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**IMPROVING THE EFFICIENCY OF CARGO TRANSPORTATION
IN INTERNATIONAL COMMUNICATION THROUGH LAND BORDER CROSSINGS
IN UKRAINE**

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**ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ПЕРЕВЕЗЕНЬ ВАНТАЖІВ
У МІЖНАРОДНОМУ СПОЛУЧЕННІ ЧЕРЕЗ СУХОПУТНІ ПРИКОРДОННІ
ПЕРЕХОДИ УКРАЇНИ**

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***Abstract.** We analyze the possibility of increasing the international cargo transportation, volumes in Ukraine through wider introduction of container transportation and optimization of border crossings at the state border in the article. The development efficiency of a new container transportation direction and the most probable routes of container trains are identified. The volumes of container transportation over the past 10-20 years are compared. Proposals about the restoration of some checkpoints and the opening of new international cargo transportation hubs are substantiated. Proposed routes will change those that lost their relevance due to the war. In addition, they will carry out a function of redistribution of cargo flows from the Ukrainian seaports to Europe.*

***Keywords:** container, terminal, checkpoint, seaport, gauge, cargo flows, designing, railway junction.*

***Анотація.** У статті проаналізовано можливості збільшення обсягів міжнародних перевезень в Україні шляхом широкого впровадження контейнерних перевезень та оптимізації роботи пунктів пропускання на державному кордоні. Розглянуто ефективність розвитку нового напрямку прямування вантажів у контейнерах і визначено найбільш імовірні маршрути контейнерних поїздів. Зроблено порівняння обсягів перевезення контейнерів за останні 10-20 років. Обґрунтовано пропозиції з відновлення деяких пунктів пропускання та відкриття нових транспортних хабів для вантажів у міжнародному сполученні. Запропоновані маршрути прийдуть на заміну тим, що втратили актуальність у зв'язку з війною. Крім того, їхньою функцією також буде перерозподіл вантажопотоків із портів України до Європи. Встановлено, що розвиток напрямку вантажопотоку через Ягодин є актуальним та економічно доцільним на сьогодні за рахунок збільшення швидкості пересування вантажів. Доведено, що найбільш ефективним способом використання універсальної тари для перевезень різними видами транспорту і залізничним рухомих складом з візками для різної ширини колії є застосування контейнерів. Тому встановлено необхідність створення терміналу поблизу станції Ягодин як найближчого до морських портів Центральної Європи переходу через кордон України. За результатами дослідження, найкоротші відстані між найбільш імовірними пунктами курсування контейнеропотоків пролягають у більшості випадках через Ягодин, що доводить оптимальність побудови маршрутів переміщення вантажів у контейнерах. Розглянуто можливість відкриття нових прикордонних переходів на заході країни, які б розвантажили існуючі та дали змогу збільшити швидкість пересування вантажів через кордон. Розвиток цього напрямку*

організації руху міжнародних вантажопотоків за участю залізничного транспорту допоможе розвантажити існуючі залізничні магістралі і матиме стратегічне значення для України.

Ключові слова: контейнер, термінал, пункт пропускання, порт, ширина колії, вантажопотік, проектування, залізничний вузол.

Introduction. Ukraine and Ukrainians in 2022 had to live through a number of radical changes that have affected all spheres of life. They needed to search for new ways of working and development of the State including of course transportation due to the war. Before the war international cargo transportation in Ukraine was mostly provided by maritime transport [1]. This has suffered complications because of the Seaports blockage, so the workload of land border crossings increased. The «Grain corridors» partially allowed a resolution of the issue of the seaports' usage. However, the threat of interruptions to their work remains, so it is necessary to develop new schemes for opportunities to quickly redirect cargo flows to European countries and to have constant readiness at border crossings to process the appropriate volumes of cargo.

Recent research and publications analysis. International cargo transportation in Ukraine and developed countries in the world is provided by containers. At the same time the development of railway infrastructure in our country primarily aims to increase cargo transportation using normal rolling stock [2, 3]. Many experts from the leading countries around the world have noted repeatedly the efficiency of container transportation. These are some of the benefits [4]:

- Adaptation to rapid loading, unloading and transshipment between different means of transport;
- Increase in the cargo delivery speed;
- Safety and security of cargo in containers;
- Lower cost of usage compared to usual packing;
- Simplicity of container transportation management.

