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INNOVATIVE SOLUTIONS FOR INLAND WATERWAY TRANSPORT

Abstract

Contemporary changes in the global economy generate a significant increase in the demand for transport, which requires changes in transport, in accordance with the principles of sustainable development. Innovative solutions in transport, aimed at meeting modern expectations, concern various areas, most often these are technical, operational and logistics innovations. Road and air transport are seen as the most innovative transport branches.

The aim of the article is to show innovations implemented in inland waterway transport in those three areas. The article shows that in this mode of transport innovations are also implemented in accordance with the idea of sustainable development.

Keywords: inland waterway transport, innovations in transport, inland shipping

Introduction

Contemporary changes in the global economy generate a significant increase in the demand for transport. Globalization, tendencies to level disproportions in regional development, demographic changes and the associated increase in mobility result in an increase in demand for both passenger and cargo transport, whose satisfaction, in accordance with the principles of sustainable development, which requires radical changes in transport showing the implementation of innovative solutions in each branch and in the entire transport system. Road and air transport are seen as the most innovative transport modes nowadays. The aim of the article is to show that inland water transport is not inferior to others in search of solutions consistent with the idea of sustainable development.

1. Innovation in transport as a way to meet growing and changing transport needs

Socio-economic changes cause particular intensification of transport problems at the back of seaports and in the cities. 87% of transport work in the world is carried out by sea. Globalization, which entails an increase in trade turnover and consequently an increase in demand for cargo transport, thus results in an increase in turnover of sea ports (container ports even several times up to 2050[1]). Thus, there is a problem of the development of transport at the back of these ports, whose a solution is a serious challenge with the terrain restrictions and modern standards of sustainable development.

Another area of accumulation of transport problems are cities whose development makes it difficult to adapt the transport offer to the growing needs of residents in terms of both passenger and cargo transport. The predicted significant increase in the population living in European cities from 72.7% in 2010 to 82.2% in 2050 (including in Western European countries from 79.5% to 87.7%)[2] will necessitate the search for innovative solutions allowing to meet new challenges with existing terrain restrictions, energy constraints, policies to reduce pollutant emissions, in particular CO_2.

Innovative solutions in transport, aimed at meeting the presented expectations, relate to various areas, most often these are:

– technical;
– operational;
– logistics innovations[3].

Technical innovations regarding the vehicles construction, the materials they are made, the use of alternative fuels, the reduction of pollutant and noise emissions, safety improvements have long been implemented in various modes of transport. Currently, research on future solutions concerns mainly unmanned transport vehicles and environment-friendly drive solutions.

Among such concepts, currently at the design and testing stage, there is the hyperloop project, which was supposed to replace the high-speed railway, but it would also be well-suited for cargo transport and not only for long distances. This solution can also be used in supplying cities. The system is not new. Different versions of this idea were implemented earlier – from pneumatic mail in London in 1853, through various versions of pipeline cargo transport, including small containers in Hamburg[4].

The hyperloop concept was created on the initiative of the American entrepreneur Elon Muska. Scientists from various countries, including Poland, take part

[1] M. Quispel, *Medium and longterm perspectives in Inland Waterway Transport in the European Union*, NEA, Brussels, 5.07.2011.

[2] *World Urbanization Prospects: The 2011 Revision*, United Nations, Department of Economic and Social Affairs, Population Division, New York 2012.

[3] S.C. Consuegra, *Thesis for the degree of Master of Science in Maritime Technology, in the Specialisation of Shipping Management. The analysis and adoption of environmental innovations in inlandwaterway transport*, University of Technology Delft, 4.05.2016.

[4] See more: A. Gojlik-Wiśniewska, *Wykorzystanie transportu podziemnego w dystrybucji towarów*, Logistics 2011, 2.

in research on new technology. Muska's idea is that in a thin-walled tube with a diameter of several meters, placed on supports about a dozen meters above the ground, six-seat capsules are to travel at the speed of up to 1200 km/h (Figure 1).

In the tunnel, the pressure is to be lowered to approximately 1 atmospheric percent. Capsules will move on a magnetic cushion, reaching speeds higher than those of modern passenger airplanes. The speed of sound propagation is a barrier for both of these means of transport[5].

