LOGISTIC REPORT
TECHNICAL, ECONOMIC AND FINANCIAL
Brazil – Uruguay Waterway:
Challenges and opportunities in the integration with South System Waterway

Studies developed by the Students of South System Team:

Juliana Marzullo
Leandro Chaves
Rafael Medeiros
Ronei Calgaro
Vitor Gomes
Vito Longhi

SUMMARY

LIST OF IMAGES

LIST OF TABLES

SUMÁRIO EXECUTIVO

Este estudo explora as oportunidades para aumentar o transporte hidroviário interior na região dos lagos da América do Sul, criando transporte internacional entre lagoas, desenvolvendo o Nordeste uruguaio através de uma plataforma logística internacional mais competitiva e sustentável disponível entre Uruguai e Brasil. Assim, expandindo o Mercosul e principalmente o desenvolvimento desta região uruguaia com melhor logística no mercado global de commodities, desenvolvendo ainda mais a infraestrutura de transporte hidroviário interior de cargas já existente no estado do Rio Grande do Sul no Brasil por meio da integração das Lagoas Mirim e dos Patos dando acesso ao Porto de Rio Grande, local já consolidado no comercio internacional.

Embora a Lagoa Mirim tenha áreas comuns entre os dois países com importante ligação para a navegação de cargas com a bacia fluvial e lacustre do estado do Rio Grande do Sul, esse transporte hidroviário interno de cargas ainda não foi explorado, embora tenha sido estudado e desejado pelos dois países há mais de 60 anos. Neste momento, pela importância estratégica de atender os novos patamares de consumo mundial de produtos florestais, minerais e principalmente agrícolas com logística mais competitiva, e pela maior frequência das discussões sobre o tema e dos acordos internacionais existentes, é oportuno reativar este estudo de interligação, que está descrito em nosso projeto.

Portanto, este projeto de transporte hidroviário internacional de cargas consolida e atualiza as informações disponíveis, criando uma análise acadêmica através dos conceitos absorvidos nesta especialização para contribuir e potencializar este elo estratégico de cargas lacustres para maior competitividade internacional e desenvolvimento regional. Embora essa navegação interior também estimule o Mercosul, proporcionando mais um modal de transporte para ser explorado nos fluxos comerciais internos entre os dois países com o acesso até região metropolitana de Porto Alegre, para o estudo, decidimos direcionar nossa análise para um futuro corredor de exportação com fluxo de exportação e importação de cargas entre o Nordeste uruguaio e o porto de Rio Grande no Brasil, motivados pelos seguintes fatores:

- a região nordeste uruguaia banhada pela Lagoa Mirim caracteriza-se pela concentração de atividades primárias com pequena competitividade logística devido a sua distância dos grandes centros e portos do próprio país, dificultando seu próprio desenvolvimento regional.
- o crescimento do consumo no mercado global de comodities exige aumento da produção nas áreas agrícolas.
- estimular o desenvolvimento do agronegócio no Nordeste uruguaio, que tem potencial exponencial para os setores florestal, agrícola e mineral, por meio de uma logística de cargas mais competitiva, com infraestrutura tímida e limitada nas soluções com modais terrestres.
- distância mais curta entre região nordeste do Uruguai ao porto de Rio Grande, Brasil, do que quando comparada aos portos uruguaios de Nueva Palmira ou Montevidéu.
- posição estratégica e infraestrutura disponível no porto de Rio Grande, a qual junto com a alternativa da ligação das lagoas consolida menor custo logístico internacional reposicionando Rio Grande para um porto concentrador (*hub port*).

Ao final do estudo apresentamos os resultados da análise econômico-financeira em comparação com soluções intermodais em outros corredores, demonstrando a viabilidade do investimento em uma empresa de navegação que explore o corredor analisado.

1. INTRODUCTION

This study seeks to explore the opportunities to increase inland water transport in South America lagoons' region, developing the Uruguayan Northeast region in a more competitive and sustainable international logistic platform available in South America, expanding Mercosur and especially the development of this region in the global commodities market. It will develop the Inland waterways transport cargo infrastructure that already exists in the state of *Rio Grande do Sul* in Brazil next to Uruguayan border, by the integration of *Mirim* and *Patos* Lagoons providing the access to the Port of *Rio Grande*.

Although *Mirim* Lagoon has communal areas between the two countries with an important connection for navigation with the river & lake basin in the state of *Rio Grande do Sul*, the internal waterway transport of cargo has not been explored so far, even though it has been studied and desired by the two countries for more than 60 years. At this time, due to the strategic importance of attending the new levels of global consumption of forest products, mineral and agricultural commodities with more competitive logistics, and due to the frequency of discussions on the subject and existing international agreements, it is opportune to reactivate this project proposed, see infographic below:

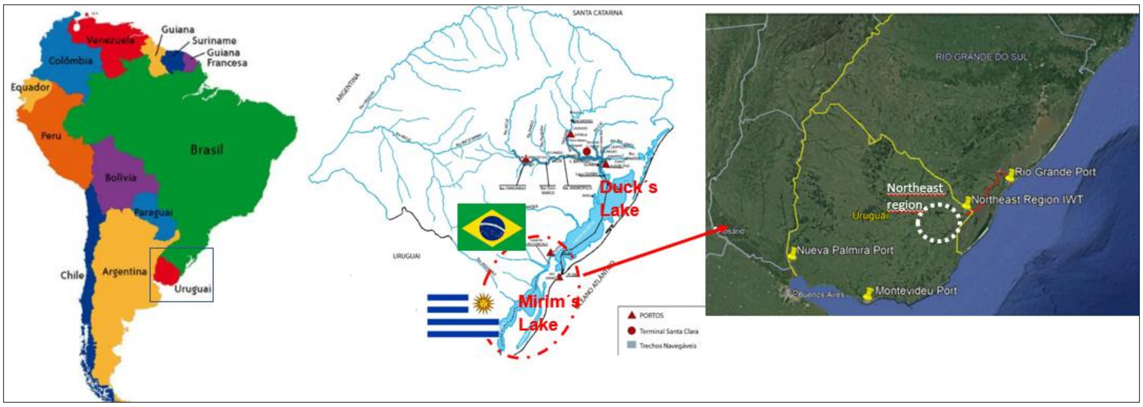


Image 1. Study Area

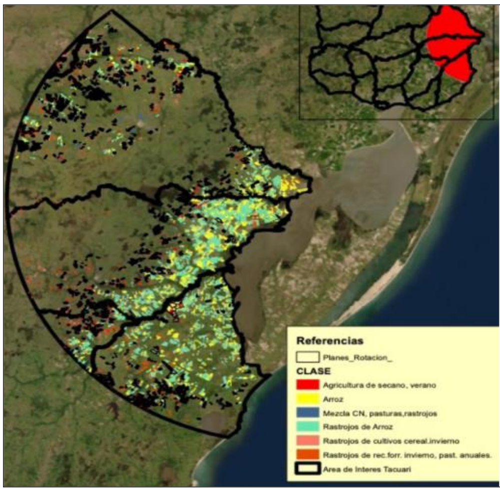
Source: Authors, based on Google Maps and Waterways Network digitalized flyer by SPH RS

Therefore, this project of international inland waterways transport cargo consolidates and updates the available information, creating an academic analysis through the concepts absorbed in this specialization to enhance this strategic lake cargo link for greater international competitiveness and regional development. Although this inland navigation also stimulates Mercosur, providing another modal transport to be explored in trade flows between the two countries, we decided to direct our analysis to a future export corridor with cargo flow between the Uruguayan Northeast and the *Rio Grande* port in Brazil, motivated by the following factors:

- the Uruguayan northeast region bathed by *Mirim* Lagoon is characterized by the concentration of primary activities with small logistical competitiveness due to its distance from the large centers and ports of its own country, hindering its regional development.
- the growth of the global market requires an increase of production in agricultural areas.
- it stimulates the development of agribusiness in the Uruguayan Northeast region, which has exponential potential for the forestry, agricultural and mineral sectors, through more competitive cargo logistics.
- shorter distance from the northeast region of Uruguay to the port of *Rio Grande,* Brazil than to Uruguayan ports of *Nueva Palmira* or *Montevideo*.
- strategic position and available infrastructure in the port of *Rio Grande* that has more international competitiveness than Uruguayan ports, consolidating a "hub port".

1.1. Characteristics of the region and *Rio Grande* port influence

The Uruguayan northeast region is characterized by primary activities mainly concentrated in the production of rice and cattle, with planted forests and other vegetable and/or mineral crops not yet explored in their potential due to the logistical difficulty of their location. However, the region is considered the place where more suitable soils for summer crops in Uruguay, having the following characteristics available:



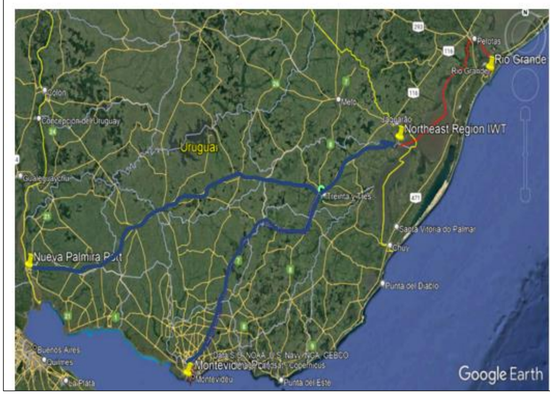
hectares	Use of land area (radius 150 km Tacuary river point)
1,209,897	Natural Field
506,506	Regenerated Natural Field
164,151	Rice Stubble
107,062	Rice
96,375	Planted Forest
59,099	Rainfood Agriculture, Summer
29,014	Winter Stubble, Natural Pastures
22,302	Stubble Of Winter Cereal Crops
2,841	Cn Mix, Pastures, Stubble
2,375	Olive Groves
327	Quarries, Open Pit Mines

Informations searched by local investor

Image 2. Regional Land Map

Source: based on the informations by Fadisol Agribusiness Group studies

Due to the growing scenario of agricultural commodities and renewable forests global consume, there is a great expectation in this region about the evolution of this inland waterway corridor that has been stagnant for more than 60 years, awaiting a definition of government investments to enable an exponential advance in the economic development of the region. When comparing the internal road logistics of this Uruguayan region to its ports with the possibility of inland waterway transport to the port of *Rio Grande*, we will see that the project is more rational, sustainable, and economical using this connection of the lagoons and the access to the port of the extreme south from Brazil. When we establish a key point in the Uruguayan northeast region at the junction of the *Tacuary* River with *Mirim* Lagoon, we will have the following comparisons on the map and table below:



FROM	TO	Modal	Distance
Tacuary river point (**UY Northeast region**)	Mirim Lake access	IWT	3,5 Km
	São Gonçalo Canal/BR	IWT	171 Km
	Rio Grande Port/BR	IWT	220 Km
	Montevideu Port/UY	Road pathway	420 Km
	Nueva Palmira Port/UY	Road pathway	540 Km

Map route legend:
- Road pathway
- Inland Waterway Transport (IWT)

Image 3. Regional Transport Options and Distances

Source: Authors, based on Google Earth

The road route of approximately 260km, which is still unexplored, on the map above due to the limitation of the *Barão de Mauá* international bridge. That could be another alternative from the northeast region of Uruguay to the *Rio Grande* port.

That bridge was built on the *Jaguarão* river in 1930, which makes the connection between the cities of *Rio Branco*, Uruguay, and *Jaguarão*, Brazil, and it has approximately 2'113 meters long with narrow way lanes for long trucks (7 axles and 2 trailers or only long trailers) being a critical bottleneck along with the profile of the highway that passes inside of downtown in the border cities.

This possibility was not developed because it is too restrictive to receive a high demand for trucks when establishing an export corridor, because in addition to the afore mentioned limitations, the international road connection still has a distance 18% bigger than the waterway transport route suggested by this study.

