Using train-passing techniques on the rail network to prevent flooding on rivers

L Halitar¹, A V Dmitrenko², E V Lesnykh², S A Becher², N S Buryanina³

¹ Ministry Transport of Mongolia, Government House No. 13, Chingis Avenue, Ulan Bator, 14251, Mongolia
² Siberian transport University, 191, Dusi Kovalchuk st., Novosibirsk, 630049, Russia
³Chukotka branch of the M. K. Ammosov North-Eastern Federal University, 3Studencheskaya st., Anadyr, 698000, Russia,

E-mail: abbiel@mail.ru

Abstract. In order to prevent floods on rivers in the presence of a cascade of hydroelectric power plants, it is possible to use the methods of railway transport in the management of their operation, which ensure the prevention of prolonged congestion in the movement of trains due to the accumulation of an increased fleet of wagons on certain landfills. In railway transport, the most dangerous in operational activities are unloading points located mainly on the outskirts of the country or the continent of Eurasia. For railway transport, the most important point in management is the reception of trains during the overhaul of tracks on main lines, mainly located in the central geographic center of the country, located in Kuzbass in Russia.

On rivers, in the event of electricity generation, the most dangerous places are hydroelectric power stations located in the middle of an extended river basin. However, the most important and effective points in managing their operation are the upper and lower hydroelectric power plants. The lower hydroelectric power plants provide a quick discharge of excess water, which helps prevent floods. Upper hydroelectric power plants allow one to raise the water level of the cascade of the entire extended river basin at a lower cost.

1. Introduction

In order to prevent floods on rivers in the presence of a cascade of hydroelectric power plants, it is possible to use the methods of railway transport in the management of their operation, which ensure the prevention of prolonged congestion in the movement of trains due to the accumulation of an increased fleet of wagons on certain landfills. In railway transport, the most dangerous in operational activities are unloading points located mainly on the outskirts of the country or the continent of Eurasia. For railway transport, the most important point in management is the reception of trains during the overhaul of tracks on main lines, mainly located in the central geographic center of the country, in Kuzbass in Russia.

On rivers, in case of electricity generation, the most dangerous places are hydroelectric power plants located in the middle of an extended river basin. However, the most important and effective points in managing their operation are the upper and lower hydroelectric power plants. The lower hydroelectric power plants provide a quick discharge of excess water, which helps prevent floods. Upper hydroelectric power plants allow one to increase the water level of the cascade of the entire extended river basin at a lower cost.
extended river basin at lower costs, which makes it possible to increase the generation of electricity.

In spite of the presence of hydroelectric power plants, long-term destructive floods occur in long river basins, leading to huge losses. Long-term traffic disruptions occur in railway transport, leading to a deterioration in the operational performance of long-distance trunk lines. The study showed that huge losses in river basins on the territory of a large country are caused by insufficient use in practice of rational methods of managing production processes in these sectors of the country's economic and economic activity [1,2]. The article describes the peculiarity of the application in practice of rational methods that ensure the improvement of economic indicators of the work of these sectors of economic and economic activity of the whole country.

Technological progress in various sectors of economic and economic activity made it possible to achieve high economic indicators both by increasing labor productivity and by reducing costs associated with an increase in production and the growth of created material assets. Thus, the construction of a hydroelectric power station made it possible to obtain a huge effect through the use of renewable energy sources. Electricity has made it possible to improve the production process, ensuring the development of lighting and increased comfort in people's lives.

Regulation of the order of water accumulation in reservoirs in spring allows avoiding large floods for a long period. However, despite the management measures taken at the constructed hydroelectric power plants, it was not possible to avoid large floods with catastrophic consequences, as it was in the summer of 2019 in Tulun.

2. Materials and methods
The occurrence of floods in recent years on extended river basins of a large area is explained by two main reasons.

- The presence of a large volume of water in the upper reservoirs, which are accumulated to increase the production of cheap electricity for the purpose of its use in production processes.
- Lack of rational methods of managing the order of electricity generation in the whole cascade of hydroelectric power plants, providing the opportunity to simultaneously: both prevent floods on rivers, and also achieve an increased volume of electricity generation throughout the year.

