PARANA- PARAGUAY RIVERS INLAND WATERWAY
by

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ABSTRACT

The Paraguay – Paraná Rivers Inland Waterway (from now on HPP, by its acronym in Spanish) is located in South America and flows through five countries: Brazil, Bolivia, Paraguay, Argentina and Uruguay. The HPP is an inland waterway 3.442 km long counted from Caceres Port in Brazil to Nueva Palmira in Uruguay where it has its nominal end. The Paraná River section of HPP is in one of the more populated and industrialized area of South America so it is a strategic link to facilitate trade between the southern Brazil, Bolivia and Paraguay and Rosario (Argentina) from where it can connect with deep draught ships with the Atlantic Ocean.

In the stretch Sanfa Fe- Corrientes the project required a final navigable channel of 12 feet draught (including 2 feet of under keel clearance) that was achieved in 2012 and since then has been maintained that way.

Capital dredging required the mobilization of approximately 1.5 M cubic meters of sediment. It was installed a modern aids to navigation (AtoN) system integrated by 330 lighted buoys and beacons, all of them designed according to IALA guidelines.

The intervention included the realization of frequent bathymetric surveys, the installation and maintenance of a 12 automatic water level measuring stations network and the installation of antennae for the reception of AIS signals (Automatic Identification System).

The paper will focus on the description of this important South American Waterway, the improvements in transportation infrastructure already achieved, the works to be done to transform the whole waterway in a modern navigation system that can produce an important effect on navigation costs and safety.

1. INTRODUCTION

The Paraguay – Paraná Rivers Inland Waterway (from now on HPP, by its acronym in Spanish) is located in South America and flows through five countries: Brazil, Bolivia, Paraguay, Argentina and Uruguay. Its catchment area is about 2.605.000 km2 (950.000 km2 from Parana River (Corrientes) + 1.095.000 km2 from Paraguay River +560,000 km2 (from Middle Paraná River south of Corrientes) but without considering the part corresponding to Uruguay River) which integrates a bigger one or about 3.100.000 km2 well known as Plata Basin, as it's finally discharge in Río de la Plata and the Atlantic Ocean.

The HPP is an inland waterway 3.442 km long counted from Caceres Port in Brazil to Nueva Palmira in Uruguay where it has its nominal end. In this length the 700 Km pertaining to the Upper Paraná from Corrientes to Iguazu (Figure 1) are not included. In spite of this end of HPP project in Nueva Palmira, the connection between this inland waterway and open deep waters at the Atlantic Ocean is done by sailing from ports of Rosario area through Parana de las Palmas and Río de la Plata (red line in Figure 1) with deep draught ships for a channel 600 km long. This connection is not included in this description.

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Figure 1- Navigable waterway in Paraguay – Paraná – Plata river system

The Paraná River section of HPP is in one of the more populated and industrialized area of South America so it is an strategic link to facilitate trade between the southern Brazil, Bolivia and Paraguay and Rosario (Argentina) from where it can connect with deep draught ships with the Atlantic Ocean. It is considered the most important integration way of MERCOSUR since it is one of the most important way of transport needed to facilitate physical integration of the five countries mentioned. Its commercial area of direct influence (hinterland) is estimated at about 720.000 km2 and about 3.500.000 km2 of indirect influence with a population of more than 40 million inhabitants.

From north to south, the HPP passes through important local ports as Caceres, Corumbá and Puerto Murtinho in Brazil; Puerto Suarez (Bolivia); Concepción, San Pedro, Asunción (Capital City) and Villeta in Paraguay; Puerto Pilcomayo, Formosa, Corrientes, Barranqueras, Paraná, Santa Fe, San Martín – San Lorenzo and Rosario in Argentina and finally Nueva Palmira in Uruguay.

We are dealing with a waterway that crosses five countries, as can be seen in Figure 1.

2. **PHYSICAL CHARACTERISTICS**

Physical characteristics and depths along Paraguay and Paraná rivers determine what kind of vessels can navigate on them and accordingly is determined the allowed draught.

