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Value-added services for river information systems




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Abstract

A River Information Service (RIS) for the European east-west transportation axis (Rhine-Main-Danube) will be installed in the near future. The system will rely on a conventional transponder-based network using radio links embedded in a wire-based communication network on shore. By the control of central management facilities tactical traffic information is provided. On-board a ship the positioning data of the vessel itself and the positioning data of the surrounding ships are compiled to generate a tactical traffic image which is displayed by using an Electronic Chart Display and Information System (ECDIS). The positioning technology used for traffic management systems on inland waterways has to fulfill high requirements regarding accuracy (better than 5 m) and availability. For positioning, DGPS with local reference stations along the rivers will be used.

The advantages of the tactical traffic image for the user are, e.g., the increased transport safety by monitoring and guiding the flow of traffic, the support of the steersman by an extensive image of the traffic situation, and the possibility to monitor the transport of dangerous goods. Commercial inland navigation benefits too, by minimizing the costs of the non-productive time at locks and in harbors. The fuel consumption can be reduced through the planning of trips with continuous speed and by simplifying the logistic flow of the inland waterway traffic.

Around 2008-2010, an upgrade of the existing technology will be possible. In order to identify the best-practice method covering the needs of commercial (transport management) as well as nautical and administrative (traffic management) requests in inland waterway navigation, the forthcoming positioning technologies are evaluated.

The project EPRIS (Evaluation of Positioning technologies for the generation of value-added services in the environment of River Information Systems) focused on future systems (EGNOS, Galileo, etc.) to identify migration paths to new positioning and navigation technologies in the system concept of today's RIS.

Kurzfassung

Entlang der europäischen Ost-West Transportachse (Rhein-Main-Donau) wird in naher Zukunft ein River Information Service (RIS) eingerichtet. Dieses baut auf einem konventionellen transponderbasierten Netzwerk auf und nutzt Funkverbindungen zur Datenübertragung neben der landseitigen leitungsbasierten Kommunikationsinfrastruktur. Sogenannte taktische Verkehrsinformationen werden unter der Kontrolle einer zentralen Leitstelle bereitgestellt. An Bord des Schiffs werden Positionsdaten und Schiffsinformationen des eigenen und der umgebenden Schiffe zu einem taktischen Verkehrsbild zusammengefügt und mittels Electronic Chart Display and Information System (ECDIS) auf einem Bildschirm ausgegeben. Die Positionierungstechnologie, die für Managementsysteme auf Binnenwasserstraßen eingesetzt wird, muss hohe Anforderungen an die Genauigkeit (besser als 5 m) und Verfügbarkeit erfüllen. Derzeit wird DGPS mit lokalen Referenzstationen entlang der Wasserstraßen verwendet.

Durch die Nutzung des taktischen Verkehrsbilds ergeben sich eine gesteigerte Verkehrssicherheit aufgrund der möglichen Verkehrsüberwachung, die Unterstützung des Steuermanns durch eine ausführliche Darstellung der aktuellen Verkehrssituation und die Möglichkeit, Gefahrguttransporte überwachen zu können. Wartezeiten an Schleusen und in Häfen werden minimiert, wodurch sich enorme Vorteile für die kommerzielle Binnenschifffahrt ergeben. Zudem kann der Treibstoffverbrauch, durch eine effektive Fahrzeitplanung mit kontinuierlicher Geschwindigkeit und eine Vereinfachung des logistischen Verkehrsablaufs auf der Binnenwasserstraße, gesenkt werden.

Um 2008-2010 wird eine Verbesserung der existierenden Technologie möglich, indem eine Best-Practice Methode identifiziert wird, die die Anforderungen des kommerziellen, nautischen und administrativen Transportmanagements an die Binnenschifffahrt abdeckt. Hierfür werden u.a. die verfügbaren und künftigen Positionierungstechnologien evaluiert.

