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Inland waterway transport (IWT): an extended gateway solution to support intermodal integration at the Port of Vitória

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Preface

The development of an extended gateway at the port of Vitória - Espírito Santo - Brazil by using a waterway as an alternative transport mode was proposed at the context of the Inland Water Transport and Multimodal Training Programme. Even though Vitória is an important solution to Brazil's Southeast Logistics Corridor, the port currently lacks connectivity and intermodal integration, which may impact the port's competitiveness in the future.

Yet, despite the existence of several projects in the port's current Master Plan, none of them proposes inland waterway transport as an alternative, which led us to the conclusion that such a theme is of relevance.

Summary

O porto organizado de Vitória/ES constitui-se em importante elo logístico do Corredor Sudeste, conforme definido pelo então Ministério dos Transportes, Portos e Aviação Civil, atual Ministério da Infraestrutura (MINFRA, 2017). Com uma movimentação de cargas da ordem de oito milhões de toneladas ao ano, o porto passou por um recente processo de desestatização dos seus serviços e transferência da sua gestão à iniciativa privada e, no contexto da citada privatização, estudos conduzidos pelo Banco Nacional de Desenvolvimento Econômico e Social (BNDES, 2021) indicam um crescimento de cerca de 1,8% ao ano na movimentação de mercadorias, atingindo a marca de 14 milhões de toneladas ao final do período de concessão.

Para que se possa alcançar tais marcas, diversos investimentos estão em curso, tais como a implantação de um novo terminal para a armazenagem de graneis líquidos combustíveis, na retroárea de Capuaba. Além disso, diversos investimentos estruturais serão conduzidos pela nova administração do porto, tais como dragagem, recuperação dos berços 206 e 905, reforma dos armazéns graneleiros de Capuaba, bem como a recuperação do acesso ferroviário e ramais internos do porto.

Inobstante, este trabalho se dedicou à análise dos gargalos e possíveis restrições ao desenvolvimento da movimentação de carga conteinerizada no porto. Isto porque existe apenas um terminal dedicado à movimentação de contêineres no Estado: o Terminal de Vila Velha S/A – TVV. Nesse contexto, foi identificado que o mencionado terminal opera em plena capacidade, com giro de, ao menos, 20 vezes ao ano. Foi verificada, ainda, a existência de diversos fatores limitantes à expansão da capacidade de armazenamento de contêineres, a citar: pouca disponibilidade de área para agregar ao TVV; crescimento da armazenagem e movimentação de granéis agrícolas e fertilizantes; acesso rodoviário único para o escoamento de cargas por caminhões.

Diante disso, foi proposto o desenvolvimento de uma hidrovia interna, conectando o TVV aos portos secos localizados em Cariacica/ES, por meio de barcaças, com a finalidade de transportar contêineres. O modelo se assemelha ao descrito por Rodrigue (2020), numa espécie de "*extended gateway*" ou "*satellite terminal*". Além de dar maior vazão de cargas, proporcionando ao TVV a oportunidade de fomentar a movimentação de cargas conteinerizadas no complexo portuário, a proposta visa endereçar soluções não previstas nos projetos atuais e futuros para Vitória, proporcionando integração intermodal, via transporte hidroviário – "inland waterway transport" (IWT).

A solução ora proposta foi verificada sob os seus aspectos de viabilidade técnica, econômico-financeira e também sob a perspectiva ESG (*environmental, social and governance*). Tecnicamente, foram constatados diversos desafios, tais como a existência de duas pontes no trajeto de 16 quilômetros da hidrovia (uma delas tombada pelo patrimônio histórico), além da necessidade de realização de dragagem e sinalização, a fim de tornar o trecho apropriadamente navegável. Todavia, nenhum desses desafios foi considerado intransponível, sendo endereçadas as soluções de engenharia descritas ao longo deste trabalho. Sob a perspectiva ESG, a solução foi considerada adequada, sendo o transporte hidroviário menos poluente e gerador de menor impacto social do que o modal rodoviário. Por fim, as simulações indicam a viabilidade econômico-financeira do projeto, que possui taxas de retorno superiores às taxas livre de risco, bem como valor presente líquido positivo.

1. Introduction

This work focuses on the logistics challenges of the Brazilian Southeast Corridor – Vitória branch, specifically with regards to the Port of Vitória, one of the nine main logistics corridors in Brazil, according to a study conducted by the Ministry of Transports, Ports and Civil Aviation in 2017 (MTPA, 2017a).

The Port of Vitória is located in the Southeast Region of Brazil, one of the five macro regions of the country, along with South, Central-West; Northeast and North. Each of the regions has specific characteristics: South and Southeast concentrate most of the industrial production and together account for over 70% of Brazil's Gross Domestic Product (GPD); Central-West has a dynamic agricultural-based economy, responsible for most of Brazil's export of commodities; whereas Northeast and North concentrate the least developed states, according to the Brazilian Institute of Geography and Statistics (IBGE, 2022).

Being a country with continental dimensions (Brazil's territory is almost half of the surface of South America), there are numerous challenges in logistics: the World Economic Forum calculates that Brazil's logistics costs account for more than 12% of its national GDP, which places Brazil 65th for transport infrastructure on a list of 137 countries evaluated, according to Getúlio Vargas Foundation (FGV, 2020). The Global Competitiveness Index (GCI) has shown Brazil's gains in competitiveness over the past four years: yet, the country is only ranked 56th out of 63 nations in the 2020 edition of the World Competitiveness Yearbook (FGV, 2020). Studies have shown that Brazil's transport matrix, highly concentrated on the road mode, contributes to the scenario of lack of competitiveness, being a common sense among specialists that the country needs a more reasonable balance, notably by increasing the participation of water and rail transport.

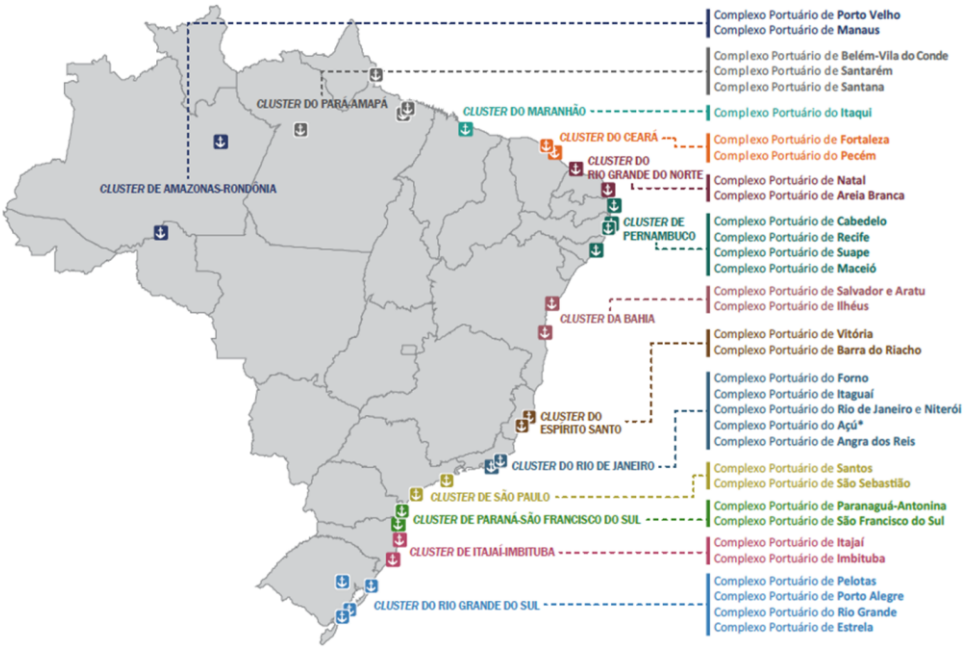
From that context, we propose to conduct a feasibility study for developing an internal waterway at the Vitória canal, aiming to connect the container terminal to an inland terminal, via barges, as an extended gateway model. The waterway will provide an intermodal solution to the port and it will contribute to the competitiveness of the corridor branch, by offering an alternative, less costly and more sustainable mode. Therefore, further in this study, an analysis of the port sector and the existing planning instruments is presented, as well as a brief characterization - of the infrastructure and operation - of the Southeast Corridor and the Port of Vitória. Lastly, a review of the infrastructure projects foreseen in the Master Plan of the port is carried out, with the objective of identifying if there is any intervention forecast for the implementation of a waterway.

2. Overview of the ports sector in Brazil

The Organisation for Economic Co-operation and Development (OECD, 2022) defines ports as places "having facilities for merchant ships to moor and to load or discharge goods or passengers to or from seagoing vessels". They play an important role in a country or in a region's development, because of their economic function by facilitating large-scale domestic and international trade. In terms of international trade, Brazil accounted for 7,3% of the global volume of loaded goods in maritime trade in the year 2020 (OECD, 2022).

According to Brazil's National Agency of Waterway Transportation (ANTAQ, 2022), there are approximately 384 port terminals in the country: 214 private ports (TUPs); and 170 terminals leased by private investors in public ports. In turn, there are 35 main public ports in the country. Those public ports are distributed among several clusters, most of which are located along the southeast and northeast coast, as shown in Figure 1.

Figure 1: Brazilian port clusters



Source: MTPA (2017b)

According to the Brazilian Development Bank (BNDES, 2022a), there are two types of ports in Brazil: public ports[1] and private ports (TUP). Public ports can be managed directly by State-owned companies or indirectly, by the private sector through public concession. Even when managed by State-owned companies, public ports lodge terminals managed by private parties, using terminal leasing agreements. The main characteristics of the two types of ports are described below. Table 1 summarizes the current models of port activities exploration in Brazil.

- **Public port:** it is a public good with a water channel and an area (polygonal) delimited by the Federal Government comprising port facilities and the protection infrastructure and port access. The public port is under responsibility of a port authority that manages the navigation channel, as well as the land exploration inside the polygonal. It is a regulated market, with the possibility of private sector participation through a concession.
- **Private port (*terminal de uso privado* – TUP):** it is a fully private port, both for the protection infrastructure and for the contiguous areas. For its operation, an ANTAQ authorization is required, but it is not a public service and, therefore, there are no regulated tariffs. Originally, TUPs installations and operations focused on the handling of solid bulk from vertical chains such as mining, steel, grain and cellulose. Currently, there are some TUPs that handle all types of cargo and not necessarily vertical chains.

Table 1: Models of port activities exploration in Brazil

	Public port	**Public port concession**	**Terminal leasing**	**TUP (full private port)**
Legal instrument	Agreement between public entities	Concession contract	Lease contract	Authorization
Type	Public service under federal jurisdiction	Public service granted to the private sector	Public service granted to the private sector	Private economic activity upon authorization

[1] The public ports mentioned are called Organized Ports, as defined in law nº 12.815/2013 (Ports Law). In this work, for the purpose of simplification, the Organized Ports will be called simply "public ports".

	Public port	Public port concession	Terminal leasing	TUP (full private port)
Period	Undetermined	Up to 35 years	Up to 25 years	Undetermined
Management	Port authority – performed by the Dock Companies or delegated to federative entities	Port authority granted to the private sector	Port terminal operator	TUP owner
Infrastructure	Public assets administered directly by the State	Managed by private investor during concession and returned to government when concession expires	Private and constituted with authorization from ANTAQ	Fully private
Berths and retro area	Public assets mostly granted (leased) to the private initiative	Negotiated between the concessionaire and the private port operator	Direct exploration by the lessor	Held by the TUP owner
Regulation	Tariffs regulated according to a pre-defined table (price cap or revenue cap) published by ANTAQ		Free negotiation with shippers	Free prices, subject to antitrust regulation
Labor	Labor Management Agency (OGMO) is responsible for the allocation, management and payment of dockers. All port operators, when operating within a public port, are obliged to hire labor through OGMO			Hiring labor is independent, according to the work legislation

Source: BNDES (2022a)

2.1 Planning instruments

The main instruments for planning the port sector in Brazil are the National Plan of Port Logistics (PNLP)[2] and the General National Leasing Plan (PGO), covering the national port system as a whole, and the master plans and the Zoning and Development Plan (PDZ) for each port complex, defined below (BNDES, 2022a):

- **National Plan of Port Logistics (PNLP):** the Federal Government is responsible for planning the Brazilian port sector, which is formalized through the PNLP.
- **General National Leasing Plan (PGO):** state planning instrument that consists of an action plan to the execution of concessions for new ports or public and private terminals, gathering the area's list to be designated for port exploration in terms of leasing, concession, authorization and delegation, with respective implementation schedules.
- **Master Plan:** the Federal Government sponsors the elaboration of a specific demand study for each Brazilian port complex, its hinterland, main cargo and projections.
- **Zoning and Development Plan (PDZ):** each port authority proposes it to government approval. It is an instrument of operational planning, considering the urban development policies where the port is located, the National Port Logistics Plan (PNLP) and the master plan.

