

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/338682350>

ESPOmar Project: New passenger maritime transport system for the Gulf of Cádiz. (Preliminary Results)

Conference Paper · January 2020

CITATIONS

0

READS

141

8 authors, including:



Luta Fernandez

University of the Visayas

209 PUBLICATIONS 3,388 CITATIONS

SEE PROFILE



Diego Sales

Universidad de Cádiz

204 PUBLICATIONS 4,064 CITATIONS

SEE PROFILE



Francisco Piniella

Universidad de Cádiz

91 PUBLICATIONS 578 CITATIONS

SEE PROFILE



Juan CARLOS Rasero Balon

Universidad de Cádiz

15 PUBLICATIONS 61 CITATIONS

SEE PROFILE

ESPOMar Project: New passenger maritime transport system for the Gulf of Cádiz. (Preliminary Results)

A Querol, P Piniella, P Sánchez, JC Rasero, LA Fernández, S Sotomayor, MC Pérez, D Sales, University of Cádiz, Spain

A Vargas, University of Huelva, Spain

F Perna, University of Algarve, Portugal

SUMMARY

ESPOMar project is a cooperation research network with the aim of designing and evaluating a new sustainable cross-border maritime transport system for the Gulf of Cadiz. The key objectives of the ESPOMar project are: to analyse the real demand of such a transport system; study the nautical condition for navigation of the area; define the capacity and specification of each proposed maritime route and optimize the design of specific ferries to compete with the established land transport system in terms of speed, safety and comfort, reducing emissions and economic viability. Economic viability and local economic impact were key tenets of the evaluation process. This paper presents the preliminary results and conclusions of the evaluation process for the proposed maritime routes examined.

1. INTRODUCTION

The ESPOMar Project, co-financed by the European Regional Development Fund (ERDF) through the INTERREG V-A Spain-Portugal (POCTEP) 2014-2020 program, is a cooperation network with the aim of Designing a Sustainable and Transboundary Transport System Maritime-Fluvial in the Gulf of Cádiz, in which participate the Spanish Universities of Cádiz (UCA) and Huelva (UHU), the Portuguese University of Algarve (UAlg) and the Public Ports Agency of Andalusia (APPA).

The purpose of this project focuses on the area of the Gulf of Cádiz, which due to its physiognomy and the existence of both Doñana Natural Park and Guadalquivir River, makes direct land connections between nearby provinces much longer than possible maritime connections they could implement. Figure 1 shows how a maritime connection between Cadiz and Faro would have a reduction in distance of more than 150 kilometres and 105 kilometres between Cadiz and Huelva.

The most important and consideration to take into account in the development of the project, is the Doñana Natural Park along with the mouth of the Guadalquivir River. This is because both areas provide refuge and shelter for an immense variety of birds and fish, being considered the most important wetland in the entire European continent. On the last 75 years, the idea of building a direct road to connect Cadiz and Huelva has been discussed. On the origin, that road was projected as a coastal road over the Guadalquivir River and throughout the National Park. Nowadays, that project has been completely withdrawn but some political groups are still planning a new road throw the north exterior border of the National Park. Some civil and political organization are really concerned about the environmental impact that this road could have, from a point of view of protection of the natural space, in addition to public expenditure; isolating the protected

area completely and turning Doñana into a kind of zoo rather than a natural area. On the other hand, this measure, even from an economic point of view, could be against the promotion of tourism in national parks.

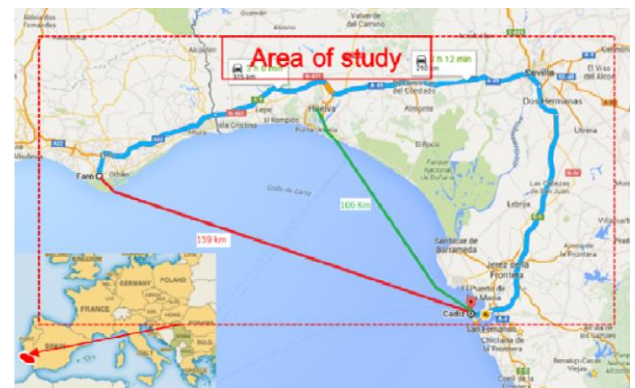


Figure 1. Gulf of Cádiz (area of study)

The existence of other motorways in service or execution and environmental requirements discourage their construction, but that does not mean that both provinces continue to call for an improvement in connections and that are even political options that put the construction of these highways before environmental criteria. In addition, with this project, an attempt is made to provide a more sustainable alternative to the direct connection that is still non-existent between the bordering provinces of Cádiz and Huelva. Currently these provinces are linked by public transport (bus and rail), but not directly. In the case of the bus, it is necessary to transfer in Seville from one bus station to a different one where another transport company take passenger from Seville to Huelva and vice versa.