1.1.1. South transport modals in the Rio Grande port

The *Rio Grande* port is located at *Rio Grande do Sul* State, the extreme south of Brazil, it has a boarder with Argentina and Uruguay being a good place to trades due to infrastructure showed below:

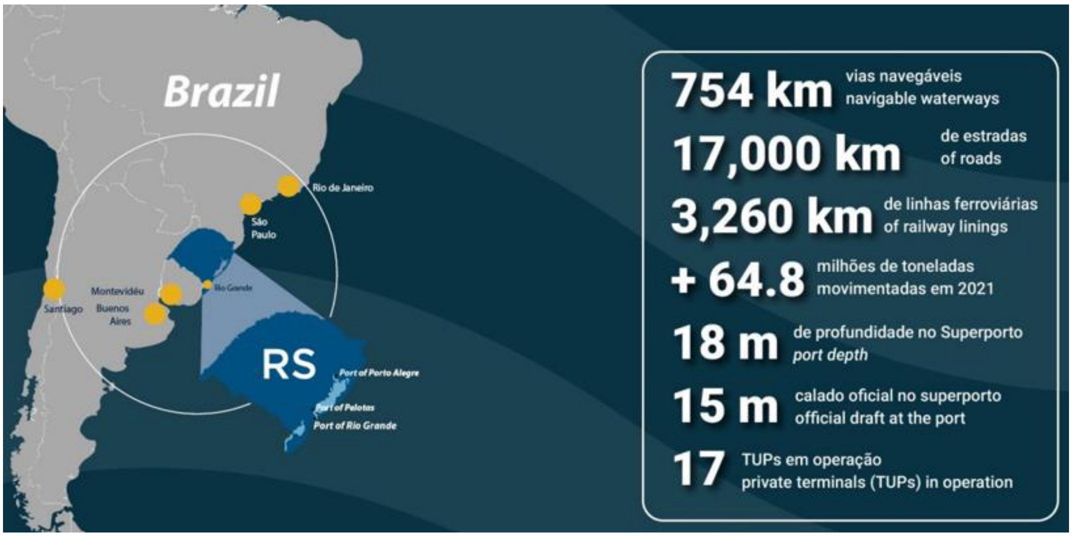


Image 4. State influence area

Source: Authors, based on map of Port Industry Rio Grande presentation

The company *Portos RS* is the manager of ports and inland waterways transport system in this region and as it says, "*…the Port of Rio Grande is privileged by its geographical aspects, established itself as strategically placed because of its strong performance in the extreme south of Brasil, being among the most important ports in the American continent in regard to productivity*".

This port has a draft of 15 meters in most of the private terminal area, it possesses excellent depth in its bulk and container terminals, superior to its corresponding one in Argentina or Uruguay ports.

Endowed with a complete operational infrastructure and normally receive the three modal of cargo transport to consolidate goods with rail, road and inland waterways providing access to the terminals and international transport with the global cargo vessels, moving and handling more than 40 million tons per year.

The Port of *Rio Grande* is considered the second most important for the development of Brazilian international trade and offers enviable mooring availability, with a 2km long wharf.

The port is connected to all regions, either through the road-rail network or through the navigable system of *Patos* and *Mirim* Lagoons, with its tributary rivers. It is of great strategic importance for the State due to the potential of inland waterways, cost reduction and fuel savings in cargo transport, especially those with large unit volumes.

Being close to the inland waterways port system is a guarantee of competitiveness for the final product, given the reduction of logistics costs.

The inland waterways transport system of *Rio Grande do Sul* has the following characteristics:

- main flows of cargo transport covering Patos Lagoon and tributary rivers.
- more than 700 km of navigable waterways connecting the ports and private terminals.

- 3 port waterways connections Porto Alegre, Pelotas, Rio Grande and other inland terminal in tributary rivers.
- 17 Privates Terminals.
- the waterways system has transported an average of approximately 8.7 million tons per year of internal flows covering all types of cargos.

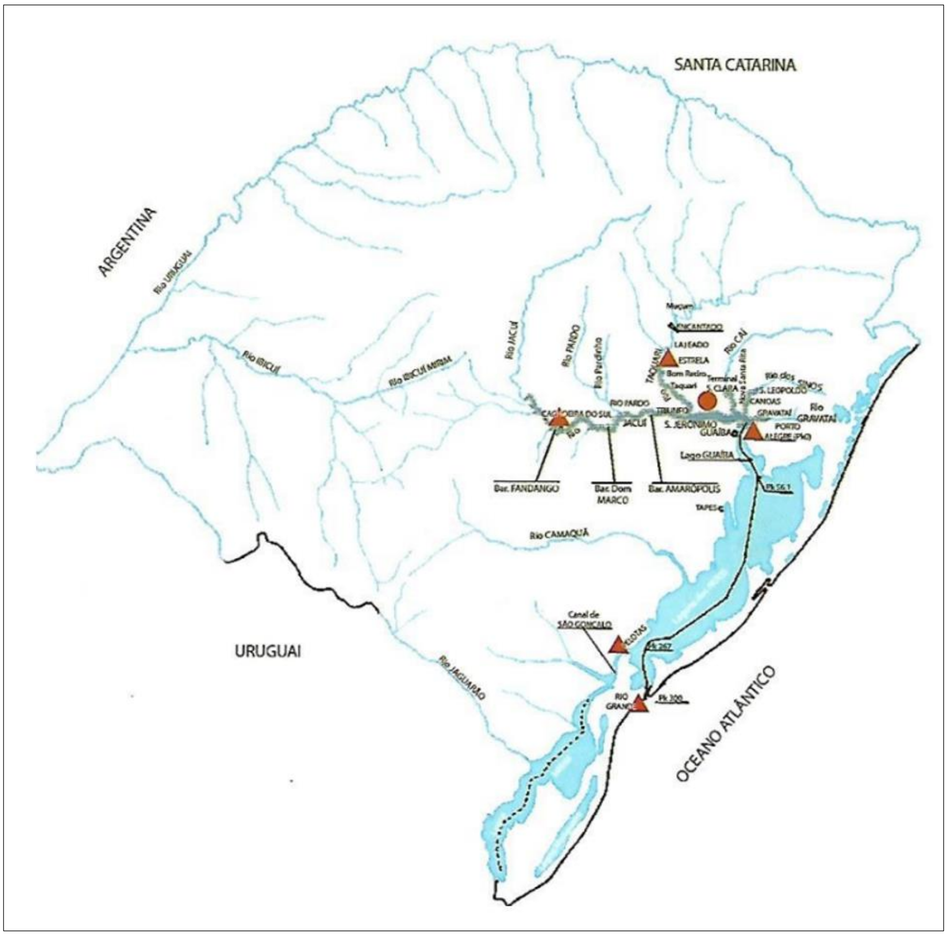


Image 5. Waterways Inland Transport South area
Source: based on flyer Waterways Network by SPH RS

This infrastructure of *Rio Grande do Sul* state a mainly *Rio Grande* port and its terminals is available to receive and develop all cargo flows of northeast Uruguayan region as showed below:

Image 6. Rio Grande Port Area
Source: Google Images

The port infrastructure has a comprehensive multimodality, a 40 feet deep draft, 22 simultaneous docking berths and 9 specialized terminals, also one of the largest retro port areas available in Brazilian ports. This port area is available to receive cargos from Uruguayan northeast region without new investments.

1.2. Demand forecast by logistics and challenges

As it is mentioned in the introduction, the study does not explore all the Mercosur flow between the two countries along the entire *Mirim* Lagoon and interior of *Rio Grande do Sul*, but it proposes an analysis of competitiveness by simulating the existence of an export corridor.

Therefore, this fertile ground area for investment from the northeastern Uruguay linked with the *Rio Grande* port provides for this scope the possibility to stablish a feasibility for a commercial flow of international cargo transport by inland waterway transport to a bonded terminal at the port.

The Uruguayan northeast region allows for greater availability of up-to-date information due to the already existing content involved in research on referential demands made available in print or digital media, opened content of presentations arising from sectorial lectures by governmental and business entities.

In this way, a consolidator point can be established as in the photo, establishing a fictitious terminal as in the figure above to capture cargo within a range of 150 km of action.

For the study, we will consider the potential of reference volume with a ten-year view simulated with the advancement of the waterway project and the very increase in the regional development of commercial activities in this region.

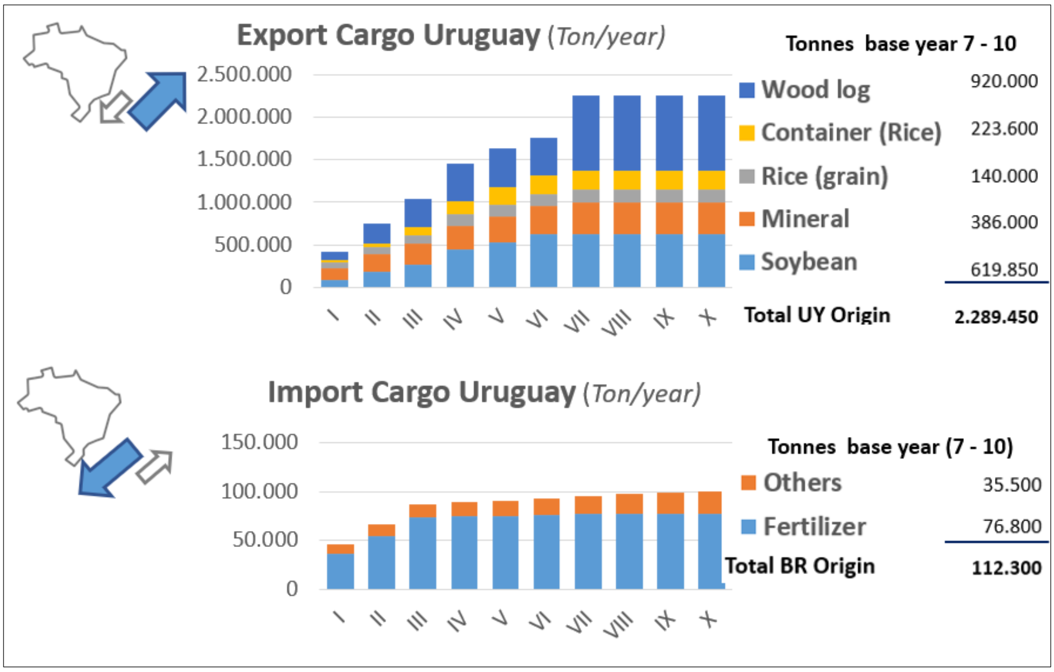


Image 7. Demand Cargo Forecast of IWT

Source: Authors, based on the informations by Fadisol Agribusiness Group studies

The graph above shows the estimative cargo demand for the region, and also illustrates that, after approximately 7 years of operations in waterway transport, the demand in this preliminary project will be stable based on the initial study, although the productivity per area would still grow for the agribusiness along time (10, 15, 20 or more years) due to the farmer maturity, soil treatment, seed development and use intensive technology.

The forecast cargo demand above demonstrates that the main IWT flow is Uruguay's exports with 95.3% of the total load and imports represent only 4.70% of the total of 2’402 million tons per year.

Although there are good perspectives to develop commercial flow and the transport linked to lagoons had been studied during many years is important to highlight the main bottlenecks of IWT to possibility this implementation.

The main factors for this challenge to develop the transport system are illustrated in the scheme for constraints below:

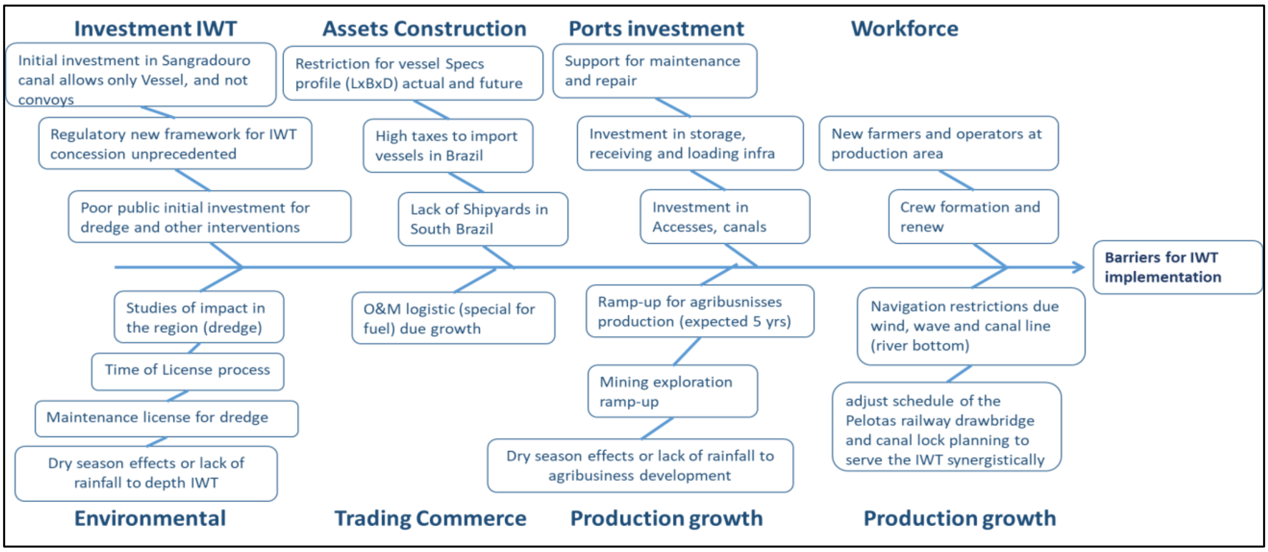


Image 8. Bottlenecks and future challenges to develop and increase the transport system

Source: Authors

In addition to the restrictions explored above, nowadays Brazil government infrastructure ministry is studying which option is the best solution for the *Mirim* Lagoon development IWT. There are doubts to be solved about profile of this infrastructure waterways, as described below:

- the uncertainty whether IWT would only address self-propelled vessel to operate vessels dimensions (100m length, 15.5m breadth and 2.5m draft) due to the limitation imposed by the *São Gonçalo* Lock Canal, which will need investment and maintenance, that is a federal responsibility.
- whether the new IWT a first private model applied in Brazil, and it will be viable having charging toll for users during the ramp up of project.
- whether the *Sangradouro* Canal dimensions (width, length straight line between curves, depth) would be developed, enabling short convoys (4 barges + 1 pusher).