According to OECD (2022), the policy makers at the port sector in Brazil are three bodies: The Ministry of Infrastructure; The National Commission of Port Authorities (CONAPORTOS) and the National

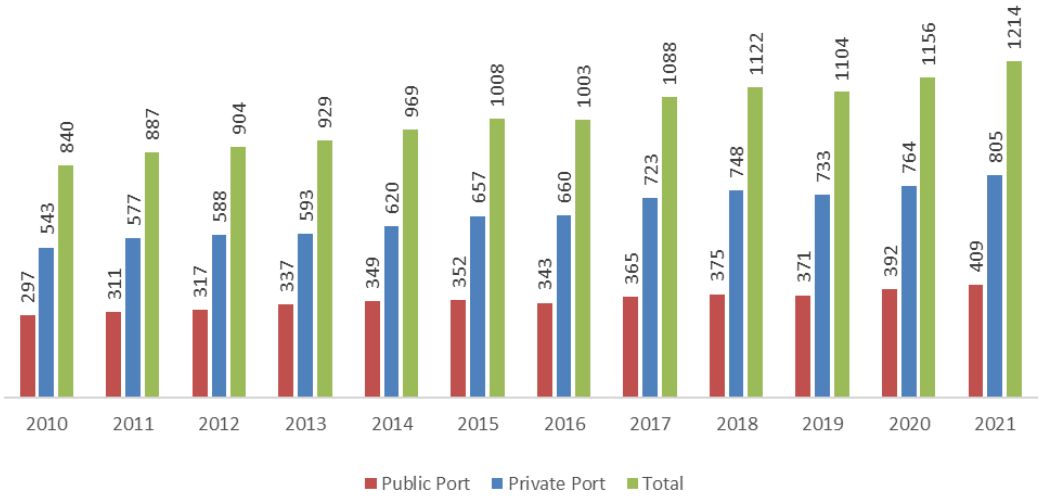
[2] The PNLP is being replaced by the National Logistics Plan (PNL) and the Sector Plans, including the Port Sector Plan, will make the connection between the PNL and the actions of the Ministry of Infrastructure.

Secretariat of Ports and Waterway Transport (SNPTA). Six State-owned port[3] enterprises called Companhias Docas are responsible for exercising the functions of port authorities in public ports. The National Agency of Waterway Transportations (ANTAQ) is an independent regulatory agent in charge of implementing the Ministry's policies on ports and waterways in accordance with the principles and guidelines established by the law.

2.2 Throughput

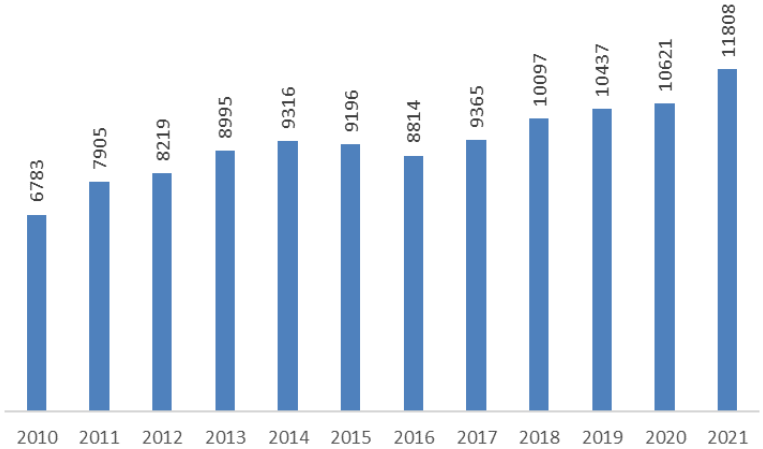
In 2021, the Brazilian ports handled 1.214 billion tonnes of cargo of all sorts - liquid and dry bulk, general cargo and containers (Graph 1). Those ports were also responsible for handling about 90% of Brazilian exports: US$ 248 billion exported in 2021, according to the Ministry of Economy (2022). In the same period, the containerized cargo corresponded to 11.808 million TEU (Graph 2). According to the National Agency of Waterway Transport (ANTAQ, 2022), 905 million tonnes of merchandise were handled by Brazilian ports from January through September/2022.

Graph 1: Evolution of cargo handling in Brazilian ports (in millions of tons)



Source: ANTAQ (2022)

Graph 2: Evolution of container handling in Brazilian ports (in thousands of TEUs)

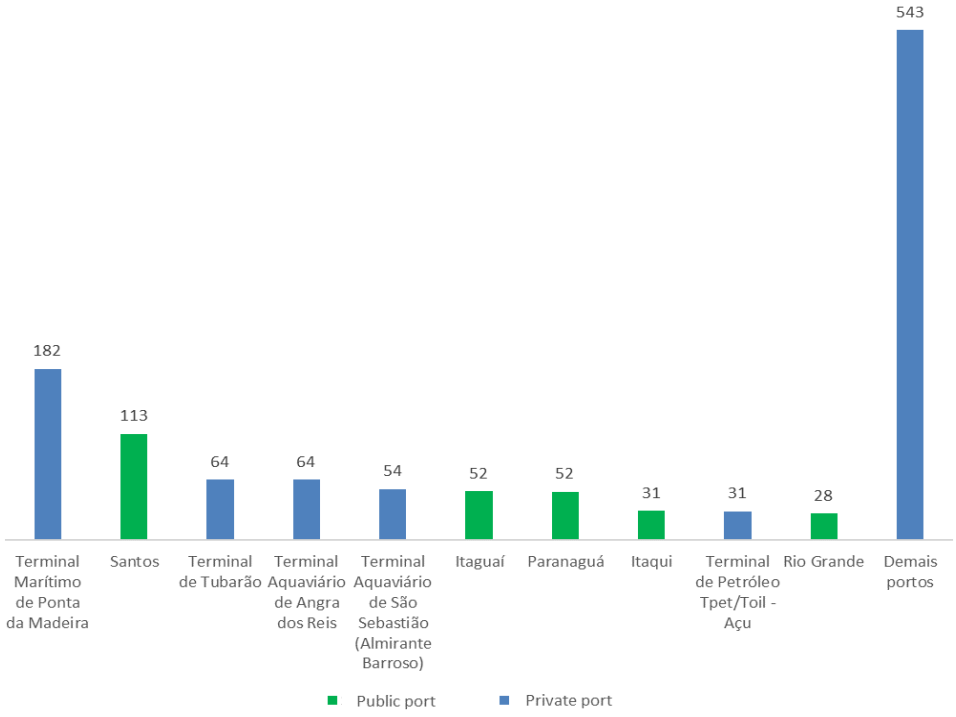


Source: ANTAQ (2022)

[3] The Brazilian government plans to privatize some of the Companhias Docas in the upcoming years. The first of those companies was CODESA, responsible for managing the ports of Vitória and Barra do Riacho, which was privatized in 2022.

The BNDES (2022a) emphasizes that the total cargo volume handled in the Brazilian ports is heavily influenced by the export of iron ore, which mostly occurs in private terminals owned by mining companies, such as Vale S.A. In fact, among the ten main ports in Brazil, in terms of tonnage handled, 5 are private and 5 are public ports, as shown in the Graph 3.

Graph 3: The ten main Brazilian ports - 2021 (in millions of tons)



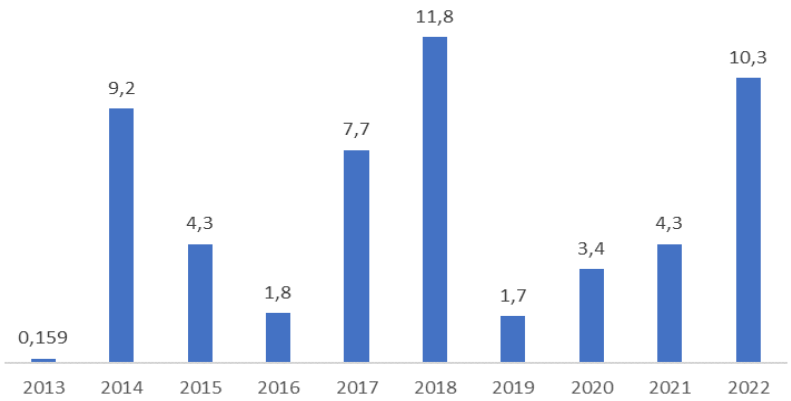
Source: ANTAQ (2022)

Those figures relate to the increasing process of verticalization of the port sector observed in Brazil in different markets, notably commodities and containers, following a global tendency (OECD, 2022).

2.3 Investments

When it comes to the implementation of investment, according to OECD (2022), after the Ports Law was passed in 2013, private ports invested around R$ 45 billion, which places those ports as important investment drivers in the sector (Graph 4).

Graph 4: Annual investment portfolios in private terminals (in BRL billions), 2013-2022



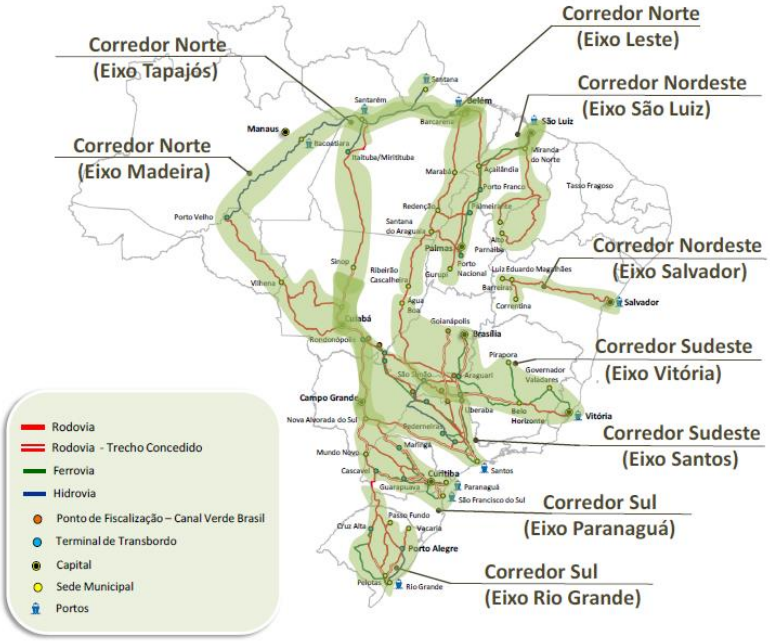
Source: OCDE (2022)

On the other hand, as far as investments in leased terminals are concerned, according to BTG Pactual (2022), from 2019 to 2021, 32 terminals have been leased, with total investments of approximately R$5 bn.

3. The Southeast Corridor – Vitória Branch

As from the Brazilian port clusters, several logistics corridors have been developed in the country. The then Ministry of Transports, Ports and Civil Aviation (now the Ministry of Infrastructure) characterized, in 2017, nine strategic logistics corridors, composed of highways, railways and waterways connected to the main ports in the country (MTPA, 2017a). The approach was based on the actual and potential use of these corridors for the flow of agricultural bulk – soy and corn – which constitute two of the main items on the country's export agenda. Figure 2 shows the nine identified corridors.

Figure 2: Strategic Logistics Corridors – Soybean and Corn Complex



Source: MTPA (2017a).

