

ATTACHMENT 1

TERMS OF REFERENCE

EXPRESSION OF INTEREST - EOI

NEW FERROESTE PROJECT

(DOURADOS/MS – PARANAGUÁ/PR – PONTAL DO PARANÁ/PR)

(Portuguese version is the official version, any divergence, the official version should be consulted)

SUMMARY

| | |
|--------------------------------------------------------------------------|-----------|
| 1. INTRODUCTION | 4 |
| 2. OBJECTIVE | 7 |
| 3. PREMISES OF THE PROJECT | 8 |
| 4. GUIDELINES FOR THE ELABORATION OF THE FEASIBILITY STUDIES..... | 9 |
| 5. DEADLINES | 10 |
| 6. BOOK 1: TECHNICAL-OPERATIONAL AND ENVIRONMENTAL STUDIES..... | 10 |
| 6.1 VOLUME 1: DEMAND STUDIES | 11 |
| 6.1.1 Introduction..... | 11 |
| 6.1.2 Methodological Aspects..... | 11 |
| 6.1.3 Results | 13 |
| 6.1.4 Definition of the Preliminary Layout | 13 |
| 6.2 VOLUME 2: ENVIRONMENTAL STUDIES | 14 |
| 6.3 VOLUME 3: ENGINEERING STUDIES | 18 |
| 6.3.1 Topographic Studies..... | 18 |
| 6.3.2 Geometric Tracing | 23 |
| 6.3.3 Geological-Geotechnical Studies | 27 |
| 6.3.4 Hydrological and Hydraulic Studies | 35 |
| 6.3.5 Earthworks | 36 |
| 6.3.6 Drainage Structures..... | 37 |
| 6.3.7 Bridges, viaducts, and other similar structures..... | 39 |
| 6.3.8 Railway Superstructure..... | 41 |
| 6.3.9 Interferences and complementary constructions..... | 42 |
| 6.3.10 Operational Control Center (OCC)..... | 44 |
| 6.3.11 Signaling Systems | 44 |
| 6.3.12 Telecommunications Systems | 45 |
| 6.3.13 Power System | 45 |
| 6.3.14 Execution Plan for the Construction..... | 46 |
| 6.4 VOLUME 4: OPERATIONAL STUDIES..... | 47 |
| 6.5 VOLUME 5: BUDGET AND SCHEDULE | 51 |
| 6.5.1 Budget..... | 51 |
| 6.5.2 Investment Costs..... | 53 |
| 6.5.3 Operational Costs and Expenses..... | 54 |

| | | |
|-----------|---------------------------------------------------------------------------|-----------|
| 6.5.4 | Physical Financial Schedule | 55 |
| 7. | BOOK 2: ECONOMIC AND FINANCIAL STUDIES AND EXTERNALITY STUDIES ... | 56 |
| 7.1 | VOLUME 1: ECONOMIC AND FINANCIAL STUDIES..... | 56 |
| 7.2 | VOLUME 2: EXTERNALITY STUDIES..... | 60 |
| 7.2.1 | Direct and Indirect benefits | 60 |

1. INTRODUCTION

Paraná is a state that is constantly growing due to its dynamism in industry, services and agriculture, thus being placed between the fourth and fifth largest economy of the country in relation to GDP.

Due to its characteristics, Paraná has a strong participation in the agribusiness sector. The fertility of its soil and the climate of Paraná contribute to the diversification of production over the years, and thus agriculture plays a fundamental role in the economic growth of the State.

The state of Mato Grosso do Sul has an economy based mainly on livestock and agriculture. The most cultivated agricultural products in Mato Grosso do Sul are: soy, corn, wheat, rice, coffee, cotton, cassava, beans, sugar cane and peanuts.

In 2016, according to the Brazilian Institute of Geography and Statistics - IBGE, Mato Grosso led as the largest national grain producer, being responsible for 23,9% of the total production, followed by Paraná, with 19,3%. Most of the agricultural products produced in Brazil are exported through ports. In Paraná, the Port of Paranaguá stands out, currently exporting approximately 75% of the state's agricultural production.

The past few years brought record-breaking operation levels in almost all product categories moved through the Port of Paranaguá, making Paraná's economy more dynamic and thrusting it forward. The main products exported through the port included soy, corn, wheat, and sugar.

On the other hand, in support of farmers, Paranaguá is the largest and most important port in the import of fertilizers, receiving 9.5 million tons of the product every year, which represents more than 35% of all fertilizers imported by Brazil.

In the current infrastructure conditions, 80% of all imports and exports that go through the Port of Paranaguá are transported through roads. The remaining products are transported through the current rail network, which in some segments is close to their maximum capacity. Currently, the main bottlenecks are in Serra da Esperança (between Guarapuava and Ponta Grossa) and the Serra do Mar (between Curitiba and Paranaguá).

The railway that serves the Port of Paranaguá, currently operated by Rumo, is over a hundred years old and is of cultural and tourist interest in the segment that crosses the Serra do Mar. Its geometry does not favor a good operational performance of the freight trains that circulate until Paranaguá. Due to these constraints, the operational design is complex. Because it is a single-track railway, the operation is slow, especially in hilly stretches, causing long wait times. In addition, because there are no alternative tracks, the current railway is subject to blockages and interruptions in case of falling barriers, accidents, or malfunctions in the rolling stock.

The transportation of freight through rail presents other bottlenecks, such as the need for expanding rail yards and the lack of distribution centers, intermodal platforms, and storage warehouses along the railway.

Another problem to be solved is related to the railway section that crosses the metropolitan region of Curitiba, since the increase of freight transportation may conflict with the increasing urban occupation.

Considering the agricultural production capacity of Paraná and Mato Grosso do Sul and the high rate of production exports, there is an urgent need to implement an efficient freight transportation infrastructure to meet the growing demand of the State, thus contributing to its economic development.

In order to analyze the demand for freight in the State of Paraná, a Multisector Working Group for the State Export Corridor (GT/CE, in its original abbreviation), through Resolution nº 03/2016, in the State Secretariat of Planning and General Coordination (SEPL, in its original abbreviation). The group works with the purpose of developing studies on the capacity of the export railway corridor in the State of Paraná. The conclusions from these studies were published, and they indicate a significant increase in the demand for freight transportation, considering the projections for the coming years.

In addition, a Working Group for the development of new railway projects in the State of Paraná was established through Concession Management Council (CGC, in its original abbreviation) Resolution nº 04/2016. This Working Group concluded that technical-operational, economic-financial and environmental studies are necessary for the structuring of the **NEW FERROESTE** (hereinafter, "**PROJECT**").

The aforementioned Working Group consulted the State Attorney General's Office (PGE, in its original abbreviation) on some legal issues concerning the **PROJECT**. Through Opinion 03/2017, the PGE consolidated the following understanding:

- (i) from the legal point of view, there is no impediment to the Concession, by the State of Paraná, of the rail network in its territory;
- (ii) the State of Paraná already has legislative authorization for the Concession and for the Subconcession of public intercity rail services, as established in the sole paragraph of Article 1 of Complementary Law nº 76 of December 21, 1995.

For the structuring of the **PROJECT**, it will be necessary to carry out Technical-Operational, Economic-Financial and Environmental **FEASIBILITY STUDIES**, seeking solutions that enable the elimination of the current bottlenecks in the existing system, in addition to fully and effectively meeting the current freight transportation demand with efficiency, safety, and the best cost-benefit ratio.

The **PROJECT** will be composed of 02 (two) rail **SEGMENTS**:

(i) **SEGMENT 1 - GUARAPUAVA** to the **PORT OF PARANAGUÁ** and an extension to the future port complex of Pontal do Paraná, in the **STATE OF PARANÁ** (State Concession);

(ii) **SEGMENT 2 - DOURADOS**, in the State of **MATO GROSSO DO SUL**, to **GUARAPUAVA**, in the **STATE OF PARANÁ** (Federal Subconcession).

The **ESTRADA DE FERRO PARANÁ OESTE S.A.** (also known by its alias "**FERROESTE**") company, a mixed economy company, created in accordance with the provisions of Federal Law No. 9,892 of 31 December 1991, linked to the State Secretariat of Infrastructure and Logistics – **SEIL**, already operates a Federal Concession, for a period of 90 (ninety) years, pursuant to Contract No. 27.101.003.089, signed on May 23, 1989, with the Federal Government, through the Ministry of Transportation, for **SEGMENT 2**.

The Federal Concession of **FERROESTE** took place via Federal Decree No. 96,913, of 3 October 1988, which grants "*the right to construct, use, and enjoy a railway in the general east-northwest direction, extending the rail network of the State of Paraná from the Guarapuava region to the region of Cascavel; a railway branch from the region of Cascavel to the region of Dourados, in the State of Mato Grosso do Sul, and also extensions necessary for the feasibility of the railway, in order to provide efficient and low cost transportation adequate to the flow of agricultural production and other products of agricultural, energy, mineral, and industrial nature*".

From 2011, the State Government resumed investments in the company with the objective of maximizing the railway transportation of products from the West of Paraná. However, the concession of only one railway segment within the production zone did not constitute a sufficient and adequate response to the needs of production expansion and social development of the State.

Motivated by the facts exposed above, the **STATE OF PARANÁ**, through **FERROESTE**, the **STATE SECRETARIAT OF INFRASTRUCTURE AND LOGISTICS – SEIL**, and the **STATE SECRETARIAT OF PLANNING AND GENERAL COORDINATION - SEPL**, hereby publicizes to the interested parties the present **TERMS OF REFERENCE** containing the guidelines for the establishment of a Procedure of Expression of Interest (hereinafter abbreviated as **EOI**) for structuring the project of the **NOVA FERROVIA DOURADOS/MS – PARANAGUÁ/PR – PONTAL DO PARANÁ/PR**.

The implementation of a railway corridor such as proposed is a logistical option that could reduce current freight costs.

In addition, other benefits will come from the economic and social return of investment on more efficient infrastructure, such as:

- Significant reduction in fuel consumption;

- Reducing the emission of pollutants, especially greenhouse gases, which results in a significant reduction of environmental damages;
- Reduction in the number of highway accidents;
- Reduction of transport costs, increasing the competitiveness of enterprises located along of the route of the railways, providing the decentralization of investments, catalyzing the generation of new enterprises and the consequent generation of permanent jobs;
- Generation of temporary jobs during the execution of the railway construction and permanent jobs during the operation of the railway, in addition to tax collection at all levels of Public Administration.

2. OBJECTIVE

The purpose of these **TERMS OF REFERENCE** is to define the guidelines and minimum requirements for carrying out the Technical-Operational, Economic-Financial, Environmental, and Externality **FEASIBILITY STUDIES** for the structuring competitive bidding processes:

(i) A **STATE CONCESSION** for the implementation, operation, management, and maintenance of Rail Freight Transportation between **GUARAPUAVA** and **PORTO DE PARANAGUÁ**, in Paraná, including a branch providing access to the port complex in **PONTAL DO PARANÁ** (hereinafter, "**SEGMENT 1**");

(ii) A **FEDERAL SUBCONCESSION** for the implementation, operation, management, and maintenance of Rail Freight Transport, between **DOURADOS**, in Mato Grosso do Sul, and **GUARAPUAVA**, in Paraná (hereinafter "**SEGMENT 2**").

Through the **EOI**, the **STATE OF PARANÁ** seeks information aiming to, among others:

- Define basic parameters for the structuring of a technical-operational model for the implementation of a rail transportation service for freight coming from the entirety of the **PROJECT**, as composed of 02 (two) railway **SEGMENTS**;
- Enable the interoperability of these 02 (two) **SEGMENTS**, as well as with the existing railway, in addition to the right of way for independent operators;
- Justify the economic and financial feasibility of each of the 02 (two) **SEGMENTS** that make up the **PROJECT**, considering the existing demand for export and import freight;
- To allow freight transportation to the **PORT OF PARANAGUÁ**, in a fast, safe, efficient, and economically attractive manner;

- To seek the best route for the implementation of the **PROJECT**, considering the use of the Railway already in operation between **CASCADEL** and **GUARAPUAVA**, in Paraná, by **FERROESTE**.

3. PREMISES OF THE PROJECT

The studies should consider that the services of freight transportation in the **PROJECT** has as their main objective the service in both **SEGMENTS**.