1.3. Brazilian Waterway Public Policy

Apart from the technical aspects demonstrated in this work, it is necessary to present the legal and regulatory framework applied to waterway transport in Brazil.

According to the constitutional provision, water transport is currently considered to be a public service since it aims at the collective interest of Brazilian society. Therefore, companies operating the waterway transport service must request authorization to operate from the state, which, in turn, acts as a regulator of the provision of the transport service. In this sense, the regulatory entity must ensure that the economic activity of transport provided by companies is not only aimed at maximizing profits, but also generates the best result for the community. Among the objectives of the regulation is the promotion of the quality and regularity of the provision of the transport service, as well as the promotion of free competition and the competitiveness of the waterway sector – all of this in pursuit of reducing costs to society.

In this context, the governance of the Brazilian federal state is shared in three instances – federal, state, and municipal – and depending on the route on which waterway transport is carried out, the legal and regulatory formalization will be the responsibility of the federal, state, or municipal government.

At the federal level, the National Waterway Transport Agency (Antaq) is the public entity responsible for executing and supervising the public navigation policy, instituted by Law No. 9432/97. Therefore, Antaq is responsible for issuing authorizations to the Brazilian Shipping Companies (EBN), overseeing them with a view to providing adequate service. Furthermore, the Agency prepares, and edits rules and regulations related to the provision of transport services and the exploitation of waterway infrastructure, as well as acts as the Granting Authority in cases of granting a concession for the exploitation of waterway infrastructure (in the port sector, this function is of the Ministry of Transport).

The characteristic of the work on screen is federal and predominantly regulated by Antaq, without excluding the participation of other public bodies and entities involved to enable the execution of the transport service.

Therefore, it is pertinent to present the normative scope that surrounds inland navigation in Brazil and the possible concession models for the *Mirim* Lagoon waterway. Another point worth mentioning are the rules for chartering foreign vessels, since Brazilian public policy gives preference to Brazilian vessels in terms of providing transport services. This preference occurs, among other reasons, to strengthen the Brazilian merchant navy, freeing the country from dependence on foreign vessel owners who, depending on the market situation, may lose economic interest in operating in Brazil and, thus, negatively impact the operation of a Brazilian waterway service generating costs and supply problems for the population.

First, regarding the possibilities of the waterway concession process, it should be noted that in the Brazilian context there is no waterway granted. The possibility of concession arises in the country from the qualification of two waterways under the Partnership and Investment Program (PPI). This Program is aimed at expanding and strengthening the interaction between the state and the private sector through the signing of partnership contracts for the execution of public infrastructure projects and other privatization measures. Qualifications are carried out via decree and become a national priority.

Partnership contracts are considered: common concession, sponsored concession, administrative concession, concession governed by sectorial legislation, public service permission, lease of public property, concession of right in rem and other public-private businesses that, due to their strategic character and their complexity, specificity, volume of investments, long term, risks, or uncertainties involved, adopt a similar legal structure.

In this sense, the concession is a type of privatization. Occurs when the state remains the holder of the public service, however, transfers its execution to the private sector. Unlike what happens with privatization, which is the transfer of ownership and operation to the private sector.

The public concession is formalized through a contract signed between the public administration and a private company, so that the latter can run and economically exploit the public waterway transport service. Therefore, it is a trilateral relationship: the Granting Power (Antaq), the concessionaire and the user. It is preceded by a bidding procedure (it can be of the competition or auction type) and is based on Technical, Economic and Environmental Feasibility Studies (EVTEA). The concession model is:

- Common: with remuneration via tariff.
- Private Public Partnerships (PPP): which can be sponsored – when there is a fee (user charge); ancillary income; government subsidy – or administrative – when there is no way to charge a fee.

1.4. Regulation applied over IWT

The regulation incident to the object of this work, which is the São Gonçalo Canal and the Mirim Lagoon Waterway, will be carried out on the following tripod: authorization of the EBNs; authorization to charter foreign vessels; and activities related to the process and the concession contract.

The South Atlantic hydrographic region connects Uruguay and Brazil through the *Jaguarão* River, *Mirim* Lagoon, *São Gonçalo* channel, *Patos* Lagoon and *Miguel da Cunha* Channel, allowing a fluvial export outlet through the Atlantic Ocean.

This work is analyzing the possible *Mirim* Lagoon waterway and the stretch of the *São Gonçalo* Channel. In accordance with current regulations, EBN must be authorized by Antaq following the provisions of Antaq Resolutions No. 80, 81 and 82, all of July 4, 2022.

Regarding to vessels, Brazilian public policy provides for preference for national vessels. This type of policy occurs in several other countries, and, in Brazil, this preference cannot be misinterpreted as a market reserve directed only at Brazilian vessels because, if that were the case, only Brazilian vessels would be legally able to operate in the country, if not. EBN interested in providing the transport service with a foreign vessel, before carrying out the charter, must send a request for the provision of service to Antaq, which, before releasing the charter authorization for a foreign vessel, verifies if there are Brazilians able to carry out the service under review. If there is no Brazilian vessel under the required technical conditions and/or the operation is not economically feasible, Antaq sends the authorization to charter a foreign vessel, substantiated by a Certificate of Authorization for Inland Chartering (CAIC).

The process of querying the availability of a Brazilian vessel in the market is known as "circularization" and its deadlines are defined according to the figure below.

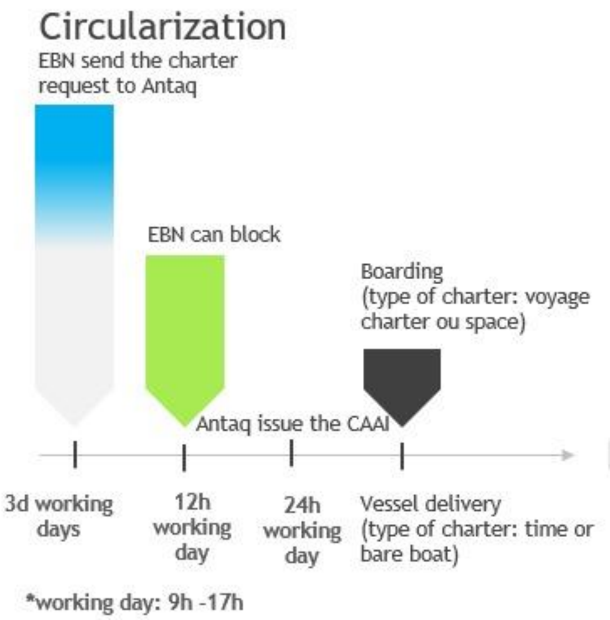


Image 9. Circularization process flow in Brazil
Source: Authors, based on public information

It is important to understand that business hours are computed between 9am and 5pm. That is, 1 day has 8 working hours. Therefore, the EBN that wishes to block the operation with a Brazilian vessel (this means showing interest to Antaq), must do so within 12 working hours.

Blocking can be total or partial. The latter refers to the operation part. It is recalled that, in all cases of circulation that have blockages, these are subject to the acceptance of Antaq, since the Agency verifies that there is compatibility between the conditions offered and the prices practiced in the national market of reference. As previously stated, there is no market reserve for Brazilian vessels in Brazil, only preference, and even when conditions are compatible with the situation analyzed here. The circularization process is fast, as previously demonstrated.

With the purpose of streamlining communication between the EBN's and Antaq in vessel chartering operations, the Chartering Management System will be made available. This system, which is already widely used in Cabotage, Port Support and Maritime navigation, known as the Maritime Navigation Chartering System (SAMA), for inland navigation will be called the Interior Navigation Chartering System (SANI) and is about to be released.

Another point that demonstrates the flexibility of this public policy is the figure of the Brazilian Special Registry (REB). The REB is nothing more than a foreign vessel that has its original flag suspended and flies the Brazilian flag. Once the legal requirements for this registration have been met, the maximum term of the REB is up to 36 months. Thus, when a vessel is registered with the REB, it receives dealings with a Brazilian vessel for chartering purposes, exempting EBN from consulting Antaq in advance.

Finally, until the conclusion of this work, regarding this waterway, Brazil and Uruguay formed a Workgroup (WG) with the purpose to discuss regulations, cartography, etc. The expectation is that this will be the first Brazilian waterway concession, considered a significant step for the national road system. Logistical infrastructures are fundamental to boost economic growth and, therefore, the development of the country.

2. THE MERCOSUR WATERWAY

The Mercosur waterway is one of the best structured waterway systems in the country, with dams equipped with locks, beacons, and installed signaling. A two-way street between Brazil and Uruguay, it is an axis of fundamental importance for commercial exchange between the countries.

In Brazil it encompasses the *Mirim* lagoon and its tributaries, especially the *Jaguarão* river and the *São Gonçalo* canal; and, in Uruguay, the *Mirim* lagoon sector and its tributaries, especially the *Jaguarão*, *Cebollatí*, and *Tacuarí* rivers.

2.1. General features

The Mercosur waterway covers 309 municipalities in Brazilian territory. *Patos* lagoon is currently navigated by commercial vessels with drafts of up to 5.1 meters, allowing maritime access up to *Porto Alegre* (*RS*).

- **Navigable Length**: 1,860 km
- **Cargo Transportation**: 4,105,384 tons (Antaq, 2014)
- **Main Cargo**: Fertilizers, fuels, mineral oils, organic chemicals, grains, mainly soybeans and wheat, celluloses, and mineral coal

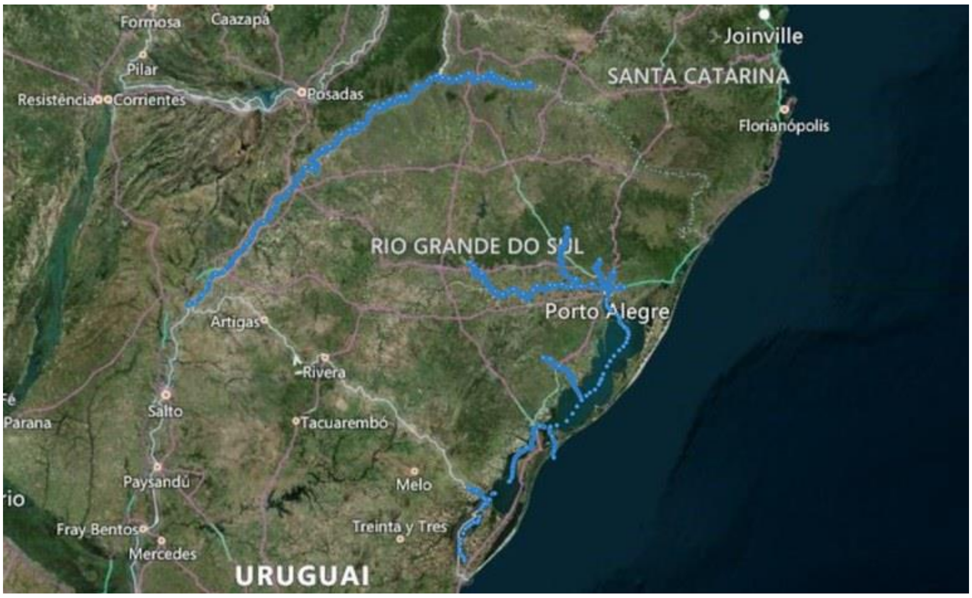


Image 10. Mercosur Waterway
Source: Brazilian National Waterway Trasnport Agency – Antaq (2022)

The future connection between the lagoons will provide an increase of cargo volume between both countries which, by the limits analyzed in this study, exploring internal flows that expand Mercosur beyond the area studied in this work, which has a focus initiated in the *Tacuary* river, Uruguay. In this way, after starting the first stretch as presented in the project, the following other points can still be explored:

- existing waterway complex that extends to the interior of the state of *Rio Grande do Sul* (*RS*), passing through *Porto Alegre* and accessing its tributaries to the interior of the state.
- develop new cargo flows originating from the southern end of the *Mirim* lagoon with future terminals in *Charqueadas* (area of influence of the *Cebollatí* river), *Santa Vitória do Palmar*.
- areas with catchment radius between the city of *Jaguarão*, Brazil and *Rio Branco*, Uruguay.

