larger compared to the other ships. Ship C is the only ship with a lower draught.

The computation of the ships wave pattern has been realised with the potential flow program RAPID. The focus was on the fore ship. Because viscous effects are not taken into account in the calculations, the calculated wave pattern around the aft ship is less accurate. Given the focus on the bow this is acceptable. All ships sailed at 15 km/h (with a corresponding Froude number of 0.127), except for ship.

A which sails at 19 km/h (Froude number of 0.127). The water depth is 5.0 m in all cases. Figure 1 shows the wave pattern of the ships, which gives a good overview of the different wave profiles generated by these ships. For several ships prominent 'transverse waves' are observed, which are in transverse direction. This type of wave causes most of the wave resistance. A more precise comparison is given in Figure 2: a longitudinal wave cut at 15 % of the ships length from the centre line. On the horizontal axis, the longitudinal position relative to the ship length, with x/L=-0.5 the position of the bow and x/L=0.0 midship. In front of the ship the water rises, alongside the ship the average water level is lower as a result of the overspeed, magnified by shallow water effects. Ship C encounters a lower overspeed due to the lower draught. More important, the waves generated by ship B are significantly lower than those of the other ships.

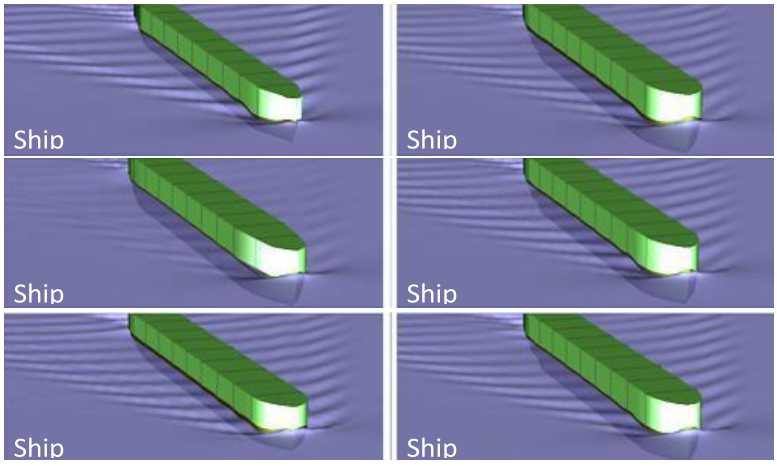

Figure 1: Calculated wave profiles (wave heights magnified 2 times)

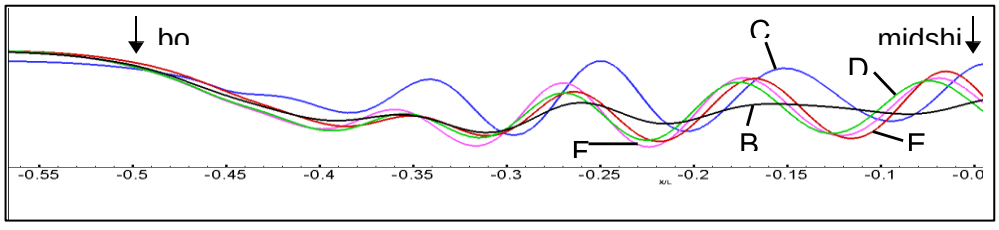

Figure 2: Wave cut at 0.15 L from Centre Line

At this Froude number (0.127) the transverse waves have a length equal to about 10 % of the ship length. Therefore, a transverse wave generated at the bow would have a second crest at about 10 % of the length behind the bow. If the fore shoulder under pressure coincides with this location, it will cancel this crest and essentially suppress the transverse wave system created by the bow; but only when the amount of under pressure is correct.

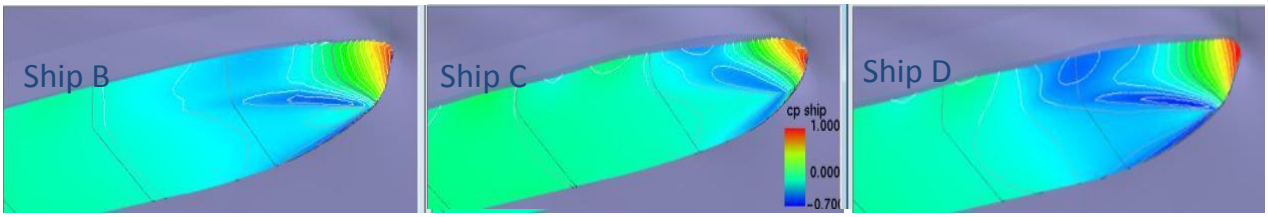

Figure 3: Calculated hydrodynamic pressure distribution ship B, C, D.

Figure 3 shows the pressure distribution in the fore ship. For example, the low pressure area of ship D is around 10 % of the length behind the bow, close to optimal; however a strong transverse wave system is still generated, due to the too strong fore shoulder curvature, see Figure 4. For ship C the low pressure area is located much more forward, as a result of a concentrated waterline curvature around x= -0.44, see also the blue line in figure 4. Therefore, the interference between bow and fore shoulder wave system is less favourable at this speed. Together with the large entrance angle this generates a stronger transverse wave system, even though the draught of the vessel is less than that of the others. This illustrates the relation between 'waterline curvature', 'pressure distribution' and 'wave making'.

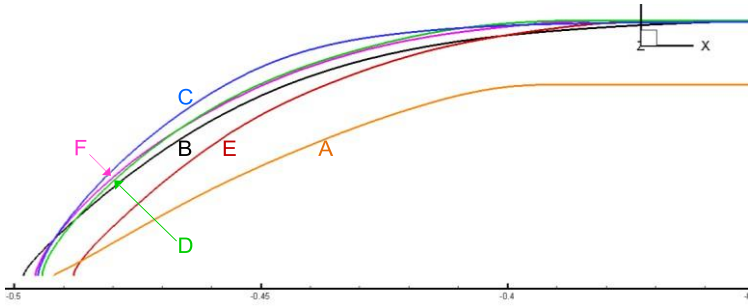

Figure 4: 2 m waterlines ship A-F

Small differences in the shape of the waterline can result in significant changes in wave height. Softening the fore shoulder in combination with the right position (during service conditions) reduces the under pressure and results in a positive effect on the resistance by decreasing wave making resistance. The bow shape of ship B results in the lowest transverse wave system. This fore ship has a slightly smaller entrance angle, an evenly distributed curvature and a relatively soft fore shoulder with the curvature at the right position. Subtle changes in the bow and fore shoulder shape and the position of the fore shoulder can have a significant influence on the wave pattern and therefore wave making resistance. By applying potential flow calculations this can be easily calculated and optimised. More on these types of analysis can be found in Larssen and Raven (2010).

In Van der Meij and Raven (2014), the findings with respect to the design of the aft ship are explained. In this paper the shape of bow thrusters tunnels is analysed, the stern configurations of the ships that participated in the SAVE project are analysed resulting in design recommendations.

3. HYDRODYNAMIC OPTIMISATION OF RECENT SHIP DESIGNS

In 2014 MARIN initiated a project to promote the optimisation of the hull of inland ships in the design phase. This project is realised with support of the Ministry of Infrastructure and Environment. Up till now four designs have been investigated and optimised. The fifth will be realised the coming months.

3.1 Optimisation of the 'Gouwenaar 2.0'

One of the designs is an inland container vessel specially designed for the trajectory Alphen aan de Rijn – Rotterdam/Antwerp. Starting in Alphen aan de Rijn, the ship sails via the 'Gouwe' to the lock in the city of Gouda, enters the 'Hollandse Ijssel' and continues the trip towards Rotterdam and Antwerp via bigger waterways. The fairway from the inland container terminal Alphen to Gouda, the Gouwe, is a CEMT class IV fairway and determined the dimensions of the ship. Figure 5 shows a containership on the Gouwe.

Figure 5: Inland container ship on the Gouwe

The design started with the specification of the number of TEU, the dimensions of the ship and a lines plan of an existing ship. The propulsion would consist of an electromotor directly on the shaft. The existing ship was propelled by two thrusters. The client asked MARIN to investigate the required number of propellers, and to optimise the shape of the hull, given the shape of the hold. Preliminary speed power calculation showed that one propeller in a nozzle should be sufficient to realize a speed of 16 km/h, with a draught of 2.6 m. and a water depth of 5.5 m. The required power in trial conditions was estimated at about 500 kW.

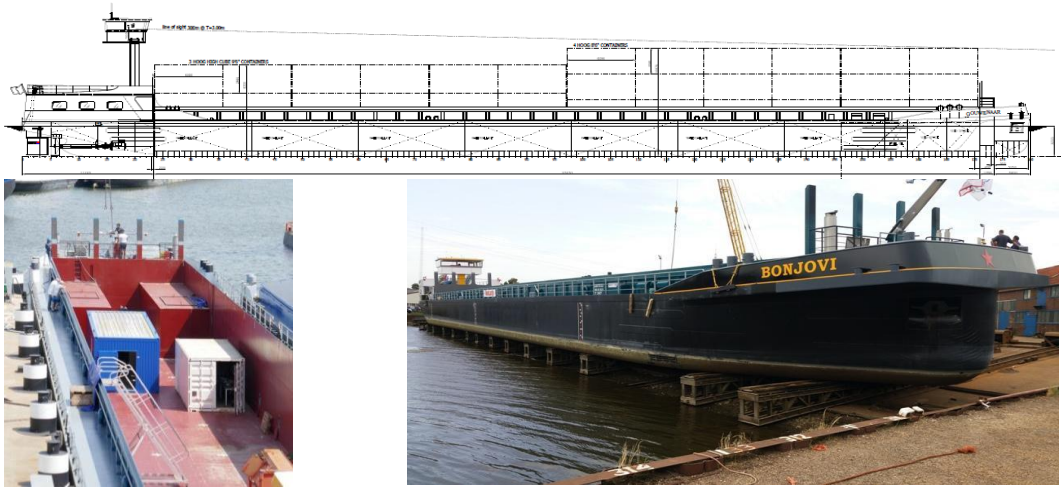

Figure 6: BonJovi, top: general arrangement.
left: view in the hold, right: on a slope before trials.

With respect to the shape of the hull, the type of propulsion, size of the hold (directly related to number of TEU) and displacement were given. The client opted for a hybrid propulsion: generator sets delivering the power and an electric engine driving the propeller shaft. The generators are situated in two 40' container box-space in the hold, figure 6, photo left. Because of this, the required space for the engine room in the aft ship decreased, allowing to raise the stern already directly under the electric engine in order to improve the flow under the aft-ship. Because of the dimensions of the hold, the fore ship remains blunt, also compared to the existing ship

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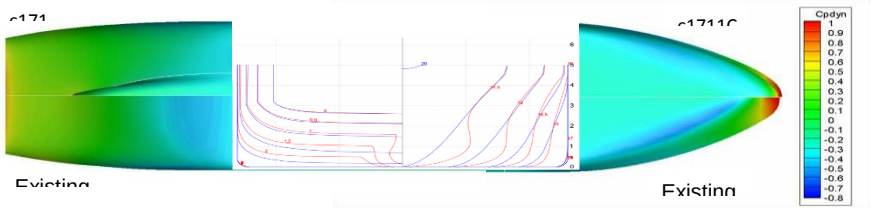
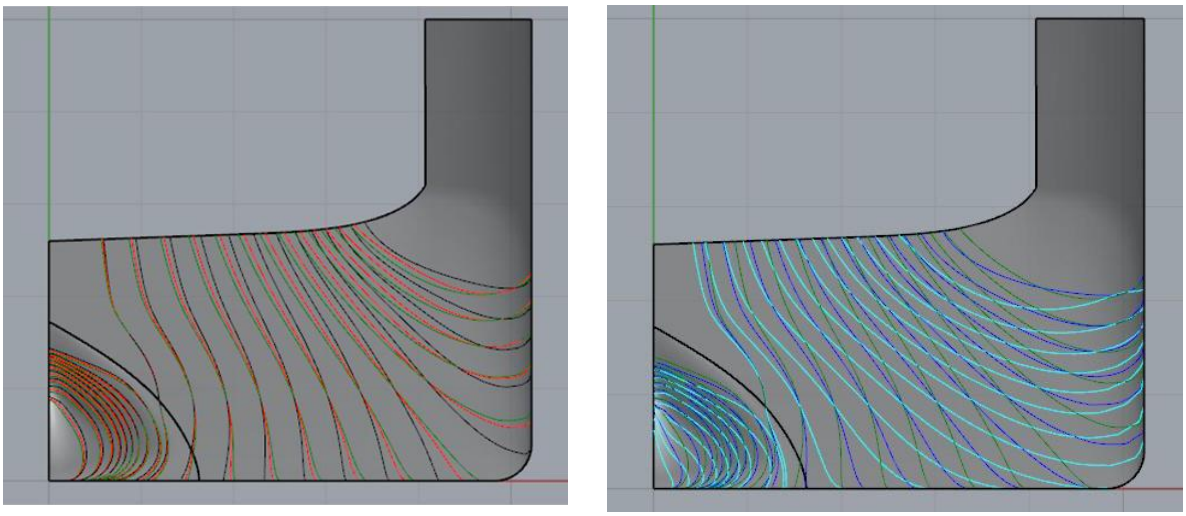


Figure 7: Left: pressure distribution aft ship. Right: pressure distribution fore ship Middle: lines plan: blue – existing ship, red – MARIN hull design c1711C

MARIN developed a fore ship with more volume, a wave profile almost the same as the existing ship, and an improved pressure distribution, see Figure 7, right-hand side.

In the aft ship a tunnel is applied to secure the flow of water to the propeller in ballast condition, see figure 10. This tunnel adds resistance during the sailing in loaded conditions. Given the findings in the SAVE project [Van der Meij & Raven, 2014], the flow around the aft ship was investigated for various water depths, applying potential flow calculation, see figure 8. In deep water the water flows around and under the ship. In the stern region, the flow direction is given by the black lines in the right-hand side of figure 8. Decreasing the water depth affects the flow, see the orange and the green line. The water flows slightly more from aside at a smaller water depth. Decreasing the water depth even more, resulting in an under keel clearance of 0.5 m at a water depth of 3.1 m, there is hardly room for the flow below the ship. So, in the aft ship the flow arrives more and more from aside, see the dark blue and the light blue streamlines in the left-hand side of figure 8. Given the sailing profile of the ship, the tunnel was aligned with the flow for the condition ‘water depth 5.5 m’.



Black: water depth infinite
Orange: water depth 6.5 m
Green: water depth 5.5 m

Green: water depth 5.5 m
Dark blue: water depth 3.9 m
Light blue: water depth 3.1 m

Figure 8: Streamlines around aft ship for different depths, draught 2.6 m, speed 13.5 km/h

Finally, the aft ship was analysed and optimised with viscous flow computations.

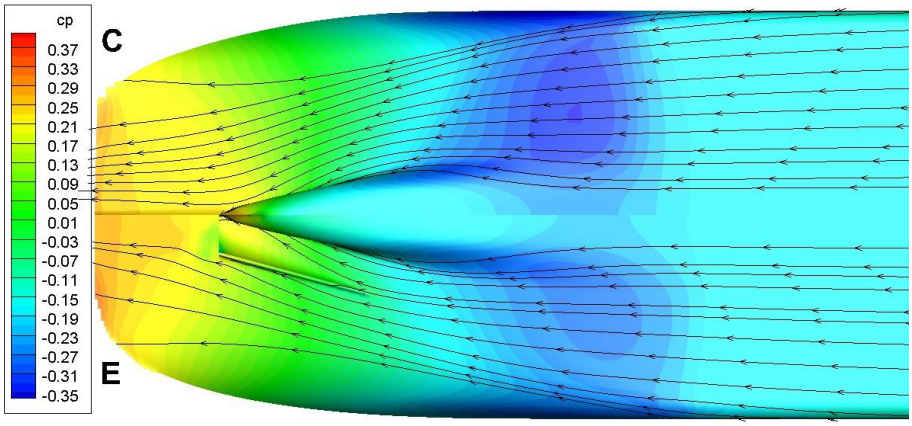


Figure 9: Streamlines on the hull, pressure distribution, c1711C top, c1711E bottom

Starting with hull design c1711C the tunnel was added, the bilge was softened and the transition from parallel midship to the aft ship was also softened, resulting in hull design c1711E. By this the pressure dip decreased.