In order to make the **PROJECT** more attractive, the **PROPONENTS** may propose the inclusion of other railway extensions, as well as offer alternative services and suggestions that they deem appropriate.

The methodologies to be followed should comply with the standards, manuals, instructions, procedures, and specifications in force in the country, and complemented, when applicable, by standards issued by international organizations.

The **PROPONENTS** should present the route layout that they deem most technically and economically feasible for the **PROJECT**, considering, necessarily, the railway already implemented and in operation by **FERROESTE**, between **CASCADEL** and **GUARAPUAVA**, in Paraná, with a length of 248 km.

Scenarios can be traced by designing mixed and broad gauge, track duplication, and tunnel gauge tuning for dual carriage designs, provided the integration with the current metric rail network.

The route of the new railway may not use the railway network (between **GUARAPUAVA** and **PARANAGUÁ**), nor the domain range, that already exists and is operated by the concessionaire in charge of the management of *Malha Sul*.

The new route of the railway should consider the increasing urban occupation of the Metropolitan Region of Curitiba, and cause minimal interference to the urban area.

The **FEASIBILITY STUDIES** should demonstrate that, of all the possible route alternatives, the route of the new railway or the intervention presented by the **PROPONENT** offers the greatest benefits in terms of low environmental impact and low construction costs.

It will be a responsibility of the **PROPONENTS** to propose the deployment stages of the two **SEGMENTS** that comprise the **PROJECT**, in order to make the enterprise viable.

The duration of the concession shall be an object of study in the EOI and **PROPONENTS** must propose scenarios with different end dates for the concession, in accordance with the enterprise's economical and financial viability.

In order to define a layout for the **PROJECT**, **PROPOSERS** may analyze the following documents:

- http://pilferrovias.antt.gov.br/index.php/content/view/1201/Maracaju_MS_Lapa_PR.html
- http://pilferrovias.antt.gov.br/index.php/content/view/1313/Lapa_PR_Paranagua_PR.html

This set of documents shall be, hereinafter, in these **TERMS OF REFERENCE**, referred to as **PAST STUDIES/ANTT**.

All data used in **PAST STUDIES/ANTT**, as well as its sources and adopted premises, may be employed for fulfilling the requirements of these **TERMS OF REFERENCE**, as long as they are updated, complemented, and refined – particularly the topographical data, geological and geotechnical data, and all data concerning railway capacity, which must be analyzed during the elaboration of the **FEASIBILITY STUDIES** by the **PROPOSER**.

4. GUIDELINES FOR THE ELABORATION OF THE FEASIBILITY STUDIES

PROPOSERS must present all studies, surveys, investigations, and projects, indicating the premises that serve as the basis for the conclusions made in each case and for each **SEGMENT** of the **PROJECT** separately.

All secondary sources used in the studies, as well as the premises adopted, must be updated and, whenever necessary, complemented. This must be the case especially for topographical and geological data.

PROPOSERS must manifest their interest for the entirety of the **PROJECT**, between **DOURADOS**, in **MATO GROSSO DO SUL**, and the **COAST OF THE STATE OF PARANÁ** (**PORTO DE PARANAGUÁ** and an extension to the Port Complex of **PONTAL DO PARANÁ**). However, the **FEASIBILITY STUDIES** for each **SEGMENT** must be delivered separately. The **FEASIBILITY STUDIES** must also be divided as follows:

- **Book 1:** Technical-Operational and Environmental Studies;
- **Book 2:** Economical-Financial and Externality Studies.

The **FEASIBILITY STUDIES** must follow the sequence:

- Demand Studies;
- Environmental Studies;
- Engineering Studies;

- Project Costs Studies;
- Economical and Financial Studies;
- Externality Studies.

However, all **FEASIBILITY STUDIES** must have a simultaneous beginning and development schedule so that, , it will be possible to identify the best alternatives for the layout of the new railway or intervention, in the case of adjustments to the capacity and changes to the layout of the segments currently under the responsibility of **FERROESTE**.

During the development of the **FEASIBILITY STUDIES**, from the Demand Studies to the Engineering Studies, the **PROPONENTS** must calculate the benefits associated to the socioeconomical analysis of the alternatives, which must be contemplated in Book 2.

The **FEASIBILITY STUDIES** must obey the specifications relative to the services and materials used in them, as described by *Associação Brasileira de Normas Técnicas* (ABNT), and by the Resolutions of the *Agência Nacional de Transportes Terrestres* (ANTT). Whenever said specifications are not available from these agencies, the regulations issued by the American Railway Engineering and Maintenance (AREMA), by the American Society for Testing and Materials (ASTM), and by the International Union of Railway – UIC may be used.

All **FEASIBILITY STUDIES** must be delivered to the Coordenação de Concessões e Parcerias (**CCP**, in its original abbreviation) in 2 digital copies. One file must be in the PDF format, and the other file must be in a format that allows full access to its contents, along with all other files, appropriately identified and formatted, that may be necessary for the delivery of the formulas and other links between the spreadsheets that serve as basis for the **FEASIBILITY STUDIES**.

PROPONENTS that have their studies chosen for the structuring of the **PROJECTS** must deliver, in the end of the process, one printed copy of the **FEASIBILITY STUDIES**.

5. DEADLINES

The provisional period for the elaboration of the **FEASIBILITY STUDIES** and other projects that are the object of these **TERMS OF REFERENCE** is of **270 (two hundred and seventy) days**, counting from the date of publication of the authorization to **PROPONENTS**.

6. BOOK 1: TECHNICAL-OPERATIONAL AND ENVIRONMENTAL STUDIES

The Technical-Operational and Environmental Studies for each of the two **SEGMENTS** of the **PROJECT** must be analyzed and delivered by the **PROPONENTS** as explained below:

6.1 VOLUME 1: DEMAND STUDIES

6.1.1 Introduction

The scope of the Demand Studies includes the analysis of the existing production of freight with a potential to be transported through the **PROJECT**, in addition to the projection of this demand throughout the duration of the Concession, the interference of other means of transportation, and the analysis of the impact of other modes of transportation on the **PROJECT**.

They also must also include the Interoperability Studies, showcasing the benefits of a continuous rail network that is able to interact with other existing networks and with new rails to be constructed afterwards, as well as accesses to these networks.

In these circumstances, the **PROJECT**, as comprised by two rail **SEGMENTS**, must be planned to be coherent and to be a continuation of the infrastructural features, rolling stock, safety features, service quality, and cost-benefit ratio of the existing network, considering the interoperability between the 02 (two) **SEGMENTS**, between the new **SEGMENTS** and the existing network, and between the new **SEGMENTS** and new rails that shall be constructed in the future.

The Demand Studies must be presented in accordance with the following:

- **Chapter 1 - Methodology**: This chapter intends to showcase the methods used for the definition of the area to be studied, for the design of the origin-destination matrix, for the projection of demand, and for the allocation of freight; and
- **Chapter 2 – Results**: the **PROPONENTS** must demonstrate the demand allocated to the railway being studied, with an analysis of the nature of the freight, with a focus on the main products, an analysis for each **SEGMENT**, and an analysis concerning the right of way for each concessionaire.

6.1.2 Methodological Aspects

In this section, it is a responsibility of the **PROPONENTS** to demonstrate the methods used for the execution of the Demand Studies, taking the following stages into consideration:

6.1.2.1 Definition of the Area of Study

In order to define the Area of Study, **PROPONENTS** must take into consideration an area of coverage large enough to hold most origins and destinations in the

transportation dynamics of the region that will be serviced through the installation of the **PROJECT**.

6.1.2.2 Structuring of the Origin-Destination Matrix

In order to assemble the origin-destination matrix, **PROPONENTS** must identify the important origins and destinations in the Area of Study, as well as the groups of products to be analyzed, aiming to identify the origins and destinations that might be relevant for the feasibility of the **PROJECT**.

It is also important to consider the seasonal features of each product, as well as their density, in the research concerning origins and destinations.

PROPONENTS may also take into consideration the expansion of the Area of Study in order to enable the construction of rail extensions for servicing specific transportation dynamics.

6.1.2.3 Definition of the Product Groups

From the mapping of freight with the potential to be transported through the two **SEGMENTS** of the **PROJECT**, it will be a responsibility of the **PROPONENTS** to present the Product Groups with freight that might be of interest to each **SEGMENT** being studied.

6.1.2.4 Methodology and Demand Projections

PROPONENTS must showcase their methodology for the elaboration of the Demand Projections, in accordance with the previously executed studies.

6.1.2.5 Allocation of Demand Dynamics in a Network

After the freight demand is projected, it will be a responsibility of the **PROPONENTS** to identify various possible flows to be transported.

The scope of this item includes the mitigation of logistical costs and the definition of the rail layout through the identification of optimal routes, considering the **distances, travel times, and logistical costs** for each transportation mode available between each origin-destination pair.

Rail transportation is essentially dependent on the multiplicity of available transportation modes, thus requiring, in most cases, integration with other transportation modes, mainly highway transportation and waterway transportation.

For that reason, the multimodal network of the Area of Influence of the **PROJECT** must be analyzed, considering the logistical integration structures for interacting with other modes of transportation as well as with the existing rail network.

Logistical costs must include, at least, freight costs, regular storage costs, freight losses, insurance costs throughout the route, storage costs while in transit, transshipment costs, and insurance costs against losses in the rail and waterway terminals.

PROPONENTS must compare the freight data for rail, highway, and waterway transportation, and classify them according to the product groups and distributing the groups by distance ranges for each means of transportation.

The volumes moved in each freight center (that is, regions that provide large amounts of freight for the operation of the railway) as defined in the **PROJECT** must be identified for each level of demand, according to their direction (imports and exports) and to the type of product being transported (considering products that are currently serviced by these poles and that might be serviced by them in the future).

6.1.3 Results

6.1.3.1 Results of the demand projection

Here, **PROPONENTS** must demonstrate the results of the studies developed focusing on the potential demand allocated on the railway, considering the date when it begins operation up until the end of the projected period, along with growth projections.

Types of freight must be considered and analyzed individually as regards their associated demand. For each type of freight, a deeper analysis of the most representative products in the West of Paraná must be carried out.

6.1.3.2 Results of the right of way per concessionaire

Here **PROPONENTS** must quantify viable uses of the two **SEGMENTS** that are part of the **PROJECT** by the concessionaires, as well as their quantity relative to the total usage, in addition to the right of way by independent operators.

6.1.4 Definition of the Preliminary Layout

After the Demand Studies are executed and its results, along with the ensuing definition of the preliminary layout, based on the data studied and analyzed by the **PROPONENTS**, are elaborated, the compatibility between said preliminary layout and the field studies performed by the project team must be analyzed. This analysis must take into consideration, among other factors, the environmental aspects and the geotechnical analysis for the improvement and the definition of the layout proposed:

For **SEGMENT 1**, starting in **GUARAPUAVA** and reaching the **PORT OF PARANAGUÁ/PONTAL DO PARANÁ**, in Paraná;

For **SEGMENT 2**, starting in **DOURADOS, MATO GROSSO DO SUL**, and reaching **CASCATEL**, in Paraná, where there shall be a connection with the segment that is currently operated by **FERROESTE**, between **CASCATEL** and **GUARAPUAVA**, in Paraná.

6.2 VOLUME 2: ENVIRONMENTAL STUDIES

The Environmental Studies must describe, throughout the conception of the **FEASIBILITY STUDIES**, the environmental situation of the Area of Influence, as regards physical, biotic, and anthropic aspects, and thus identify possible situations that may affect the layout proposed by the **PROPONENT**, as well as develop a prognosis of the effects generated by the implantation and operation of the railway, especially concerning the environmental impact coming from the works and from environmental liabilities.

Environmental analysis plays an important role in the development of layout alternatives and of engineering solutions that are applicable to each case, serving as an alert concerning the conditions that may restrict the access options and possible implications of specific interferences, as well as the generation of undesired effects.

For the physical environment, studies must include, at least, analysis concerning topography, geology, geomorphology, climate, land usage and occupation, hydrographic basins, and land geotechnical features.

Concerning the biotic environment, studies must include a detailed description of the region's flora and fauna, especially of the forest remainders and other types of natural vegetation that may be impacted by the construction of the railway. They must also include the identification of the legally protected areas in the region, along with information concerning the distance between such areas and the construction site.

