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The use of artificial intelligence in infrastructure projects

Technology and Innovation are concepts not so easy to define. While the first one is commonly known as the application of scientific knowledge to practical situations, the latter has a big sort of definitions, ranging from an improvement in an existing technology (incremental innovation) to creating something new that changes the existing patterns or models (disruptive innovation). Despite the cloudiness of the definition, innovation is being used to fasten and improve quality of infrastructure projects all over the world due to the increasing pressure to create value to the economy and the society.

One of those projects is the *New Ferroeste*, developed in the south region of Brazil. The project aim is to build a railway between the state of *Mato Grosso do Sul*, in the central west of Brazil and the *Paranaguá* Port in the state of Paraná, with the objective of increasing the transport capacity in the region to export mainly the soy and its subproducts cultivated in the middle portion of the country. To accomplish this endeavor, it will be necessary the construction of 1 300 km of railways, crossing two states, to get the cargo to the Brazilian shores. The project is in the phase of technical, economic, environmental, and legal feasibility, in which TPF Engenharia participated, with an execution deadline of one year.

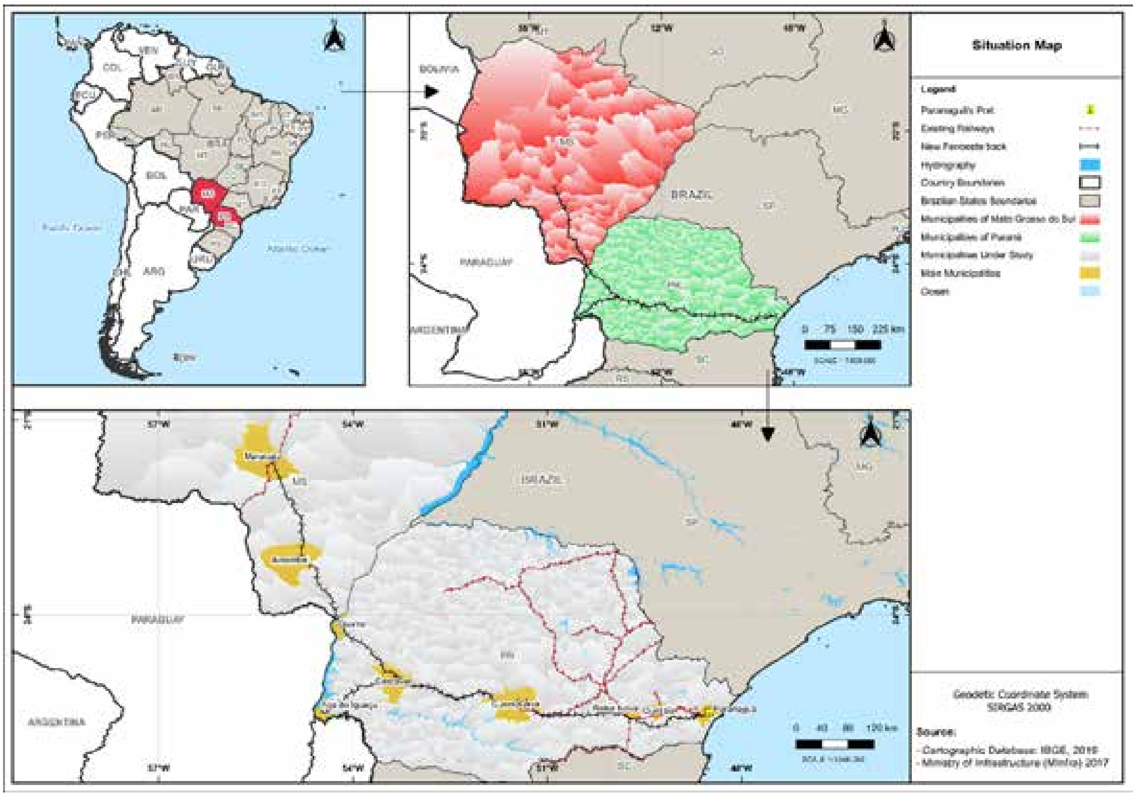

Figure 1 - Situation Map of the New Ferroeste.