The port of Vitória is part of the Southeast Corridor – Vitória Branch. Comprising the Public Port of Vitória, nearby private ports and road and rail routes. The corridor, although initially characterized based on the handling of agricultural dry bulk, presents significant handling of other products, as will be seen in the course of this work.

3.1 The port of Vitória

The Public Port of Vitória is the structuring node of the Southeast Corridor. It is located in the cities of Vitória and Vila Velha, in the state of Espírito Santo. It is part of the Espírito Santo cluster, which includes, in addition to the two public ports – Vitória and Barra do Riacho – several Private Use Terminals (TUPs) in operation[4] and some still in the design phase[5] according to the Companhia Docas do Espírito Santo (CODESA, 2018).

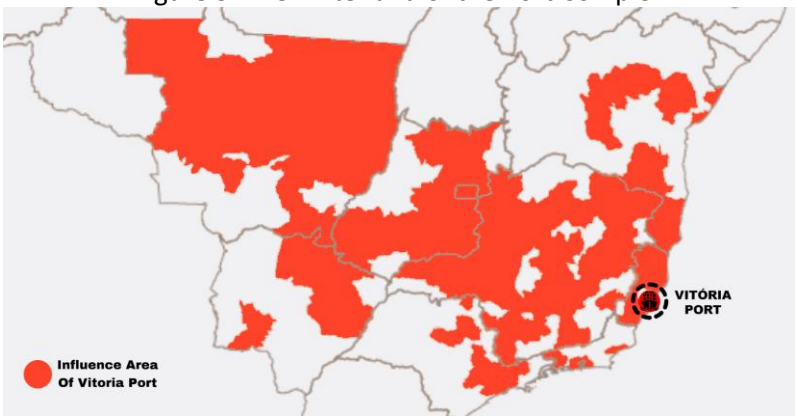
[4] TUPs in operation: Companhia Portuária Vila Velha (CPVV), Terminal de Praia Mole, Terminal de Tubarão, Terminal Marítimo de Praia Mole, Portocel, Terminal Aquaviário Barra do Riacho (TABR), Terminal Barcaças Oceânicas (TBO), Terminal Marítimo Ponta Ubu, Terminal Portuário da Glória (TPG), Estaleiro Jurong, Zemax Log (CODESA, 2018).

[5] TUPs in design phase: Imetame Logística, Porto Central e Porto Norte Capixaba (CODESA, 2018).

3.1.1 The hinterland

The area of influence of the cluster comprises mainly the states of the Southeast Region (especially Minas Gerais and Espírito Santo), Midwest (manly Goiás) and Northeast (Bahia) (Figure 3). Bulk ores, steel products and pig iron come from Espírito Santo and Minas Gerais for export, as well as imports of mineral coal. The region, together with Bahia, represents an important origin of cellulose. In Goiás and Minas Gerais there are also grains and fertilizers. Espírito Santo is an important origin of granite and destination of cereals such as wheat and malt, according to the Ministry of Infrastructure (MINFRA, 2019).

Figure 3: The hinterland of the Port Complex



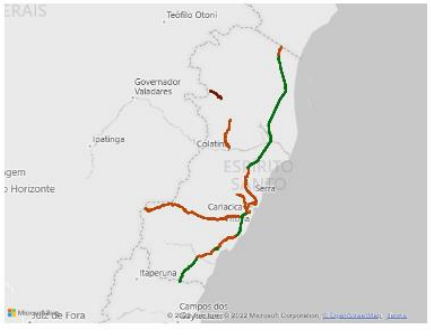
Source: Adapted from MINFRA (2019)

3.1.2 Access to the port

The access to the ports of the Port Complex occurs by highways and railroads. Currently, there are no structured inland waterways and, as a result, there is no inland waterway transport in the region. The existing highways in the hinterland are BR-101, BR-259, BR-262, ES-010, ES-257, ES-445, ES-124, ES-080, ES-060, ES-146 and ES-162. BR-101, BR-262 and ES-080, being considered the main connections to the Port of Vitória. According to data extracted from the CNT Highway Survey 2022 from National Confederation of Transport (CNT, 2022), BR-101 (granted to the private sector) has good general condition, while BR-262 and ES-080 highways have fair and bad ratings, in its paved sections - part of the road is not-paved or still planned (Table 2).

Table 2: Condition of access roads to the Port Complex

Road	State	Extension	General condition	Pavement	Signaling	Road geometry
BR-101	ES	477	Good	Good	Good	Fair
BR-262	ES	197	Fair	Fair	Good	Fair
ES-080	ES	92	Fair	Fair	Fair	Bad
ES-080/BR-381	ES	27	Bad	Bad	Bad	Very bad

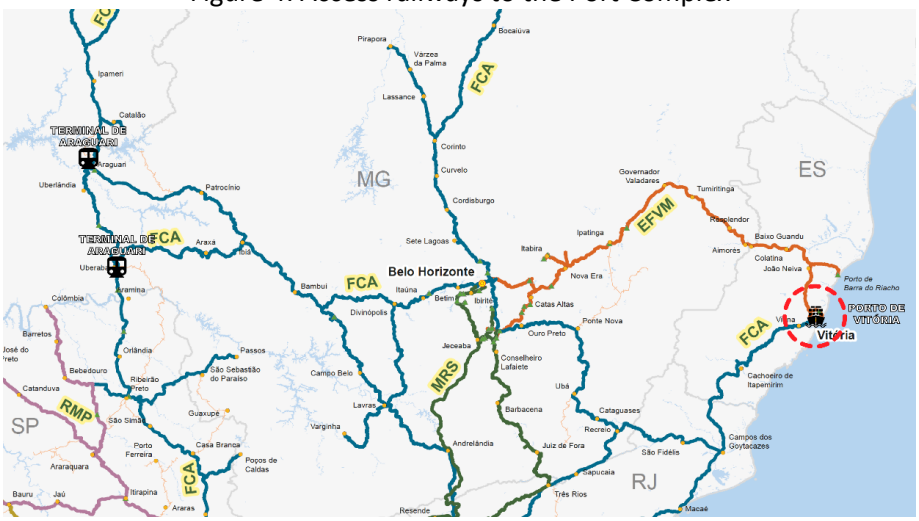


Source: CNT (2022)

Two railroads, the Vitória-Minas Railroad (EFVM) and the Centro-Atlântica Railroad (FCA) also serve the Complex. According to the National Land Transport Agency (ANTT, 2022), the EFVM is 895 km long and connects the ports of Espírito Santo – notably the Port of Vitória and the TUP of Tubarão – to the State of Minas Gerais. The railroad is connected to the rail networks of MRS Logística S.A. and FCA.

FCA, in turn, is a more extensive railroad, with 7,890 km, which connects seven states – Espírito Santo, Alagoas, Bahia, Minas Gerais, Goiás, Rio de Janeiro and São Paulo – and the Federal District. The network is connected to three railroads: EFVM, Transnordestina Logística S.A. (TLSA), Rumo Malha Paulista (RMP) and MRS Logística S.A.(Figure 4).

Figure 4: Access railways to the Port Complex



Source: Elaborated by the authors

According to estimates presented in the Port of Vitória - Barra do Riacho Port Complex Master Plan, 77% of cargo arrived at these ports in 2017 via rail, 13% via road and 9% via pipeline. In the Public Port of Vitória, however, the road modal is predominant, accounting for 86% of the volume in the same year (MINFRA, 2019).

3.1.3 Infrastructure and throughput in the port of Vitória

The Port of Vitória recently underwent a process of privatization, after which the port service was transferred to a private organization, through concession. It currently has 14 berths, distributed among: commercial pier (4 berths), Capuaba (2 berths), Atalaia, CPVV, Flexibrás, Paul, Peiu, Sao Torquato (1 berth each) and TVV (2 berths) (CODESA, 2022a). In these structures, 8.1 million tons of cargo was handled in 2021, of which, 3.28 million were handled at TVV (containerized cargo and general cargo), 2.66 million at the Capuaba pier (mainly solid bulk), 1.38 million at Paul's quay (notably liquid and dry bulk) and the remainder (about 780 million tons) at the other quays (Graph 5). The following graphs show the distribution of movement in the Port of Vitória according to pier and cargo profile (CODESA, 2022b).

Graph 5: Distribution of cargo throughput at the Port of Vitória, by pier and cargo profile

Source: CODESA (2022b)

According to a study conducted by BNDES (2022b), it is estimated that the demand will grow at a rate of 1.8% per year, reaching 14 million tonnes by 2060, which represents almost two times the current throughput. In order to capture that cargo influx it is mandatory that the port invest in logistics solutions, so as to maximize its efficiency. From this context, the existing and planned projects and programs for the port infrastructure are described in the next chapter.

3.2 Existing projects and programmes for the port of Vitória

Companhia Docas do Espírito Santo - CODESA, the company responsible for the administration of the port of Vitória, has recently undergone a process of privatization. The shares that belonged to the federal government were transferred to the private equity fund Quadra Capital. As a result of the process (the first of its type at the Brazilian port sector) it is expected that the new shareholder will establish the strategic plan and respective priorities to the port in the upcoming months. Nevertheless, there are important projects in progress. For the specific purpose of the present work we divided the existing projects into the following categories:

- Technology: projects that involve port connectivity.
- Infrastructure: those are mainly related to ports' usual infrastructure facilities.
- Environmental, Social and Governance (ESG) projects.

The projects, programmes and initiatives recently concluded and the ongoing projects come from the Master Plan (MINFRA, 2019) and the Zoning and Development Plan (CODESA, 2018). The main future projects, under the responsibility of the new concessionaire, in turn, come from the documents relating to the privatization process (BNDES, 2022b).

3.2.1 Technology

CLPI – Smart Logistics Chain

In 2021 the port of Vitória initiated the assisted operation of 8 smart gates (4 gates in and 4 gates out). The new equipment will allow port operations to flow in a more automated manner, ensuring safety and agility. The most relevant improvements include an OCR system and a set of cameras with night vision (Figure 5).

VTMS – Vessel Traffic Management System

Codesa's Vessel Traffic Management System has been fully operational since September 2017. The port of Vitória was the first public complex in Brazil to adopt such a system, which is a very important tool to ensure navigation safety and to minimize incidents. Codesa's VTMS utilizes high technology in its equipment, sensors, cameras and radars. The traffic control software is called Navi Harbor 4.6 VTS 3D, which is also used in multiple ports worldwide (Figure 6).

Figure 5: CLPI in Capuaba Port

Figure 6: VTMS facilities in Capuaba Port

Source: CODESA (2022d)

3.2.2 Infrastructure

As a port authority, Codesa must provide users with good infrastructure so that operators are able to perform at high service levels, generating logistics efficiency. Over the last years Codesa has conducted important projects to enhance the infrastructure of the port. Some of those were concluded recently; others are still in progress and there are some initiatives that will be under the responsibility of the new concessionaire, as part of the obligations assumed by contract. Below we list the main projects/initiatives.

Projects/programmes/initiatives concluded

Expansion of berths 101 and 102

The project involved a 20m extension of the commercial pier at berths 101 and 102, and it was concluded in 2013. The purpose of the construction of this area was to increase the storage capacity, in addition to enabling the mooring of vessels with higher loading volume.

New berth – 207

Berth 207 is located in the structure once called "*Dolfins do Atalaia*", "Watchtower's Dolphins" in free translation, and underwent a rectification process through which the structure composed of two docking dolphins was replaced by a run pier called "*Cais do Atalaia*", continuous to berth 201. The length of the pier is 270m, approximately - 16m wide and 14m deep, and will have 14 bollards and 12 fenders, enabling the operations of liquid and solid bulk and general cargo. Berth 207 will be connected to a 1,500m long pipeline to operator Oiltanking Terminals Ltda., as well as a pipeline with two transfer points that connects it to the Liquiport terminal tanks. The berth will also feature three new pipelines connecting it to the TGL storage structure. The project includes, in addition to the rectification of 207, the availability of approximately 15,300m² of retroarea adjacent to the pier, adding a significant storage area to the pier, which has 4,200 m². The total area contemplated in the project corresponds to approximately 19,500m² and the berth was inaugurated in 2020.