In addition to the physical building of the infrastructure, it is necessary to consider legislative aspects. There are a rather limited number of documents related to container transportation in Ukraine [5]. However, work in this area is progressing. An example is the adoption of the Law of Ukraine «On multimodal transportation» [6]. This document improves the existing legal framework, and introduces legal schemes for wider use of multimodal/container cargo transportation in the Ukrainian transportation system. This, in turn, will contribute to the environmental protection through the reorientation of most of the cargo transportation, from roads to maritime and other more ecological means of transport. In addition, there will be optimized time and cost of cargo delivery by implementing a single multimodal transportation contract.

There are scientists who have researched this topic: Y. Alyoshynsky, M. Andriyenko, T. Butko, L. Vismans, V. Vozniuk, D. Lomotko, N. Piddubna, K. Pluzhnikov, M. Postan, G. Prokudin, O. Tymoshchuk, S. Khamadi, O. Kharchuk etc. In the article by Y. Alyoshynsky «Organizational principles of multimodal transportation planning» the author noted that the choice of the route depends both on the availability of the railway network and the location of the main cargo terminals, as well as on the cost of transportation by possible options. In addition, the container unit is selected depending on the type of the cargo and the volume of transportation [7]. T. Butko in her publication «Improvement of the organization of interaction between railway junctions and ports in container transportation» wrote that in 2018 the main volume of container transportation is provided by railway and maritime transport, while the same

transportation by cars is much faster, but twice or even three times more expensive [8]. In the article of D. Lomotko «Issues of the formation of a modern container system on the Ukrainian railways based on logistics principles» it was noted the necessity of the creation of modern container logistics centers in Ukraine [9]. But in all these researches the main advantage is given to maritime transport, routes of which are currently partially blocked. Therefore, it is necessary to note the possibilities of using land border crossings.

Research purpose and objective. The purpose of this article is to study the possibilities of increasing the efficiency of international cargo transportation as one of the most important directions of maintaining the economy of Ukraine during the war, and the state restoration after its end. One of the most appropriate opportunities is within container transportation, so it is necessary to analyze its current state in Ukraine and future development. It is also necessary to note the state of the infrastructure for cargo (container) transportation at the international borders, and the improvement program in the most promising and currently underdeveloped regions.

Main part of the research. Cargo transportation operators have to look for the most convenient and efficient way of transporting goods in the face of rapidly increasing volumes of cargo. As a result,

containers have become more and more popular. According to the data of the container market, the volume of container traffic increased almost 4 times during the past 24 years [10].

Nowadays, the average annual growth in this sector by volume is approximately 3-4 %, the same rates are predicted until 2025 [11]. It is important to note that most of the world's container transportation is provided by maritime transport. This is explained by the need for mass of cargo and they are carried out because of specialties by both mean of transport and package.

The development of container transportation in Ukraine became noticeable in the 2010s. This is due to both historical reasons (cargo transportation carried out mostly according to the principles of Soviet times) and the focus on the CIS countries (low containerization rates). Long-awaited changes started after the redirection of mass cargo. Annual growth of volumes of containers, transported by railway, reached 10-11 % starting from 2016 (Fig. 1, 2).

In addition, Ukrainian Railways has its own department, which carries out organization of container intermodal transportation, called «CTS «Liski». There were 22 routes for container and counter-trailer trains in the directions «North-South» and «East-West» before the war.