Studies on the associated anthropic aspects must present a synthesis of the current socioeconomic situation of the main communities to be affected by the construction of the railway, the identification, location, and a short description of the nearby areas of historical, archeological, speleological, cultural, scenic, and ecological value, in addition to indigenous areas.

Environmental analysis shall have an important role for the development of the Engineering Projects, carrying a warning as to the restrictions that may intercept restricted areas and the possible implications of deviations.

The Environmental Studies shall have the fundamental objective of diagnosing the impacts and obstacles that will be imposed to the deployment of the **PROJECT**, especially as regards the existence of Environmental Conservation Units, of indigenous reserved areas, of quilombola areas, of resources that guarantee the survival of traditional populations, of protected areas such as caves, of aquifers and

water springs, of the need for interventions in urban areas (and size thereof), and more.

The environmental guideline of avoiding increasing the conflicts of railway traffic near urban areas must be observed through the adoption of the recommendation to deploy the rail tracks away from urban agglomerations, especially as regards the development of the rail layout going through the Greater Curitiba area.

With the evaluation of the Environmental Studies, the **PROPONENTS** must take into consideration the environmental aspect under the perspective of the impact generated by the physical deployment of the railway as well as under the legal perspective.

The legal analysis must be performed taking into consideration the objective legal restrictions (those in which the law clearly defines the length of safety spaces and other dimensions that must be followed) and non-objective legal restrictions (in which cases there is a legal restriction in place, but with no numerical or quantitative parameters that must be followed, such as dispositions concerning conservation units of sustainable use).

The existence of areas that must be protected and other restrictive measures concerning the usage of the land for railway activities (in conditions such as urban areas and areas protected by law) must be confirmed with the organ competent for doing so.

Environmental Studies must identify:

Areas of Necessary Deviation: These are areas that, under the technical and legal perspective, are not recommended for the deployment of railway tracks, due to them being protected by objective legal restrictions.

Said areas include places in which there are registered underground natural cavities, Full Protection Conservation Unites, sites with historical remnants of quilombos, and areas occupied by indigenous communities.

Areas of Preferential Deviation: These are areas in which relevant environmental features are evident but where, considering the occasion of and the depth of the study being developed, it is not possible to precisely identify the presence of environmental features upon which the law imposes objective prohibitions.

In the future, however, with a detailed analysis of the environmental intervention of this venture, on the occasion of its environmental licensing, the **PROJECT** may find delicate zones as regards their environmental implications, including zones under objective legal prohibitions.

These zones may be areas with a high potential of underground natural cavities (these areas are suggested to be avoided as Environmental Studies concerning them have not been performed yet) and Forest Areas.

Areas of Negotiable Deviations: These are areas in which it is not recommended to deploy the railway due to there being some kind of non-objective legal restriction, and therefore the deployment depends on impact evaluations to be performed by managing organs; or areas that are under objective legal restrictions, which are forecasted to be reduced through the adoption of mitigating or compensating measures.

These zones may be conservation units of sustainable usage, Atlantic Rainforest areas that present primary or secondary vegetation on medium or advanced stages of regeneration, surroundings of quilombola land, and surroundings of indigenous communities.

Areas of Unnecessary Deviation (with mapped aspects): These are areas in which there is no objective technical or legal need recommending a detour or deviation of the railway tracks, but with mapped environmental features that must be considered.

These areas may include conservation unit buffer zones, and areas included into the Map of Priority Areas for Environmental Conservation as issued by the Ministry of the Environment.

Areas of Unnecessary Deviation: These are areas where environmental features were not mapped or they do not exist.

The collected data shall provide support for the execution of the environmental diagnosis of the deployment area of the **PROJECT**, considering its domain range. It shall then be possible to use the data collected during the environmental diagnosis and to resolve on a proposed layout.

The product of the Environmental Studies consists in the elaboration of the Preliminary Environmental Diagnosis of the Area of Influence of the **PROJECT**, and in the analysis of the occurrences registered in the environmental surveys and 'of the environmental impacts with the execution of the works, aiming at a proposal of environmental protection measures.

This preliminary diagnosis should include a map of environmental characterization, of which the basic purpose is to present the main environmental characteristics of the region of interest and its surroundings, highlighting, mainly, the existence of Environmental Conservation Units and Indigenous Land, as well as other information of environmental interest concerning the area.

Thus, the map should present the environmental interfaces of the **PROJECT**, such as biomes, archaeological sites, indigenous lands, areas of environmental protection - APAs, permanent protection areas, quilombola areas, river basins, urban centers, permanent bodies of water, animal breeding areas, and mineral extraction areas, among other relevant features.

It is suggested that these maps include information on water networks and hydrographic basins.

Other information, such as the type of predominant vegetation, the geomorphology of the region, types of soils, burn area and the extent of deforestation, among others, may be requested for the complementation of analysis, in specific cases.

In all maps Areas of Direct Environmental Influence and Areas of Indirect Environmental Influence will be adopted with radii of approximately 2.5 km and 10 km around the **PROJECT**. This information is important because it shows the approximate limits of the areas that will be directly or indirectly affected during the execution of the works. It should be noted, however, that for each type of project, the Ministry of the Environment, through IBAMA, defines the most appropriate limit to be adopted for each case.

For the physical environment, at least the topography, geology, geomorphology, climate, land use and occupation, hydrographic basins, and geotechnical characteristics of the soil should be considered.

In relation to the biotic environment, a characterization of the flora and fauna, especially forest remnants, and other forms of natural vegetation that may be impacted by the **PROJECT**, must be identified. This analysis must also include the identification of legally protected areas in the region, with information concerning the distance between them and the **PROJECT**.

For the anthropic environment, a summary of the current socioeconomic situation of the main communities to be affected by the project and the identification, location, and brief description of the areas of historical, archaeological, speleological, cultural, landscape and ecological value, as well as indigenous areas, must be presented.

During the preparation of the Environmental Studies, the **PROPONENTS** will also need to develop the following activities:

- monitoring the preparation of the Railway Engineering Studies, verifying the environmental suitability and presenting, if necessary, solutions aimed at eliminating or minimizing potential impacts;
- drafting opinions that inform the decisions of the project team relative to the areas indicated as sources of construction materials, as well as decisions concerning proposals for the environmental recovery of these areas;
- verification of the existence of factors restrictive to the use of the soil (urban areas and Conservation Units) with the competent environmental agencies;
- proposing measures to avoid or mitigate environmental problems identified through studies.

6.3 VOLUME 3: ENGINEERING STUDIES

The objective of the Engineering Studies is to determine if the proposed preliminary route is in fact feasible considering the demand and constraints of the Environmental Studies, as well as to determine the necessary investment and the operating costs of the proposed model, analyzing operational alternatives that can solve and/or circumvent bottlenecks and critical segments.

These studies should be performed on a scale of at least 1:10,000 and be presented graphically at least on a 1:20,000 scale, based on the cartographic data and on images, by combining them with existing available data in order to obtain the information for determining, with sufficient and sufficient assertiveness, the investment costs in the implementation and operation of each **SEGMENT** and each alternative.

6.3.1 Topographic Studies

The Topographic Studies shall consist of the aerophotogrammetric restitution of the range covered by the route prepared by the **PROPONENT** and shall comply with the following guidelines.

6.3.1.1 Coverage Area

Aerial surveying and restitution shall be carried out along the axis of the route prepared by the **PROPONENT**, at least in the most critical portions of the **PROJECT**, in order to seek an assertiveness in the definition of the final route. Particularly noteworthy are the segments that will cross the Serra da Esperança and the Serra do Mar, as well as the urban densities that will be affected by the route, with a minimum coverage that is 600 meters wide (300 meters for each side of the axis) and sufficient width for the perfect definition of the trajectory of each **SEGMENT** of the railway.

The services and their stages consist essentially of:

- Aerophotogrammetric Coverage and Airborne Laser Profiling;
- Field support;
- Digital Stereotogrammetric Restitution;
- Digital Terrain Models;
- Generation of Level Curves;
- Vectorization of rivers, main and secondary roads, bridges, buildings, and property limits when identifiable by surveys;
- Cartographic Editing and Generation of the End Products.

6.3.1.2 Technical Specifications

The object of these specifications is mainly composed of a network of basic field support, photogrammetric ortho-images, planimetric restitutions, and digital surface and ground models - MDS and MDT, produced on the basis of field services, photogrammetric flights, or airborne laser scanning (LiDAR).

The digital surface and terrain models produced should, regardless of the process used, meet the same specifications of these **TERMS OF REFERENCE**.

It is however assumed that, depending on the characteristics of the vegetation cover of the areas and their magnitude, different processes will be used in order to meet the specifications.

6.3.1.3 Specifications of the Services

The specifications must be geared towards the acquisition of studies that are in accordance with the minimum precision requirement including the 1:10,000 scale and cartographic precision standard PEC Class A, allowing for altimetry with an inaccuracy of up to 1 meter.

In the execution of the survey project, solutions and practices should be adopted to ensure the achievement of this quality standard.

6.3.1.4 Aerophotogrammetrics Surveys

This activity aims to establish the documentary, technical and operational references necessary for the complete execution and technical monitoring of the works.

The Engineering Studies must present, in accordance with the chosen technology, at least the following elements:

For the photogrammetric flight alternative, the studies should define:

- Geographical positioning of the bands (axes and coverage in the boundaries of the area);
- Position of the initial and final exposures;
- Photo-index;
- Altitude and flight height;
- Altitude of reference considered in each band;
- Sensor calibration certificate with a recent date. In the case of digital sensors, the manufacturer's document that technically characterizes the sensor and

equivalent to the calibration certificate of the conventional cameras must be presented;

- Technical analysis of the longitudinal and lateral overlays, with appreciation of their adequacy to the objectives of the survey and the configuration of the terrain;
- Flight ranges with no stereoscopic voids and no connection between adjacent stereoscopic models, as well as no sharp variations in aircraft altitude (KAPA, PHI and OMEGA) that may compromise the development of the triangulation and photogrammetric restitution process;
- GSD with at least 35 centimeters;
- Other elements considered essential to the qualification of the coverage project, such as the solution adopted to ensure compliance with the GSD recommended by this specification;
- Detailed technical information about the perfect geometric integration of systems that provide support to its operation, such as GPS and inertial systems (IMU);
- The distance between the ends of the ranges and the field support bases, for the sensors that require ground control during the flight (maximum limit of 40km must be clearly defined).

For the LIDAR scan, the studies should define:

- The technical characteristics and the most important parameters of the profiler to be employed, as well as the characterization of the perfect geometric integration of the systems that support its operation, such as GPS and IMU;
- Flight height and altitude, FoV angle, maximum distance between points in MDT of uncovered surfaces (bare land), the density of points considered per square meter, among other elements important for the characterization of the planned mission, in light of the accuracy defined by a standard error of 0.7 meter at the density of 1 ppm and of 0.3 meter at the density of 4 ppm in the MDT, as a function of the type of LIDAR aerolevation defined by the O.S.;
- The quantity, distribution, orientation, lateral amplitude, lateral overlap with the contiguous bands and the length of the sweeping bands, as well as the justification of the solution employed, even considering considerations about the conditions due to the vegetation and the topography of the area to sweep;
- The expected density of points for the formation of MDT, in light of the predicted theoretical distance between swept points and the type of vegetation and terrain existing in the areas to be mapped;

- The distribution of the fixed GPS tracking stations that will be used in the support and post-processing of each area (maximum limit of 40 km must be evidenced);
- The calibration procedures of the LIDAR system (including GPS and IMU) for each mobilization, highlighting the relationships between the results achieved and the recommended accuracy for the final products;
- The standard errors expected for the planimetric and altimetric positioning of the points.

For field services, the studies shall define and submit the corresponding documentation:

- The vertices SAT and RRNN from IBGE or RIBAC that the studies intend to use as references;
- The network configuration of the basic landmarks to be implemented and determined;
- The configuration (quantity and approximate positioning) of the field support points to the quality control and determination of the geoid ripple;
- The expected configuration of the points of the supplementary support to the aerotriangulation, with the justification of the solution adopted, in light of the type of sensor used;
- The planned design of the solution for the determination of all points, both within the GPS tracking system and in the leveling, making it clear, for each area, which will be decisive points and what are the points to be determined.

PROPONENTS shall provide illustrative charts of circuits, lines, triangulations, and measurements designed for all field measurements and photogrammetric coverage or LIDAR.