The analysis performed showed that the water management and power generation system mainly takes into account the management procedure for individual isolated hydroelectric power plants. The proposed measures made it possible to take into account the uneven inflow of water by regulating only individual hydroelectric power plants, preventing floods [3].

However, the scientific studies carried out have shown that regulating the flow of water only for individual hydroelectric power plants does not provide flood prevention in large river basins, as was the case repeatedly on the Amur River. It will be possible to achieve great success due to the integrated regulation of the operational work of several hydroelectric power plants of the entire extended river basin at once, taking into account their capabilities, due to being at different heights above sea level.

Taking into account the peculiarities of complex regulation, it will be possible to achieve great success in the operation of all hydroelectric power plants in the basin by using the possibilities of controlling the movement of trains on railway transport, which make it possible to achieve success in ensuring the transportation process on a national scale.

To assess ways to improve the efficiency of controls in the technical and economic calculations, the presence of the main factors encountered both in railway transport and in the operation of a cascade of a hydroelectric power plant in an extended river basin was taken into account.

- The most dangerous points in which the greatest losses from emergency situations will occur, both in railway transport and in the operation of hydroelectric power plants of an extended river basin.
- The most important control points from which it will be possible to achieve the greatest
possible and cost-effective improvement in the overall operational environment.

- The procedure for complex regulation as a whole for the entire production process throughout the country. Here the question becomes about the advisability of different ways of owning large expensive technical objects: private or public way.

3. For railway transport of the continent of Eurasia

Long-term disruptions in train traffic have occurred and continue to occur in rail transport at long-range landfills. They arise not only due to insufficient bandwidth of the individual limiting elements. They also occur mainly due to the appearance of an increased fleet of wagons on individual landfills and adjacent main railway lines.

The analysis showed that in recent decades, the most prolonged traffic jams and downtime of trains en route have arisen due to untimely unloading of cars, occurring mainly on the outskirts of a large country [4]. Thus, throughout the continent, the initial long delays of freight trains en route occurred due to untimely unloading of cars at sea and river ports within the country and in the sea ports of the continent of Eurasia. The resulting long delays in freight trains caused the appearance for a long period of an increased fleet of cars, which subsequently paralyzed the operational work of long main railway lines. Therefore, the outskirts of the continent and border crossings between states are the most dangerous points at which long-term complications begin in the transportation process on the railway transport of the continent of Eurasia.

The improvement of the train traffic control system will be possible in two main ways. It will be necessary to choose a method that allows you to achieve the greatest success in managing the movement of freight trains with lower costs.

- At present, if there are separate roads and in the presence of private property, the control of the passage of trains is carried out at these specific enterprises or sections in case of difficulty in the movement of trains. Planning is carried out due to longer stops of freight trains in front of the point of main difficulties in the movement of trains on main railway lines.
- If management measures are taken on the most dangerous section, where the main difficulties in train traffic occur.

In this case, at the beginning of traffic disruptions, on the approaches to the most dangerous place, there are long delays of freight trains, which subsequently spread over a long range. At the point of main difficulties, delays in freight trains continue due to restrictions in capacity or deterioration in the operational work of final destinations.

![Figure 1. Scheme of delays for freight trains at the point of major initial disruptions in traffic at destination stations on the continent of Eurasia](image)

Fig. 1 shows that in the event of the appearance of restrictions, for example, at points of unloading in the eastern part of the continent of Eurasia, further trains pass through with their long delays along the route.

Improving the options for the passage of trains as a whole throughout the entire railway network of a large country will possibly be carried out by the integrated management of the passage of trains throughout the railway network of a large country. In this case, in front of the tracks located in the central geographic point of the country, at the cargo-handling point, in the Kuzbass region in Russia, it
will be necessary to delay the trains of freight trains going to the points of major traffic disruptions before the tracks being repaired. In this case, freight trains detained before being repaired at a freight station on the continent of Eurasia will then reduce the time they spend in front of their destination. In this case, a more stable passage of freight trains in general along the entire main railway line will be provided.

**Figure 2.** Scheme of the passage of freight trains when driving them on the main railway line.

The above conventional example shows that the best result in managing the operational work of the railway network as a whole is not achieved when management measures are carried out only at the end points of the beginning of the main disruptions in traffic. This option takes place in the presence of private railways in the country and their isolated traffic control only on their own sections. The greatest management effect is achieved when rational measures for the management of the country's railway network are carried out in far-removed points located in the central geographic center of the Eurasia continent with the largest volume of wagon loading.