Both options contemplated initial studies mapped by Administration of South Waterways (AHSUL/DNIT) in 2014.

Image 11. Expansion Mercosur Waterway
Source: AHSUL/DNIT (nov/2014)

2.2. Navigation challenges between Mirim and Patos lagoons

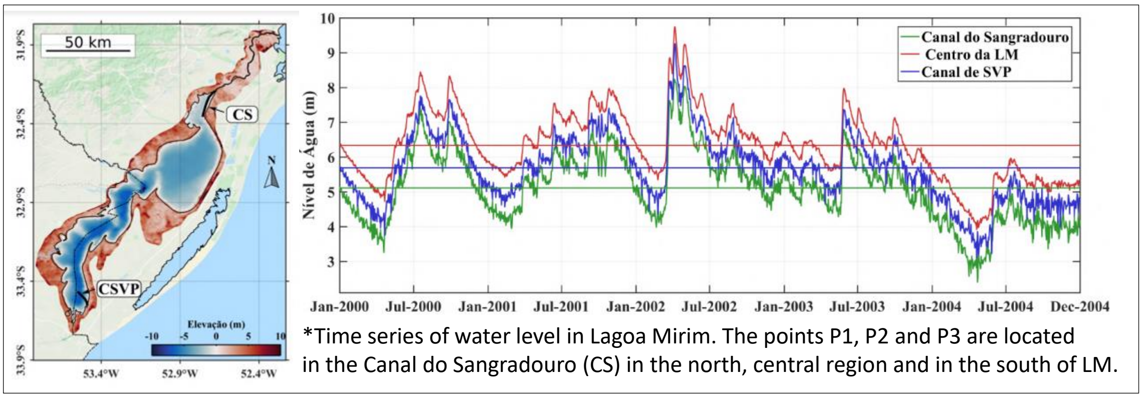
The *Mirim* lagoon is linked to *Patos* Lagoon through *São Gonçalo* canal that bathes the city of *Pelotas*, 60 km from *Rio Grande* port. *Pelotas* port is in the southern region of the state of *Rio Grande do Sul*, on the left bank of the *São Gonçalo* canal, which connects the lagoons.

The infrastructure consists of three warehouses, bonded, with an area of 2’000 sqm, capacity of 5’000 tons each, several storage yards and provides separate areas for multi-purpose terminals and general cargo. In 2021 handled over 1.2 million tons in products such as wood logs, clinker, and soy.

Image 12. Mirim Lagoon
Source: Authors, based on Gallery Photos at Portal PPI website Brazilian Government

Between *Mirim* and *Patos* lagoons, where the *São Gonçalo* canal with 70 km is located, there is a bottleneck that makes the transition to arrival at the *Mirim* lagoon called *Sangradouro* canal (*CS*).

The first 17 km of extension at this location represent the worst silting condition for navigation, it is where the greatest investment in dredging services will be needed to initiate and maintain the possibility of inland waterway transport. The depth variation in this location is illustrated below:



*Time series of water level in Lagoa Mirim. The points P1, P2 and P3 are located in the Canal do Sangradouro (CS) in the north, central region and in the south of LM.

Image 13. Time series of water level in *Mirim* Lagoon

Source: 2020 Morphodynamic Hydro Numeric Study of Lagoa Mirim RS Brazil Analysis, page 77, by Antonio Raylton Rodrigues Bendô

Although the Rio Grande do Sul navigation has been operated more than 100 years with commercial cargo flows in the lagoons and its tributary rivers, we must consider the specific characteristic of inland waterways transport in this region. Practically in this local more than 95% of inland waterways transport production is realized by self-propelled vessel.

The internal flows have a river line fleet vessel dedicated and only short convoys has operated in determinates conditions, as well as ocean vessels due to the limitations and restrictions, other kind of navigation fleet as big or medium convoy cannot operate in this waterway's canals. It happens cause of several characteristics as described below:

- wind speed and wind gust history in the lagoon´s region (Beaufort scale often appears in the week among 4, 5, 6 and 7 range).
- there are wave variations in *Patos* lagoon due to sea currents, wind directions, lakebed morphology and cause of the ocean connection with *Rio Grande* port.
- there are 15 waterways canal in this region (width and depth constraints).
- rail, road and road drawbridges in the *Porto Alegre* metropolitan area and tributary rivers.
- tributary rivers close to *Porto Alegre* and *São Gonçalo* canal in *Pelotas* are intermittent rivers, with flow variation and consequently seasonal draft.
- 1 private canal: *Santa Clara*.

When this study deep about the conditions to navigate between *Mirim* and *Patos* lagoons it should consider other constraints inside this route. There are several engineering constructions for other modals transposition over the *São Gonçalo* canal near *Pelotas* port, according to the features and the photos following below:

- two road bridges with a 27m air draft and a central span of 52m.
- a railroad drawbridge with a maximum air lift of 23m (air draft) and a central span of 39m, conflicting infrastructure time schedule daily.
- dam connected with ship lock, this construction was built to prevent the salinization of *Mirim* lagoon, whose lock measures 120m X 17m for navigation and 4.5m depth.

Image 14. São Gonçalo Canal
Source: Google Images

The conditions about wind speed and gusts in this extreme east coast of South America have been a key factor not only for navigation, but it has also developed several studies to sustainable projects of green energy (wind turbine area) as have demonstrated the figure comparative of wind map between the different decades following bellow:

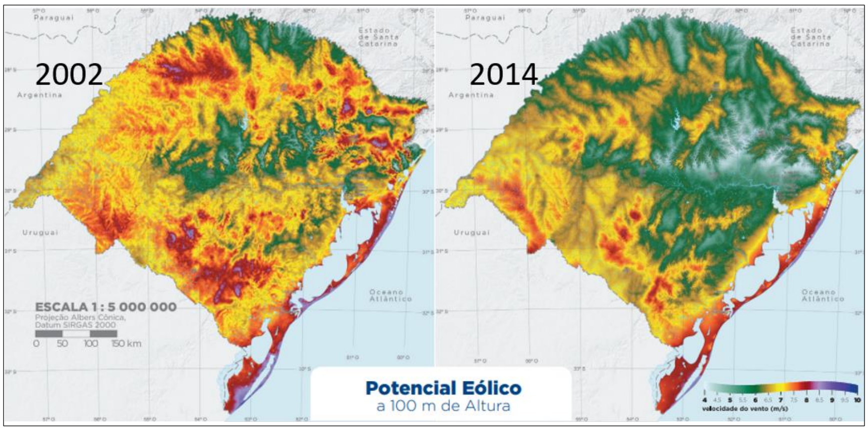


Image 15. Wind Forces and Gusts in the *Mirim* Lagoon region
Source: Wind Power Atlas (2014)

The red color in the regions of the maps above indicates the higher incidence of the winds in *Rio Grande do Sul* to develop green energy and, it can be noticed the concentration of wind forces around the *Patos* and *Mirim* lagoons interfering directly in the waterway's navigation.

The red color in the regions of the maps above indicates the higher incidence of the winds in *Rio Grande do Sul* to develop green energy and, it can be noticed the concentration of wind forces around the *Patos* and *Mirim* lagoons interfering directly in the waterway's navigation.

The Brazilian Coastal Public Ports Report, searched by the Brazilian National Waterway Transportation Agency (Antaq) and other entities about the impacts and risks of climate change showed the ranking of windstorms risks in Brazilian public ports in the page 21, where the southern area is represented for *Rio Grande* port ant this local ranks first as in the table below:

Posição	Porto	Observado
1º	Rio Grande	1,000
2º	Aratu-Candeias	0,993
3º	Cabedelo	0,856
4º	Natal	0,792
5º	São Francisco do Sul	0,792
6º	Recife	0,750
7º	Paranaguá	0,661
8º	Santos	0,627
9º	Imbituba	0,618
10º	SUAPE	0,604
11º	São Sebastião	0,596
12º	Fortaleza	0,509
13º	Rio de Janeiro	0,481
14º	Salvador	0,461
15º	Ilhéus	0,426
16º	Vitória	0,398
17º	Itaguaí	0,397
18º	Itajaí	0,308
19º	Itaqui	0,292
20º	Angra dos Reis	0,283
21º	Niterói	0,249

Image 16. Ranking of the Windstorms BR ports Risk
Source: Impacts and Climate change Risks in brazilian public coastal ports, Antaq Report, Nov/21

3. RIVER BOATS APPLICABLE TO THE MERCOSUR WATERWAY COMPLEX

In this study it was evaluated the best alternative for the transportation of bulk cargo between the river terminals. It will also be taken into consideration the type of vessel that is being considered in the studies of the National Department of Transport Infrastructure – DNIT. The technical characteristics of both types of convoys will be demonstrated.

In was not considered in this project the construction of type convoys, but rather considering *Tietê-Paraná* type convoys and / or *Patos* lagoon type convoys, which are operated today with self-propelled barges.

3.1. Features and models of inland waterway transport vessels

This chapter will present the main characteristics of the project vessels adopted for this phase. The two conceptual models well established in Brazil will be presented. The *Tietê-Paraná* model and the *Patos* lagoon model.

- **Model I**: *Tietê-Paraná*
- **Model II**: *Patos* lagoon

Model I are waterway vessels composed of barges and pusher craft, called convoys, like the Mississippi river models.

Model II are also waterway vessels, but composed of a single asset, called self-propelled barges, like the Netherlands models.

The following topic will detail the relevant models as an option for the study.

3.1.1. Model I - Tietê-Paraná (alternative 1)

We considered for the project the use of river convoys of the standard type of the *Tietê-Paraná* waterway hub and barges of the Mississippi type in this Alternative 1, given the vast and current availability of this type of asset in the Brazilian river navigation market.

Each convoy will be composed of one pusher tugboat with approximately 800hp to 1’200hp of installed power, to be chosen according to the studies of power versus maneuverability but being considered azimuthal due to the excellent performance in maneuverability, and four Mississippi-type barges, each carrying approximately 1’000 tons at an operational draft of 2m, as shown in the figure below.

Each Mississippi-type barge is 60m length overall (LOA) and 10.67m beam (B).

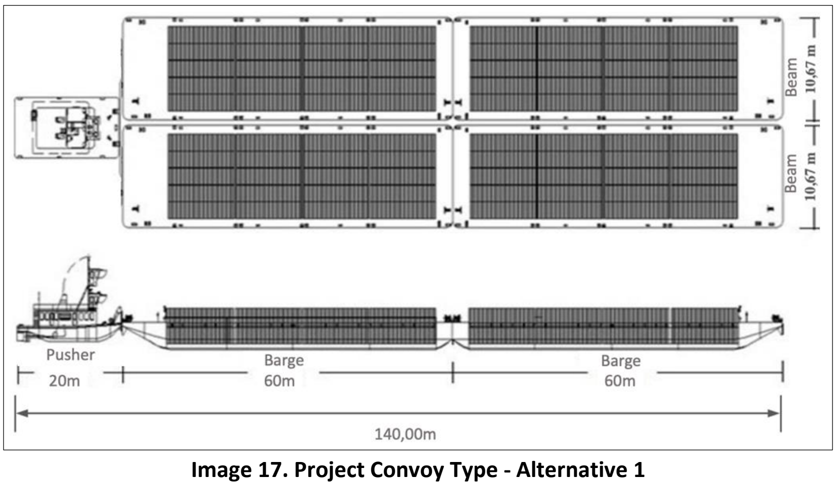


Image 17. Project Convoy Type - Alternative 1
Source: Authors

We know that this type of barge, the Mississippi type, has a nominal capacity of 2 tons of cargo per barge, considering its maximum draught.

However, for the project, we are considering that the river works in a regime of "full" and "dry", seasonality of the year, thus we consider as premise for the project an effective draught that transports 6 tons per convoy, already considering the UKC - under keel clearance.

In case of constant dredging, the vessels type will be able to carry the cargo at their maximum allowed load. Figure below example of convoy type 2x2, 2 barges in LOA and 2 barges of B.