In this design it was assumed to align the tunnel to the nozzle. There are different solutions known in the design of inland ships: the tunnel aligned to the nozzle versus a more widened tunnel, see figure 10. The motivation to apply a more widened tunnel is to provide a good flow of water to the nozzle and propeller, see figure 10. At the other hand this might lead to a flow to the propeller from aside. In this project a more in-depth analysis was not possible. This project was the motivation for a research project exploring stern configurations of inland ships focussed on different tunnel/nozzle configurations. This research is in progress.

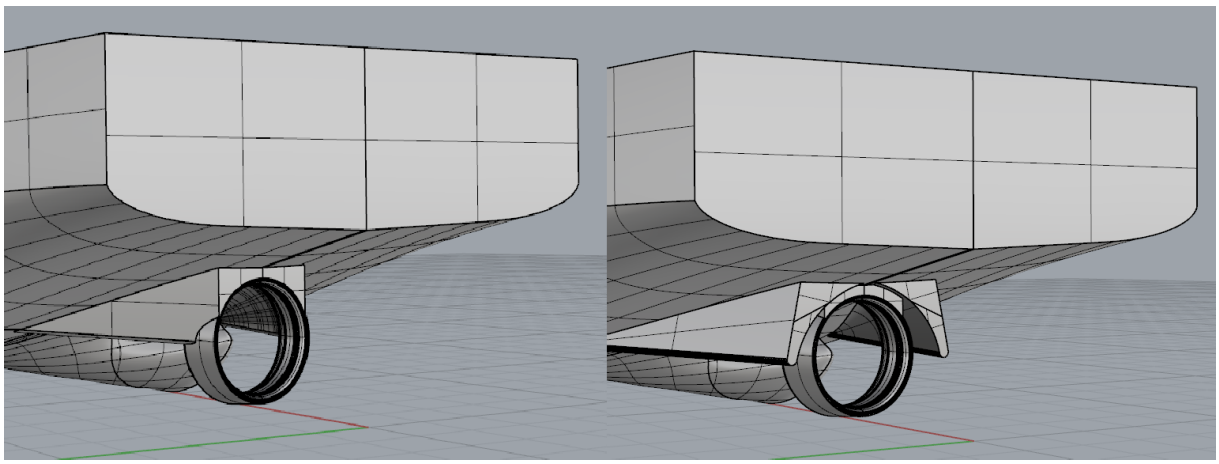


Figure 10 Different tunnel designs

Another relevant research in this respect is the TOPSHIPS project, in which MARIN participates since 2013. This project studies the impact of different stern parameters on resistance and propulsion in a systematic way, see Rotteveel, Van der Ploeg and Hekkenberg.

4. ECONOMIC ANALYSIS/tRHINECO

In 2014, 2015 MARIN participated in the tRHINEco project together with DST Duisburg, the University of Duisburg and the Radboud University Nijmegen. The tRHINEco project was developed within the scope and funding of the INTERREG IV, a European stimulation programme for the region at the German-Dutch border. The tRHINEco project aimed at identifying opportunities for Inland Waterway Transport focussing on continental cargo flows, see De Boer. In this project the focus was on the transport of 45' high cube containers on the route Rotterdam-Berlin, see Figure 11. The route is part of the TEN-T corridor North Sea-Baltic. (TEN-T: Trans European Network for (intermodal) Transport)

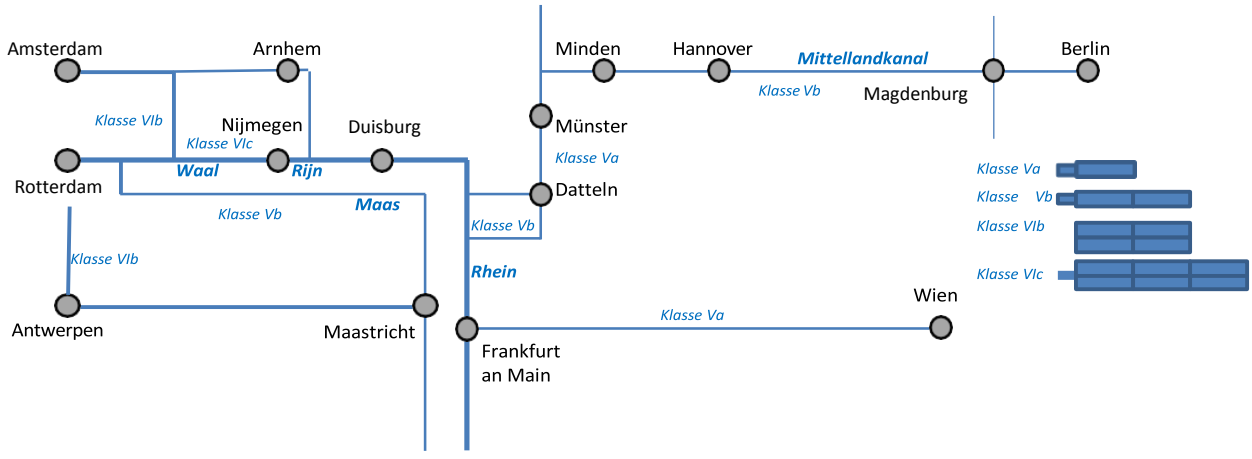


Figure 11 Fairways Rotterdam-Berlin

The German waterways are in a process of upgrading. The improvement of the east west connection

from Duisburg to Berlin, finally to the river Oder, is in progress. Around 2022/2025 the route from Datteln to Berlin will be fit for use for CEMT class Vb: a pushtow of 185 * 11.40 m^2 or an inland ship pushing a barge in front (a coupled unit). At the Havel canal, at the West side of Berlin, a container terminal is located (Havel Port Berlin).

A concept design was the development of a coupled unit for transport of 45' containers (continental containers). Until the completion of the upgrading on two parts of the route, the maximum ship-length allowed is 110 m.

The main requirements of this design are:

1. Coupled unit, ship plus barge: maximum length 185 m. Ship maximum length 110 m.
2. Barge with own propulsion because on two trajectories the allowed total length is 110 m: South of Munster for 60 km and in the Havel canal, the final 13 km of the route.
3. The dimensions of the hold of the ship allow the use of six 45'containers in length and four containers side by side, so that pallet wide, high cube containers can be used.
4. The coupled unit should be able to pass the bridges with a height of 4.50 m and with a load factor of 80 %. With an assumed weight of the cargo 50 % loaded containers, 50 % empty containers based on TEU's. (In this calculation an empty TEU weights 2.1 tonnes, loaded TEU 12.5 tonnes)
5. Maximum draught 2.85 m. Service draught about 2.10 m.
6. The ship should be equipped for sailing with four rows of containers in height, for example on the river Rhine. This impacts the range over which the wheelhouse has to be lifted.
7. The barge should be designed for certification as a ship on the service draught with two rows of containers, capable of sailing with a speed of 13 km/h on deep water.

The main aim of the design was to provide insight in the economic capabilities of this coupled unit.

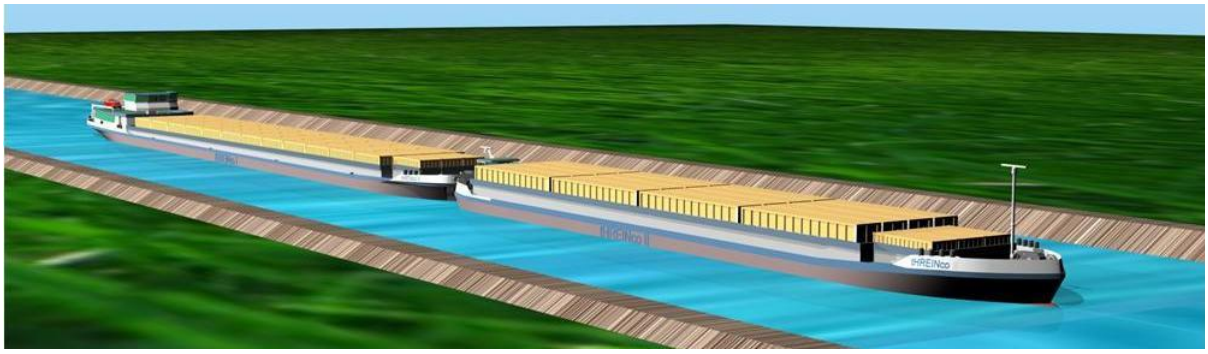


Figure 12: Impression of a 185-m coupled unit

For this purpose, a business model has been developed. This model has been validated in extensive discussions with ship owners and representatives of ING Bank in Rotterdam.

Two indicators were calculated to compare different business alternatives:

1. 'Payback Period'
   The payback method measures the time needed to recoup the initial investment. The alternative with the shortest payback period is preferred. Projects with longer payback periods claim funds over a longer period and cash flow predictions further into the future are less certain. This method is easy to understand. The major weaknesses are: it neglects time value of money and cash flows after the investment has been recovered are not taken into account.
2. 'Net Present Value – NPV'
   The NPV is calculated using the required rate of return (a percentage), which is the minimum acceptable rate of return on an investment. The NPV method calculates the expected net gain or loss from a project by discounting all expected future cash inflows and outflows to a present point in time, using the required rate of return. Ultimately, only investments with a positive NPV are acceptable: the return from these projects exceeds the costs of capital. In alternatives which are comparable the alternative with the highest NPV is preferred.

First different speed regimes were explored: a higher speed results in more roundtrips, so more revenues (assuming a constant load factor). At the other hand: a higher speed results in more fuel

consumption. The economic most attractive scenario was used to compare different business alternatives. In defining these alternatives, the following forecast with respect to the upgrading of the channels was used; The channels will be improved and upgraded over the next 5-7 years. As soon as this upgrading is realised the allowed maximum length will be 185 m.

The three scenarios were:

1. Building and operating a new coupled unit (ship plus barge) optimised for transport of 45' containers. Barge with own propulsion. This scenario is applicable in the existing channels.
2. Charter an existing coupled unit for the transport of 45' containers. These kind of ships and barges are designed for the transport of TEU's and 40' containers. They have less capacity for the transport of 45' continental containers and can operate in the existing channels.
3. Given the situation after 2022/2025, the channels having been upgraded, the maximum allowed length is 185 m on the route Duisburg-Berlin. In this scenario the barge does not need own propulsion.

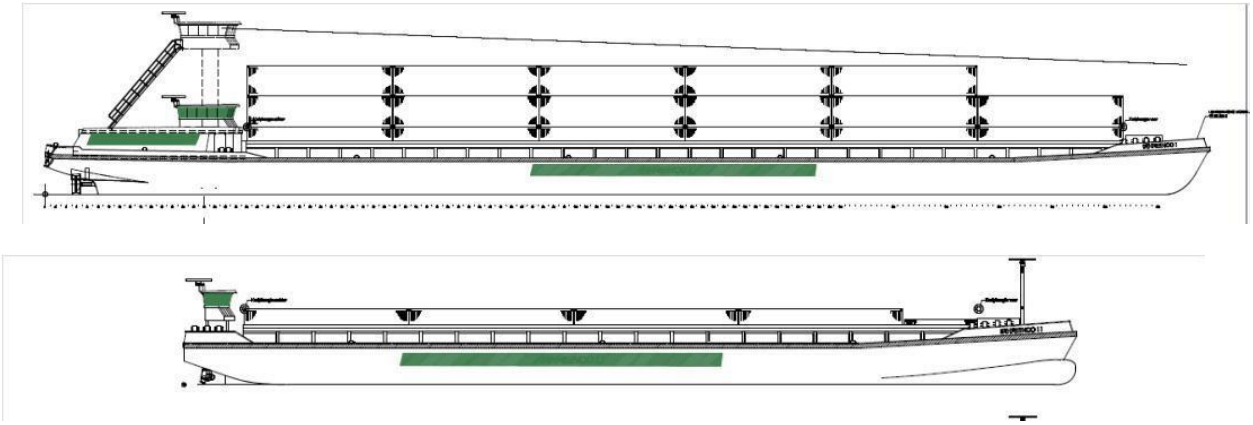


Figure 13 Side view of general arrangement ship and barge

Figure 13 provides some more detail of the ship and the self-propelled barge. The design of ship and barge were based on 4 rows of containers in height and four rows in width. On the route to Berlin the load capacity is restricted to two rows in height because of the bridges.

In Table 2, the three scenarios are compared with respect to economic feasibility. Given the assumptions with respect to costs and fees, chartering a ship plus barge is favourable. Chartering also means less risk if the transport of containers does not develop as anticipated.

If the transport volume is as expected, as soon as the channels are upgraded (2022-2025), the barge does not need own propulsion and investing in a coupled unit optimised for the transport of 45' containers could be an option.

	1. Ship & barge designed and built, barge with own propulsion	2. Ship & barge chartered	3. Ship & barge designed and built, no propulsion in barge (situation 2025)
Capacity (2 rows)	78 * 45' + 6 TEU	72 * 45' + 8 TEU	78 * 45' + 6 TEU
Fees	€ 510 / 45' € 255/TEU		
Payback time	9 years, 4 months	n.a.	6 years, 10 months
Net Present Value	€ 2,190,000	€ 4,200,000	€ 4,480,000

Table 2: The business scenarios compared

This study was performed in 2014. With the present knowledge, interest rates and fuel prices were decreasing. Different scenarios haven been calculated: lower and higher fuel costs and different interest rates. Table 3 below shows the impact on Net Present Value. Lowering the fuel price does not change the difference between scenario 1 and 2. The comparison between interest rate 5 % and 4 % learns that

if the interest rate remains relative low investing in a new coupled unit (optimised for 45' containers) becomes more attractive, especially from the moment the channels haven been upgraded and the barge does not need its own propulsion (scenario 3).

Finally, this kind of calculations can be of use if different ship design alternatives need to be compared in terms of costs and benefits.

	1. Ship & barge designed and built, barge with own propulsion	2. Ship & barge chartered	3. Ship & barge designed and built, no propulsion in barge (situation 2025)
Fuel € 600/m^3 Interest rate 5 %	€ 2,190,000	€ 4,200,000	€ 4,480,000
Fuel € 500/m^3 Interest rate 5 %	€ 3,450,000	€ 5,470,000	€ 5,670,000
Fuel € 600/m^3 Interest rate 4 %	€ 2,960,000	€ 4,580,000	€ 5,390,000

Table 3: Impact of fuel process and interest rate on the Net Present Value

5. CONCLUSIONS

Important points demonstrated by recent research and projects on inland ship design are:

- Subtle changes in the bow and fore shoulder shape and the position of the fore shoulder can have a significant influence on the wave pattern and therefore wave making resistance.
- Water depth has a significant impact on the flow around the ship. At a decreasing water depth (decreasing under keel clearance), more water will flow along the sides of the ship. As a result, the flow in the aft ship changes and the flow lines will originate more and more from the side of the ship.
- Today's computational tools can give important indications on possible improvements of the hull form designs that can save fuel.
- More research is needed and has been initiated with respect to the aft ship design of inlands ships.
- Finally, a ship operates in logistic chain. Financial metrics, for example the Net Present Value, can be of help in exploring different alternatives with respect to ship design and with respect to different logistic optimisations.

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THE HUMAN FACTOR RELEVANCE IN THE DECISION MAKING PROCESS FOR MANOEUVRING A VESSEL WHEN NAVIGATING IN INLAND WATERS

by

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ABSTRACT

The reduction of costs in maritime transport has imposed the construction of ships larger than those initially established for the ports, causing modification of its operational parameters. Any modification to be authorised by the Competent Authority demands several technical studies of navigation and manoeuvre under various conditions and scenarios. However, they do not usually consider the time needed in the decision making process by whoever manoeuvres the ship. It is necessary to take in mind that restricted water navigation is a complex navigation that imposes fast and correct decisions to the pilot or to the Captain, which explicitly represent the Human Factor in the success of the manoeuvres. By means of Monte Carlo simulation, the critical reaction time to maintain the vessel within the navigation channel can be estimated, considering the rudder angle variations used for the normally used speed ranges. On the other hand, the reaction times of the person who navigates and usually perform manoeuvres in the port area can also be estimated by interviewing harbour pilots.

Usually aids to navigation tools and key navigational points along sea coasts, channels and harbour and also river entrances contribute to the better perception of the scenario and greater awareness of the real situation. However, such features do not enter into autopilot simulations. Herein we consider that a comparative analysis of simulations using an autopilot and a critical analysis of that simulations conducted by different pilots may introduce the person feeling. This analysis will allow us to establish a criterion to introduce the human reaction time in the manoeuvres of a ship navigating in a channel (or harbour). So, the relevance of this study is the introduction of the Human Factor in the operational limits of ports, contributing to the safety of navigation.