In general, for all railway transport, measures for the control of train traffic are provided by the following tracks.

Major train disruptions occur on the outskirts of a large country. At the same time, rational measures to control the movement of trains find themselves in far-removed parts of the main lines located in the central geographic center of the country. This example also shows that private railroad management, as is the case in the United States, does not guarantee good economic results if trains are scheduled to run only on their own trunk lines. Only a comprehensive regulation of the passage of trains and the organization of management from a single center according to rational technology, taking into account the delays of trains along the route, and first of all during the overhaul of the track, makes it possible to ensure a more rational achievement of success in management than private management of the order of passage of trains on individual roads big country.

In general, for the entire railway transport of the continent of Eurasia, the performance parameters will be evaluated as follows.

The most dangerous points in the management of train access in railway transport are the final points of unloading and border points, usually located on the outskirts of the continent of Eurasia. At the same time, the best management results will be achieved when rational measures for the management of train traffic are carried out primarily in the central geographic center of the continent of Eurasia. This region is located in Kuzbass, where the largest volume of cargo is loaded on the continent as a whole.

### 4. Water transport, management of the operation of a complex of hydroelectric power plants
There are certain analogies with the railway transport of the continent of Eurasia. In an extended river basin, several hydroelectric power plants are usually installed, the so-called cascade of hydroelectric power plants, for example, on the Angara River. For a cascade of hydroelectric power plants, the use of methods of operational work of railway transport is possible by choosing options that ensure the achievement of higher economic results, compared with the options for isolated management of the operational work of only individual hydroelectric power plants. Operational work management options will be established as follows.

The lack of integrated management in the operational work of a number of hydroelectric power plants on long rivers leads to frequent floods. For example, in 2019, catastrophic floods occurred twice on the Angara River in Tulun, with four large hydroelectric power plants in a cascade on the Angara River. These floods occurred with an interval of only one month in June and July. On the Amur River, floods with catastrophic consequences occur regularly due to the increased water level due to the lack of rational water level management.

At the same time, due to the irrational system of using the water of the cascade of hydroelectric power stations in 2019, the Volga River became shallow. Failures in the use of water resources on long rivers occur due to the lack of scientific foundations for the influence of hydroelectric power plants on each other. The peculiarity of the operation of hydroelectric power plants located both in the lower reaches or at the mouth, as well as in the upper reaches at the sources of rivers was not taken into account. The peculiarity of the location of hydroelectric power plants at different heights above sea level was not taken into account.

The probability of occurrence of the most dangerous places of an extended river basin for the possibility of emergence of critical situations with floods was not established. The points for the regulation system were not established, the use of which in practice at the most important points allows to ensure the achievement of the best results in the management of water energy resources in a number of countries of the world.

To obtain the best results in ensuring the achievement of a faster discharge of water in the basins, in order to prevent the occurrence of destructive floods on individual rivers of each extended river basin, it is necessary to take into account that in the presence of a cascade of hydroelectric power plants, different power plants are located at different heights above sea level. Therefore, each of them has a different potential in generating electricity. This feature will have a significant impact on the procedure for establishing a rational method of management in their use, both to ensure greater generation of electricity and to prevent the occurrence of catastrophic floods on large rivers of the river basin.

In managing the operation of a cascade of hydroelectric power plants, it is necessary to solve two main problems in operational conditions:

- to provide a temporary reduction in water flow for the most dangerous location in the entire cascade of hydropower plants;
- to provide high potential in electricity generation for existing situations of fluctuations in the water flow and for its reduction in winter, in general for the entire river basin of a large extent.

Each of these tasks, taking into account the presence of a cascade of hydroelectric power plants located both at the mouth and in the upper reaches of the rivers of the river basin, will be solved in the following way.

It is necessary to assess the situation separately: both for the lower hydroelectric power plants located both at the mouth of the river and in the upper reaches of rivers located at high altitudes above sea level.