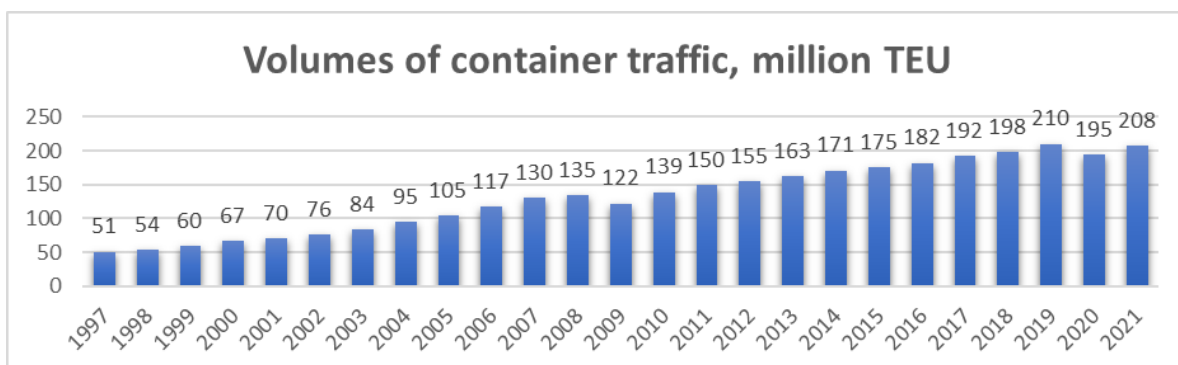


Fig. 1. Increase in container traffic (1997-2021)

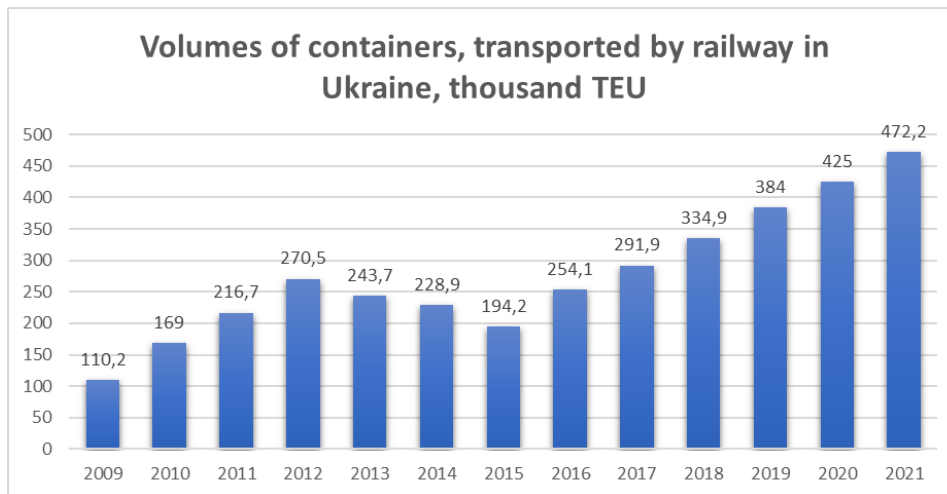


Fig. 2. Changes in container transportation on Ukrainian railways

Railway border crossings are one of the most congested places. They often work at maximum possible throughput and aren't able to handle large volumes of cargo. The greatest number of railway border crossings is situated on the Ukrainian-Polish border. The load is often distributed unevenly because of lack of specialist cargo handling equipment. As an example, there is Mostyska with an active cargo facility, Rava-Ruska and Yagodyn with minimum of freight capability. A big junction station, Chop, is situated on the Ukrainian-Slovakian and the Ukrainian-Hungarian borders. It is able to work with cargo, which passes to/from these countries. There are two railway lines (to Poland and Slovakia), which pass into these countries without track gauge change.

Container terminals on the Ukrainian side are situated in Mostyska and near Chop. At the same time Slovakia and Poland have their own terminals for Ukrainian containers. Railway capacity on these routes is gradually being increased. However, facilities at the underutilized border stations Yagodyn and Rava-Ruska aren't effectively utilized.

Railway border crossing «Yagodyn» is the northernmost on the Ukrainian-Polish border. It is situated closer than others to the Polish seaports of Gdansk, Gdynia, Szczecin and Swinoujscie, so it could be the most

convenient passing point for cargo transportation in these directions. In addition, there are some issues related to the absence of electrification and bad track conditions, but these can be resolved with the right will.

In addition to the construction of border terminals we should discuss the domestic network of container terminals in Ukraine. Our country occupies a large territory with an uneven density of potential users of freight transport. It is true that the highest concentration is situated in big cities and near them. At the same time, it is necessary to consider a suitable distance from the war zone during designing the network. We could consider General container terminals – special structures, that would include the necessary engineering and technical facilities for maintenance (loading, unloading and sorting) of containers and an administrative area for dealing with container documents and client service. An example is the West container terminal in Ternopil. It has advantages such as its situation in the geographical centre of Western Ukraine and equidistance from other regional centres [12].