1. INTRODUCTION

This work continues Adriana et al (2016) and is inserted in the context of MarCom WG 171 (2014), PIANC (2014) and IALA (2007), to investigate aspects of the Human Factor in the maritime filed as new channels design and seek to improve simulations with new type of vessels.

The main discuss is regarding decision making process for manoeuvring a vessel when navigating in inland waters, considering seconds prior to the rudder order to assesses the probability of the ship out of the channel, as the delay for the moment of turn. Captain or Pilots should consider the elements of navigation, vessel characteristics, and the influence of current, wind and waves, hydrodynamic effects, the bridge team behaviour, according to their individual perception, which is affected by other conditioning related to human factor.

To do this, first addresses theoretical assumptions are necessary for the better understanding of the

concepts employed in analysis, with technical issues related to the ship control and looking for elements that interact in the process decision, according to socio-technical model, called 'The Septigon Model' [Koester, 2007].

Then, presents the methodology for this work that in summary, separately analyses the data obtained from a questionnaire of the real situation at region under study, as well as, result from trials performed in a fast time simulator. Comparative analysis of these two tools, simulation and questionnaires, it appears that delays occur in reality and that these values converge to a maximum time of about 7 seconds. This one time is regarded as the tolerance limit for the start of the turn, with reference to the wheelover point in the various conditions of wind, current and waves.

This methodology allows concluding that it is appropriate to include the Human Factor in the Report 121 of PIANC among those considered for the channel width calculations, as well as other parts of new projects. Features as a suggestion that in real time simulations should include a 'time delay' in races evaluation and validation of conceptual designs, corresponding to the Human Factor. This 'delay time' must be obtained by convergence between simulations in fast mode and by applied questionnaires.

2. THEORETICAL REFERENCE

2.1 The Human Factor in the Maritime Context

Michelle et al (2008) define five tasks in maritime work focuses on navigation: navigation (route planning, maintenance of tracking and avoiding collisions), propulsion maintenance, cargo stowage, maintenance of the ship in all subsystems and ship command, which handles the allocation of resources, control, supervision and communication.

Human error is always present, and thus can be defined "an inappropriate or undesirable behaviour or human decision that angiograms – or has potential for reducing system effectiveness, safety or performance". For example, in Brazil, during investigation about safety of maritime casualties and incidents according to Brazilian Maritime Authority Standards nº09, many accidents happen due to human factor perception. So, it is concluded that the SHEL model (software, hardware, environment and liveware), used in the aviation world, tends to be replaced by 'socio-techinical system model', considering typical elements maritime environment, such as crews' nationality and culture.

2.2 The Influence of the Human Factor in the Decision Making Process

In analysis of future decisions, conditions or events dependent on an uncertain context, considered in the decision problem, are called states of nature. Sometimes in the literature, the states of nature are designated as scenarios, events, assumptions, among others, which lend itself to terminology. However, independent the context of decision problem, this assessment may result in:

- objective measurement, by observation of the real world; or
- estimation by application of an analytical model; or
- estimation by the application of a simulation programme; or
- subjective estimation.

Estimative regarding the decision-making process discussed in this study, were made subjectively, listening to the opinion of experts, pilots working in the area under study, collected by an elicitation process. It is noteworthy that according to Ayyub (2001), an expert can be defined as a very skilled person, with deep knowledge in a particular field of knowledge, and your opinion is a formal judgment on a subject matter or it may mean a belief based information or knowledge. Therefore, it is a subjective assessment, an estimate of the quality or quantity of something of interest, which seems valid, true or likely in the mind of the specialist. The elicitation process is a systematic approach in order to synthesise subjective judgments on a subject where there is uncertainty due to lack of data or when the data are unattainable due to physical constraints or lack of resources [Slottje et al., 2008]. Teixeira (2015) mentions that several researches and intense debates in different fields of science, such as psychology, statistics and decision analysis, discuss the proper way to treat an elicitation process, whatever its purpose. Due to the different characteristics of the areas involved, different problems are reported in this process. Despite the differences, there is agreement with regard to the fact that the analysis should not only take into account what are the questions that must be done, but also how these questions are asked. These facts have led this field of research to be strongly influenced by psychological

and cognitive aspects that influence the way people represent their information regarding uncertain variables, and how they respond to that information. Initially, studies were made by Tversky and Kahneman (1974) which identified three types of heuristics often used by people in defining their opinions: heuristics of representativeness, the availability and anchorage. Research has thrived on several fronts and there is a vast literature on this subject, largely devoted to identifying the factors that influence it, such as the works presented by Speirs-Bridge et al. (2010), Lin and Bier (2008), Tsai et al. (2008), Tetlock (2005). Another debate concerns the fact that it involves a group of several experts as the opinions may differ, and there may be hidden agendas. In this context, opinions can be elicited independently and then combined for consensus [Teixeira, 2015].

Thus, this work investigates the different perceptions and knowledge of individuals (harbour pilots), understanding that in the real-time simulations the response of each individual can be distinguished. As the simulations in fast time enable numerous races, it is pertinent to initially introduce amounts time delay arising from questionnaires answered by pilots, and such values can be validated in real-time simulations.

2.3 The Influence of Some Factors in the Turn

2.3.1 Navigation Planning and Ship Control

The maximum velocity inside the channel can be established by specific standards or the security term constant speed in Rule 6 COLREGs. This speed will be used in the planning of navigation, in particular by defining the Waypoints and Wheelover pair for each turn. This speed is correlated directly with the machine system, and has influence in the ability of the vessel make a turn and keep under control during the turn (control of rate of turn), considering the loading condition.

The characteristics of the ship design also influence their ability to turn and their degree of directional stability. The zig-zag test allows assessing the manoeuvrability of the ship, but such data are not included in the Pilot Card or Wheelhouse poster. Thus, the browser plans the point wheelover ‘by the book’, i.e. uses data from the Gyro curve, without being sure what speed the ship really is. It did not have knowledge of literature that shows the exact point and moment to change the wheel.

The use of wheelover point calculation methodology considering the speed and rate of turn is not accuracy because the ship will need to have and calibrated rate of turn indicator. There is a correlation table between rudder angle and rate of turn, and the rate of turn may vary uniformly or acceleration or deceleration, depending on the type of directional stability of the ship: stable, unstable or neutral.

Another important aspect is that the discharge in the rudder (flow) has influence in the ability to control the turn and the ship. So, it may occur that during the turn the water flow at the helm is not sufficient to control the ship, being necessary to increase the discharge if there is still such availability machine.

Thus, it is concluded that the theoretical reference for turn is not accurate and does not indicate when to use the rudder to ensure that the ship will not overshoot or remain in the channel. This results in the need to listen to the experts. It will be up to those with the manoeuvre to have their references to navigate and maintain control of the ship during the navigation and especially during turn moments.

2.3.2 Ship Loading Conditions

In spite of the fact that the previous item has already mentioned some characteristics of the ship that interest in the decision of the turn, there are others that also act in the capacity of turn and control of the ship.

Even keel – a vessel may change its directional stability characteristics according to trim. If trimmed the bow can to behave like an unstable ship, for example. The trim situation does not go into the curves available to the navigator or to those in the manoeuvre.

Likewise, the block coefficient of the ship has direct repercussion on its stability, especially considering the coupling of the axles.

The results are the zig-zag curve can give ship behaviour clues, but still do not include the trim variations.

2.3.3 Environmental Factors

The visibility can be a decisive factor to reduce speed, no longer the one on which the browser was based for calculations of the wheelover point. Winds and currents lengthen or reduce the turning curves, but also have the ability to slow shifts head's angle according to the location, intensity, angle of attack and format of living works in the case of currents; area of exposure, position, angle of attack and intensity in case of winds. In the case of waves, may be delaying the shift depending on the height, speed, timing and angle of attack. So, these forces must be understood and compensated.

2.3.4 Shallow Water Effects

The shallow water effect tends to lengthen the turning curve. The vessel may have greater directional stability, retarding its yaw.

The behaviour of the ship in shallow water can be estimated by observing the Wheelhouse Poster, where there is a turning circle for shallow and deeper waters. From the questionnaires, it was found that the wheelhouse poster is rarely consulted, being worth only the expert of his experience of previous manoeuvres and feeling.

2.3.5 Bridge Team

Pilot Card counts the time of movement of the rudder. However, the time between the order to the rudder and effective demand for the steering system is difficult to measure and may depend on the nationality of the crew. This fact was reported in the questionnaires. On some ships, the helmsman expects the Commander repeat the order, if there is practical; in other ships, the helmsman jumps a little, checking if he is taking the helm to the right edge; there are still situations where the helmsman asks to repeat the order.

The experts use the first twists to measure this delay. Thus, it appears that the interaction d bridge team influences the delay of the yaw.

3. METHODOLOGY

3.1 Contextualisation

The navigation area studied, as well as the input data on the simulator are the same as Adriana et al. (2016).

3.2 Approach

The chosen method of approach was the phenomenological [GIL, 2008], and used the technical methods of research employees: experimental and observational [GIL, 2008], and comparative [Lakatos and Marconi, 2007]. The phases for the research were theoretical preparation, field work; data processing; analysis and interpretation of data; and the elaboration of this work. This work has a theoretical and practical genre [DEMO, 2000], and can be considered an applied research.

This work group is composed with a multidisciplinary characteristic and specialised people, oriented towards the objective it proposes. The field work was divided into two phases: form and simulation. The questionnaire was prepared based on Aaker (2001). The objective of the work was informed both in the email that sent the attached form and in the body of the form. The questions were selected to attract the pilot for an easy job, with expected execution time in 15 minutes. Part of Human Factor, item 1 of the questionnaire was based on a questionnaire applied by the Research and Prevention of Aeronautical Accidents Navy thus consecrated use. Part of the 'Perception of navigation' was drawn up specifically seeking to know the important aspects that should be known for use in simulations. Closed, open, semi-open, dichotomous, and chained questions were asked. The questionnaire was individual and it was sent by electronic mail to all 74 pilots from pilotage zone 15 - ZP-15. Twelve questionnaires were received, representing 17 % of the total number of pilots. The questionnaire answers received can be considered valid, allowing a qualitative and quantitative analysis.

4. DATA ANALYSIS

4.1 Simulator

Adriana et al. (2016) considering that the human factor is expressed in the decision-making regarding the moment of the turn, a delay value was inserted in the positioning loop of the ship in fast mode.

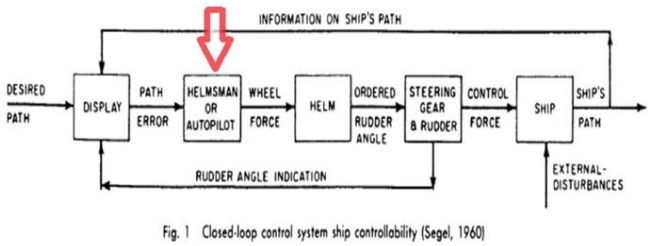

Fig. 1 Closed-loop control system ship controllability (Segel, 1960)

Figure 1: Closed-loop control ship controllability (Segel,1960).

The graph below shows the probability of channel output as the delay time (in second) increases.

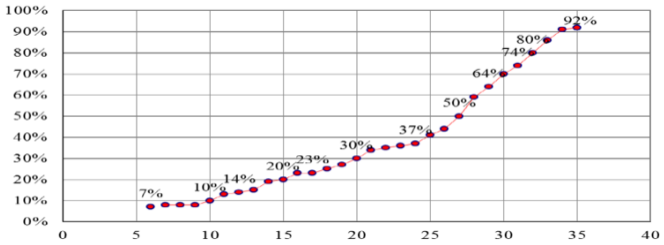

Figure 2: Probability exit channel x time delay

The graph below illustrates the navigated away out of the channel, the delays in the yaw.

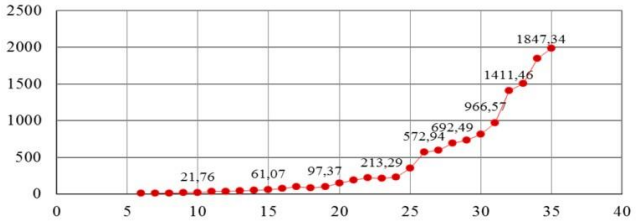

Figure 3: Distance navigated out of channel x time delay

It should be noted that delays in the sour cherries do not necessarily imply the exit of the channel, because the environmental conditions are different and contribute to the ship remaining in the channel. So, this situation amounts to influence the experience of the expert, which in a real situation purposely delays the shift to offset the environmental effects.

Another important aspect with regard to the simulation was that the ship's exit occurs on both banks of the channel, either by the advance and the depreciation in the margin, or by the overshooting in the margin, at some point after the waypoint. It is concluded that the manoeuvrability is directly related to the success of the manoeuvre.

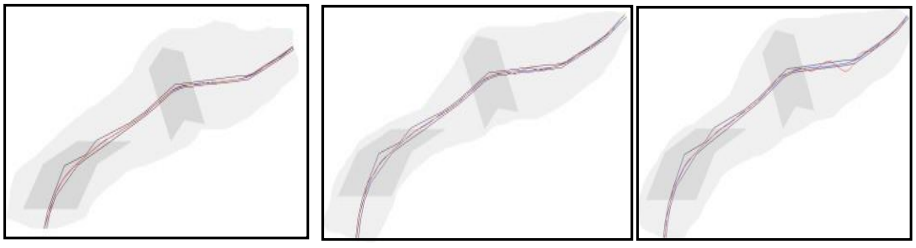

Figure 4: Results of simulations runs – time delay of 0 seconds, 10 seconds and 20 seconds, respectively. 4.2 – QUESTIONNAIRES

4.2.1 The Main Results Obtained in the Questionnaires Were:

- ✓ 75 % have difficulty to sleep between manoeuvres, with 50 % sleep 4 hours between manoeuvres;
- ✓ When not working 100 % sleeps between 7 and 8 hours; and claim that the period range is sufficient;
- ✓ 83 % says that they are be adapted to the pace of work;
- ✓ 83 % say they consult the Pilot Card;
- ✓ 75 % do not use the Wheel House Poster;
- ✓ 83 % say manoeuvring feeling ill or tired;
- ✓ 75 % indicate that warn colleagues when they notice any errors, 100 % said that have good relations between pilots, 83 % confirm that disclose physical changes in the workplace, and 92 % report their mistakes to colleagues;
- ✓ 100 % indicate that they have good relationships with captains and crews and 83 % prefer to work in groups than alone;
- ✓ 92 % well informed they feel about standards, charters and technical material.
- ✓ 83 % perceive as good the physical conditions (light, temperature, noise) of work;
- ✓ 100 % feel fully qualified for work and 83 % realise that they will always be held responsible for the occurrence of accidents; and
- ✓ 83 % do not feel compelled to make risky manoeuvres for financial reasons and 66 % will not feel compelled to make a manoeuvre faster to start the next.

Thus:

- It is found that there is little chance of fatigue occurrence, since the period between scales is enough to rest, as well as the number of hours of sleep.
- On the other hand, the interval between manoeuvres does not allow physical and mental replacement, and there is a tendency for the pilots to work with some tiredness.
- The good relationship between pilots allows for a good exchange of experience and mutual learning, as a result of observations and analysis of one's mistakes and colleagues.

- Pilots like to work in groups and have good relationships with captains, so bridge team work can be enhanced.
- The Practical seek to be up to date technically.
- The conditions of work environment tend not to negatively influence the manoeuvre.
- In spite of feeling fully qualified, there is a feeling that will always be held responsible in case of accidents.

- Fortunately, for most, is not admitted abnormal risks for financial reasons, but it is possible that some do their manoeuvres faster to be able to meet the next manoeuvre.

4.2.1 Perception of Pilots during Navigation and Manoeuvres

The main results obtained in the questionnaires were:

- ✓ **Anxiety** – some pilots decide to anticipate the order to the helmsman to avoid the risk of delay on the manoeuvre and, sometimes, to make sure the change on course will occur ‘just in time’.
- ✓ **Situation awareness** – distraction, wrong perceptions, too much noise and lights on the bridge may reduce the perception.
- ✓ **Fatigue** – pilot may be performed many pilotage duties on the same day, or work on consecutive night time makes the pilots tired and it may cause some disturbance on the perception or delay on reaction.
- ✓ **Crew nationality** – misunderstanding by foreign crew can cause a stressful situation or even a dangerous situation if the order is not correctly understood and performed.
- ✓ **Crew delay on response (bridge team)** – in some ships the helmsman waits the master or the mate repeat the pilot’s order and it may cause a stressful situation.
- ✓ **Estimated vessel position** – when navigating in inland waters there is no time enough to check the vessel’s position on the nautical chart. Electronic Chart Display and Information System (ECDIS) installed on vessels is helpful but neither all have the same accuracy, charts updates and depending on circumstances, for instance, low visibility, the showed position seems not to be exactly the one estimated by the pilot.