During forced floods, with a large amount of snow melting, an excess of water appears, which can lead to floods. Also, during the period of melting of glaciers or snow in the mountains or during the period of prolonged heavy rains, devastating floods may occur.

or the upper hydroelectric power plants there is a small flow of water from a limited area. For these hydroelectric power plants, it is possible to both retain and discharge water. In any case: either water is
discharged or retained, it in any case remains in the sphere of the hydroelectric power station of the entire given river basin. During floods (or hazardous situations) in the lower part, the retention of water in the upper hydropower plant allows for a low risk of flooding downstream of the river. However, the possibilities for flood prevention in this case will be limited.

In the future, as we move downstream for the analysis of the operation of the hydroelectric power station, an increasing volume of water flow is recorded. This makes it possible to reduce the volume of water, both by increasing power generation and by dumping. The flood prevention capabilities of these hydropower plants are increased compared to those located in the upper reaches of this long river basin.

It should be taken into account that in the event of an increased discharge of excess water from the upper hydropower power plants, as we move downstream of the river, the possibility of floods is created, since the water level in the hydroelectric power stations located downstream for this part of the river will increase. In general, for all hydroelectric power stations, except for the lower one, this water will remain for a certain time within the considered river basin of a large extent and with an increased total water supply.

A completely different situation will be with the operation of the lowest hydroelectric power station for this river basin. In this case, it is possible to quickly discharge the increased volume of accumulated water from the entire river basin, and not only from its part, as it was for higher-located hydropower power plants. In addition, the water leaves this river basin forever and is the greatest prevention of huge floods with catastrophic consequences.

In addition, from the lower hydroelectric power plants, water immediately enters the ocean or sea at a constant level. Therefore, the water flowing out of the lower hydroelectric power station does not create additional potential for increasing the level of electricity generation as a whole in the entire cascade of hydroelectric power stations of this large-area river basin with abundant precipitation.

Therefore, in order to get rid of excess water in a given river basin, it will be necessary first of all and to the greatest extent to get rid of excess water by means of its increased release from the lower hydroelectric power station.

The accumulation of water potential for the generation of increased volumes of electricity can be carried out as follows.

To ensure the achievement of higher success in the use of powerful resources, it is necessary to control the cascade of hydroelectric power plants in such a way that, with the available flow of water, a large generation of electricity is provided, and primarily throughout the entire year.

When assessing the options for the operation of the hydroelectric power station, it is necessary to take into account that the external inflow of water in the winter period of the year is very small. At the same time, there is an increased flow of water in spring.

The generation of large volumes of electricity will be achieved when water enters the turbines from a high altitude of each reservoir. To achieve this goal, it will be necessary that the water level at all hydropower plants in the river basin has an increased value.

In spring, and at certain times of the year during heavy torrential rains, the water level is dangerous and can lead to catastrophic floods. However, in the rest of the year, if all units of each hydroelectric power station are in operation, it will lead to a rapid loss of the level of accumulated water in the reservoirs. Therefore, during the period of reduced water intake, there should be a smaller number of units that generate electricity. This will make it possible to maintain a high level of operation of the hydroelectric power station and ensure an increased generation of electricity during the day and throughout the year.

In order to accumulate more potential, one should bear in mind, first of all, the upper hydroelectric power stations. It is located at the highest altitude above sea level. However, in practical terms, the water accumulated at the uppermost hydroelectric power station has the greatest energy potential. Therefore, this hydroelectric power station should have improved results during the period of filling the reservoir.

In addition, the uppermost hydroelectric power station will be located in the mountains. The
surface of the reservoir will be small. Therefore, if a certain amount of water is filled in a short period, the level of the river reservoir rises to a great height. Therefore, the upper hydroelectric power station will have to include more than the average level of the number of units in order to provide a large amount of electricity generation at low water consumption.

With a small external water supply, the units of each hydroelectric power station will have to have a large reservoir height. This large height should be formed by reducing the number of operating units of the hydroelectric power station. In this case, with a high level of reservoirs in general at all hydroelectric power plants during the winter period, the number of units of operating hydroelectric power plants will gradually decrease.

In spring, the amount of incoming water begins to increase at a fast time. Compared to the winter period, special conditions for the operation of the hydroelectric power station must be created.