Time is always a scarce resource, but in the *New Ferroeste* project, it represented a major challenge to overcome. Imagine conceiving, designing, and modelling 1 300 km of railways, crossing two states with a considerable accidented topography, a high pluviometry index, an extensive list of environmental interferences, such as permanent conservation areas, indigenous conservation areas, and *quilombola* [xvii] areas in only one year. On top of that, to arrive to the *Paranaguá Port*, it was necessary to overcome more than 900 m of unevenness, a formation called *Serra do Mar*, which has an accidented relief that must be adjusted. Due to this global picture, one of the main challenges was to perform the preliminary trace of the railway, which had to cope with all these interferences and obtain the best possible solution to the project. Another key point is that the definition of the preliminary trace will pave the way to all the other studies performed, which means that its quality is fundamental once it may even affect the feasibility of the entire project.

Traditionally, the definition of the preliminary trace is done individually by the specialists in each discipline. So, the process starts normally with the topography, where the engineer decides where the best path for the railway is, according to its experience. Then, the project is passed to the hydrology specialist that will analyze if there are any interferences in the original trace. If so, he will perform the changes and return the project to the first engineer for validation and so on. It continues for all the disciplines involved, including the environmental, becoming iterative, which takes a lot of time, once the definition of the preliminary trace must be consensual between all the specialists involved. Moreover, the trace is usually conditioned to the first one drawn, which eliminates the study of other possibilities that could be as good as the chosen one, or even better.

Due to time restrictions and the big length of the railway, *TPF Engenharia* had to innovate and developed a new way of defining the preliminary trace, once the traditional approach would be very costly in terms of time and effort. The solution was designed in terms of the experience of the specialists, multicriteria analysis and artificial intelligence.

First, the specialists on each discipline did a profound study of the characteristics of the region, such as hydrology, topography, geology, environmental, social, and others. Then, each dimension defined some attributes and gave a grade from 0 to 10, considering its positive or negative impact in the trace of the *New Ferroeste*. For example, in the geotechnical discipline, Soil A was really good for the crossing of the railway and was graded 10, while Soil B was really bad and graded 0. Another example is in the environmental field. The Integral Protection Areas were all graded 0, once crossing it is an environmental crime and other areas where the railway could pass without any problem were graded neutrally, 7, so that it did not influence too much the analysis.

After the grading of the attributes, a multicriteria analysis was performed to determine which disciplines are more relevant to the trace of the *New Ferroeste*. It was done through a methodology called Analytical Hierarchy Process (AHP), presented by Saaty (1977), normally used to decision support in a multivariable scenario. It consists of analyzing the chosen variables two by two and attributing weights of relative importance between them to create a comparison matrix, such as presented in *Figure 2*. For so, the specialists from each discipline gathered in a council to define those weights based on the study previously done.

AHP Matrix				
	Mercadological	Physical Environment	Logistics	Socio-Environmental
Mercadological	1	0,50	2,00	0,60
Physical Environment	2,00	1	2,50	0,80
Logistics	0,50	0,40	1	0,40
Socio-Environmental	1,67	1,25	2,50	1

Figure 2 - Example of an AHP comparison matrix.

With the grading done by the specialists and the multicriteria analysis, the data was inserted in a software of geographical information system (GIS) to process all the information generated and obtain the best traces, called favorability corridors. Due to the huge amount of data and the connection between all the dimensions analyzed, the computational process was done through Artificial Intelligence (AI) to gain velocity and to analyze all variables at once. Then, an AI code was created inside the GIS software to process all the information and then spatialize the favorability corridors, marked from dark green to light yellow, as seen in *Figure 3* so that the engineers could perform the necessary analysis.

