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Legal and Political Quandary in the Securitization of the Gulf of Aden

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ABSTRACT

The use of the world's navies in the protection of the maritime stretch of the Gulf of Aden against Somali pirates has offered much impetus in the drive towards ensuring maritime security in that water course. But such successes have accordion consequences in the resolve of the pirates to record more successes evident in the spread of their activities into the high sea, use of arms and greater violence to compel ships to stop, as well as the grave danger that hostages are subjected to. The nature of Somali pirates as distinct from the traditional pirates known to international law and the challenges nations participating in the naval mission encounter in their effort to make the gulf safe for navigation, arresting and prosecuting apprehended pirates are posing great challenges to the entire securitization process amidst gaps in international law in this regard. This paper argues that a more effective measure in addressing piracy in the gulf would be a comprehensive diplomatic effort that takes into cognizance the myriad of the critical mass of issues within and outside Somalia which brought about and or are sustaining the unfortunate maritime security situation in the Gulf of Aden.

1. Introduction

Piracy is a global venture that still occurs in South/East Asia and Indian Sub-continent (Bangladesh, Indonesia, Malacca Straits, Malaysia, Philippines, Singapore Straits, South China Sea, Vietnam, Arabian Sea, Indian Ocean - off Seychelles and Madagascar); Africa (Nigeria, Tanzania, Guinea, Ghana, Gulf of Aden, Somalia); South and East America (Brazil, Peru) (Oceans Beyond Piracy Project - Fact Sheet No5).

Indeed, Piracy is one of the oldest crimes on earth after murder and rape. Besides being a crime in almost all jurisdictions of the world and under international law, and being "one of the most widespread crimes, since attacks occur in nearly every sea and ocean", it is: A highly episodic crime, where base levels around the world are maintained but different regions periodically emerge as piracy hotspots. These hotspots tend to attract large amounts of international attention while consistent attack levels are ignored. That attention leads to a reduction of piracy in specific regions, only to have increased incidents emerge elsewhere. (Oceans Beyond Piracy Project - Fact Sheet No5).

The current pirate hotspot is the Gulf of Aden and is receiving the necessary international attention. However certain issues attendant to the securitization of the pirate infested waters of the Gulf of Aden raise many questions as regards the nature of maritime diplomacy, armed humanitarian intervention, international Military Corporation and international humanitarian law in the post-cold war era. These set the stage for a critical assessment of the appropriateness, justification, successes and challenges of the deployment of the world's most powerful Navies to protect a 2,000,000km^2 water way against a bunch of "rag-tag army of Somali youths, some barley in their teens, sailing in sometimes rusty mother ships and using skiffs and speed boats and armed with AK47s, hand and shoulder held rocket propelled grenades" (Odeke, 2011:2) since year 2009.

1.1. Theoretical framework

The theoretical framework for analysis here underscores the futility of Gunboat Diplomacy in tackling crimes committed by non-state actors. This is based on the understanding that in the absence of state authority to exert pressure on Gunboat Diplomacy is bound to be counterproductive. More so when it is being applied in an area where the citizens are disillusioned as to the intention of the international community and

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what possibly could be the advantage of a partial intervention that would rather address symptoms instead of causes.

The manner of maritime diplomacy as is being applied in the Gulf of Aden seems to be a clog in tackling the menace of piracy in that water course and is making nonsense of the whole maritime security protection effort and the deployment of Naval Platforms in the region, as well as aggravating the danger piracy poses to seafarers in that waters.

Potgieter (2008) observed that: The deployment of naval vessels to the region in an effort to enhance maritime security is in principle a good idea, but then there must a clear commitment, policymakers must give clear guidelines and a clear mandate to navies. Examples in military history abound of fiascos resulting from forces being deployed without clear strategic objectives and political commitment. The mere presence of a force and the application of firepower on its own are simply not enough. (Potgieter, 2008:18).

It is this noticeable absence of "clear commitment" by policymakers to "give clear guidelines and a clear mandate to navies" that is giving room for worries as to the chances of real success of the naval patrol in the Gulf of Aden as a diplomatic measure to addressing an international challenge.

The deployment of Navies to the Gulf of Aden appears to be in tandem with the understanding that "the traditional gunboat diplomacy can work if illegal acts are attributed to a specific state or group of states" (Potgieter, 2008:13). The absence of a state authority in Somalia is the foundation for the use of force against the pirates, but real success seems to be impeded by operational strategies, and legal constraints. The operational strategies include the absence of the ideal "collective security", co-operation by navies, and regional governments; and sharing of information and responsibility at sea and on land; whereas the legal constraints revolve around issues of jurisdiction, proof of cases in courts, the doctrine of non-refoulement among others.

To adequately address the maritime security situation in the Gulf of Aden, there must be higher awareness on the need for maritime security by all including Somalis, regional cooperation with the international community to address issues relating to governance inside Somalia, piracy, harbour security, illicit fishing, illicit dumping of toxic waste, collaboration of participating Navies as against the current individual state Naval action running on severely limited budgets and a recognition that "international and regional cooperation may allow more to be done with less" (Potgieter, 2008:14).

2. Piracy in the Gulf of Aden

The Gulf of Aden is an important water way in world trade, providing transit for about 11 percent of the world's seaborne petroleum, and ships plying the route as a shortcut between Europe and Africa through the ever busy Suez Canal, as well as for ships making longer voyages around South Africa's Cape of Good Hope (Ploch et al., 2009). By her unique location in the Horn of Africa, and jutting out into the India Ocean, Somalia's harbours and ports (Port Aden in Yemen, Post Djibouti City in Djibouti, and Ports Zeila, Berbera, and Bosaso in Somalia) are naturally ports of call for ships and traders sailing the all-important trade route (Ploch et al., 2009).

Somalia is not new to the changing dynamics of international politics having been exposed to the machination of the British, French, Italian, and lately the Soviet Union, and the US. The state is but a victim of counterfeit diplomacy which the region and the entire African continent has been exposed to. The failure of Somalia's romance with these giants to produce positive transformation for the Somali is the reason for the present maritime security situation in the Gulf of Aden and calamity experienced inside Somalia.

The maritime security in the Gulf of Aden even though has been said to be a lot better having reduced from 49 ships hijacks in 2010 to12 ships hijacks in 2012 (see Table 1) has a direct link with the situation inside Somalia after all "Maritime Security is a key component of National Security" (Pmma - Gs Mount Pinatubo, 2008).

Table 1: Somali Piracy 2008 – 2012.

Year	2008	2009	2010	2011	2012 (Jan-May)	Total
Ships Attacked	111	215	219	237	21	843
Ships Hijacked	42	47	49	28	12	178
% Success Rate	38%	22%	22%	12%	20%	21%
Hostages	815	865	1016	470	188	3,356

Source: Maritime Piracy around the World Synopsis. Oceans Beyond Piracy Project – Fact Sheet 5: 2012.

The political history of Somalia indicates that Somalia has been raped repeatedly over the years by very many people and abandoned immediately after the romance ceased. Somalia was in a pristine state (Hirsch and Oakley, 1995:3), a world of "egalitarian anarchy" (Samatar, 1991:6) until the opening of the Suez Canal made the hitherto remote state attractive because of her natural harbour that where found excellent for mid-sea breaks and refueling. That led to the scramble for and consequent partitioning of this hitherto homogenous land into lots in the 1880s between Britain, France, and Italy and later on Ethiopia – which saw some Somalis domiciled in Djibouti (formerly French Somalia) and others domiciled in Ogaden Ethiopia and "set the stage for latter conflict in the horn" (Hirsch and Oakley, 1995:5).

At independence, the colony was not prepared for self-government - no unified, trained civil service, and no accepted political norms; civil administration in the north and south had inherited different European languages, culture, and administrative structure. The absence of any genuine assistance for its sustenance and survival from Britain led Mohammed Siad Barre to forge a relationship with the Soviet Union in search for arms to recover Ogaden and perhaps Djibouti.

When the US "cut off residual economic assistance" because "Somali-flagged Merchant Ships were discovered delivering arms to north Vietnam", Said Barre became excited. The excitement exaggerated his sense of military strength and potential soviet support and encouraged him to launch "war against Ethiopia in October 1997 in an effort to regain the Ogaden" (Hirsch and Oakley, 1995:6). However, Soviet's military support to the Marxist regime of Mengistu Haile Mariam during that war prompted Bare to eject the Soviet Military Advisors from Somalia. The Somali Army routed in the absence of anymore military equipment from Soviet Union or from anywhere. The collapse of Soviet-styled Somali Economy, unchecked corruption, and Clan based insurgency added to the turmoil and brought Somalia to its knees; the escape of Said Barre got the country to descend into civil war.

The US intervened on humanitarian grounds, but did not achieve much in ensuring that peace and order were restored as it did in her clinical intervention in Iraq, Bosnia, Panama, etc (the principle of neutrality in armed intervention, and respect for sovereignty was still intact then), and perhaps assist in composing a new Somali Central Government that will be acceptable to the warring parties.

This mismanagement of the conflict in Somalia was unfortunate, and no good reason has been offered to explain this error[1]. Besides the US, no other country of the world was willing to send its men and materials to help save the situation in Somalia. But today almost all have their Navies stationed in the Gulf of Aden – a beneficiary of the ciaos in Somalia – to protect their respective private interests.