Another of the objectives of the ESPOMar Project is the participation in the sustainable development of this area, improving connectivity, the tourist offer, the use of heritage resources, the management of natural resources

and trying to reduce greenhouse gas emissions. In this way, the natural and cultural potential of the area would be exploited in a non-invasive way, so that this would contribute to a greater and better economic development of all this part of the Iberian Peninsula coast. To carry out this research, a series of activities were established that will be fully developed in this paper:

- Demand study and analysis
- Design of transport lines
- Design of sustainable vessels
- Environment effect investigation
- Economic analysis
- Optimization

2. METHODOLOGY

The methodology used in the different activities that are being developed during the execution of this project is detailed below:

2.1 DEMAND STUDY AND ANALYSIS

The aim of this activity is to determine the possible demand of a new maritime transport system, information which is needed to correctly adjust the capacity of the lines and determine the economic and environmental viability of the transport system. The information included in this demand study are the following:

- Frequency and characteristics of displacements between the study populations (Cádiz, Huelva and Portuguese region of Algarve).
- Predisposition to travel by boat
- Importance of factors or conditions to travel by boat:
 - o Travel time from the starting point to the departure port and from the arrival port to the destination
 - o Weather conditions
 - o Quantification of the maximum price to be paid
 - o Journey time
 - o Preferred destinations (which are the ports of greatest interest)
- Respondent profile

To carry out this work, a series of stages have been followed, which will be defined and summarized below:

2.1 (a) Obtain preliminary information: collect data on the resident population, as well as the tourist population received.

2.1 (b) Definition of objectives under the consensus of all the researchers participating in the project: definition of the variables from which information is sought, as well as determination of the universe of the study, the type of sampling to be used and the optimal sample size.

2.1 (c) Preparation of the questionnaire for the analysis of the resident population. For the tourist population, given the impossibility of being able to access this public by the dates of execution, a script was prepared to carry out an exploratory investigation from a panel of experts.

2.1 (d) Fieldwork: to carry out the surveys, an external company was hired, the same questionnaire was also used to obtain answers online and in relation to the panel of professionals in the sector, the interviews were conducted by the researchers themselves.

2.1 (e) Tabulation and registration of the data: design of a database to record the information from the surveys prepared previously.

2.1 (f) Analysis and interpretation of the results: this work was carried out with the support of statistical techniques.

2.1 (g) Preparation of the final report.

2.2 DESIGN OF TRANSPORT LINES

The objective of this project activity is to establish maritime routes between the regions of Cádiz, Huelva and Algarve, for which it is necessary to study different factors that will determine which routes are the most feasible according to the meteorological limitations of the area and existing infrastructure in the different ports of the study regions and their peculiarities.

The result of these activity is orientated to determine the different possible lines (using different ports for of the three areas under study), and the capacity, service speed and number of boats required to comply with the demand study requirements. All this will help to select the best connections in terms of economic and environmental viability.

2.3 DESIGN OF SUSTAINABLE VESSELS

This activity has begun with the development of a parametric statistical study with the main characteristics of similar ships. This study has been used to analyse the relationships between the passenger capacity and speed versus the installed propulsion power. With this information, it has been possible to make a preliminary dimensioning of the ships to be used in the analysed potential maritime lines. This dimensioning, in terms of length and propulsion power has been used to carry out a study of consumption and emissions of all proposed lines, so that both economic and environmental viability could be determined and thus select the most optimal design alternative to then deepen and define the boat.

Note that the design of these new ferries must face several challenges, among which are competing in time with the existing land transport in the area as well as

being efficient and ecological, providing comfort and safety to passengers.

2.4 ENVIRONMENTAL STUDY

The methodology used at this stage has started with a general study on the polluting factors associated with maritime traffic. Similarly, environmental regulations affecting international maritime navigation have also been considered, and then proceed to establish the most important potential environmental impacts linked to such mode of transport.

To conclude, all this information and regulations have been applied to the transport system of the project, in addition to making an environmental comparison of the carbon footprint for the three means of transport considered in the study (car, bus and ship).