- ✓ **Ship behaviour** – for a precision manoeuvre, the pilots need to know or estimate the reaction of the ship to the rudder and engine. Speeds different from those described in the pilot card is a clear indication that the ship is unknown even by the crew. This situation affects how and when the pilot manoeuvre the ship and wrong perception or ship's response may cause delay.
- ✓ **Aids to navigation available** – for some pilots, buoys are extremely important when navigating on a channel at night. On the other hand, some pilots also described that signal lights at night are not good and may cause confusion regarding vessel position (visual perception). Mistakes may occur if one buoy is unlit.
- ✓ **Channel geometry** – time delay is more common on curvilinear channel sections than rectilinear ones. Vary narrow channels increase the situations awareness, but also make then stressful, affecting the perception.
- ✓ **Environmental conditions** – the moment sea conditions (mainly sea spectrum) have an important influence on the decision related to change vessel's course, speed and heading in order to keep vessel on position. Bad sea conditions also make pilots concern about disembarkation, dividing the attention between the manoeuvre and the correct conditions for a safe disembark.

4.3 Comparative Analysis between the Results Collected in Field

4.3.1 Main Deductions

Comparing the analysis of simulation and questionnaires, it is concluded that:

- ➢ The convergence for values between 7 and 10 seconds for the delay time validates the simulation data.
- ➢ The draw technique of environmental conditions shows that delays higher than the values do not necessarily imply leaving the channel. The conclusion is that the turn delay occurs precisely to compensate for environmental conditions, according to the pilot's expertise.
- ➢ Practice makes personal standards established, even if there is different perception for different manoeuvres. This goes for real manoeuvres and simulators.
- ➢ This time delay value can represent a common maximum delay time pattern between different pilots. In this way, it can be used to increase the degree of realism of the races performed in full mission simulators, since the introduction by the Control Group of delays in the decisions taken during the simulation. This becomes important because in the simulations to evaluate new projects, successive races are performed by a small group of pilots, who end up repeating patterns with each race, as the unknown controllability in a ship becomes more identified with each race.
- ➢ The simulation performed did not evaluate the result of anticipated turning.
- ➢ During the turn the reaction time decreases to approximately 2 seconds, indicating that the situation awareness changes during the turn.

4.3.2 Proposals for the Introduction of the Human Factor (Design and Simulation)

4.3.2.1 Simulation

Aspects related to the simulator and the questionnaire, it is worth stating two questions, which permeate the contents of this work: how can we increase the level of realism regarding human factor data when performing simulating runs? How can we introduce human factor evaluation on conceptual design parameters of a harbour (width design)? To answer these two questions, this work proposes the following procedure as an approach:

1st step – obtain an estimative time delay (ETD) to be considered on fast time simulations (pilots interview)

2nd step – perform fast time simulations (t=0, t=ETD and t=2x ETD) 3rd step – results analysis

4th step – perform real time simulations to obtain real time delay – RTD)

5th step – comparative analysis ETD x RTD

6th step – perform fast time simulations with RTD 7th step – results analysis

8th step – evaluate the human factor relevance in the decision making process for manoeuvring a vessel when navigating in inland waters

4.3.2.2 Channel Design

The channels and manoeuvring basins that follow the PIANC (2014) calculations already consider several factors (in the case of channel width, 13 factors). However, in reality, the factors presented in item 2 affect the manoeuvre, and other elements intrinsic to the man affect his decision process. Thus, it is to verify the feasibility of the project in real-time simulators.

It is important to emphasise that as the races are carried out, there is a learning process in a controlled environment – this means that there are more hits than mistakes. In addition, races are performed by a small number of people, who may not express all the personal characteristics of everyone who makes the manoeuvre. To correct this feature of the simulation, the Simulator Control Group can introduce delays in the fulfilment of given orders. For example, when the rudder order is given 'starboard 10', the helmsman only responds with 5 seconds of delay – this will allow to verify if the design of the channel is sufficient to guarantee that the ship stays in the channel, for possible evaluation errors.

Thus, the project may be adjusted so that the ship does not leave the channel in the next kick to a significant shift from one side or the other channel.

The aspects mentioned as Human Factors Components that tend to cause delays should be raised and dealt with separately, but as part of the project, each should be monitored and evaluated continuously.

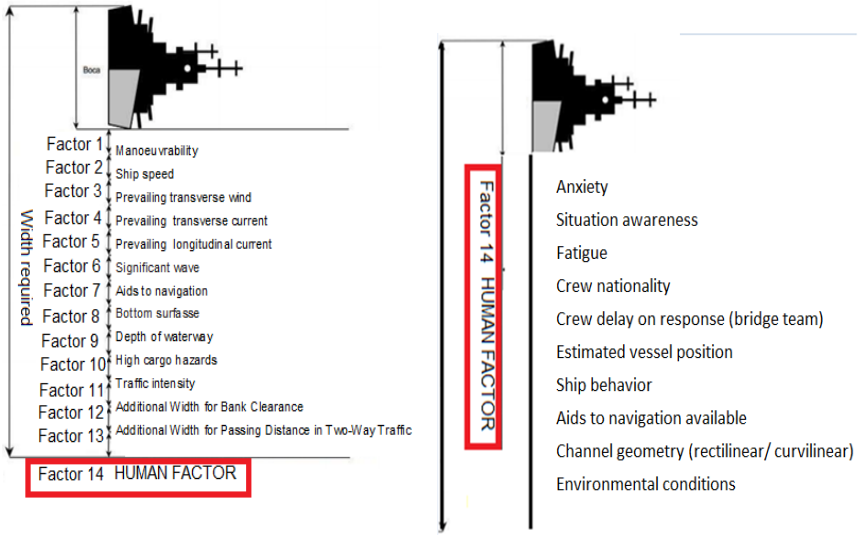

Figure 6: Proposal to consider Human Factor in comparison PIANC (2014)

5. CONCLUSION

The decision process is critical for a new design to succeed. The modification of the machinery regime and the use of the rudder represent the possibilities of using forces that, in addition to the external ones, hydrodynamic and those intrinsic to the design of the ship will cause the ship to remain in safe waters.

In this work, it was verified that the order of magnitude of the time so that one can perceive the moment of turn and the execution of the yaw varies approximately 7 to 10 seconds. These values were obtained by comparing all the information collected in questionnaires applied to practical and fast mode simulations.

Calculations for wheelover are only references to the swings, the practical use their experience to adapt the theory to practice, making up for all effects and making the shift at the time it deems appropriate, including any adjustments to the influence of the bridge team. During the shift, the time between the perception of the situation and the use of the rudder, if necessary, to keep the saw in the channel drops to about 2 seconds, indicating that the situation changes if awareness. That is, the Human Factor undergoes changes along the crossing.

In real-time simulations, in full mission simulators, this Human factor also undergoes changes,

including by learning each race. To obtain more realism in the evaluation of new projects, it is proposed to introduce delay times in rudder orders and/or machines. The time of this order of magnitude will depend on previous simulations in fast mode and interviews with the practical or commanders, the new project members.

The Human Factor should definitely be incorporated into the project in calculations of channel dimensions, manoeuvring basins, etc. There must be some slack for variations in decision times. In a systematic way, the aspects raised that affect the man that is in the manoeuvre, must be treated in a systematic way parallel to the development of the project.

6. RECOMMENDATIONS

Pilots and Captains should seek to establish their own brands of wheel over point, trying to get with the help of Bridge Team a distance or marking a conspicuous point, every time yaw based on feeling, for each type of vessel. This procedure will establish another alert to reach the starting point of the turn.

Reducing the noise on the bridge when approaching a turn, placing an Officer next to the helmsman in order to correct it in case of error or not understanding the order given to him.

Check the passage plan before starting the manoeuvre, paying attention to plotting the wheelover point.

Include on the bridge of ships the results of the zig-zag and the pull-out tests. On ships, include the wheelhouse sheet together to the Pilot Card, as well as the results of these tests.

Use the time obtained in this type of simulation to be used in the simulations to evaluate new terminal designs or to use new classes of ships, so that the number of races performed contains the Human Factor through the delay of the decisions of who is in the manoeuvre.

Use the same methodology on another channels or harbours in other to validate or perfect it.

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LINKING MODAL SHIFT TO INLAND PORTS

by

Bruce Lambert

ABSTRACT

There has been considerable interest in developing container on barge services in the United States. Several container on barge services have been attempted within the United States, but with various degrees of success. [Kruse, 2010] The role of inland navigation and the importance of ports to attract and retain cargos remain just as important to supporting these services. This presentation will seek to identify some of the common elements that have been shown to be successful in developing inland navigation services, while also identifying possible cargos that could be divertible to inland waterways, with a focus on divertible/containerisable and oversized/overweight cargos.

The presentation will examine the relative costs of moving various cargos through the United States, including discussions on inventory carrying costs and other related supply chain considerations. At the same time, the presentation will review what types of cargos could potentially be attractive to waterways, based on linkages to global and/or specific domestic markets. Finally, the study will discuss the role of inland ports in approaching governments, shippers/carriers to understand the relative benefits of waterway traffic.

This final point, that decision makers may not understand the commitment required to support modal shifts to waterways, should reflect that these commitments require a long-term view concerning the role of the port and its related cargos, as they may potentially benefit their local communities.

Oftentimes, these decisions are treated as simply a ‘quick fix’, so focusing on what has worked, and not worked in the past, should provide some areas of discussion when examining the potential for the nation’s waterways.

1. INTRODUCTION

A true dilemma in transportation centres around the fact that these robust systems exist with heavy social dependencies, yet there are shortfalls when explaining how we can better leverage resources and why specific systems exist and require public participation. This paper will discuss some thoughts on this shortfall and how containers on barge services could succeed on domestic waterways in the context of a public-sector infrastructure provider, such as a port or a government agency.

There are three core questions to consider: (1) Why would containers move on domestic waterways? (2) What are the supply chain considerations of these moves? (3) What are the public benefits to support such activities?

This paper discusses some of the costs associated with discussing mode shift to container on barge by comparing mode shift to the experience of rail-highway intermodal shifts. The paper also discusses mode shift from the perspective of satisfying both carrier and shipper’s needs, and that the public sector is somewhat limited in its ability to start such services without addressing the business case for container on barge services.

To initiate the path leading to answer to these unveiling questions, we should not only discuss mode choice, but also discuss who has responsibly for what part of this transportation system. The public and private sector roles need to be clearly defined. Figure 1 is a visual representation of the divided roles – the horizontal public sector creates the foundation upon which businesses flourish. This sector provides utilities, transportation networks, regulatory oversight, workforce education, etc., and other supporting activities. [Pallme, 2015]

The vertical private sector is composed of the shippers (cargo owners) and the carriers (providers of transportation), who create jobs, the warehouses, the sites, etc. that generate economic activity. One could conclude that the ground level or below represents public sector responsibility, while everything above the ground is private sector activity.

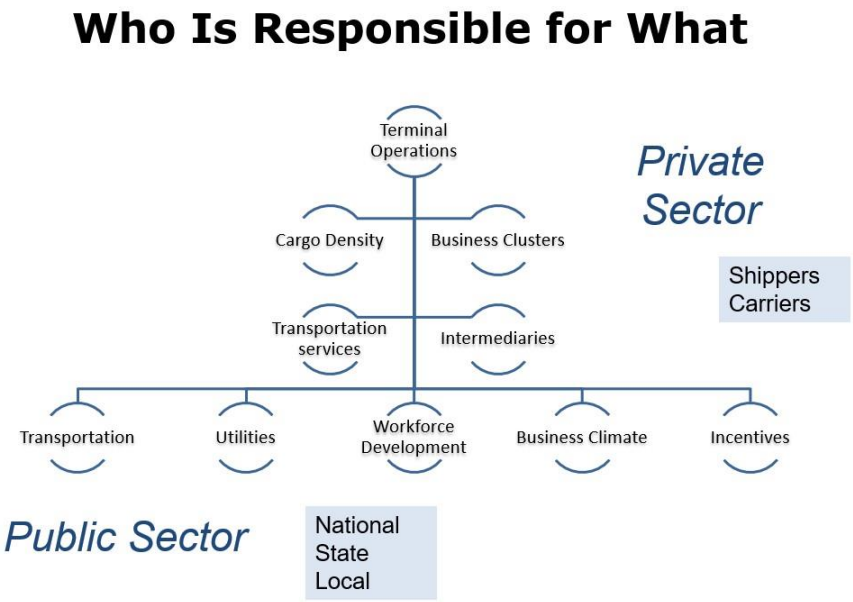

Figure 1. Public and Private Sector Responsibilities

Mode is decided within the private sector, where they are the intermediaries of stevedores and customs house brokers. They choose immediate transportation options available to them now and not in the future. The private sector arranges transportation with a close look at cargo activities and terminal operation, while trying to find ways to leverage business clusters and partners in a region. When we discuss how to encourage mode shift, it really boils down to if a shipper or the beneficial cargo owner can tell his boss, “I put my container in this mode”. Thus, the barge service can satisfy their shipment needs at a low-cost reliable service, whereas, a carrier can operate profitably.

As such, there are three main elements to the question of mode choice: a) cargo service needs, b) the shipper’s expectations, c) the public-sector response.

When making comparisons between mode choices, you might begin with considering average speeds between truck to railroads or waterways. For example, when looking at rail intermodal market share there is a trade-off between the rail and highways speeds. Distances over 700 miles are competitively served by rail cars, while shorter distances are better served by trucks (Figure 2) (Federal Railroad Administration). A truck moves 50 to 60 miles per hour, while rails move 25 to 30 miles per hour, and water moves 5 to 7 miles per hour. We must look at the low rate of speed that water transports in comparison to other modes. Notably, trucks must take rest stops, while trains stop in terminals or sidings, and waterways stop for lockages when necessary. Each mode has associated delays within their operations, so the total time should include not only transit, but also all the intermediate stops in-between.

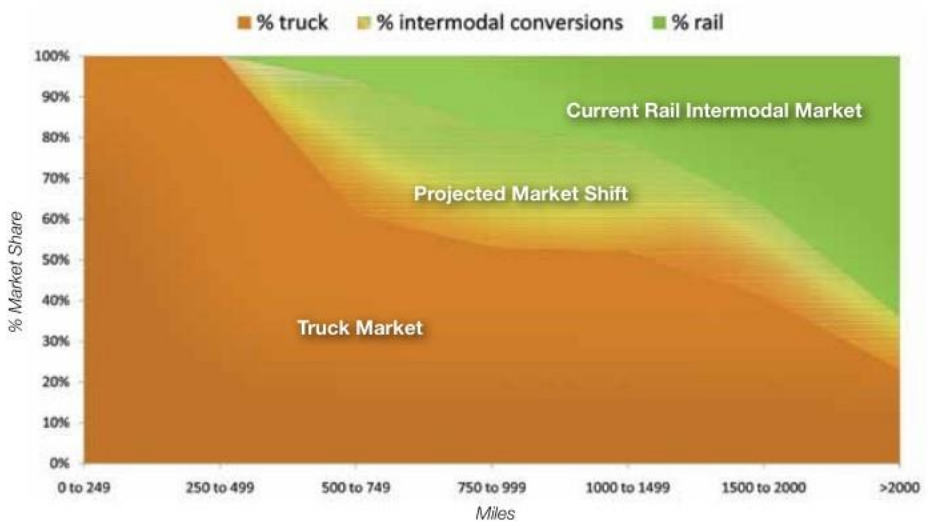

Figure 2. Rail Intermodal Truck Cargo Market Share by Distance
[United States Department of Transportation, Federal Railroad Administration, 2010]

There is not a similar mode share comparison for highway/rail for intermodal cargo as in Figure 2, but knowing that service band would be helpful to decision makers.

Concluding with this thought: How do we encourage people to think about waterways as a practical alternative for certain types of cargos? The repeated problem is that we have this slide of large barges to trucks and rail cars. If we focus on pure volume (scale), and not necessarily on service, large volumes of containers move off the highways and through various domestic ports (Figure 3) [National Waterways Foundation, 2017]. Carrying a significant amount of cargo does not guarantee the expected service requirements that a shipper requires.