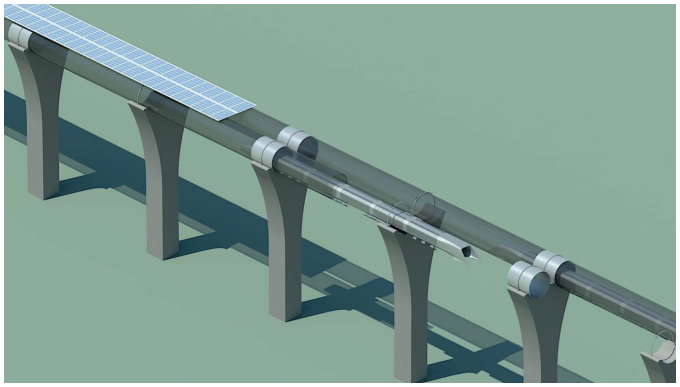

Figure 1. Hyperloop capsule in a pipeline with attached solar panels
Source: K. Urbański, *Hyperloop – railway for the future*, http://www.forbes.pl/hyperloop-szybka-kolej-nadchodzi-rewolucja,artykuly,204963,1,1.html (access: 26.03.2017)

The advantage of the hyperloop will be:

- low cost (according to hyperloop calculations on the San-Francisco – Los Angeles route, it would cost 10 times less than the passenger railway, traveling at a speed of 350 km/h and the ticket would cost $20);
- shorter transport time (this route would be travelled within half an hour);
- the possibility of building terminals in the city center;
- using renewable energy for the drive – the capsules (passenger cabins) are to be moved thanks to the use of electricity supplied by solar panels located along the entire route;
- no vibrations and noises in the cabin.

In Poland, there is a Hyper Poland University Team, which includes 25 engineers from the Warsaw University of Technology and the Wrocław University of Technology who are trying to develop a hyperloop solution for Polish conditions. The capsule according to the design of Polish scientists resembles modern high-speed trains (Figure 2). It is powered by electric motors and can move both on wheels and float with magnetic levitation depending on the current speed[6]. The design speed is approximately 430 km/h, while the maximum is 1200 km/h. The construction will be very light and at the same time very durable. For safety

[5] K. Urbański, *Hyperloop – railway for the future*, http://www.forbes.pl/hyperloop-szybka-kolej-nadchodzi-rewolucja,artykuly,204963,1,1.html (access: 26.03.2017).

[6] Spacex Hyperloop Pod Competition II, http://www.hyperpoland.com/news.html#news-1 (access: 20.04.2017).

reasons, it will be equipped with two independent braking systems. In addition, the electronic system will monitor the vehicle while driving and, if necessary, automatically initiate emergency safety procedures[7].

Figure 2. The project of the Polish hyperloop
Source: Hyper Poland materials, http://www.hyperpoland.com/news.html (access: 20.04.2017)

The location of the construction of the prototype currently under consideration is the Warsaw-Wrocław route, which the new means of transport would travel in less than 20 minutes. This route is among 35 potential routes selected in the Hyperloop One Global Challenge. The company intends to invest in building the prototype in the best location. Perhaps this technology, cheaper than traditional rail and providing transport in a much shorter time, will avoid the development of high-speed rail in Poland.

Another future project concerning the transport of both cargo and passengers may be the airship concept, which was submitted in the DHL competition.

The Blue Sky Transport Design Award airship is powered by solar panels, which may generate additional energy from wind, can carry 500 tons of cargo or passengers at speeds of up to 250 km/h[8] (Figure 3).

Figure 3. Airship for transporting cargo or passengers
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

[7] *Ibidem*.
[8] *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018).

An autonomous delivery vehicle or a mobile parcel machine, powered by electric motors (a project also submitted for DHL's competition by designer M. Bakalowitz) may be an interesting concept for servicing urban supply. This vehicle is an ecological solution for urban deliveries. One time it can cover a distance of 120 km and its load capacity is 500 kg (Figure 4)[9].

Figure 4. An autonomous delivery vehicle project
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/pl/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

Operational solutions primarily include:
– advanced route planning;
– energy-saving driving techniques;
– ongoing traffic monitoring of vehicles;
– intelligent transport systems for better use of vehicles and infrastructure.

Innovative logistics solutions include, above all, activities aimed at facilitating the integration of various transport branches, i.e. creating distribution centers or logistic centers, inter-branch flow of information on transport infrastructure, various types of network integration[10].

