Public Transportation on River Tagus

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Abstract: Finding new ways for traveling at a high commercial speed, comfortable, safe, cheap and preserving as much as possible the environment by using less fuel is the new challenge for the public transport operators that run their business in the 21st century. One of the alternatives for the passengers that are using public transportation vehicles is to travel using water buses or ferries. The paper presents the five public transportation routes on water that connects Lisbon with the other cities nearby. It is presented the entire boat fleet used by the local transport operator Transtejo and Soflusa. The article is focused on finding solutions for a particularly transport route that is Barreiro-Terreiro do Paço. The problem consists of using boats having a capacity of 600 passengers out of rush hour leading to half loaded boats. Using boats with a capacity of 500 passengers out of rush hour will have a high impact for the transport operator, passengers and environment as it will be showed in the paper. The paper is structured as follow: introduction, data regarding routes and boat fleet, case study route Barreiro-Terreiro do Paço, fuel consumption simulation, solutions for the problem, conclusions and further research, acknowledgment, reference list.

1 INTRODUCTION

In the 21st century, mobility, transportation costs, time spent in vehicles and environment protection became the most important things. Due to these facts governments along with public transport operators came with solutions to these problems by offering citizens living in big cities a better mobility, with lower costs, in a shorter time and avoiding as much as possible the pollution of the environment. One of the solutions for passengers that are using public transportation vehicles is to travel using water buses or ferries. "This mean of transportation can be seen in many capitals and big cities around the world such as: Amsterdam, Budapest, Lisbon, Paris, Rotterdam, Venice and many others. In these cities we can see many floating vehicles for public transportation of passengers such as: water taxis, water buses, amphibious, vaporettos, ships, ferries" (Ştefănescu, 2012). This alternative is better than the other means of transportation due to the fact that there are no: traffic lights, traffic queues, many stops and offers a high commercial speed compared to the other public transportation vehicles such as buses, trolleybuses, trams. It is safer with fewer accidents than on land with the buses, taxis and other public transportation vehicles. It is cheap for passengers, in the price per fair are included many and heavy luggage and sometimes even cars example using ferries, it is cheap for the public transportation operator also due to the large transportation capacity of the ship and the operating cost is less than other public transportation vehicles. This type of transportation can be divided into two categories: for passengers that want to travel from point A to point B and for sightseeing such as "hop on hop of trips" (Ştefănescu, 2012). This paper analyzes the situation when passengers connect with other means of transportation for reaching their desired destination point. The paper is focused on river Tagus that separates Lisbon from the other cities, route Barreiro-Terreiro do Paço presents the actual situation, provides solutions to efficiencies public transportation on river Tagus by: reducing fuel consumption, using smaller boats with lower transportation capacity and increasing the frequency of transportation by increasing the travel speed. The goal is to obtain benefits for the passengers and

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public transportation operator and at the same time to protect the environment. The paper is structure into 6 chapters as follow: short introduction, data regarding routes and boat fleet used by the transport operator, chapter 3 is a case study of route: Barreiro-Terreiro do Paço, in chapter 4 is made a fuel consumption simulation, chapter 5 offers solutions for the problem and the last part presents conclusions and further research along with the acknowledgment and reference list.

2 ROUTES AND BOAT FLEET

It all began with the "founding of Transtejo in 1975 and later, with the creation of Soflusa in 1993" (http://www.transtejo.pt/pt/quem_somos/missao.html)."The operational fleet consists of 33 vessels of which 20 are Catamarans, 4 ferries (monohulls and catamarans) for passengers and vehicles and 9 conventional vessels" (http://www.transtejo.pt/pt/quem_somos/frota_list.htm). Nowadays Transtejo Soflusa is the public transport operator offering services for commuters that want to cross river Tagus. In Table 1 is presented the boat fleet and main characteristics (ferries excluded) and crew number.

Table 1: Fleet information.

Boat Model	No.	Transport Capacity	Service Speed	Av. Cons.	Crew
Cacilhense	6	480	≈7 Knots	50 L/h	4
Martim Moniz	2	1000	≈7 Knots	180 L/h	5
Marvila	1	293	≈7 Knots	38 L/h	4
Algés	4	496	22 Knots	410 L/h	4
S. Juliao	4	496	22 Knots	540 L/h	4
Cesário Verde	2	292	22 Knots	320 L/h	4
Fantasia	1	146	22 Knots	110 L/h	4
Damiao de Goes	9	600	22 Knots	600 L/h	4

According to Table 1 more than half of boats are new boats, the declared service speed is 22 Knots for the new boats and around 7 knots for old boats. The highest fuel consumption is registered at the new 600 passengers' boats that are used also to serve route between route Barreiro and Terreiro do Paço. In "Figure 1" (http://www.transtejo.pt) is represented the medium fuel consumption per passenger/km during 3 consecutive years for the entire boat fleet.