Image 18. Project Convoy Type
Source: Authors

Therefore, the technical characteristics of the barge, pusher and convoy formation are detailed in the table below:

Table 1: Technical Characteristics of the Convoy - 1
Source: Authors

Convoy	
Capacity (ton)	1.600 x 4 = 6.400
Fleeting system	Yes
Loa (m)	120
Beam (m)	10,67 x 2 = 21,4
Operational Draft (m)	3,2
Operational speed (knots)	5
Convoy type 2x2 Mississippi (4 Rake)	
Pusher	
Power (HP)	800
Loa (m)	20
Beam (m)	8
Draft (m)	1,8

We estimate that the Convoy will sail at an average speed of 6 knots.

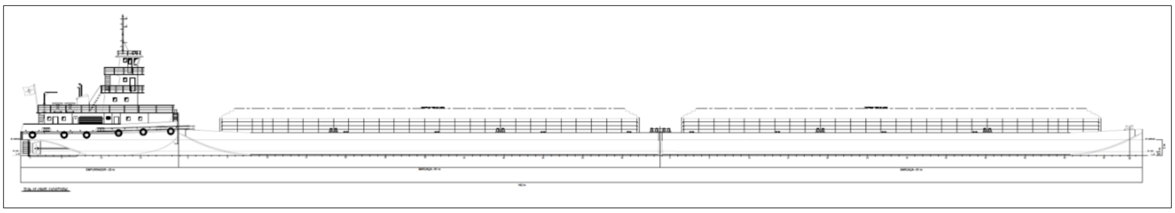


Image 19. Convoy Type - Side View

Source: Authors

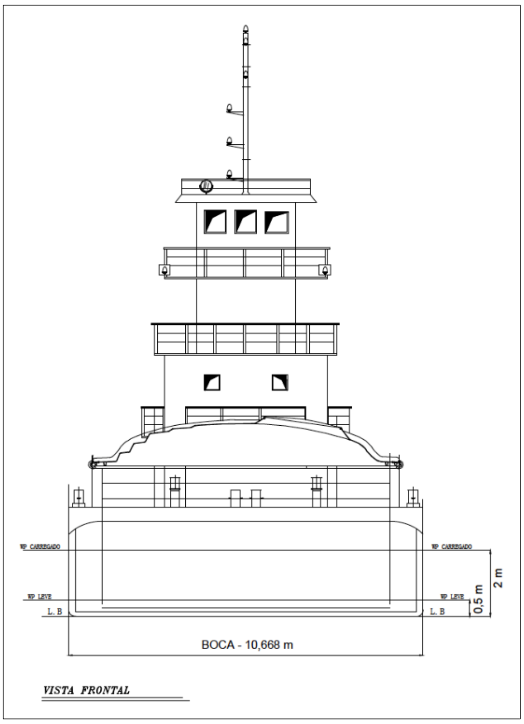


Image 20. Convoy Type – Front View
Source: Authors

At this moment, there is availability of assets of the *Tietê-Paraná* waterway among the various operators in the region, given the adverse environmental conditions that prevent the full operation of this waterway.

The barge models available on the referred waterway are barges normally available with aluminum lids, "retractable lid" model, however, in the Northern region of Brazil it is common this type of barge with fiberglass lids, like those operated on the Mississippi River in the United States.

We recommend that, in the subsequent phases of these studies, after the analysis of environmental conditions and canal depth (bathymetry), non-binding agreements be signed with the various operators to determine, with greater precision, the most suitable assets with market availability to start according to the project schedule.

3.1.2. Model II – Patos Lagoon (alternative 2)

We considered for the project the use of standard type river convoys in *Patos* lagoon, considered as alternative 2, this type of asset does not have a great availability in Brazil and it is used a lot in *Patos* lagoon, due to the strong winds in the region and incidence of waves over 1.5m high due to the winds.

Despite not being an asset with great availability in the Brazilian market, we know that it is easily found in European rivers, thus can facilitate even a shipowner to bring used equipment from Europe.

In this case the convoy is only a single asset, called a self-propelled barge, where this type of barge is reflected and resembles a mini ship, its physical structure is remarkably similar to a ship but with much smaller proportions.

Normally this type of self-propelled barge has an installed capacity of approximately 2 MCP's - Main Combustion Engine, 400hp of installed power, totaling 800hp, but with conventional propulsion.

Each self-propelled barge is 100m LOA, 15.5m Beam and 2.5m draft, as shown in the figure below.

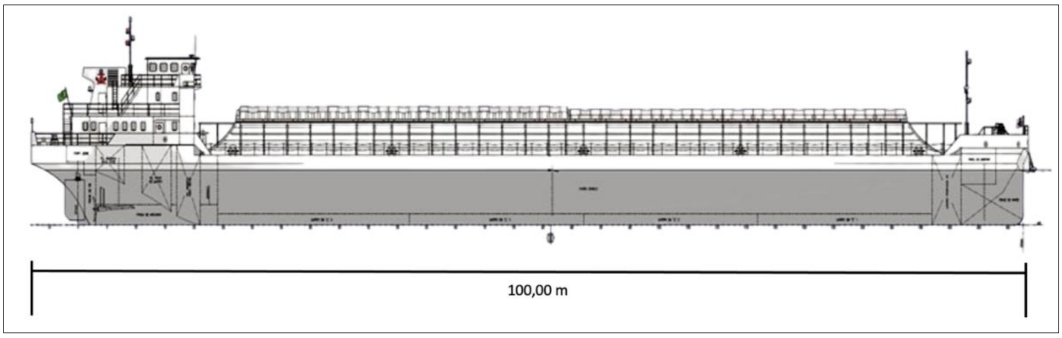


Image 21. Project Convoy Type - Alternative 2
Source: Authors

We estimate that the Convoy will sail at an average speed of 6 knots.

Table 2: Technical Characteristics of the Convoy - 2
Source: Authors

River line Vessel	
Capacity (ton)	2.800
Fleeting system	No
Loa (m)	90
Beam (m)	15,50
Draft (m)	2,5
Operational speed (knots)	8
Self-propelled	
Power (HP)	800
Loa (m)	-
Beam (m)	-
Draft (m)	-

At this moment, there is no availability of self-propelled barge type assets in Brazil between the two operators in the *Patos* lagoon region. The Brazilian shipyards are very disputed, with no forecast in the short or medium term.

Image 22. Self Propelled Vessel
Source: Authors

This type of asset, if built in Brazilian shipyards, would probably only be available for operation in the second half of 2025.

Image 23. Project Convoy Type - Front View
Source: Authors

The self-propelled barge models available in the duck lagoon, are barges normally available with aluminum lids, "retractable lid" model, as shown in the figure below.

Image 24. Self Propelled Vessel
Source: Authors

We recommend that, in the subsequent phases of these studies, after analyzing the environmental conditions and the depth of the canal (bathymetry), non-binding agreements be signed with the various operators to determine, with greater precision, the most suitable assets with market availability to start according to the project schedule.

3.2. Established routes

The project comprises the waterway navigation between two countries: Uruguay and Brazil. This waterway, called Mercosur waterway, is in the south of Brazil in the State of *Rio Grande do Sul*.

The Mercosur Waterway is composed of several rivers. The waterway has 1’860 km of navigable waterways, but in the project, we are considering navigating through the *Mirim* lagoon passing through the *São Gonçalo* canal arriving at the *Patos* lagoon, as shown according to figure 01.

After traveling 25km in Uruguayan rivers/territory, the convoy passes through the border between the countries and sails for another 200km in Brazilian waters, totaling a navigation of 220km, the vessels will unload at the terminals in Brazilian ports in the state of *Rio Grande do Sul*, as shown in the Figure below.

Image 25. Navigation Detail
Source: Authors

The Brazilian terminals have the capacity to receive and unload barges, with a large storage capacity and of course the capacity to dock OGV's – Ocean-Going Vessels, for the exportation of products.

3.2.1. São Gonçalo canal lock

Between the point of origin, in Uruguay, of the cargo to the destination point in Brazil where the 220km are contemplated, the convoys should face several adversities such as river variation, wind, rain, and even wave. However, when in Brazilian waters, the convoys must pass through a lock, called *São Gonçalo* canal Lock, as shown in the figure 13.

The lock is on the left bank of the *São Gonçalo* and is 120m long, 17m wide, and 5m depth, as shown in the figure 13. With the dimensional restrictions of the lock, it will be necessary to dismember the model Convoy type 1, model *Tietê-Paraná* Alternative 1. The dismemberment will be necessary due to the beam of the Convoy being larger than the width of the lock.

For the dismemberment to occur, it will be necessary to have two mooring buoys, one upstream and one downstream of the lock, to support the operations. An extra pusher will also be needed to support the maneuvers. The lock time extra to the total cycle time is estimated to be 4 hours, for convoys with 4 barges, and 1 hour for self-propelled vessels.

The dam was necessary to be built to prevent the intrusion of saline waters, which come from the sea, through *Patos* lagoon and are conducted through the *São Gonçalo* canal to the *Mirim* lagoon. The inhibition of the movement of saline waters, in this direction and sense, guarantees the quality of the water in the upstream condition of the dam for multiple uses, which require fresh water, whether for human consumption, animal feeding, or other agricultural purposes, such as irrigation.

3.2.2. Restrictions and bottlenecks – Sangradouro canal

Another point of attention is undoubtedly the *Sangradouro* canal, located in the Brazilian part of the waterway. The *Sangradouro* canal is in *Rio Grande do Sul* estate, located on our route before the *São Gonçalo* lock as shown in the figure below.

Image 26. Location of the Sangradouro Canal
Source: Authors

This canal has many navigation restrictions in terms of its depth. The canal must be constantly dredged. The initial investment for first dredge and conditions for public maintenance or a private concession model is under study.

3.2.3. Macro flowchart

Our team designed / developed the simplified flow chart of the shipping logistics cycle of our project. The flow chart comprises from the farms to the shipping terminals of the OGVs, as shown in the Figure below.

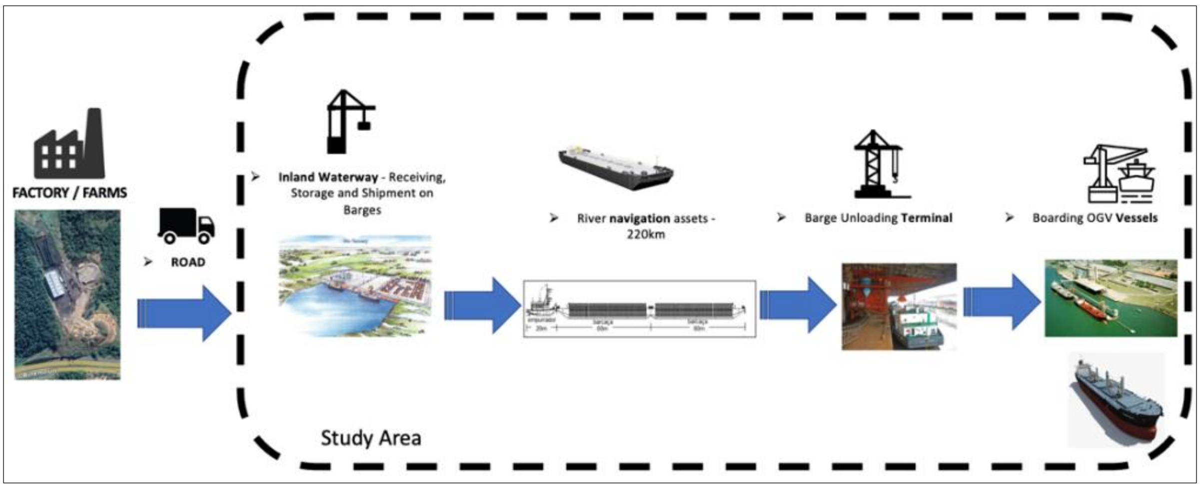


Image 27. Project Macroflowchart
Source: Authors

In the Figure below are the main points comprised in our project:

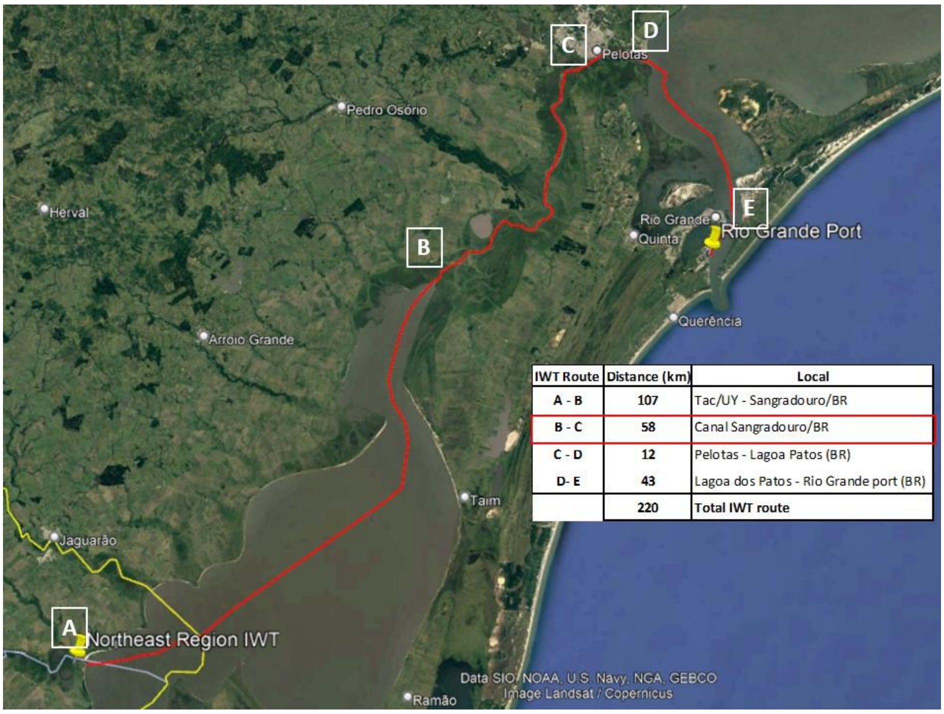


Image 28. Mapped Points

Source: Authors

The main points mapped in this work are:

- Point A: Shipment area of the cargoes into Uruguayan territory
- Point B: *Sangradouro* canal
- Point C: *São Gonçalo* lock
- Point D: Entrance into *Patos* lagoon
- Point E: *Rio Grande* port to discharge cargo in Brazilian territory

This convoy will sail for approximately 220km through the Mercosur waterway, passing through the *Mirim* lagoon waterway and the *São Gonçalo* canal, and will dock at *Rio Grande* port.