As can be observed in Figure 2, from Caceres to Santa Fe Port navigation is allowed with barges loaded up to 10 feet; from Santa Fe Port to Rosario Port the allowed draught is 25 feet and from Rosario to Atlantic Ocean, including Buenos Aires Port, is 34 feet. Nowadays the biggest ship that has been arriving at Buenos Aires is a containership of 10.200 TEUs of capacity and 330 m Loa.

Figure 2- Allowed draft along Paraná - Paraguay Rivers Inland Waterway

3. CARGO TRANSPORTATION

Main cargoes for this route are iron ore and grains with some participation of containers and fuel. It is important to notice that two countries, both Paraguay and Bolivia, have this waterway as their main and more convenient international trade connection due to their condition of land locked countries.

The hinterland of the waterway has a very big agriculture potential as well as reserves of iron ore and manganese that are of worldwide importance.

Soybean, byproducts and recently also vegetable oil, iron ore and fuels gather at least 87 % of total freight.

In Table 1 it is shown tonnage passed through the waterway from 2010 to 2016 and a forecast for year 2021 of around 25 M tons.

Products	**Total Cargos** [tons]							
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2021**
Soybeans (& derivates)	6.517.544	6.966.184	4.225.150	7.978.427	7.757.154	7.721.289	8.322.094	10.715.904
Other Grains	1.462.169	1.449.211	2.230.112	2.327.078	2.756.674	4.214.646	633.464	3.360.156
Iron ore	3.850.348	5.269.551	4.273.014	5.313.151	6.625.000	4.126.000	3.564.751	3.500.000
Liquid Cargo	2.940.419	2.833.960	2.314.998	3.047.732	3.456.864	4.064.111	3.679.247	4.314.390
General Cargo	608.384	1.052.533	777.521	1.423.752	1.306.260	1.460.559	1.075.810	1.504.545
Container [tons]	1.040.000	1.120.000	792.000	1.104.000	1.360.000	1.400.000	1.440.000	1.664.000
[TEUs]	130.000	140.000	99.000	138.000	170.000	175.000	180.000	208.000
Total **	**16.418.864**	**18.691.439**	**14.612.795**	**21.194.140**	**23.261.952**	**22.986.605**	**18.715.366**	**25.058.995**
*** Total does not include figures in TEUs.*								

Table 1: Cargoes tonnage passed through the waterway. Years 2010 – 2015 and forecast for 2021

The increasing tonnage of cargo transported through the waterway in following years will put a strong demand of additional barges and pushers.

For a long time aged Mississippi barges had been imported from EEUU for being used in HPP but later this practice was forbidden in some countries by new legislation. Therefore several local shipyards are supplying these barges and also recently a couple of new shipyards have been installed in Paraguay.

4. NAVIGATION THROUGH THE WATERWAY

The Santa Fe–Confluence waterway handles both domestic and international commercial river traffic to and from Argentina, Uruguay, Paraguay, Bolivia and southern Brazil.

The transport of cargo is done by a fleet composed by barges and pushers. These barges are formed in convoys of different sizes pushed by tugs (pushers) of adequate power.

Most bulk barges are “Mississippi” type, so their dimensions are: Loa = 60 m; B = 11 m; D = 10 feet and DWT = 1,500 ton. Since several years ago, a new type has been developed and is called “Jumbo” barge. These ones have Loa = 66 m; B = 15 m; D = 10 feet and DWT = 2,500 ton. In Figure 3 both types of barges are shown.

A majority of the fleet is under Paraguayan flag. This is a problem arising from having the countries different policies on fundamental aspects such as labor regulations, taxes and others.

Cargo is transported in convoys of barges with different configurations for each stretch of the river as can be seen in Figure 4.