Piracy in the Gulf is in protest to the abandonment of Somalia in time of need, and application of counterfeit diplomacy in the crises in Somalia at the outset. Somali piracy arose out of the need to survive, having lost their source of livelihood to war, and to superior fishing skills of fish thieves in the surrounding waters. The initial idea was for local fishermen in the coastal communities, who had no real weapons and no military expertise, to enlist local Somalia militias to garner capacity to defend their waters against unlawful foreign fishing companies who used arms against local fishermen. Unfortunately, the disengagement of about 1,500 Somali youths trained in the "use of sophisticated radio equipment, GPS, satellite phones, speed boats and mother ships, Internet resources to locate sea vessels, as well as boarding techniques" (Hansen, 2008) by private security companies (Hart and Co, and SOMCAN) (Marchal, 2011) mobilized by the Puntland Government between 1998 and 2005 to disarm "rouge militias", provide security to reduce competition, ensure uninterrupted revenue from fishing in Somali waters – offered an impetus to the pirate enterprise. That saw Somali fishermen hijacking illegal fishing vessels.

Somali Piracy moved from survival to profit i.e. "secure a sizable ransom which is frequently delivered directly to the pirates on-board the captured ship" (Rotberg, 2010) by willing governments and shipping companies who prefer to pay ransom for the release of their vessels and crews because they consider that the sums demanded as ransom are relatively small compared with the value of a ship and its cargo (Chivers, 2010) - as well as the effort the countries would have put in to restore order in Somalia.

Currently, Somali piracy is an establishment and typed into three categories - subsistence pirates made up of "poor fishermen, engaged in piracy closer to the coast in order to survive" (Hansen, 2008:539); middle class pirates whose leader owns the boat used for operations but gets mid-level Somali businessmen from his clan to partake under a shareholding contract (Backhaus, 2010); and professional pirates run under a PLC arrangement where a fund raiser, taking advantage of the lapses in the naval commands, arranges funds from "professional pirates" (Hansen, 2010) "who may be off-shore, to fund large scale pirate missions" and is entirely profit-driven, outright criminality and employs a great deal of tactical knowledge and networks in her operations.

Nonetheless, the piracy and pirates in the Gulf of Aden is a hybrid: Indefinable under known rules of both customary and treaty international law due to its unique characteristics. It includes armed robbery at sea, kidnaping, hostage taking, general security, links to terrorism, money laundering and international organized crimes. Unlike old pirates, these started as armatures, sometimes under age and operating from a country with no islands, creeks or coves and instead hunting in the open sea, dressed in modern attires (Odeke, 2011:136).

Hitherto international law had taken cognizance of pirates as Buccaneers (Young, 2005:1-33) and or Privateers (Someone, 2007) described as "one-eyed fellow (with patch on the other eye and a parrot on his shoulder), a sword wielding and rum drinking outlaw, unshaven and bizarre dressed with plundering for selfish and private motives" (Odeke, 2011:136).

However, Somali pirates have built "support among clan elders, officials, and intellectuals" and have an: Entrepreneurial approach to the use of ransoms. The key beneficiaries invest locally or regionally and do not spend their resources exclusively on the sumptuary celebration of their feats. This contributes to strengthening their popular legitimacy and the sympathy of the public (Marchal, 2011).

Therefore, while they are called pirates by the international community they are regarded as heroes and defenders of Somalia maritime interest. Besides making their loots available to their kinsmen, they also offered a counter model to Shabaab activists, enjoy life in an epicurean manner, thereby encouraging the dream of many youngsters - to marry very early and leave Somalia with a genuine visa to settle overseas (Marchal, 2011).

This irreconcilable image of the Somali pirate, the hybrid nature of their activities, the gaps in international law and the method of intervention are making caricature of the whole naval mission in the Gulf of Aden. These issues are manifesting in the trial of pirates caught in the act, as well as those that offered themselves willingly to be arrested by the intervening Navies, the reluctance of neighbouring states to continue to participate in the criminal prosecution of pirates, and most recently the adoption by NATO countries of the "catch and release" (Sterio, 2012:111) method of piracy control by the intervening navies or Russian method of releasing pirates in "a tiny boat in the middle of the Indian ocean, with no food, water, or navigation devices" (BBC News, 2010; Saoirse, 2010).

Meanwhile, emerging piracy trends are raising suspicions that some pirates' attacks may be phantom attacks arranged by ship owners - or Professional pirates (Hansen, 2008) who invest huge sums of money and provide other logistics in piracy en-

[1] Some writer have argued that the non-successful armed intervention by the international community in Somalia was as a result of the fact that it was the first of its kind after the end of the cold war

terprises using advanced networks and syndicates both "within Somalia and the wider Diaspora" (Rotberg, 2010) to abdicate liabilities and or in return for huge cuts from ransom.

In his critique of the current practice in the armed intervention in the Gulf of Aden, Kraska (2009) observed agreeing to an extent with Christoffersen and Buckley that "until regional and bilateral agreements are executed, along with more structured coordination, disposition and logistics issues associated with persons picked up during counter-piracy operations will persist". His argument is that since: Piracy prosecutions involve cases with suspects from one country and witnesses and victims from others. The vessel likely is registered in yet another state, and is transporting cargo owned by corporations from one or more additional countries. In addition, the flag state of the warship that conducts the interdiction could be from a distant state and on a deployment in the region (Kraska, 2009:197-216).

Therefore, coordination on Somali piracy disposition and logistics should go beyond the current ad hoc approach to an institutionalized collaboration and "work to develop a single regional counterpiracy center that can coordinate and deconflict naval operations" (Kraska, 2009:197-216).

3. Securitization of The Gulf of Aden

This is a result of the failed state situation in Somalia. However, many issues in international law (humanitarian, customary and treaty) are arising from the securitization option to the maritime security situation in the Gulf of Aden.

The Navies running the waters of the Gulf are from different nations – with different standards of human rights, training, code of conduct, operational strategies, budgets, and objectives. These pose great challenges to the success of the entire securitization efforts. Certain events in Somalia and off Somalia (treatment of pirates, captives, conduct of rescue exercise, patrol patterns, indiscriminate shooting etc.) have raised issues as to whether peace operations are not "proper soldiering" (Potgieter, 2008:13). Indications are that "unmotivated, poorly trained forces with flawed objectives can lead to disaster from a peacekeeping and humanitarian point of view" (Pugh, 1999:87), as a sense of worth, pride and spirit de corps is removed from peace operations.

These account for the absence of coherence in the naval operation that leaves all the naval units in the area all to themselves except for issues of avoiding clashes amongst the participating Navies and offending other countries in the region as well as other participants diplomatically which the professional pirates have capitalized on to perpetrate their dastardly acts.

China's experience in the securitization effort in the Gulf of Aden identifies the challenges the disjointed naval operations under the concept of "naval nationalism" (Christoffersen, 2009) are open to. China's official policy on Somalia piracy "closely parallels the UN's position, and reflects an emphasis on comprehensive security instead of the use of warships" (Christoffersen, 2009:2) – which is the UN's kind of comprehensive security approach to Somalia. As observed by Christoffersen (2009), China's kind of comprehensive security is one that "would address the root causes of piracy – poverty, lack of economic development, and threats to environmental security by commercial overfishing that has forced Somalian fishermen into piracy".

One gap in the securitization effort became visible in October 2009 when China faced "a long stand-off that would be a definite loss of face and loss of legitimacy domestically" (Christoffersen, 2009:16) because China could not mount an immediate rescue of its own to rescue her ship "the De Xin Hai" hijacked by Somali pirates because China's PLA-N ships stationed in the Gulf of Aden were far from the De Xin Hai. A situation that would have been averted were all the nations involved in the anti-piracy operations in the Gulf working in concert with clarify defined areas of responsibility and better coordination (Christoffersen, 2009:16) (Buckley, 2009:22).

On the issue of the impact of international humanitarian law on the securitization effort, arguments are that if not for international humanitarian law (1984 Convention Against Torture, the 1966 International Covenant on Civil and Political Rights, the 1950 European Convention on Human Rights – which placed positive and negative obligations on states to ensure that individuals' rights are protected at all times), the international community would have taken decisive military action and crushed the Somali pirates, both at sea and their networks ashore (Lennox, 2008). Nevertheless, by virtue of international humanitarian and human rights laws and certain UNSC resolutions on Somalia UNSCR 1918, UNSCR 1851, S.C. Res. 1851, SC Resolution 1897 etc., Navies are constrained to act in a quick and decisive manner to achieve the desirable result in bringing to an end the piracy brouhaha. Therefore, "whilst the international community has assembled an impressive array of maritime power, this has achieved little more than contain the levels of piracy. It may also have made pirates more violent and more professional" (Reid, 2011:4).

The implication is that while "counter-piracy efforts make attacks more difficult; pirates are becoming more aggressive and increasingly likely to use weapons to get vessels to stop" (Reid, 2011:4 -5). Interestingly, the incident of Somali pirates firing at ships to stop rose from 39 in 2008 to 114 in 2010 (IMB, 2010b). Included in this figure are about twenty attacks using rocket propelled grenades (RPG) some of which were against oil or chemical tankers (Houreld, 2010). Besides increasing application of violence, use of hostages as human shields, and extending areas of operation to other criminal activity, pirates (professional) have also studied the patrol patterns of the naval warships and adapted their tactics accordingly, and seem well versed in the legal and political limits that are constraining the efforts of Western warships to stop them (Lennox, 2008).