Figure 3. Modal Capacity Comparison

Shippers do not care about scale, beyond their own cargo. Unless they are moving 1,000 semi-trailers in a single direction, their focus is on what service inland waterways can provide. Therefore, we tend to see a general pattern (Figure 4). Cargo is more likely to move via truck or air for time sensitive shipments; on the other hand, water tends to handle large, less time sensitive shipments with lower per unit costs.

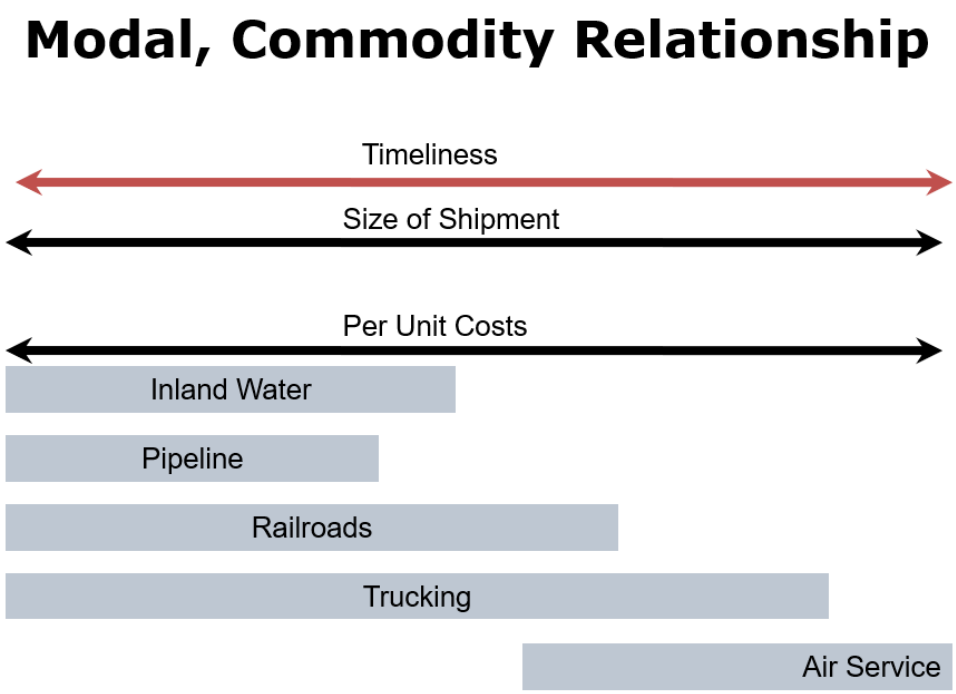

Figure 4. Modal Choice Considerations

There is this trade-off that people make. T he more expensive the product, the more likely air or trucking will be the mode selected. Depending on the shipment size, people are more likely to use water, rail or pipeline for similar cargos. As a result, there is always this prism upon which people base the mode they are going to select based upon the value, timing, and size of the cargo.
A high quantity of barge traffic moves between facilities, such as coal or chemicals. There are many small barge configurations moving up to a distance of 50 miles, which highlights opportunities where the barge industry can leverage truck comparable services using these smaller barge configurations.

Shippers can always adjust supply chains with an extended timeline. For example, firms utilise global supply chains to source and export cargo. There are costs associated with transit times such as inventory carrying costs. Extended transit times may result in higher costs than if the cargo is moved quickly to a 'sale'. If a shipment is going from Asia to the United States – a 40-day delivery cycle can be expected. If the timeline is already long, perhaps another two or three days could be considered if the result is delivery at a lower cost. This is the story railroads developed in the 1980s. Railroads are selling intermodal service which takes trucks off the highway and puts them on the rails with comparable service. [Monios, 2013]

The shipper will generate traffic that can support containerised barge services (pending of course, a carrier offers a competitive service that is profitable to run). For example, when starting a Container on Barge Service along the Tennessee-Tombigbee Waterway, SeaCor identified their cargo market in both directions to understand the competitive trucking rates. In addition, they provided storage for equipment and containers aided by a tax exemption from Mississippi to encourage firms to use the service. SeaCor made the service both reliable and cost effective with incentives to help mitigate the shipper's risk by having tax exemption.

Shippers want to mitigate the risks for using a new mode of transport and establish a relationship with the carrier. For example, if my transportation intermediates do not use barge services, my cargo will probably not move on the waterway. Shippers must balance inventory costs along with the cost associated with unexpected delays in their supply chains. Effectively managing supply chain variability lies at the core of most logistics systems. As a result, shippers hope to manage with a single point of contact, someone who can offer simplified methods while mitigating all possible failures.

Waterways provide a viable alternative that should be heavily explored, as the private sector recognises that highway and rail congestion is a true issue. There are multiple studies on containerised inland

waterway traffic that reveal overlapping cargo catchment areas which results in less attractive sites for intermodal facility expansion unless the cargo activity is supported in both inbound and outbound moves. The market must generate the density that a carrier needs to develop/operate these types of services. When we talk about how to move more truck cargo onto the waterways, we should look at services that offer comparable operators to trucking. Due to the economic geography of the United States, we cannot assume that waterways are a possibility everywhere, but could work when price, service and demand can be matched.

2. CONCLUSION

Can waterways work? Yes, they work now. They have worked in the past and they can work in the future. We forget the basic story – waterways might be a choice for certain markets with all facts considered. Can we assist in getting people to the waterways or to think about waterways as a part of their business? This can be challenging to answer, as shippers, carriers, logistic intermediaries, and even economic development professionals need to be informed on waterway options.

To start, we must collaborate on operating container on barge services and manage expectations for all participating parties. As the number of services that have started and stopped over the past twenty years will show, we have had many experiences to examine how to encourage modal shift to waterways. You are the best champion for your stretch of river. Shippers, carriers and port authorities also depend upon that river – and you.

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HYDRAULIC REGULATION OF 'CANAL DEL DIQUE', A PROPOSAL OF INTEGRAL ENVIROMENTAL RESTORATION

by

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ABSTRACT

In the Caribbean coast of Colombia, the project for the restoration of degraded ecosystems of the Canal del Dique is underway, led by the Fondo Adaptación of the Colombian Government. As a response to the effects evidenced that have directly altered the dynamics and structure of the lotic and lentic water bodies of the system, and modified the marine ecosystem bringing estuarine functions to bays of Cartagena and Barbacoas. As a result of the 2010-2011 Niña phenomena, water levels within the Canal del Dique increased, causing a breach (km 3), flooding the south of the Atlántico Department and from there downstream to Gambote village in Bolivar Department (km 66), and affecting the ecosystems associated to the channel. In order to prevent, mitigate, correct and/or compensate for the effects of degradation in the system, the implementation of engineering works was organised to control the water discharge entering the Canal from the Magdalena River, and to diminish the sedimentary contributions to the associated bodies of lotic and lentic type along the channel. Activities to increase water levels in the Ciénagas (lentic) have been developed, guaranteeing the supply of the fish resource and the preservation of strategic ecosystems. The project incorporates the effects of climate change, which allows projecting the interaction of the sea with the coastal zone. This strategy integrates the degraded ecosystems of the terrestrial and marine protected areas and the lotic and lentic water bodies. Cushioning the effects of future extreme climatic events such as El Niño and La Niña phenomena, and to prevent future floods, maintaining the dynamics of the Canal del Dique, navigability and stabilising the elasticity in the Ciénagas, with a decrease of tensors on the Marine ecosystems, a condition that will allow grassland, mangrove, corchales, coral reef and littoral ecosystems to restore their environmental services through resilience mechanisms.

1. INTRODUCTION

The Canal del Dique is located at North-West of Colombia. At present has a length of 116 km and establish an artificial fluvial way to connect the Magdalena River, (one of the principal Colombian waterway), with the Port of Cartagena. Hydrocarbons, source materials and other products are transported through the river from the centre of Colombia to the Port of Cartagena and vice versa. Furthermore, the canal has other functions like water supply for treatment to Cartagena City and other village in its banks. Gives water for agricultural activities and in rainy periods feeds with water the associated 'Ciénagas' (shallow lagoons) securing the entrance and interchange of ictics species, which invigorate the fishing offer of this systems.

During La Niña period in 2010, there were exceptional water levels that made a breach in the protection levee in the K3+200, flooding a vast area at south of the Colombian Caribbean, affecting villages, crops, irrigation district, livestock areas among others.

From this fact, the Colombia goverment, appointed Fondo Adaptación, entity attached to Finance Ministry, to attend the emergencys made by the rainy period in 2010 and manage projects to adapt Colombia to climate change. That is how Fondo Adaptación contracted to Consorcio Dique (Royal Haskoning and Gomez Cajiao) to develop the enviromental studies and final designs of the project: 'Restauration of System Canal del Dique'.

2. HISTORY OF THE CANAL

The modern history of the canal it dates back to the mid-17th century. Sailing through little streams and existing cienagas, Cartagena City was connected with Magdalena River, one of the principal waterways of Colombia and with the centre of the country, mainly with its capital city Bogotá.

During the dry period, the half of the path between Cartagena and Magdalena River, was not navigable (Figure 1) so was necessary to excavate channels to allow the navigation during all the year. But the quantity of sediments was too high to clogging the channels and the commercial needs increased the size of the ships. The Colombian government took the decision to increase the cross sections of the existing channels. In the 20th century the cross section of the Canal was enlarged and the curves were reduced to improve the navigation trough the Canal, this bring not just a rise in the water flow also the transported sediments. The result was the eco-systemic fractionation of the associated cienagas to the canal and by the other hand helped and speed up the clogging of some of them. Conditions that have changed the dynamics from a marine system to an estuarine one, with a very high charge of sediments which not only affects the bays near to Cartagena, but also reduces the depth of these impacting the productive activity of the port.

The changes made in the Canal adaptation and the needs to connect the Magdalena River with the port zone of Cartagena generated serious problems related with the continuous changes in the ground cover, flow of water and sudden demographic changes generated by the colonization and growth of the population. These factors have changed the ecosystems offers and in a direct way, set up an environmental stress. Is very evident this fact if compares the images of the 17th century with some of the present time. In the first one, is possible to observe the existence of a big one cienaga named Matuna (Figure 1) which was purely marine and has a cushion function in the delta zone (red box). This system disappeared with the grow in the water flow, the sediments and therefore the ecosystem was fractionated and change the marine condition to a fresh water one.

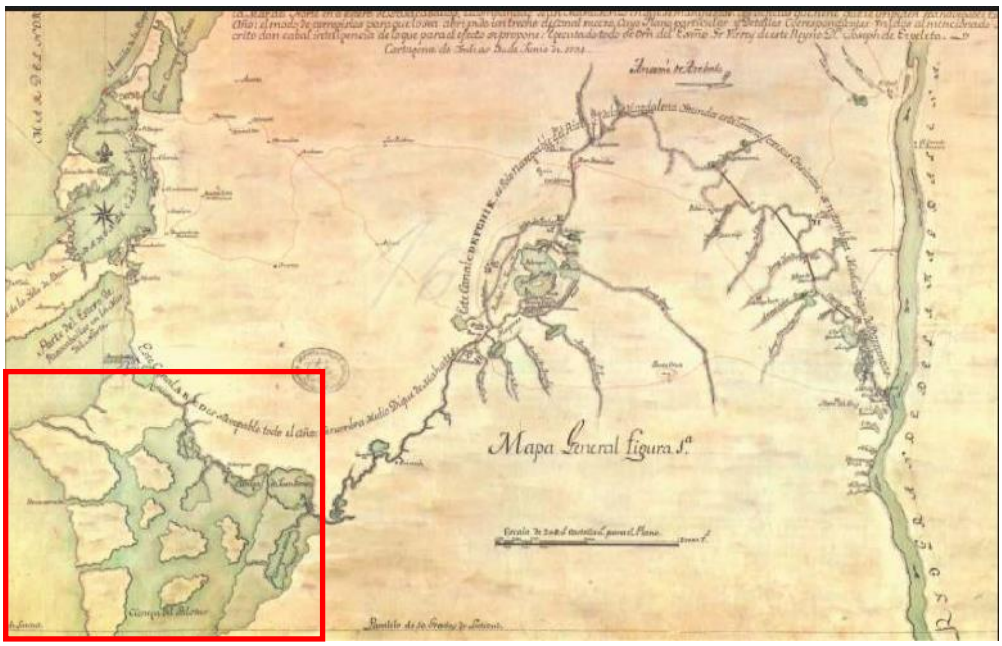

Figure 1: Ancient Matuna Cienaga, 1794

(Antonio de Arébalo, año 1794, número 94, Servicio Histórico Militar, Cartografía de Ultramar, Carpeta Cartográfica, Madrid, 1980. Taken from Mogollón, 2013)

In Figure 2, at present day, it is possible to see the effect of the sediments in the Cartagena and Barbacoas bay also in the delta zone.

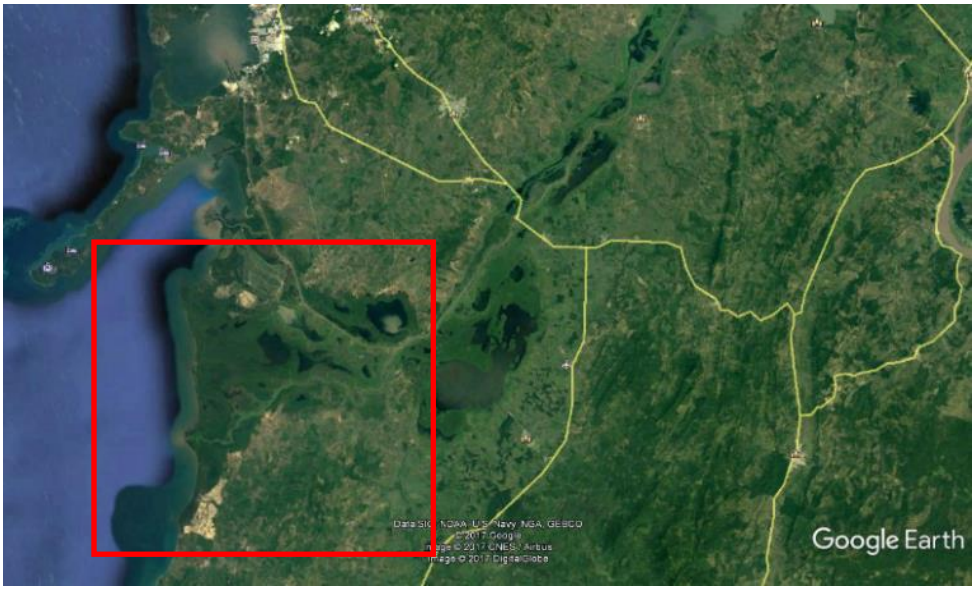

Figure 2: Current view, modified area ancient ciénaga of Matuna. Taken from Google Earth (2017)

The increase of fresh water in the delta zone modified the salinity conditions and influenced the existing ecosystems, which changed the vegetation, fauna and affecting the communities who lives near to the canal. It allowed the creation of new niches, generating typical biotopes of fresh water, as the case Pterocarpus officinalis 'Corcho'. Due to its singularity, the Colombian government rise the delta zone to the grade of Flora and Fauna Sanctuary 'Mono Hernández'.

In order to restore the associated ecosystems to the canal and to the bays, the project designed engineering works that allows to control and reduce environmental tensors that guarantees in the medium and the long-term a process of resilience that leads a ecosystem restauration. Therefore, the project has the six following objectives:

- Control of the sediment flow between Magdalena River, Canal del Dique, Cienagas, and the bays of Cartagena and Barbacoas.
- Establish the scenarios for adaptation to climate change and floodings.
- Improvement of water quality, through the recovery of connections (Canal-Cienaga and Cienaga-Cienaga), in accordance with the current eco-hydrological dynamics. (Cienaga elasticity and hydraulic retention times).
- To guarantee the supply of water from the canal for drinking water, agriculture, fishing and other services.
- Maintenance of Navigation along the Canal.
- Restoration of ecosystems associated with the Canal and the marine system National Natural Park Rosario's and San Bernardo Islands.

3. ENGINEERING WORKS TO BUILD

For the project, 'Restauration of System Canal del Dique' principal and complementary works were designed.

Among the principal works were:

- Calamar Zone (K3+200): it will build a gate of regulation of water flow, which will allow the entrance of necessary quantity for the requirements of water supply. Besides a navigation lock for the transit of convoy through the canal. These works were designed with the entire infrastructure associated for its operation and maintenance as the control buildings, electric substation, and maintenance workshops, among others.