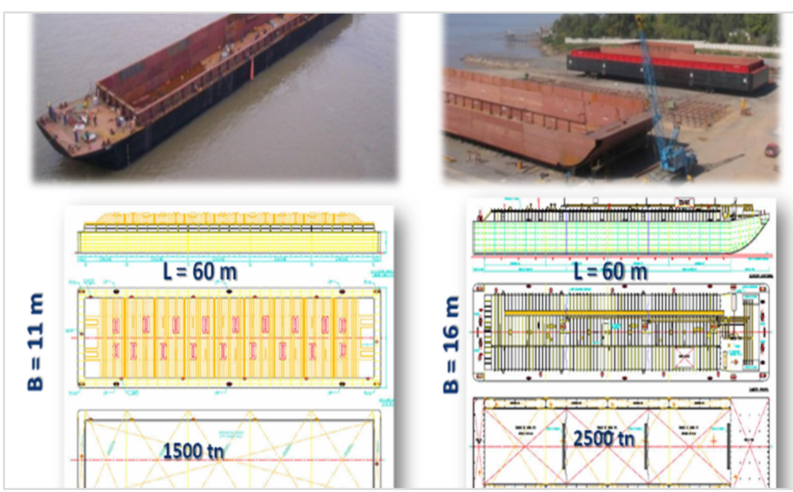

Figure 3 – Dimensions of “Mississippi” and “Jumbo” barges

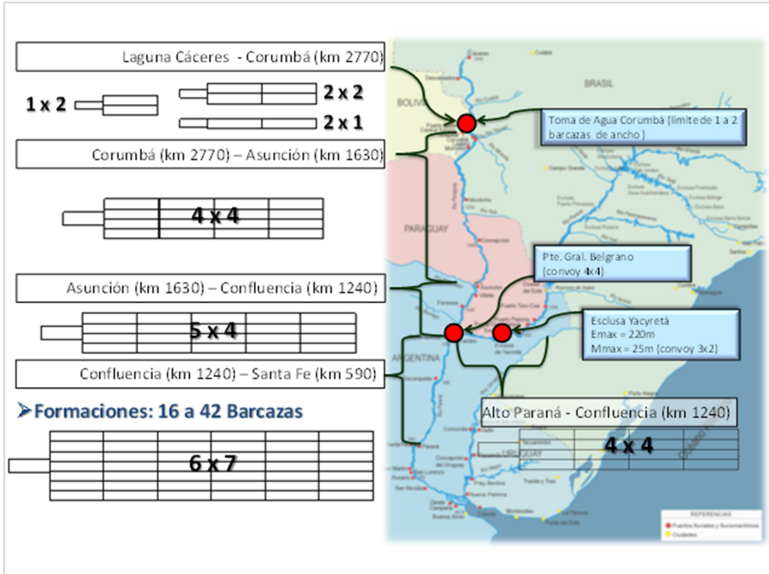

Figure 4- Configuration of convoy

Maximum convoy size is a 6 x 7 barges with a pusher of more than 7,000 HP with a total length of approximately 410 m. A barge convoy of such characteristics is shown in Figure 4 and a photo of one of them in Figure 5.

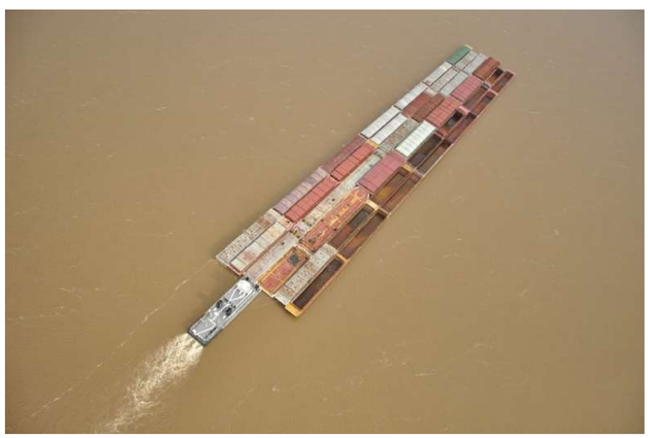

Figure 5: Example of a 6 x 7 barges convoy

The number of barges and tugs present in the waterway, period 2010 – 2016, are shown in Figures 6, 7 and 8. It can be observed that there are an important number of barges that goes out of service and that are replaced by new units every year. This happens due to the high average age of the fleet. This fact also explains the recently installation of new shipyards in Paraguay to satisfy this market.