In order to compare the efficiency of the two different transport systems under discussion (land and sea transport) and having in mind that any development of existing propulsion power systems such as the use of electric engines, the use of natural gas or hydrogen as fuel or other future development, could be installed in vehicles used for both, maritime and inland transport, it was decided to do the comparison analyse using similar fuel and propulsion engines in all vehicles. In our case, similar diesel engines were theoretically “installed” in some standard bus, car and ferry and the transport efficiency comparison was then made in terms of installed power consumed per passenger, and therefore, fuel and CO₂ emissions made per passenger. This comparison has been based on the hypothesis that there is a direct bus connection between the study populations, as well as that the occupations of the different transports are 100% and that the propulsion system used by them is the same.

2.5 ECONOMIC ANALYSIS

In this activity, an estimation of the costs that would involve the implementation of the maritime lines of study has been carried out. For this purpose, the costs associated with the different phases of the exploitation of this new transport system have been established, such as the acquisition and/or rental of the vessels, maintenance, personnel on board and land, cleaning, ...

Taking into account the maximum price to be paid for the sea route established in the demand study previously carried out and the estimated costs according to the information obtained, a cost-benefit analysis of the different maritime lines considered in the investigation has been carried out.

All these data, together with more information, will be used to study also the economic impact that the implementation of this project could have in the area of action.

2.6 OPTIMIZATION

In this activity, the optimization and improvement of the transport system is also carried out based on the results obtained and the final conclusions of the entire study being carried out.

Note that in addition to the main activities mentioned here, other phases had been also carried out and are carrying out in the project, such as the preparation, management, coordination and communication of the project.

3. RESULTS

3.1 DEMAND STUDY AND ANALYSIS

After having carried out the surveys and having collected all the information in relation to the demand that would exist in the area, it is determined that leisure would be the main reason for the passenger displacements, both during vacation periods and, to a lesser extent, throughout the year. In other words, the maritime transport is not seen by the potential users as a regular transport system but as an attractive new way of transport used to connect touristic regions or populations. There are preferences for traveling with family or group and, if possible, in the morning. With respect to travel conditions, the price variable is the most important, ranging from € 20 - € 40 for a single ticket per way.

Furthermore, the maximum travel time allowed by the respondents is 3 hours for the Cádiz-Huelva connection and 4 hours for Cádiz-Algarve or Algarve-Huelva, allowing an increase of 1 hour on all trips provided they are accompanied by playful activities. The time taken to travel from the origin to the departure port and from the arrival port to the destination point has also been taken into account, which should be between 30-45 minutes.

The ports preferred by respondents in the province of Cádiz are Cádiz capital, Puerto de Santa María and Sanlúcar; while for the province of Huelva they are Huelva capital, Matalascañas, Punta Umbría and Isla Cristina; and in the Algarve area, the ports of Faro, Lagos and Albufeira stand out.

Table 1 summarizes the characteristics that, according to the demand study, the maritime connections between the different areas should have.

Provinces	Passengers/day	Trip duration (h)	Maximum ticket price (€)
Cádiz – Huelva	1,614	3	30
Cádiz – Algarve	1,512	4.5	40
Algarve - Huelva	886	4.5	30

Table 1. Summarised result of demand study

Note that the season of the year and the number of passengers per day with which the study has been carried out, are those considered during the holiday period, that is, from June to September, since, according to the demand analysis, it is when greater demand would be.

3.2 DESIGN OF TRANSPORT LINES

Once the study of the different nautical factors that determine the viability of the possible maritime lines has been carried out, it has been proven that navigation is the Gulf of Cádiz is fully feasible. According to the climatological study, it is expected that in some occasions the proposed connections would be affected by wind and waves, having to suspend their operation, although it should be noted that in the summer this hypothesis would be very low. On the other hand, there are ports that are conditioned by the limitations of navigation speed in inland waters, due to its physiognomy, compatibility with other port activities or environmental protection as *Faro in Algarve* or *Muelle de Levante* in Huelva. In addition, we must also take into account that there are ports in the area of action without the necessary infrastructure to operate with passenger ship. For these and other reasons, some of them have been excluded in the study, thus discarding the maritime lines in which they intervened.

In the same way, other ports of interest have been taken into account, both those detected in the demand study that were not previously contemplated, as well as those considered by the technically viable researchers from the nautical point of view, such as Vilamoura and Portimao in Portugal, Mazagón in Huelva and Chipiona and Rota in Cádiz, being defined as follows, how can we see in Table 2, the maritime lines used in this study.