6.3.1.5 Basic Field Support

The geodetic reference system to be adopted will be SIRGAS 2000, materialized by the SAT vertices of the fundamental IBGE network. In some specific cases, reference can be made to other ANTT network points, replacing the SAT vertices.

All basic support landmarks may have ortometric altitudes determined by geometric leveling from RRNN of the IBGE, or from existing network landmarks, as appropriate, including leveling and counter-leveling. The leveling should be performed in circuits or in single lines supported in different RRNN.

GPS networks of the basic support measurement should be structured in triangles formed by differential sections. Solutions by simple vectors or adjustments within plane-rectangular coordinate systems will not be allowed.

The measurements on the base support stations shall be performed by the relative or static differential method, using a minimum of 3 geodetic trackers, operated simultaneously, from the occupation of 2 known stations and one to be determined. The length of the baselines shall be less than 50 km, preferably less than 30 km.

The screen will observe a minimum of 6 satellites, elevated at least 15 degrees from the site's horizon plane. The PDOP should be less than or equal to 3 in each work section. The screening time should be at least 120 minutes, with a records every one second. In the adjustment of the position vectors by the least squares method, the final coordinates (X, Y, Z) should have a standard error of less than 5 cm per point and a scale error of less than 1/100,000 per vector

The basic network determined by GPS should be calculated and adjusted in the official Brazilian system (SIRGAS2000). The calculations will be based on the least squares adjustment and will take place within SIRGAS geodetic coordinate systems. If necessary, another adjustment will be made to SAD69.

The basic stations used to support LIDAR and photogrammetric flights should be part of the basic support, that is, they will integrate the ANTT base network or another, and they should be determined according to the specifications described here.

6.3.1.6 Generation of MDS and MDT

Digital surface models - MDS shall not have any vacuum of scanning or reduction of the density of pulses per specified square meter, caused by the presence of clouds, by occasional steep terrain, except in the naturally restrictive cases, such as water mirrors.

The final digital files, which record the result of the generation of MDS and MDT, must contain as many points as possible, resulting from the post-processing of the raster and / or laser data, even if these files are very large.

6.3.1.7 Ortoimage generation

Orthoimages produced under digital photogrammetry systems should be prioritized in their central portions in order to optimize the quality of the mosaic.

As for the mesh of plane-rectangular coordinates, it should be represented based on the UTM projection system, at a spacing of 10 in 10 cm (square mesh with a side measuring 10 cm).

Orthoimages, which make up the orthomosaic, should have their original geometric resolution (GSD of 35 cm) consonant with the images matrix digitally or directly obtained in the digital camera, in TIFF format with TFW.

The minimum altimetric representation will be given through level curves spaced every 2 meters, with representation of master curves every 10 meters. The points conventionally represented by elevations, depths of depressions, plateau areas, banks of water bodies, places of extensive terrain planning, among others - should be evidenced, in the altimetric representation put on the ortomosaic, through the positioning and typing of the altitude extracted from the MDT.

The entire altimetric database (including level curves, calculated points, texts, and more) shall be represented in CAD formats.

6.3.1.8 Final Products

After performing the Topographic Studies, the **PROPONENTS** shall submit to **CCP** the following Products in 02 (two) separate digital storage means:

- Digital archives of aerophotogrammetric images;
- Photoindex digital archive;
- Digital files of color orthophotos, scale 1:10,000, with appropriate vectorizations, in TIFF, TFW format;
- Processed and georeferenced point cloud in LAS format;
- Digital Terrain Model and Digital Surface Model in DEM and LAS format;
- Digital files of planimetric plants in the scale of 1:10.000, in Shapefile format and CAD format in the DATUM specified in this **TERMS OF REFERENCE** and converted to SAD69;
- Digital files of the altimetric plants with level curves every 5 meters in AUTOCAD format, in Shape format and CAD format in the DATUM specified in this **TERMS OF REFERENCE** and converted to SAD69;
- Hypsometric maps;
- Final report containing the description/records of all phases of elaboration of Topographic Studies, including calculation memories.

The final products should be delivered in a standard USB hard drive with planimetric vector data and contour lines.

6.3.2 Geometric Tracing

The purpose of the survey is to lay down, on the topographic basis obtained from the Topographic Studies, the corrections or modifications that are necessary due to the altimetric and planimetric inaccuracies of the original base.

If the **PROPONENTS** choose to use the **PREVIOUS STUDIES/ANTT**, they must carry out the adaptation of the geometric guideline developed in these studies.

In the accomplishment of the Geometric Trace, the following elements must be analyzed.

6.3.2.1 Table of technical characteristics of the layout in plant and profile

Plant design, at least in the 1:10,000 scale, with graphical representation in 1:20,000, containing, among others:

- Axis of the route marked every 100m and with a kilometer indicative every 1 km;
- Remarkable points;
- Elements of horizontal curves;
- At least, the value of the master curves every 10m and level curves every 2 meters;
- Domain Range;
- Marking of the limit of lakes of dams and the corresponding NA;
- Representation of plants in marshy lands, marshes, soft soils, etc.;
- Representation of the main water bodies and their respective denominations;
- Representation of engineering works;
- Representation of interference (highways, transmission lines, etc.);
- Representation of complementary construction (containment works, etc.);
- Crossing the coordinate axis by entering its coordinates;
- Geographical North Indicator;
- Delimitation of the representative segments.

Design in Profile in the minimum scales of 1:10.000 (H) and 1:1.000 (V) containing, among others:

- Representative mesh with intervals in the indicated scales containing reference to the dimensions in the vertical scale, located in the left side;
- Terrain line;
- Sub-ballast alignment;
- Direction and value of ramps;
- Elements of vertical curves (PVC, PIV, PTV and maximum, Y and dimensions);
- Engineering Works;
- Survey profiles (classification of materials);
- Standardization of references – adopt the kilometer in curve frames, level references, drainage structures, etc., as follows: Km 350 + 334.080;
- Footer, containing:
 - Mileage;
 - Terrain dimension reference;
 - Project dimension reference;
- Mileage interval of the boundaries of the sheet, in the format stamp;
- Cross sections typical of the earthmoving platform, for the corresponding representative segments.

6.3.2.2 Criteria and Parameters for Geometric Tracking

6.3.2.2.1 Planimetry:

- Minimum radius on Main Track: 500m. Horizontal curves with radii of less than 500m limited to a minimum radius of 312 meters in specific stretches shall be allowed provided that they are technically justified on the basis of the geomorphology of the region;
- Minimum radius in the internal lines of the Rail Yard: 150 meters;
- Curves with transition: curves with spiral transition (Chothoid) for radii equal to or less than 1,800 meters will be adopted;
- Transition length: 1 meter per minute of the degree of the curve. Dimensions corresponding to 0.5 meter can be used when there is not enough distance between curves;

- In the presence of reverse horizontal curves, they shall be connected to a tangent of not less than 40 meters.

6.3.2.2.2 Altimetry

- Vertical curves will be used between two ramps, when the algebraic difference of the ramps is equal to or greater than 0,10% ($i_1 - i_2 = 0,10\%$);
- Parabolic curves will be used;
- Maximum compensated ramp: 1.45%; Steeper ramps shall be accepted, as long as they are no steeper than 1.8%, in extraordinary portions of the railway, and are accompanied by a technical justification based on the region's terrain features;
- Compensation of curve ramp: 0,06% per degree of curve (G20);
- Alignment measures should be studied, whenever possible, aiming at maintaining a minimum distance between the inflection points of vertical curves, as composed of two consecutive ramps of opposite directions equal to the length of one train as adopted in the project. The minimum length of the vertical curves will be determined based on the rate of variation per 20m landmark pole, of 0.10% for concave and convex curves.

6.3.2.2.3 Rail Yards

- The maximum ramp in the rail yards for maneuvering, loading, and unloading, will be 0.25%;
- All railway switches must be located on horizontal tangents;
- The earthmoving platform shall have a minimum width of 7.70 meters for the metric gauge and of 8.20m if mixed gauges are of viable implementation, and a minimum transversal declivity of 3% in order to accommodate the entire superstructure and drainage devices and safe range;
- Crossing rail yards will have a useful length that will be determined according to the operational need between the 02 (two) **SEGMENTS** and should be located, preferably, in flat areas. They shall have at least 02 (two) lines, in addition to 01 (one) dead-end line that is 300m long. The sample should not be less than 4.50 meters and preferably 5.50 or more;
- Exchange rail yards shall have at least 3 exchange lines with sufficient useful length to meet the estimated demand, 1 deviation line of at least 300 meters, and 1 reversion triangle with a minimum radius of 180m and a minimum reversion length of 100m.

6.3.3 Geological-Geotechnical Studies

The geological studies should provide the indispensable basis for the rational planning of the geotechnical works required for the Earthmoving Projects, the foundation of bridges, viaducts, and other similar structures, the transposition of solid objects and structured containments, and the obtaining of construction materials, including the elaboration of cartographic documentation of the occurrences considered interesting for use at the time of construction.

The geological-geotechnical studies will have the purpose of analyzing the lithology and morphology, gathering information regarding the occurrences of construction materials available in the area of implantation of each **SEGMENT** of the railway.

These materials range from materials needed for land fills to materials for construction works, including materials for the deployment of sub-ballast and ballast, among others.

Structural and stratigraphic analysis should allow the identification of problem points that may require special projects to overcome the problems presented.

Among others, problems such as crossings of hydromorphic soils, areas of erodible soils, structures unfavorable to stability of cut slopes, areas of unstable slopes or near instability points should be raised.

The geological studies must be completed by geotechnical investigations, so that the geotechnical research orientation should aim at the best adaptation of the civil construction Foundation Projects.

For the elaboration of the research program (drillings and tests) to be carried out, the **PROPONENTS** should indicate the working methodology used, with the identification of "representative segments" along the route of the railway, with topographic, geomorphological, pedological and lithological characteristics stratigraphics that are homogeneous and representative of a greater portion of the railway.

Geotechnical testing campaigns should be developed in selected segments as testimony of the representatives, whose results, complemented by visits to the field with geologists and geotechnical engineers, will define the basic design characteristics, including the typical sections of land fill and cutting (spacing between sidewalks, inclination of slopes, superficial and deep drainage), being used for all of the representative segment in question.

The representative segments as well as the testimonies should be identified according to the sequence of studies detailed below:

- a. Joint analysis of geological and topographic charts, maps, geological and pedological and other geological information;

- b. Considerations describing the topographical and geomorphological characteristics of **SEGMENTS** of the railway track;
- c. Field inspections of the team of geologists and geotechnical engineers;
- d. Improvement of stability interpretations from the new topography surveys to be performed.

The segments identified according to the above considerations should be subdivided, if necessary, in order to better represent and characterize a certain extension of the railway, considering the better individualization of variations in soil and terrain types.

For the areas of occurrence of construction materials, according to the evaluation of field visits, specific test campaigns may be programmed, aiming to define the applicability of certain material as sub-ballast and as ballast.

6.3.3.1 Geotechnical Investigation Programming

The objective of this program is to present a forecast of the investigations through drill, percussion and mixed drilling, and other field tests, samplings and laboratory tests, to analyze the soils sampled.

This programming should be defined as oriented in VALEC Specification 80-EG-000F-17-7006 - (General Geotechnical Studies Specifications), but may be adjusted to a methodology developed specifically for each geological unit - homogeneous geotechnical individualization.

Following the standards of testimonial excerpts, drill surveys, inspection wells and percussion drills should be programmed to check the subgrade, located on the axis of implantation of the railway. For defining the type of foundation to be employed in bridges, viaducts, and other similar structures, percussion and/or rotary (mixed) surveys shall be scheduled.

In each well-characterized sample, typical cuts should be chosen for representative geotechnical detailing to evaluate slope stability and the typical sections of land fill and cut to be considered in the studies.

For the identified occurrences of materials for sub-ballast, after evaluation of visits to the field, only small drillings can be programmed and for the occurrences of materials for ballast sampling and laboratory tests should be programmed, as described below.

The confirmation of the planned schedule, particularly for special foundations and OAs depends on field recognition, aiming at consolidating or adjusting the Preliminary Investigation Program to define the type of solution to be adopted in the implantation of each **SEGMENT** of the railway.

The geotechnical investigations to be programmed, together with the field visits, should collect information on the level of the water table, identifying possible zones of excessive humidity, and on the support capacity of the foundation lands of the land fills, where applicable, by geological segment Characteristic (representative section).