Ongoing projects/programmes

Liquid bulk terminal (VIX 30)

The project contemplates a new terminal for liquid bulk, upon the conclusion of a lease of the VIX30 area, a greenfield area (clean and without goods and equipment usable by the tenant), of approximately 74,000 m², located in the retroarea of Capuaba. The area will be destined for the installation of a terminal focused on the operation and storage of fuels. The terminal will be serviced by berth 207, at Cais do Atalaia, which recently underwent a rectification process, as described earlier. The connection between the berth and the storage structures will be made through three new pipelines, with approximately one thousand meters long each, in addition to another 3,000m of lines for internal connections, between tanks, pump square and loading/unloading stations. The project is currently at the phase of approval by the environment authority (IEMA).

Maintenance dredging

Investment of R$ 17 million in order to maintain port navigability and improve draft conditions. 378.273 cubic meters of dredged material.

Main future projects (under the responsibility of the new concessionaire)

Structural reform of the PAUL/PEIÚ mooring berth 206

- The concessionaire will perform the complete structural recovery of the platform, which consists of a reinforced concrete platform measuring 12m wide and 260m long, supported by pipes measuring 2m in diameter.
- Berth 206 is responsible for handling solid bulk, general cargo and vehicles. The maximum deadweight (DWT) of the served ships is 70,000 metric tons, with maximum length overall (LOA) of 244.99m, maximum beam of 32.49m and maximum draft of 10.10m plus tide.

Structural reform of PAUL/GUSA mooring berth 905

- A structural set similar to that of berth 206, measuring 160 meters long, was considered for berth 905. The Concessionaire must perform the structural recovery of the entire platform.
- Berth 905 is responsible for handling pig iron. The maximum deadweight of the ship served is 70,000 metric tons, maximum total length of 244.99m , maximum beam of 32.49m and maximum draft of 10.10m plus tide.

Recovery of the Capuaba railways and their accesses

- The Concessionaire shall provide the recovery of the railway access to Capuaba by performing restoration services on the general cargo yard tracks and the grain terminal of the Capuaba pier, on the stretches indicated in the engineering study; mobilization, demobilization, building site and its maintenance and local administration; preliminary services; regularization, compaction and reinforcement of the subgrade; tie tamping; needle alignment; recovery of gutters; maintenance of AMV (Track Change Apparatus); alignment, leveling and set-up of rails and AMV; signaling; and preservation, cleaning, lubrication and mechanical maintenance services.

Replacement of mooring bollards for berths 201 and 202

- Although the overall state of the infrastructure of berths 201 and 202 does not indicate the need for comprehensive immediate interventions, the bollards should be replaced for operational reasons.
- The bollards must be dimensioned for the vessel's deadweight, which are established in the NORMAP (Standard for Traffic and Permanence of Ships and Vessels in the Port of Vitória).
- Berths 201 and 202 are responsible for handling coal, copper concentrate, petroleum coke, fertilizers, granite, malt, steel products, caustic soda, wheat and vehicles. The maximum deadweight of the served ships is 70,000 metric tons, with maximum length overall of 244.99m, maximum beam of 32.49m and maximum draft of 11.70m plus tide.

Replacement of berth 905 fenders

- The fenders on berth 905 consist of tires hanging along the front face. Such buffer elements do not guarantee an adequate absorption of the berthing energy, exposing both the pier and the vessels to the occurrence of damages during berthing. Therefore, new and appropriate fenders must be installed to replace those existing in berth 905, and must be sized to absorb the energy compatible with the mooring of a 70,000 DWT ship. In addition, the minimum specifications for the replacement of the fenders must comply with current technical standards of reference (NORMAN, ABNT, among others).

Recovery of warehouse structures (1, 2, 3 and 4) and adaptation of the sidewalks, according to Municipal Law nº 6.525/2005

- The warehouses checked already have a long life, but they are not at the end of their useful life.

- The Concessionaire must provide the maintenance of the gutters, hydraulic installations, restoration of the concrete structure with the proper treatment of the exposed reinforcements and the recovery of the plaster/painting in all warehouses.
- Most of the inner and outer walls show the presence of moisture. The immediate consequence of this pathology is the disaggregation of the plaster, as it contains clay in its composition; dark stains and oxidation of the reinforcements with the appearance of cracks and fissures. The Concessionaire must map all areas with compromised plastering and paint and present a recovery plan.

Remodeling of the grain warehouses at the Capuaba Grain Terminal (Horizontal Silos)

- The Concessionaire shall perform corrective maintenance, consisting of (i) complete civil and electrical maintenance; (ii) total repair of the conveyor belts; and (c) maintenance of the hopper assembly, elevators, drives, chutes, feeders, retrievers and trippers.
- The Capuaba Grain Terminal – TCC, currently has only two Bulk Warehouses in the retroarea of Capuaba. The construction years were 1984 and the second in 1994, both measuring 50m x 100m = 5,000m2 with static capacities of 36,000 tons of grain each. (c) The TCC's reception has a road-rail hopper and a railway hopper with a reception and loading capacity of 300t/hr each. Horizontal bulk warehouses can be loaded by means of overhead conveyor belts, and cargo is moved from the Warehouses to ships, road or rail by two underground conveyor belts.

Dredging

- Throughout the entire duration of the agreement, the Concessionaire will be responsible for the maintenance dredging of the berths and the waterway accesses for the Ports of Vitória and Barra do Riacho, always complying to the NORMAP technical specifications.
- The concessionaire must monitor the conditions of the channel at both ports through bathymetric campaigns (Cat. B – NORMAM 25) with maximum intervals of up to 12 months, including the sizing of the sedimentation rate.

Investments required for the proper maintenance of the concession assets

- Throughout the entire duration of the concession agreement, the Concessionaire shall make the investments necessary for the proper maintenance of the concession assets including, but not limited to:
    - Expenses with operation and maintenance of VTMIS at the Port of Vitória.
    - Operation and maintenance of nautical beaconing at the Ports of Vitória and Barra do Riacho.

Implementation of Fire Fighting System in berth 207

- The Concessionaire must implement a fire fighting system to support vessels carrying up to 70,000 tons of fuel and flammable liquids. Each pump must be capable of pumping water at 700 m^3/h at 95 m.c.a., using the following standards of reference:
    - ISGOTT – The International Safety Guide for Oil Tankers and Terminals;
    - NFPA – National Fire Protection Association No. 11 - Standard for Low Expansion Foam and Combined Agent Systems;
    - NFPA – National Fire Protection Association nº 20 – Standard for the Installation of Centrifugal Fire Pump.

Executive Project of Capuaba Access

- Refers to the development of an executive project for the aimed work in reconciling the situation of the community site with the desired capacity increase and infrastructure

improvement. The proposed solution is the construction of a heavy traffic viaduct, which would isolate port-bound traffic from local traffic.

3.2.3 ESG

It is up to the Concessionaire to provide the recovery, rectification and management of environmental liabilities related to the Concession, in order to maintain the environmental conformity of the Public Ports of Vitória and Barra do Riacho. It also includes the identified and recognized environmental liability of the Liquid Bulk Terminal of San Torquato.

As seen, among the current investments planned for the Port of Vitória, there are no inland waterway projects expected. However, with the transfer of the port to the private sector and the re-prioritization of interventions, the waterway alternative may become part of the port's portfolio. It is noteworthy that the development of the waterway modal, in addition to the economic benefits, also brings socio-environmental advantages, from the reduction of emissions, traffic congestions, road accidents, etc. In this context, the present work will detail, over the following items, the implementation of the proposed waterway.

4. Analysis of the existing bottlenecks

We will summarize below the three main problems that the development of the waterway modal connected to an extended gateway, as an alternative route, seeks to solve.

4.1.1 Surface area limitation in the public port region for container handling and storage

The Public Port of Vitória has 2 long-term leasing contracts PEIU (nº 06 - until dec/2023) and TVV (nº 11 - until 2048). The other available areas will be explored by the concessionaire under the new private regime, allowing flexible deadlines for new contracts. Considering the high demand for solid bulk (fertilizers, grain, coke, coal and others), there is a strong tendency for available areas to be used for the development of storage projects for this type of cargo, reducing the availability of storage area for containers, which is already restricted (Figure 7).

Figure 7: Operational areas at the Public Port of Vitória

Source: CODESA (2022c)

4.1.2 Access restrictions and impacts in productivity

Login TVV Terminal operates all the demand for Container handling in the state of Espírito Santo, with approximately 40% imports and 60% exports, with 2 dedicated berths capable of serving Panamax ships, in an area of 108,000 m^2 with nominal capacity of 350,000 TEUs per year. The terminal currently operates with the following equipment: 3 RTG cap. 40t; 2 MHC Liebher 550 cap. 150t; 6 reach stackers of cap. 41t/6HC; 14 semitrailers chap. 65t; 4 forklifts cap. 2.5t, 2 cap. 5.5t, 1 cap. 7t; 1 forklift of 16t; 2 hoppers cap. 60m^3; 2 grabs of 12m^3; 2 container scanners; 6 automated gates with OCR (character recognition); 8 road scales cap. 100t.

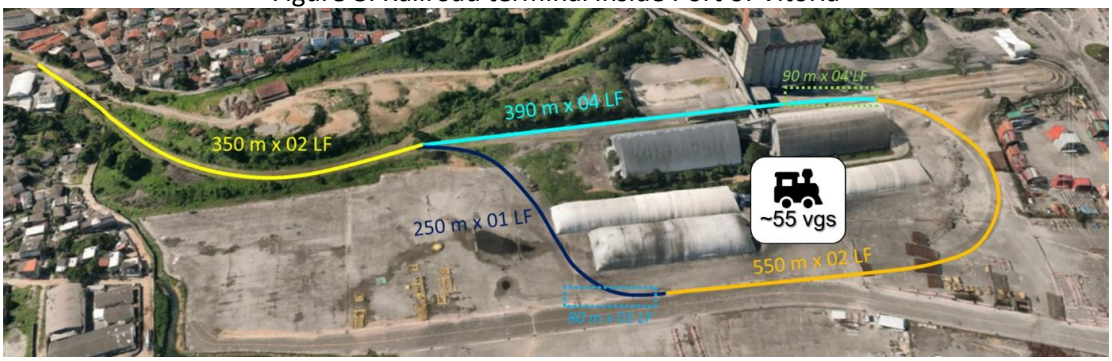
To achieve the current demand of approximately 180,000 TEU per year, the terminal operates with very high productivity (turnaround = 20 times per year), being completely dependent on the road modal in this process. The other terminals close to the region need to operate "just in time", demanding an optimized synchronization in the replacement of full containers for empty containers to be able to achieve the required ship performance, considering the scarcity of land area to support the lot formation for an average vessel (ship with average intake from 2,000 to 2,500 TEU).

However, the port has only one access road in the region of Capuaba as previously mentioned, being a single road with one lane only. Considering the future expansion of the port, with the expected increase in bulk cargo handling, and the start of operations in 2024 of the liquid bulk terminal (140 trucks/day) the road access will be certainly overstressed and facing blockage risks, which requires the development of an alternative route for cargo transportation.

4.1.3 Low rail terminal capacity

TVV currently does not operate railroads, and the Capuaba rail terminal has a 1,280m railroad section with capacity to operate approximately 55 wagons, which limits the operation of a standard composition which is made of 84 wagons. This limitation causes an excess of train maneuvers, reducing the handling capacity and increasing operational costs. In addition, the railway section outside CODESA dates back to the 60s/70s and passes through the city, which limits the service speed due to the interference from the community that was raised along the line, directly impacting the railway performance. Therefore, having a railroad in the contour region solves these problems, as it is located in an area with a very low population density (Figure 8).

