Integrated Vessel Traffic Management Systems in the Function of Inland Waterway Traffic Optimization

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Abstract. Awareness of an efficient and sustainable vessel traffic management is a result of raised traffic congestion as well as of increased waiting times at locks and inland ports. The established vessel traffic management systems will have to be modified by 2025, to challenge the expected increase in the transport demand on navigable European inland waterways. Substantial benefits to traffic flow optimization are anticipated by the dissemination of an accurate information regarding the waterway and the management of the locks in the waterway network. Positive effects resulting from a harmonised implementation of traffic management systems optimize also the use of waterway infrastructure by means of reducing dredging activities and lock utilization. The outcomes of this paper will give a concise assessment of the benefits of an integrated traffic management implementation to private and public stakeholders of inland navigation.

Keywords: optimization, traffic management, inland waterways, assessment.

1 Introduction

The implementation and overall efficiency of an intermodal freight transport system with inland navigation as a core mode is an important and challenging issue in the EU Transport Policy of the 21st century. On-going research studies that are being carried out on a European level determine in what way the European inland waterways transport could be used more efficiently and consequently integrated into the future European intermodal transport system. The vessel traffic management is aimed at making the inland shipping a competitive and safe means of transport, that makes the optimal use of the available capacity. This implies smooth shipping which strengthens the position of inland navigation as a cost-efficient link in the transport network and contributes to the efficient use of the available transport infrastructure and any future extensions to it [2]. The objective of this paper is to assess vessel traffic management systems with respect to the costs and benefits for the different target group actors. This involves a comprehensive cost/benefit analysis for private and public stakeholders of inland navigation, in general a shipper, freight forwarder, logistic chain manager, ship owner, skipper, barge operator, terminal operator, and the competent authorities for which the costs are supported by the public authority.

J. Mikulski (Ed.): TST 2012, CCIS 329, pp. 117–123, 2012.

2 Interaction between Private and Public Stakeholders of Inland Navigation

In order to understand the interaction between private and public stakeholders it is essential to analyse a decision process. The navigation as well as the support from traffic management services influence the decisions made by a navigator. The navigator makes decisions on courses to sail as well as on speeds, whilst a traffic management operator attempts to affect the decisions of a navigator by providing a relevant information that enables him to make correct navigation decisions.