Budgetary constraints pose great challenges to military success in combatting piracy in the Gulf of Aden. Granted that the naval armada in the Gulf have collectively made some remarkable success in the fight against pirates by disrupting 411 out of 706 pirate operations encountered in 2009: 269 pirates arraigned for prosecution – 46 jailed, and 11 killed (Rotberg, 2010), but analysis indicate that the available warships are too few to cover the span of waters wherein ships are at risk of attack (Lennox, 2008), and absence of corporation among participants make the warships even fewer and efforts less effective.

In view of the forgoing, (Lennox, 2008) suggested that maritime forces in the Gulf should be empowered to conduct supporting operations ashore Somalia. But there is this apprehension by contributing Governments, emanating from the behaviour of Somali pirates (increased use of violence against ships, crews, hostages, prolonged detention of hostages, and non-release of hostages even after ransom has been paid) that extending the naval operations onshore Somalia could engender an escalation in violence against merchant shipping as pirates seek revenge (Stockbruegger, 2010).

This perhaps explains the current strategy of containing: the threat to a level which can be tolerated by the international community. Arguably, this is being achieved but the cost effectiveness of the strategy is questionable and may not be sustainable in the current financial climate. The most likely outcome is that naval forces committed to future counter-piracy operations will reduce at a time when more individuals are being drawn to piracy (Reid, 2011:9).

Incidentally despite the buildup of naval forces in the region, pirate activity continues to increase (IMB, 2010:47). Monetary gains in the absence of any alternative within Somalia, and or the possibility of arrested and prosecuted pirates being transported to Europe to start a new life under the international law doctrine of non-refoulement are propelling more people to enlist in the Somali pirate cult.

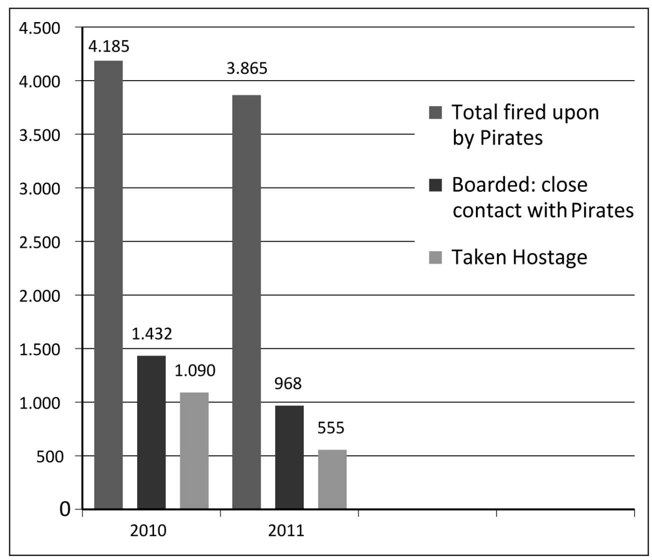
It is therefore being suggested that piracy ought to be seen as "a dynamic activity mutually dependent on global economic development, government policies, corporate strategies and actions of regional and local players" (Reid, 2011:6). In which case any "assessment of future trends must therefore include an analysis of the security dynamics within Somalia and the relationship between pirates and other key actors" (Reid, 2011:6). Hopefully, an understanding of the security dynamics within Somalia, the relationship between pirates and other key actors and applying corresponding actions will put paid to piracy in the Gulf of Aden.

4. Naval deployment – an assessment

The presence of the world's Navies in the Gulf of Aden has significantly reduced piracy (see Table 1). The number of seafarers subjected to armed attacks decreased in 2011 by 8% from the previous year. The most notable change was a 50% decrease in the number of seafarers kidnapped by pirates and taken hostages. There were 2,895 seafarers subjected to weapon-fire in these unsuccessful attacks. In this scenario, pirates fired assault rifles and RPGs at both their place of work-the bridge-and their living quarters (International Maritime Bureau and Oceans Beyond Piracy, 2011:6) (see Figure 1).

But these have brought about some other challenges and consequences. For instance even though the number of successful pirate attacks have reduced (See Figure 1), there is a rise in the hostage deaths, duration of captivity, increase in violence, increased regional cost, confusion as to the identity of pirates[2], use of hostages as human shield, death of pirates, (International Maritime Bureau and Oceans Beyond Piracy, 2011:6), and non-release of hostages even after payment of ransom because of their nationality.

Figure 1: Seafarers attacked in 2010 compared with 2011.



Source: Made out from Figure 2, "The Human Cost of Somali Piracy, 2011" (22nd June 2012), International Maritime Bureau and Oceans Beyond Piracy.

Somali pirates held 1,206 people hostage in 2011. This number represents 561 people captured in 2011 and 645 people who were taken captive in 2010 and remained in pirate hands for some or all of 2011. The fact that 645 people were taken in 2010 and remained hostage in 2011 highlights the large number of attacks in late 2010, and increase in the average length of time to negotiate the ransom, and in some cases, stalled negotiations. The victims are citizens of more than 47 countries, the vast majority of which are from Asia - especially the Philippines, China, and India (International Maritime Bureau and Oceans Beyond Piracy, 2011:7).

The fact that majority of hostages (invariably ships attacked) are from countries other than the US, UK, France, Russia [Philippines (17%), China (9%), and India (8%)] is a clear indication of the understanding by pirates of the disunity and unevenness of the naval forces in the Gulf of Aden.

However, in recent times, issues arising from the handling of apprehended pirates have given room for contemplation on whether or not the Navy option is indeed a success. The current predominant practice in handling apprehended pirates is tagged the "catch-and-release" method. This trend is developing fast because many of the countries that have their Navies in the Gulf of Aden are gradually developing cold feet as far as prosecution of pirates is concerned. It is estimated that about

[2] The use of local vessels causes confusion over pirates posing as fishermen e.g. two Indian fishermen were killed by Italian marines aboard the *MV Enrica Lexie* in 2012 on suspicion of being pirates.

90 percent of "suspects pirates" apprehended by the patrolling Navies are released almost immediately without trial or botched trial such that the "practice [of catch-and-release] has now become the rule and judicial prosecution the exception" (Lang, 2001:21).

The reasons advanced for this recent developments are traceable to law and practice of international human rights law. They include issues of jurisdiction, the difficulty of proving a case, immigration, the operation of the doctrine of non-refoulement, the United Nations Convention on the Law of the Seas among others.

JURISDICTION = international law permits any state to try any pirate it apprehends in the High Sea even if the state has no direct connection with pirates crime (Article 105 of the United Nations Convention on the Law of the Seas). However, the venue for such a trial is becoming an issue in jurisdiction. The current trend is to look for a state outside Europe to try pirates apprehended/arrested by the UK. Reports have it that the United Kingdom has arranged a prosecution procedure whereby "suspects pirates" apprehended by UK Navy are handed over to states in the Gulf of Aden (Seychelles, Kenya, Tanzania) for trial. On the conclusion of the trial, the convicts are then returned to a territory in Somalia (in line with an agreement made at the London Conference on Somalia between President James Michel and Somaliland President Ahmad Mohamed Silyano) (Somaliland) to serve their prison terms founded on sentences pronounced in accordance with "UNODC-established penal facilities" ("Seychelles Hands Over Pirates to Somaliland" (Somalia Report, 2012) in prison facilities established with the support of the UNODC).

This arrangement as beautiful as it may be has some inherent challenges. Primarily it offends the international law doctrine of non-refoulement Farmer (2008:2-43); Douglas (2010:152); Kontorovich (2009); Treves (2009:405); Treves (2009:12-13); Article 33 1951 Refugee Convention. More so, international law has no provisions for trials by third-party-states. Within its universal jurisdiction over piracy provision, it contemplated only trial "in the courts of the State which carried out the seizure" (The United Nations Convention on the Law of the Seas -Article 105) without consideration for any reasons for which a state that arrested a pirate would rather desire to prosecute the pirate in any other jurisdiction (for purposes of cost).

Other intrinsic elements in jurisdiction herein are judicial and penal capacity, human rights records of the "third-party-states"; security at trial venues, willingness to continue with such an arrangement[3], possibility of reprisal or pressure by pirate gangs, and/or limited prison capacities of "third party state".

DIFFICULTY OF PROVING A CASE = traditionally, proving cases of crime is difficult. The difficulty usually arises from the level of prove in criminal cases which is beyond reasonable doubt. This is even worse in circumstances where the available evidence is circumstantial, or issues of capacity of the offender to commit a given offence and or face trial for such an offence are present or witnesses are difficult to procure.

In the case of Somali pirates a lot of obstacles in this regard exist. The peculiarity with the trial of Somali pirates is that they rarely fit into traditional definition of pirates. They are usually not caught in the act. Most often they are arrested because they are found in the High Sea in possession of weapons suspected to be capable of being used for attacks on ships or equipment suspected to be capable of being used in boarding ships. Ordinarily, these do not amount to any crime. Besides many pirates are known to throw incriminating equipment in their possession over board upon siting approaching Navies, and claim to be ordinary fishermen when accosted by Naval Forces.