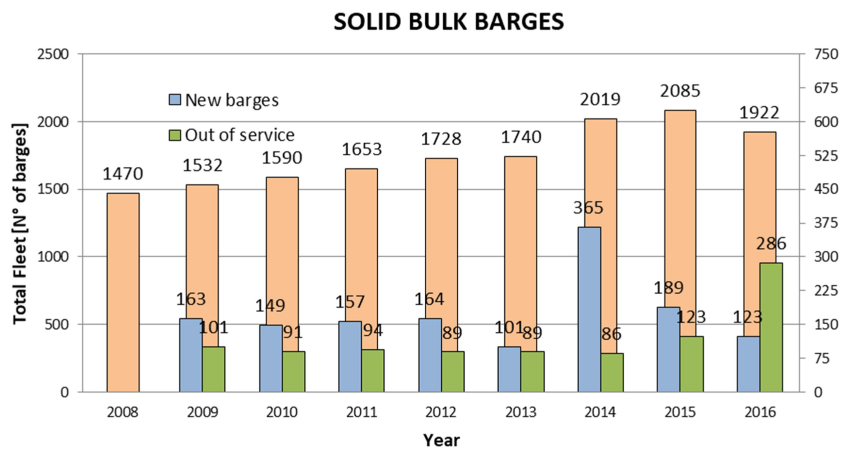

Figure 6: Solid Bulk barges fleet. Period 2010-2016

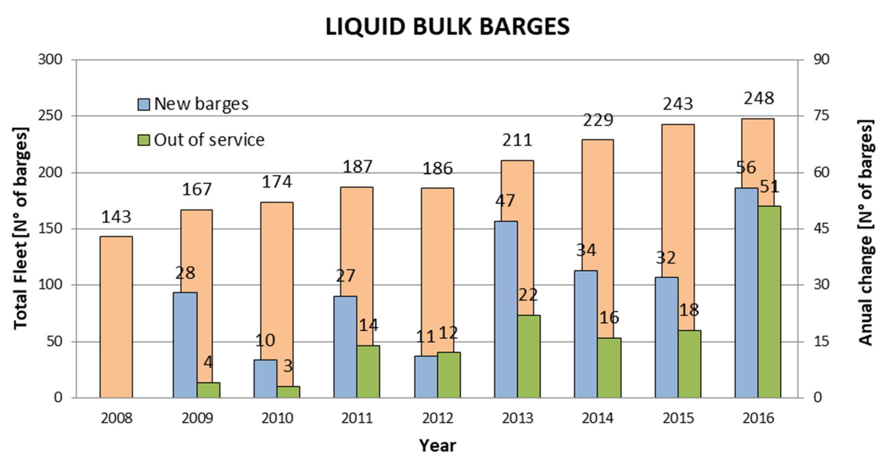

Figure 7: Liquid Bulk barges fleet. Period 2010-2016

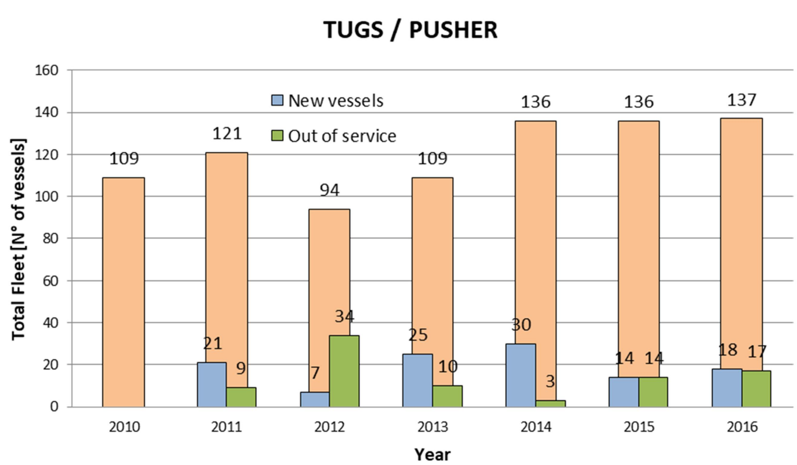

Figure 8: Tug fleet. Period 2010-2016

5. INFRASTRUCTURE INVESTMENTS ALREADY DONE

Between 2010 and 2012, investments were realized in Argentinian Paraná river section from Santa Fe port up to the confluence of Parana and Paraguay rivers. This project section, 640 km long connects Santa Fe port with Barranqueras and Corrientes ports at the North and is known as “Santa Fe – Confluencia” section of the HPP waterway.