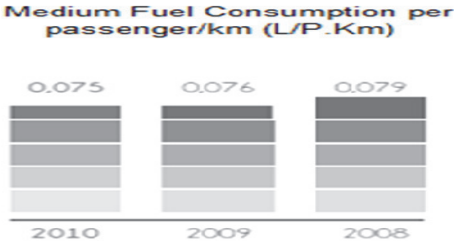

Figure 1: Medium fuel consumption per passenger/km.

Fuel consumption decreased from 2008 to 2010 because the transport operator introduced new boats; some routes were redesign and became shorter and the schedule modified by operating the boats at a lower service speed and increasing with an average time of 5 min. the trip. So instead of staying 5 extra minutes at the docs the boats are cruising at a lower service speed of 24km/h instead of 30km/h increasing the time trip by 5 extra minutes. One example for this situation is route Barreiro - Terreiro do Paço. In "Table 2" (http://transporlis.sapo.pt) are presented the 5 routes operated by Transtejo Soflusa and the CO_2 emissions, the price per fare and the number of bicycles that can be carried on board the ship.

Table 2: Route characteristics and facilities.

Route	Dist.	CO_2	Price	Bike
Trafaria - Porto Brandão – Belém	4,20 km	21g	1,15€	15
Cacilhas - Cais do Sodré	2,21 km	114g	1,20€	3
Seixal - Cais do Sodré	7,50 km	374g	2,30€	3
Montijo - Cais do Sodré	15,00 km	751g	2,70€	3
Barreiro - Terreiro do Paço	10 km	406g	2,30€	2/5

The CO_2 emissions are determined by the length of each route along with the model of the boat and the cruising speed that influence the fuel consumption. The price is calculated taking into consideration the route length and number of passengers that use it. This is why the price for one ticket between Cacilhas and Cais do Sodré is 1.20€ with 0.05€ more than on route Trafaria - Porto Brandão – Belém which is with 2km longer. Another example is Montijo - Cais do Sodré that is twice as long as Seixal - Cais do Sodré and the price for one ticket is just with 0.40€ more. The facilities for passengers that want to take their bicycles with them depend on some safety regulations. It is not only the time but also the space management and the ebb and

flow of the river for the safety of the passengers. "Figure 2" (Ricardo Ferreira MUBi, 2012) represents the interface of ground public transportation with the fluvial transportation. It highlights the 5 routes and the facilities for commuters that have to change the vehicle to arrive at their destination. The figure shows that Lisbon has a well design infrastructure and the transfer hubs are very good equipped satisfying passengers' needs in terms of public transportation.

Figure 2: Fluvial transportation hubs.

3 CASE STUDY BARREIRO - TERREIRO DO PAÇO ROUTE

We identify this route from Barreiro to Terreiro do Paço with some issues that can be efficiencies obtaining benefits for: passengers, transport operator Transtejo Soflusa, municipality of Lisbon and protect the environment. The main problem that we discovered here is that the operator is using all the time same model of boat with same capacity for passengers not taking into consideration the capacity demand on rush hour and out of rush hour. This apparent small thing generates lots of problems for: passengers, transport operator and environment. Transtejo Soflusa prefers to use the big boats with a capacity of 600 pass. in spite of the fact that out of rush hour the demand is less than 200 pass. Regarding fuel consumption: boats with capacity of 600 passengers consume 600L/h and boats with capacity of 500 passasengers consume 410L/h. The operating speed will be 30km/h instead of 24km/h and the crew number will be the same 4 persons. In table 2 on route Seixal - Cais do Sodré where the 500 passengers boats are operating, the CO_2 is lower with 32g per each trip. The time schedule will remain the same but the trip will be faster with 5min. instead of 25min. that is now out of rush hour it will be 20min. The difference of 5 min. will be spent by each ship in the docs. Now the trip last 25min. due to the fact that the boats are cruising at 24km/h instead of 30km/h as normal to save fuel making the trip longer for each passenger that uses this route out of rush hour. The number of bicycles that can be taken on board will increase by 1. The single small inconvenient is that the operator has to switch the boats three times per day when entering and exiting the rush hour. In the next table are presented the number of boats by route, time and some characteristics.