Das Projekt EPRIS (Evaluierung von Positionierungstechnologien zur Generierung von Mehrwertdiensten im Umfeld von River Information Services) zielte auf zukünftige Systeme (EGNOS, Galileo, etc.) ab um diese neuen Technologien in das derzeitige Systemkonzept von RIS zu integrieren.

1. Introduction

Recent traffic forecasts [1] for goods transport on the Trans European Network (TEN) show an average annual increase of 3-5%. This means doubling the overall goods transport volume within the time frame until 2015. In [2] a more detailed analysis is given showing that the average increase on the highly sensitive east-west transport axis will be enormous. One reason is the economic growth of the Central Eastern European Countries which is higher-than-average. Further analysis show that the major part of this traffic increase will occur on the Trans European Road Network. The road transport segment has been growing continuously during the last 20 years and is cumulating at about 80% of the overall transport volume today. A critical saturation of the road network has been reached causing accidents, delays, and a loss of 300 billion € every year on the European gross domestic product. Significant effort is required to keep the traffic flowing.

The transportation capacity of many inland waterways especially on the river Danube is used at a very low extent. The traffic on the European rivers can be increased significantly over the next years (e.g. see [1]). As the road network reaches its economical and ecological limits a shift of transportation capacities to inland waterways will make the situation easier. Another positive effect of this possible shift is that CO_2 emissions will be cut significantly (cf. Figure 1).

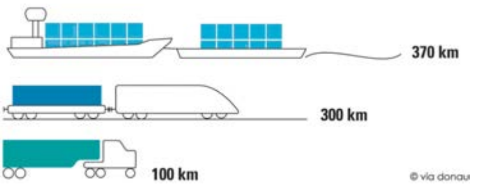

Figure 1: Comparison of the energy consumption of different common carriers.

One problem connected with the river Danube is the occasionally possible big change of the water-level in the upper part of the river. Other problems for the traffic on inland waterways are the low reliability for travel time and ETA (estimated time of arrival) as well as the poor 'status information' about the inland navigation overall. Furthermore, increasing transport operations on the Danube will increase the probability of accidents, waiting periods at locks, and endanger the ecologic balance of the river system.

Most recent technological concepts within RIS can provide online traffic information and position-based nautical support for inland navigation and will transform the inland waterways to reliable and competitive transport ways.

2. Donau River Information Services (DoRIS)

RIS is defined as a concept for harmonized information services to support traffic and transport management in inland waterway navigation including interfaces to other transport modes.

In autumn 1999 the European research project INDRIS (Inland Navigation Demonstrator for River Information Services) showed the technical feasibility of a concept for RIS, on a demonstration site on part of the Austrian Danube (see Final Report of INDRIS).

Due to the INDRIS project results, the Austrian ministry for transport, innovation, and technology decided the stepwise implementation of RIS in Austria. Together with a subsidiary of the ministry, the Danube Transport Development agency (via donau), an INDRIS-based system concept has been developed and a European tendering procedure was initiated. According to the tendering documents a consortium of private companies started to implement a RIS test-center on a limited section of the Danube in Austria which was finished in the third quarter of 2002.

This test-center is used to verify and improve the chosen technical approach and should further serve as an international reference system where all parties involved in the European RIS process get the possibility to perform studies in a working RIS environment.

2.1. Concept

Figure 2 shows the concept of the DoRIS which is based on a fast short-distance radio communication between the involved ships and to land-side control stations exchanging ship identification, position, time, and other transport-related information. A RIS enables the generation of a Tactical Traffic Image (TTI) supporting nautical operation on-board the ship and traffic monitoring by the responsible federal administration at a national traffic control center.

In its concept the river information system DoRIS has two main objectives:

1. to provide an overview of the actual traffic situation and the traffic control by a TTI, which represents the nautical component.