Figure 8: Railroad terminal inside Port of Vitória



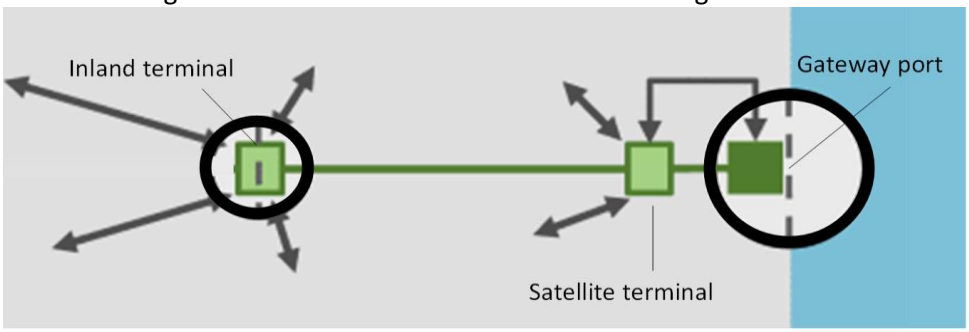
Source: Elaborated by the authors

5. The development of a waterway for the Port of Vitória

As we described earlier, among the ongoing projects at the port of Vitória, there are no programmes specifically aimed at developing the waterway modal. Nevertheless, we identified the unexplored capacity of the Santa Maria River so as to connect the public leased terminal (TVV) to the dry ports, via barges, using an inland terminal as an extended gateway to the Port of Vitória.

Considering how important the container throughput is to the port of Vitória, our target is to apply the satellite terminal model with waterway connection, vastly explored in European ports. According to Rodrigue (2020), satellite terminals are intermodal facilities built in proximity to the ports (in general, gateway ports) in order to handle additional traffic, particularly if the port facility is congested and presents high costs (Figure 9). These infrastructures are also widely used to support container transloading activities.

Figure 9: Location of a satellite terminal in a logistic chain



Source: Adapted from Rodrigue (2020)

The logistics solution proposed will generate significant changes to the current logistics model, in which the container transport to the inland terminals in the hinterland is done mostly via road by trucks. The proposed modal shift is beneficial not only in terms of cost reduction, but it also carries social and environmental gains, which will be discussed later on.

The present chapter will present in detail the characteristics of the logistics model. We will also explore the existing bottlenecks that possibly explain why the waterway transport is not currently explored. Subsequently we will estimate the future revenues and both the capital and operational expenditures in order to calculate the financial feasibility of the project. We will also present a brief discussion on the overall costs and benefits expected.

5.1 Proposal for a logistics solution

As previously mentioned, the hinterland of the Port of Vitória has a conglomerate of inland terminals (Dry Ports[6]), Logistic Operators, Carriers Yards and Warehouses structured to meet the port demands.

Regarding dry ports, the internalization of port activities to secondary zones, in addition to being recommended by the State Governments themselves, eases the waiting time at port and airport terminals. Currently, it is the provision of logistics and foreign trade services in these areas that guarantees the full development of import and export activities, enabling agility and fluidity in the flow of goods in the Primary Zone.

According to the Associação das Empresas Permissionárias de Recintos Alfandegados do Espírito Santo (APRA, 2022), the 03 Dry Ports in the state of Espírito Santo correspond to 15% of the total bonded area among the 57 dry ports in activity in the country, being the largest in Brazil in a contiguous area, guaranteeing the state a prominent position in the Dry Ports segment in Brazil. They have significant

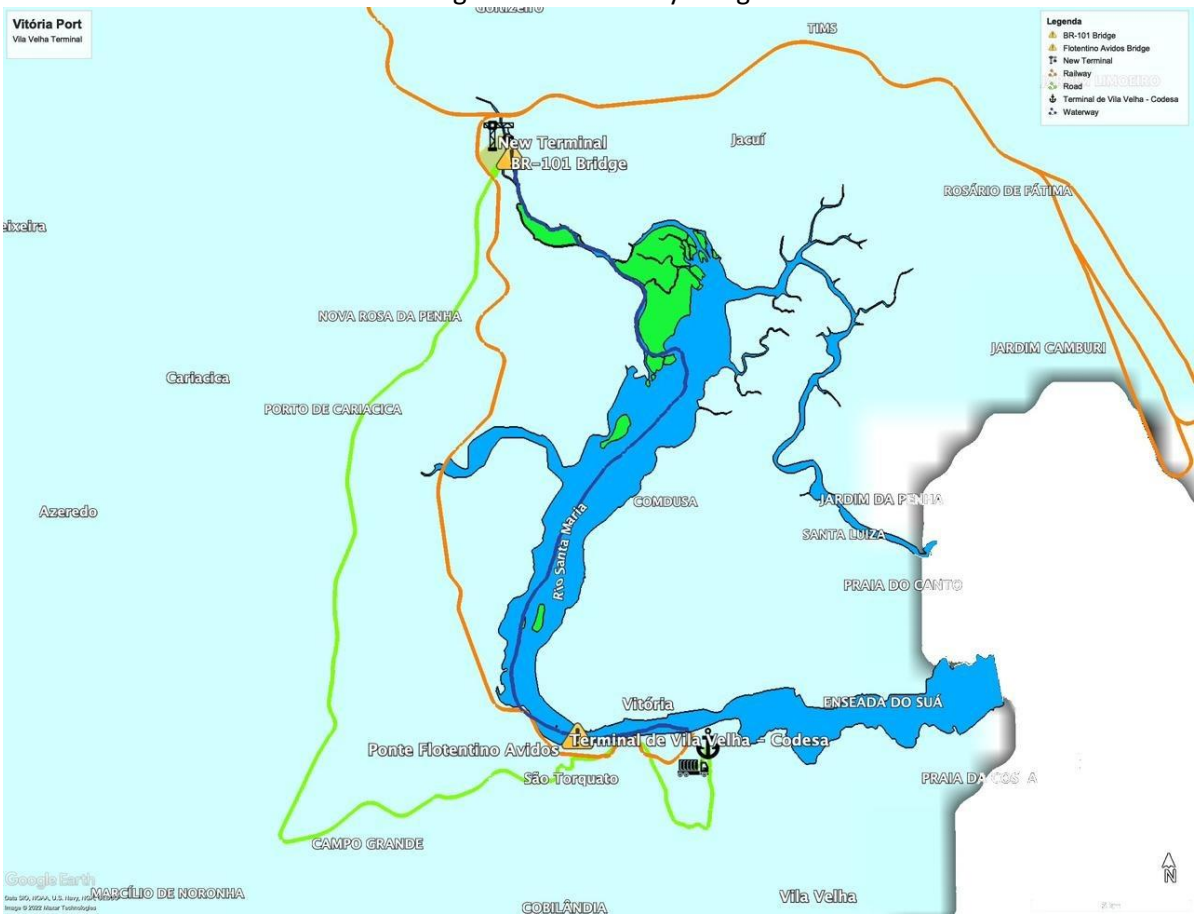
[6] The Federal Revenue Service of Brazil (RFB, 2022), defines Dry Ports as "customs facilities for public use, located in a secondary zone, in which operations of movement, storage and customs clearance of goods and baggage are carried out, under customs control". In dry ports, all customs services are performed by the Federal Revenue Service of Brazil, including the processing of import and export customs clearance (customs conference and clearance), thus allowing the internalization of these services in the country. The Secondary Zone comprises the entire national customs territory (including territorial waters and airspace), except for the primary zones, which are areas demarcated by the local customs authority, which include: the continuous or discontinuous land or water area in the customs ports; the land area, at bonded airports; and the land area, which comprises the customs border points.

investments in facilities, systems, equipment, personnel training and support for intervening and regulatory federal authorities.

Therefore, an alternative to reduce the cost of transporting cargo via road modal is the consolidation of cargo via waterway transport (barge), taking the cargo from the seaport to the inland terminals and vice versa, becoming a viable alternative with immediate capture. We propose the development of an inland barge terminal to handle cargo between dry ports and seaport, via waterway modal, shortening overall cargo shifting distances.

The new waterway covers a 16 km of the Santa Maria River and will be used to transport containers from TVV, which uses road (mainly). The Figure 10 illustrates the design considered for the waterway.

Figure 10: Waterway design



Source: Elaborated by the author

The access between the inland barge terminal to the Vitória seaport via waterway modal will be made through the port of Vitória channel. However, investments in dredging and implementation of nautical beaconing will be necessary, and the Port Authority will be responsible for them.

It also must be noted that there is a bridge on the Santa Maria River whose dimensions limit the size of the barges. However, as it is an infrastructure that is listed as a historical and cultural public heritage, it cannot be easily modified. The Florentino Avidos bridge, called “five bridges” (Figure 11), has 5 spans of 66 m of length and approximately 7,85m of height.

Figure 11: Florentino Avidos bridge

Source: Ipatrimonio (2022)

There is another bridge over the Santa Maria River, located near the new terminal – the "Canal dos Escravos" bridge – that also has height limitations. This bridge will need to be demolished and a new one built in its place. Information about these interventions is described in item 5.3.3 of this paper.

For the transport operation through the Santa Maria River, three barges (50mx16m) and a pusher will be used, each barge having the capacity to transport 46 TEUs. The navigation time the 16 km between the Vila Velha Terminal (TVV) and the proposed new barge terminal is expected to last 45 minutes and the average time for loading and unloading is estimated in 02 hours, which together will lead to a total time of 3 hours and 30 minutes in a full cycle. In a 24-hour period, 4 round trips will be made, where 184 TEUs/day will be transported, totaling 5,520 in one month, 40% of the current volume of TVV.

5.2 Required Investments – Port Authority

The Port Administration will invest in the project and apply a custom fare for the utilization of access channel infrastructure, which will cover beaconing, bathymetry and dredging required investments. The list of investments of the Port Authority is in the Appendix I.

5.3 Required Investments – Terminal and Barges Operation

5.3.1 Barges

The specifications of the pusher-barge systems to be used in the container transport service are listed in Table 2.

Table 2: Specifications of the considered pusher-barge systems

	LOA	BEAM	Draught
Barges	50.0 m	16.0 m	2.5 m
Pusher	20.0 m	6.0 m	1.50 m

Source: Elaborated by the authors

The costs involved in the barges' bareboat chartering is estimated at R$ 272.50 thousands per month. The crewing and manning costs, as well as the accessory labor factors that include the additional associated costs are listed in Appendix II A.

5.3.2 Terminal

For the development of the terminal was considered the region across Cariacica/ES, close to the railroad and "*Canal dos Escravos*", a tributary of the Santa Maria river. The terminal will be built in an area of approximately 63,700 m^2 with a static capacity of approximately 8,900 TEUs and a nominal capacity of 150,000 TEUs on the first stage, and stock areas for a future expansion to 148,300 m^2 (Figure 12).

Figure 12: Inland terminal / barge port areas.

Source: Elaborated by the authors

The infrastructure package projects the construction of a railway branch of the Vitória-Minas railway, currently a concession ran by VALE S/A, that will build three lines of approximately 600 m with the capacity to allocate 40 wagons each, sufficient space to operate the composition up to 120 flat wagons and support the demand (Figure 13).

Figure 13: New terminal projected access gates and railway.

Source: Elaborated by the authors

In addition the terminal will have 4 gates with OCR, with 2 road scales and 2 container scanners and access control with scheduling via smart net system.

The terminal has direct access to the BR-101 highway, which connects the country from North to South along the coast, and access to BR-262 highway, which connects the state of Espirito Santo to the state of Minas Gerais.

The planned investments comprise: executive project and engineering studies; fenders; pier and warehouses; circulation routes and internal traffic signs; railway office; electrical, IT, automation network and lighting; and drainage network. The estimated overall investments in the new terminal totalled R$ 104.23 millions. The required investment calculation rationals are listed in the Appendix II B.

5.3.3 New bridge

It will be necessary to demolish and rebuild the "*Canal dos Escravos*" bridge, due to its height limitation as shown in Figure 14.

Figure 14: *"Canal dos Escravos"* bridge

Source: Elaborated by the authors

The new bridge will be designed with a minimum height of 20m and width of 45m. The cost for the old bridge demolition and the construction of the new one is estimated at R$ 8.20 millions. The required investment calculation rationals are listed in the Appendix II C.

5.3.4 Equipments and Machinery - terminal

Among the investments in superstructure, the acquisition of various equipment is planned, totaling R$ 96.37 millions, as shown in Table 3.