Table 3: Model of boat for each route and time table.

Route	Boat Model	Boat Capacity	No. Of Boats In Rush Hour	No. Of Boats Out of Rush Hour
Trafaria - Porto Brandão – Belém	Cacilhas Class - slow boat	470 pass.	1 boat	1 boat
Cacilhas - Cais do Sodré	Cacilhas Class - slow boat	470 pass.	3 boats	2 boat
Seixal - Cais do Sodré	Algés Class São Julião Class Pedro Nunes Class All fast boats	500 pass. 500 pass. 300 pass.	2 boats	1 boat
Route	Boat Model	Boat Capacity	No. Of Boats In Rush Hour	No. Of Boats Out of Rush Hour
Montijo - Cais do Sodré	Algés Class São Julião Class Pedro Nunes Class All fast boats	500 pass. 500 pass. 300 pass.	2 boats	1 boat
Barreiro - Terreiro do Paço	Almeida Garrett Class - fast boat	600 pass.	7 boats in the morning 6 boats in the evening	2 boats After 23h30 until 2am - 1

4 FUEL CONSUMPTION SIMULATION

In this paragraph we will present a fuel consumption simulation for the actual fleet (600 capacity boats) and a fuel simulation for 500 capacity boats. All the technical data is obtain from the transport operator Transtejo Soflusa.

Table 4: Technical data regarding 600 pass. boats.

Capacity		600 pass.		
Motor's Bore (m)		0,165		
Number of boats		9		
			Cons (L/h) 1 moto	
RPM	Km.h-1	Knots	12V	16V
2000	62,20	33,59	421,4	561,8
1800	55,98	30,23	315,2	422
1200	37,32	20,15	93,6	131,3

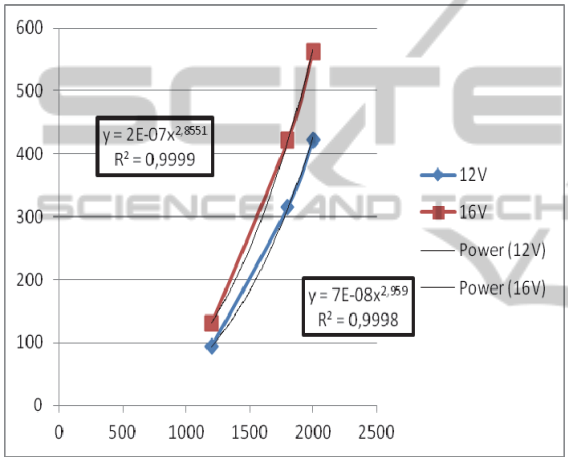

Figure 3: Fuel consumption for 600 pass. boat.

Table 5: Technical data regarding 500 pass. boats.

Capacity		496 pass.	
Motor's Bore (m)		0,165	
Number of boats		4	
RPM	Km.h-1	Knots	Cons (L/h) 1 moto
1900	59,09	31,91	263,5
1725	53,65	28,97	198,2
1510	46,96	25,36	130,5
1195	37,17	20,07	67
600	18,66	10,08	11

As we can conclude from the two charts it is a difference of fuel consumption of more than 150 L/h if both boats are equipped with a 12V engine. A huge difference of more than 340 L/h is recorded if we compare a 600 capacity boat with a 16V engine with a 500 capacity boat with a 12V engine. Using boats with a capacity of 500 passengers is not only saving gas but also makes the trip shorter with 5 minutes giving the crew the possibility to rest at the end of each trip.

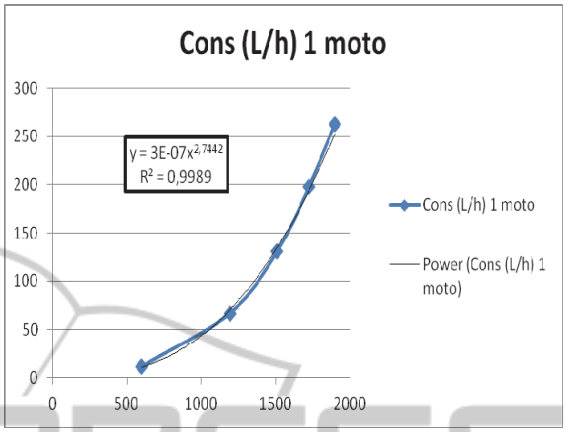

Figure 4: Fuel consumption for 500 pass. boat.