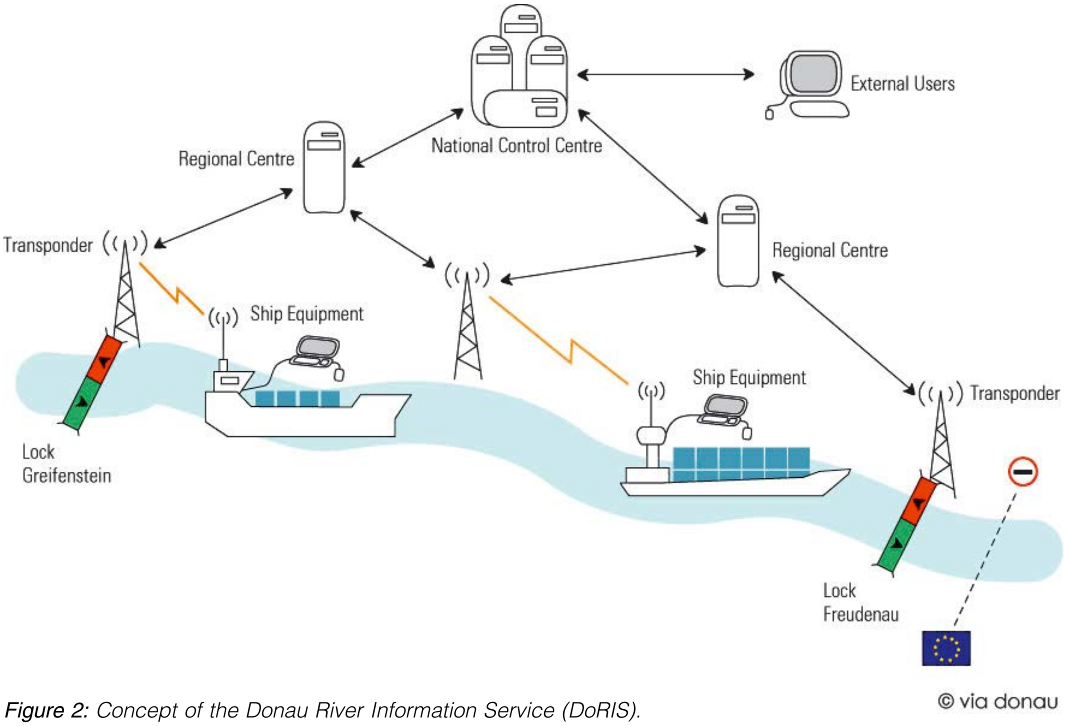

Figure 2: Concept of the Donau River Information Service (DoRIS).

2. to provide online traffic information by an information system in order to fulfill the needs of management tasks in inland waterway traffic operation. This can be seen as the navigational component.

2.2. Transponder

One main element of the DoRIS system are AIS (Automatic Identification System) transponders. Within DoRIS, the transponders exchange positioning information and other relevant information via VHF. The transponder is connected to a notebook where a TTI is produced (see below). Each vessel needs to be equipped either with a fixed or a removable transponder. Additional transponders are installed ashore to provide local and governmental authorities with an actual traffic image. Traffic data are processed and stored in a central data base and allow the reconstruction of accidents and the workout of statistics if needed.

2.3. Positioning component

Positioning technologies used for traffic management systems on inland waterways have to fulfill different requirements regarding accuracy, availability, integrity and actuality. The evolution of the needs for navigational purposes as well as the needs for producing value- added services for the traffic and transport management on inland waterways will be discussed in detail below. At the moment, DGPS with local reference stations along the river will be used in the DoRIS system.

In the project EPRIS emphasis were led on the forthcoming GNSS systems like EGNOS and GALILEO and their contribution to the generation of value-added services.

2.3.1. EGNOS

The regional satellite-based augmentation system (SBAS) EGNOS emits augmentation signals via two geostationary Inmarsat-III satellites and the geostationary Artemis satellite. The augmentation signal is designed in a GPS-like manner and carries differential corrections, integrity data, and ionospheric corrections.

One advantage of EGNOS are lower horizontal and vertical positioning errors compared to GPS. GPS standalone provides 13 m and 22 m for the horizontal and vertical positioning accuracy (95%), respectively (see [6]). With GPS augmented by EGNOS this accuracy can be improved to 1 - 3 m for the horizontal and 3 – 5 m for the vertical component. Even more important is the possibility to get information on the integrity of GPS and EGNOS itself and implied alarm limits for positioning with a time to alarm of better than 6 seconds.

