The Automated Inland Vessel

Edwin Verberght & Edwin van Hassel

edwin.verberght@uantwerp.be, edwin.vanhassel@uantwerp.be

TPR
Departement of Transport and Regional Economics
University of Antwerp

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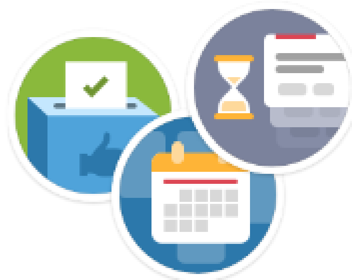
OUTLINE



- Who?
- Why?
- What?
- How?

Intro: first of all…

Social Cost-Benefit Analysis (SCBA)

System of Innovations Approach (SIA)

CONCLUSION

Q&A

16 slides of presentation, Q&A and questions for audience (if time left)

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Who?

Edwin Verberght & Edwin van Hassel

TPR
Department of Transport and Regional Economics
University of Antwerp

C-MAT
Centre for Maritime & Air Transport Management
University of Antwerp

seRIS DIRECT

INN-IN
INNOVATIVE INLAND NAVIGATION

NOVIMAR
VESSELTRAIN

TransportNET
The University Network for Transport Education & Research

AINS 2020
Antwerp Inland Navigation School

Why?

IWT is part of solution for congestion (Modal Shift)
IWT has low external costs (Sustainable)
IWT seems slow and not very visible (Perception)

Socio-Economic motivation

Innovative inland navigation

Building further on in-house innovation research and IWT expertise

To explore the business case of an automated inland vessel

To identify failure and success innovation factors

FIRST OF ALL…

*There is **no** fully automated inland vessel on the market (**yet**) that allows unmanned freight waterway transport. the innovation is in the initiation phase and it is ought to be technological feasible.*

WHAT WE SEE NOW:

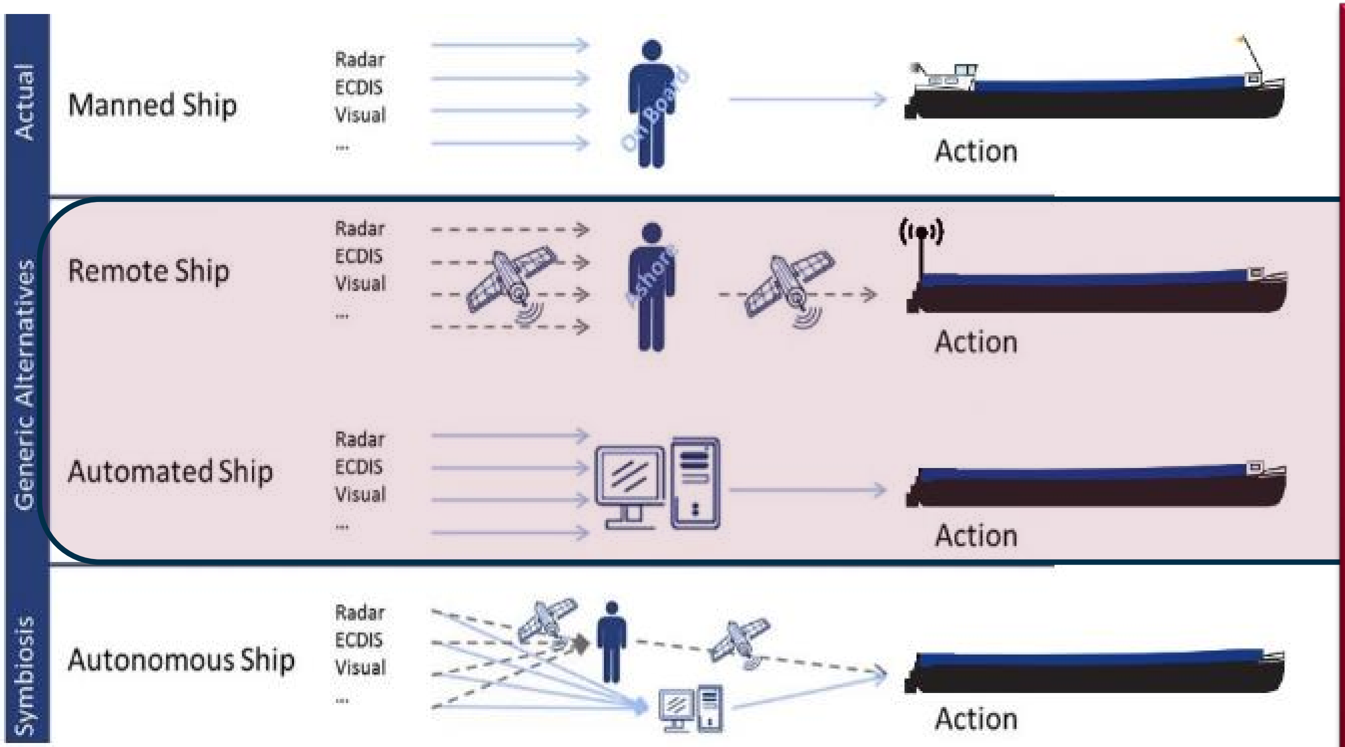
- **DEVELOPMENT OF (SUB)COMPONENTS** (mooring, navigation, scanners, algorithms, shore control centers and robotics)
- **MACHINE LEARNING** (measuring ship's behavior, data collection)
- **REGULATION:** CCNR, CESNI TI, expected update of RIS Directive
- **WINDOW OF OPPORTUNITY:** Global industry in all modes; technological; commercial spin-offs (e.g. NASA); supportive European policy (funding, reviewing regulation)