2. Innovation in inland water transport

Inland waterway transport is often wrongly perceived as outdated branch. Meanwhile, solutions have been implemented in this branch for many years to adapt the means of transport to new loads, spheres of application, environmental requirements, development of inter-branch cooperation, and thus to implement social, economic and ecological challenges of sustainable transport development.

Technical solutions are manifested first of all in the construction of ships enabling new areas of application of this mode of transport, e.g. river containers or ships used to supply cities (Figure 5).

[9] *Ibidem*.
[10] *Stay on top with the Innovation Radar*, https://eibip.eu/innovation-radar/ (access: 1.12.2017).

Figure 5. The ship transporting DHL shipments in cities
Source: *Alternative ways for distributing goods in Amsterdam: boat & bikes (The Netherlands)*, http://www.eltis.org/discover/case-studies/alternative-ways-distributing-goods-amsterdam-boat-bikes-netherlands (access: 12.10.2017)

An important direction of exploration is the use of alternative energy sources, variable drive sources (hybrid vehicles), as well as reducing energy consumption and pollution reduction, and, as in other means of transport, productivity growth through the use of intelligent transport systems to manage traffic or better use the loading capacity of ships and the implementation of logistic concepts (Figure 6).

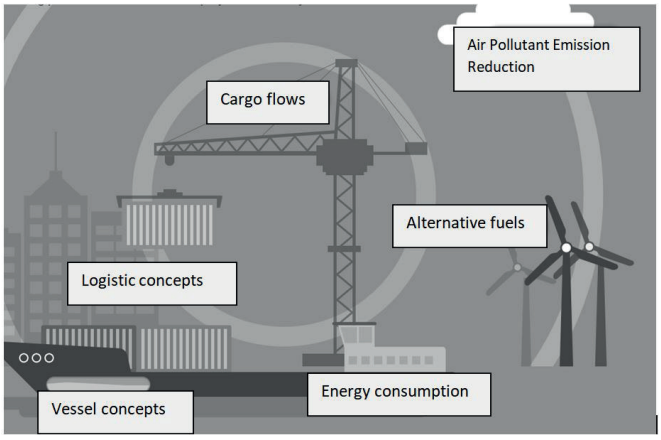

Figure 6. Areas of innovation in inland water transport
Source: *Stay on top with the Innovation Radar*, https://eibip.eu/innovation-radar/ (access: 1.12.2017)

As regards the use of alternative fuels, an especially attractive innovation solution in inland water transport is equipping ships with LNG (liquefied natural gas) engines. In inland waterway ships, these solutions involve the use of drive systems:
– dual-fuel, simultaneously supplied with oil and gas or
– mono-fuel (powered only by LNG).

In ships equipped with dual-fuel engines, both diesel and LNG are used. The main advantage of this drive system, compared to mono-fuel engines, is the possibility of using such ships on waterways without adequate infrastructure enabling bunkering of ships into LNG fuel. The first LNG ship with a dual-fuel engine in Europe ("MTS Argonon" tanker) was launched on November 25, 2011 and since December 2011 it has been operated on the Rhine between Rotterdam and Basel[11].

However, the future solution is an engine powered only with natural gas. The world's first LNG riverboat ("Greenstream" motorboat) was launched in March 2013 and put into operation on the Rhine in April 2013[12]. These ships are characterized by even lower emissions, in particular nitrogen oxides (NOx). However, these ships can only be used on waterways over which LGN bunkering stations are located at the proper distance.

The specific solution for inland waterway transport is the so-called "cold ironing" – ships mooring in the port do not use additional engines, but port facilities used to power ships from land by electricity. The advantage of this technology is the reduction of emissions of harmful substances – the emission level is then reduced to zero – and thus, the degradation of the environmental impact is reduced. In the port of Rotterdam, 160 land connections for inland navigation were installed. Similar devices operate in other seaports and increasingly their introduction is also postulated in inland ports.