The results should be presented in the same plan and geometric design profile, obeying the coordinates, staking, typology of the study (land cut, fill, bridges, viaducts, drainage structures, and other structures), depth and other data needed to understand the solutions adopted.

In order to minimize the number of drillings required, geophysical methods may be used for indirect investigation of geological and geotechnical data, such as eletroresistivity or seismic refraction, particularly to improve the workability classification parameters of the materials to be excavated.

6.3.3.2 Subgrade

Along the selected route and based on the Geometric Project, the Geological-Geotechnical Zoning, and the excerpts previously identified, probes should be programmed in the testimonial sections at intervals of approximately 3 km, complemented by drilling the percussion for collection of Samples and / or tests, as applicable, in order to define the characteristics of the subgrade for the implantation of the railway in each **SEGMENT**, respectively.

Preferably, these probes should be located at central points of cuts and fills.

In sample stretch, the surveys should preferably be carried out with a depth of 1,50m below the projected alignment for the sub-ballast. If the presence of impenetrable material at small depth (equal to or smaller than 3m) is identified, the hole should be moved.

If materials that are impenetrable to the product are reached, or when this process becomes inoperative or there are cuts greater than 5m in height, then the SPT test should be performed. If the percussion probe encounters impenetrable material before reaching the programmed depth, the need to use rotary drilling must be evaluated, which may be performed depending on the geological characteristics of the site, or until 1,5m below sub-ballast base alignment. Or, to predict the escarificability studies (earthwork studies) through indirect (seismic) investigations.

These surveys should be located in a way to obtain definitions of the land fill foundations and the rocky top at the center point of the cuts. Also, according to the methodology used in the sample sections, at least one probe should be programmed in the central sections of the layout, with the objective of defining the depth and geomechanical characteristics of the soil layers and / or the presence of rock, and the thickness and classification of materials.

The samples collected in each hole from the various material horizons should be subject to characterization tests involving physical limits, granulometry, compression and California Support Index (ISC/CBR).

Additionally, in each test run, test series of at least 5 Density tests and natural humidity tests shall be performed in inspection wells, in the sections considered as representative.

At first, a uniform schedule, irrespective of the lithological type, should be adopted, based on the terrain, guideline and alignment measures of the railway established in previous studies.

The investigations should be carried out with the following objectives:

- Characterization of the materials to be excavated as construction material and its classification;
- Determination of support conditions of the subgrade;
- Determination of the hydrogeological conditions with or without the presence of water tables interfering with the track alignment and slopes;
- Determination of the homogenization factors to be applied to the excavated volumes and required for the study of compensation (land cut and fill) for each segment that presents similar geotechnical characteristics.

The planned tests must comply with current standards, as established ABNT, DNIT, and DER/PR (Department of Roads of Paraná).

6.3.3.3 Crossing Engineering Works

As described above, in order to better predict the type of foundations of bridges and overpasses, mixed, - SPT and/or rotary surveys should be provided.

For exceptional crossings (i.e. over 400m, or where one margin has an erosion profile and the other margin tends towards silting), at least one survey shall be provided on each margin.

For the determination of the minimum number of surveys the following criteria will be considered:

- Polls will be carried out in at least 20% of the constructions of implantation of each **SEGMENT** of the railway under study;
- The construction that will be object of surveys will be chosen by the bridge team and geotechnic team and may or may not be in the mentioned representative sections.

6.3.3.4 Tunnels

Geological and geotechnical surveys should be carried out in sufficient quantity and reliability to meet the needs of risk assessment, prediction of behavior, indication of types of support and coating and cost estimation for the implementation of possible tunnels.

Thus, in the regions where the tunnels are installed, the number and type of drilling and surveys to be carried out must be evaluated by the technical team, depending on the complexity of the mass and the work, accessibility to the site and the depth and length of the tunnel.

In general, the region of the packaging has a higher degree of risk, due to weaker materials and a more intense presence of lithological contacts, at least 1 survey should be carried out in the area of each coupling.

In the case of tunnels, given the cumbersome access difficulties, one must maximize the use of non-traditional survey methods or indirect methods, such as refraction seismics.

6.3.3.5 Study of Occurrences of Construction Materials

The identification of the areas of deposits for construction materials, especially material for ballast and sand, will occur after the verification of the data of the mining register of authorized mining in the National Department of Mineral Production (DNPM).

In the case these areas do not appear in the DNPM registry with reasonable average transportation distances, a regional scale scan should be carried out to identify alternatives, including with terrestrial routes, based on the information of the regional geology to be provided by the Geological Studies team.

6.3.3.6 Sub-ballast

After identification of the areas by the geology and geotechnical engineering teams, geological and geotechnical mapping and visits to the field, drillings should be provided at the site or inspection wells with sample withdrawal to perform the following field tests:

- Characterization Tests (Limits and Modified Proctor Compaction);
- Granulometry;
- Natural Density;

- Natural Humidity and ISC and Expandability.

The effective execution of this program and its extension will depend on the development of the Earthworks Project, and consideration should be given to the possibility that part of the sub-ballast necessary for the implantation of the railway is served by materials from the obligatory excavations.

6.3.3.7 Land Loan Areas (subgrade)

The **PROPONENTS** should indicate the areas of loan of material to compose land fills in areas near the rail yards and near the meetings of bridges and viaducts.

The need for identification of other areas should be established by the calculations of volumes and compensation between land cut and fill, defined by the Geometric and Earthworks Projects.

In these areas of material lending, if necessary, inspection wells should be performed, samples collected and the field tests of natural humidity and *in situ* density carried out and the following laboratory tests performed:

- Characterization Tests (Granulometry and Physical Limits);
- Compacting (Intermediate / Modified Proctor), ISC and Expandability;
- Natural Density and Humidity.

The effective implementation of this programming and its extension will depend on the volume requirements to compose the body of land fills to be ascertained with the development of the earthmoving project, considering the possibility that most of the land fill material necessary for the implantation of the railway is served by materials from the obligatory excavations of cuts.

6.3.3.8 Sand fields

A survey of sand fields already licensed, in exploration, or still to be explored, and geological and geotechnical mapping and field visits should be carried out.

In the field visits and aerial photogrammetric surveys, if any, potential deposits should be identified, not yet explored or licensed.

The selection of deposits to be used along the entire railway should first be based on the criterion of the most efficient transport distance, according to the sites with the highest rate of usage of materials – bridges, viaducts, common and special drainage structures, culverts, and precast areas, in addition to their availability and ease of access. In addition, river banks and riverbeds should be verified, since they may constitute a source of small aggregates.

Based on these criteria, the selected deposits along the railway should be inspected, taking pertinent technical information and collected samples into consideration. Granulometry tests by sifting and powder content must be carried out in the collected samples of sand.

6.3.3.9 Quarries

Rock deposits must be collected for the production of large aggregates ("Quarries") already licensed, in exploration or still to be explored, geological and geotechnical mappings and field inspections.

In the field visits and aerial photogrammetric surveys, if any, potential deposits not that have not been explored or licensed yet should be identified.

The selection of deposits to be used along the railway should first be based on the criterion of the most efficient transport distance, since the application of ballast will occur throughout the entire length of the railway, and that periodic maintenance in the **SEGMENTS** of the railway will require replacing the ballast.

The availability and ease of access must be checked, as well as the need to install crushers, which require electricity and/or diesel, requiring greater investment, or if they are pre-existing.

Based on these criteria, the selected deposits along the railway should be visited and have technical information and samples collected.

Rock samples collected in non-commercial occurrences will be sent to the laboratory for Los Angeles abrasion, apparent specific mass, water absorption and apparent porosity tests, performed in accordance with currently valid specifications.

6.3.3.10 Presentation of Results of Geotechnical Studies

The Geotechnical Studies will be presented in the Final Report of the Engineering Studies, comprising at least the following items:

- Geological map: this study must present a geological map that compiles all the geological information and the litho-stratigraphy that contributed to define the crossed geotechnical units and their characteristics, as well as to have served as a base for the scheduling of the activities of field survey and polls;
- The delimitation of the geotechnical units should be based on the maps collected and photointerpretation of the images resulting from the aerophotogrammetric and Landsat 9.5.4 images;
- Mapping of Susceptibility to Erosive Processes: the soil, slope and land use and cover variables should be characterized and classified according to their susceptibility to erosion in the study area and adequately represented on the geological-geotechnical cartography;

- Geotechnical Zoning Maps: this activity represents the segmentation of the stretch into homogeneous geological-geotechnical units, from which the research and extrapolation of the results obtained for the instruction of the other disciplines (earthworks, stability, foundations, etc.) are programmed. The main geotechnical characteristics, the presence of the water table and so on. The information should be released on the basis of the range, in a scale of 1:1,000;
- Summary sheet of the tests carried out;
- Bulletins of the surveys carried out;
- Bulletins of percussion drillings performed;
- Bulletins of rotating and/or mixed surveys performed;
- Reports of the seismic sections executed;
- The effective location of the surveys, in coordinates of the geographic system endowed with the geometric design;
- Conclusive text of the results obtained, describing and justifying all the geotechnical parameters adopted as well as a longitudinal geotechnical profile, by means of the evaluated sample, as well as, for each of the special engineering works (tunnels, bridges and viaducts) with more than 150m of extension.

6.3.3.11 Final Objective of Investigations

The investigations should be directed towards the following objectives:

- Classify of the material to be excavated;
- Characterize the support of the subgrade;
- Identify the level of the water table;
- Characterize the capacity of the foundation sites and identify the types of foundation applicable to land fills and crossing structures (that is, bridges, viaducts, and other similar structures) and the classification of the solid bodies that constitute the tunnels.

In each section, properly characterized, typical cuts will be chosen for representative geotechnical detailing to evaluate the slope stability and the typical sections of land cut and fill to be considered in the studies.

6.3.3.12 Land fills with low bearing capacity

For those sections where there are deficiencies in the support capacity of land fill foundations, in field inspections and/or drillings carried out, engineering solutions established for similar cases must be considered, such as balance berms, land fill overload, vertical drains, staked concrete structures, total or partial expulsion or replacement of soft soil, and others, adopting the one that best suits the problem, evaluating economic, environmental and time-of-execution aspects.

The constructive methodology must be analyzed in parallel, so that the adopted solution is consistent with the effective execution of the constructions.

6.3.3.13 Study of Foundations of bridges, viaducts, and other crossings

From the geometric elements of bridges, viaducts, and other engineering structures with the same goal, it will be possible to define their extensions and from surveys performed, the type of foundation expected for each structure.

This definition of the foundations will follow the results obtained in the surveys, the results of the occasional tests carried out and the water levels of the water table observed.

6.3.3.14 Definition of Slopes

It should be based on the information contained in the previous studies, on the results of the surveys and geotechnical tests carried out, on field observations and on the work carried out in the surroundings, such as highways, and in particular as regards the erodibility/deterioration of slopes.

6.3.3.15 Tunnels

From the geometrical elements of the tunnels, it will be possible to define their extensions and from the detail mapping and possible geotechnical investigations carried out, it will be possible to define the type of treatment expected for the packages and their underground extension.

As an alternative source of data, possible tunnels should be checked at other points in the solid bodies in question, e.g. on nearby highways, and the treatments applied there.

6.3.4 Hydrological and Hydraulic Studies

The studies to be developed should consider the drainage elements calculated by the **PROPONENT**, adapting them to the possible changes of tracing and/or alignment to be defined by the geometric project, resizing, if necessary, the areas of the contribution basins.

For each representative segment, the flows defined in previous existing studies, in particular those of ANTT, should be validated.

The hydraulic design of bridges, viaducts, and other similar structures should also be validated, crossing the Hydrological/Hydraulic Studies information with the topographic surveys, enabling the measuring of the length and height of these structures.

6.3.5 Earthworks

The Earthworks Project should consider the alternatives that are presented to the handling of the earthmoving volumes, seeking to maximize the land cuts and fills, also taking into account any urbanization and landscaping plans, whether existing or planned.

The final table should summarize the cut volumes, by category, and the volumes of fills to be compacted.

The Earthworks Project should consider:

- Regulation, Technical Specifications and standard projects of VALEC and/or DNIT;
- Results of Geotechnical Studies;
- Topographic Studies and Geometric Tracing;
- Hydrological Studies.