3.2.4. Operational Ratios

Thus, for scenario 1 as we can see at table 3 bellow, the transit of a total cycle time expected for the project is around 54 hours, considering 4.3 hours for loading of the barges, plus 19 hours of navigation of the 220km, plus 1 hour of lock, and finally 10 hours of unloading at the destination terminal, as shown in the table below.

For the convoys formed with pusher + barge, scenarios 4 to 11, there is possibility to implement a fleeting to improve the cycle times due extended periods of load and unload. This option brings an important efficiency on the navigation system as we can see on the table below.

As an assumption we are also using an additional down time, around 70% of running hours, due to rain, wind, waves, and other conditions that may impact on regular operation at this specific region.

Thus, each cycle for scenario 10 with 1 pusher + 1 barge (80m length, 15m bean and 2.5 draft) as we can see also in table 3, will have a total of 73 hours. Each Convoy will have the capacity to give a total of 7 trips per month. Totaling of 20.8ktons per convoy per month.

Table 3: Operational Ratio

Source: Authors

Scenario	Tipe Vessel	Ton / Voyage (Soy & Grains) [ton]	Avarage Speed [knots]	Voyage Time [h]	Eclusage Time [h]	Unloading Time (260 ton/h) [h]	Loading Time (600 ton/h) [h]	Cicle Time [h]	Cicle/Month [#]	Ton / Month [tons]	Ton / Year (6 months) [tons]
	Self Propeled L (length) x B (bean) x D (draft)								75% affective due downtime		
1	Vessel IWT - 110 x 15 x 2,5	2.600	7,2	19	1	10,0	4,3	54	9,9	25.856,35	155.138
2	Vessel IWT - 110 x 15 x 2,8	3.000	7,0	19	1	11,5	5,0	57	9,6	28.672,57	172.035
3	Vessel IWT - 110 x 16 x 2,2	2.400	7,3	19	1	9,2	4,0	53	10,2	24.360,90	146.165
	Convoy (Pusher+Barge) Barge (L x B x D) : Pusher					w/o Fleeting	w/o Fleeting		70% affective due downtime		
4	2 (60 x 12 x 3,34) : 1	3.880	5,0	30	2	14,9	6,5	85	5,9	22.898,36	137.390
5	4 (60 x 12 x 2,5) : 1	5.600	4,6	30	4	21,5	9,3	99	5,1	28.566,80	171.401
6	4 (60 x 12 x 3,34) : 1	7.760	4,6	30	4	29,8	12,9	111	4,6	35.330,08	211.980
7	2 (60 x 10,6 x 3,5) : 1	3.600	5,0	30	2	13,8	6,0	84	6,0	21.651,55	129.909
8	4 (60 x 10,6 x 2,5) : 1	5.400	4,6	30	4	20,8	9,0	98	5,2	27.828,22	166.969
9	4 (60 x 10,6 x 3,5) : 1	7.200	4,6	30	4	27,7	12,0	108	4,7	33.693,59	202.162
10	1 (80 x 15 x 2,5) : 1	3.000	5,0	27	1	11,5	5,0	73	7,0	20.855,17	125.131
11	1 (80 x 15 x 3,5) : 1	4.000	5,0	27	1	15,4	6,7	78	6,5	25.813,06	154.878

The convoys configured using pusher + barge there is also the possibility to add another barge in for fleeting operations that optimizes the cycle time, as que can see now for scenario 18 with 1 pusher + 1 barge as we can see also in table 4, will have a total of 60 hours. Each Convoy will have the capacity to give a total of 8.4 trips per month, totaling of 25.2ktons per convoy per month depending on the weather conditions (wind forces, waves, rain probability during cargo loading and unloading processes).

Table 4: Operational Ratio with fleeting

Source: Authors

Scenario	Tipe Vessel	Ton / Voyage (Soy & Grains) [ton]	Avarage Speed [knots]	Voyage Time [h]	Eclusage Time [h]	Unloading Time (260 ton/h) [h]	Loading Time (600 ton/h) [h]	Cicle Time [h]	Cicle/Month [#]	Ton / Month [tons]	Ton / Year (6 months) [tons]
						w/ Fleeting	w/ Fleeting		70% affective due downtime		
12	2 (60 x 12 x 3,34) : 1	3.300	4,6	30	2	2,0	2,0	68	7,4	24.459	146.753
13	4 (60 x 12 x 2,5) : 1	4.950	4,6	30	3	2,0	2,0	70	7,2	35.640	213.840
14	4 (60 x 12 x 3,34) : 1	6.600	4,6	30	4	2,0	2,0	72	7,0	46.200	277.200
15	2 (60 x 10,6 x 3,5) : 1	3.600	4,6	30	2	2,0	2,0	68	7,4	26.682	160.094
16	4 (60 x 10,6 x 2,5) : 1	5.400	4,6	30	4	2,0	2,0	72	7,0	37.800	226.800
17	4 (60 x 10,6 x 3,5) : 1	7.200	4,6	30	4	2,0	2,0	72	7,0	50.400	302.400
18	1 (80 x 15 x 2,5) : 1	3.000	5,0	27	1	2,0	2,0	60	8,4	25.200	151.200
19	1 (80 x 15 x 3,5) : 1	4.000	5,0	27	1	2,0	2,0	60	8,4	33.600	201.600

3.3. Data on navigation and performance on the Mercosur waterway

In this study our team evaluated the navigation data with a focus on port handling and the several types of cargo on the Mercosur waterway hub.

It is important to emphasize that Mercosur waterway is today a navigable waterway with a strong presence mainly in the state of *Rio Grande do Sul*. Although its name is Mercosur waterway, we will see that in fact a large part of the navigation and port movement takes place within Brazilian territory.

3.3.1. Port Handling

All port movement systems in Brazil are very well monitored and mapped by the Federal Government, specifically by its agencies. In the case of port movements, our main source of information is the Brazilian National Waterway Transportation Agency – Antaq, through its waterway statistics data, as shown in the figure below.

Image 29. Waterway Statistician - Mercosur Waterway

Source: Antaq (2022)

According to Antaq (2022), the participation of port movements is divided almost 50-50 between public and private ports, totaling in 2020 around 56 million tons and in 2019 about 58 million tons handled in the ports that comprise the Mercosur waterway hub, considering only the Brazilian ports in the estate of *Rio Grande do Sul*, as shown in the figure below.

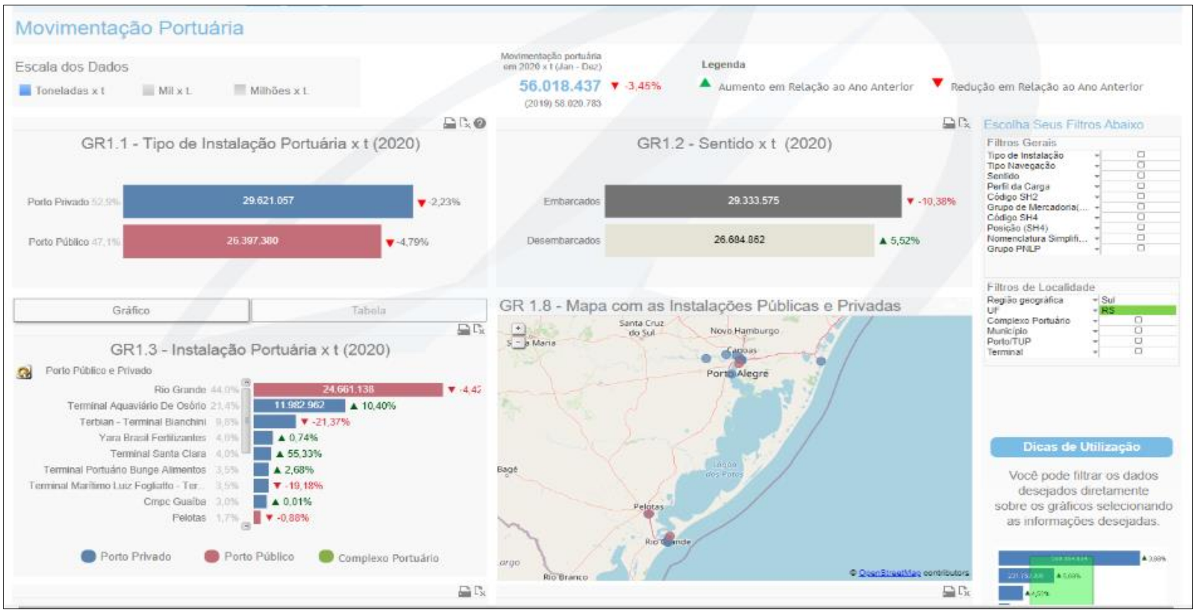


Image 30. Port Handling

Source: Antaq (2022)

Other points that stand out is the direction of the cargo, between exports and imports, thus we also have a similar number of 50% to 50% in the balance, considering a volume of 39 million tons of exports and 26 million tons of imported cargo.

Another significant data for our project is the division of this volume referring to the profile of the cargo in tons, being its division as follows for the year 2020, a percentage of 42.5% for Solid Bulk, Liquid Bulk 27.9%, General Cargo of 15.2% and Container with 14.2%, as shown in the figure below:

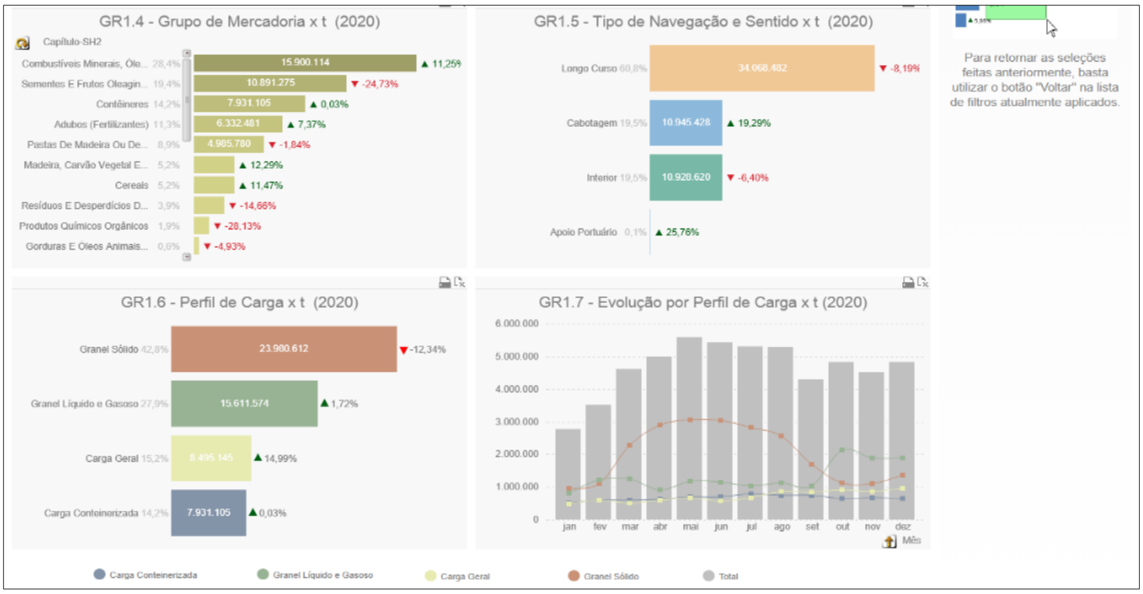


Image 31. Merchandise Category

Source: Antaq (2022)

It is important to emphasize that of all these volumes of cargo handled in the ports of Rio Grande do Sul, only 60.8% were long-haul cargo, which is cargo that was imported and exported through the ports by OGV vessels.