The operational innovations, analogous to other modes of transport (enabling, for example, better planning of transport routes, improvement of energy-saving navigation techniques, tracking the current traffic situation), include the River Information Service (RIS). They are harmonized information services that enable transferring information on the navigational situation on waterways, traffic volume, shipping and port fees, allow for proper traffic management, supporting mitigation of catastrophic events, etc. The benefits of using the RIS system result primarily from the possibility of determining the estimated time of arrival of ships to locks and port terminals. These data are provided to sluice and port operators in advance, allowing for flexible scheduling of lock time and port operation. Information on ship's sailing time results in shortening the waiting time for locking and optimization of reloading processes, mainly due to shortening the waiting time for cargo operations.

The concept of autonomous (unmanned) means of transport is a novelty, just like in road or rail transport. One of the most interesting projects of this type is the autonomous container ship (120 TEU) whose devices automatically reload containers. The ship from the so-called series "zero emission" is environmentally friendly (Figure 7).

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[11] *Argonon, LNG Dual Fuel in inland waterway transport, Bestfact, Best Practice Case Quick Info. Green Logistics & Co-modality*, http://www.bestfact.net/wp-content/uploads/2013/08/bestfact_Quick_info_greenlogistics_2-048_Argonon_LNG_Dual_Fuel.pdf (access: 23.01.2018).

[12] P. Złoty, *Barki zasilane na LNG na Renie*, http://gazeo.pl/cng-lng/cng-i-lng-dla-biznesu/przemysl-cng-lng/Barki-zasilane-LNG-na-Renie,artykul,6856.html (access: 23.01.2018).

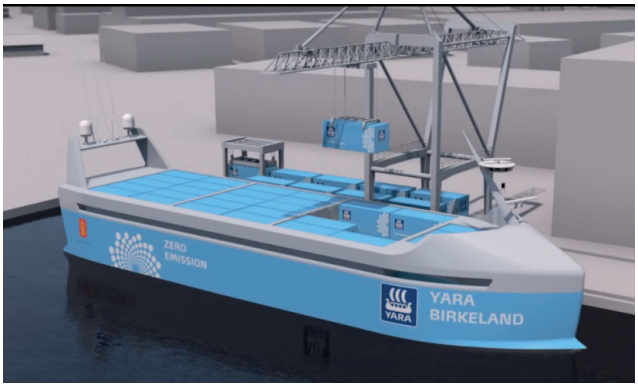

Figure 7. Autonomous container ship
Source: L. Rote, *This Emission-Free Container Ship in Norway is Changing the Industry*, https://gbdmagazine.com/2018/container-ship-yara-birkeland/ (access: 10.01.2018)

Another interesting idea is the Water Strider autonomous hydroplane with electric drive that can carry cargo and passengers. It has the cargo volume of a standard delivery van (Figure 8).

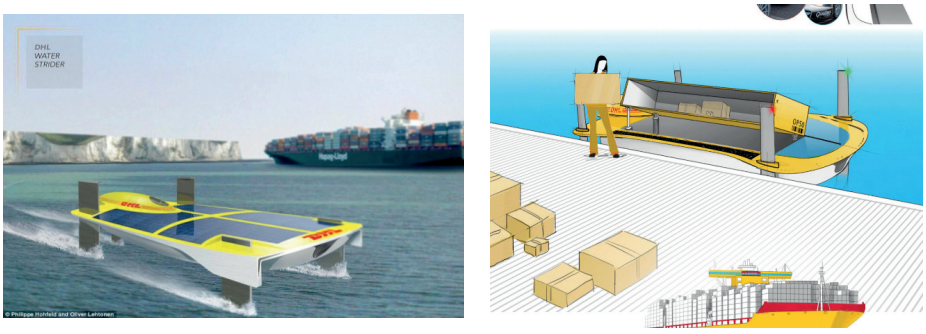

Figure 8. The concept of Water strider
Source: *14 innovations that will soon unload traffic jams in cities*, https://www.trans.eu/en/aktualnosci/14-sposobow-na-korki (access: 22.01.2018)

Among logistic innovations in inland water transport, the concept of creating "dry ports", based on river ports equipped with container terminals, should be mentioned, which thanks to the connection of seaports with the immediate background of the transport branch with high capacity, which is inland water transport, would act as places of cargo concentration and further distribution[13]. The "dry port" and not the seaport are in this concept the destination point of sea transport. Preliminary research shows that ensuring efficient connections between

[13] S. Grulkowski, *Analiza celowości i możliwości budowy „suchego portu" w pobliżu Trójmiasta*, https://www.researchgate.net/publication/283514752_Analiza_celowosci_i_mozliwosci_budowy_suchego_portu_w_poblizu_Trojmiasta (access: 23.01.2018).

a "dry port" and sea and land terminals within a day requires that the "dry port" transshipment capacity should be at least 1 million TEU[14].