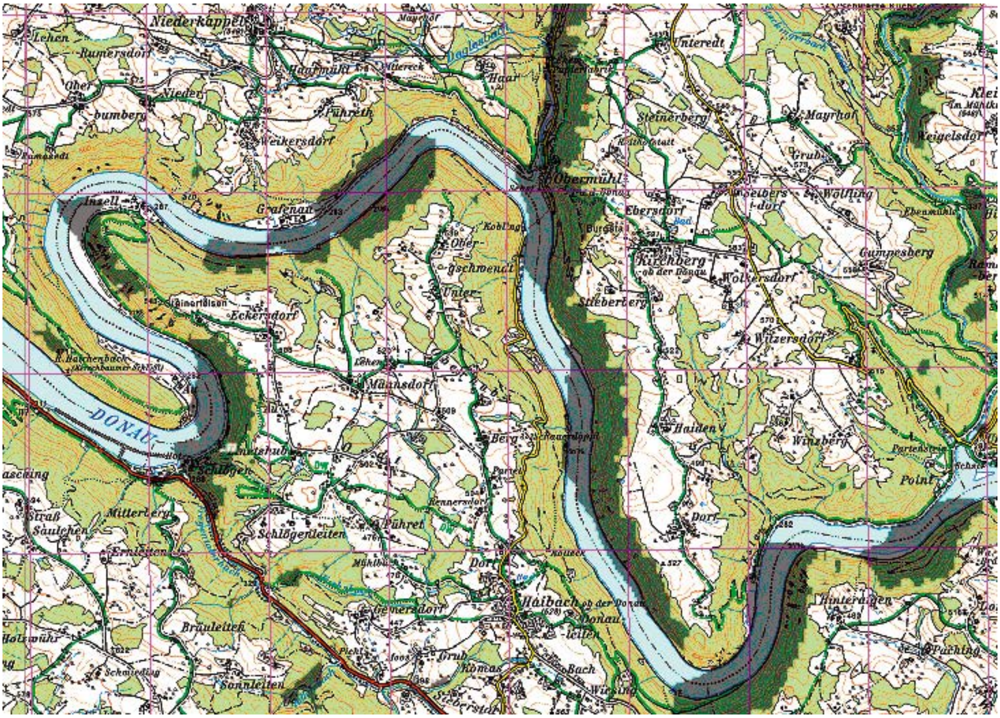

Figure 3: Visibility of IOR along the Danube near the German-Austrian border.
The dark gray pattern marks obstructions of the EGNOS signal.