Table 3: Superstructure investments

Description	Quantity	Unity Price	Valor (R$)
MHC Liebherr 550 cap 150 t	2	R$ 28.000.000,00	R$ 56.000.000,00
Empilhadeiras 16 t	1	R$ 900.000,00	R$ 900.000,00
Empilhadeira 5,5 t	4	R$ 350.000,00	R$ 1.400.000,00
Semireboque	12	R$ 100.000,00	R$ 1.200.000,00
Reach-stackers	2	R$ 2.500.000,00	R$ 5.000.000,00
RTG	2	R$ 2.500.000,00	R$ 5.000.000,00
Terminal Tractor	10	R$ 467.600,00	R$ 4.676.000,00
Gates - Instalação/Montagem/Sistema	4	R$ 950.000,00	R$ 3.800.000,00
OCR	4	R$ 85.000,00	R$ 340.000,00
Balanças	4	R$ 100.000,00	R$ 400.000,00
Scanners de Container	2	R$ 3.500.000,00	R$ 7.000.000,00
Galpões	1	R$ 10.500.000,00	R$ 10.500.000,00
CFTV / Controle de Acesso	1	R$ 150.000,00	R$ 150.000,00
Total Cost			**R$ 96.366.000,00**

Source: Elaborated by the authors

5.3.5 Workforce and management of the new terminal

The generation of 142 direct jobs and over 1,000 indirect jobs is expected. The monthly overall cost of labor is estimated at R$ 1.69 million. The estimated fixed cost calculation rationals are listed in Appendix II D.

5.3.6 Operational Expenditure - Opex

As shown in Table 4, we have the modeling of OPEX, considering fixed and variable costs for the assumptions adopted. According to Table 4, the total monthly cost is R$ 3.66 millions.

Table 4: Operating cost modeling

Account	Type	Monthly value
Workforce	FIXED	R$ 1.844.439,23
Food	FIXED	R$ 41.400,00
Uniform	FIXED	R$ 1.715,83
Personal protective equipment	FIXED	R$ 4.331,00
TI Service	FIXED	R$ 9.000,00
Crane Service	FIXED	R$ 6.000,00
Environmental services	FIXED	R$ 1.500,00
Maintenance Services	FIXED	R$ 23.807,60
Safety services and Fire Fight	FIXED	R$ 6.335,00
Freight services (truck)	FIXED	R$ 15.000,00
Bunker	VARIABLE	R$ 111.030,10
Other parts and materials	FIXED	R$ 144.549,00
Office Material	FIXED	R$ 4.500,00
Energy	VARIABLE	R$ 15.000,00
Water and sewage	FIXED	R$ 1.500,00
Mobile Phone and similar	FIXED	R$ 450,00
Vessel maintenance and docking services	FIXED	R$ 963.660,00
Bare boat Charter Party	FIXED	R$ 272.500,00
Legal Services	FIXED	R$ 5.000,00
Marine cables and similar	FIXED	R$ 3.000,00
Insurance	FIXED	R$ 183.333,33
Port Authority Rates	VARIABLE	R$ 267.768,60
Total monthly cost		**R$ 3.658.051,09**
Total annual cost		**R$ 43.896.613,13**

Source: Elaborated by the authors

5.4 Business model

Our business model is based in the reception, handling and transport of containers between the seaport container terminal (TVV), located in the Port of Vitória, with the use of pusher-barge systems (shuttle service) and the inland terminals and industrial facilities located in the metropolitan region of Cariacica/ES, to be accessed through the new terminal, whose design and construction was described in Item 3.3. This proposed logistics model is similar to the one proposed by Rodrigue (2020), as shown in Figure 9. For that, the logistics operator will be remunerated by prices freely negotiated with the customers and, initially, englobes the following range of services for containers: warehousing, terminal handling, barge shuttle service, positioning for inspections, weighing and infrared scanning.

5.4.1 Revenue estimates

Considering the adopted range of offered services, the estimated revenues were calculated as per the following fees:

- Warehousing: R$ 400,00/TEU
- Terminal Handling Charge: R$ 938,00/TEU
- Barge Shuttle Service: R$ 938,00/TEU
- Positioning for inspection: R$ 550,00 x 500 TEUs (10% of the handled volume)
- Weighing: R$ 499,00/TEU
- Infrared scanning: R$ 369,00/TEU

Considering the work premise of handling 5,000 TEUs per month, we estimate a monthly revenue of R$ 15.995.000,00 and an annual overall gross revenue of R$ 191.940.000,00, according to Table 5.

Table 5: Estimated revenues

Terminal Service	Tariff per TEU	TEUs / Month	Monthly Revenues	Annual Revenues
Warehousing	R$ 400,00	5.000	R$ 2.000.000,00	R$ 24.000.000,00
Terminal Handling Charge	R$ 938,00	5.000	R$ 4.690.000,00	R$ 56.280.000,00
Barge Shuttle Service	R$ 938,00	5.000	R$ 4.690.000,00	R$ 56.280.000,00
Positioning for inspection	R$ 550,00	500	R$ 275.000,00	R$ 3.300.000,00
Weighing	R$ 499,00	5.000	R$ 2.495.000,00	R$ 29.940.000,00
Infrared Scanning	R$ 369,00	5.000	R$ 1.845.000,00	R$ 22.140.000,00
		Overall monthly revenues		R$ 15.995.000,00
		Overall annual revenues		R$ 191.940.000,00

Source: Elaborated by the authors

5.4.2 Value proposition

The proposed business model, whose financial feasibility will be shown in the forthcoming item, shows synergy with good sustainability practices for the transport sector. The implementation of the waterway, in addition to the economic aspects related to port efficiency, will also generate a series of social and environmental impacts. The main ones are listed below:

- Reduction of the cost of freight and, consequently, of the goods: according to the CNT (CNT, 2019), the cost of waterway freight is 60% less than road freight.
- Reduction of traffic congestion and accidents within the city: one of the most important benefits of replacing the road modal by the waterway is the removal of truck traffic that disturbs the daily life of the population of the city of Vila Velha, which in addition to causing great congestion, also damages the infrastructure of the highways. This change would initially remove 3,974.4 tons of cargo per day, in addition to a congestion of 2.2 km.
- Reduction of CO2 emissions: waterway transport emits around 20 grams of CO2 per TKU (tonne per kilometer useful) while road transport emits 101.2 gCO2/TKU and rail transport, 23.3 gCO2. So, it emits 80.2% less than road. In the proposed project, modal switching would emit 1,994.75 KgCO2 per day.

The analysis of strengths, weaknesses, opportunities and threats (SWOT analysis) of the business model is presented below:

- Strengths:
  - Logistics vocation of the port of Vitória;
  - Intermodal connectivity;
  - Lower emissions of CO2;
  - Reduced road traffic congestion and accidents.
- Weaknesses:
  - Physical barriers (bridges) that limit the dimensions of the barges;
  - Required dredging in order to adapt the canal and nautical beaconing;
  - Investments require a partnership with the Port Authority.
- Opportunities
  - Growth of mining and agriculture in Brazil - both require imported equipment;
  - Opportunities of investment motivated by privatization;
  - Tax subsidies for imports;
  - Increase of revenues by adopting accessory services for dry bulk and project cargo.
- Threats
  - Social constraints;
  - Port competition (especially Açu);
  - Development of new rail connecting the port of Açu;
  - Absence of proper regulation.

5.4.3 Financial analysis

The consolidation of investments and operating costs per year is presented in the Table 6. It must be noted that the investments in Capex consider contributions of 25% every 5 years to recondition the infrastructure, dock the pusher-barges systems for maintenance and make relevant interventions in the superstructure. Furthermore, the growth rates considered are the following: attractiveness: 9.38%; revenue growth: 2.5%; and expense growth: 1.5%.

Table 6: Financial analysis

	CAPEX	OPEX	REVENUE	CASH FLOW	PV - CASH FLOW
Year 0	-R$ 62.638.449,38	-R$ 6.584.491,97	R$ -	-R$ 69.222.941,35	-R$ 69.222.941,35
Year 1	-R$ 107.007.351,03	-R$ 13.366.518,70	R$ -	-R$ 120.373.869,72	-R$ 110.051.078,56
Year 2	-R$ 43.873.013,92	-R$ 45.223.388,26	R$ 115.164.000,00	R$ 26.067.597,82	R$ 21.788.391,68
Year 3		-R$ 45.901.739,09	R$ 191.940.000,00	R$ 146.038.260,91	R$ 111.597.096,51
Year 4		-R$ 46.590.265,17	R$ 196.738.500,00	R$ 150.148.234,83	R$ 104.898.325,30
Year 5	-R$ 59.058.046,73	-R$ 47.289.119,15	R$ 201.656.962,50	R$ 95.309.796,62	R$ 60.876.257,82
Year 6		-R$ 47.998.455,94	R$ 206.698.386,56	R$ 158.699.930,63	R$ 92.672.146,56
Year 7		-R$ 48.718.432,78	R$ 211.865.846,23	R$ 163.147.413,45	R$ 87.099.319,03
Year 8		-R$ 49.449.209,27	R$ 217.162.492,38	R$ 167.713.283,12	R$ 81.858.561,47
Year 9		-R$ 50.190.947,41	R$ 222.591.554,69	R$ 172.400.607,29	R$ 76.930.316,64
Year 10	-R$ 66.818.759,10	-R$ 50.943.811,62	R$ 228.156.343,56	R$ 110.393.772,84	R$ 45.036.578,16
Year 11		-R$ 51.707.968,79	R$ 233.860.252,15	R$ 182.152.283,36	R$ 67.938.743,46
Year 12		-R$ 52.483.588,32	R$ 239.706.758,45	R$ 187.223.170,13	R$ 63.841.718,09
Year 13		-R$ 53.270.842,15	R$ 245.699.427,41	R$ 192.428.585,26	R$ 59.989.693,00
Year 14		-R$ 54.069.904,78	R$ 251.841.913,10	R$ 197.772.008,32	R$ 56.368.172,79
Year 15	-R$ 75.599.292,83	-R$ 54.880.953,35	R$ 258.137.960,93	R$ 127.657.714,75	R$ 33.264.291,68
Year 16		-R$ 55.704.167,65	R$ 264.591.409,95	R$ 208.887.242,30	R$ 49.762.846,18
Year 17		-R$ 56.539.730,17	R$ 271.206.195,20	R$ 214.666.465,03	R$ 46.754.087,04
Year 18		-R$ 57.387.826,12	R$ 277.986.350,08	R$ 220.598.523,96	R$ 43.925.838,40
Year 19		-R$ 58.248.643,51	R$ 284.936.008,83	R$ 226.687.365,32	R$ 41.267.375,83
Year 20	-R$ 85.533.660,79	-R$ 59.122.373,16	R$ 292.059.409,05	R$ 147.403.375,09	R$ 24.532.908,94

Source: Elaborated by the authors

According with this scenario, at the end of the project, applying the NPV, IRR, profitability rate and discounted payback formulas, the following results are measured: TMA: 9.38%; NPV: R$ 991.13 millions; and IRR: 35.06%.

Conclusions

This scientific project proposed the implementation of a logistics solution for container transportation, via barges, between Terminal de Vila Velha - TVV, a container seaport located in the public port of Vitória - Southeast Brazil and the dry ports located in the hinterland of the port, with the use of an inland barge terminal working as an extended port gateway.

TVV is the sole container terminal in the State of Espírito Santo, which is located in Southeastern Brazil, the most developed economic region in the country. The storage area of the terminal is modest - approximately 100.000 sq meters. Because of that, TVV has got to be extremely efficient to meet the cargo demand. The average turnaround is 20 times a year. There is little room for expansion too and the only existing access is made by road.

Considering the predicted increase in the dry and liquid bulk throughput in the port in the upcoming years, which will generate great impact on the road modal, as well as the limitations for expansion in the storage area of the terminal, the transport of containers via barges is presented as a logistics solution to the system.

Despite the challenges in terms of infrastructure development (such as dredging and nautical beaconing in order to make Santa Maria river navigable), the proposal has shown to be socially and environmentally sustainable.