Cabotage, which is the transfer of cargo between ports in the same country, was equivalent to 19.5% of the total volume of cargo and inland navigation, navigation of cargo through rivers, was 19.5%, a significant figure.

4. COSTS CALCULATION METHOD AND RESULTS

The logistic cost is an important drive for commodities market and may direct production flows thought different routes inducing investments in a significant amount. The South Corridor itself has different modal and intermodal options to transport the production of its hinterland area, stretching the competition between the solutions available.

Looking only for the interest influence area of *Mirim* lagoon and Mercosur waterway, it is possible to identify two potential options to export the agriculture and mineral production and import fertilizers. The next chapters will bring this costs perspective considered on the evaluation of profitability, or not, for Mercosur waterway.

To simulate the asset investment, operational costs and forecasted revenues, and assumptions made, as following:

Assumption 1: the seasonal flow for soy and other seeds can be complemented with a wood cargo constant flow during all year long. To the calculations will be conserved a 50/50 dedication of convoys vessel IWT during a year at maturity. If this hypothesis about cargo distribution along of year will not a tendence, so will be necessary of new analysis.

Assumption 2: the unitary costs, operational data and ratios are based on similar operations performed in the region.

- Fuel Consumption: based on calculation model applied on the course.
- Crew: based on the navy rules and workforce category union.

Assumption 3: the costs related to navigation assets investments considered a calculation of bareboat solution, returning the capital invested and with costs for docking.

Table 5. Costs and freight components per month

Source: authors

Tipe Vessel:		IWT Vessel Self Propeled (2,5 draft)		Convoy (Pusher+Barge) 2,5 draft 1 barge w/ Fleeting		Convoy (Pusher+Barge) 2,5 draft 4 barges w/ Fleeting	
	UM	Soy	Wood	Soy	Wood	Soy	Wood
Volume	('000 tons)	25.856	18.552	25.200	15.750	37.800	25.200
Values per [Month]							
Variable Costs	('000 R$)	327	327	238	238	259	259
Fixed Costs	('000 R$)	570	570	556	561	611	577
SG&A - Other Expenses	('000 R$)	92	92	85	85	85	85
Asset Related Costs	('000 R$)	599	599	491	491	1.167	1.167
TAX + Margin	('000 R$)	887	998	785	886	1.216	1.347
TOTAL Gross Income	('000 R$)	2.431	2.542	2.152	2.258	3.334	3.431
Costs and Tariff per Convoy	R$/ton	94,03	137,03	85,41	143,36	88,20	141,18
Costs and Tariff per Convoy	U$/ton	17,74	25,86	16,11	27,05	16,64	26,64

The final tariff resultant over the cost perspective and commercial margin, is US$ 17.74 per tonnage for soy transport, and US$ 25.86 for wood transport, considering the IWT Self Propelled Vessel with draft of 2.5m operating 12 months per year with good weather conditions during the operations, as well as no queue to access the terminal and low rain probability during cargo loading and unloading processes.

4.1. Correlation between navigation R$/ton with draft of waterway

As an output of this work is possible to produce a comparison between different solutions for navigation on *Lagoa Mirim* waterway, even considering that there is some bottlenecks and restrictions applicable over some models, which can exclude this option until bigger investments are implemented.

For this study was considered the same Cost analysis for the IWT vessels now applied over different possible drafts, after dredge, and beam of convoy, after interventions.

The model of IWT self-propelled vessel has higher costs per ton, resulting on a higher freight price, comparing with convoy solutions of 1 or 4 barges.

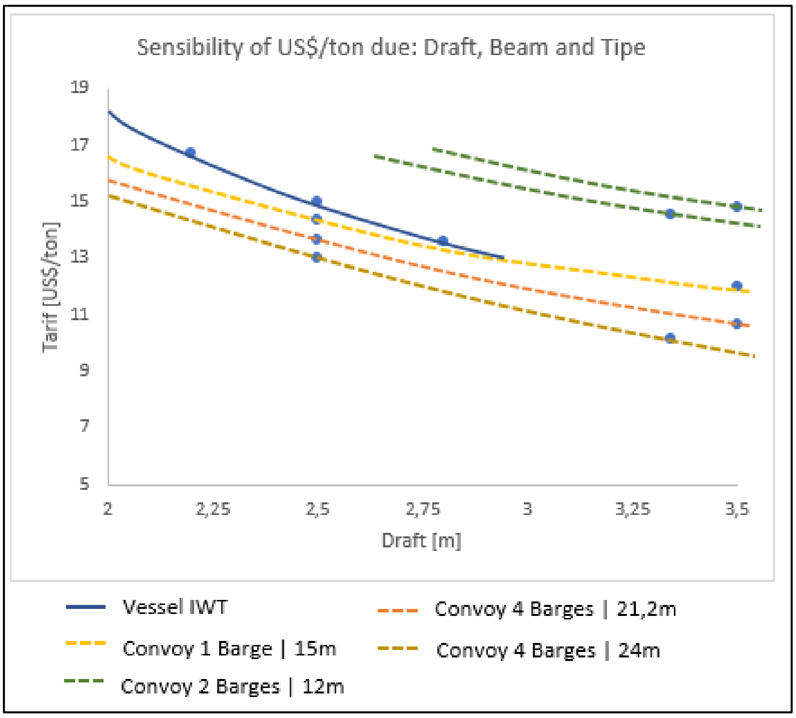


Image 32. Freight sensibility analysis
Source: authors

Table 6. Freight sensibility analysis
Source: authors

Scenario	Tipe Vessel	Draft [meters]	Beam convoy [meters]	Tariff [US$/ton]
	Self Propeled L (length) x B (bean) x D (draft)			
1	Vessel IWT - 110 x 15 x 2,5	2,5	15	14,32
2	Vessel IWT - 110 x 15 x 2,8	2,8	15	13,59
3	Vessel IWT - 110 x 16 x 2,2	2,2	16	16,67
	Convoy (Pusher+Barge) Barge (L x B x D) : Pusher			
4	2 (60 x 12 x 3,34) : 1	3,34	12	14,53
5	4 (60 x 12 x 2,5) : 1	2,5	12	13,65
6	4 (60 x 12 x 3,34) : 1	3,34	24	10,11
7	2 (60 x 10,6 x 3,5) : 1	3,5	10,6	14,76
8	4 (60 x 10,6 x 2,5) : 1	2,5	10,6	13,02
9	4 (60 x 10,6 x 3,5) : 1	3,5	21,2	10,63
10	1 (80 x 15 x 2,5) : 1	2,5	15	14,97
11	1 (80 x 15 x 3,5) : 1	3,5	15	11,95

Even these cost reductions been representative for an analyze of investment return to extinguish these bottlenecks for the trade-off analysis only the vessels of convoys already possible to navigate were taken into consideration. Some variables can change these references due to restriction in the navigation of convoy (wind forces and waves) during the period operated, as well as the rain probability during cargo loading and unloading processes. Besides convoy needs of a new infrastructure condition to attend navigation bends (canal size, width, length, depth and section conditions).

4.2. Export logistics costs trade-off

Looking for a trade-off approach comparing the two possible corridors to export the cargo, main soy, seeds in general and wood, presented and discussed on the chapters before, a study was elaborated seeking all the costs components for each logistic arrangement.

For the alternative of cargo flows through Uruguay can be exported by Montevideo ports the estimated costs are presented on table 7, with specific assumptions:

Table 7. Costs for entire logistic through Montevideo-UY
Source: authors

a **Uruguay transport**		**Export Cargo**	
		Soybean	
Road transport pathway 420 km FTL 3R - MVD	US$/t	*$*	*48,50*
Port Operation MVD (Export/Import)	US$/t	$	10,00
Ship Port Cost in the Terminal Operation (value per ship loaded)	US$/t	$	1,81
Ocean freight rates simulation to Shanghai/China	US$/t	$	64,00
Maritime Agency Costs Montevideu Port (PDA)	US$/t	$	2,08
Total Logistic Costs	US$/t	**$**	**126,39**
Vessel (t grain exportation) depht port 13 m shiploader 1.200 t/h:	45.000		

In other hand, using the IWT of *Lagoa Mirim,* and all the information provided by this study, the total costs using Self-propelled Vessel, presented on table 8, are around 10% lower than from table 7.

Table 8. Costs using IWT and port of *Rio Grande*
Source: authors

		Self-propelled Vessel (Minibulker 2,5 draft 2.600 cargo			
b **South System BR-UY Project Integration (Self-propelled vessel)**		Soybean Exportation (with IWT toll)		Soybean Exportation (no IWT toll)	
New Terminal (IWT) Northeast UY region	US$/t	*$*	*10,00*	*$*	*10,00*
Short leg FTL (internal road pathway to terminal UY)	US$/t	*$*	*8,00*	*$*	*8,00*
IWT Freight rates 3R - RIG	US$/t	$	17,74	$	19,28
Port Operation RIG (Fobbings Export Cost)	US$/t	$	8,00	$	8,00
Ship Port Cost in the Terminal Operation (value per ship loaded)	US$/t	$	1,02	$	1,02
Ocean freight rates simulation to Shanghai/China	US$/t	$	66,50	$	66,50
Maritime Agency Costs Rio Grande Port (PDA)	US$/t	$	0,94	$	0,94
Total Logistic Costs	US$/t	**$**	**112,20**	**$**	**113,74**
Vessel (t grain exportation) depht port 15 m shiploader 3.000 t/h:	65.000				
Savings estimate with IWT South System BR-UY Project (b / a)			**-11,2%**		**-10,0%**

Another alternative, also using the IWT of *Lagoa Mirim,* now using the alternative of Convoys Barges and Pushers the total costs, are form 11% till 14% lower than from option using Montevideo ports, as presented on table 9.

Table 9. Costs comparison with convoys alternatives

Source: authors

c **South System BR-UY Project Integration (Convoy operations)**		Short Convoy 2 B Fleeting (Pusher + 1 barge 2,50m draft 3.000 ton)		Convoy Pusher + 4 barges 2,50 m draft 5,400 tonnes c/ fleeting	
		Soybean Exportation (with IWT toll)	Soybean Exportation (no IWT toll)	Soybean Exportation (with IWT toll)	Soybean Exportation (no IWT toll)
New Terminal (IWT) Northeast UY region	US$/t	$ 10,00	$ 10,00	$ 10,00	$ 10,00
Short leg FTL (internal road pathway to terminal UY)	US$/t	$ 8,00	$ 8,00	$ 8,00	$ 8,00
IWT Freight rates 3R - RIG (without toll expenses)	US$/t	$ 16,11	$ 17,65	$ 12,48	$ 14,02
Port Operation RIG (Fobbings Export Cost)	US$/t	$ 8,00	$ 8,00	$ 8,00	$ 8,00
Ship Port Cost in the Terminal Operation (value per ship loaded)	US$/t	$ 1,02	$ 1,02	$ 1,02	$ 1,02
Ocean freight rates simulation to Shanghai/China	US$/t	$ 66,50	$ 66,50	$ 66,50	$ 66,50
Maritime Agency Costs Rio Grande Port (PDA)	US$/t	$ 0,94	$ 0,94	$ 0,94	$ 0,94
Total Logistic Costs	US$/t	**$ 110,57**	**$ 112,11**	**$ 106,94**	**$ 108,48**
Vessel (t grain exportation) depht port 15 m shiploader 3.000 t/h:	65.000			* Toll review (+ inrastructure)	
Savings estimate with IWT South System BR-UY Project (c / a)		**-12,5%**	**-11,3%**	**-15,4%**	**-14,2%**
Currence Exchange $	*5,30*				

5. CONCLUSION

The development of a IWT between Brazil and Uruguay have upmost importance for both countries. For Uruguay, it would help to develop the northeast region of the country, where a green filed could be potentially explored for agriculture and wood production. For Brazil it would ramp up the already existing infrastructures for cargo transportation at *Rio Grande do Sul* and develop a low utilization of the navigable potential of the *Patos* and *Mirim* lagoons, as well as the local rivers and their tributaries.

