Design aspects of inland waterways and ports
Jan van Overeem – ARCADIS
What is ARCADIS?

- A consulting, project management and engineering company
- A solid presence in Europe, North and South America
- Top 3 in Europe and top 10 worldwide
- More than 13,000 people strong
- Despite difficult market another record year with 15% growth
- Over € 1.7 billion in annual revenues
A worldwide network

.....based on strong local positions
We focus on four market segments

- **Infrastructure** to drive mobility
- **Buildings** to create place of distinction
- **Environment** to ensure sustainability
- **Water** to protect and improve quality of life
Water

Deltas and rivers:
- Strategy development and decision support
- Structural engineering
- Rivers & Coasts

Water management:
- Urban water management
- Development and Regional planning
- Knowledge & Policy advice

Ports:
- Ports and waterways
- Hydraulic engineering
Ports and Inland Waterways

ARCADIS offers all disciplines necessary for an integrated approach for:

- General cargo terminals
- Container terminals
- Dry & liquid bulk terminals
- Fast ferry & Ro-Ro terminals
- Cruise terminals
- Locks & Inland Waterways
- Rail, road & pipe hinterland connections
Ports and Inland Waterways

Typical items for IWT studies:

- Master planning
  - Economic development of hinterland
  - Traffic & cargo forecast
  - Selection of barge system
  - Design of waterway
  - Design of port facilities
  - Operational aspects
  - Cost – benefit analysis
  - Institutional aspects

- Feasibility studies
  - Environment Impact Assessment
  - Basic and detailed design
  - Tendering and supervision
  - Project coordination
Brazilian Waterways and Inland Navigation
General map of rivers

Main Inland Waterways: 11

Total Length: 13,000 km / 65,000 km

- Amazon Basin
- North-eastern Basin
- Sao Francisco Basin
- Tocantins Araguaia Basin
- Paraguay Basin
- Tietê Paraná Basin
- Southeast Basin
- South Basin
Modal split of transport 2005 - 2025

TRANSPORT MODAL SPLIT
BRAZIL - 2005
source: PLNT

- Trucks: 58%
- Rail: 25%
- Water: 13%
- Pipelines: 4%
- Air: 1%

TRANSPORT MODAL SPLIT
BRAZIL - 2025
source: PLNT

- Trucks: 33%
- Rail: 32%
- Water: 29%
- Pipelines: 5%
- Air: 3%
Brazilian Waterways
Main problems (1)

- High potential with low utilization
- Integration with other river basins and other transport systems
- Connection with sea ports
- Improvement of infrastructure (inland terminals, navigation systems, buoys)
Brazilian Waterways
Main problems (2)

- Navigation locks required to pass high dams, i.e. Itaipú and Tucuruí
- Master plan required for combining hydropower plants and river navigation.
- Maintenance dredging required, especially in Southern Brazil
- Environmental processes cause long procedures for permissions
Brazilian Waterways Opportunities

- Design of navigation channels, locks and other structures to overcome missing links
- Prepare an integrated plan for the logistics of transport over water and land
- Implementation of advanced navigation systems for increased safety and optimal navigational conditions
- Transfer of technology in the field of hydrodynamics, morphology and nautical expertise and modelling (i.e. with INPH)
Missing link in transport corridors in Europe (1)

- North sea - Black sea: Rhine - Main – Danube

- Man made link:

  **Main-Danube Canal**
  (South Germany)
Missing link in transport corridors in Europe (2)

- Basin of Seine – Basin of Rhine/Scheldt
- Missing link: **Canal Seine Nord Europe** (between Compiègne and Cambrai)
Canal Seine Nord Europe (1)

- Length 110 km, 54 m wide, 4.5 m deep
- For barges and push tow up to 4,400 ton (= 220 trucks)
- Strong reduction of transport cost
- Strong potential for economic development in areas along waterway
- Increase throughput from 15 million ton in 2020 to 30 million in 2050
- 7 locks to overcome elevation of 60 m
- 3 aqueducts
- 59 bridges
- 16 terminals
- EUR 4.2 billion, partly EU financed
Arcadis (FR and NL) was commissioned in 2005 by VNF (Voie Navigable France) to perform the following work:

