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The Interaction of Sea and Rail Transport at the Example of the Port of Aktau



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ABSTRACT

The paper analyzes the cargo turnover of the seaports of the Caspian basin, examines the main seaports of the Republic of Kazakhstan, assesses the features of their port facilities, and their importance for the country's transport potential. The study also comprises the analysis of the indicators of the transshipment of cargo in the seaport of Aktau, of its railway and maritime infrastructure, the SWOT analysis of the railways at the approaches to the port. The port's strengths and weaknesses, as well as key forms of interaction between rail and sea transport and their sphere of effective use have been identified.

It is shown that the technical capacity of the port and port rail facilities plays a considerable role in ensuring the further growth of cargo turnover of Kazakhstan's ports. Main tasks of the optimal interaction of rail and sea transport at the port transport hub are formulated. It is concluded that it is necessary to develop a model for the rational interaction between the port facilities and railways in order to increase their capacity, reduce the downtime of wagons and locomotives at stations and berths, as well as to reduce the cost of rail transportation within the port.

Keywords: port transport node, seaport hub, seaport, port complex, cargo turnover, cargo transhipment, railway infrastructure, port rail hub, berth complex, interaction between sea and rail transport.

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Introduction. Port transportation nodes (PTN) include a port complex: a seaport with its facilities and infrastructure; port rail hub with stations, yards, freight areas, intra-node tracks, various facilities for the maintenance of wagons and locomotives; industrial, automotive, pipeline and urban transport. The main role of the PTN is to transship cargo from the sea to land transport and back, that is to execute export and import transportation.

Besides, the most important role of transportation nodes, comprising seaports, is to ensure the transport independence and defense capacity of a state, to develop new destinations to promote transit traffic. National maritime, customs and border policies, and state port control are implemented at seaports. The task of a country is to forward cargo flows first through its ports, and not through the ports of neighboring countries.

The *objective* of the study was to analyze the cargo turnover of the seaports of the Republic of Kazakhstan and their port complexes, the main forms of interaction between rail and sea transport in the port transportation nodes. The study used statistical *methods*, SWOT analysis, system analysis, methodology of business process analysis.

Kazakhstan's seaports

The study of maritime traffic in the Caspian Sea area and the analysis of cargo turnover showed [1] that all the main ports of the Caspian States are carrying out work to increase handling capacity and to upgrade port infrastructure. During recent years, work has been carried out to develop additional capacity in the ports of Astrakhan, Olya, Turkmenbashi, Anzali. The construction of the first phase of the port of Amirabad has been completed.

Kazakhstan is one of the main cargoflows generating countries in the Caspian Sea area, its main exported goods are oil, metal, grain, fertilizers. The system of ports and sea routes of Kazakhstan is represented by five ports at the Caspian Sea: Aktau Sea Trade Port (ASTP); port (cargo area) of Bautino; Kuryk port, designed for transshipment of oil cargo and ferry transportation; Atyrau port, located in the Ural river delta, and the Sartas port under construction on the shores of the Mangistau Bay.

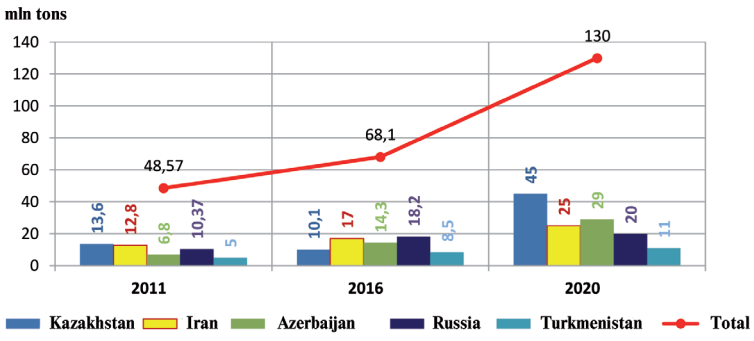
Aktau port is the only sea trade port and the largest of five seaports of the Republic of Kazakhstan, the managing company of which is JSC National Company Aktau Sea Trade Port (JSC NC ASTP). The port is the leader in cargo turnover among ten international sea trade ports of the Caspian basin.