Part of the difficulty in proving that "suspect pirates" are truly pirates is in securing witnesses. Piracy prosecutions: involve cases with suspects from one country and witnesses and victims from others. The vessel likely is registered in yet another state, and is transporting cargo owned by corporations from one or more additional countries. In addition, the flag state of the warship that conducts the interdiction could be from a distant state and on a deployment in the region (Kraska, 2009:197-216).

Besides, most of the competent and compellable witnesses are difficult to bring to attest in courts or have their testimonies recorded for onwards transmission to court. This difficulty may be as a result of fear, absence of logistics (finance), language barer, and the fact that most of the appropriate witnesses are seamen who are always on the move.

Another part of the difficulty is that exhibits recovered from the arrested pirates must be properly handled, typed and preserved by the capturing authority, shipped back to the trial forum and dutifully presented in court. Others include securing willing persons to offer translation services to the court.

THE DOCTRINE OF NON-REFOULEMENT = developments in a few successful prosecution of pirates are pointing towards a direction most states are finding difficult to accept. The application of the doctrine of non-refoulement makes it imperative to withhold ex-convict pirates from leaving the state in which they were tried, convicted (or acquitted) and perhaps served their prison terms - this explains the rationale for the recent adoption of "third-part-state" in pirate prosecution and also the "catch and release" approach to Somalia pirate crackdown. Under this doctrine, it is forbidden for a person who has successfully served his term in prison to be released to go back to the same situation that warranted his committing crime to be exposed to committing the same crime for which he has been punished again.

Based on the forgoing many states are apprehensive that prosecuting "suspect pirates" within their jurisdiction would mean permanently relocating or rather accepting ex pirate convicts as citizens. It is for this reason that most states, UK in particular, are quick to either bring the pirates back to Somalia, under a pre-arranged agreement, for trial or unconditionally release them.

WEAPONS POSSESSION AND USE ON THE HIGH SEAS = the presence of the Navies in the Gulf of Aden is adding impetus to the argument as to the regime of Weapons

[3] At the outset of this "third-party-state" trial arrangement, Kenya was in the forefront of receiving pirates arrested by other states, but could not sustain it beyond one year. The reasons for that cancellation are still not in public domain.

possession and use on the High Seas, the relevance of allowing seamen bear arms when the waters are protected by troops, and the use of military action against pirates.

At the moment it appears that the standard in this respect is not defined or at best restrictive. The "current draft guidelines in circulation, following the laws of many nations, only allow the use of lethal force when facing imminent danger to life or limb" (Kontorovich, 2012).

Somali Pirates are not soldiers or insurgents, and are not involved in wars, therefore are ordinary civilians within the confines of international law, so ought not to be dealt with aggressively in military fashion except on apprehension of immediate danger to self-defense.

However, the presence of Navies in the Gulf of Aden has not guaranteed the absence of attack on ships. Instances have been reported of Navies of a country turning the other way when ships of states other than theirs are being attacked. What seems to deter the pirates are ships that are armed. But it appears that the traditional understanding of the doctrine of "self-defense", which assumes that there will be police response, is impeding reality i.e. that such expected police (or naval) response in times of need for self-defense has some limitations on the high seas. Yet lives are at stake and the EU and US Naval Forces in the Gulf of Aden are expected to be operating within the confines of the "old" rules in matters that are beyond those rules, whereas states like Russia, Iran are going beyond the limits of customary international law in dealing with pirates by adopted more aggressive measures.

5. Conclusions

It is doubtful, in view of recent developments, that securitization of the Gulf of Aden will ensure maritime security in that gulf. The victory that may be won by the navies in the Gulf of Aden will be unsustainable, the successes in combating Somali piracy will be short leaved if the political situation in Somalia is not brought under control and a functional central government reestablished. The Somali government would be in a better position to get the scavengers in the Gulf of Aden back on track – this is because of the perception of Somalis of the supposed pirates as saints and martyrs of Somalia.

Using force against the pirates in the Gulf of Aden while the political situation in Somalia remains unresolved and the surrounding waters scavenged by foreigners will only strengthen the resolve of the Somali youths to enlist more force in their quest to defend their fatherland.

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Development Rate of Maritime Container Ports: A Case of Transatlantic Ports

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ABSTRACT

This article aims to determine the development (rate) of maritime container ports in a case involving transatlantic container transport in order to ascertain a model of container flows between container terminals in the United States and container terminals in Western and Northern Europe. The model proposed by the authors is made using the following eight key elements: transport infrastructure and suprastructure, influence of the intelligent information system, economic growth, transport ecology, transport flows, innovations and safety and security and transport energy. The research builds mainly upon empirical data analysis.

1. Introduction

Port and urban specialists often focus on what may appear as processes and actors of distinctly different nature. One example is the large body of research on so-called port systems where neighboring port nodes go through successive development phases marked by varying traffic concentration levels. Geographers have been particularly active in describing the spatial evolution of port systems where load centers and offshore hubs influence the port hierarchy due to their competitiveness and attractiveness in the transport and logistics chain at sea and on land (Fleming and Hayuth, 1994; Notteboom and Rodrigue, 2005).

The reaction to the financial and economic crisis has shown a new redesign of scenarios taking into account the changes made by maritime companies choosing different ports (González et al., 2010). In this research, containerized traffic evolution in 2008 and 2010 is described, both in big ports and geographic regions as from the emergent port activity areas. Database used is a sample of the world containership fleet movements that have called in some Chinese port in the years analysed. Calculus methodologies based on Graph Theory are applied to this set of data, able to give information about the global and local importance of a port given. Containerized goods transportation network have been contracted between 2008 and 2010 respect the port throughput, but there's no contraction in the distribution capacity of the main hub ports, which seem to have adopted commercial diversification strategies and foreland expansion. On the other hand, port emergent regions placed in the entrance and exit of Panama Canal will have important business opportunities.

A dramatic boom in the Pearl River Delta (PRD) port system has emerged during the past two decades, from having Hong Kong as the only gateway hub to the coexistence of three world-ranked container ports. PRD port system development to date and identifies the underlying forces driving the port system evolution. In particular, the unique process by which the PRD port system went from one gateway port to two ports and the undergoing regionalization with specialization is examined. The network strategy is stressed in shaping the port system structure. With the advantage of a hinterland regionalization, Shenzhen, among the gateway ports in PRD, has acquired the market share from Hong Kong. Shenzhen and

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Guangzhou ports move from the hinterland-dominated regionalization to a more balanced regionalization based on an established inland transport network, whereas Hong Kong undergoes a foreland regionalization. If the hinterland connection remains relatively weak, the gateway function of the port in Hong Kong will further decline, but its transhipment role will further dominate (Liu et al., 2013).

The main purpose of this research is to work out an optimal overseas model of container transport based on the predetermined rate of the United States Atlantic container ports and ports in Western and Northern Europe. In order to elaborate upon such a model, it is first necessary to compare development rate of maritime container ports, and on this basis, to determine attraction of maritime container terminals of the above-mentioned ports. To enable the managers to carry out the important tasks in container transportation on basis of quality and with competence, they have to know the following eight important elements of the container transportation model, which derive from the main areas that are important to container carriers and influence the calculation of the development rate of maritime container ports.

Our research questions are the following:

1) 'What is the role of the development rate of maritime container ports?'

2) 'How can a new optimal overseas model of containers' (TEU) transport be developed?'

2. Literature review

The commonly used, idealized model on network development as presented by (Taaffe et al, 1963) suggests an increasing level of port concentration as certain hinterland routes develop to a greater extent than others in association with the increased importance of particular urban centres. As a consequence of the competition among seaports, among inland centres and between seaports and inland centres, the geographical system evolves from an initial pattern of scattered, poorly connected ports along the coastline to the sixth and final stage of the Taaffe et al model, whereby a main network consisting of corridors between gateway ports and major urban centres is established. The resulting port concentration can cause degradation of minor ports in the network. Eventually, some smaller ports may even disappear. Recently, (Slack, 1990) added a seventh stage to the model of Taaffe et al, indicating a further concentration of traffic flows on major corridors as a result of the realities of intermodal systems. He states that where a fully developed intermodal system has been accomplished, hereby referring to the extensive intermodal network in the US, all former inland terminals that no longer serve as hubs will be excluded from the network.

The model developed by (Barke, 1986) is quite similar to the Taaffe et al model. In the final stage of his five-phased model, however, he introduces a process of deconcentration. This occurs when large and rapidly growing port areas begin to suffer from excessive congestion, thus encouraging some port activities to leave the urban core for less-congested suburban or peripheral port sites. In a less extreme form this deconcentration phase refers to the infrastructural extension of ports away from the historical core to less-urban port areas. The downstream development of terminal infrastructures in many European ports illustrates this process. In a more extreme form this deconcentration tendency implies an activity shift from major ports to adjacent less-congested (new) ports. Also, in the latter case the deconcentration process described by Barke is limited in space. A more radical spatial deconcentration process can be found in the Hayuth model on the dynamics within container port systems (Hayuth, 1981). This model is a result of empirical research in the US container port sector and is of particular interest in the study on concentration tendencies in the European container port sector.