Papers should present the guidelines for the following items:

- Volume correction coefficients
- Declivity of the slopes;
- Indicative of the preliminary services to be developed;
- Typical cross sections of cut and fill, indicating
- Width of cut platform;
- Width of fill platform;
- Transversal declivity;
- Indication of the geometry of the sidewalks as well as the maximum height of the slopes;

- Final cut and fill volumes;
- Present table with final volumes;
- Present summary table of average DMTs.

The representation of the cross sections and the corresponding volume worksheets should be performed in the form of computer reports and their representation in specific drawings is not required.

If there is a need to use lateral loans as well as deposits to obtain materials, determine average distances and transport moments based on geological and geotechnical studies to be used to compose the costs of earthwork services.

However, the supplementation of volumes (loans) should preferably be obtained by extending cuts. In the case of the use of deposits, their identification, their potential for exploration and, if they exist, preference must be given to the commercial areas already used in other constructions.

6.3.6 Drainage Structures

Projects of cell and tubular culverts, wings, and merges should, as far as possible, follow the existing standardization, using standard designs already available for the axle loads currently adopted.

In the case of superficial drainage, studies must define the necessary amount for each device, per section, per type of land cut and fill, and for each sample portion, according to the dimensions of land cuts and fills.

Similarly, extensions of dissipating devices and routing of drained water should also be defined.

Surface drainage devices, such as ridge gutters, sidewalk channels or slope foot gutters, gutters, dissipating ladders, sub-horizontal drains, and others, will follow typical DNIT details and are indicated in the studies.

The surface drainage and deep drainage projects will be elaborated according to the typical details and presented in drawings at an appropriate scale.

The Drainage Project must be developed in order to allow the selection of the best solution, through the analysis of the general conditioning elements of the project. At this stage, in relation to drainage devices, the following shall be defined:

- Number;

- Nature;
- Probable location;
- Approximate length;
- Quantities and cost estimates.

The guidelines for the use of drainage devices listed below should be presented.

6.3.6.1 Thalweg transposition drainages

Objective: to eliminate waters belonging to the basin that, due to hydrological imperatives, should be diverted so as not to compromise the structure of the railway.

Devices:

- Culverts;
- Bridges.

6.3.6.2 Surface Drainage

Objective: to intercept and capture, leading to the safe discharging of the waters coming from their adjacent areas and those that precipitate on each section of the railway, safeguarding the security and stability.

Devices:

- Land Cut protection gutters;
- Land Fill Protection gutters;
- Cutting gutters;
- Fill gutters;
- Ditches;
- Water descents;
- Water disposal;
- Collecting boxes;
- Railway culverts;
- Power sinks;

- Slope scheduling;
- Cutters;
- Relief drainage for retaining walls.

6.3.6.3 Underground or deep drainage

Objective: to intercept and lower the underground water table to prevent the progressive deterioration of the supports of the layers of the terraces and superstructure.

Devices:

- Deep drains;
- Fishbone drains;
- Draining mattress;
- Sub-horizontal drains;
- Side gutters;
- Vertical drains.

6.3.7 Bridges, viaducts, and other similar structures

The locations of bridges, viaducts, highway viaducts and walkways will be those defined after the optimization studies and the adjustments made in function of the new geometric tracing of the railway.

The characteristics of the superstructure solutions to be adopted should be defined. The isostatic spans shall be modulated, and the structures may be in reinforced or prestressed concrete, mixed, or metallic structures. This choice will depend on the characteristics of each construction, the logistical conditions of its place of implementation, and the equipment available for its assembly.

In the case of technical and economic advantages in the use of different structural systems, this condition should be justified.

With the definition of the type of superstructure solution that will be adopted, the standardization of the spans between supports and the definition of the width of the board, the superstructure should be sized for the standard train defined throughout this scope, using current norms corresponding to each type of solution.

As Brazilian Regulations do not include railway bridges in mixed or metallic structures, if these alternatives are studied, it is suggested to use German standards, which are internationally recognized.

The total length of each bridge, viaduct, or similar structure must be defined according to the profile of the terrain, the obstacle to be transposed under its structure, and the intended use of the construction. The configuration of the access land fill and the slopes of the aforementioned structure's header should be defined according to environmental conditions, the loads transmitted to the soil under the fill and their characteristics of deformation and resistance, and the necessary protection to guarantee their integrity to face extreme events such as rains and floods.

The pillars should be standardized according to the following parameters:

- Short pillars: up to 14 meters;
- Medium pillars: from 14 meters to 22 meters;
- Tall pillars: from 22 meters to 35 meters;
- Special pillars: above 35 meters.

The pillars should be dimensioned using the loads coming from the superstructure and the compositions in traffic and in accordance with the current technical standards.

As foundations will be classified as superficial, of medium depth, or deep foundations. They will be dimensioned based on the data provided by the Geotechnical Studies. Within the representative sections defined in these studies, they are chosen as constructions considered as samples to be probed, with preference being given to the highest and longest foundations.

The choice of foundation type, footings, excavated stakes, metal roots, among others, should be that which is the most appropriate to the existing soil, to the logistic aspects of the place of deployment, and to the execution equipment. One should always look for a standardization of the type of element used, aiming for efficiency in economies of scale, logistics and equipment use.

Also, the merge points of the rail crossing structures (bridges, viaducts, and other), classified as short, of up to 7 meters, and tall, of up to 14 meters, should be defined. Special care should be taken in constructions with horizontal strain relieved at the junction, as well as with the definition of the extension of the constructions, providing, if necessary, intersections, in order to protect the outer portions of fills when dealing with fluvial transpositions.

The protecting barriers must be metallic and shelters should be provided every 10 meters.

Once all the structures' design elements have been dimensioned, as described above, drawings will be generated, representing the blueprints, elevation, and transversal and longitudinal sections, with a level of detail that will allow an adequate characterization and quantification of the projected services for the implementation of various standard solutions for said structures. Preference will be given to the use of projects already in place, with characteristics similar to those in the ANTT studies, in order to increase the accuracy of estimates of the necessary quantities of the associated services.

6.3.8 Railway Superstructure

The Railway Superstructure consists of the structural dimensioning of its components, as well as its standardization. It comprises the basic components, rails, sleepers, ballast and sub-ballast, among others.

The specification of the superstructure of the **PROJECT** shall follow the standards usually adopted by VALEC, but must take into account the dimensioning resulting from the Geotechnical and Operational Studies developed from of these **TERMS OF REFERENCE**, respecting the gauge adopted in the Malha Sul and by **FERROESTE**. However, in case studies demonstrate it to be viable, preference shall be given to mixed gauges.

PROPONENTS must observe the following elements:

- The sleepers will be of monoblock-prestressed concrete with Under Sleeper Pads (USP) of polymeric compounds (new or recycled), or other material that is appropriate for the axle load that is being moved, which must retain its durability for the length of the Concession;
- The ballast shall have a minimum height of 30 centimeters under the sleeper, with a shoulder width of 30 cm, and a 2V:3H or softer slope. The height of the ballast shall be determined by the vertical distance between the underside of the sleeper in the region of the rail support area and the platform of the line;
- For the other specifications, granulometry, abrasion and physical properties, the ballast shall comply with NBR 5564 in its most up-to-date version;
- The rail should have the UIC 60 profile (that is, 60 kilograms per meter). The profile shall meet the dimensions described in the UIC specifications. If the associated technical and economical feasibility is proven, and in compliance with the requirements of the Operational Study, the UIC 60 rails may be replaced by TR 68 rails and in this case they shall comply with the AREMA Manual (American Railway Engineering and Maintenance of Way Association) 2011 edition, part 1, chapter 4, section 1.1, figure 4-1-5;
- The long welded rails (TLS) should be at least 240 meters long, and will be joined with electric butt flash welding, thermal aluminum welds with disposable

crucibles, or 6 hole splice joints. In situations that present a practical impossibility to adopt this length, and conditioned to a technical justification concerning the issue, lengths of less than 240 meters are acceptable;

- The railway switches in and out to the main line/crossing will have 1:14 openings. On diverted lines, the switches should have a minimum opening of 1:8;
- Lubrication devices must be provided along the railway section.

These specifications may be changed, subject to technical justification approved by the **CCP/GTS**.

6.3.9 Interferences and complementary constructions

6.3.9.1 Interferences

All existing or projected interferences that directly or indirectly influence the execution of the constructions must be identified.

They should be cataloged and analyzed, from the technical and economic points of view, for the definition of the solution to be adopted for their relocation or relocation.

6.3.9.2 Crossings

Rail level crossings will not be allowed in the railway. The projects should propose alternative solutions, such as lower or higher crossings on the roads and relocation of roads for crossings in two levels.

6.3.9.3 Optical Fibers

The **PROPONENTS** should analyze the possibility of deploying optical fiber along the line during the construction works.

The fiber optic network shall be composed of at least 36 fibers per cable in the underground pipeline infrastructure along the entire length of the main line of the railway section.

The ducts shall be in high density polyethylene (HDPE), with diameters of 40 x 34 mm (for external/internal dimensions), colored and taped, in a trench at least 15 centimeters wide and 80 centimeters deep. The products should comply, whenever possible, with standards NBR 14.683 - 1, NBR 15.155 - 1, NBR 13.897 / 1398 and NBR 14.692.

The costs for the installation of type R1/R2 type concrete boxes, with iron covers affixed to the boxes, must be verified, with the concrete part having a minimum thickness of 8 centimeters. Iron covers must be painted with anti-corrosion paint, with

security locks and reinforced hinges that guarantee their prolonged use, with identification, including all the necessary civil material.

The definition of the appropriate point and the correct spacing for the installation of tick boxes should also meet the needs associated with the specifications of the railway Signaling and Telecommunications Systems.

6.3.9.4 Domain Range

The Domain Range will have the width specified in the table below. The minimum width shall be divided symmetrically starting from the Track Shaft and shall be widened so as to house the cutting and filling offsets with a clearance of 10 meters.

Minimum Width of the Domain Range

| Segment | Minimum Width |
|------------------------|----------------------|
| Single Line | 30 meters |
| Double or Triple Lines | 50 meters |
| Exchange Rail Yards | 80 meters |

The final Domain Range should take into account the need for deploying service routes (which shall later be used as accesses for maintenance) as well as for widening cuts (from which fill material will be extracted) and fills (which shall be used as excess material disposal areas).

In case of use of tracks in operation, the existing track must be maintained; when there is a need to expand the existing band, the requirement of 10 meters of clearance beyond the offset persists.

The Domain Range will be protected with wire fences in rural areas and steel screens with concrete masts in urban perimeters, as specified by DNIT and/or Valec.

The Domain Range should be defined taking into account the entire area of intervention of the proposed route in order to quantify the affected area.

The registration of environmental liabilities in the railway's Domain Range is not part of the scope of these Engineering Studies.

However, if over the course of these studies the existence of relevant liabilities of significant recovery costs is detected, these should be listed and described in a specific report, annexed to the final report of the Engineering Studies. The corresponding recovery costs must be evaluated and included in the estimate of socio-environmental costs, to be included in Book 2, which was dealt with in the studies contracted with a view to the environmental licensing of this enterprise.

Likewise, the costs of occasional expropriations and removals of interferences in each **SEGMENT** of the railway should be estimated, and the calculations shall be included in Book 2 - Externality Studies.

The **PROPONENTS** shall estimate the cost of expropriation of the Domain Range for the route alternatives under analysis. This will be based on a survey of the market prices for the various types of land and buildings within the Range considered, on analysis of the venal values, and on field surveys concerning the affected properties. It is very important, because of the gravity of this factor, that the criteria used to evaluate the costs of the different alternatives are as similar and consistent as possible.

6.3.10 Operational Control Center (OCC)

In order to control railway traffic, maintaining operational efficiency and safety, **PROPONENTS** must propose scenarios, considering economic and operational conditions, for the construction of, preferably, one shared **OCC** for **SEGMENTS 1 and 2**; or two **OCCs** that service **SEGMENTS 1 and 2** separately, indicating the equipment necessary for the Control Center's appropriate operationalization.