- Puerto Badel Zone (K95+000): a navigation lock was designed and all the associated infrastructure for its operation and maintenance, such as the Calamar Lock.

For he complementary works, the influence area was divided in eight (8) zones (A, B, C, D, E, F, G and Delta Towns) where were designed the connections between Cienaga-Canal and Cienaga-Cienaga. The works consisted in the adequacy of existing channels and/or ancient rivers overflow structures, levees, box culvert, canoes passes, and fish passes. Figure 3 shows the location of the principal works and the zone for the complementary works.

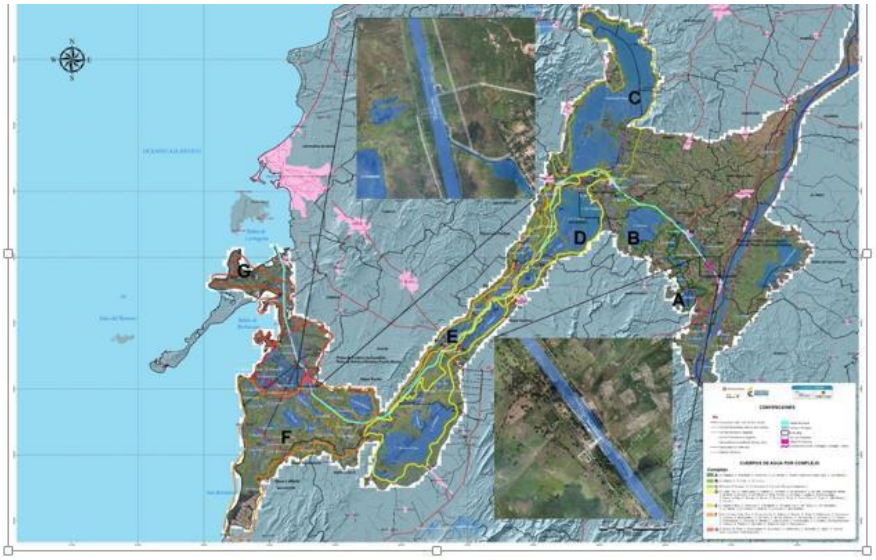

Figure 3: Location of works Restoration System of Canal del Dique

4. MULTITEMPORAL (DIACHRONIC) ANALYSIS OF BIOTOPES

The diachronic cartography of biotopes gives an opportunity to characterise and quantify the complexity of the patterns and spatial and temporal process of the soil, its uses and its changes. The mentioned processes are the result of the action of different drivers of change operating at different levels and it is possible to see, in a technical point of view, the desirable point of the restauration of the system. [Steve et al., 2008] The factors which generate changes in the biotopes (Figure 4) are strongly related with the changes actors that interact, depends and gives feedback each status. Thus, for example, the market economy needs to rely in programmes, policies, the laws and institutions. Access to land, labour and technology are limited by them. [Burgi et al.,2004 ; Geist and Lambin, 2002]

In order to establish patterns of changes, the project defined five (5) scenarios in which were identify the coverage of the historic biotopes corresponding to the decades of: 1950, 1970, 1980, 1990 and present day. Different resources were used, such as: satellite images, bibliographical sources, historic cartography, consults to experts, and people who knows the local communities, so for the fifth scenario current biotopes, the cartography of Coverage and Biomass generated in this project, were integrated with the function Intersect of ArcGIS.

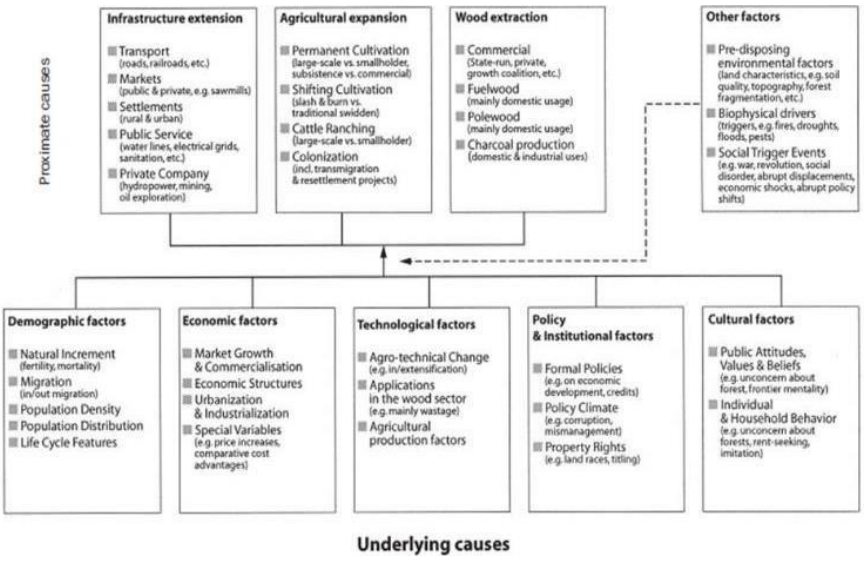

Figure 4: Driven Forces of the Landscape. Source Geist y Lambin (2002)

Together with these tools, the social actors were incorporated with whom were identified 34 milestones which have generated changes. It was identified 36 positive aspects generated by 34 historic milestones and 57 negative aspects. This characterisation allowed an initial approach to the features of the general territorial problems, which was mainly oriented to the following themes:

- The environmental and social effects of the builder works (bridges, irrigation district, head of the canal, embankments, gates, harbour, etc.)
- The consequences of the floodings generated by The Niña Phenomenon and highly rainy seasons
- Ruptures in the Canal del Dique (Levees) with is correspond floodings.
- The presence of natural phenomenon (Hurricane Joan, the Niño phenomenon) and its effects.
- Anthropic actions and its effects (sedimentation, contamination, drying out and closure of water bodies).
- The environmental and social effects of the dredging into de canal.

The diachronic analysis of Biotopes involved the identification, spatialisation and quantification of the changes in the defined periods: from 1950 to 1970, 1970 to 1980, 1980 to 1990 and from 1990 to current (2014). From these results it was possible to see the relevant changes and the period where was the maximum expression of the biotopes, point of the arrival of the system restauration process. The restauration process was oriented to the biomass shows in Figure 5

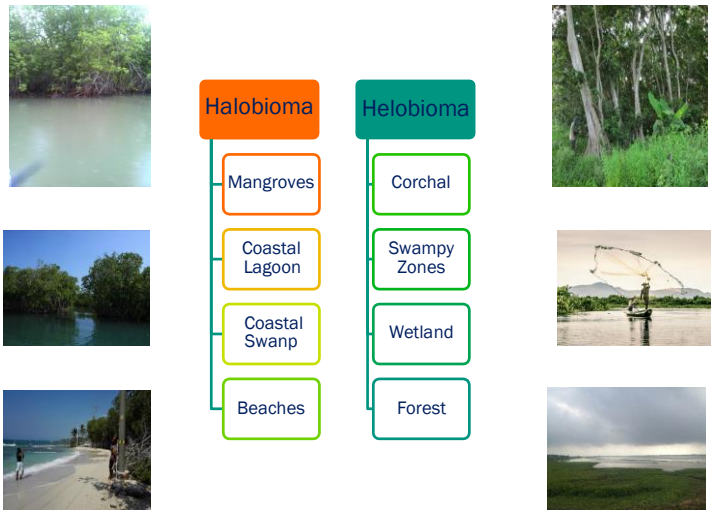

Figure 5: Biomas present in the Canal del Dique. [Consorcio Dique,2017]

The Halobioma Biotopes in the study area are located mainly in the Barbacoas and Cartagena bays and the delta of Canal del Dique, where they find adequate conditions of salinity and water table to thrive favourably (Figure 6).

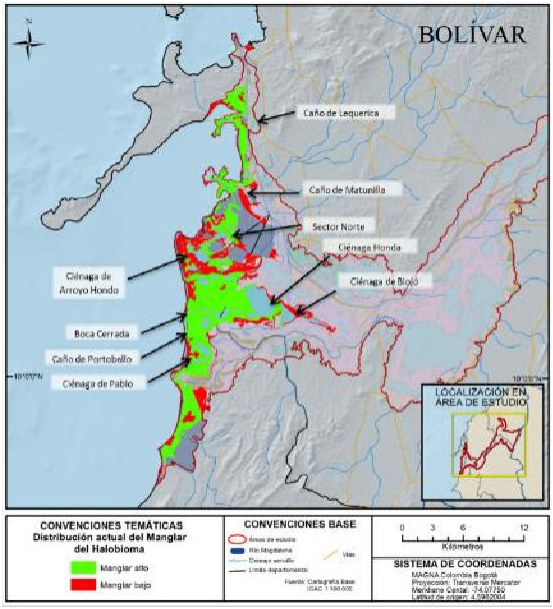

Figure 1 Current distribution of the Halobioma Mangrove Biotope. [Consorcio Dique 2015]

Changes at the level of the halobioma for each of the biomes that comprise it were established. An example of this is the mangrove, evidencing a transformation in the structure from high to low mangrove in time; nevertheless, the best moment was in the 1950s, where the influence of fresh water was minimal and sediments did not alter the availability of nutrients. In synthesis for this biome it was established that: the change from high to low mangrove has been generated in places whose conditions of the Halobioma do not vary, allowing that after being felled, the mangrove recover the same coverage in a very short period. In the field is evident the mangrove swidden by the communities of Bocacerrada and Labarcés that have used the mangrove trees traditionally for the construction of their houses and canoes, as well as firewood for domestic consumption. In the antiquity, the bark of R. mangrove was extracted for tannin production, to supply the tanneries located in Turbaco and Barranquilla. In addition, coal production with mangrove wood was common. [Ulloa-Delgado and Gil-Torres, 2001]

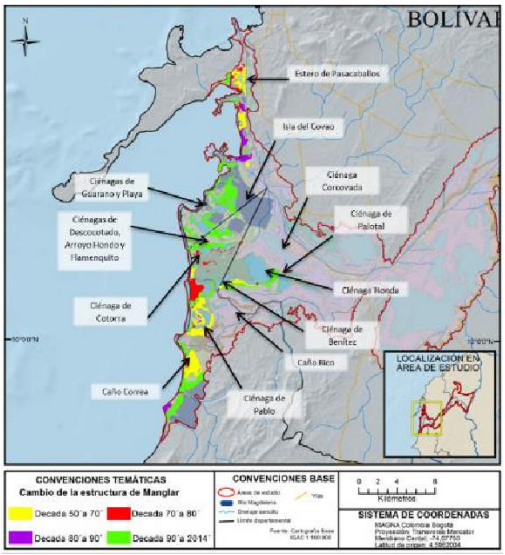

Figure 7 Development of the structure of the Mangrove Biotope. Indicates the change from low to high mangrove in the periods evaluated. [Consorcio Dique, 2015]

The Helobiomas are mostly represented by natural water bodies and herbaceous and shrub vegetation, which, like mangroves, have a high production of foliage that is basic for fish production. The dominance of the 'cork' communities of Pterocarpus officinalis of this biome can be highlighted, which in turn are associated with cantagallo forests (Erythrina fusca). Like the previous one, the changes in the helobioma exemplified with the Marshlands Biotope, which includes the natural cover composed by the herbaceous vegetation, shrub and the one of antropic use composed by the covers of Mosaics of grasses and cultures with natural spaces and Mosaic of grasses with natural spaces (Figure 8).

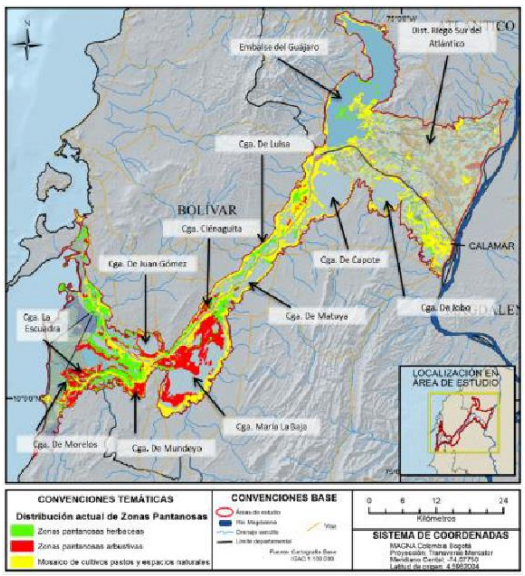

Figure 8 Current distribution of the Heloidoma Marshland Biotopes. [Consorcio Dique, 2015]

For the helobioma, it was identified that the loss of the Marshland Biotope according to the cartography was 19,089 ha for the first period (50 to 70), 6,948 ha for the second (70 to 80), 4,363 ha in the third 80 to 90) and 5,200 ha for the fourth (90 to 2014).

As relevant conditions of the diachronic cartography, it was evident that the losses in the marshy areas occur in the Cienaga de los Negros (nowadays it is desiccated), Machado and Sabana. An effect mainly due to the construction of dikes for drying; the construction of secondary and tertiary land routes (generating a confinement and subtracting permeability towards this sector); and the closure of the canal that fed them from the Magdalena River to the Canal del Dique at the beginning of the 20th century.

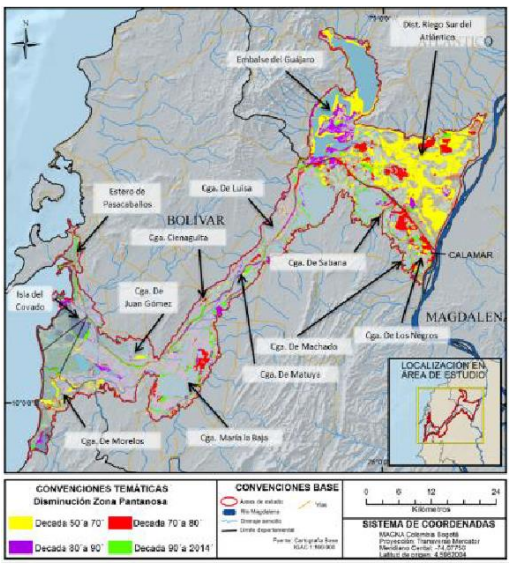

Figure 9 Loss of Wetlands. [Consorcio Dique, 2015]

With the diachronic information, which shows the changes in profits and losses in the different biotopes, plus the effects on the marine systems due to the effects of freshwater and sediment discharges, the hydraulic dynamics in the channel were established. The implementation of the mathematical models SOBEK 1D and 1D2D, established the operating rule along the channel, and as a premise the dynamics of pulses that the Magdalena River has remained (Figure 10).

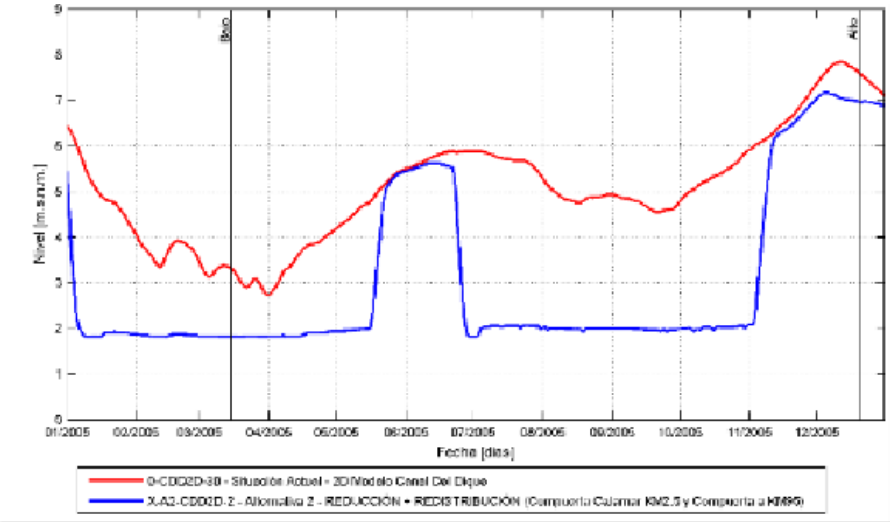

Figure 10: Hydraulic dynamics. Current levels in the channel, (red line,) vs hydraulic dynamics water in the canal restoration project (blue line.) [Consorcio Dique, 2015]

5. WORKS AS RESTAURATION TOOLS

Once the changes in the time of biotopes have been established, the mathematical models of hydraulic character have been designed. Which allows the restoration of the associated ecosystems and, at the same time, fulfil the objectives. from the fact that they can control the active flow of water, which determined the average flow that entered the channel from the mouth of the Magdalena River and how much it left in the bay. This was observed in the canal rectification works which generated a tube, limiting the exchange with the marshes and that generated a discharge of almost 100 % of the fresh water and thirsty to the marine system. (Figure 11)

Figure 11: Average flow intake Canal del Dique, outlets to marine system. [Consorcio Dique, 2015]

In order to reach the targets, a structure was designed for the active control of flow, which is located at km 3 + 200 in Calmar Village, characterised by a lock and gates (Figure 12).