There is an intimate relationship between national security, as it is broadly defined, and economic and social development; the former requires the fullest and most profitable commitment of national potential in all fields of endeavour, including social, economic, political and military (Ademuni-Odeke, 1984). If without security there can be no development, the reverse is also true. The relationship between the two factors of security and development provides the precise forms and proper perspective for an analysis of the problem of transport in all its intricate and multifold aspects (Black and Black, 1982). Although transportation is vital to every nation, the relative importance of each of several modes of transport may vary from one nation to another. This variance depends on the interplay of a multiplicity of physical and economic factors, such as geographic location; territorial arrangements and topography; extent of navigable inland waterways (Black and Rimmer, 1982), economic and technological advances; size of the domestic market; direction of the main stream of trade; or even entirely subjective factors, such as the national inclination or disposition of its people (Bannister, 1983).

The proposed classification of the European continental container port system into three main port ranges is particularly interesting in view of the assessment of inter-range port competition, i.e. the competition between ports situated in different port ranges. Hence, extensive hinterland networks allowed deeper inland penetration and contributed to the establishment of vast hinterlands shared by the major European ports. These developments encouraged inter-range port competition, especially in the container sector (Notteboom and Winkelmans, 1994).

Recent studies have analysed varying impacts of railway capacity, port efficiency, containers and logistics. Cambridge Systematics, Inc. (2007) assessed current and long-term capacity expansion of US freight railroads and the role of congestion among corridors. Christenson Associates (2008) indicated capacity "tightness" is primarily due to congestion at terminals or other specific network locations. Port efficiency has been examined in several studies (Notteboom, 2006; Heaver, 2006; Talley, 2007; Brooks, 2007; Ramos-Real and Tovar, 2010 and De Borger and De Bruyne, 2011). Ramos-Real and Tovar (2010) examined economics of scale in container shipping and (De Borger and De Bruyne, 2011) examined effects of vertical integration between port activities and hinterland congestion. Notteboom (2006) evaluated the effect of delays on shipping logistics. Rodriguez-Alvarez et al. (2011) indicated that port terminal costs are impacted by demand uncertainty. O'Kelly and Bryan (1998) developed a model to reflect scale economies that are generated on inter-hub links. Racunica and Wynter (2005) and Rodriguez et al. (2007) used optimization models of huband-spoke type networks for rail freight. Fewer studies have analyzed impacts of congestion on spatial and inter-port competition (Maguire et al., 2010; Ilmer, 2010). Crainic and Kim (2007) discussed the interpretation of congestion in the context of network flow models of intermodal transportation. Other studies on container shipping and congestion include (Fan et al., 2009, 2010; Fan and Wilson, 2011).

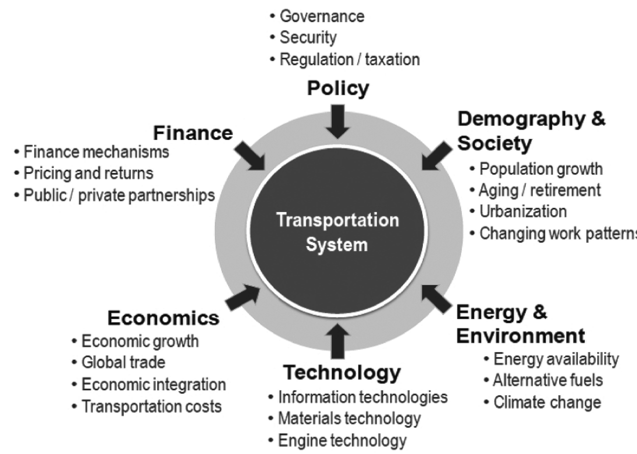
Supply-chain optimization models developed by (Leachman, 2008) and (Jula and Leachman, 2011a,b) used mixed integer programming models to determine the least cost supply chain for an importer of containerized products to US regional distribution centers. The models focused on location decisions and included logistical costs and strategies including inventories, inventory costs, lead time, etc. as well as analyzing risk pooling strategies. Capacity constraints and congestion were not part of the model and some of the shipping channels were pre-determined, though these were suggested as areas for future research.

More recently Leachman and Jula (2011, 2012) analyzed congestion for west coast imports of containers by estimating dwell times for ports and railways and included these in their logistical model for importers' location decision.

As global logistics and supply chain management plays an important role on the products and service flow for sustainable economics, several studies have been conducted to highlight the importance of container route optimization (Lee, 2011) and visualization (Lee et al., 2011) of the results for management decisions. (Luo and Grigalunas, 2003) analyzed import and export container markets in Canada by optimizing container routes and simulating hypothetical ports as alternative entry points. In their research, they applied a minimum cost path algorithm based on a shipper's decision-making process in reallocation of network volume. (Leachman et al., 2005) and (Leachman, 2008) estimated the optimized routes and trips for the import container markets in the U.S. by assigning a "trade partner" through feasible rail and highways.

Obviously, maritime transportation is comprised of maritime ship transportation and the dimension of maritime ports. The areas listed in Figure 1 are main areas whereby to establish the vision of future development of maritime transportation. They will help with the changes involved in overcoming the obstacles; assist with the development of new innovations; and facilitate the establishment of the operational structure at the global and national levels, which shall also contribute to the development of a durable society and a successful transport system. Furthermore, one should also consider how the transport system can change based on momentary transport requirements and political goals that could influence the planned development trends of the maritime transportation industry.

Figure 1: Influence of important areas on the carriers for the future.



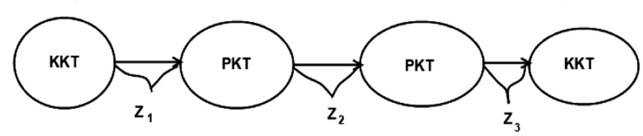
Source: Adapted from (Rodrigue, 2010).

3. Research design

The main objective of this study is to ascertain an optimal overseas model of container transport based on the pre-determined rate of maritime container ports in Eastern states of the United States of America and countries in Western and Northern Europe.

In such, our research elaborates on an optimal overseas model of container (TEU) transport, which can be determined as follows (Figure 2).

Figure 2: An optimal overseas model of containers' (TEU) transport



$$Z = Z_1 + Z_2 + Z_3 \quad (1)$$

KKT –Continental container terminals

PKT –Maritime container terminals

Z_1 –Container transport optimisation (TEU) on the road, from the continental container terminals of the Eastern states of the United States of the America (KKT/A) to the maritime container terminals in the Eastern states of the United Stated of the America (PKT/A)

Z_2 –Container transport optimisation (TEU) on the sea, from the maritime container terminals in the Eastern states of the United States of America (PKT/A) to the maritime container terminals in Western and Northern European countries (PKT/E)

Z_3 –Container transport optimisation (TEU) on the road, from the maritime container terminals in Western and Northern European countries (PKT/E) to continental container terminals in Western and Northern European countries (KKT/E)

In the problem of the optimisation of container transportation (TEU), there are m resources with the capacities of Ui units and n users with demands for Di units. The problem is balanced when the joint capacities of resources are equal to the demands of end users.

Let's denote the number of containers (TEU) that need to be shipped from the resource i to the user j with X_{ij} and transport costs per number of containers (TEU) with C_{ij}, u_j is attraction of maritime container terminals and S_{r_j} is the development rate of maritime container ports.

Mathematical model of the problem:

$$Z = \sum_{j=1}^{n} \sum_{i=1}^{m} c_{ij} x_{ij} \rightarrow \min \quad (2)$$

$$Z = \sum_{j=1}^{n} \sum_{i=1}^{m} u_j S_{r_j} x_{ij} \rightarrow \min \quad (3)$$

Under conditions:

$$\sum_{j=1}^{n} x_{ij} = U_i \qquad i = 1, \ldots, m \quad (4)$$

$$\sum_{i=1}^{m} x_{ij} = D_j \qquad \mathrm{j} = 1, \ldots, n \quad (5)$$

Subect to:

$$x_{ij} \geq 0 \quad (6)$$

$$\sum_{j=1}^{n} U_i \leq \sum_{i=1}^{m} D_j \quad (7)$$

4. Attraction of maritime container ports

To enable the managers to carry out the important tasks in container transportation on basis of quality and with competence, they have to know the following eight important elements of the container transportation model, which derive from the main areas that are important to container carriers and influence the calculation of the development rate of maritime container ports: 1) transport infrastructure and transport suprastructure, 2) influence of the intelligent information system, 3) gross domestic product – economic growth, 4) transport ecology, 5) transport flows, 6) innovations, 7) safety and security and 8) transport energy. Development rate of maritime container ports – Sr_i can be defined as follows:

$$S_{r\,i} = f_i \sum_{i=1}^{n} \left(\frac{y_{i,t} - y_{i,t-1}}{y_{i,t}} \right) \qquad i = 1, 2, \ldots, n \quad (8)$$

$$S_{r_i} = f_1 \times S_{r_{pi\sup}} + f_2 \times S_{r_{iis}} + f_3 \times S_{r_{bdp}} + f_4 \times S_{r_{pek}} + f_5 \times S_{r_{pt}} + f_6 \times S_{r_{ino}} + f_7 \times S_{r_{va\,var}} + f_8 \times S_{r_{pene}} \quad (9)$$

$$\sum_{i=1}^{N} f_i = 1 \quad (10)$$

$$f_i = \frac{r_i}{\sum_{i=1}^{n} r_i} \quad (11)$$

$$u = \frac{C_i}{Sr_i} \quad (12)$$

Subject to:

- y_i –value status of the element of the container transportation model (transport infrastructure and transport suprastructure, influence of the intelligent information system, gross domestic product-economic growth, transport ecology, transport flows, innovations, safety and security, transport energy)
- t –year
- f_i –influence portion of certain element per average development rate
- r_i –development rate of individual element of the container transportation model
- C_i –transportation price
- u –attraction of maritime container terminals

Attraction of a port –u: determines which maritime container port generates the majority of transport flows of containers (TEU) shipped from continental container terminals to state maritime container terminals, and which maritime container port in other countries generates the majority of transport flows of containers shipped from state maritime container terminals.