The port (cargo area) of Bautino (124 km north of Aktau) is the base for supplying oil fields in the north-east of the Caspian Sea, the port of Kuryk (70 km south of Aktau) is the construction base for oil floating platforms. Port Sartas, 130 km away from Aktau, is under construction and is designed to support offshore operations and quickly respond to the needs for maintenance of offshore facilities (repair and refueling of ships, treatment of household waste, etc.).

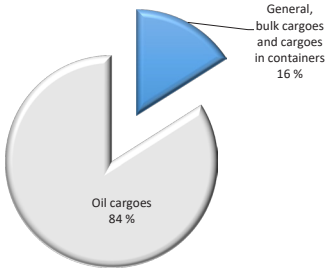
The characteristics of the three main seaports are presented in Table 1.

Located at the junction of Europe and Asia, at the intersection of several transport corridors, Aktau seaport allows for transportation of goods from east to west, from north to south and in the opposite direction, developing as part of the New Silk Road project aimed at implementing the transit potential of the Republic Kazakhstan.

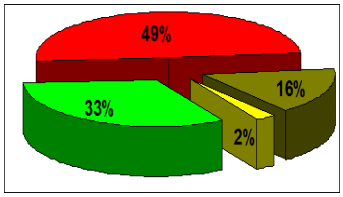
Aktau Port is ice-free and operates 12 months a year and 24 hours a day. The port is open year-round for all types of ships to enter, subject to safety of navigation in port waters and safe berthing and mooring. If the wind



Pic. 1. Forecast of cargo turnover of seaports of the countries of the Caspian basin, mln tons [2].



Pic. 2. Cargo structure of the port of Aktau as a percentage.



Pic. 3. The percentage of transshipment of goods of the country of the Caspian basin.

Table 1

Port complexes of the main seaports of Kazakhstan

	Aktau seaport	Bautino port	Kuryk port
Territory, ha	81,7	1,5	4,0
Port characteristics	non-freezing	non-freezing	non-freezing
Throughput	11 mln tons of oil, 2 mln tons of dry cargo	150 thousand tons of dry cargo	1,3 million tons of oil dry cargo
Number of berths	7 dry cargo, 4 oil berths	1 berth with a length of 125 m	2 berths of railway and road complex
Port infrastructure	Tracks, warehouses	Access road ways	Access railway 12,5 km, 2 railways fleet, drawbridge, ferry for transporting trains
Characteristics of cargoes	Metal, grain, oil	Metal, pipes, ship supply and equipment	Grain, oil products, fertilizers, chemicals

force exceeds 18 m/s, the port entrance and exit, as well as cargo operations, are suspended.

On average, the structure of cargo transshipment according to [3, p. 6] of Aktau port as a percentage is shown in Pic. 2.

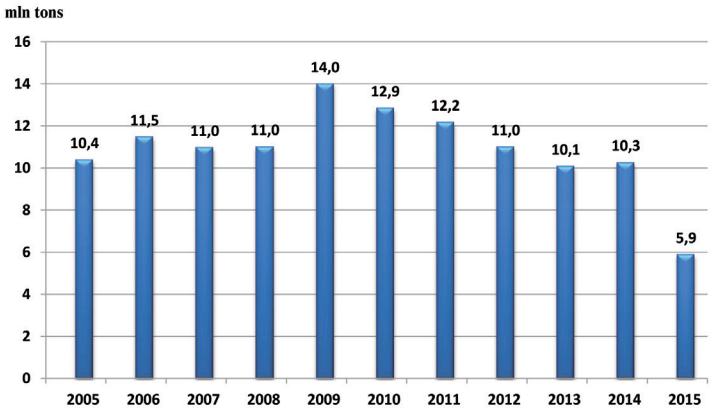
Pic. 3 shows that about a half of all cargo transshipments (49 %) are carried out by Aktau port towards Russia, while 33 % are forwarded towards Azerbaijan, followed by Iran (16 %), and Turkmenistan (2 %).