As it comes to the financial analysis, the project was considered feasible. Applying the NPV, IRR, profitability rate and discounted payback formulas, the following results are measured:

- Positive NPV;
- Internal rate of return of 35.06%, therefore higher than the adopted minimum attractiveness rate of 9.38% and ANTAQ's reference rate of 8.03%
- The discounted payback time was 4 years and 2 months.
- There is also a great opportunity for expanding revenues by adding accessory services to the terminal portfolio, such as dry bulk and project cargo handling.

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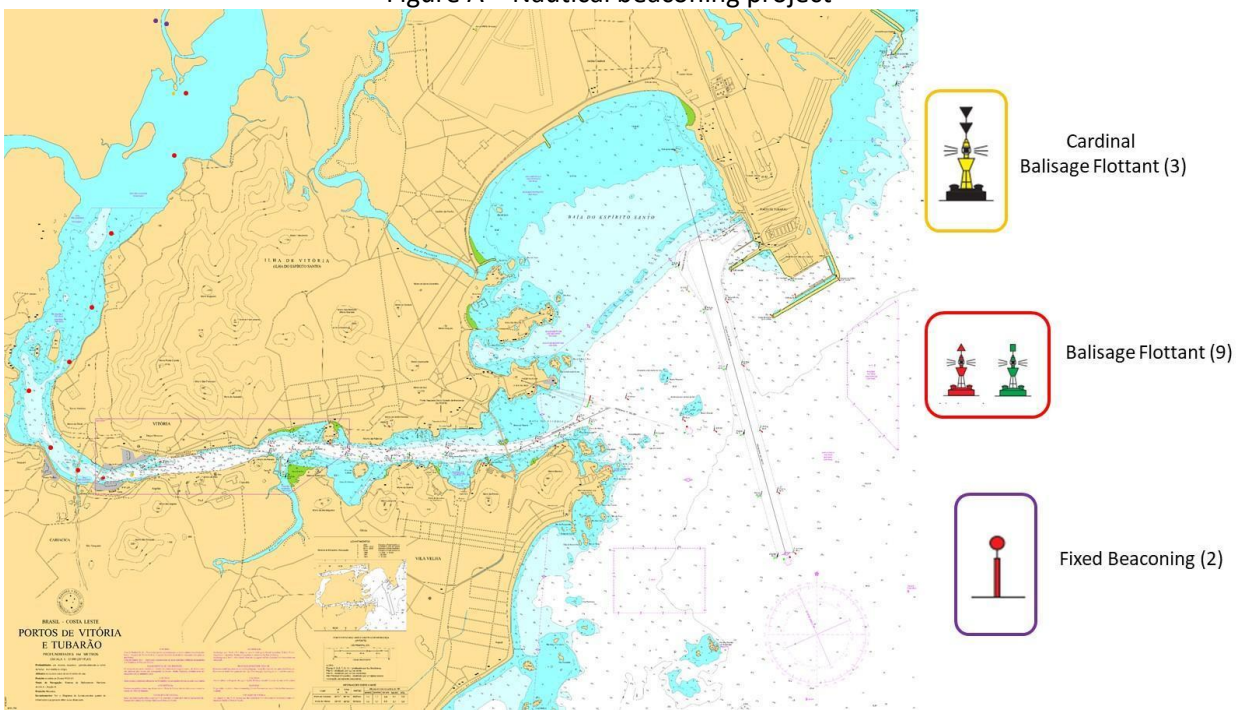
Appendix I - Required Investments – Port Authority

Nautical beaconing

The project complies with the premises of Maritime Standard Nº 17 (NORMAM 17), which recommends establishing rules, procedures and instructions on navigation aids, for application in Brazilian Jurisdictional Waters (AJB), thus contributing to the safety of navigation, the safeguarding of of human life at sea and the prevention of pollution in waterways.

Figure A – Nautical beaconing project



Source: Elaborated by the authors

Table A: Estimate of the investments required for the implementation of nautical beaconing

Description	Quantity	Unity Price	Total Price
Fixed Beaconing - Supply and Installation	2	R$ 18.879,81	R$ 37.759,62
Balisage Flottant - Supply and Installation	9	R$ 107.576,37	R$ 968.187,33
Cardinal Balisage Flottant - Supply and Installation	3	R$ 93.544,67	R$ 280.634,01
Total Cost			**R$ 1.286.580,96**

Source: Elaborated by the authors

Dredging

The projected terminal is located in a region of the mouth of the Santa Maria River, and to enable safe navigation, it will be necessary to carry out a maintenance cycle of deepening and development of the channel profile, following the Maritime Standard (NORMAM Nº 11) which has the purpose to establish procedures to standardize the request for an Opinion for the performance of works under, on and on the banks of the Brazilian Jurisdictional Waters (AJB), with regard to the planning of waterway space and navigation safety.

The materials to be dredged are those from the sedimentation process of the hydrodynamic interaction of the Santa Maria River estuary with all the contributions that the channel receives, including the effects of the tides, contributions from the drainage system of Cariacica, Vitória and Vila

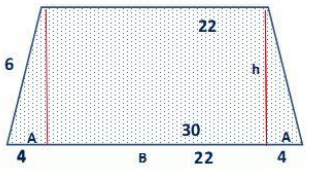
Velha, from all economic activities that make use of the Vitória channel and the stabilization of slopes resulting from the deepening dredging.

The channel region consists mostly of organic clay with a very soft consistency, and it does not expect to find rocks in the contractual frameworks.

Table B: Estimate of the investments required for the dredging

Coordenadas do empreendimento	
Latitude	20°13'27.32"S
Longitude	40°21'56.83"O

1) Determinação de altura e área



Características Operacionais	
Profundidade de Dragagem	6,0 m
Profundidade de Projeto	6,0 m
Largura	29,53 m
Extensão navegável (Silotec - TVV)	16,45 km
Extensão navegável	122 km

Item	PMU	Custo
Volume (m^3)		114.175,60
Dragagem	R$ 27,89	R$ 3.184.357,48
Movimentação de Boias (9)	9000	R$ 81.000,00
Mob/Desmob	R$ -	R$ 3.889.287,11
Gerenciamento Ambiental (Dragagem)		R$ 1.000.000,00
Gestão de Condicionantes (Rotina)		R$ 400.000,00
Custos Administrativos		R$ 64.000,00
Estudos Ambientais Lhpré		R$ 180.000,00
Total		**R$ 8.912.820,19**

Source: Elaborated by the authors

Appendix II - Required Investments

Appendix II A – Barges

Table C: Labor factor

Código	Descrição	Mensalista (%)
	Grupo A (Encargos Sociais Básicos)	**37,80**
A1	INSS	20,00
A2	SESI	1,50
A3	SENAI	1,00
A4	INCRA	0,20
A5	SEBRAE	0,60
A6	Salário-educação	2,50
A7	Seguro Contra Acidentes	3,00
A8	FGTS	8,00
A9	SECONDI	1,00
	Grupo B (Encargos Sociais que recebem incidência de A)	**16,97**
B1	Repouso Semanal Remunerado	0,00
B2	Feriados	0,00
B3	Auxílio-enfermidade	0,71
B4	13º Salário	8,33
B5	Licença Paternidade	0,06
B6	Faltas Justificadas	0,56
B7	Dias de Chuvas	0,00
B8	Auxílio Acidente de Trabalho	0,09
B9	Férias Gozadas	7,20
B10	Salário Maternidade	0,02
	Grupo C (Encargos Sociais que não recebem incidências globais de A)	**11,57**
C1	Aviso Prévio Indenizado	4,23
C2	Aviso Prévio Trabalhado	0,10
C3	Férias Indenizadas	3,32
C4	Depósito Rescisão sem Justa Causa	3,56
C5	Indenização Adicional	0,36
	Grupo D (Taxas incidÇencias e reincidências)	**6,79**
D1	Reincidência de A sobre B	6,41
D2	Reincidência de A sobre Aviso Prévio Trabalhado e Reincidência de FGTS sobre Aviso Prévio Indenizado	0,38
	TOTAL (A+B+C+D)	**73,13**

Table D: the crew cost (work schedule 12 x 36 hour)

Operação da Barcaça				
Cartão de Tripulação de Segurança	**Letra A**	**Letra B**	**Total**	**Valor**
MCB	1	1	2	R$ 15.909,99
CTR	1	1	2	R$ 14.681,18
MNC	1	1	2	R$ 10.266,24
MOC	1	1	2	R$ 9.086,59
CDM	1	1	2	R$ 14.132,17
MNM	1	1	2	R$ 11.646,79
Ferista	1	1	2	R$ 14.406,67
Subtotal	7	7	14	R$ 90.129,62
Labor Fator				73,13
Total per month				**R$ 156.041,41**