5. Results of the empirical analysis

The development rate of the element i of container transportation (TEU), depending on the element j, is defined as the growth of the estimated state of the i element of container transportation (TEU) Δy_{it} and the value of the estimated j element of container transportation (TEU) in the period t.[1]

Table 1 shows the estimation of elements of the container transportation model (TEU) in 2009, 2015 and their growth up to 2015, including: transport infrastructure and transport suprastructure, the influence of an intelligent information system, gross domestic product – economic growth, transport ecology, transport flows, innovations, safety and security and transport energy.

The values of elements of the container transportation (TEU) (e.g., as an estimated state, parameter, etc.) are denoted with y_{it} and $y_{i,\,t-1,}$ for i transport container element (TEU) in the period of t and t-1. The period t is the year 2015, the period t-1 is the year 2009. The growth of the value of estimated state of the i element of the container transportation element (TEU) is, according to (Stojanović, 1988):

$$\Delta y = y_{it} - y_{i,t-1} \tag{13}$$

The development rate of the element i of container transportation (TEU), depending on the element j is defined as the growth of the estimated state of i element of container trans-

Table 1: Estimation of elements of container transportation model.

Elements of container transport model	Estimated state y_{it}		Growth	Notes
	2009	2015	y_i 2015	
1. Transport infrastructure and transport suprastructure	4.78	4.87	0.09	Total of average value of the following countries USA, Germany, France, the Netherlands, Spain; http://data.worldbank.org/indicator, (accesed 6 December 2009).
2. Influence of intelligent information system	120,500,000,000 $	122,909,972,931 $ (value calculated based on the GDP value)	2,409,972,932 $	Ezell, S. (2010) 'Intelligent Transportation Systems', The Information Technology & Innovation Foundation, January, pp. 10.
3. Gross-domestic product – economic growth	22,258,715,599,486 $	22,703,889,911,476	445,174,311,990 $ (2 % growth)	Total average value of the following countries USA, Germany, France, the Netherlands, Spain; Retrieved from http://data.worldbank.org/indicator, (accesed 6 December 2009); http://www.targetmap.com/viewer.aspx?reportId=4284 (accesed 6 December 2009).
4. Transport ecology	21.28	21.07	0.425 (GDP growth by 2 % taken into account)	Transport ecology expressed in an average index value of biodiversity (value 0 – no potential of biodiversity, value 100 (the biggest potential of biodiversity) for following countries USA, Germany, France, the Netherlands, Spain; available at http://data.worldbank.org/indicator/ER.BDV.TOTL.XQ/countries, (accesed 6 December 2009).
5. Transport flows	530,000,000 TEU	590,000,000 TEU	60,000,000 TEU	*'Maritime Transportation: Drivers for the Shipping and Port Industries',* International Transport Forum, Transport and Innovation: Unleashing the Potential, Paper Commissioned for the Experts "Session on Innovation and the Future of Transport", Paris, January 2010, p. 15 (taken into account is the maturity scenario).
6. Innovations	491,917,614,748 $ (2.21 % GDP)	501,755,967,043 $ (2.21 % GDP)	2,459,588,074 $	Total average value of the following countries USA, Germany, France, the Netherlands, Spain; http://data.worldbank.org/indicator/EG.USE.COMM.KT.OE/countries, (accesed 6 December 2009).
7. Safety and security	1,294,776,520 $	1,320,672,050 $	25,895,530 $ (GDP growth by 2 % taken into account)	http://ec.europa.eu/transport/maritime/studies/doc/2009_04_scanning_containers.pdf, (accesed 6 December 2009).
8. Transport energy	588,271 kt oil	654,868 kt oil	66,597 kt oil	Total average value of the following countries USA, Germany, France, the Netherlands, Spain; Retrieved from http://data.worldbank.org/indicator, (accesed 6 December 2009). - calculated based on the transhipped amount of containers.

Source: Authors.

[1] Stojanović, D. (1988) '*Matematičke metode u ekonomiji, dodatak matrica rasta*,' seventh revised edition, Contemporary Administration, Belgrade, pp. 351.

portation (TEU) Δy_{it} and the value of the estimated j element of container transportation (TEU) in the period t, or as the case may be:

$$r_{ij} = \frac{\Delta y_{it}}{y_{it}} \qquad i,j = 1, 2, \ldots\ldots, 8. \qquad y_{i,t-1} \neq 0 \tag{14}$$

The development rate of a certain element of the container transportation can be expressed in the development matrix:

$$f_i = \begin{bmatrix} r_{11t} & r_{12t} & \ldots & \ldots & r_{1nt} \\ r_{21t} & r_{22t} & \ldots & \ldots & r_{2nt} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ r_{n1t} & r_{n2t} & \ldots & \ldots & r_{nnt} \end{bmatrix} \qquad t = 1, \ldots, T \tag{15}$$

$$\Delta y'_{2015} = \begin{bmatrix} 0.09 \\ 24.0997\times10^8 \\ 4451.7431\times10^8 \\ 0.425 \\ 0.6\times10^8 \\ 24.5958\times10^8 \\ 0.2589\times10^8 \\ 0.0006\times10^8 \end{bmatrix} \tag{16}$$

In Table 2, the development rates of individual elements of the container transportation (TEU) between the Eastern states of the United States of America and Western and Northern European countries in the time period of 2009-2015 have been shown.

Subject to which are the elements on the main vertical that denote direct development rates (i=j), the others denote indirect development rates of an individual element of the model. The elements in the line i denote the growth of the estimated state in the element i of the container transportation model (TEU) in the function of sustainable development based on the estimated state in other elements of the container transport model (TEU). The elements in column i denote the growth of the value of the estimated state in all elements of the model according to the estimated state of the element i in the period t = 6 years.

The highest development rate is present in the transport flows element and the transport energy element in the time period of 2009-2015 with the value of 0.1; following are the transport infrastructure and suprastructure element, influence of the intelligent information system element, the gross domestic product-economic growth element, transport ecology, innovations, and safety and security, with the value of 0.02.

The calculated portions of a certain element of the container transportation model (TEU) per an average development rate of maritime container ports in the Eastern states of the United States of America and in the Western and Northern European countries are shown in Figure 3.

Figure 4 shows that the highest influence on the calculation of an average development rate of individual maritime container ports in the time period of 2009-2015 contains two elements—the transport flows element and the transport energy element—with the value of 0.3; following are the transport infrastructure and the suprastructure element, gross domestic product-economic growth, transport ecology, innovations, safety and security and influence of the intelligent information system, with the value of 0.1.

The data for the calculation of the development rate of maritime container ports in the Eastern states of the United States of America and in Western and Northern European countries are shown in Table 3.

$$1/y_{2015} = (1/4.87;\quad 1/1229.0997\text{x}10^8;\quad 1/227038.8991\text{x}10^8;\quad 1/21.07;\quad 1/5.9\text{x}10^8;\quad 1/5017.5596\text{x}10^8;\ 1/13.2067\text{x}10^8;\ 1/0.0654\text{x}10^8) \tag{17}$$

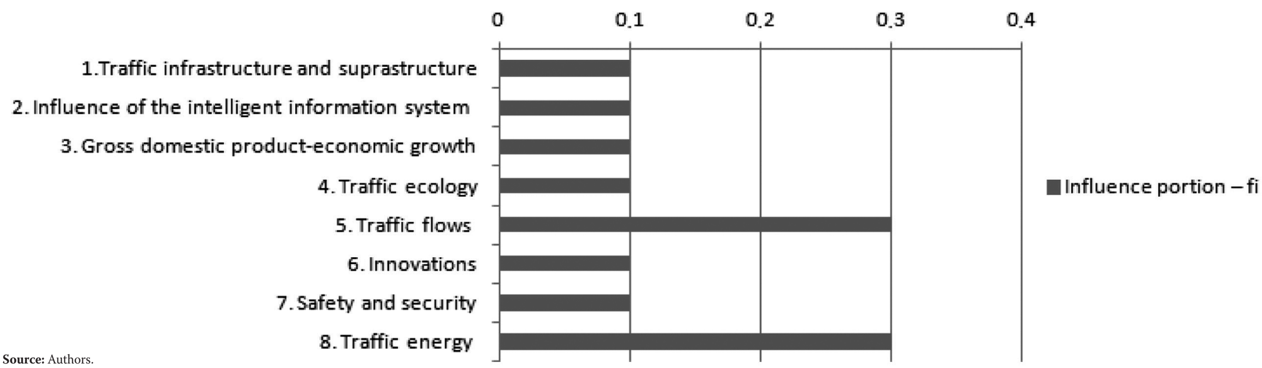
$$\mathbf{R}_{2015} = \begin{bmatrix} 0.02 & 0 & 0 & 0.0043 & 0 & 0 & 0 & 0.000137 \\ 4.9486\times10^8 & 0.02 & 0.000106 & 1.1437\times10^8 & 4.1 & 0.005 & 1.8 & 0.000036 \\ 914.1156\times10^8 & 0.36 & 0.02 & 211.2834\times10^8 & 754 & 0.9 & 337 & 0.00679\times10^8 \\ 0.09 & 0 & 0 & 0.02 & 0 & 0 & 0 & 0 \\ 0.12396\times10^8 & 0.000049 & 0.000002 & 0.0284\times10^8 & 0.1 & 0.00012 & 0.045 & 92 \\ 20.2019\times10^8 & 0.008 & 0.00043 & 0.4669\times10^8 & 17 & 0.02 & 7.4 & 0.00015\times10^8 \\ 0.05317\times10^8 & 0.000021 & 0.000001 & 0.0123\times10^8 & 0.04 & 0.000005 & 0.02 & 39 \\ 0.00013\times10^8 & 0 & 0 & 0.00003\times10^8 & 0.00011 & 0 & 0.00005 & 0.1 \end{bmatrix} \tag{18}$$

Table 2: The development rate of individual elements.