Before the war routes of container trains connected Ukrainian cities and Baltic seaports with Odesa. They had the advantage of not needing to change bogies on borders. We couldn't do without it during the formation of

new routes so we should focus on distance and capacity. Two-track electrified railway lines are able to transport the most amount of cargo. There are three busy railway directions which have a common line of length of more than 50 km, near Lviv. This line doesn't have any alternatives, which is not practical for a country at war [13]. There are 3 railway directions from Lviv to the border, 2 of them pass through the Carpathians and contain some mountain cuts. A disadvantage is there would be a concentration of cargo flows in Lviv, which increases risks related to its overloading. Inside Ukrainian cities are well enough provided by means of communication,

while international transportation is complicated by passing through border crossings.

We consider the most probable routes through Yagodyn for more detailed research. This will make it possible to clearly verify the necessity of this direction. Kyiv, Kharkov, Odesa and Dnipro we can assume to be departure points for containers. Comparison will be made with the closest container terminals to Yagodyn – Mostyska in Ukraine and Sławków in Poland. As a result, in three cases out of four the smallest distance is through Yagodyn (Fig. 3).

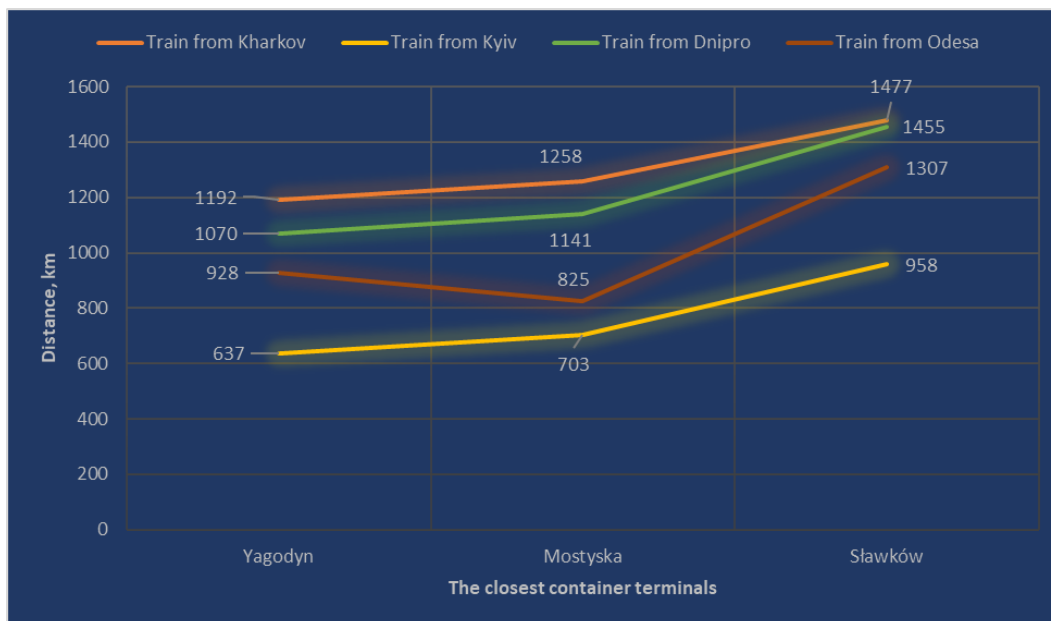


Fig. 3. A comparison of distances (city – terminal)

After a distance comparison from cities to terminals it is necessary to do the same with terminals and final destinations of containers which are situated beyond Ukraine. We consider the closest European seaports (in this case – Szczecin, Gdansk in Poland and Klaipeda in Lithuania) as we aim to replace Ukrainian ones.

It is possible to find out that the shortest distance to the Polish seaports is from

Sławków. This town is situated in the central part of Poland and it has a relatively advantageous geographical position. The distance to Klaipeda is shorter from Yagodyn. In addition, a container terminal in Poland wouldn't have an advantage if we combined comparisons and marked the distance along the complete routes (Fig. 4).