Appendix II B – Terminal

Infrastructure Investments						
Custos Engenharia e Administração	**Unit**	**Quantity**	**Unity Price**		**R$**	**3.755.121,00**
Elaboração de Projeto	und	1,00	R$	500.000,00	R$	500.000,00
Licenciamento Ambiental	und	1,00	R$	180.173,00	R$	180.173,00
Contingência	und	1,00	R$	324.948,00	R$	324.948,00
MOBILIZAÇÃO E DESMOBILIZAÇÃO	und	1,00	R$	300.000,00	R$	300.000,00
CANTEIRO DE OBRAS	und	1,00	R$	950.000,00	R$	950.000,00
ADMINISTRAÇÃO LOCAL	und	1,00	R$	1.500.000,00	R$	1.500.000,00
Plataforma do Berço	**Unit**	**Quantity**	**Unity Price**		**R$**	**89.972.787,02**
CARGA MANUAL DE ENTULHO EM CAMINHÃO BASCULANTE 6M³	m³	12.740,00	R$	150,96	R$	1.923.205,94
TRANSPORTE DE ENTULHO COM CAMINHÃO BASCULANTE DE 6M³	m³ x km	340.009,36	R$	7,30	R$	2.480.812,74
APLICAÇÃO DE ARGAMASSA POLIMÉRICA PROJETADA	m³	2.190,38	R$	7.773,08	R$	17.026.005,84
ARMAÇÃO DE PILAR OU VIGA DE UMA ESTRUTURA CONVENCIONAL DE CONCRETO ARMADO EM UM EDIFÍCIO DE MÚLTIPLOS PAVIMENTOS UTILIZANDO AÇO CA-50 DE 12,5MM - MONTAGEM. AF_12/2015	kg	635.201,55	R$	21,39	R$	13.584.247,57
FORMA DE CHAPAS DE MADEIRA PLASTIFICADA DE 17MM DE ESPESSURA, SERVINDO 1 VEZ, PARA VIADUTOS, INCLUINDO PEÇAS DE TRANSFERÊNCIA PARA ESCORAMENTO METÁLICO, EXCLUSIVE ESTE, INCLUSIVE FORNECIMENTO DE MATERIAIS E DESMOLDAGEM, EM LAJES, VIGAS, PAREDES, ETC. INCLUSIVE FORNECIMENTO DOS MATERIAIS E DESMOLDAGEM SERVINDO A MADEIRA 1 VEZ, TÁBUAS DE MADEIRA SERRADA, COM 2,5CM DE ESPESSURA, SERVINDO TAMBÉM PARA TRAVESSAS, EXCLUSIVE ESCORAMENTO.	m²	19.861,92	R$	150,96	R$	2.998.317,31
GROUTEAMENTO	ms	9.860,79	R$	3.703,00	R$	36.514.522,16
ESCAVAÇÃO MECANIZADA	ms	3.736,14	R$	31,45	R$	117.500,11
CARGA E DESCARGA DE MATERIAL	ms	32.440,80	R$	3,27	R$	106.106,02
REATERRO COMPACTADO	m³	16.220,40	R$	56,61	R$	918.225,17
FORNECIMENTO E LANÇAMENTO CONCRETO FCK 40MPA	m³	19.110,00	R$	691,89	R$	13.222.040,83
REATERRO COMPACTADO	m³	19.110,00	R$	56,61	R$	1.081.803,34
Defensas	**und**	**10**	**R$**	**43.376,28**	**R$**	**433.762,77**
Sinalização Transito	**und**	**1**		**365.545,32**	**R$**	**365.545,32**
Ferrovia	**Unit**	**Quantity**	**Unity Price**		**R$**	**3.302.087,86**
FORNECIMENTO E ASSENTAMENTO MECANIZADO DE TRILHOS, TR57, COMPRIMENTO DE 12M.	km	0,70	R$	202.554,00	R$	141.787,80
REGULARIZAÇÃO E COMPACTAÇÃO DE SUB-LEITO ATÉ 20CM DE ESPESSURA	m³	1.750,00	R$	17,20	R$	30.100,00
REFORÇO DO SUB-LEITO. INCLUSIVE TRANSPORTE E EXECUÇÃO	m³	140,00	R$	336,76	R$	47.146,40
SUB-BASE ESTABILIZADA GRANULOMETRICAMENTE COM MISTURA SOLO-AREIA NA PISTA (COM MATERIAL DE JAZIDA)	m³	140,00	R$	325,47	R$	45.565,80
FURAÇÃO, UTILIZANDO EQUIPAMENTO LEVE. DE TRILHO TR57	un	350,00	R$	68,00	R$	23.800,00
POSICIONAMENTO DE JOGO DE DORMENTES DE MADEIRA PARA AMV 1:8, BITOLA MÉTRICA	km	0,70	R$	14.694,94	R$	10.286,46
PRÉ-ALINHAMENTO MECANIZADO DA GRADE, PARA BITOLA, DORMENTE E TRILHO DE QUALQUER TIPO E COMPRIMENTO	km	0,70	R$	31.000,00	R$	21.700,00
PRÉ-LANÇAMENTO DE LASTRO, B. MÉTRICA, DESCARGA DE PEDRA BRITADA DE CAMINHÕES, INCLUSIVE FORNECIMENTO BRITA	m³	140,00	R$	261,76	R$	36.646,40
NIVELAMENTO CONTÍNUO COM SOCARIA MANUAL DA VIA AMV 1:10, COM 15CM DE LASTRO SOB O DORMENTE. BITOLA MÉTRICA DORMENTE DE MADEIRA	km	0,70	R$	83.000,00	R$	58.100,00
POSICIONAMENTO FINAL E ACABAMENTO MECANIZADO DA VIA CORRIDA, BITOLA MÉTRICA OU LARGA. DORMENTE DE MADEIRA	km	0,70	R$	25.000,00	R$	17.500,00
CORTE, COM UTILIZAÇÃO DE EQUIPAMENTO LEVE. DE TRILHO TR57	un	46,00	R$	80,00	R$	3.680,00
JOGO DE DORMENTES DE MADEIRA, PURO CERNE OU TRATADA. BITOLA MÉTRICA, PARA AMVS. ABERTURA 1:8	jg	1,00	R$	36.000,00	R$	36.000,00
JOGO DE DORMENTES DE MADEIRA, PURO CERNE OU TRATADA, BITOLA MÉTRICA, PARA AMVS. ABERTURA 1:10	jg	2,00	R$	36.000,00	R$	72.000,00
ASSENTAMENTO DE JOGO DE DORMENTES DE MADEIRA PARA AMV 1:8, BITOLA MÉTRICA	jg	1,00	R$	18.200,00	R$	18.200,00
ASSENTAMENTO DE JOGO DE DORMENTES DE MADEIRA PARA AMV 1:10. BITOLA MÉTRICA	jg	2,00	R$	18.200,00	R$	36.400,00
FORNECIMENTO DE AMV 1:10. TR57	jg	2,00	R$	567.800,00	R$	1.135.600,00
ASSENTAMENTO DOS MATERIAIS METÁLICOS DOS AMV 1:10. TR57. BITOLA MÉTRICA - DORMENTE DE QUALQUER TIPO.	un	2,00	R$	62.000,00	R$	124.000,00
FORNECIMENTO DE AMV 1:8 TR57	jg	1,00	R$	554.800,00	R$	554.800,00
ASSENTAMENTO DOS MATERIAIS METÁLICOS DOS AMV 1:8. TR57. BITOLA MÉTRICA - DORMENTE DE QUALQUER TIPO.	un	1,00	R$	62.000,00	R$	62.000,00
PRÉ-ALINHAMENTO MANUAL DA GRADE DO AMV 1:10.COM DORMENTE DE MADEIRA	un	2,00	R$	3.850,00	R$	7.700,00
PRÉ-ALINHAMENTO MANUAL DA GRADE DO AMV 1:8, COM DORMENTE DE MADEIRA	un	1,00	R$	3.850,00	R$	3.850,00
LANÇAMENTO MANUAL DE LASTRO EM AMV. COM DESCARGA DA BRITA POR CAMINHÃO	m³	6,00	R$	50,00	R$	300,00
NIVELAMENTO SOCARIA MANUAIS DE AMV 1:8. BITOLA MÉTRICA - COM ATÉ 20CM ALTURA LASTRO E QUALQUER TIPO DE DORMENTE	un	1,00	R$	24.000,00	R$	24.000,00
NIVELAMENTO E SOCARIA MANUAIS DE AMV 1:10. BITOLA MÉTRICA - COM ATÉ 20CM ALTURA LASTRO E QUALQUER TIPO DE DORMENTE	un	2,00	R$	25.000,00	R$	50.000,00
ALINHAMENTO MANUAL DE AMV 1:8, PARA QUALQUER ABERTURA E QUALQUER BITOLA	un	1,00	R$	2.540,00	R$	2.540,00
ALINHAMENTO MANUAL DE AMV 1:10. BITOLA MÉTNCA. COM DORMENTE DE MADEIRA OU AÇO - TRILHO DE QUALQUER TIPO	un	2,00	R$	2.540,00	R$	5.080,00
POSICIONAMENTO FINAL E ACABAMENTO MEC. DE AMV 1:8. BITOLA MÉTRICA - QUALQUER TIPO DE DORMENTE E TRILHO	un	1,00	R$	1.160,00	R$	1.160,00
POSICIONAMENTO FINAL E ACABAMENTO MEC DE AMV 1:10. BITOLA MÉTRICA - QUALQUER TIPO DE DORMENTE E TRILHO	un	2,00	R$	1.160,00	R$	2.320,00
PAVIMENTAÇÃO EM BLOCO DE CONCRETO SEXTAVADO ESPESSURA DE 10 CM. ASSENTADO SOBRE COLCHÃO DE PÓ DE PEDRA, AJUSTE COM ARGAMASSA TRAÇO 1:4 (CIMENTO E AREIA) COM REAPROVEITAMENTO DE BLOCO DE CONCRETO- PISO NOVO	m²	6.575,00	R$	111,00	R$	729.825,00
Rede elétrica	**und**	**1**		**1.225.805,90**	**R$**	**1.225.805,90**
Iluminação	**und**	**1**		**319.374,31**	**R$**	**319.374,31**
Drenangem e obras de arte correntes	**und**	**2**		**2.426.765,01**	**R$**	**4.853.530,02**
Total Cost						**R$ 104.228.014,20**

Appendix II C – “Canal dos Escravos” bridge

New "Canal dos Escravos" Bridge - Contour Highway				
Description	**Unity**	**QTD**	**Unit Price**	**Total Price**
Serviços Preliminares				**R$ 2.207.533,21**
Capina e Limpeza Manual de terreno	m^2	450,00	R$ 2,05	R$ 921,06
Escavação carta e transporte solos moles DMT 0 a 200 m	m^3	3.750,00	R$ 26,97	R$ 101.136,00
Coleta, transporte e destinação finalo de resíduos	m^3	3.750,00	R$ 444,76	R$ 1.667.841,00
Demolição Manual de estrutura de concreto armado	m^3	179,52	R$ 379,47	R$ 68.121,81
Escavação em rocha branda a frio	m^3	840,00	R$ 383,16	R$ 321.858,10
Carga mecanizada de rocha em caminhão basculante	m^3	1.768,20	R$ 5,30	R$ 9.367,22
Transporte com caminhão basculante de 14 m3 em via urbana em leito natural	m^3 x km	17.952,00	R$ 2,13	R$ 38.288,03
	Unity	**QTD**	**Unit Price**	**Total Price**
Infraestrutura e fundações				**R$ 3.276.798,46**
Ensecadeira de madeira com parede dupla	m^2	468,72	R$ 596,50	R$ 279.589,61
Escoramento comum em valas tipo contínuo c/ pranchas peroba	m^2	525,00	R$ 128,69	R$ 67.562,46
Equipamento de rebaixamento de lençol freático	dia	360,00	R$ 344,00	R$ 123.840,00
Estaca raiz Diâmetro 310 mm - até 90 tf	m^2	2.880,00	R$ 450,59	R$ 1.297.694,59
Estaca raiz Diâmetro 410 mm - até 125 tf	m^2	864,00	R$ 650,85	R$ 562.332,67
Lona Plástica preta 150 micra	m^2	468,00	R$ 1,70	R$ 796,91
Confecção e lançamento de concreto magro betoneira AC/BC	m^3	23,40	R$ 452,65	R$ 10.592,07
Escoramento para obras de artes correntes	m^3	2.165,64	R$ 79,00	R$ 171.084,69
Forma Tábua p/ concreto em fundação s/reaproveitamento	m^2	1.110,90	R$ 203,58	R$ 226.156,13
Fornecimento, dobragem e colocação em forma de armadura CA-50 A grossa diâmetro de 12, 5 a 25 mm	kg	17.838,00	R$ 9,46	R$ 168.747,48
Concreto estrutural fck=30 Mpa	m^3	560,40	R$ 595,58	R$ 333.765,50
Aparelho apoio neoprene fretado	dm^3	243,00	R$ 142,54	R$ 34.636,35
	Unity	**QTD**	**Unit Price**	**Total Price**
Superestrutura				**R$ 2.716.485,41**
Escoramento para estrutura de obras de artes correntes	m^3	3.600,00	R$ 79,00	R$ 284.398,56
Concreto estrutural fck=30 Mpa	m^3	789,00	R$ 595,58	R$ 469.916,09
Fornecimento, dobragem e colocação em forma de armadura CA-50 A grossa diâmetro de 12, 5 a 25 mm	kg	106.143,27	R$ 9,46	R$ 1.004.115,33
Sistema pré-fabricado de forma metálica	m^2	1.440,00	R$ 44,72	R$ 64.396,80
Montagem, desmontagem e reparos em formas p/pré moldados	m^2	1.440,00	R$ 95,51	R$ 137.536,70
Ancoragem Ativa para cabo com 12 cordoalhas	UN	162,00	R$ 942,96	R$ 152.758,81
Fornecimento e colocação de cantoneira de ferro	kg	5.087,82	R$ 57,69	R$ 293.510,23
Confecção e colocação de cabo com 12 cordoalhas	kg	12.830,40	R$ 18,25	R$ 234.144,54
Passeio cimentado camurçado com argamasa de cimento e areia	m^2	300,00	R$ 134,50	R$ 40.351,20
Guarda corpo metálico - cromado	m	96,00	R$ 368,30	R$ 35.357,15
Total Cost				**R$ 8.200.817,07**

Appendix II D – Workforce and management of the new terminal

Terminal Operation and Administration			
Job role	**Salary**	**Quantity**	**Monthly cost**
Manager	R$ 20.016,68	1	R$ 34.654,88
Mechanical	R$ 4.389,47	6	R$ 45.596,92
Electrician	R$ 5.706,31	1	R$ 9.879,33
Planner	R$ 5.680,43	5	R$ 49.172,64
Supervisor	R$ 6.458,83	3	R$ 33.546,52
Administrative Assistant	R$ 2.611,47	2	R$ 9.042,48
Operator	R$ 4.003,18	90	R$ 623.763,50
Chief Clerk	R$ 5.680,43	6	R$ 59.007,17
Operation leader	R$ 4.383,33	5	R$ 37.944,30
Safety technician	R$ 4.389,47	5	R$ 37.997,43
Stockman	R$ 2.952,08	1	R$ 5.110,94
Biller	R$ 5.680,43	3	R$ 29.503,59
Subtotal			**R$ 975.219,68**
Factor			73,13
Total			**R$ 1.688.397,83**