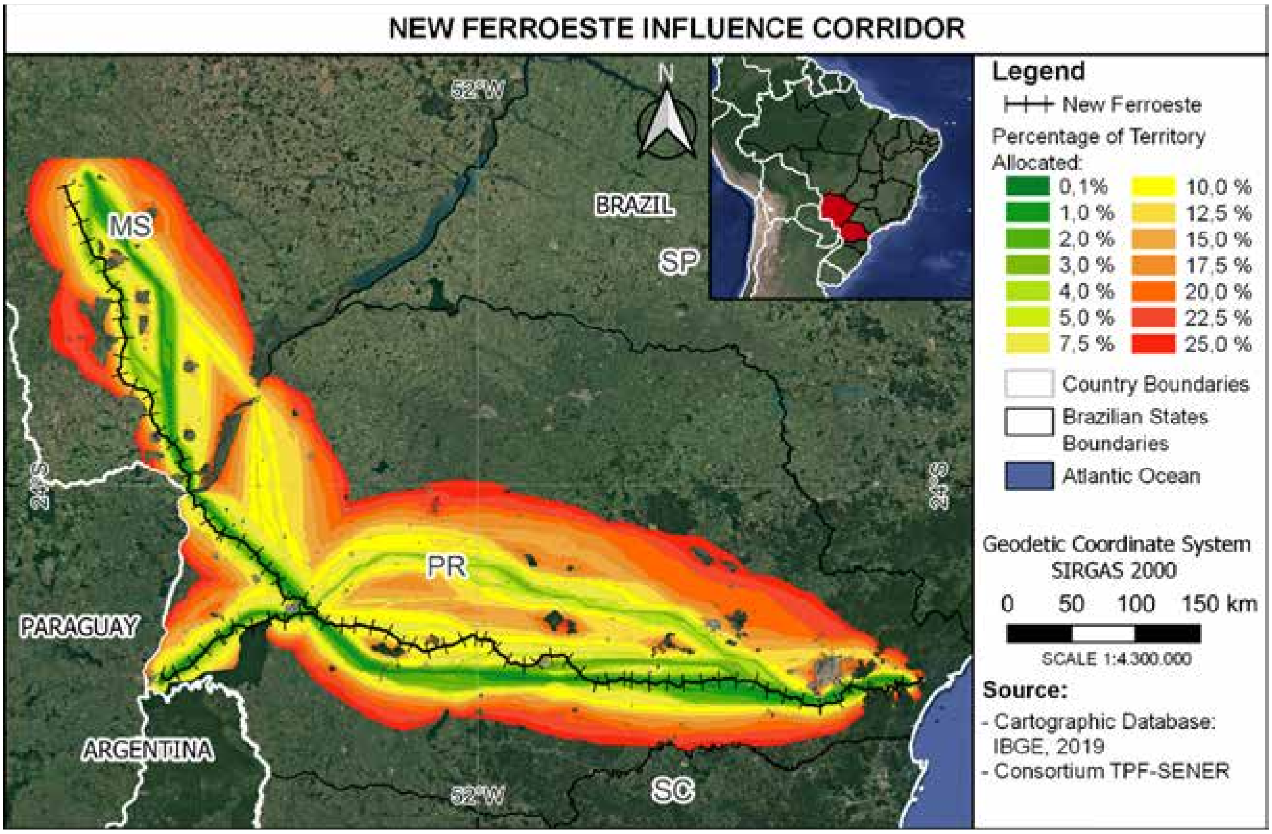

Figure 3 - Favorability Corridors

Finally, with the best corridors defined, the engineers of the team could gather and perform the refinements to determine the trace to be chosen, which is not necessarily the best one indicated by the algorithm, indicated in dark green. As seen in the image above, the chose one is marked in black.

The creation of this innovative approach combining AHP and AI to the definition of the preliminary trace in railway projects avoided the use of trial-and-error methodology or the use of the iterative traditional approach, which gave celerity and assertiveness to the project. Moreover, one of the most important contributions was to help deviate from sensitive environmental areas, indigenous areas and *quilombola* areas, speeding up the process of environmental licensing, which is a huge achievement due to the bureaucratic and restrictive process in Brazil. This was fundamental to obtain the environmental feasibility of the *New Ferroeste* and the support from the concerned stakeholders once the ecological damage was reduced due to the methodology.

One important remark to be done through the entire process regards the role of the engineers. The use of AI did not exclude their participation in the process but put their work on the spotlight. By directing the efforts to the analysis of the scenarios created by the algorithm and reducing the area of analysis, too large in the traditional approach, the team and the specialists could focus on more strategic tasks and use their time to go deeper in the project or even work on other ones. After the analysis of the obtained results, the team did not choose the best alternative according to the algorithm, but the one defined based on other restrictions, such as existing infrastructure, and the experience of the specialists. In addition, it values the professional, because the specialists need to be really good so that the entire process can work smoothly and be effective.

In light of all the exposed above, the power of innovation and combination of new technologies disrupt the traditional process of conceiving traces to railways, shifting the perspective from a vertical approach, where each specialist must do its part and passes to the next, to a horizontal approach, where they can discuss together at the beginning of the project to achieve the best overall result, increasing the speed and the quality of the outcome.