The process of separating imported containers into individual relations and individual recipients, according to this concept, is therefore not carried out at sea terminals (due to existing infrastructural constraints) but in "dry ports", in accordance with the hub-and-spoke principle. However, in the case of export, i.e. from the back-up to seaports, "dry ports" would be a place of concentration of containers from different call-sizes and their distribution to individual sea terminals or even sea ports in accordance with their specialization.

It is estimated that, thanks to this solution, limiting logistics activities, in particular limiting the storage processes in seaports, should lead to a reduction of costs in logistic chains, and the higher the more participants will be included in the "dry port" network.

In Poland, despite the problems with the development of inland waterway transport, resulting from the neglect of infrastructure of inland waterways, there are no examples of searching for innovative solutions, primarily in the field of inland waterways drives and their construction solutions.

For several years, solar powered water trams have been exploited. New ideas for this type of ships are also being created. The designers from Nelton Design Office in Pruszcz Gdański designed a passenger ship with electric drive (Figure 9). Like the latest generation of electric cars, ships would be powered by electric motors, powered exclusively by the energy accumulated on them in lithium-ion battery assemblies[15]. Ships designed for the Norwegian ship-owner could be used for passenger navigation on the waters of the Żuławy Loop, including the Martwa Wisła, Przekop Wisły, Szkarpawa, Nogat, Dolna Wisła (from Biała Góra to Kiezmarka) and the Vistula Lagoon.

One achievement in Poland is also the inclusion, from 16 May 2014, of the lower Oder section (97.3 km) of the River Information Services system (RIS-Odra), whose managing body is the Director of the Inland Navigation Office in Szczecin[16]. It is assumed that this system will have a significant impact on the optimization of traffic on inland waterways, improving safety and increasing the efficiency of inland waterway transport.

[14] H. Kerstgens, K. Kahl, *Perspektiven des Kombinierten Verkehrs mit Binnenschiff*, Internationales Verkehrswesen 2012, 2.

[15] J. Sieński, *Autostrada Wodna na Wiśle. Elektryczne statki mogą stać się naszym przebojem*, http://www.dziennikbaltycki.pl/po-drugie-wisla/a/po-drugie-autostrada-wodna-na-wisle-elektryczne-statki-moga-stac-sie-naszym-przebojem,9827190/ (access: 14.01.2018).

[16] Centrum River Information Service, Office of Inland Navigation in Szczecin, https://szczecin.uzs.gov.pl/sbpuz_o_centrum_ris.htm (access: 23.01.2018).

Figure 9. Eco-friendly cruise ships with electric drive
Source: J. Sieński, *Autostrada Wodna na Wiśle. Elektryczne statki mogą stać się naszym przebojem*, www.dziennikbaltycki.pl/po-drugie-wisla/a/po-drugie-autostrada-wodna-na-wisle-elektryczne-statki-moga-stac-sie-naszym-przebojem,9827190/ (access: 14.01.2018)

Conclusions

Innovations in transport are generally aimed at reducing its degradative impact on the environment through the use of environmentally friendly technical solutions, improvement of logistics processes and better use of existing means of transport and infrastructure.

Inland waterway transport is one of the branches least degrading the environment. However, as has been shown, solutions are also sought in this branch to offer more environmentally friendly solutions. Technical innovations are manifested first of all in the construction of ships enabling new areas of application of this means of transport and the use of alternative energy sources for the propulsion of ships, or the use of a specific solution for inland navigation, which is the so-called "cold ironing". Innovations allow to reduce energy consumption and pollution. Among the operational innovations, analogous to other means of transport, aimed primarily at increasing efficiency and safety in transport, one can notice the use of intelligent transport systems for traffic management or better use of ship capacity and the implementation of autonomous means of transport. Among the logistics innovations in inland water transport, it is worth mentioning the concept of the so-called "dry ports". The article shows that this branch is not inferior to the search for innovative solutions consistent with the idea of sustainable development.

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