Actual wheelhouse on “young” vessels (<20 years)

European inland fleet

INLAND AIS/ECDIS
Auto-pilot
Radar (layered)
Communications
Rudder assistance
Engine data
Navigation data
Alarms
Internet connection
Engine control
Monitoring systems
Digital compass
ERI
NtS

What?

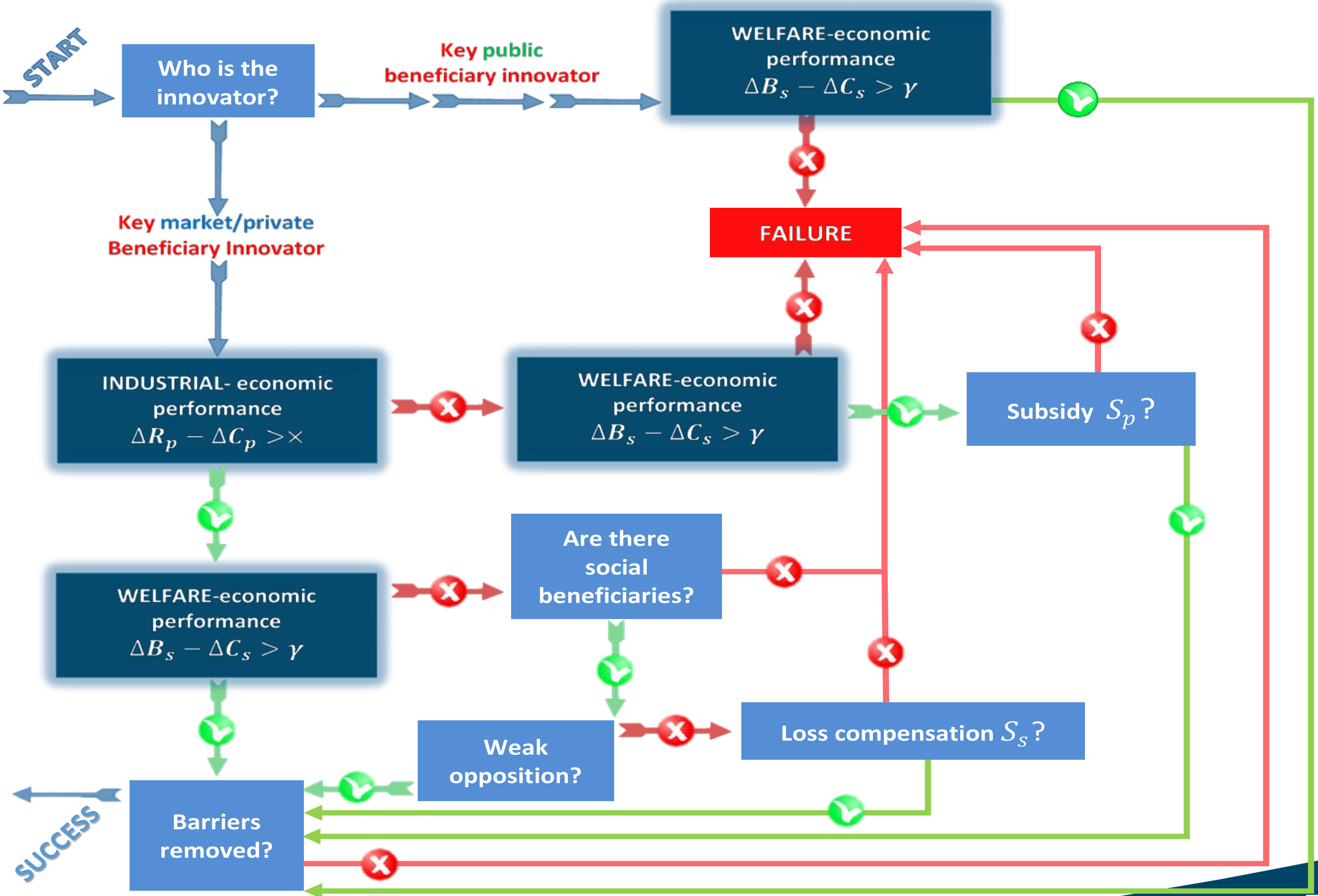


Automated and unmanned vessel

- Rhine Vessel, 110 m length, max/ loading 3,300 ton dry bulk
- Exploitation mode B: S2, but unmanned
- Shore Control Centre with annual service fee
- Equipped with automated mooring devices
- Estimated building cost EUR 5,900,000 (3x conventional vessel)

How?

Social Cost-Benefit Analysis (SCBA) and System of Innovations Approach (SIA)



Based upon Aronietis (2013): simplified without mixed forms

How?

Social Cost-Benefit Analysis (SCBA) and System of Innovations Approach (SIA)

Systems of innovation approach (SIA)*

- ❑ **Pattern recognition**
- ❑ **Network and actors identification**
- ❑ **Innovations as interactive and non - linear process**
- ❑ **Qualitative approach**
- ❑ **Success and failing factors:**

1. **INFRASTRUCTURAL (digital, physical)**

2. **INTERACTIONAL (Lock-in effects**, weak/strong links, innovation network, capabilities)**

3. **INSTITUTIONAL (soft: subsidies, cultural; hard: regulations)**

***** Based on Roumboutsos A. (2017); Arduino et al, 2013: INNOSUTRA project; Aronietis (2013); Verberght et al. (2019)
**** LOCK-IN EFFECTS:** The inability of complete (social) systems to adapt to new technological paradigms. Neglect of developments outside the own sector or existing system

How?

Social Cost-Benefit Analysis (SCBA)

BASICS: Automated vessel compared with conventional vessel, dry bulk, 110 m , Rhine, mode B, S2, base year 2015,

ASSUMPTIONS:

- Fixed freight rate EUR 2.15/ton (first year)
- Lifespan 40 years
- Loan 15 years (70% of total investment), interest 4.5%
- Residual value EUR 80,000
- Charter rate for AV: 1%, for CV 7% (tested)
- Fuel costs: different forecast scenario’s (tested), decrease of 20% (= emission decrease)
- Maintenance & repair outsourced
- SCC outsourced with annual fee
- Without subsidies
- Lower port dues and fairway fees
- 70% of administration is related to HR
- 10% discounting and 1.8% inflation
- Need for automated on-board and on-shore mooring devices
- Accident costs are zero
- Conventional propulsion and engine for both vessel models

How?