	1	2	3	4	5	6	7	8
1	0.02	0	0	0.0043	0	0	0	0.000137
2	4.9486x10^{8}	0.02	0.000106	1.1437x10^{8}	4.1	0.005	1.8	3.680
3	914.1156x10^{8}	0.36	0.02	211.2834x10^{8}	754	0.9	337	0.00679 x10^{8}
4	0.09	0	0	0.02	0	0	0	0
5	0.12396x10^{8}	0.00049	0.000002	0.0284x10^{8}	0.1	0.00012	0.045	92
6	20.2019x10^{8}	0.008	0.00043	0.4669x10^{8}	17	0.02	7.4	0.00015 x10^{8}
7	0.05317x10^{8}	0.000021	0.000001	0.0123x10^{8}	0.04	0.000005	0.02	39
8	0.00013x10^{8}	0	0	0.00003x10^{8}	0.00011	0	0.00005	0.1

Source: Authors.

Figure 3: Portion of the influence of the element of the container transportation model.



Source: Authors.

Table 3: The data for the calculation of the development rate of maritime container ports.

Maritime ports	f_1	Sr_{pisup}	f_2	Sr_{iis}	f_3	Sr_{bdp}	f_4	Sr_{pek}	f_5	Sr_{pt}	f_6	Sr_{ino}	f_7	Sr_{vavar}	f_8	Sr_{pene}	Sr
Boston[2]	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.3	0.3	-0,004	0.1	0.4	0.1	0.2	0.3	0.8	0.4
New York[3]		0.7		0.2		0.2		0.6		-0.0004		0.3		0.02		0.5	0.3
Philadelphia[4]		0.5		0.2		0.6		0.8		-0.0008		0.5		0.02		0.6	0.4
Baltimore[5]		0.2		0.1		0.7		0.5		-0.0002		0.5		0.01		0.4	0.3
Norflolk[6]		0.1		0.1		0.02		0.6		-0.0006		-0.8		0.03		0.7	0.2
Savannah[7]		0.6		0.7		-0.1		0.7		-0.0004		0.1		0.8		0.4	0.4
Rotterdam[8]		0.5		0.8		-0.04		0.1		-0.0004		0.2		0.2		0.2	0.2
Bremerhaven[9]		0.6		0.6		-0.06		0.2		-0.0007		0.1		0.1		0.2	0.2
Hamburg[10]		0.4		0.6		-0.3		0.1		-0.015		0.3		0.2		0.1	0.1
Le Havre[11]		0.3		0.9		-0.1		0.8		-0.0004		0.3		0.2		0.2	0.3

Source: Authors.

Notes:

2 – http://www.epa.gov/region1/topics/air/sips/ne_sip_summaries.html#me; http://www.massport.com/port-of-boston/Pages/Default.aspx (accesed 7 September 2009).

3 – http://www.epa.gov/region1/topics/air/sips/ne_sip_summaries.html#me; http://www.panynj.gov/port/terminal-improvements.html, http://www.panynj.gov/about/pdf/CAS-FINAL.pdf (accesed 7 September 2009).

4 – http://www.philaport.com/ (accesed 7 September 2009).

5 – http://www.mpa.maryland.gov/_media/client/planning/2012/EconomicImpact.pdf, http://www.mpasafepassage.org/mpanews/2010/2010GreenPort.pdf (accesed 7 September 2009).

6 – http://www.nscorp.com/nscorphtml/pdf/foundation-report-2009.pdf (accesed 7 September 2009).

7 – http://www.philaport.com/news/archives.htm (accesed 7 September 2009).

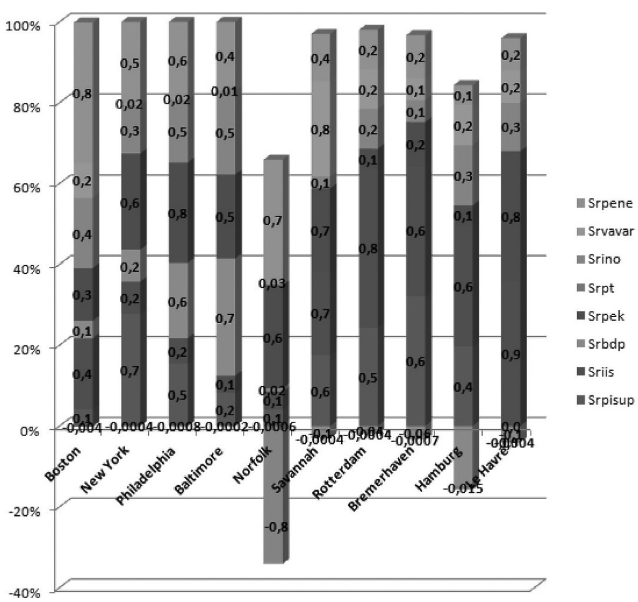
8 – http://www.portofrotterdam.com/en/Port-authority/finance/annual-report/Documents/ (accesed 7 September 2009).

9 –http://www.bremenports.de/en/location/media-centre/downloads (accesed 7 September 2009).

10 –http://www.hamburg-port-authority.de/en/ (accesed 11 September 2009).

11 –http://knoema.com/tbocwag#France, http://www.havre-port.fr/images/brochures/flashinfoport2000avril2010.pdf; http://www.norwaypost.no/index.php/business/money-and-finance/27710; http://www.greenport.com/news101/vessel-build-and-maintenance/initiatives/constant-air-quality-monitoring-at-le-havre (accesed 11 September 2010).

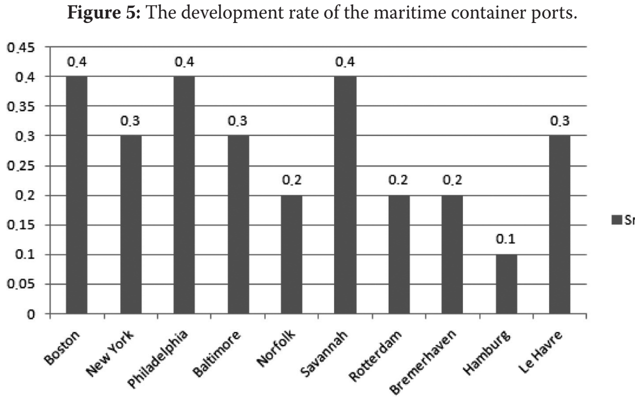
Figure 4: The shown data influence the development rate of the individual elements.



Source: Authors.

The development rate of the maritime container ports in the Eastern states of the United States of America and in Western and Northern European countries is shown in Figure 5.

Figure 5: The development rate of the maritime container ports.



Source: Authors.

The maritime container ports with the highest value of development rate in 2009 were the Philadelphia, Boston and Savannah ports, with the value of 0.4. Following are the maritime container ports of New York, Le Havre and Baltimore, with the value of 0.3; the maritime container ports of Norfolk, Rotterdam and Bremerhaven, with the value of 0.2; and the maritime container port of Hamburg, with the value of 0.1.

Table 4: Average development rate of maritime container ports.

Country	*Average development rate of maritime container ports – Sr_i (2009)*
Netherlands	0.2
Germany	0.2
USA	0.3
France	0.3

Source: Authors.

It is clear from Table 4 that maritime container ports in the USA and France have a higher development rate than maritime container ports in the Netherlands and Germany.

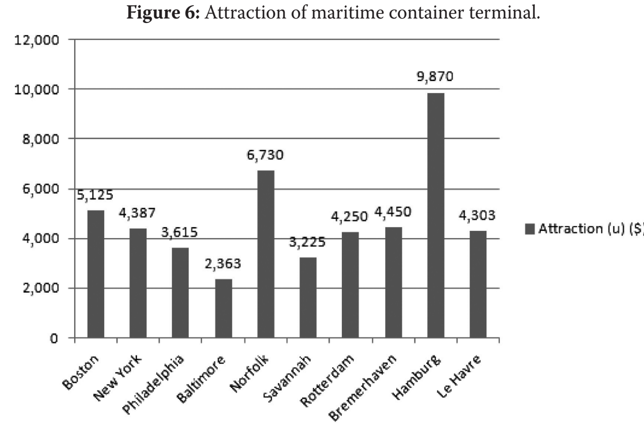
The calculated attraction (u) of the maritime container terminals in the Eastern states of the United States of America (PKT/A) and in the maritime container terminals in Western and Northern European countries (PKT/E) in 2009 is shown in Table 5.