Provinces	Lines	Populations		Boat capacity	Service Speed (knots)	No. of journeys
Cádiz-Huelva	Line 1-a	Cádiz	Huelva	400	28.8	2
	Line 1-b	Cádiz	Huelva	200	28.8	4
	Line 2	Cádiz	Mazagón	200	24.0	4
	Line 3	Rota	Mazagón	200	26.1	4
	Line 4-a	Chipiona	Mazagón	200	22.2	4
	Line 4-b	Chipiona	Mazagón	100	22.2	8
Cádiz-Algarve	Line 5-a	Cádiz	Portimao	750	30.3	1
	Line 5-b	Cádiz	Portimao	375	30.3	2
	Line 6-a	Cádiz	Vilamoura	750	24.0	1
	Line 6-b	Cádiz	Vilamoura	375	24.0	2
Algarve-Huelva	Line 7	Portimao	Huelva	220	27.6	2
	Line 8	Portimao	Mazagón	220	24.9	2
	Line 9	Vilamoura	Huelva	220	29.7	2
	Line 10	Vilamoura	Mazagón	220	26.2	2

Table 2. Maritime lines analysed

Since the demand study only contemplated the use of the ports of Cádiz, Huelva and Faro, multimodal connections have been established that include the transfer in shuttle buses from the alternative ports (Chipiona, Mazagón and Rota) to the main ports of Cádiz and Huelva and vice versa, in order to be able to use the demand data and connection times required in the analysis of these alternative lines.

Also included in this nautical research, is the study of the applicable regulations regarding maritime safety and pollution prevention that the vessel has to comply with that carry out this activity have also been considered.

3.3 DESIGN OF SUSTAINABLE VESSELS

As we have said before, in this activity an initial parametric statistical study has been carried out, which has helped in the preliminary design of the vessels that could be used in the study transport system. In order to analyse the most optimum condition of the environmental study, the best existing ferries, in terms of lower installed propulsion power per passenger, were selected according to the capacity and speed required by the demand study. Table 3 shows the consumption per passenger and emissions of each of the analysed lines in case these existing ferries were used.

Provinces	Lines	Populations		Power (kW)	Total diesel consumption (litres)	CO ₂ emissions (kg) / pax (g)
Cádiz-Huelva	Line 1-a	Cádiz	Huelva	1,940	1,013.4	6.6
	Line 1-b	Cádiz	Huelva	1,940	1,106.8	14.4
	Line 2	Cádiz	Mazagón	1,340	617.2	8.8
	Line 3	Rota	Mazagón	1,340	538.2	8.6
	Line 4-a	Chipiona	Mazagón	1,340	465.1	6.7
	Line 4-b	Chipiona	Mazagón	684	251.6	8.1
Cádiz-Algarve	Line 5-a	Cádiz	Portimao	5,386	4,130.9	17.8
	Line 5-b	Cádiz	Portimao	2,459	2,249.1	17.6
	Line 6-a	Cádiz	Vilamoura	5,386	3,415.3	14.7
	Line 6-b	Cádiz	Vilamoura	2,459	1,687.4	13.2
Algarve-Huelva	Line 7	Portimao	Huelva	1,574	1,370.7	15.8
	Line 8	Portimao	Mazagón	1,574	1,230.0	14.6
	Line 9	Vilamoura	Huelva	1,574	1,101.5	13.1
	Line 10	Vilamoura	Mazagón	1,557	1,014.2	12.6

Table 3. Consumption and emissions of existing vessels

As we can see in Table 4, the maritime line with lower consumption per passenger comparing with bus and therefore, with greater environmental viability, is the one that connects the provinces of Cádiz and Huelva. For this

reason, the optimized vessel model for the exploitation of regular passenger transport of this line is being designed. Meanwhile, for the other maritime connections of the project (Cádiz-Algarve and Huelva-Algarve), the development of recreational/tourist vessels in this geographical area is being designed in collaboration with the University of Coventry.

It should be noted that the design of the vessel for the Cádiz - Huelva connection has to be a hydrodynamically and structurally optimized design to be able to achieve a more efficient maritime transport than a hypothetical direct public transport line that is now non-existent, as previously mentioned.