5 SOLUTIONS

Our proposal to increase the efficiency of public transportation on route Barreiro-Terreiro do Paço is to change out of rush hour boats that are used now with smaller boats with a capacity of 500 passengers. This modification will generate benefits for: passengers, Transtejo Soflusa, municipality and will protect the environment.

Passengers' spent time on each trip out of rush hour will decrees from 25min. to 20min. The total number of bicycles allowed to be carried on board will increase from 2 that are now to 3. Ticket price will be lower out of rush hour due to the decreasing of operating cost for the transport operator.

This switch between the two types of boats will generate a better management of the boat fleet and increase the income of the transport operator by decreasing the operating costs. The crew will have 5 extra minutes for resting in the docs at the end of each trip. Fuel consumption will decrees and will avoid exploiting the boats engine below the operating speed of 22Knots. Decreasing the ticket price the transport operator can attract more passengers.

Increasing the number of passengers that use the boat service to cross river Tagus will lead to a decongestion of the 2 main bridges that connect Lisbon with the cities located on the other side of the river. The area will be more quiet and cleaner by reducing the traffic on the 2 bridges and the CO_2 level produced by road vehicles and bigger boats. A

higher income for municipality will be generated by increasing the number of passengers that use the on water public transportation and decreasing the costs with maintaining the road infrastructure of the 2 bridges.

Reducing the CO_2 level produce by the bigger boats that are in use now and by the vehicles that are using the bridges to cross the river Tagus will help the environment. Reducing the noise and dust in that area helps the birds to live there. In "Figure 5" (http://www.transportes-xxi.net/forum/download/file.php?id=109531&mode=view) is presented a boat with a 600 passengers capacity and in "Figure 6" (http://www.transportes-xxi.net/forum/download/file.php?id=109531&mode=view) is a 500 passengers capacity boat that are in service now.

Figure 5: Boat with a 600 passengers capacity.

Figure 6: Boat with a 500 passengers capacity.

6 CONCLUSIONS

Good management is when the stakeholders in our case: municipality, transport operator and passengers obtain the results that they predict without destroying the environment. Municipality focuses on a clean and green city with good connections between city centre, suburban places and other cities. Having a transport operator that makes his job and bring income to the municipality budget is another goal. The operator wants to attract new passengers, to obtain profit, to have lower operating costs with the fleet and the infrastructure and if it is possible to obtain a monopoly of the area where it operates. Passengers want to travel fast, safe, comfortable, at a lower price and with less number of transfers between routes. Also they need mobility to take with them their bicycles and cars and easy access to information panels and for purchasing tickets. Traveling with one "contactless card and the possibility to use it for other porpoises and recharge it from ATM, internet or vending machines" (Ştefănescu et al., 2012) is another goal for passengers. Saving money, time and protect the environment is possible by: using less papers tickets due to the implementation of the "ticketing system" (Ştefănescu, 2012), increasing the commercial speed, using hybrid engines or electrical power vehicles such as "amphibious that are used in Budapest and Rotterdam" (http://riverride.com/ and http://www.floatingdutchman.nl/en/about-the-bus/) "and for ground transportation Phileas buses as in Eindhoven" (http://www.apts-phileas.com/) reduces the CO_2 emissions. It is faster and safer to travel by boat but the infrastructure and the fleet are very expensive and if there is no river that everything is reduce to public transportation with ground and underground vehicles. "Timişoara is one of the cities that have the oportunity to develop a public transportation on water but strugle with the investment in infrastructure and fleet" (Ştefănescu, 2011) "In his book (Ghionea, 2010) says that there should be a philological level for transfers from one vehicle to another that should not be crossed. In his example for citizens living in big cities the total number of transfers during a trip should not exceed one and for commuters should not be higher than three". The conclusion to this fact is that commuters are more tolerant than citizens living in big cities and for Lisbon passengers that use boats have to change just once or twice due to the fact that the bots terminal are connected in most of the cases with all the public transportation vehicles such as: taxi, buses, trams, metro, trains as showed in picture 2. An interesting question raised in (Clayton, 1987) paper is „if hovercraft can be the new solution for high speed channel ferries" this topic will represent the future work for this paper.

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