As can be seen from the analysis of cargo flows (Pic. 4), the total volume of transportation in the port of Aktau by 2009 had increased by 1,4 times. This was the result of reconstruction of the port at the beginning of the 2000s.

The reconstruction project [4] was not limited to improving production capabilities, but also provided for advanced training of port employees and workers, introduction of the latest technologies with regard to marketing systems, office work, and management. In 2011, a lot of work was done to automate control systems, introduce the latest statistics tools to monitor cargo turnover, automate calculations, which is explained by a number of reasons, one of which is switching oil transshipment to the pipeline. Key indicators, quantitative indicators of cargo transshipment for 2016–2017 according to the data of [1] are presented in Table 2 and in Pic. 5.

Analyzing these indicators, we can conclude that, according to the results of 2017, the total transshipment of goods amounted to 3,033 million tons. Compared to 2016, the total volume of cargo transshipment decreased by 2,432 million tons, or 45,5 %. But as soon as in the first quarter of 2018, according to [1], the shipment of goods through the port of Aktau increased by 45 % compared to the same period of 2017.

The analysis of transshipment of cargo at ASTP showed that, despite the decline in actual cargo turnover by 2016 (5,5 million tons) for the entire range of goods by almost 50 % as compared to 2013–2014 (an average of 11,5 million tons), according to forecasts for the medium term, the main cargoes transshipped through the port of Aktau, as before, will be oil, rolled ferrous metals, grain, transit cargo from China, Russia and countries of the Persian Gulf. It is planned to attract new cargo flows to the port, improve its own marketing policy, increase throughput through construction of new dry cargo terminals, transfer loading and



Pic. 4. Dynamics of transshipment of all goods in the port of Aktau for the period 2005–2015, mln tons.

Table 2

Quantitative indicators of cargo transshipment for 2016–2017

No.	Indicator	Fact 2016, thousand tons	Plan 2017, thousand tons	Fact 2017, thousand tons	Deviation, %	
					Fact 2017 to plan 2017	Fact 2017 to fact 2016
1	Oil	2321	2678	1437	53,7	61,9
2	Metal	1268	1300	365	28,1	28,8
3	Grain	528	500	494	98,8	93,6
4	Other cargoes	267	256	177	69,1	66.3
5	Ferry cargoes	1081	517	560	108,3	51,8
	Total:	5465	5251	3033	57,8	55,5

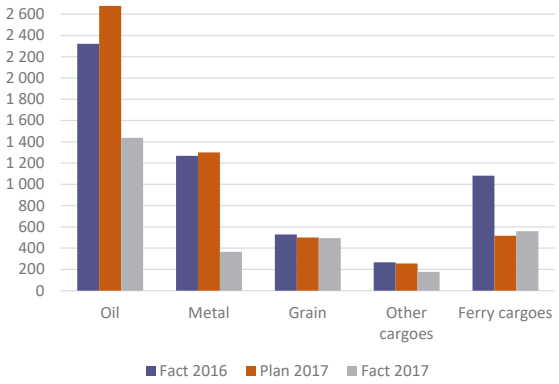
unloading operations to automatic mode, increase the fleet. This will ensure an increase in total cargo transportation from 11,5 million tons to 20,5 million tons by 2020.

Currently, Aktau port operates according to international management system standards (ISO 9001) and meets the safety requirements for navigation and ship maintenance. A particular operation mode has been established within territory of the port within the framework of the special economic zone «Seaport Aktau».