The project here requires a final navigable channel of 12 feet draught (including 2 feet of under keel clearance) that was achieved in 2012 and since then has been maintained that way.

Capital dredging required the mobilization of approximately 1.5 M cubic meters of sediment. It was installed a modern aids to navigation (AtoN) system integrated by 330 lighted buoys and beacons, all of them designed according to IALA guidelines.

The intervention includes the realization of broad and frequent bathymetric surveys, the installation and maintenance of a 12 automatic water level measuring stations network and the installation of antennae for the reception of AIS signals (Automatic Identification System).

In Figure 9 it is shown the stretch from Santa Fe to Confluencia (Corrientes), with the position of water level measuring stations, AIS receiving stations, and places of main shallow waters.

Figure 9 – Stretch from Santa Fe to Corrientes

A longitudinal profile of the river measured on the dredged axis of the Santa Fe- Confluencia waterway can be seen in Figure 10 where a stretch of 100 km has been represented as an example. Areas with depths up to 80 feet are present along most of the route but there are also stretches with depths lower than 12 feet. The last ones account for about 60 km of the 640 km of the total length of the waterway. These shallow areas are denominated “fords” (or “*pasos*” in Spanish). Number of shallow areas is around 37 in the 640 length of the waterway. In these shallow areas is where dredging works have to be performed in order to allow safe navigation of convoys. Minimum design depths are to be guaranteed 92.5 % of the time

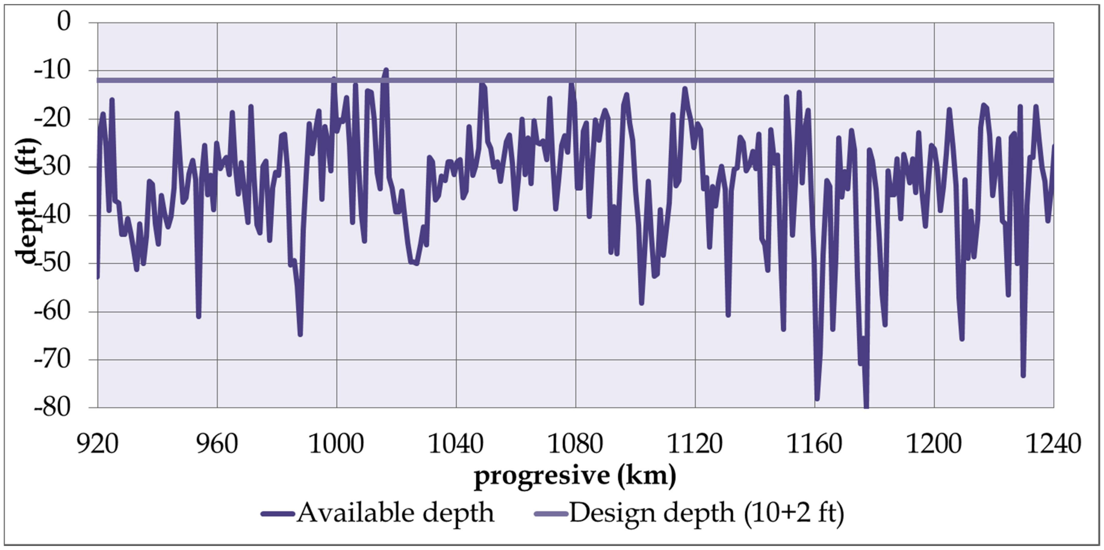

Figure 10 - Longitudinal profile of the river

Due to the intense sedimentological activity, in addition to the dredging works needed, one very important task that has been realized is the continuous adjustment of waterway axis following the river thalweg that allowed to reduce significantly the amount of dredging carried out. Detailed bathymetric surveys and continuous buoytenders assistance to adjust the aids to navigation position that marked the route have been done. In table 2 is possible to appreciate the importance of the job that has been done.