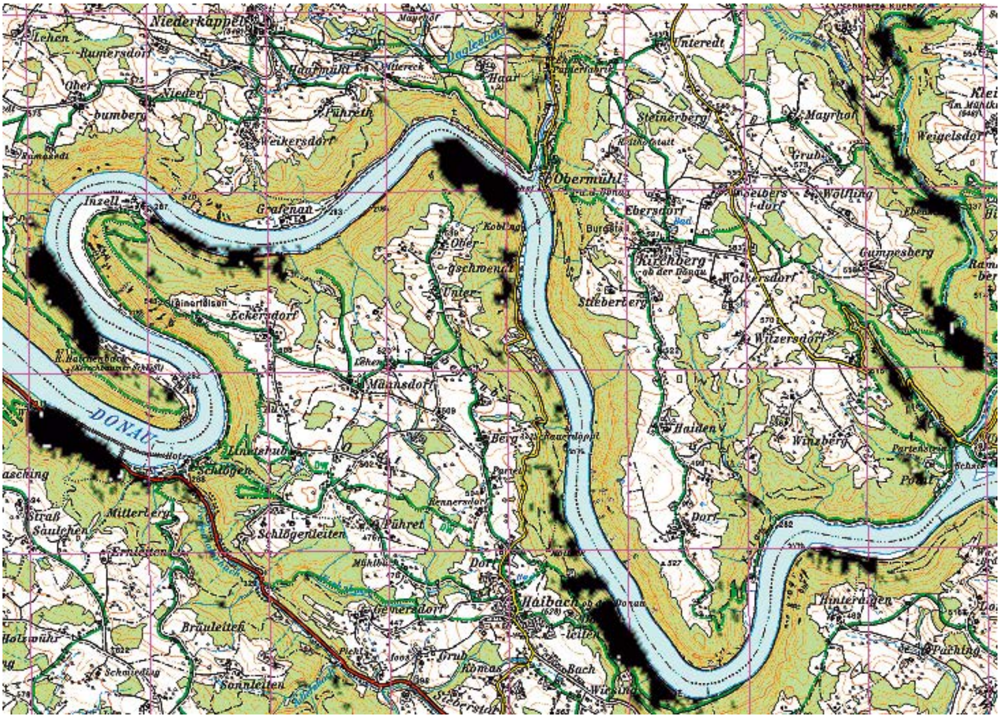

Figure 4: Visibility of AOR-E along the Danube near the German-Austrian border.
The dark gray pattern marks obstructions of the EGNOS signal.

The receiving of EGNOS signals needs a line of sight to one or more of the geostationary satellites (AOR-E, IOR, and Artemis). Obstacles (dense vegetation and high rocks ashore, brides etc.) may cut off the connection. As the satellites are placed over the equator they are "visible" in the southern part of the sky regarding locations in the northern hemisphere. This is the reason why in deep valleys running from east to west problems may occur. Figure 3 and Figure 4 show a simulation of the visibility conditions of AOR-E and IOR. All together the approach using EGNOS for positioning is promising. Nevertheless applications requiring redundant EGNOS signals for safety reasons will need additional augmentation measurements.

During the GALEWAT (Galileo and EGNOS for Waterway Transport) project [3], a concept for the provision of the EGNOS correction signals by the use of the terrestrial AIS infrastructure was shown. This concept [3] and [5] pointed out clearly the possibility to provide the EGNOS corrections even in regions, where the EGNOS signal can not be received directly from the geostationary satellites. Nevertheless, this system concept is not realized until now.

2.3.2. GALILEO

The forthcoming European satellite navigation system GALILEO is a civilian system which will provide accurate positioning information on a worldwide basis. GALILEO's navigation and positioning services will be interoperable with GPS and GLONASS. The accuracy of the real-time positioning information will be in the meter range. The availability of selected services will be guaranteed. Also the integrity is high. The GALILEO system will consist of 30 satellites in medium earth orbits (MEO) and will be operable around 2012 presumably.

The foreseen GALILEO-services (open service, commercial service, safety-of-life service and public regulated service) will be complemented by local GALILEO components if higher user requirements concerning accuracy, availability, integrity, and continuity are needed. Further details can be found in [8].

2.4. TTI

By the control of central management facilities, tactical traffic information on a GIS-based application is provided. On-board a ship the position data of the vessel and the position data of the surrounding ships are compiled to generate a TTI which is displayed by an ECDIS (see Figure 5). The TTI is a function creating a graphical impression of the current traffic situation in a certain area. The TTI can be used in control centers on shore and onboard of an inland waterway vessel. On shore the TTI will support a new method of traffic guidance through monitoring traffic using AIS, GPS and inland-ECDIS technology. Onboard of inland vessels the TTI will become the navigational display using the same technologies. This image is further enhanced by reports from vessels to the information center where an overview of vessels active in the respective area is generated. The AIS technology will improve the TTI in such a traffic center since ships can be identified and additional information is available.

3. Economical and ecological aspects

The deployment of RIS will meet both ecological and economical aspects as well as governmental/administrational requirements.

According to [2] and [7], the main advantages are:

- Increased safety of transport operation.
- Improved catastrophe management and calamity abatement.
- Minimization of the use of the waterway in sections declared as protected areas, e.g., the National Park "Donau-Auen" by commercial shipping.