- Preparation period. This is for a month of massive snow melting or increased water inflow into the river basin. In this case, it will be necessary to ensure the preparation of reservoirs for the unhindered passage of water flows, and at this time there will be a high water level in the reservoirs.
- Period of massive snow melting, when the accumulation of water reserves for the coming season occurs first.
- Period of increased electricity generation throughout the summer.
- Winter period of gradual decrease or reduction of water reserves in reservoirs. Preparing for massive snow melt.

The accumulation of water and the degree of filling allows a higher level of power generation to be achieved in a faster time. The amount of electricity generated does not only depend on the volume of water. The degree of power generation depends to a large extent on the height of the hydroelectric power station: the lower or upper hydroelectric power station.

The higher the water is, the greater the potential will be in generating increased flows of electricity. Therefore, it will be necessary to use the obtained potential to a greater extent to generate increased volumes of electricity generation while reducing the volume of accumulated water.

In the absence of rational regulation (private ownership of hydroelectric power plants), the most important and most dangerous points in the operation of the entire cascade will be established as follows.

In the article under consideration, we will assume that the increased water flows will gradually shift: from the sources - up to the mouth. At the same time, the likelihood of flooding will be assessed in the absence of operational control of the operation of the hydroelectric power station and the absence of centralized regulation of the flow of water in various parts of the river of a long river basin.

In case of heavy rains, only the upper reaches of the river basin will have the largest area. Such a flow of water from a small area can be relatively easily discharged below or become easily directed to create increased water reserves in the upper part. In this case, the largest volume of water discharge (over the capacity of the units) will not lead to disastrous consequences in the lower part of the longest river.

In the case of increased flows of water at the mouth, released in large volumes, they will quickly fall into the ocean. In this case, there is no accumulation of water and usually there is practically no
deterioration in the living conditions of people near the ocean level. At the same time, it is necessary to prevent flooding of houses, since as you move up, the height of the river above sea level increases.

Table 1. Comparison of the performance indicators of railway transport with the operation of a cascade of hydroelectric power plants in an extended river basin under conditions of seasonal fluctuations in water flows

| Indicators                                      | For rail transport                                      | For the operation of the hydroelectric power station |
|------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------|
| Lack of a single control center for the operation of a hydroelectric power station or isolated control of train traffic on each road | There are long delays of freight trains along the route | Leads to floods or reduced electricity generation and deterioration of navigation in river basins |
| The presence of a single control center with rational network technology | Allows to significantly reduce delays of freight trains en route, ensures stability in the operation of railway junctions | Makes it possible to prevent the occurrence of large floods, causes increased electricity generation throughout the year |
| The most dangerous points where long-term failures in their work most often occur | Final destinations at unloading stations on the continent of Eurasia | The central part of the river basin, where increased water flows are concentrated |
| The most important points in managing the operation of technical objects | The central geographic part of the continent of Eurasia with an increased volume of loading, where the cargo point is located | Outlying hydroelectric power plants of the river basin: the initial one - at the mouth and the upper hydroelectric power station at the source of a large river |
| Management of train traffic and power generation at hydropower plants in river basins | The best results are achieved when rational measures are applied in the central geographic part of the continent of Eurasia, located in Kuzbass, Russia | The best results are obtained in the operation of hydropower plants located at both ends of the river basin: at the upper and lower hydropower plants. Upper hydroelectric power plants serve to store water or energy potential, as well as to increase electricity generation. The use of lower hydroelectric power plants allows to remove excess water in a faster time in order to prevent large catastrophic floods in river basins |

5. Conclusion

- Methods of centralized control over the passage of trains on railway transport, as well as the management of the operational work of a cascade of hydroelectric power stations on long rivers, can improve the economic indicators of the country's energy economy.
- In railway transport, as well as for river basins, the operation of hydroelectric power plants must take into account their outskirts and central part.
- For railway transport, the most dangerous points in operational work are the outskirts of the continent of Eurasia or border points between states. For the energy sector, the most dangerous points causing catastrophic floods are the central part of long river basins.
• In the management of train traffic on railway transport, the greatest effect is achieved by regulating the sequence of passage of freight trains in the central geographic part of the continent of Eurasia. For a river basin, the greatest effect is achieved for hydroelectric power plants located at the mouth of the river, as well as at its source.
• The lower hydroelectric power plants at the estuary make it possible to prevent destructive floods with an excess of water in the reservoirs. Upper hydropower plants located high above sea level create potential for high-volume power generation.

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