Upstream & Feasibility Study
of a Railway Connection
Between
Peru and Ecuador

EXECUTIVE SUMMARY
&
BIM Presentation

Railway project for AFD & ENPC

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ABSTRACT

The Trans-Peru-Ecuador project is confronted to all problematic deriving from the creation of a near nearly -4000-km connection link in between two political unstable countries in under-developed development zones areas with almost no existing infrastructure. Such an ambitious project had to be well-built in order to succeed.

First, there is a strong (need for) communication need in order to change all common states-of-mind of transportation: almost all travels journeys are all made by car.
With railway tracks (railroad tracks) following both the Pan-American road and the Pacific coast for the major part of the route, the train will place itself as a real pertinent (relevant) and affordable alternative.

There is a strong potential for travelers' market, with a train line serving both countries' capitals and most important cities.

A delicate topography imposes the construction of a few viaducts and tunnels, despite a maximal optimization of the delineation. The new tracks will be connected to the existing ones in Ecuador and in the south of Peru. The use of ERTMS signaling will be only effective on the densest sections.
With 50 units of hybrid rolling stock for passenger traffic and freight trains located.

The bi-national specificity of the Trans-Peru-Ecuador project implies the establishment of a supranational entity which will regulate every administrative steps and then manage the infrastructure's construction, following a detailed planning. The project scheduled will come in the horizon of 2030.

This project is also unique due to its cost: nearly: almost 30 billion Euros (26 27 for infrastructure, which add the staff and rolling stocks costs). Even though while the risks are high with the cost and with the bet about the population's immigration from car to train, the Trans Peru-Ecuad project represents a huge opportunity for issues related: environmental, territory territorial meshing and regional integration matters.

It could create an artery between Peru and Ecuador, thereby linking them and providing a background that would be perfect for growth on a large-scale.

The Trans-Peru-Ecuador project is about creating a global transportation system in Peru and Ecuador. As the railway service is almost inexistent on both countries, the project requires a large study on the geographical, climate, political, economic, demographic, diplomatic and financial domains. With the aim of connecting Equator's capital Quito to the city of Arequipa in the south of Peru, with this emphasize the hugeness of such a project: almost 4000 km of railway, two countries, thirty stations, and tough landforms.

The most important points at stake are the meshing of the territory with a strong service, for fright, passengers or both, depending on the potential benefits it could provide.

1- The current situation analysis:

Peru and Ecuador are two neighbors Latin-Americans countries with a wide opening on the Pacific Ocean. They are not yet considered as developing countries, even though they are on the way to becoming ones. Ecuador has a population of 16 million people, half of Peru's one, on a more than four times smaller surface: 300 000 km² against 1 300 000.

Both countries present a similar geographic and climatic situation, cut vertically in three very distinct parts. The west coast is the most populated zone and is quite desertic, while the "Sierra" zone is located in the center of both countries and is very mountainous. On the east of each country, the "Selva" zone occupies an immense space full of forests. It is a very tropical and therefore unlivable zone. The most important cities are located on the coast, where can find the majority of the roads and infrastructures of both countries. It is also the safest place to build a train line, far from high mountains and dense forests.

Peru has had a growing economy in the last 15 years, which led to a good development of the quality of life. Ecuador also shows a better GIB year after year. Nevertheless, both countries had a tough historical relationship, and their political situations are blocked following many years of violent public manifestations and of divided public opinion.

In transportation terms, Peru and Ecuador are once again having a very similar situation. A few daily flights connect the principal cities to the respective capitals. Railway transportation is almost inexistent, as all equivalent distances are traveled by car, bus or truck on the Pan-American Highway. All railway infrastructures are small, disconnected and scattered on the territory. The aim is to reconnect these pieces to build an efficient line. The railway freight represents only a fifth of the global traffic, the rest being made with trucks. Therefore, the major stake is to create corridors for freight transport, and to take the best of the climate

argument in order to reduce road traffic for a more sustainable transportation system. Moreover, ports are also some key places to connect to the network, as they represent a significative part of the countries' exportations.