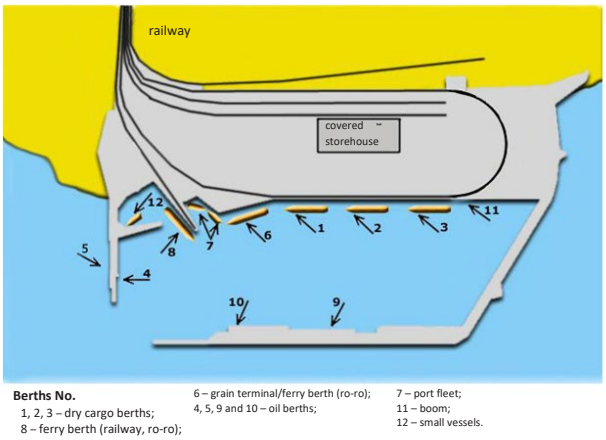
According to the Program for further development of Khorgos International Center for cross-border cooperation for 2007–2011, Aktau seaport [5, 6] is defined as a strategic port regulator in the structure of the single transport and logistics system of the Central Asian transport and industrial corridor.

The port of Aktau has all types of access roads, related infrastructure for discharge, loading and storage of oil and oil products. There are product specialized transport organisations that operate in the port, leasing land plots.

Based on the Code of Customs of Aktau International Sea Trade Port [7], the berth complex has (Pic. 6): 12 berths, of which: 5 bulk berths with a design capacity of 10,4 mln tons per year (berths No. 4, No. 5, No. 9, No. 10, No. 11), 2 universal dry cargo terminals (general cargo/containers) with a design capacity of 1,5 million tons per year (berths No. 1, No. 3), a grain terminal with a design capacity of 600 thousand tons and one-time storage of 25 thousand tons of grain, berth for heavyweights and mooring of ro-ro ferries (berth No. 6), ferry complex with capacity of 1 million tons of cargo per year (berth No. 8), general berth for cargo/containers and mooring of the ro-ro type ferry (berth No. 2), ferry berth No. 8, berth No. 7 for the port fleet, berth No. 12 for small vessels. Maximum throughput: oil berths – 12 million tons, dry cargo berths – 2 million tons, grain terminal – 0,6 million tons, ferry berth – 2 million tons.



Pic. 5. The diagram of quantitative indicators of the port of Aktau for cargo transshipment for 2016–2017. Source: [1].



Pic. 6. The layout of the berths in the port of Aktau [Source 3].

The port has the following equipment: gantry cranes with a lifting capacity of 10 to 42 tons; mobile cranes with a lifting capacity of 36 to 84 tons; autoloaders with a loading capacity from 1,6 to 28 tons; oil spill cleanup equipment. The port has the following port fleet: m/v «Batyr» – port tug – 2700 hp; m/v «Zhenis» – port tug – 1700 hp; «Bulak» – tanker that collects bilge and fecal waters; waste and oil spill collection vessel NMS-205A.

Based on the analysis of the infrastructure of the port complex of Aktau, we can conclude that the port:

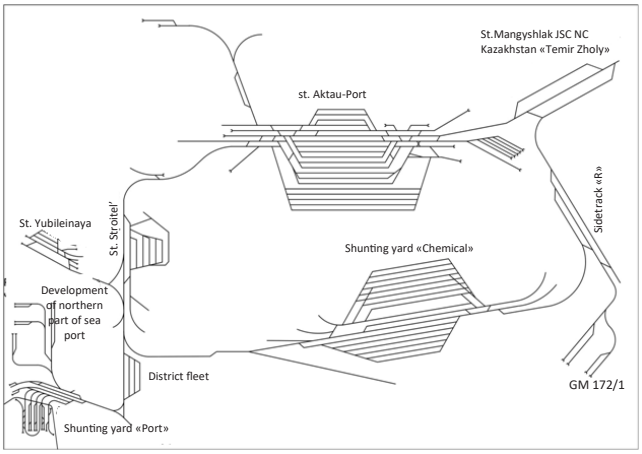
- Has a large storage area.
- Has a high investment potential (1st place in the Caspian region).
- Is included in «North–South» and «East–West» programs of the International Transport Corridors.
- Has extensive government support.
- Has modern equipment.
- Provides high quality and speed of transshipment.
- Conducts dynamic marketing activities.