3.4 ENVIRONMENTAL STUDY

As we have seen in the previous sections, the study of 14 maritime lines has been carried out. This study includes a comparison, which we can see in table 4, of fuel consumption and CO₂ emissions between the maritime transport system of this project and the existing land transport in the area, resulting in emissions from passenger, compared to the private vehicle, are smaller for maritime connections between Cádiz and Huelva, while these are increased for the connection of Cádiz and the Algarve and of Huelva with the Algarve. If we make the comparison with an ideal connection in public transport, that is, if there is a direct bus line between the main connection ports, all the maritime lines studied would have a higher consumption and emissions per passenger.

Provinces	Lines	Populations		Maritime Line vs Bus	Maritime Line vs Car
				CO ₂ Emissions (%)	CO ₂ Emissions (%)
Cádiz-Huelva	Line 1-a	Cádiz	Huelva	177	70
	Line 1-b	Cádiz	Huelva	385	153
	Line 2	Cádiz	Mazagón	234	93
	Line 3	Rota	Mazagón	229	91
	Line 4-a	Chipiona	Mazagón	180	72
	Line 4-b	Chipiona	Mazagón	216	86
Cádiz-Algarve	Line 5-a	Cádiz	Portimao	474	189
	Line 5-b	Cádiz	Portimao	470	187
	Line 6-a	Cádiz	Vilamoura	392	156
	Line 6-b	Cádiz	Vilamoura	352	140
Algarve-Huelva	Line 7	Portimao	Huelva	420	167
	Line 8	Portimao	Mazagón	389	155
	Line 9	Vilamoura	Huelva	348	139
	Line 10	Vilamoura	Mazagón	335	134

Table 4. Environmental comparison in terms of CO₂ emissions

Within all lines analysed, the one with the highest energy efficiency and, therefore, the greatest environmental viability is the one that connects the provinces of Cádiz and Huelva through the ports of Chipiona and Mazagón, thus being able to implement regular passenger transport. While, for the other maritime lines (Cádiz - Algarve and Huelva - Algarve), the implementation of a recreational / tourist transport system is being considered.

3.5 ECONOMIC ANALYSIS AND OPTIMIZATION

From the preliminary cost-benefit analysis that has been carried out, there are several connections that are more economically viable, among which are some lines that link Cádiz-Huelva and Cádiz-Algarve. This study is being analysed in order to improve the results. In addition to this an analysing of the economic impact that will occur in the area of action in the event that this new maritime passenger transport system is implemented.

Once we have determined all factor that allows us compare the technical, economic and environmental viability of the different maritime connections studied, we are able to select the optimum and best option to be publicly recommended.

4. CONCLUSIONS

In the demand study we can observe that there is a great interest for local citizens in having the possibility of using this new mean of transport, mainly in a playful/tourist way during holiday periods. So much so, that the business association of Chipiona (ACITUR) has created a civic platform (Uniendo Provincias) in which the implementation of this maritime connection between the provinces of Cádiz and Huelva is promoted, in addition to other groups, such as the “Mesa de la Ria” in Huelva, which also have been years promoting this as a political and civil demand.

From the study of the transport lines, we can extract that the navigation in the geographic area of the research, the Gulf of Cádiz, is totally feasible and that the lines with greater probability of execution have been selected for later analysis.

In the design of sustainable vessels, work is being done on the optimization of the vessel that would connect the provinces of Cádiz and Huelva, through the ports of Chipiona and Mazagón. This line is, according to the environmental impact study, carried out, which presents greater energy efficiency and greater environmental viability for regular passenger transport.

For the design of all the vessels of the project, including those for recreational purposes, the powers and, therefore, the consumption and emissions, determined by the design of the lines and by the parametric statistical study initially carried out, are being taken into account.

The results, for now, of the study being carried out, indicate that the most efficient line is 4, Chipiona - Mazagón. So the design of an optimized and sustainable vessel is focusing on the Cádiz - Huelva connection for regular passenger transport through these ports, together with the analysis of cost-benefits and economic impact in the area of the Gulf of Cádiz.