Thus, the global situation underlines the need of an efficient, connected and meshed service, for both freight and commercial services. It will be necessary to create jobs for the system construction and operation, and train the future employees for these totally unknown and new tasks.

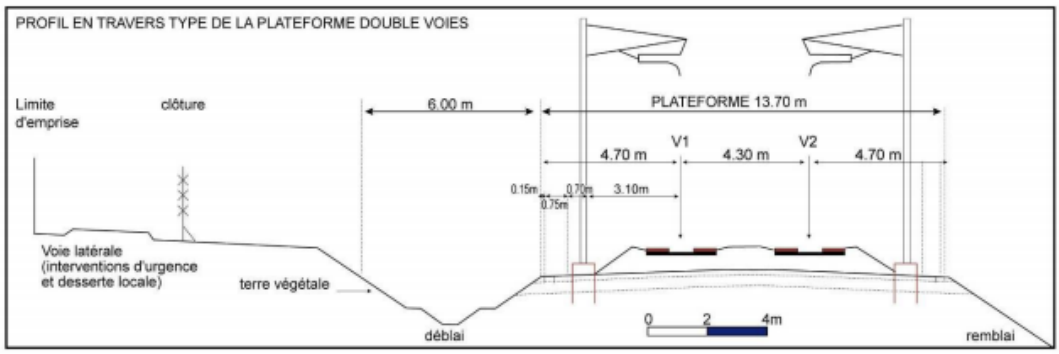
In order to facilitate the building of this project, also it must to take into account the numerous protected UNESCO monuments in both countries.

The Peruvian Ministry of transports already proposed a strategic plan for railway development in the country, which aims to connect Peru to Brazil, Paraguay and Bolivia. This plan is an important basis to build the project on. Nevertheless, with the consideration the political situation between Peru and Ecuador and their relationship, the Trans-Peru-Ecuador is a bi-national project. Once again, the similarities between them, as both dealt with many coups in a very unstable political system. The last two hundred years have been marked by continuous wars battles at the border, which did not help Peru and Ecuador to build a strong and prosperous relationship. However, the climate has improved over the last twenty years, and such a project could accentuate these mutual efforts in the right direction.

Therefore, how can connect these numerous cities taking into account the geographical, geological, political, climatic, geostrategic constraints and using the existing infrastructure? Which decisions to make for the delineation to embrace the civil engineering, signalization and rolling stock requirements? What decisions to take to embrace the requirements of civil engineering, signalization and rolling stock for the delineation?

2- Delineation and designing

The goal was to reduce the infrastructure costs. Therefore, the localization of all large-scale infrastructure, bridges and tunnels, have also been well reflected represented. A standard width is chosen for the tracks, a ballasted railway and a speed limitation of 220 km/h for the passenger trains. The following document details all lateral dimensions of the railway:



It is important to remember that there are strong seismic zones at both countries.
That is why there will be plenty of sensors all along the line.

The total line is 3704km long, with 2788km to be constructed as 916 already exist between Quito and Guayaquil, and Cuzco and Arequipa. Our choices in the delineation lead to the railway crossing and serving many rural, cultural, industrial and commercial areas.

The following table details the itinerary of the path:

Country	Section	Les gares De Ville à Ville	distance between stations (Km)	Average slope (%)
Ecuador	from Quito to Guayaquil 400 Km (Existing line)	De Quito à Tambillo	34	3,3
		Tambillo - Canton	60	2,1
		Canton - Ambaton	40	2,2
		Ambaton - Riobamba	51	3,6
		Riobamba - Huigra	92	6,6
		Huigra - Guayaquil	123	6,8
	from Guayaquil to la boarder 201 Km (new line)	Guayaquil - Naranjal	68	1,4
		Naranjal - Machala	76	0,7
		Machala - Santa Rosa	20	0 ,2
		Santa Rosa - La frontière	37	0,4
Peru	from la frontière à Lima 1155 Km (new line)	La frontière - Sullana	230	0,5
		Sullana - Piura	45	0,3
		Piura - Chiclayo	200	0,1
		Chiclayo - Chepen	80	0,1
		Chepén – Trujillo	110	0,7
		Trujillo - Chimbote	118	1,3
		Chimbote – Huacho	247	0,4
		Huacho - Lima	125	1,4
	from Lima to Nazca 432 Km (new line)	Lima - San Vicente	140	0,3
		San Vicente - Chincha	60	1,1
		Chincha - Pisca	30	0,7
		Pisca – Ica	70	0,9
		Ica - Nazca	132	1,4
	From Nazca to Arequipa 484 Km (new line)	Nazca - Chala	155	1,9
		Chala - Camana	190	4,8
		Camana - Arequipa	139	5,6
	From Nazca to Cuzco 516 Km (new line)	Nazca - Puquio	130	10,3
		Puquio - Abancay	266	8,7
		Cuzco - Abancay	120	8,7
	From Cuzco to Arequipa 516 Km (Existing line)	Cuzco - Sicuani	128	3,2
		Sicuani - Juliaca	190	2,5
		Juliaca - Arequipa	192	3,4
Total	**3704 Km**			
	916 km existing **2788 km to be constructed**			

The departure station is located in Quito, in Equator.

The railway tracks join Guayaquil using existing tracks for 400 km.

The cities of Tambillo, Canton, Ambaton, Riobamba and Huigra are served on the way.

The line continues in the south direction for 201km on a new infrastructure before joining the border station, a new station, necessary for all administrative matters.
Between these two points, the tracks serve Naranjal, Machala and Santa Rosa, all equipped with new stations.

Until now, the average distance between two stations is 40 kilometers. The remaining and most important part of the railway infrastructures are located on Peruvian territory.

The border station is located near the coast. From the point on, the tracks will border the Pacific coast in order to avoid a tough topography and to serve the biggest cities of Peru.

The railway joins Sullana, Piura, Chiclayo, Chepen, Trujillo, Chimbote, Huacho and then the capital of Lima on 1155 km. All these cities have important ports.

Between these first Peruvian stations, the distance is a lot far bigger: 145 km. So far, the railway tracks join both countries' capitals in an economic, commercial, social and touristic strategy Policy.

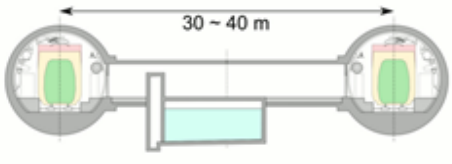
With the aim of a durable development in the country, we propose a north/south link between Lima and Arequipa, serving the city of Nazca.
On the way, San Vicente, Chincha, Pisca and Ica are served before joining Nazca. Al these cities will benefit from new stations. We observe an interstation of 86 km on 432 km long

By proposing a loop (carousel) on the deep south of the line, that joins existing tracks between Cuzco and Arequipa. Nazca is a huge railway node and logistics centre, and providing an efficient service to a potential freight market is crucial.

The loop will facilitate the operation with a unique railway, which we chose to use there. Nazca and Ica both have an airport and are close from the St Juan port, and have therefore an important potential for both (considerable capacity both) freight and passengers' traffic. New tracks on the bottom part of the loop will directly connect Nazca to Arequipa.

On the way, they will serve Chala and Camana on a 484 km long distance. The top part of a loop is also made of 516 km of new tracks, and serves Puquio, Abancay before Cuzco. There is already the connection in the East between Cuzco and Arequipa).

Construction of several tunnels is needed. For example, we will take the first of the routes (km point 37,5), which will be 3 km long, and the bi-tube. Each tube will have an intern diameter of 4,2m, and an external one of 4,9m.



These tracks have to be constructed on the toughest topography of the delineation (up to 10,3% of steep incline between Nazca and Chala). Six work bases will help the infrastructure's construction.

The same precautions are taken for all viaducts and earthwork. Between Lima and Nazca, a viaduct 3 kilometers long and 30 to 40 meters high will be constructed. By calculated and projected a total price of 114 million for each kilometer of bridge.
Thus, the global infrastructure will cost 8,4 million Euros per kilometer, which represent 23,6 billion Euros for the 2788 kilometers of tracks to build. To that amount we add all tunnels and viaducts costs of 3,6 billion Euros. The total is increased to 27 billion Euros.