This study analyzed the financial and technical aspects of the development of the mentioned corridor, concluding that besides the natural barriers to be solved, as in *Sangradouro* canal, as well as regulatory issues, the current infrastructure available and the assets would allow the IWT to be feasible and profitable, reducing the transportation costs of the commodities, which due to the low added value of the product is very sensible to transport costs.

After analyzing the economic and technical feasibility, introduced on this study, is necessary to advance with additional studies to complement the decision-making of all stakeholders involved. To direct the next complementary studies the subjects must be discussed as following:

- evaluate the uses of renewable energy sources into navigation assets applicable at this region, as electric engines fed by wind farms.
- establish a follow up forum focused on others work front promoted by each state and private initiatives.
- promote an analysis of legal models for the exploration of waterway in Mirim Lagoon.
- Analysis and careful advanced studies of the operational logistic model.
- Analysis and careful advanced studies of the Capex of River Assets and availability (shipyards and market).
- Analysis of maneuverability, navigability and mooring of convoys.

This IWT would be the first Mercosur trade waterway corridor, and the extension of the route covering the 190km of *Mirim* lagoon, up to *Santa Vitória do Palmar* would expand the Mercosur trade flow and potential creation of new terminals as hub ports.

6. BIBLIOGRAPHY

Antaq (2022) – https://www.gov.br/Antaq/pt-br – accessed in September 2022.
DH (2022) – http://www.dh.sp.gov.br/travessias – accessed in October 2022.
DNIT (2022) – https://www.gov.br/dnit/pt-br – accessed in October 2022.
Free3d.com – https://www.Free3d.com (2022) – accessed in October 2022.
Clarkson's – https://www.clarksons.com/services/research – accessed in October 2022.
Portos RS – https://www.portosrs.com.br – accessed in October 2022.
United States Department of Agriculture: Brazil Soybean Transportation Second Quarter 2022 – https://www.ams.usda.gov/sites/default/files/media/Brazil_Quarter2_2022.pdf – accessed in October 2022.
2020 Morpho dynamic Hydro Numeric Study of Lagoa Mirim RS Brazil Analysis, FURG page 77, Rio Grande, April 2020 by Antonio Raylton Rodrigues Bendô.
Brazil – Law no. 9432, from January 9, 1997 (Waterway Transportation Law).
https://www.planalto.gov.br/ccivil_03/leis/l9432.htm
Brazil – Law no. 9537, from December 11, 1997 (Waterway Traffic Safety Law).
https://www.planalto.gov.br/ccivil_03/leis/l9537.htm
Brazil – Law no. 13334, from September 13, 2016.
http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2016/lei/l13334.htm
Brazil – Decree no. 10865, from November 19, 2021.
http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/decreto/D10865.htm
Brazil – Brazilian Federal Constitution from 1988, article 21, XII, d.
https://www2.senado.leg.br/bdsf/bitstream/handle/id/243334/Constitution_2013.pdf?sequence=11
Brazil – Antaq Resolution no. 80, from July 4, 2022.
https://juris.antaq.gov.br/index.php/2022/07/07/80-2022/
Brazil – Antaq Resolution no. 81, from July 4, 2022.
https://juris.antaq.gov.br/index.php/2022/07/07/81-2022/
Brazil – Antaq Resolution no. 82, from July 4, 2022.
https://juris.antaq.gov.br/index.php/2022/07/07/82-2022/
Brazil – Decree no. 2256, from June 17, 1997.
http://www.planalto.gov.br/ccivil_03/decreto/1997/d2256.htm

7. APPENDIX I – RATIO ANALISYS REPORT

Scenario	Tipe Vessel	Ton / Voyage (Soy & Grains) [ton]	Avarage Speed [knots]	Voyage Time [h]	Eclusage Time [h]	Unloading Time (260 ton/h) [h]	Loading Time (600 ton/h) [h]	Cicle Time [h]	Cicle/Month [#]	Ton / Month [tons]	Ton / Year (6 months) [tons]	
	Self Propeled L (length) x B (bean) x D (draft)								75% affective due downtime			
1	Vessel IWT - 110 x 15 x 2,5	2.600	7,2	19	1	10,0	4,3	54	9,9	25.856,35	155.138	
2	Vessel IWT - 110 x 15 x 2,8	3.000	7,0	19	1	11,5	5,0	57	9,6	28.672,57	172.035	
3	Vessel IWT - 110 x 16 x 2,2	2.400	7,3	19	1	9,2	4,0	53	10,2	24.360,90	146.165	
	Convoy (Pusher+Barge) Barge (L x B x D) : Pusher					w/o Fleeting	w/o Fleeting		70% affective due downtime			
4	2 (60 x 12 x 3,34) : 1	3.880	5,0	30	2	14,9	6,5	85	5,9	22.898,36	137.390	
5	4 (60 x 12 x 2,5) : 1	5.600	4,6	30	4	21,5	9,3	99	5,1	28.566,80	171.401	
6	4 (60 x 12 x 3,34) : 1	7.760	4,6	30	4	29,8	12,9	111	4,6	35.330,08	211.980	
7	2 (60 x 10,6 x 3,5) : 1	3.600	5,0	30	2	13,8	6,0	84	6,0	21.651,55	129.909	
8	4 (60 x 10,6 x 2,5) : 1	5.400	4,6	30	4	20,8	9,0	98	5,2	27.828,22	166.969	
9	4 (60 x 10,6 x 3,5) : 1	7.200	4,6	30	4	27,7	12,0	108	4,7	33.693,59	202.162	
10	1 (80 x 15 x 2,5) : 1	3.000	5,0	27	1	11,5	5,0	73	7,0	20.855,17	125.131	
11	1 (80 x 15 x 3,5) : 1	4.000	5,0	27	1	15,4	6,7	78	6,5	25.813,06	154.878	
										1,36		
						w/ Fleeting	w/ Fleeting		70% affective due downtime			Increment Due Fleeting (+%)
12	2 (60 x 12 x 3,34) : 1	3.300	4,6	30	2	2,0	2,0	68	7,4	24.459	146.753	7%
13	4 (60 x 12 x 2,5) : 1	4.950	4,6	30	3	2,0	2,0	70	7,2	35.640	213.840	25%
14	4 (60 x 12 x 3,34) : 1	6.600	4,6	30	4	2,0	2,0	72	7,0	46.200	277.200	31%
15	2 (60 x 10,6 x 3,5) : 1	3.600	4,6	30	2	2,0	2,0	68	7,4	26.682	160.094	23%
16	4 (60 x 10,6 x 2,5) : 1	5.400	4,6	30	4	2,0	2,0	72	7,0	37.800	226.800	36%
17	4 (60 x 10,6 x 3,5) : 1	7.200	4,6	30	4	2,0	2,0	72	7,0	50.400	302.400	50%
18	1 (80 x 15 x 2,5) : 1	3.000	5,0	27	1	2,0	2,0	60	8,4	25.200	151.200	21%
19	1 (80 x 15 x 3,5) : 1	4.000	5,0	27	1	2,0	2,0	60	8,4	33.600	201.600	30%

Scenario	Tipe Vessel	Ton / Voyage (Wood) [ton]	Avarage Speed [knots]	Voyage Time [h]	Eclusage Time [h]	Unloading Time (260 ton/h) [h]	Loading Time (600 ton/h) [h]	Cicle Time [h]	Cicle/Month [#]	Ton / Month [tons]	Ton / Year (6 months) [tons]
	Self Propeled L (length) x B (bean) x D (draft)								75% affective due downtime		
20	Barge 110 x 15 x 2,5	1.625	7,2	19	1	4,6	2,7	47	11,4	18.552	111.311
21	Barge 110 x 15 x 2,8	1.875	7,2	19	1	5,4	3,1	49	11,1	20.876	125.258
22	Barge 110 x 16 x 2,2	1.500	7,2	19	1	4,3	2,5	47	11,5	17.308	103.846
	Convoy (Pusher+Barge) Barge (L x B x D) : Pusher					w/o Fleeting	/o Fleeting		70% affective due downtime		
23	2 (60 x 12 x 3,34) : 1	2.425	4,6	30	2	2,0	2,0	68	7,4	17.974	107.841
24	4 (60 x 12 x 2,5) : 1	3.500	4,6	30	3	2,0	2,0	70	7,2	25.200	151.200
25	4 (60 x 12 x 3,34) : 1	4.850	4,6	30	4	2,0	2,0	72	7,0	33.950	203.700
26	2 (60 x 10,6 x 3,5) : 1	2.250	4,6	30	2	2,0	2,0	68	7,4	16.676	100.059
27	4 (60 x 10,6 x 2,5) : 1	3.375	4,6	30	3	2,0	2,0	70	7,2	24.300	145.800
28	4 (60 x 10,6 x 3,5) : 1	4.500	4,6	30	4	2,0	2,0	72	7,0	31.500	189.000
29	1 (80 x 15 x 2,5) : 1	1.875	5,0	27	1	2,0	2,0	60	8,4	15.750	94.500
30	1 (80 x 15 x 3,5) : 1	2.500	5,0	27	1	2,0	2,0	60	8,4	21.000	126.000

8. APPENDIX II – COSTS ANALYSIS REPORT

	Tipe Vessel:	IWT Vessel Self Propeled (2,5 draft)		Convoy (Pusher+Barge) 2,5 draft 1 barge w/ Fleeting		Convoy (Pusher+Barge) 2,5 draft 4 barges w/ Fleeting	
	UM	Soy	Wood	Soy	Wood	Soy	Wood
Volume	('000 tons)	25.856	18.552	25.200	15.750	37.800	25.200
Values per [Month]							
Variable Costs	('000 R$)	327	327	238	238	259	259
	l/km	9	9	15	15	16	16
	l/h	118	118	136	136	136	136
	l/t.km	820	820	1.571	1.571	1.379	1.379
	KM	225	225	225	225	225	225
	Ciclos	10	10	5	5	5	5
Fuel Costs	R$/Month	284	284	235	235	255	255
	R$/ton	10,97	15,29	9,32	14,92	5,07	10,13
Port Charges	Cost in cicle	43	43	3	3	3	3
	R$/ton	1,67	2,32	0,13	0,20	0,06	0,13
Canal Dues	R$/ton	TBD	TBD	TBD	TBD	TBD	TBD
	R$/ton	0,00	0,00	0,00	0,00	0,00	0,00
Fixed Costs	('000 R$)	570	570	574	577	611	577
	HC/Crew	7	7	7	7	7	7
	R$/HC (w/ charges)	14	14	15	15	15	15
	Crew/Vessel[1]	1,65	1,65	1,65	1,65	1,65	1,65
Crew Expenses	kR$/Vessel	160	160	175	175	175	175
	R$/ton	6,19	8,62	6,94	11,11	3,47	6,94
O&M	3% Over asset	98	98	89	89	89	89
Class Assesment Anual	Lump sum	40	40	40	40	40	40
Insurance	1,0% over asset	33	33	27	30	63	30
Administration	10% over crew	16	16	18	18	18	18
Provisions	10% over crew	16	16	18	18	18	18
Managment And Support Te	lump sum	208	208	208	208	208	208
		410	410	**399**	**402**	**436**	**402**
	R$/ton	15,87	22,12	15,83	25,52	8,64	15,95
SG&A - Other Expenses	('000 R$)	92	92	85	85	85	85
SG&A	incomes	92	92	85	85	85	85
	R$/ton	3,54	4,94	3,37	5,40	1,69	3,37
Asset Related Costs	('000 R$)	599	599	491	491	1.167	1.167
Bareboat lease fee	R$	550	550	451	451	1.072	1.072
	R$/ton	21,27	29,65	17,91	28,65	21,27	42,53
Class Renew (2 and 5y)	new asset/year	49	49	40	40	95	95
	R$/ton	1,89	2,63	1,59	2,54	1,88	3,77
Total Costs		1.544	1.544	1.385	1.388	2.118	2.084
		50,42	70,28	45,77	73,42	37,02	72,70
TAX + Margin	('000 R$)	887	998	795	897	1.216	1.347
Income Taxes	9,25%	225	235	202	211	308	317
EBITDA Margins	30%	662	763	594	686	908	1.029
TOTAL Gross Income	('000 R$)	2.431	2.542	2.181	2.285	3.334	3.431
Costs and Tariff per Convoy	R$/ton	94,03	137,03	86,53	145,09	88,20	141,18
Costs and Tariff per Convoy	U$/ton	17,74	25,86	16,33	27,38	16,64	26,64