Analysis of development prospects

To select a rational system for servicing seaports by rail, let us consider the system of a port railway junction using Aktau seaport as an example (Pic. 7) and consider a SWOT analysis of its railway infrastructure, presented in Table 3 according to [8].

Analysis of the railway infrastructure, as well as of weaknesses and strengths revealed by SWOT analysis, shows that the absence of a specialized container terminal with proper handling equipment for containers and storage platforms allows processing only 20-foot containers with a gross weight of not more than 10 tons at a universal dry cargo berth. Transshipment of a container from a vessel to a platform takes 7 minutes per container, the storage area has a limited area (about 120 containers), which is reflected in very high container transshipment rates (more than 350 US dollars per container).

The port has a few receiving alternate rail tracks. Four tracks that serve cargo flows in and



Pic. 7. Port railway junction of the seaport of Aktau.

out of the port, as well as to nearby terminals, are not sufficient. That shortage thereof is the main obstacle to increase in capacity and the main cause of delays in removal of empty cars and supply of the next batch of loaded cars to the terminals.

The presence of different owners of the railway lines (KTS and KTZ) leads to the fact that KTS sets its own tariffs independently of KTZ and is an independent organization commercially. Shippers have to conclude two separate contracts (with KTZ and KTS), which prevents many of them from using the route through Aktau-Port station.

The absence of own shunting locomotives in the port requires an agreement between KTS and KTZ on the mutual access of locomotives to the network from Mangyshlak station to the berths. Such a solution will reduce time for shunting operations at the port itself, for shunting and sorting operations at Mangyshlak station, and will also simplify wagons' exchange between KTZ and KTS at Aktau-Port station, which will significantly reduce the load on its infrastructure.

In order to reduce the load of access roads in the port and increase their throughput, customs clearance of goods must be carried out outside the port territory (for example, at Aktau-Port station).To maximize the throughput capacity of the junction stations, it is necessary to allow passage of trains of 57 cars, as provided for by the agreement between KTS and KTZ.

Thus, using the example of Aktau Port, analysis of cargo flows and its port facilities, strengths and weaknesses derived from SWOT analysis of the port's railway infrastructure system, we can conclude that it is necessary to develop a model for rational interaction of a port complex and railway transport with the aim of increasing the throughput capacity of port and railway arrangements, reducing downtime of cars and locomotives at stations and moorings, as well as reducing the cost of rail transportation in the transport hub.

The following main factors influence the choice of rational technologies for servicing port complexes by rail: size and structure of the transshipment cargo flow, its change during navigation, location of station and transshipment areas within the hub, conditions for receipt of mixed cargoes for transshipment, organization of hub operations aimed at delivery of local goods. Some of these factors are intranodal and are determined only by the operating conditions of the transport hub under consideration. Others depend on the work of a whole sector of mixed railway-water ways or of its autonomous part.

In addition, the technical equipment of the port and port railway arrangements play a large role in ensuring further growth of cargo turnover. The rational and effective organization of cargo transshipment through the port is also important, taking into account logistics technologies that consider the interests of customers and carriers and are necessary to increase coordination of their activities in the transportation market.

Improving the competitiveness of the transport system of Kazakhstan and international transport corridors passing through its territory largely depends on clarity of interaction of rail and sea transport in NC JSC ASTP.