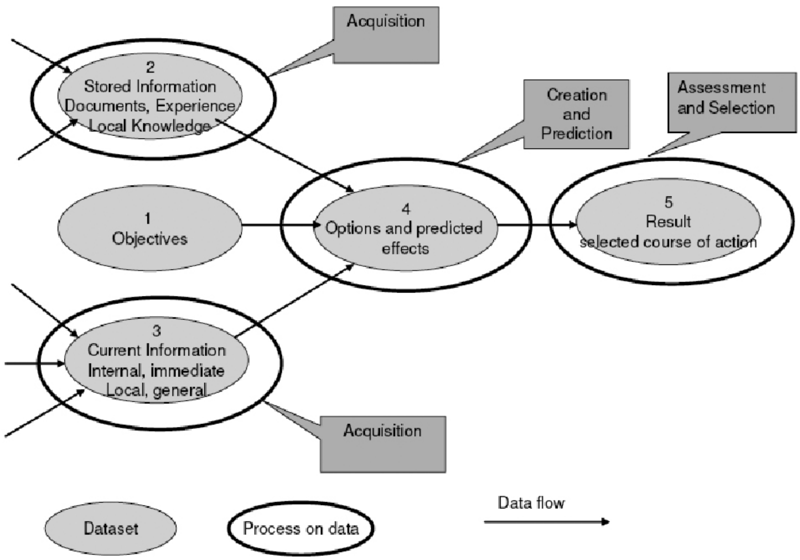

Fig. 1. Schematic review of an inland navigation decision process

The Fig. 1 contains ellipses which show various elements of the decision process in the inland navigation. The ellipse marked 1 represents the objectives for the decisions to be made. The ellipse marked 2 is the long-term information, such as documents, expert judgment, local knowledge and experience. The ellipse marked 3 represents the internal current information. It might also have a local and general information. In many cases the information stored as well as current should be acquired. This is indicated by the squares. A decision maker is affecting some processes on the datasets that are represented by ellipses 2 and 3. The results of the processes are options with their predicted effects. The process that is drawn around the 5th ellipse is the assessment of the different options and their predicted effects. The assessment as a final result, the selection of an option takes place taking the objectives into account. Figure 1 depicts the key to understanding the process of navigation and provided Vessel Traffic Management services [5].

3 Problem Solving Approach

The following fundamental relationships have been derived from the definition of vessel traffic management: the first basic relationship to be highlighted is between the management and the *safety and capacity* of the waterway traffic. In other words, the relationships between the level of information and knowledge provided to the waterway users and the reduction of the risk and of the number of accidents as well as the reduction of the time delays and the use of optimum drafts. The second basic relationship is the saving of *costs in infrastructure* investment as a result of traffic management implementation. Many locks have large deceleration works that are necessary for mooring the inland vessels that have to wait for a lock cycle. By precise planning of the RTA's, based on ETA's send by skippers the number of waiting vessels can be reduced and hence the length of the deceleration works can be reduced. On-going development of planning messages that are a part of VTM might help this process [4].

Moreover, by positively affecting the traffic flows throughout locks it is possible to make the traffic supply through a lock more uniform over the day, implying a better usage of the locks. An integrated VTM application on waterways would imply that the lock might be operated for a longer period without renewal or replacement of the lock. The investment costs may also be reduced. Benefits due to the reduction of fuel consumption and waiting times at locks in a RIS covered area, the reduction of dredging work, replacing VTS-centres by new established RIS centres, smaller investments in deceleration works and the delay of investment of locks could derive benefits.

3.1 Basic Indicators

Quantitative indicators for the traffic management implementation offer suitable basis for a set-up of cost benefit analysis framework assessment. Basic indicators consist of monetary resources that go into the financial aspect of VTM implementation process, inputs (technical components), outputs (traffic management services) as well as outcomes which occur as a result of integral implementation.

Table 1. Basic indicators

Indicators			
Costs	VTM inputs	VTM outputs	VTM outcomes
Monetary resources	Technical components - VHF - Radar - ENC - AIS - ICT infrastructure	- Traffic Planning - VTS - Lock management	- Safety - Reliability - Cost efficiency - Competiveness - Effectiveness

3.2 Calculation Methodology

A clear and structured methodology is essential for summing up efforts into general results. Approaches are based on practical considerations in relationship with the available data and information. Therefore, the methodologies used is this paper define and regroup benefits and make assumptions of the expected changes based on the input data, modelling and on the expert judgment.

The above-mentioned calculation is based on the following three-steps methodology:

1. Evaluation of the costs

Review of the “clusters” as regards the targeted actor group, the necessary related on board and shore equipment (hardware, software, communication means, etc…), as well as the navigation mode of operation (on-demand, continuous, etc.). For each of the “clusters” the determination of the capital cost, of the investment lifetime, of financial rates, of yearly operating cost according to the level/intensity of use, and of assumptions related to the level of the fleet equipped with.

2. Evaluation of the benefits

As an introduction to the calculation of the cost/benefit analysis it is important to highlight the most important benefits that VTM can provide to the private and public stakeholders: optimization of traffic delays, substitution of VTS and introduction of RIS centres, optimization of dredging costs, optimization of deceleration works and capital costs of locks.

3. Extrapolation of results

Results will comprise a calculation of the costs that an actor (public or private) could support when working without VTM services or with VTM. By comparing the results the authors will obtain quantified benefits in the final analysis. Authors developed a model for the period between 2005[1]-2020 on the river Rhine and its tributaries. It is assumed that a full integration of vessel traffic management services to users will occur in 2015, and that the efficiency will increase to 100 % by 2020 [6]. The following table provides modelling of the level of vessel traffic management implementation and contribution to the optimization of costs [3].