Figure 12: Lock and Gate in Calamar. [Consorcio Dique, 2015]

With this work, it is possible to reduce the income of 56 % of the flow and with it an equal amount of suspended sediment (reduction work). And a second work at the height of Badel port (K95 + 000), characterised by a lock and a dam (Figure 13).

Figure 13: Puerto Badel Navigation Lock and dam. [Consorcio Dique, 2015]

With this, the passage of fresh water and sediment to the bays of Cartagena and Barbacoas, (redistribution work) (Figure 11) is suspended, removing four tensors on the system, freshwater inputs, sediment discharge, nutrient inputs, which increases the transparency in the bays and generate processes of transformation towards the marine system original condition of the area.

In the delta area, a redistribution of fresh water and sediments is carried out. Discharges that according to the study of climate change, allow a level of compensation, the increase in sea level is projected by 1 cm per year. With the redistribution, a deposition of the sediment is projected in a proportion of one 1 cm per year. This behaviour guarantees the development of the mangrove in the zone, and the contributions to fresh water along the Caño Correa and Caño Rico channels allow the normal development of the cork, generating the survival of the species and preserving the sanctuary of flora and fauna (Figure 11).

Simultaneously, the dynamics of the bodies associated to the channel (marshes) were integrated. Water bodies in which it is projected to re-establish the flows through a system of waterfalls, for which the existing old streams will be enabled. Smaller works such as box, natural channel overflow, channel and fish passages that allow maintaining the system's optical offer, with the potential to increase its dynamics once the water quality in each marsh is improved.

These works are oriented to restore the flow along the system maintaining the dynamics generated by the rectification of the channel, ‘marshes on the right margin and left margin of the channel’; with the flows are guaranteed higher minimum levels and that in times of high rainfall these systems do not overflow.

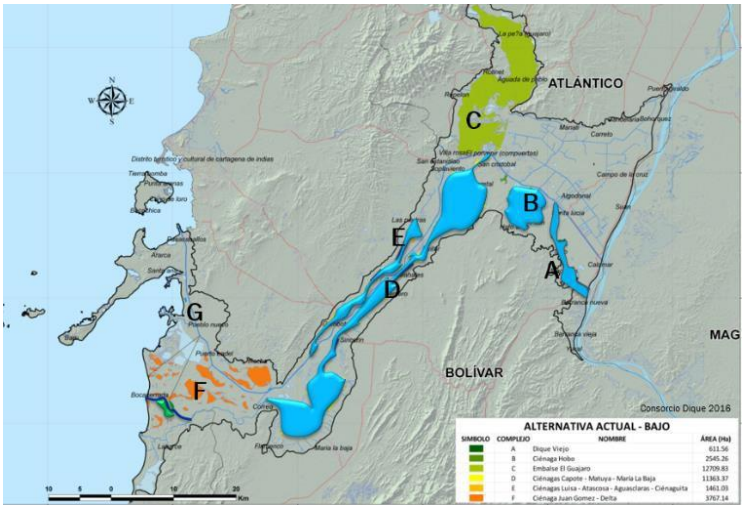

Figure 14: Channel reconnaissance works associated with the Canal del Dique [Consorcio Dique, 2015]

6. SUMMARY

Continuous flows allow the recovery of primary productivity in the muddy systems, and in turn guarantee food for the resident and migratory fish species that allow them to restore the life cycles in the marshes and with that to give a greater offer to the communities that live of the in these sectors.

On the other hand, the suspension of the tensioners in the bays guarantee the transition to their original condition, marine system, and with it the recovery of ecosystems as seagrass, and a better environment for the development of corals, projecting in the long term the recovery of the typical structure in the Caribbean zone.

7. ACKNOWLEDGMENT

- Fondo Adaptación of Colombia
- Consorcio Dique (Royal Haskoning DHV and Gómez Cajiao)

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PIANC INLAND NAVIGATION COMMISSION (INCOM)

by

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ABSTRACT

The Inland Navigation Commission (InCom) is one of eight PIANC Commissions, currently composed of more than twenty active members, professionals involved in inland navigation activities in Europe, Americas and Asia. This paper reviews the main activities this Commission is currently performing.

1. INTRODUCTION

For the last years, InCom has been very active. New members have joined the Commission, some of them coming from Latin America. InCom is proud to have a significant number of active Working Groups and some new and recently launched ones, some of them about very specific topics, such as Navigation Locks. Interesting workshops, short courses and published new reports are scheduled for the near future.

2. INCOM MEMBERS

The Inland Navigation Commission (InCom) has 32 members, coming from 21 countries in Europe, Asia and Americas. This broad range of countries enriches discussions and promotes experience interchanges. For the last years, the number of members coming from Latin America has been increased notably. This has opened a range of new projects and perspectives for the Commission.

3. INCOM WORKING GROUPS

3.1 Active InCom Working Groups

Currently, there are 12 active InCom Working Groups, four of them in the last stage process, almost ready to launch the report.

WG 125 – RIS Guidelines – Update 2011 is the permanent Working Group, originally established in 2002, with revision in 2011, has again gathered experts in the field of River Information Services with a goal to update RIS Guidelines with newest developments in this field.

WG 128 – Alternative Technical-Biological Bank Protection Methods for Inland Waterways is the Working Group with the goal to introduce the reader with the current developments and experiences in alternative bank protection measures, in relation to different influences, and with the goal to fulfil technical purposes and improve ecological conditions.

WG 141 – Design Guidelines for Inland Waterways – With the goal to provide guidance on the hydraulic design of fairways, approach channels, and structures, depending on characteristic vessels on rivers and canals.

WG 154 – Mitre Gate Design and Operation – The main objective of the WG was the identification of 'best practices' for the design, fabrication, and operation of lock mitre gates, for typical sized low, medium, and high head mitre gates. The report was finalised in 2017 and a workshop was organised in November 2017 in Brussels, Belgium.

WG 166 – Inflatable Structures in Hydraulic Engineering – Experts working on this report are defining a general methodology for the analysis and design of inflatable structures, in particular of the membrane and the anchoring system.

WG 173 – Movable Bridges and Rolling Gates – Experts from different fields (mechanical, electrical and constructive engineers) joined this WG with the goal to assemble 'lessons learnt' from navigation bridges and rolling gates and their operating systems and to give recommendations for future design.

WG 179 – How to Deal with New Ships in the CEMT '92 Classification – Towards a New CEMT (ITF) Classification – Having in mind new developments in size and forms of barges, as well as their means to manoeuvre, it was necessary to revise CEMT classification from 1992. Experts from Europe are participating in preparation of new classification of European waterways.

WG 189 – Fatigue of Hydraulic Steel Structures – Design, Analysis, Assessment, and Maintenance – With the structures getting into the certain age of exploitation, different influences are impacting their performances. Fatigue damages, particularly to lock gates, emphasised the need for guidelines in this field. This WG gathered structural and mechanical professionals, specialised in hydraulic structures.

WG 190 – Corrosion Protection of Lock Equipment – No matter that topic of steel corrosion protection is well elaborated subject, specific applications to the aquatic environment are not well documented and difficult to obtain. The goal of this WG is to gather knowledge, and experiences, and provide it to readers of this report.

WG 191 – Composites for Hydraulic Structures – Composites are widely used in marine, aviation, and auto industry. The goal of this WG was to compile available documents where composites provide a benefit over conventional materials for hydraulic structures. Future report will provide info on history of composites, provide definitions, and identify possible applications of composites.

WG 192 – Development in the Automation and Remote Operation of Locks and Bridges – The goal of this WG is to work on the update of the report published in 2008 (InCom WG 96), with a special attention to the development in remote operation of structures.

3.2 New InCom Working Groups

Five new Working Groups have been launched during 2017 (WGs 197, 198, 199, 201 and 203). Work has just been started, and experts are more than welcome to apply for participation through their National Sections. Terms of References can be found at the PIANC web site (www.pianc.org).

WG 197 – Small Hydropower Plant in Waterways – The goal of this WG is to provide guidelines on best practices regarding use of energy with small hydropower plants on inland waterways.

WG 198 – Saltwater Intrusion Mitigations and Technologies for Inland Waterways – The goal for this WG was to identify state-of-the-art methodologies to quantify saltwater intrusion induced, for instance, by lock operation, including salt propagation in the upper reach.

WG 199 – Health Monitoring for Port and Waterways Structures – The idea for this WG was to provide quantified probabilistic measures of risk and reliability necessary to make operational and financial decisions concerning the functionality and safety of waterway and port structures.

WG 203 – Sustainable Inland Waterways – A Guide for Waterways Managers on Social and Environmental Impacts – The goal of this WG is to provide a general document showing possible contributions of the waterborne infrastructure managers, in particular of inland waterways, in the global process of a more sustainable development of the society.

3.3 Joint PIANC– CEPAL WG 201 'Development of a Proposal of an Inland Waterway Classification for South America'

The first meeting of the Joint Working Group took place on 19 September in Pittsburgh, USA, and was attended by 22 participants from PIANC, sectorial Ministries of Argentina, Brazil, Colombia, Peru and

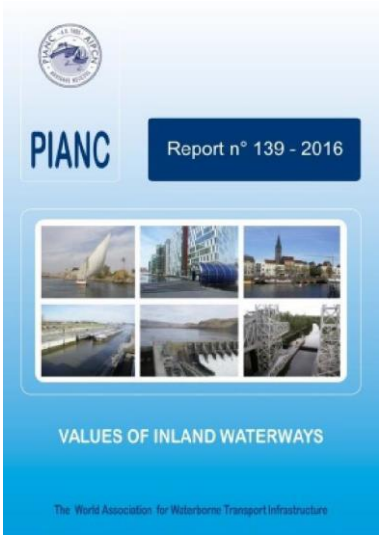
Paraguay, as well as other experts from academia and inland navigation industry. Building upon the results of the PIANC/ECLAC/ANTAQ Workshop during the PIANC-COPEDEC IX Conference in Rio de Janeiro, in October 2016, and the Joint ECLAC/PIANC Working Paper on 'Classification of Inland Waterways in South America' (IWCSA), WG 201 analysed the existing national classifications in South America, the link between classification and public policies and put forward general recommendations for the work of IWCSA, as well as the specific recommendations on the objectives and technical parameters of the classification. It was agreed that dedicated expert groups would carry out the main tasks for preparing the first proposal, including extending the survey on the objectives and parameters of the classification, analysis of the existing classifications, first methodology proposal and identification of data requirements. The first interim report was expected for December 2017 and the preliminary methodology is to be presented in May 2018 at the PIANC Congress in Panamá.

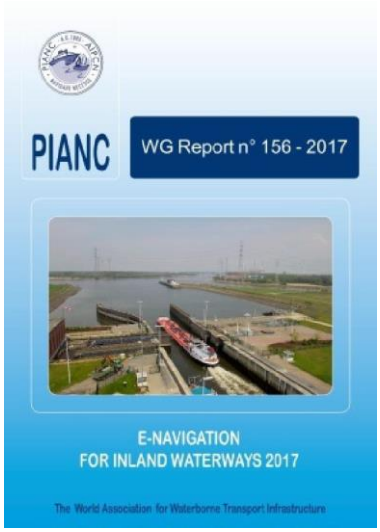
4. INCOM – NEW REPORTS

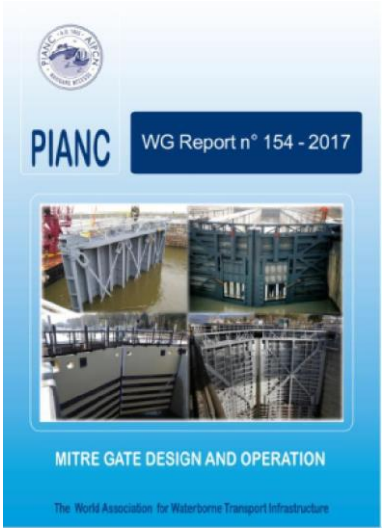
As the result of the extensive work of some Working Groups during last years, some interesting reports were recently published and some others are planned to be published soon:

4.1 InCom Latest Reports

Three reports have been published recently: Working Group report 139 – 'Values of Inland Waterways' has been published in 2016, Working Group report 156 – 'E-Navigation for Inland Waterways' and Working Group report 154 – 'Mitre Gate Design and Operation' were published in 2017.







It is important to stress that some workshops related to these Working Groups were carried out at the occasion of some PIANC-related events (PIANC-SMART Rivers Conferences, PIANC Congress, PIANC-COPEDEC, Med Days, etc.). InCom is determined to continue with these activities in the future, to promote the topics related to these reports.

4.2 InCom Reports to be Published

In the coming months, the plan is to publish three new reports at the beginning of 2018. Working Group 141 – 'Design Guidelines for Inland Waterways' has worked on an extensive and complete report, scheduled to be published soon. Also, Working Group 166 – 'Inflatable Structures in Hydraulic Engineering', as well as Working Group 173 – 'Movable Bridges and Rolling Gates' will publish their reports in the next months.

5. INCOM WORKING GROUPS ON NAVIGATION LOCKS

A special mention goes to the significant number of reports about navigation locks that InCom has promoted for the last years. Eleven Working Groups have kicked off in order to improve the state-of-the-art in navigation locks:

- PIANC Report on Locks (1986)
- WG 106 – 'Innovations in Navigation Lock Design' (2009)
- WG 151 – 'Impacts of Seismic Loads and Ship Impact on Lock Gates' (2016)
- WG 155 – 'Ship Behaviour in Locks and Lock Approaches' (2015)
- WG 173 – 'Movable Bridges and Rolling Gates' (2017)
- WG 189 – 'Fatigue of Hydraulic Steel Structures'
- WG 190 – 'Corrosion Protection of Lock Equipment'
- WG 191 – 'Composites for Hydraulic Structures'
- WG 192 – 'Automation and Remote Operation of Locks and Bridges'
- WG198 – 'Saltwater Intrusion Mitigations and Technologies for Inland Waterways'
- WG 199 – 'Health Monitoring for Port and Waterway Structures'
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6. INCOM WEBPAGE

To promote the dissemination of the InCom activities, events and the status of the Working Groups, the Commission has worked strongly on the webpage: www.incomnews.org.

On this webpage, which is open to the public, one can get information about the InCom Working Groups, be informed on the InCom members (even contact them if necessary) and be informed on other InCom activities.

The 'Members Only' Section allows the InCom members to share information related to the InCom activities and the Working Groups processes.

FRP COMPOSITE STRUCTURES IN THE US INLAND WATERWAYS

by

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ABSTRACT

The US inland waterway infrastructure serves as a backbone to the nation's economy by carrying an equivalent of 51 million truck trips each year. Its importance has been neglected by not thinking towards its update since 1950s, and as a result, the nation's inland waterways infrastructure obtained a rating of D^{-} from the American Society of Civil Engineers in 2017. The US Army Corps of Engineers (USACE), who owns the nation's Inland navigational lock and dams, are obligated to spend 73 % of their annual budget in repair and maintenance, to keep them functioning. Due to massive budget cuts and the regular repair works associated with the use of conventional materials, the USACE has started exploring the use of durable fibre reinforced polymer (FRP) composites. Lightweight and non-corrosive FRP composites pose as the most viable solution to the problems of corrosion and deterioration faced by USACE in their waterway structures. In this work, FRP composites have been utilised to replace some of the traditional waterway structural components such as wicket gates, recess protection panels, and mitre blocks, which were built of steel and timber in the past. This research discusses the several facets of design, manufacturing, testing, and field implementation of these structures in the US navigation.