3- Equipment and Signaling

Our system will be alimented by 2 x 25 000 V single-phased supplying, with feeder and catenary in phase opposition. The project will have two sub-stations equipped with power transformers. Line posts ensure the cut of both catenary and feeder if needed.
After analyzed each section of the line and their respective projections of traffic (detailed below). Thus, between Guayaquil and Lima, the railway tracks must be built with BAL signaling and will be expanded before the construction of the project begins

All train detection will be assured by track circuits.
A critical part will be the connection to already existing tracks. Junctions will be banalized and limited in speed to 160 km/h. Signal tower and safety rooms will be automated and SIL4 security will be guaranteed. Moreover, the proposal is level 1 ERTMS in all stations, and automatized level crossing. A global monitoring system will ensure all installations' security in real time.

4- Rolling stock

An important part of the total railway's length will not be electrically supplied. That is the raison of chose a hybrid rolling stock. Classically, a call for tender allows the operator to choose its trains. In our case, the example of one rolling stock equipped with all our specifications: Alstom's Hybrid Coradia Polyvalent train. The following images presents our colours and interior amenagement choices, neutral white for the exterior, and red and yellow on the inside to remind both countries' colours:

The alliance of thermic motors and battery groups allows stocking the surplus of energy generated in traction or braking and using it later on non- electrified tracks and economizing this energy. All traction chains will be put on the roof.
After a length optimization calculation, our trains will be equipped of four cars for each train, joinable. Each train will cost about 15 million of Euros. An estimate showed that 15 trains will be necessary at first, which requires and investment of 225 million of Euros for the rolling stock. The maintenance cost is estimated at 2€/km.

5- Traffic estimation and Transport plan

Section	Travelers /day	Travelers /year
In 2030		
Equator (Quito - Border)	4416	1611840
North of Peru (Border - Lima)	24337	8882838
South of Peru (Lima - Arequipa)	18863	6884877
South-east of Peru (Nazca - Juliaca)	3320	1211719
In 2040		
Equator (Quito - Border)	4946	1805290
North of Peru (Border - Lima)	31595	11532097
South of Peru (Lima - Arequipa)	24488	8938255
South-east of Peru (Nazca - Juliaca)	4310	1573108

	Departures/day (Equator)	Departures/day (North of Peru)	Departures/day (South of Peru)	Departures/day (South-east of Peru)
2030	8, 4 in each direction	48, 24 in each direction	36, 18 in each direction	6, 3 in each direction
2040	10, 5 in each direction	62, 31 in each direction	48, 24 in each direction	8, 4 in each direction

The project's route serves the most important cities of both Equator and Peru, which concentrate more than 60% of the population.

Taking into account the growth estimations (0,9% per year in Peru and 1,2 in Equator), and touristic previsions, we calculated a traffic projection for 2030 and 2040 on the left:
At the 2030 horizon, we forecast a total number of 48 trains per day, increased to 62 at the 2040 horizon.
These values could be increased or decreased, following the real demand and use of the system.
A multiple-unit train will be used for the heaviest circulations.

A total cost of 122 million Euros is predicted to operate the system, 70 000 000 for the rolling stock maintenance, 46 million for energy, 6 million for human resources.
The estimated revenue is estimated up to 1,6 billion Euros each year. The fare will be aligned with bus prices, as it is the most used mean of transportation in both countries.

6- Freight

The possibility of a mixed line (passengers/freight) has been considered. With 511 000 tons of freight being transported between Peru and Ecuadorian 2017, this market is not negligible. The current growth of freight market lets us hope for a traffic of 1 million tons of merchandises goods traffic from 2040 onwards, from which 60% may be shifted to rail freight.

Therefore, 750-meter-long trains charged of 800 tons could be operated at this stage of maturity of the project. With underline the fact that the tracks delineation all along the coasts allows to serve efficiently Peru's most important ports.