Economic advantages:

- Improved logistics operation by more efficient use of transport means.
- Improved transshipment process between road/rail and vessels.
- New infrastructure within the information technology.
- Reduced danger of accidents and therefore reduction of follow-up costs.
- Fuel and time savings.
- Integration of an information service for commercial users like ship owners, brokers, ports and tourist businesses, etc.

Administrative advantages (governmental level):

- Common traffic guidance system with integration of the corresponding public authorities, e.g., navigation, customs, defense, and hydraulic engineering authorities.
- Services for the water supply and distribution as well as for the regional planning.
- Fast and efficient information service for skippers ('notices to skippers').

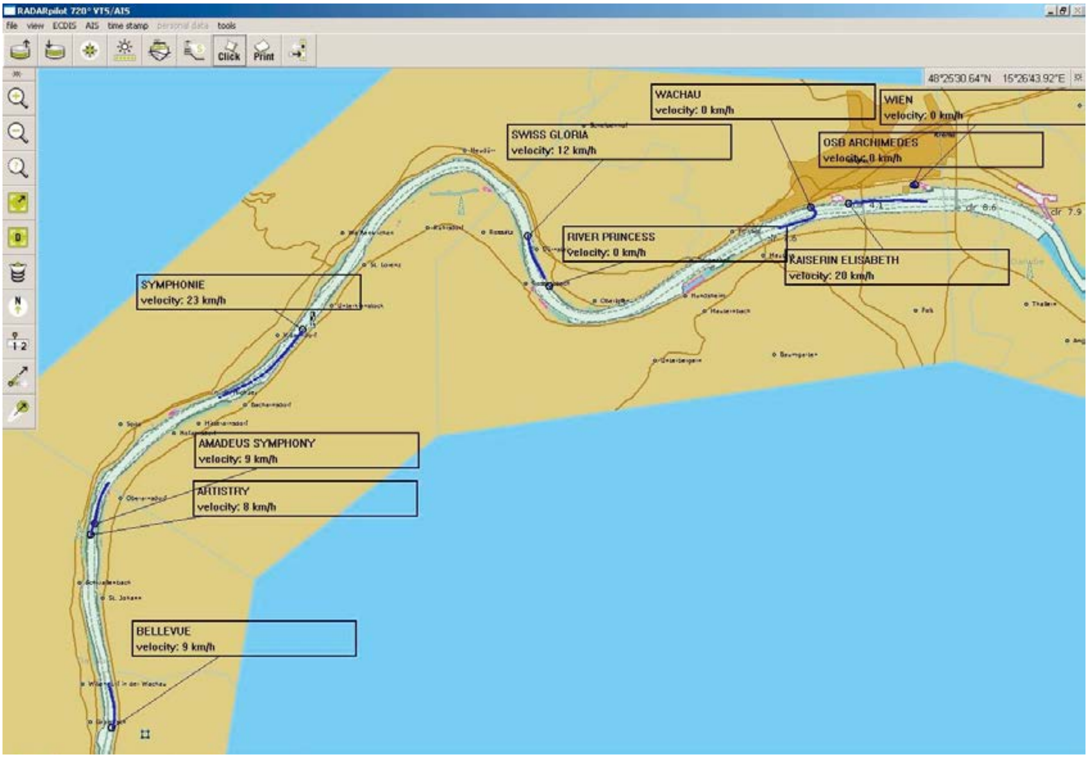

Figure 5: *Example of a TTI.*

With RIS, the responsible Austrian federal government expects both, improved safety for transport operation on the Danube and improved competitiveness of inland waterway transport as part of modern supply chain management. This will encourage the modal shift of cargo transport from road to inland waterway on the highly saturated east-west road transit transport axis in Europe (Amsterdam, Rotterdam and Antwerp to Black Sea).

4. Value-added services

[1] focuses on future systems (EGNOS, Galileo, etc.) to identify migration paths to new positioning and navigation technologies in the system concept of RIS.