1. INTRODUCTION

The inland navigation system of the US serves as a backbone to its economy carrying an equivalent of 51 million truck trips each year [USACE, 2015]. Yet, many hydraulic locks and dams including navigational gates have already exceeded their design life as they have not been updated since 1950s. The American Society of Civil Engineers (ASCE) has rated the nation's inland waterways infrastructure as D^{-}. Hydraulic structures withstand harsh hydrodynamic and corrosive forces, freeze-thaw effects, impact, and abrasive forces and are prone to severe corrosion and deterioration. Corrosion leads to expensive repair, closure, and in some cases replacement of the structure. Traditional steel and timber used in navigation infrastructure deteriorate within 10-15 years of service and require periodic costly repair. The US Army Corps of Engineers (USACE), who maintain the nations' more than 236 hydraulic locks consisting of navigational, flood control and waterfront structures, spend almost 73 % of their budget in repair and rehabilitation of current facilities and further requires more than US$ 13 billion by 2020 to keep the infrastructure functioning [ASCE, 2012]. Several repair and maintenance efforts conducted in the past by USACE using conventional materials and methods have proven to be less effective and less durable.

Meanwhile, FRP composites are emerging as an excellent solution for both rehabilitation and new construction because of their superior structural properties as compared to conventional materials [Vijay et. al., 2016]. The advantages with FRPs include lighter weight, high strength and stiffness, corrosion resistant, excellent durability, low thermal expansion, and enhanced fatigue and wear resistance. FRPs offer potential for construction or repair of critical components of navigation system at reduced costs and greater durability. Due to high maintenance budget expenditure associated with the use of conventional materials, the USACE has started to explore and implement FRP composite structures in their infrastructure. This paper highlights on the research conducted in collaboration with the USACE to design, manufacture and implement three FRP structures in the US inland navigation.

2. DEVELOPMENT OF FRP WICKET GATES

Wicket gate is a movable dam that can be raised in times of low water. It is generally constructed of steel or iron frame with timber leaf. It is hoisted into position with a gantry operated crane and are hinged just below their centre point and held in an upward position with a prop that slides into a hurter (Figure 1). Typical sizes of wicket gate ranges from 1.2-3 m in width and 4.6–6.1 m in length (height).

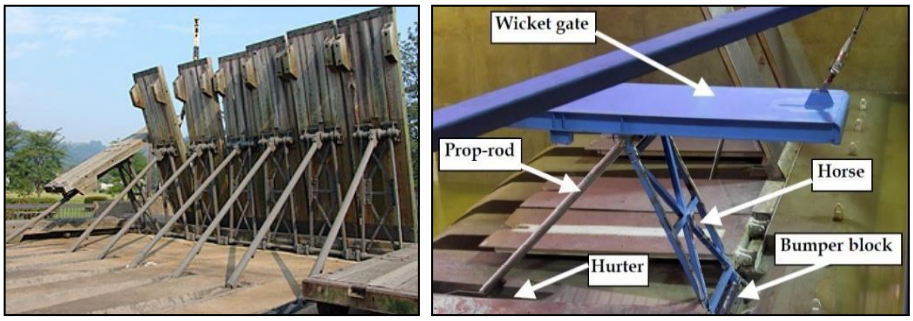


Figure 1: (a) Timber wicket gates, (b) parts of a wicket gate [Chaudhary & Davis, 2001]

The gate was analysed to obtain maximum design forces at operating, resting, and lifting positions. FRP wicket gate were manufactured as sandwich sections, with symmetric unidirectional and triaxial fabrics in the face-sheet. The web cores were reinforced with ±45° fabrics to form strong and stiff webs. The hollow core between webs were filled with foam. In addition, two 9.5 mm thick steel plates were embedded inside the upstream face sheet and ultra-high molecular weight polyethylene (UHMWPE) sheets were bonded on the front and sides of the gate for superior impact and abrasion resistance A FRP section 1.17 m (46”) x 216 mm (8.5”) was selected with flange thickness of 13.3 mm (0.523”) and web thickness of 10.16 mm (0.4”) (Figure 2). The moment of inertia of a selected FRP module was 39,250.6 cm^4 (943 in^4). In addition, two steel plates were embedded inside face sheets to enhance moment of inertia, reduce deflection and buoyancy [Vijay et. al., 2016].

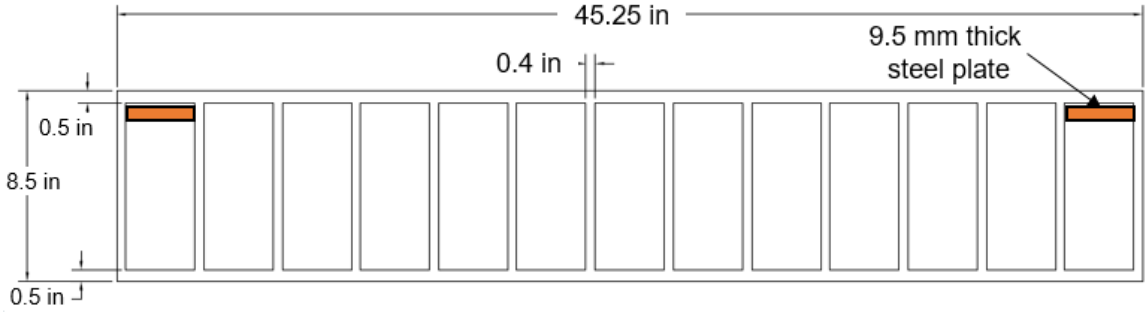
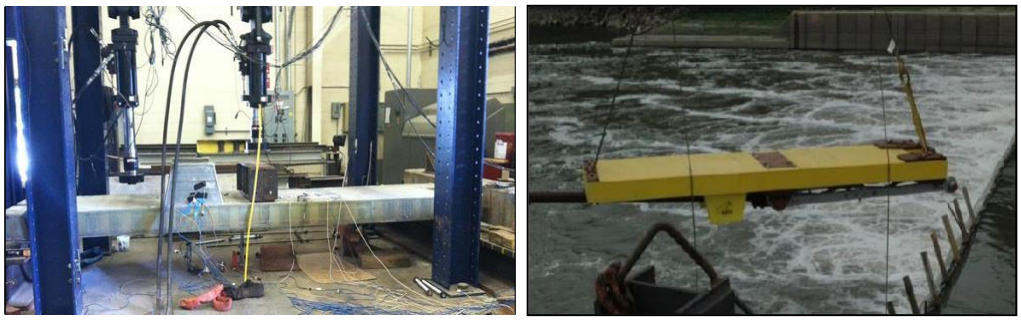


Figure 2: FRP wicket gate section

After the FRP section was designed and manufactured, it was tested under 3-point bending with a span of 4.57 m and a central load of 89 kN (Figure 3). The maximum deflection and tensile strain were 14.81 mm and 978 με, respectively. The gate was fatigue tested at (53-107 kN) for 50,000 cycles and 3-point bending was performed with a load of 89 kN. The max. tensile strain was 975 με as compared to 978 με before fatigue loading. The strain energy absorption capacity of the gate was not reduced after fatigue. After successful testing of the gate, four FRP wicket gates were manufactured and installed in the Illinois River at Peoria lock and dam in Fall 2015, which are performing very well without any signs of deterioration. These FRP gates were manufactured at about 2/3 cost of timber gates based on a first cost basis and with the expected life of more than 50 years for FRP gates vs. 15 years for timber/steel gates, there is a huge amount of long-term saving.



(a) (b)

Figure 3: (a) 3-point bending, (b) field installation of a FRP wicket gate

3. DEVELOPMENT OF FRP MITRE BLOCKS

Mitre blocks create a watertight seal between two mitre gate leaves in closed position (Figure 1a).

These blocks are important part of the navigation channel and are made of solid steel block. Typical cross-section of the mitre block is 101.6 mm x 63.5 mm, with a top radius of 609.6 mm and are drilled with 20.32-mm holes at every 457 mm along its length. Blocks withstand wet-dry cycles, corrosive elements, mitring forces, freeze-thaw effects, a compressive stress of 9.65 MPa through its mitring surface, and 10,000 cycles of opening and closing operations in a year [Vijay et. al., 2015]. Existing steel mitre blocks become completely dysfunctional within 10 years of service life or sooner due to deterioration and corrosion. Corrosion of steel blocks have been the cause of gate misalignment and potential lock closure. Through this research, FRP mitre blocks of sizes 63.5 mm x 101.6 mm were manufactured with vacuum assisted resin infusion process (Figure 1b). The curing was done in two stages. The thickness of the block was achieved through 2 layers of surface veil and a total of 96 layers of 680 gm woven glass roving soaked in Hetron® FR992 epoxy vinyl ester resin. After curing, the edges of the block were feathered and sealed using two coats of FR992 resin and wax additive.

(a) (b) (c)

Figure 4: (a) Steel mitre block, (b) FRP mitre block, (c) installation of FRP mitre blocks

During laboratory testing, FRP blocks were subjected to compression in all directions (Figure 3). The maximum value was 379 Mpa (55 ksi) and the minimum was 165 Mpa (24 ksi). Blocks were also tested in fatigue with a load range of 8.9-48.9 kN for 500,000 cycles and showed no signs of cracking. Testing of these blocks showed that they have higher than required strength, stiffness, and ductility properties. Depending upon the height of the lock gate, FRP mitre blocks can be subjected to not only moisture but also to water pressure, thus, FRP mitre blocks were cut to smaller lengths and few specimens were coated with an epoxy, while others were not coated. Both coated and uncoated specimens were kept in a container filled with water at NTP and inside a water chamber pressurised to 15.5 Mpa. After 60 days, specimens were tested for moisture absorption. The application of a resin coat on cut specimens helped in reducing the absorption of moisture. The application of pressure resulted in an increase of 90-200 % moisture ingress. Wet FRP blocks were tested in compression and were found to be lower but still above service requirement values.

Figure 5: (a) Compression testing, failure in (b) through-thickness, (c) widthwise, (d) lengthwise

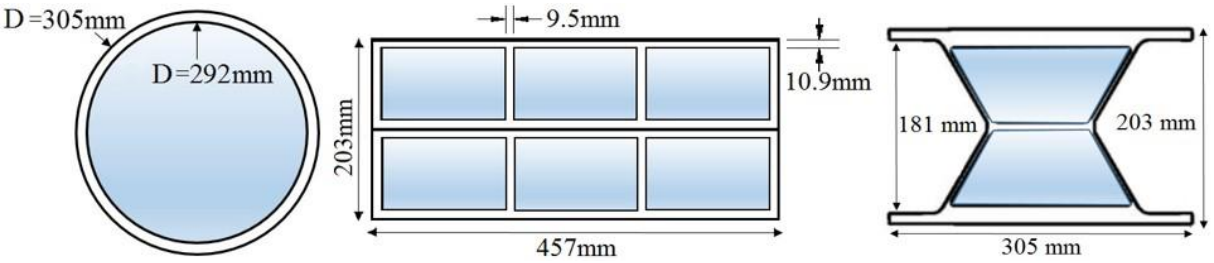
After successful test results, FRP blocks were installed in the existing lock gate at Hiram M. Chittenden Locks, Washington, USA in summer 2015 by bolting them to the gate leaves. Workers were able to handle light-weight blocks and install them with ease (Figure 1c). Solid FRP block was manufactured at a cost of US$ 500 per metre length. With an expected service life of 50 years for FRP blocks, there is tremendous savings in terms of materials, labour, equipment, and others.

4. DEVELOPMENT OF FRP RECESS PROTECTION PANELS

Recess protection panels are used in the upper lock chamber to protect the chamber and lock walls from barge impact damage. The panels protect the recess area in the lock and allows the emergency gate to rise when mitre gates are inoperable. Current panels are 12” thick and made of welded 12WF45 steel I-beams, angles, and plates. Current steel recess panels are heavy to lift and corrode in a short time requiring regular corrosion resistant surface coatings (Figure 6). The panels are supposed to be designed to withstand a barge impact load which when calculated required over 100 foot-kip section.

Figure 6: Steel recess protection panel

Currently available off-the-shelf shapes such as FRP superpile, FRP cellular module, and FRP superdeck were explored to obtain the best suitable FRP shape to develop FRP recess protection panels (Figure 7). Based on three different configurations evaluated under bending, hexagonal deck was the best shape in terms of energy absorption. Crushing failure and moment capacity of the single FRP superdeck at a clear span of 96” was 48.4 kip and 96.8 ft-kip, respectively (Figure 8). It was made with 12 FRP superdecks and edge steel channels. In the field, the impact force from the barge is distributed to several beams of the FRP panel system, thus carrying significantly higher loads.



(a) (b) (c)

Figure 7: FRP shapes: (a) FRP superpile, (b) FRP low-profile deck, (c) FRP superdeck

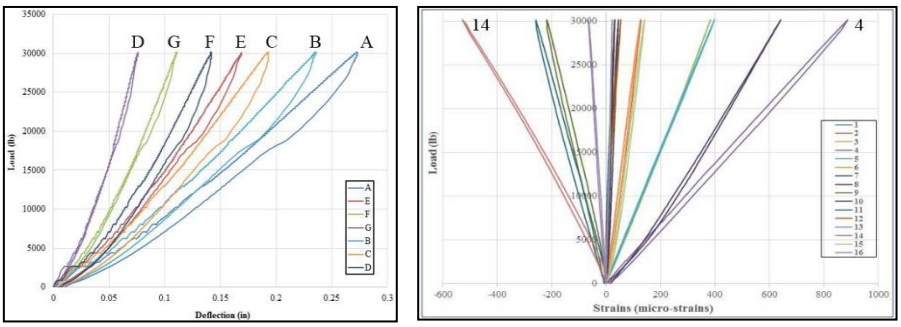
(a) (b) (c)

Figure 8: Three-point bending on FRP shapes: (a) superpile, (b) cellular module, (c) superdeck

(a) (b)

Figure 9: FRP hexagonal assembly (b) FRP recess protection panel with steel framing

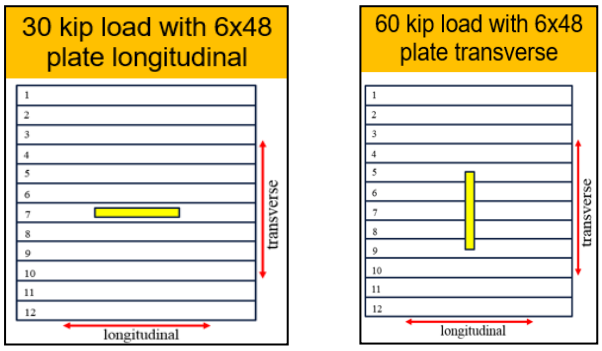
Twelve pultruded FRP superdecks and hexagonal shear keys were assembled by adhesive bonding (Figure 9a). The assembled FRP panel was housed in steel channel sections to facilitate smooth angles for ship and barge impacts (Figure 9b). Following the panel assembly, top surface was coated with 0.375” thick impact resistant polyuria resin. Final dimension of the panel was 9’10.5” x 11’10”. After manufacturing, the panels were tested in the laboratory under bending after attaching several strain gages and lvdts on the panel. The first test was performed with the application of 30 kip load through 6” x 6” plate, placed at the centre of the seventh hexagonal FRP beam. Figure 10a shows the load vs. deflection plot, while Figure 10b shows the load vs. strain plots. The maximum deflection obtained at centre was 0.27” and the maximum bottom tensile strain was 880 micro-strains.



(a) (b)

Figure 10: (a) Load vs. deflection, (b) load vs. strain

The panel was then loaded until 30 kip longitudinally with the help of 48” long spreader beam as shown in Figure 11a. The applied load was distributed to other beams of the panel through hexagonal keys that were used in between FRP beams during the assembly. The load distribution factors (LDF) for different beams of the panel were calculated and it was observed that around 80 % of the load applied on the central beam was distributed to other beams of the panel, showing that the panel is acting as a unit.



(a) **(b)**

Figure 11: (a) Longitudinal loading on a panel, (b) transverse loading on a panel

Similarly, the panel was then loaded until 60 kip in a transverse direction with the help of 48” long spreader beam as shown in Figure 11b. It was observed that around 85 % of the load applied on the central beams was distributed to other beams of the panel, showing that the panel is acting as a unit. After successful experimental testing and evaluation of FRP panels, three FRP recess protection panels were field implemented at Willow Island lock and dam in Ohio River in summer 2016, which are working very well under service conditions based on the field inspection.

5. CONCLUSIONS

FRP wicket gates, mitre blocks, and recess protection panels were successfully designed and developed as replacements to conventional material-based structures with adequate safety factors against bending, shear, and fatigue. These structures were lighter, cost effective, and easily fabricated and installed in the field. There is an additional scope to optimise these products to achieve better design strength, enhanced safety and durability. Regular monitoring and inspection of field implemented FRP structures will help in understanding their long-term performance, effectiveness, and durability for their mass implementation in hydraulic infrastructure.

6. ACKNOWLEDGMENTS

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