Social Cost-Benefit Analysis (SCBA)

Costs

PRIVATE: crew (0), fuel (-), SCC (+), maintenance & repair (-), technical compliance (-), insurance (+), administration (-), communication (-), charterers provision (-), fairway fees & port dues (-)

SOCIAL: Infrastructure cost (+)

Benefits:

PRIVATE: revenue (+, more trips & cargo), efficiency (+), time benefit (+)

SOCIAL: costs of emissions, greenhouse gas, safety (-)

How?

Social Cost-Benefit Analysis (SCBA)

INDUSTRIAL-ECONOMIC

Scenario	0	1	2	3	4	5	6	7	8	9	10	11
Vessel	CV	AV	AV	AV	AV	5 AV's	5 CV's	AV	5 AV's	AV	AV	CV
Payback time (years)	15	15	25	15	15	15	15	15	15	15	15	15
Fuel cost increase	high	high	high	small	high	high	high	high	high	high	lower m³	high
Earnings	high	high	high	high	low	high	high	high	high	high	high	high
Charterer provision	7%	1%					7%	1%		7%	1%	7%
SCC cost in EUR (year 1)	0	190,960				286,440	0	95,480		190,960	190,960	0
Crew cost in EUR (year 1)	272,800	0				0	1,364,000	0		0	0	409,200
NPV in EUR (equity)	1,384,550	410,915	565,858	642,372	-2,143,143	5,968,490	6,922,750	1,239,261	7,625,181	-154,436	718,094	201,202
NPV in EUR (enterprise)	3,741,767	4,744,269	4,889,341	5,301,335	139,807	30,789,368	18,708,837	6,240,154	33,781,136	3,723,318	5,304,682	1,604,795
IRR (equity)	22%	11%	12%	11%	5%	13%	22%	13%	14%	10%	12%	11,35%
IRR (enterprise)	15%	10%	10%	10%	5%	11%	15%	11%	12%	9%	10%	9,99%

In red: scenario 0, 6 and 11 refer to conventional vessel with different conditions

Differences with related CV	1	2	3	4	5	7	8	9	10
ΔNPV_{equity}	-973,635	-871,214	-1,025,826	-1,497,340	-954,260	-145,289	702,431	-1,538,986	-666,459
ΔNPV_{ent}	1,002,502	1,098,397	876,889	55,300	12,080,530	2,498,387	15,072,299	-18,449	1,562,909

Equity perspective = equity of the firm.

Enterprise perspective = equity + debts of the firm.

NPV, Net Present Value= the difference between the present value of cash inflows and the present value of cash outflows over a period of time. The net present value shows if the project is profitable.

Scope of business case is assumed to be 40 years, payback time of loan differs

How?

Social Cost-Benefit Analysis (SCBA)