Value-added services indicate services improving basic GNSS data by increasing the quality (accuracy, integrity, availability and continuity) and combining it with additional information (navigation, communication etc.).

The signal in space (SIS) of positioning and navigation systems is free to everyone (neglecting restrictions for the moment). In general the knowledge of an accurate and actual position represents no added value. Normally an added value is achieved if the position information is combined with other information sources (geographical information systems, traffic information etc.) and communication tools.

4.1. Value added chain

Participants of a value-added chain provide additional services for the improvement of the SIS from pure data to the end user. The steps from the generated SIS to an end user application can be described by the example of a traffic service. The basic SIS data is supplemented by GIS-data provider information. Afterwards object data provider and traffic data provider information are added. Before the improved data is delivered a data integration is done. One group to be concerned with this topic is the Research Group Geoinformation at the Technical University Vienna (see e.g. [4]).

4.2. Components of value-added services

Value-added services are generated by several processing steps where the basic information is supplemented by other data sources. At the beginning the SIS and a number of other data basis (knowledge data basis, GIS etc.) are needed. The data collected from the different sources are combined and reprocessed thus improving the contents of the data.

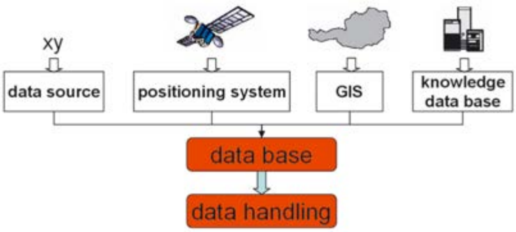

Figure 6: Components of value-added information services step 1.

For the estimation of the added value it is of fundamental importance to know the requirements of the end user for the application environment.

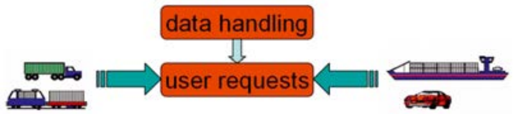

Figure 7: Components of value-added information services step 2.

As a next step a user-specific processing, visualization and storage is done. Finally the value-added service is provided to the user. All components of added values (shown by the red color) contribute to the refinement of the data and thereby to value-added services. The acceptance and perception of value-added services is directly influenced by the time needed for processing, delivering and storing the data thus influencing the willingness to pay for value-added services.

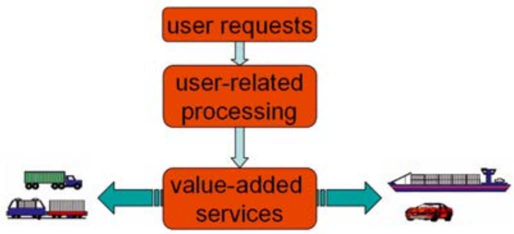

Figure 8: Components of value-added information services step 3.

5. Evaluation of positioning technologies

Within [1] an evaluation of positioning technologies for applications and value-added services in the transport and traffic management of inland waterways was carried out. The following parameters and assessment criteria were used.

Absolute accuracy: stands for the needed accuracy of the positioning data given in meters.

Spatial and temporal availability: describes the availability of the particular positioning technology needed for the chosen application. Assessment criteria are: low, medium, and high.

Integrity: stands for the need of integrity of the particular positioning technology. Assessment criteria are: none, medium, and high.

5.1. ETA

The ETA is the basis of improved logistic operations for the optimization of the transporting process as a whole. Knowing the ETA will simplify and accelerate the inland waterway navigation process through the improved access to resources of ports and terminals. The time for loading and unloading can be kept as short as possible. ETA has its advantages also in managing operations at locks, supporting customs authorities in planning their resources (personal). Concerning positioning aspects an accuracy of better than 100 m is needed. Integrity and availability need to be high.