6.3.11 Signaling Systems

In order to reduce operating costs, rail operations must be carried out in a continuous and safe manner. In this regard, the Signaling and Control Systems of Trains play a fundamental role. The **PROPONENTS** should then propose solutions that seek the safety and efficiency of the railways, describing, in detail, the equipment that will compose the System and its benefits, as well as the interoperability between the two **SEGMENTS** and with the existing network, covering, at least:

- Detection of occupation or presence of trains;
- Broken track detection;
- Field signaling via lateral signals;
- Microprocessed vital interlocking;
- Automation of track elements;
- Maintenance of train spacing to avoid rear collisions;
- Automation of the process of liberation of licenses and track occupation;
- Locomotive parameters monitoring;
- Allow communication between the locomotive and the **OCC**;
- Ensure the proper functioning of the systems in the weather and physical conditions present throughout the railway network;

- Allow automatic instant identification of the compositions (including the owner of goods and the features of rail locomotives and cars that perform interconnections between railways;
- Ensure the complete integration between the systems of telecommunications, **OCC**, tracks, on-board and railway traffic management equipment and between Infrastructure Managers and Independent Rail Operators;
- Allow the Independent Rail Operators to access the database with real-time information on the location, activity, status information and position of the railway vehicles.

6.3.12 Telecommunications Systems

The **PROPONENTS** should present studies for the implementation of Telecommunications Systems, which shall then be responsible for meeting the demands of data and voice communication for the integration of the systems and interfaces between **OCCs** and conductors, guaranteeing the level of performance and reliability adequate for the correct operation of the Systems in each **SEGMENT** of the **PROJECT**, with at least the following features:

- Support and registration of all voice and data communication between trains, stations and **OCCs**;
- Integration between railways and **OCCs**;
- Recording all communications made by the **OCC**;
- Use of a communication protocol in accordance with the dispositions of the regulations applicable to Communication and Signaling Systems established by ANTT;
- Radio frequency coverage suitable for the perfect functioning of voice and data systems;
- Adequate selection of the frequency bands of radiocommunication equipment according to ANATEL regulations currently in effect and to standardization parameters established by ANTT;
- Availability, reliability and performance parameters as established by ANTT.

6.3.13 Power System

The **PROPONENTS** shall analyze and present solutions for the implementation of the Power System, which is responsible for the electricity supply throughout the 2 **SEGMENTS** that make up the **PROJECT**, including at least the following basic elements:

- Substations;
- Medium and low voltage transformer, in accordance with the standardization parameters;
- Meet the characteristics and demands of the systems to be implemented for operating the railways;
- Energy management and automation system. This system must allow remote operations such as power switching between substations, selection of track portions in maintenance or under failure and supervision procedures, as well as management of the power parameters; conventional aerial power distribution network.

6.3.14 Execution Plan for the Construction

In the Plan of Execution of the Constructions the main aspects related to the **PROJECT** should be described, addressing at least the following subjects:

6.3.14.1 Local conditions for the implementation of rail SEGMENTS

- Influence of topographic and geological-geotechnical aspects in the execution of the constructions;
- Conditions of access to work fronts and to service roads;
- Considerations on the impact of climate and pluviometry on the execution of services;
- Location of Quarries;
- Location of loan areas;
- Excess material disposal areas.

6.3.14.2 Executive planning

- Plan of attack and definition of service fronts;
- Physical schedule of the services with indication of the important dates;

- Time x Path diagram;
- Sizing of resources: Labor and Equipment;
- Administrative organization of the construction;
- Schedule of permanence of Direct and Indirect Labor;
- Schedule of equipment permanence;
- Histograms of the main services.

6.3.14.3 Main proposed construction methods

- Constructive methods of Infrastructure;
- Interference solutions with highways, transmission lines and others;
- Constructive methods of the Superstructure.

6.3.14.4 Logistics and support

- Location of support beds;
- Layout of support beds;
- Facilities to support the personnel assigned to the work;
- Material supply logistics;
- Logistics of recruitment, selection and hiring of personnel;
- Mobilization of personnel and equipment.

6.3.14.5 Interference between the execution of the construction and the other transport systems

- Identification of the main interferences;
- Constructive Processes to be employed.

6.4 VOLUME 4: OPERATIONAL STUDIES

The main objective of the Operational Studies is to define the most efficient operational model for the proposed investments and to determine revenues and

costs and operational expenses. That means the Operational Studies will be the basis for the determination of the operational expenditures of the enterprise.

They should also cover Interoperability Studies, demonstrating the benefits of a continuous and operational rail network compatible with existing or existing rail networks of cargo, and access to such networks.

The costs of investments and operating expenses presented by the **PROPONENTS**, in fixed and variable amounts, should consider the adopted standard train used to determine the travel time, fuel consumption and operational capacity of each of the rail **SEGMENTS**.

6.4.1.1 Operational Studies

The Operational Studies should contemplate, at least, the following activities for each **SEGMENT**, separately:

- Dimensioning of physical needs with presentation of the basic and operational characteristics of the railway; specification of the rolling stock that will be used in the railway, its supporting capacities, and the most modern and high capacity type currently used;
- Concepts of the systems for Licensing of Trains, signaling, telecommunications, energy, and **OCC**, with the associated estimates of necessary investments;
- Determination of the commercial fleet of locomotives and wagons required to meet the demand, as well as of pairs of trains in each direction;
- Production and productivity of rolling stock of the commercial fleet in each direction;
- Determination of the necessary investments in rolling stock of the commercial fleet in each direction;
- Forecast for the operation of passengers trains and trains in internal service;
- Elaboration of the loading of the network in net weight, laden weight, in trains/day in each direction;
- Consolidation of the route plan of the section projected in the Railway, considering the useful and total lengths of the crossing deviations;
- Based on the Simulation of Train Performance, the parameters of the railway operation will be established, emphasizing, compulsorily, the average velocities of the circulation of trains, the travel times between the deviations of

crossings of the performance and the fuel consumption of the locomotives, in the Railway in each direction;

- Calculation of the traffic capacity of the road in number of trains per day according to the type of the train; travel times between crossing deviations; usable length of the deviations; train licensing time; interruption time for track maintenance, among other factors in the railway;
- Comparison of the traffic capacity of the track with the expected demand considering the passenger trains and the internal services, in number of trains, with the objective of identifying the existing bottlenecks in the railway;
- With the identification of bottlenecks, analyze the possibility of increasing installed capacity either by widening the existing diversions, and/or through the implementation of new rail yards between those already envisioned in the project;
- Identification of the total volumes that will be operated at each freight center, and the elaboration of the layout, dimensioning, and location of the rail yards and terminals;
- Calculation of the necessary quantities of rolling stock in the internal service, track equipment and rescue cranes in the Railway;
- After the quantitative identification, the analysis of the best location for the implementation of workshops and other support facilities for the maintenance of the rolling stock (including the materials employed in the commercial fleet, internal service, and rescue cranes), of track equipment, and of rescue teams will be provided, as well as the minimum required areas for these facilities;
- Analysis of the best location for the train shed for the administration building with the railway **OCC**, for the railway residences and systems, and for the welding rail yard.

6.4.1.2 Interoperability Studies

Considering the size and complexity of rail freight systems, it is necessary to explain the specific features of the requirements essential to the operation of the railway, thus considered in its entirety, establishing the fundamental parameters and setting the minimal technical specifications for enabling the interconnection and interoperability of the two **SEGMENTS** of the corridor, as well as with the regional and national rail networks, with these networks being either currently deployed or still under planning, as regards the components, interfaces, and access to these networks.

The interoperability between the two rail **SEGMENTS** is, therefore, fundamental for the feasibility of the **PROJECT**, as the **PROJECT** must promote the integration of the region, from **DOURADOS, MATO GROSSO DO SUL**, to the **PORT OF**

PARANAGUÁ, in Paraná, connecting these regions with a rail that reduces the costs of transportation.

The interoperability must consider, at least, a set of guidelines that will conduct the elaboration of the **FEASIBILITY STUDIES** of the **PROJECT**, providing the justification for the implantation of the two rail **SEGMENTS**, considering features such as right of way, as well as the usage of the rail by independent operators.

In order to establish the interoperability guidelines of the Railway, the **PROPONENTS** must demonstrate, in their Demand Studies, the feasibility of two **SEGMENTS** that enable the safe and uninterrupted circulation of the freight that will be transported using the rail.

In addition, while elaborating the Engineering Students, **PROPONENTS** must analyze and demonstrate which Interoperability Technical Specifications (“**ITS**”) are necessary for the full functioning of the railway, in addition to its integration with the existing rail network.

Interoperability Technical Specifications (ITS):

The proposition of Interoperability Technical Specifications that, in principle, are aimed at enabling the interconnection and interoperability of the **DOURADOS – GUARAPUAVA** – Paranaguá Rail Connection with the *Estrada de Ferro Central do Paraná* must take the following into consideration:

a) All subsystems shall be the object of an **ITS**

As regards the subsystems that are associated to the environment, to the exploit of the rail, or to the users, **ITS** shall only be elaborated if they are discovered to be necessary in order to ensure the interoperability of the southern Brazil freight rail network concerning infrastructure, the control and command of operations and signaling, and the rolling stock;

b) Subsystems must be in accordance with **ITS**.

This conformity must be permanent throughout the usage of each subsystem;

c) If necessary, so that the interoperability of the Brazil freight rail transportation system is concrete, the **ITS** must:

- Precisely describe the essential requirements and apply them to the subsystems and to their respective interfaces;
- Establish the fundamental parameters (minimum infrastructure standards, Minimum Radius gauge, axle load, rail yard minimum width, Operational Control Center features, etc.) that will be necessary for meeting the essential requirements;

- Establish the conditions and see that the specified performance levels are met by each of the following categories of tracks:

- Tracks especially built for this Project;
- Existing tracks, adapted for the current operation model;
- Tracks that were especially adapted for the current operation model, with specific features due to topographic, terrain, or urban obstacles;

d) Determine the interoperability components and the interfaces that must be subject to local specifications, incorporating European standards, as well as, if necessary, AREMA standards, in order to fulfill the interoperability of the Brazilian freight rail system, thus meeting essential requirements.

ITS cannot be in conflict with any resolution, ruling, or decisions taken by ANTT and other concessionaires relative to the usage of new infrastructure or relative to the usage of infrastructure adapted for the circulation of other train compositions or assemblies.

The **ITS** proposals must be elaborated while trying to adopt procedures and guidelines that are already put into practice and accepted in other federal concessions, and that may be reviewed and adopted in accordance with the provisions of the ANTT Regulation Acts, and that may be incorporated into currently valid procedures.

6.5 VOLUME 5: BUDGET AND SCHEDULE

6.5.1 Budget

With all the services identified and quantified according to the provisions of these **TERMS OF REFERENCE**, a Services and Quantities Worksheet will be elaborated.

Based on the studies previously discussed, estimates concerning the necessary costs for the construction and operation of the enterprise shall be elaborated, according to each alternative under study. Quantitative estimates should reflect the highest degree of detail and precision possible and adopt the same criteria and concepts for all alternatives under analysis.

For each of the services of this worksheet the corresponding unit cost will be adopted, obtained from the worksheets of the Sistema de Cursos Referenciais de Obras (SICRO) from National Department of Infrastructure and Transport - DNIT, of SICFER, if already authorized by ANTT, or of the Sistema Nacional de Custos e índices da Construção Civil (SINAPI) from the Brazilian bank Caixa Econômica Federal.

If this is not possible, a specific unit cost composition for the service in question, based on properly substantiated market research, should be presented.

They should also present the composition of social charges, with proper justification of the premises adopted.

In addition to investments in infrastructure works, the amounts of investments planned by ANTT for railway equipment, expropriations and to cover socio-environmental costs must be adjusted to the new project data. Costs of recovering environmental liabilities, expropriation and removal of interference must be added to the latter.

The necessary investment for each of the alternatives studied should include, when applicable, the following items of direct and indirect cost:

- Construction sites;
- Mobilization and demobilization;
- Earthworks;
- Drainage;
- Culverts and other drainage structures;
- Railway superstructure;
- Bridges, viaducts, and other crossings;
- Signaling;
- Complementary works;
- Relocation of local public services;
- Acquisition and transportation;
- Construction of road accesses to the main courtyards and freight transfer points;
- Resettlement of the population affected by the deployment;
- Landscaping and urbanization;
- Expropriation of the Domain Range and purchase of access rights;
- Cost of studies and design;

- Supervision and management;
- Environmental costs.

In the estimation of costs, the values will be referred to prices valid on base date of the **FEASIBILITY STUDIES** and indicated in financial values (market prices).