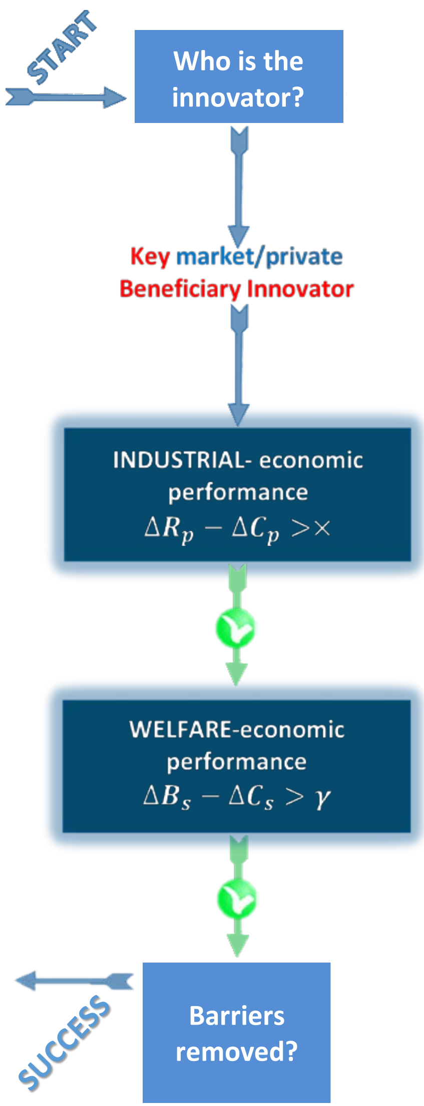
WELFARE-ECONOMIC

Scenario	0	1 (25% infra)	12.5% infra	0% infra
External cost per vessel in EUR	CV	AV	AV	AV
Accident costs	7,497	0	0	0
Infrastructure costs	138,000	193,545	174,191	157,623*
Emission cost	427,500	383,724	383,724	383,724
Total external cost	**572,997**	**577,269**	**557,915**	**541,347**
Compared with baseline scenario	**0**	**-4,272**	**15,082**	**31,650**

First year of operation, if infrastructure costs increase with 12,5%, the social benefit is EUR 15,082 for an AV compared to a CV. With no additional infrastructure, the benefit of the AV (of scenario 1) is 16% higher than during the first year of the CV.

How?

Social Cost-Benefit Analysis (SCBA)



RESULTS

INDUSTRIAL – economic performance > x if more than 6 VTE's are replaced (in model), with 5 AV's (economies of scale) and issues are solved, otherwise **< x**

WELFARE – economic performance > y with 16% less social costs without additional infrastructure investments.
If no differences in fuel consumption (emissions), accidents and performance, y = 0 or negative.

Possible benefit of avoiding negative mode shift (e.g. automation in competing modes versus non-automated IWT) was not quantified

How?

System of Innovations Approach (SIA)

SIA-MATRIX, FAILURE & SUCCESS

Identified Success and Failure factors linked to responsible innovation actors

Actors / Factors	Demand: VO/O's, large vessel owners, charterers, industry with own vessels	Shippers/ forwarders	Third parties lobbyists; manufacturers, consultants, sector organizations	Knowledge institutes, funding, standardization bodies,
Infrastructure				
Hard Institutions				
Soft Institutions				
Weak Networks				
Strong Networks				
Capabilities				

How?

System of Innovations Approach (SIA)

- **Automation infrastructure** (on-shore mooring, Shore Control Centers, 5G)
- Possible **lock-in** (e.g. ignoring developments in other modes)
- Relatively high **development costs**, low-scale mass consumers and high SME's percentage
- **Integration** in IT logistics chain and need for legal **e-documents**
- **Redundancy of devices**, data security and internet coverage, **big data**
- Fragmented **public support** (pilots and subsidies) and relatively large **regulatory bottleneck** (e.g. Liability); differences between Member States; need for **technological neutral standards**
- Potential **safety benefit, but** relatively low accident rate
- **Issues** such as human error shifts to programming, ethical flaws, cognitive lackadaisicalness, deskilling

CONCLUSION

Combination of SCBA and SIA provides a comprehensible in-depth view in the automated inland vessel (both quantitative and qualitative).

The number of uncertainties concerning automation, the relatively low benefit in replacing the crew of a conventional vessel by an SCC service in most scenarios, legal uncertainty and the lack of automated infrastructure, give less incentives to invest in a AV for now.

Relatively high social cost if trucks and trains become automated and IWT does not
→ potential loss of modal share, weaker position in logistics chain (need for further research)

RECOMMENDATIONS

Regulation & standards, legal definition for automation/autonomous, liability, crew requirements, e-government (incl. IT training, cyber security, e-documents), funding, accident data, cross-border exchange

"If the highest aim of a captain were to preserve his ship, he would keep it in port forever."

St. Thomas Aquinas

Thanks for your attention!

Goede vaart!

Q&A

For more information

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https://hdl.handle.net/10067/1571790151162165141

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