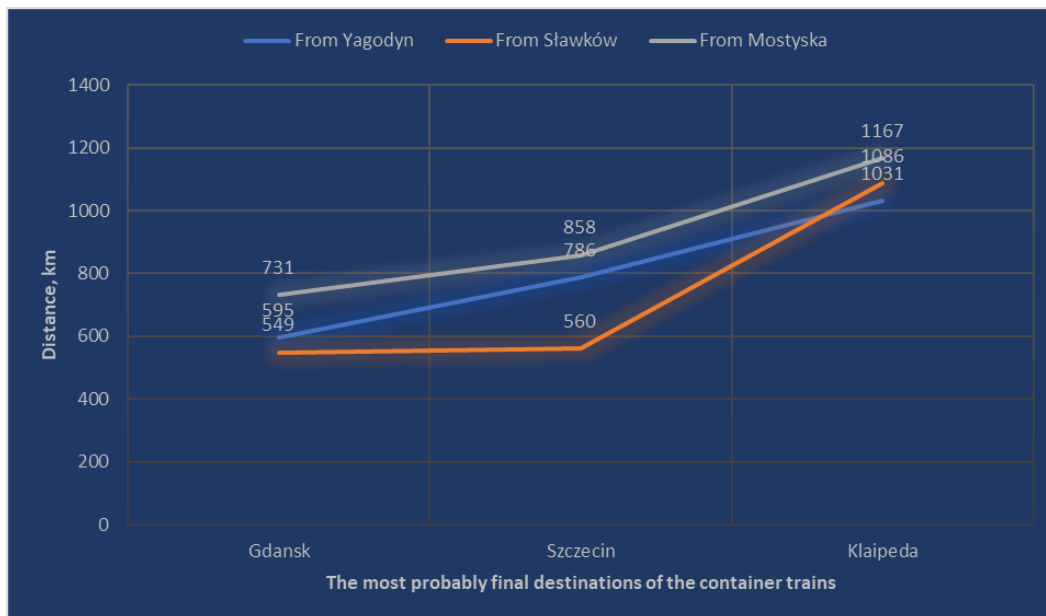


Fig. 4. A comparison of distances (terminal – seaport)

The following table 1 gives the shortest distances through Yagodyn at 11 of 12 proposed directions. They are about 200 km in most cases, so we are able to speed up the movement of containers for almost a day at the current average speed of 200-300 km/day [13]. In addition, the cost of transportation will decrease, so it will attract potential customers. As an example we can look at the delivery of an own TEU container in Railway’s carriage. In this case we should use the tariff scheme № 10 of the Tariff Guide № 1 [14]. According to this, the cost of transportation of a container within the borders of Ukraine will be about 1800-1900 hryvnas. Shortening the distance will allow customers to save about 100 hryvnas on a container, this will be about 80000 hryvnas for the average amount of containers in a train.

These facts allow us to admit a need for designing the new cargo railway corridor through Yagodyn. Nowadays this station carries out bogie changes on a small amount of passenger trains, so it is necessary to design devices to work with freight. If cargo is delivered in containers, a decision to create a

new container terminal in Yagodyn will be the most optimal. In addition, at this station there are tracks with different gauges, so there is a need to provide arriving carriages with bogies of both 1520 and 1435 mm (Table).

We could also note the possibility of creating new border crossings in the west of the country. They would allow us to relieve existing ones and to increase the speed of cross-border transportation. There is an ambiguous situation near Chop. In this town border crossing to Hungary both cars and trains are able to pass. At the same time a border control towards Slovakia is provided for railway transport only. The road to Slovakia was closed in 1946 and there have been approaches to link the border since those times. Both countries have plans to open a new border crossing to allow the restoration of traffic on this road [15]. If opened, it will duplicate the existing «Chop (Strazh)» on crossing railway and relieve the car checkpoint in Uzhgorod. So nowadays we have a big demand to reopen this transborder road.