Table 3

SWOT analysis of Aktau railway infrastructure system

S (strong sides)	W (weak sides)
S1. Aktau port is connected to the railway network. S2. The railway network connects the main cities of the Republic of Kazakhstan. S3. The railway system is connected to the railways of neighboring countries.	W1. Not all berths in the port are equipped with railways. W2. There is no specialized container terminal. W3. There are few sidetracks in the port. W4. Access roads to the port are managed by the private company JSC Kaskor-Transservice (KTS), thus increasing the number of participants in the transportation process. W5. The companies of KTS and JSC NC Kazakhstan Temir Zholy (KTZ) apply different tariffs for rail transportation services. W6. There are problems of coordination between authorities and the port administration, KTS and KTZ. W7. The length of the route from China to the port of Aktau and the need to change bogies to a different gauge.
O (opportunities)	T (threats)
O1. The plan for creating a new seaport in Kuryk. O2. Two ferries for 28 cars and 52 cars, respectively, can be loaded at Aktau port. O3. Bringing railway tracks at berths to a standard length of 57 cars. O4. Opportunity to access locomotives of KTS and KTZ in each other's network and port. O5. Opportunity of customs clearance outside the port territory. O6. Increasing the capacity of KTS railway line to 16 trains per day. O7. Construction of a new railway line between the port and KTZ network. O8. No shortage of cars either platforms. O9. Construction of planned new lines in Kazakhstan will reduce duration of transportation in the direction East–West. O10. Reduction in the volume of goods transported by road from Europe to Asia.	T1. Transportation of crude oil will lead to reduction in container transportation. T2. Grain transportation on ferries with a capacity of 28 cars on Aktau–Baku line instead of 52 cars. T3. KTS is already operating at full capacity. T4. Aktau-Port station is overloaded. T5. Beineu–Aktau railway line is a single track along the entire length. T6. Grain cars awaiting loading are transferred onto siding tracks. T7. Reduction in international cargo transportation due to the economic crisis.

The main tasks, simultaneous solution of which contributes to a clear interaction of these modes of transport, should include:

• supply of cars to the transport hub in accordance with loading and unloading capacity of the port for the entire range of goods;

• supply of vessels at the time of accumulation of a shipload for a given ship at the port;

• correspondence of the capacity of the port's storage space to the volume of cargo transshipped.

The solution to these problems is possible only if a systematic approach is implemented, according to which all participants in the transportation process (shippers, rail and sea carriers, sea ports) are considered and operate as a single system [9, pp. 91–105; 10–14].

Interaction of rail and sea transport

The main forms of interaction between rail and sea transport and the scope of their effective application are shown in Table 4.

Currently, against the background of the widespread introduction of automated and information and logistics systems, organization of a single information space for participants in rail and sea transportation, a comprehensive approach and innovative solutions with regard to management and distribution of operational work in the seaport are required. In the conditions of unevenness and fluctuations in ship calls to the port (influence of seasonality and weather conditions) and supply of railway rolling stock, with disproportionate capacities and loadings of the port and railway infrastructure, new solutions would provide for establishment of a rational interaction between the railway transport and the seaport taking into account existing and future technical equipment, the adopted technology of work and implementation of various operational dispatching measures for optimal organization of traffic control and management.

Conclusions. The rational interaction of sea and railway transport in port transportation node should include solution of the following tasks:

• development and implementation of agreed schedules of ships and rail wagons;

• optimal organization of work of loading and unloading mechanisms during cargo transshipment;

• ensuring the best use of rolling stock in terms of turnaround time, static load and other indicators;

• automation of preparing of shipping documents, payments for transportation of

Table 4

Interaction of rail and sea transport in PTH

Interaction form	Interaction participant	Impact element	Effective scope
Operators of sea terminals	Shipper, port, ship	Supply of a ship by a certain date	Correspondence of the number of arriving cars to the unloading capabilities of the port. Uniform arrival of cars and ships
Sea and rail carriers	Shipper, rail carrier, port, ship, foreign port, consignee	Coordinated supply of a ship to the date of arrival of cars at a port	Correspondence of the number of arriving cars to the unloading capacity of the port
Traffic control dispatch center	Railway carrier, port	Coordinated supply of cars to the date of arrival of a ship	Correspondence of the number of arriving cars to the port's unloading capabilities
Managing transport and logistics centers	Shipper, rail carrier, ports of the region, ships, foreign ports, consignees	Mutually coordinated supply of cars and ships	For any ratio of the volume of shippers' applications for loading to the ports of the region and their unloading capabilities

goods and performance of cargo forwarding operations;

• development of an operational plan for distribution of rolling stock by stations when entering the port railway hub;

• optimal organization of labor and distribution of labor resources in order to increase labor productivity and reduce the cost of transportation of goods.

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