	Waterway axis							
	2011	2012	2013	2014	2015	2016	2017	
Fords	25	28	26	43	40	38	57	257
In between fords	13	15	15	20	22	19	15	119
TOTAL	38	43	41	63	62	57	72	376

Table 2: Waterway route axis adjustments

Accordingly to actual legal requirements an important and conscious Environmental Impact Assessment (EIA) process took place before beginning the intervention in this stretch. In that process, the Environmental Impact Study (EsIA) considered the fluvial ecosystems in river flow and its floodplain, aquatic and riparian biota, nature conservation, water and sediment quality as well as social aspects like other uses of the system. That EsIA took in consideration that the waterway is close to 14 natural protected areas, 2 wetlands RAMSAR Sites, 2 bird conservation areas and fish aquatic reserves. This EsIA was carried out in order to identify, predict and evaluate the environmental impacts of doing the projected dredging works and installment of aids to navigation (AtoN) along the waterway. Based on the results of this EsIA management actions and mitigation measures were proposed.

6. ACHIEVEMENTS & LESSONS LEARNED

As conclusion of the work done it can be said that there were several navigation restrictions that existed previous to the systematization of the stretch that were solved with the improvements done. For example:

- In some places (due to several problems as water depths) big barge convoys had to be disassembled and moved from one point to another in repeated movements. This practice required additional times and efforts. Nowadays convoys are not disassembled any more.
- Convoys had no possibilities of doing night navigation due to the lack of lighted AtoN. This shortcut has been removed.
- In times of low water barges had to be loaded several feet less than the design draught due to lack of enough depth in critical zones. Actually the design depth is guaranteed for the 92,5 % of time along a year.
- All aspects mentioned previously have an important economic effect.

Continuous adjustment of waterway axis following the river thalweg, allowed to reduce significantly the amount of dredging carried out.

Once the improvements in the waterway were done, several difficulties caused by local traditions were evidenced:

- Many of the pushers do not have satellite navigators installed.
- Captains do not have experience in the use of electronics charts.
- At the time of the project, there were no electronic charts available for the area. Today some barges companies have their own digital charts (not S 57 format)
- Most of the navigation is done loaded downstream and on ballast upstream. In the second case there is a tendency of using shortcuts in curves as navigating upstream.
- Previous to the works on the area no bathymetric surveys were available. Therefore convoys used small boats navigating in front of them to determine depths. Nowadays as updated charts are available, there are almost no convoys still using the old procedure in Santa Fe-Confluencia stretch. This aspect denotes more trust in the information provided.

7. FINAL REMARKS

Although this stretch of the river is 640 km long, it is only a minor part of the whole Parana - Paraguay River waterway and others waterways of the region.

Very important is to take notice that despite the work is completed, time is needed for the captains to fully use it. Special training programs are needed.

Local traditions need time for education and training the community so as to pass from a semi artisanal way of navigation to a technical supported way of doing so.

All aspects of the project conforms a virtuous circle. Now we have a waterway with dredged depths and modern AtoN. The investment in infrastructure works is the first step. For doing that, water level measuring stations have being installed and regular bathymetric surveys are being done. With this information it is possible to draw navigation charts and to make it electronic. AIS receiving antennae permit the following of convoys movements that allows both to control the navigation and to improve the design of the waterway.

From this intervention it can be seen that the improvement of the waterway is possible applying the appropriate working methodologies and the results are worth the money required to do the job because there are ways of solving the difficulties to make inland navigation more effective and efficient.

If this effort is spread upstream, a time will come when the whole waterway will be upgraded to a modern system of navigation and therefore having an important effect on navigation costs and safety.

As PIANC WG 201 is developing a classification system for Latin American waterways, and one point of discussion is the main parameter to take into consideration as basis for the classification, from the description presented in this paper for the HPP waterway can be concluded that the main parameter used is clearly the natural and dredged depth.