The shortest distances for the routes, km

Passing and destination points	Points of container trains departures in Ukraine			
	Kharkov	Kyiv	Dnipro	Odesa
Szczecin through: Yagodyn Sławków Mostyska	1978	1423	1856	1714
	2037	1518	2015	1867
	2116	1561	1999	1683
Gdansk through: Yagodyn Sławków Mostyska	1787	1232	1665	1523
	2026	1507	2004	1872
	1989	1434	1872	1556
Klaipeda through: Yagodyn Sławków Mostyska	2223	1668	2101	1959
	2563	2044	2541	2393
	2425	1870	2308	1992

The Rava-Ruska railway junction is underrated. It has four directions (two each inside Poland and Ukraine). A track to Hrebenne was used only by passenger trains to Warsaw until 2005, then it was dismantled. Another track to Werchrata has rare freight service. This line duplicates the Lviv – Przemyśl route through Mostyska railway connecting Rava-Ruska with the Polish mainline Przemyśl – Rzeszów – Krakow. The junction is situated between Lviv and Warsaw and has already been used as a transit point with plans of building a track with 1435 mm gauge. The following shows a scheme, that a distance between Lviv and Warsaw through Rava-Ruska is shorter than the similar one through Przemyśl by 60 km, the difference between the distances from Kyiv to Warsaw through Yagodyn and through Lviv is 210 km.

There are some obstacles for development of this railway hub: a poor state of tracks, an absence of electrification, and all lines have only one track in each direction. So, it is necessary to restore the railway line to Hrebenne to relieve the Mostyska border crossing, to rebuild new border crossings for

freight. It is also possible to design a new container terminal near Rava-Ruska. The junction could become a main hub for cargo from Western Ukraine to seaports of Poland and Germany, and as an additional hub for freight to Silesia and the Czech Republic (Fig. 5).

Conclusions. The necessity for the development of cargo flows through Yagodyn was defined. By the analysis this measure will increase the speed of freight moving. Using containers was defined as the most efficient means of transportation by both railway rolling stock with bogies for gauge 1520 and 1435 mm. For that it is necessary to design a new container terminal near Yagodyn as it is the closest border crossing to the Central Europe seaports. The shortest distances between the most probable points of container flows in most cases pass through Yagodyn. The possibilities of proposed border crossings in the west of the country were considered, including new border crossing for cars to Slovakia in Chop, which will relieve the car checkpoint in Uzhgorod, and the promising railway junction in Rava-Ruska, which will

allow speeding up cargo flows to Europe, provided it is restored. The development of this routes will help to relieve the existing

railway lines and thus will be of strategic importance for Ukraine.

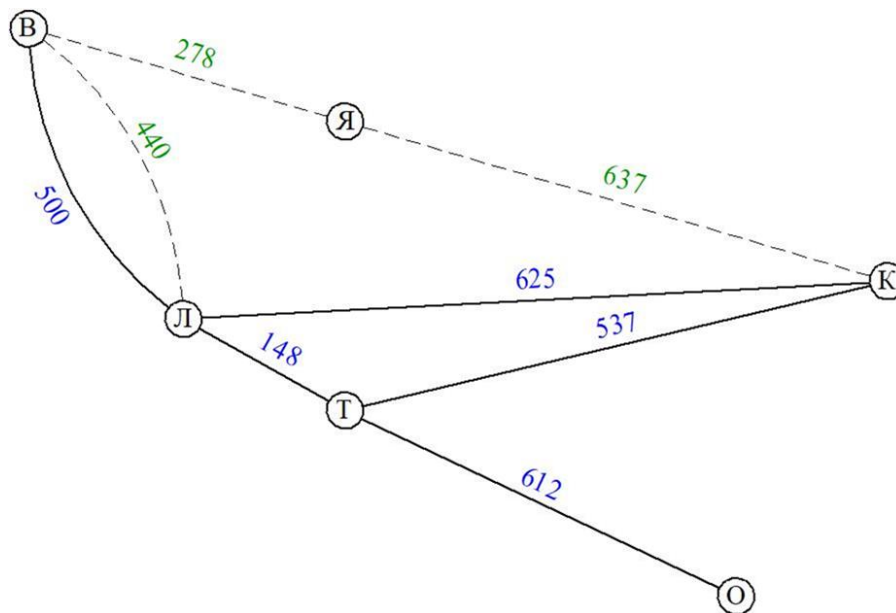


Fig. 5. A scheme of container flows routing from the cities of Ukraine to Warsaw, distances by railway in km. Proposed routes are dotted. Letters indicate cities (K – Kyiv, B – Warsaw, Я – Yagodyn, Л – Lviv, О – Odesa, Т – Ternopil)

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