- Design of lock levelling system, including water saving basins for 7 locks (heads of 15 to 30 m)
- Nautical design of outer harbours near locks
- Design mooring system in outer harbour and lock during lock levelling
- Design of wave damping basins in canal
- Design of civil engineering works of the locks (structural and geotechnical)
Canal Seine Nord Europe (3)

- Design aspects of lock levelling system
  - levelling time (maximum 20 min)
  - vertical velocity in the lock
  - water slope in the lock
  - dimensions of the lock chamber
  - water use (5 water saving basins were applied)
  - mathematical model and hydraulic models were used to check levelling time and to determine valve operation and culvert dimensions
Manoeuvering studies to determine:
- behaviour of design ship during entering and leaving of lock (SHIP-NAVIGATOR simulation model)
- dimensions of outer harbours
- required manoeuvring facilities in lock and outer harbours (waiting berths and dangerous cargos)
- design criteria for the guiding walls for safe entry manoeuvring
Canal Seine Nord Europe (5)

- Mooring studies to determine:
  - behaviour of the moored design vessel (using SHIP-MOORINGS model)
  - mooring facilities (i.e. bollards) in outer harbour and locks (floating bollards were applied in lock due to high filling and emptying speeds (30 m in 15 min)
  - movement of moored vessels as a result of wave oscillations in canals due to discharge of water from locks
  - the impact of forces of crosswinds on vessels
  - characteristics of guiding walls for safe entry manoeuvring
Set-up of bauxite transport system in Suriname
Transport route from Apoera to Paranam

- **Barge to Paranam (250 nm)**
- **Rail to Apoera (72 km)**
- New port at Apoera
- New port at Paranam
- New Bakhuis Mine

**Map Details:**
- Location: GUYANA, SURINAME
- Scale: Kilometers
- Route distances: 72 km (Rail to Apoera) and 250 nm (Barge to Paranam)
- New port at Apoera and Paranam
- New Bakhuis Mine

**Route Overview:**
- **From Apoera:** Rail (72 km) to Apoera, then barge (250 nm) to Paranam.
- **From Paranam:** Rail to Paranam, then barge to Apoera (72 km).
Corantijn River studies

Barge Transport study

Hydraulic and morphological study

Nautical study
Hydraulic and morphological study

Study objectives:

- Design of the navigation channel to be dredged
- Determining flow conditions along the entire transport route for the logistic model
- Determining flow conditions for the manoeuvring simulations (SHIP-navigator)
- Determination of volumes yearly maintenance dredging (using DELFT3D morphological model)
A logistic model was used to determine required number of tugs and barges:

- Speed of vessel results from flow velocity, flow direction and water depth (hydrodynamic model)
- Alternative barge capacities
- Alternative dredging strategies
- Optimum for 3 million ton/yr: 3 tugs and 4 barges of 10,000 ton
Nautical Study

- Design of channel dimensions and turning basin, taking into account ship and channel dimensions and local flow conditions
- Making use of real-time SHIP manoeuvring simulations
- Confirm safety of arrival and departure manoeuvres at Apoera
- Determine sailing speed under different conditions (river bank erosion)
Articulated tug and barge

- Fixed hydraulic connection
- Sailing on rivers and ocean
- Good maneuverability
Example of articulated tug and barge (fuel)
SHIP - navigator

- Real-time ship simulator (vessel steered by active pilots) for design purposes. Developed by Arcadis / Alkyon
  - Ship bridge controls and ship behaviour as in reality
  - Environmental conditions are input (wind, waves, currents, bathymetry)
  - Effect of muddy bottom
  - Bank suction, ship-ship interaction
  - Use of tugs
  - Simulation of entering and departure
  - Definition of limiting conditions
  - Used in last 5 years in more than 50 projects worldwide.
SHIP - moorings

- Similar to SHIP – navigator, developed by Arcadis / Alkyon
  - Simulation of behaviour of a vessel moored to a jetty, quay, SPM or spread mooring system
  - Also for non-linear mooring line characteristics (composite lines)
  - Output results are motions, mooring forces and fender forces.
Thank you