5.2. Travel plan

In order to establish a travel plan for ships additional information besides the ETA is needed. Fairway information of the actual and predicted water-levels of the waterway, port cycles, stream velocities etc. are provided. The ecological effect of this value-added service is evident through fuel and time savings. The information will be supplied on a regional basis. The integrity and availability has to be high. The positioning accuracy needs to be 1–50 m.

5.3. Flow of goods

This service incorporates all the information needed for improving the planning and guiding of logistic operations. Mainly information about the cargo and the vessel are incorporated. While for this service no integrity is needed, the availability needed is middle and the accuracy of the position needed is about 100 m.

5.4. Statistics

The information collected in a RIS may be analyzed and described by statistical parameters. Statistics supports numerous management decisions of operational and logistic centers, public authorities, federal administrations, locks, ports, terminals, ambulance, disaster management etc.

5.5. Traffic information

Traffic information stands for all data needed for guidance and navigation. The information is provided on an inland-ECDIS together with the electronic inland navigation. Two operational modes of the ECDIS exist: in the navigation mode the inland-ECDIS is used for navigating the ship (additional radar information is provided). The information mode of the inland ECDIS is used for information purposes only and no additional radar information is provided. As the traffic information is used for navigation the accuracy needed ranges from 0.5 to 5 m [2] with a high availability and integrity.

5.6. Infrastructure

The service provides information on the actual infrastructure on a regional basis. Fairway information, water-levels, stream velocities etc. are contained. The accuracy needed is 100 m with a high availability and middle integrity.

5.7. Traffic control

The traffic control supports the traffic and transport management on inland waterways. The basis for the traffic guidance are accurate positioning data of all vessels. The traffic guidance uses the TTI and STI. The accuracy needed for the positioning data is high and ranges between 0.5 and 5 m. The availability and integrity need to be high.

5.8. Locks

The positioning data of vessels is used to optimize the time needed for passing through a lock. In other words the service allows to allocate time slots for the ships at a lock in advance. It supports the lock-keeper during the planning stage. The accuracy needed for this service is about 30 m.

5.9. TTI

The TTI is a service creating a display of the current traffic situation (around a ship, in a limited area or the whole river). The advantages of monitoring the traffic are the increased safety of the transport operations and the improved traffic management. In a TTI the different information provided by a RIS are combined: radar data, AIS information, fairway information, water level (actual and predicted), stream velocities. The visualization of the TTI is provided via ECDIS. As the TTI supports the skipper in his responsibility for navigation decisions the positioning accuracy needed is high (between 0.5 and 5 m). Additionally availability and integrity requirements are high. The TTI can be used on shore or onboard of a vessel.

5.10. Automatic charging

With the help of position information automated port and canal prizing can be done. The needed accuracy is 100 m, the availability is high and with middle integrity.

5.11. Safety applications

Applications related to the safety of transport operations on waterways are divided into active and passive safety services. Active safety services are used for the prevention of accidents and improved catastrophe management. Passive safety services support the reconstruction and examination of safety-critical events. The availability as well as the integrity of the position information needed for this service are high.

6. Conclusion

The benefits of value-added services of a RIS in transport and traffic management will improve transport efficiency, will help to increase safety and security on inland waterways and will support the skipper in his actual nautical decisions. Cost-effectiveness, the acceleration and simplification of logistical processes will make the waterways a competitive alternative to rail and road transport systems. By the use of value-added services inland navigation will become reliable, flexible and more planned in future thus increasing its attractiveness.

Acronyms and Abbreviations

AIS	Automatic Identification System
DGPS	Differential Global Positioning System
DoRIS	Danube River Information Services
ECDIS	Electronic Chart Display and Information System
EGNOS	European Geostationary Navigation Overlay Service
EPRIS	Evaluation of Positioning technologies for the generation of value-added services in the environment of River Information Systems
ETA	Estimated Time of Arrival
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

INDRIS	Inland Navigation Demonstrator for River Information Services
RIS	River Information Services
SBAS	Satellite-Based Augmentation System
STI	Strategical Traffic Image
TEN	Trans European Network
TTI	Tactical Traffic Image
VHF	Very High Frequency

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