Table 2. Percentage of cost optimization to private and public stakeholders as a result of integrated VTM implementation

Level of VTM implementation and contribution to the optimization of costs				
Year	2005	2010	2015	2020
VTM efficiency	0%	50%	50%	100%
Optimization of traffic delays	0%	5%	10%	10%
Introduction of RIS centers	0%	50%	100%	100%
Optimization of dredging costs	0%	12.5%	25%	25%
Optimization of deceleration works	0%	12.5%	25%	25%

[1] RIS Directive (2005/44/EC) established framework for harmonised deployment of vessel traffic management systems across Europe within the scope of the author’s model. As a consequence, year 2005 was taken as a reference in the model.

The cost optimization is calculated by multiplying the optimization percentage of table 2 with the statistical data gathered by the study "Assessment of INDRIS on the basis of the Rhine, Seine and Danube demonstrator". The results are discounted using the European Commission discount rate of 4 %. Also the Net Present Value is calculated for the above-mentioned cost optimization.

4 Cost/Benefit Analysis of Integral Vessel Traffic Management Implementation

A cost-benefit analysis links the cost of an action to its consequences expressed in monetary units. This analysis is based on all the positive and negative impacts of a project for all the actors involved in the project and on the society as a whole [1]. As stated, the private stakeholders benefit from direct short-term effects of VTM.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Authors have calculated average values of the costs that the private parties would support in three particular situations and for two cases: without-VTM and with-VTM. If we compare the results of the situations we will obtain the following benefits due to the RIS implementation for the private stakeholders. For an investment to be justified from the economic evaluation theory point of view, the value of the Benefits/Costs (or Advantages/Costs) ratio should be equal or greater than 1 (B/C ≥ 1) [1]. The following table provides the B/C ratio as calculated for the private stakeholders. Benefits consist of the reduction of delays caused by the traffic congestion and locks utilization.

Table 3. Benefit/Cost ratio for private stakeholders

B/C private stakeholders	
	Net present value
Optimization of traffic delays	9.727.127
Total benefits, private stakeholders	9.727.127
On board equipment Rhine corridor	4.310.996
Total costs, private stakeholders	4.310.996
Benefit/Costs Ratio	***2.56***

The following table provides the B/C ratio calculated for the public stakeholders, the competent authority. The most relevant costs are the costs of RIS centres introduction as well as the extra costs to equip the locks with adequate RIS technology.

Table 4. Benefit/Cost ratio for public stakeholders

B/C public stakeholders	
	Net present value
Optimization of VTS costs	36.299.147
Optimization of dredging costs	6.721.217
Optimization of deceleration costs	15.373.510
Delay of investments in locks	14.513.822
Total benefits, public stakeholders	72.907.696
Introduction of RIS centers	65.753.883
RIS lock centers	4.785.933
Total costs, public stakeholders	70.569.816
Benefit/Costs Ratio	***1.03***

5 Conclusion

The Vessel Traffic Management system as a part of River Information Services is aimed at optimizing the use of waterway infrastructure as well as at facilitating the navigation safety. The measurement of benefits and their relationship to costs is a commonly used practice while evaluating infrastructural projects. The VTM system provides the parties involved with positive B/C ratios. The private stakeholders on the stretch of the river Rhine will have a large return (2.66 B/C ratio) for any investment that they are prepared to make. The public authorities may also have a positive B/C ratio (1.03) but the application of VTM will not bring them many benefits. However, as managers of the waterway infrastructure they may be expected to co-operate with a change that is clearly in the interest of the private stakeholders.

Authors conclude that the implementation costs per stakeholder are relatively easy to evaluate but the benefits can only be estimated based on the assumptions, modelling and on the expert judgment. It can be concluded that performed studies within this article come to a very high C/B ratio, making the Vessel Traffic Management system as part of RIS a prospective infrastructural project for the inland navigation.

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