To locate freight rolling stocks at first, as calculations underlined the impossibility of making a benefit in the early stages of the project's deployment. The fare has been detailed in order to cover all costs of maintenance: 3,25€ per kilometer.
Thus, the fright possibility is only justified by the tracks' construction for passengers. Otherwise, the benefit would be too small and such a project would be too risky. With a low traffic for passengers and freight as proposed, a mixed line is constructible. The main argument in favor of railway freight is environmentally friendly: it would actively participate to the global effort for C02 emission's reduction.

7- Financing

First, an international finance group will consist of sovereign loans from AFD (15%), Global Bank (20%), and the CAF (20%), which is a Latin-American developing bank. The remaining 45% will be funded by Peru (35%) and Ecuador (15%), both participations depending on the impacts of the project, and the tracks length in each country.
Also, a USDF "Green bond" is a pertinent option in order to reduce Peru's and Equator's contribution.

The total infrastructure has a cost of 27 billion Euros. Therefore, Peru would participate for 9,45 billion Euros, Ecuador for 2,7 billion Euros, AFD for 4,05 billion Euros, CAF and GB for 5,4 billion each.

8- Planning

200 km of tracks will be constructed Each year. The cycle will be carried out in four sections: first the one between the border and Lima, the second between Guayaquil and the border, the third between Lima, Nazca and Cusco, and the last one between Nazca and Arequipa respectively. 15 years will be necessary for the infrastructure's construction.
A few milestones show a higher risk: land acquisition, financing, bridges and tunnels realization. Of course, these milestones follow the mandatory political decision to launch the project.

On top of that, the making establishment of a bi-national project implies the creation of an Organizing Authority of mixed transportation, under national authority in each country, which will first ensure the progress advancement of all decisive critical tasks: creating the funding database, maintaining cooperation between the two countries, coping with any possible misunderstandings, creating the qualified staff teams and finally regulate the line's traffic.
Deployment of the project will be split in three phases: preliminary design, installation and operation, and link.

9- Presentation by BIM Method

1- https://drive.google.com/file/d/1ZuorSQIhYDNBfsMnkS1_6C_pEUrx2Lvq/view
2- https://drive.google.com/file/d/1j1WZipwhW34J8DT2XGw9czxj1T_Rpl-Z/view

References:

- IADB, 2015. Freight Transport and Logistics Statistics Yearbook. - https://publications.iadb.org/handle/11319/6885#sthash.hcma43xl.dpuf
- MTOP, 2016. Plan Estratégico de Movilidad (PEM) 2013 – 2037. - http://mtop.gob.ec/el-mtop-trabaja-bajo-el-plan-estrategico-de-movilidad
- WBG, 2016. The Logistics Performance Index and its Indicators. Trade Logistics in the Global Economy. http://lpi.worldbank.org/report
- WEF, 2016. The Global Competitiveness Report 2016-2017. - https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1
- El Plan Estratégico de Movilidad [PEM] orienta el desarrollo del Sistema de Transportes de Ecuador, Le plan stratégique de mobilité [PEM] guide le développement du système de transport de l'Équateur 2013- 2037, 2015
- Données de l'UNESCO - http://whc.unesco.org/fr
- Projet de ligne ferroviaire de référence pour le calcul des coûts : DFBOT, Tren de Cercanias Lima – Ica, 2018.
- Le Point, article du 3 juin 2013 - https://www.lepoint.fr/automobile/les-routes-du-perou-parmi-les-plus-mortelles-d-amerique-latine-03-07-2013-1690513_646.php
- Présentation nationale du Pérou - https://www.diplomatie.gouv.fr/fr/dossiers-pays/perou/presentation-du-perou/
- Histoire des deux pays - https://www.franceinter.fr/emissions/les-histoires-du-monde/les-histoires-du-monde-03-octobre-2019
- Prévision de croissance de la population entre 2020 et 2050 - https://estadisticas.cepal.org/cepalstat/PerfilesNacionales.html?idioma=english
- Données sur la population - http://www.citypopulation.de/
- Coût de la vie - https://www.numbeo.com/cost-of-living/country_result.jsp?country=Peru
- https://www.numbeo.com/cost-of-living/country_result.jsp?country=Ecuador
- https://resourcetrade.earth/data?year=2017&exporter=76&importer=604&units=weight