6.5.2 Investment Costs

In the investment costs it is necessary to demonstrate, among others, the costs related to:

6.5.2.1 Infrastructure Area

- Construction of the Railwa
- Crossing Deviation Implementation;
- Implementation of the Load Centers;
- Implementation of the systems;
- Implementation of the Locotrol System, if necessary;
- Acquisition of rolling stock in internal service;
- Acquisition of track equipment and relief crane equipment;
- Investments in support facilities for the maintenance of rolling stock in internal service and in relief cranes;
- Investments in administration buildings;
- Investments in soldering shipyards;
- Investments in a road equipment maintenance workshop.

6.5.2.2 Operating Area

- Acquisition of rolling stock for the commercial fleet;
- Construction of workshops and other support facilities for the maintenance of the rolling stock of the commercial fleet;
- Construction of equipment dormitories;
- Acquisition and assembly of locomotive on-board equipment.

6.5.3 Operational Costs and Expenses

Operational costs and expenses, which shall be presented in fixed and variable terms, shall include the following activities:

6.5.3.1 Permanent Track Area and Systems

- Maintenance of the road superstructure;
- Maintenance of the track infrastructure and environment conservation;
- Maintenance of the systems;
- Maintenance and operation of track equipments;
- Operation of welding shipyards;
- Maintenance of rolling stock for the internal service.

6.5.3.2 Maintenance of Rolling Stock and Relief Cranes

- Maintenance of the Road Superstructure;
- Maintenance of the Track Infrastructure and Conservation of the Environment;
- Maintenance of the Systems;
- Maintenance and Operation of Track Equipments;
- Operation of Welding Shipyards;
- Maintenance of Rolling Stock for the Internal Service.

6.5.3.3 Railway Operation

- Personnel for train movement;
- Locomotive equipments;
- Railyard and Terminal personnel;
- Consumption of Fuels and Lubricants;
- Costs with the Means of Transmission for the Operation of the Systems.

6.5.3.4 General Expenses

- Administration, Commercial, and General;

- Patrimonial Insurance, as well as insurance policies for the operators' freight.

6.5.4 Physical Financial Schedule

With the Physical Schedule defined in the Execution Plan of the Works and with the Investments defined in the Budget, the Physical and Financial Schedule of the implementation and operation phase must be prepared for each **SEGMENT** of the **PROJECT**.

7. BOOK 2: ECONOMIC AND FINANCIAL STUDIES AND EXTERNALITY STUDIES

With 02 (two) volumes (Economic-Financial Studies and Externality Studies), the studies of this Book must be consolidated in a digital worksheet with the calculation log, the formulas used in the log, and the possibility of changing the premises used for the construction of the projected scenarios. Both components of each volume should be consolidated in a digital worksheet open for editing by the **CCP**, observing the minimum requirements and the guidelines of each volume.

7.1 VOLUME 1: ECONOMIC AND FINANCIAL STUDIES

The Economic and Financial component of the Studies should provide a model indicating the economic feasibility for each **SEGMENT**, according to the projection of revenues and investments, to the Physical-Financial Schedule, and to the operational cost structured in Book 1, in order to reflect the financial situation of the Concessionaire throughout the Concession period.

The Economic-Financial Studies shall contain and indicate the commercial feasibility conditions for private investments and the proposed financing structure according to the investments concerning each **SEGMENT**.

The studies should also contain the sensitivity analysis, in order to indicate the factors that increase the value of the **PROJECT** from the investor's, the Public Administration's, and the population's perspectives.

For the purposes of evaluating economic feasibility, the free cash flow of the **PROJECT**, of the annual expenditures of each alternative studied, over the course of the Concession, shall be discounted by the Internal Rate of Return ("IRR") for conversion to present value.

The minimum time unit to be used shall be the *year*, and the currency of the period and the base date to which the study refers should be indicated.

The reference **IRR**, to be set as the target of the **PROJECT**, and to be part of the Concession tariff framework, will be regulated according to the current ANTT resolutions.

This volume must have, at least, the following:

A. Digital worksheet containing the economic-financial model for the Concession and the Concessionaire remuneration proposal. The spreadsheet should highlight all the premises used and include the following:

- Projection of the individualized demand by activity/product/service for each **SEGMENT**, based on the calculation log;
- Detailed projection of each item of revenue by **SEGMENT**, based on the calculation log;
- Detailed projection of Extraordinary revenue and Financial revenue;
- Detailed projection of each item of expenses and costs by **SEGMENT**;
- Investment Physical and Financial Schedule;
- Tax effects of possible expropriations and other instruments that seek the tax efficiency of the business;
- The Results Statement for the Fiscal Year should be projected per **SEGMENT** and per period throughout the Concession period;
- The Balance Sheet should be projected per **SEGMENT** and per period throughout the Concession;
- The Free Cash Flow of the Project should be projected for the period and for the **SEGMENT**, consolidating the Revenues, Investments, Costs and Expenses of the model, the Taxes and the Working Capital required;
- From the target **IRR** for railway infrastructure projects, defined by ANTT, the Concessionaire's remuneration model should be proposed for different scenarios, depending on the variation of the premises;
- For the proposed remuneration model, readjustment mechanisms should be provided, highlighting the calculation premises and formulas.

B. Proposal of model of financing in a report including a digital spreadsheet, based on the analysis of financial feasibility. The spreadsheet should highlight all the premises used for its preparation and include the following:

- Identification of funding agents, including all costs, fees and premises for each possibility;
- Index of Debt Coverage per **SEGMENT**;
- The Leveraged Cash Flow should be projected for a period and per **SEGMENT**, which in addition to considering the consolidations of the Free Cash Flow of the **PROJECT**, should present financing funding and amortizations, evidencing the premises, rules, rates, among others, and the calculation log used;

- The Shareholder's Cash Flow should be projected for each period and **SEGMENT**;
- Calculation of financial indicators of the Concessionaire's situation;
- Calculation of the capital stock, of the capital to be paid in, and of the exposure of the Shareholder for the selecting of future **PROPONENTS** in a competitive bidding procedure that might take place.

C. Consolidated report of the economic-financial model, containing the results of the spreadsheet and marginally showing the scenarios, with projections of Cash Flows, Balance Sheets, Income Statements, Costs and Expenses, Investments, Revenues, and Taxes.

D. A report containing a risk matrix and the quantification of risks transferred to the Concessionaire. The report shall include the result of carrying out the following tasks:

- Identification, characterization and description of risks related to the construction and operation of the proposed system, including, but not limited to:
 - **Construction Risk:** which includes all obstacles of civil works, such as non-compliance with agreed deadlines, with the Detrprojected budget, or framework in the stipulated specifications;
 - **Infrastructure Risk:** the necessary infrastructure might not be available for its full and perfect use;
 - **Design Risk:** the design risk is the possibility of not enabling the provision of the services necessary for a faithful execution of the contract or of compromising performance or quality standards;
 - **Economic Risk:** the current economic situation at the time of hiring might undergo radical changes, to the point of interfering in the indexes of other projected numbers;
 - **Environmental Risk:** risks arising from the environmental impacts that the **PROJECT** may cause in the environment in which it is installed and in adjacent areas;
 - **General Risk:** risk of delays or substantial modifications in the **PROJECT**;
 - **Legislative Risk:** risk of legislative changes raising project costs;
 - **Demand Risk:** risk of the demand for services being lower than planned;

- **Commercial Revenue Risk:** takes into account the risks to the total revenues of the enterprise, especially those raised in the products of Book 1.

- Identification, detailed description, and shared suggestions of the main risks associated to the **PROJECT**, in the case of Concession.
- Monetary assessment of risks, based on risk evaluation techniques, whenever possible.
- Analysis of the implications associated with the risk allocation contemplated in the elaborated matrix, through the identification of the contractual mechanism by means of which said allocation could be accomplished.

E. A report containing the proposed Performance Indicators Table. The report shall include the results of the following studies:

- Identification of the indicators and their justification;
- Stress events of the performance indicators on the financial indicators;
- Description of procedures, form, and periodicity in which each performance indicator will be measured;
- Impact of the Performance Indicators Table on the financial situation of the Concession for different scenarios.

F. Report containing a detailed description of all Concession obligations. The report shall include the result of carrying out the following tasks:

- Detailed description of the Concessionaire's obligations, with consequent elaboration of the Concessionaire's Book of Responsibilities;
- Detailed description of the obligations of the Public Administration in the execution of the Contract.

G. Report on the structure of guarantees required for the Concession. The report shall include the results of the following studies:

- Identification of the volume of guarantees necessary to ensure the economic attractiveness of the Concession;
- Proposing type of guarantees and their characteristics in order to ensure the economic attractiveness of the Concession;
- Study of the Concessionaire's Cost of Opportunity.

H. Report on the insurance structure necessary to the Concession, contemplating at least the following Studies:

- Proposition of type of insurance and its characteristics in order to guarantee the economic attractiveness of the Concession;
- Study of the Concessionaire's Cost of Opportunity.

7.2 VOLUME 2: EXTERNALITY STUDIES

The Externality Studies present in the **PROJECT** should identify and calculate the economic gain derived from the direct and indirect benefits. The calculation of these benefits, when possible, should be presented in a digital spreadsheet, open to editing, highlighting the methodology and formulas used.

The studies should demonstrate the economic features of the chosen model in relation to the traditional direct hiring through competitive bidding or to the execution of the **PROJECT** directly by the Public Administration instead of hiring a contractor.

7.2.1 Direct and Indirect benefits

Simultaneously with the other studies that will be developed by the **PROPONENTS**, the Externality Studies should identify and calculate the economic gain derived from the direct and indirect benefits, understood as follows:

- **Direct Benefits:** resulting from investments that imply reduction of transport costs, emission of pollutants and accidents;
- **Indirect Benefits:** arising from the social and economic development of the Region in view of the investments made. In this item will also be calculated the impacts on tax collection and employment, during the construction period.

7.2.1.1 Direct Benefits

The **PROPONENTS** shall prepare a report demonstrating the direct benefits to each of the **SEGMENTS** of the **PROJECT**.

The annual amounts of the direct benefits shall be projected from the first year after the implementation of the **PROJECT** until the last year of the concession term.

Among the direct benefits of the **PROJECT**, the studies must cover, at least:

7.2.1.1.1 Reduction on Transportation Costs

Reducing transportation costs could be appropriate to the demand that would no longer be used in other modes. Thus, the benefit may consider formulations of

multimodal cost, which can be calculated by generalizing the reduction of transport costs by replacing other modes with rail transportation.

7.2.1.1.2 Reduction of the Cost of Pollutants Release

The benefit related to the reduction of emission of pollutants will be calculated, among other factors, by the reduction of the use of fossil fuels mainly due to the substitution of the road modal by rail transportation in the **PROJECT** that is being studied.

The quantification methodology adopted should be justified by the **PROPONENTS**. However, any methodology that is used should consider the quantification of vehicles/year, with the production of pollutants in this emission period that would no longer be released into the atmosphere.

7.2.1.1.3 Reduction of Accidents

The benefit associated with the reduction of accidents can be counted from the current number of accidents registered by freight vehicles on the highways in proportion to the percentage of those vehicles that would cease to traffic yearly by transferring the product to the railway under study.

7.2.1.2 Indirect Benefits

It will also be incumbent upon the **PROPONENTS** to demonstrate the indirect benefits that will come, with the implementation of the **PROJECT**, to each **SEGMENT** of the **PROJECT**.

Among others, the net increase of value of properties and the impacts on tax collection and employment generation, during the Concession period, should be demonstrated.

The analysis of the risks of pre-construction and construction activities related to the **PROJECT** will be of fundamental importance, as it will enable the choice of mitigating actions for the risks that may be identified, in order to provide the financing agents of the **PROJECT** greater security to decide on their respective participations.

The **PROPONENTS** shall also present a Report showing the efficiency gains derived from the hiring through Concession. The report shall include the results of the following studies:

- Construction of a public sector comparison matrix, including transferable risks, that reflects the net benefits or net costs of implementing and operating the road network through a direct implementation by the State;
- Construction of a private comparison factor that allows comparison with the public sector factor;

- Description and analysis of qualitative factors that have not been evaluated in the elaboration of the matrix;
- Comparison of direct execution and concession alternatives, justifiably indicating the one that presents the best social and economic cost-benefit ratio.