5. ACKNOWLEDGEMENTS

The authors would like to thank the European Regional Development Fund (ERDF) of the European Union (EU) for co-financing the project "ESPOmar" under the "INTERREG POCTEP 2014-2020 program". We also like to thank to all researchers and staff of the different public organizations involved on the project for their dedication and professionalism:

University of Cádiz: Antonio Arcas de los Reyes, Antonio Querol Sahagún, Antonio Rafael Peña Sánchez, Begoña Flethes Bernal, Diego Sales Lérida, Diego Sales Márquez, Emilio Bravo López, Emilio Rodríguez Díaz, Enrique Nebot Sanz, Francisco Piniella Corbacho, Germán Jiménez Ferrer, Jose Angel Llamas Alfaro, José Ruiz Chico, Juan Antonio Palacios García, Juan Carlos Rasero Balón, Juan Ignacio Alcaide Jiménez, Juan Moreno Gutiérrez, Luis Alberto Fernández Güelfo, María del Carmen Pérez Peña, María José Legáz Almansa, Mercedes Jiménez García, Nieves Endrina Sánchez, Patricia Sánchez Garrido, Rafael Jiménez Castañeda, Raquel Núñez- Barranco González-Elipse, Ruth García Llave, Sebastián Sotomayor González, Vanesa Durán Grados.

University of Huelva: Alfonso Vargas Sánchez, José Albendín Moya.

University of Algarve: Cláudia Almeida, Fernando Perna, Francisco Serra, Margarida Santos, Maria João Custódio.

Andalusian Public Port Agency: Diego Anguís Climent, Fernando Copado.

6. REFERENCES

ADOLF K.Y., NG JASON, MONIOS CHANGMIN JIANG "Maritime Transport and Regional Sustainability", *Elsevier*, 2019

GUNES U., BEJAN A., SAHIN B., "The evolution of air and maritime transport", *Applied Physics Reviews* 6, 2019

CHRISTODOULOU A., WOXENIUS J., "Sustainable Short Sea Shipping", *Sustainability*, 2019

NTANOS S., PARAVANTIS J., SAMBRACOS E., "Energy Consumption and Carbon Dioxide Emissions of

a Suburban Coastal Transport System", *Munich Personal RePEc Archive*, 2008

PARAVANTIS J.A., GEORGAKELLOS D., "Trends in Energy Consumption and Carbon Dioxide Emissions of Passenger Cars and Buses", *Technological Forecasting and Social Change*, 74, 682-707, 2007

SAMBRACOS E., "Investment Evaluation of a Suburban Coastal Transport System", *10th International Conference of IFORS (International Federation of Operations Research Societies)*, 1-3 April 2001, Athens, Greece, 2001

COTTAM H., ROE M., CHALLACOMBE J., "The impact of transitional changes of maritime passenger transport on Croatian tourism development", *Maritime Policy & Management* 34(3):185-202, 2007

PINIELLA F., RASERO JC, QUEROL A., "Maritime Passenger Transport as an Urban and Interurban Alternative on the River Guadalquivir: GuadaMAR", *Maritime Transport VIAT: Barcelona Volume: 1*, 2014

7. AUTHORS BIOGRAPHY

F Piniella, holds the current position of Rector of the University of Cádiz, and Full Professor at Department of Sciences and Techniques of Navigation and Naval Constructions at University of Cádiz, Spain.

A Querol, holds the current position of Principal Researcher of ESPOmar Project and Associate Professor and Director of Departmental Section of the Department of Sciences and Techniques of Navigation and Naval Constructions at University of Cádiz, Spain.

P Sánchez, holds the current position of ESPOmar Researcher at Department of Sciences and Techniques of Navigation and Naval Constructions at University of Cádiz, Spain.

JC Rasero, holds the current position of Associate Professor at Department of Sciences and Techniques of Navigation and Naval Constructions and Director of the Central Service for Resources and Nautical Infrastructures at University of Cádiz, Spain.

LA Fernández, holds the current position of Associate Professor at Department of Environmental Technologies and Deputy Director of the Verinsur Chair in Environmental Research and Technology at University of Cádiz, Spain.

S Sotomayor, holds the current position of Associate Professor at Department Financial Economics and Accounting, Director of Departmental Section of the Department Financial Economics and Accounting in Functions and Vice-Dean of Academic Management and

Institutional Relations of the Faculty Social Sciences and Communication at University of Cádiz, Spain.

D Sales, holds the current position of Full Professor and Director of Department of Materials Science and Metallurgical Engineering and Inorganic Chemistry at University of Cádiz, Spain.

A Vargas, holds the current position of Full Professor in the area of Business Organization at University of Huelva, Spain.

F Perna, holds the current position of Coordinating Professor in the area of economics and tourism at University of Algarve, Portugal.

MC Pérez, holds the current position of Interim Lecturer of the Department of General Economy at University of Cádiz, Spain