Table 5: Attraction - (u) of maritime container terminals.

Maritime container terminal	*C_i ($)*	*Sr_i*	*Attraction (u) ($)*
Boston	2,050	0.4	5,125
New York	1,316	0.3	4,387
Philadelphia	1,446	0.4	3,615
Baltimore	709	0.3	2,363
Norfolk	1,346	0.2	6,730
Savannah	1,290	0.4	3,225
Rotterdam	850	0.2	4,250
Bremerhaven	890	0.2	4,450
Hamburg	987	0.1	9,870
Le Havre	1,291	0.3	4,303

Source: Authors.

Figure 6: Attraction of maritime container terminal.



Source: Authors.

The most attractive (u) for users is the maritime container terminal Baltimore, followed by the maritime container terminals Savannah, Philadelphia, Rotterdam, Le Havre, New York, Bremerhaven, Boston, Norfolk and Hamburg. The average prices for container transportation C_i are shown in Table 5. (K Line America Inc., 2009a, 2009b).

6. Conclusions

The research results, as specified above, have revealed that elements of the proposed model of container transport have a considerable impact on the sustainable and economic development of maritime container ports in the Eastern states of the United States of America and Western and Northern European countries with decreasing operation costs in the original hub port.

The maritime container ports in the USA and France had a higher development rate than maritime container ports in the Netherlands and Germany in 2009. The highest value of the development rate in 2009 was received by the maritime container ports of Philadelphia, Boston and Savannah, with the value of 0.4. Following are the maritime container ports of New York, Le Havre and Baltimore, with the value of 0.3; the maritime container ports of Norfolk, Rotterdam and Bremerhaven, with the value of 0.2; and the maritime container ports of Hamburg, with the value of 0.1. The maritime container terminal considered most attractive for users is the Baltimore terminal, followed by the maritime container terminals of Savannah, Philadelphia, Rotterdam, Le Havre, New York, Bremerhaven, Boston, Norfolk and Hamburg.

More significantly, with the proposed optimal model of containers' (TEU) transport between the Eastern countries of the United States of America and Western and Northern European countries, it is possible to lower the total average price of container transportation (TEU) to some extent.

Given that the development rate of container ports along the sea may be limited by the geographical conditions, there is a considerable incentive to start new terminals.

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Angle of Loll Calculation By Cubic Spline

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ABSTRACT

Several years ago the Basque Government supported the programming of the software ARKITSAS in order to provide all existing vessels with a specific software to calculate stability, cargo and longitudinal strength data. The aim of this article is to present the part of that research concerning the definition of the static stability curve by cubic spline in its initial end when the metacentric height is negative. Taking into account that the slope at initial end is known, the precision of the results for low heeling angles may be improved and, in this way, the accuracy in the calculation of loll should be enhanced. This method of calculation is compared to other traditional methods used for wall-sided ships by the application to three different ships.

1. Introduction

The static stability curve represents the values of GZ arms for the different heeling angles. However, the stability booklet usually provides GZ arms for every ten or fifteen degrees of heeling angles. This means that the rest of righting arms have to be obtained by drawing the static transversal stability curve passing through the known data. In this way, the global cubic splines seems to be one of the most suitable methods to define the static stability curve since the same have to pass through some control points. The local splines pass also through the control points, although its degree of smoothness is lower than the global splines. On the other hand, the B-splines would not be suitable because the curve would not pass through the control points. Consequently, the GZ arms obtained by global cubic spline interpolation appear to be appropriate enough.

The ends of spline curve are usually free under this interpolation method. However, the slope of the static stability curve for the heel of 0° (when the vessel is up righted) is known specifically, it is equal to the metacentric height divided by the value of one radian in degrees. Therefore, it is possible to fix the initial end of the static stability curve to make the GZ arms within the initial stability more precise and, taking into account that the angle of loll is usually small; its calculation would be suitable by means of non-free end cubic spline method.

When the ship is 'wall-sided' the approximate formula in (1) may be enough to calculate the angle of loll (Barrass and Derret, 2012). However, this method of calculation would not be suitable for those ships that have very fine bowlines and stern contours. Even in the case of box shaped ships the angle of loll calculated by this formula is not as accurate as that obtained graphically from the static stability curve. For this reason, the method presented in this paper takes advantage of the graphic definition of the static stability curve by cubic spline to obtain the angle of loll by the cross of this curve and the abscissa axis.

$$\tan\varphi_{loll} = \sqrt{\frac{2\cdot GM}{BM}} \quad (1)$$

2. Static stability curve definition by cubic spline

The static stability curve defined by global cubic splines is made up of different portions of curves connected in control points called knots which coincide with the known data. Therefore the curve is a piece-wise function defined by multiple subfunction in the form of the equation in (2), n being the total data provided in the cross stability curves.

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$$GZ_i(\varphi) = A_i + B_i \cdot (\varphi - \varphi_i) + C_i \cdot (\varphi - \varphi_i)^2 + D_i \cdot (\varphi - \varphi_i)^3 \quad i = 0, n \quad (2)$$

Obviously, the adjoining subfunctions coincide in value at knots and, moreover, the slope and the curvature at knots is the same for the adjoining subfunctions, which makes the whole curve smooth. Therefore, the following conditions have to be fulfilled (Borse, 1991):

1st condition: the value of a cubic subfunction at initial knot is known.

$$GZ_i(\varphi_i) = A_i \quad (3)$$

2nd condition: the value of two different adjoining subfunctions at common knot is the same.

$$GZ_i(\varphi_{i+1}) = GZ_{i+1}(\varphi_{i+1}) \quad (4)$$

3rd condition: the slope of two different adjoining subfunctions at common knot is the same, which means that the derivative of both subfunctions is the same as well at common knot.

$$GZ_i'(\varphi_{i+1}) = GZ_{i+1}'(\varphi_{i+1}) \quad (5)$$

4th condition: the curvature of two different adjoining subfunctions at common knot is the same, which means that the second derivative of both subfunctions is the same as well.

$$GZ_i''(\varphi_{i+1}) = GZ_{i+1}''(\varphi_{i+1}) \quad (6)$$

The definition of a curve by global cubic splines is related to the task carried out in the past at the shipyards by the draughtsmen who used a flexible strip of metal for drawing curve lines. The strip was fixed at the points or nodes through which the curve had to pass and the ends of the strip were left free. Bearing this in mind, the ends of a curve defined by global cubic spline may be left free if the curvature is nil at the ends. Thus, another additional condition may be added for the ends of the curve:

$$GZ_0''(\varphi_0) = 0 \qquad GZ_n''(\varphi_n) = 0 \quad (7)$$

Nevertheless, as has been mentioned before, the end of the first curve segment is fixed in the case of the static stability curve, since the slope at the end is known (Rawson, 2001).

$$GZ_0'(\varphi_0) = \frac{GM}{57{,}3} \quad (8)$$

All these conditions will let us calculate the coefficients of the different cubic subfunctions. Thus, the coefficients C_i can be obtained either by substitution, if the GZ data are equidistant, or by Gauss-Siedel. As the cross stability data may not be equidistant, the method of Gauss-Siedel seems to be the most adequate. Therefore, the coefficients C_i are obtained by the equation in (9).

$$C \cdot a = R \quad (9)$$

where:

$$C^t = [C_1 \quad C_2 \quad \dots \quad C_{n-2}]$$

$$R^t = [R_1 \quad R_2 \quad \dots \quad R_{n-1}]$$

$$a = \begin{bmatrix} a_{1,1} & a_{1,2} & 0 & 0 & \cdots & 0 & 0 \\ a_{2,1} & a_{2,2} & a_{2,3} & 0 & \cdots & 0 & 0 \\ 0 & a_{3,2} & a_{3,3} & a_{3,4} & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \cdots & 0 & 0 \\ 0 & 0 & 0 & 0 & \cdots & a_{n-1,n-2} & a_{n-1,n-1} \end{bmatrix}$$

$$a_{i,i-1} = \varphi_i - \varphi_{i-1}$$

$$a_{i,i} = 2 \cdot (\varphi_{i+1} - \varphi_{i-1})$$

$$a_{i,i+1} = \varphi_{i+1} - \varphi_i$$

$$R_i = \frac{3 \cdot (A_{i+1} - A_i)}{(\varphi_{i+1} - \varphi_i)} - \frac{3 \cdot (A_i - A_{i-1})}{(\varphi_i - \varphi_{i-1})}$$

To solve the equation 9, it is necessary to give an initial value to the coefficients C_i and to apply an iterative process until convergence criteria is reached or a maximum of iterations is exceeded, depending on the degree of accuracy. In first instance the coefficients C_i at the ends of the curve (C_0 and C_n) would be equal to zero by application of the formulae in (7).

The coefficient B_i is calculated by the formula in (16), which is obtained from the first four conditions.

$$B_i = \frac{A_{i+1} - A_i}{\varphi_{i+1} - \varphi_i} - \frac{(\varphi_{i+1} - \varphi_i) \cdot (2 \cdot C_i + C_{i+1})}{3} \quad (10)$$

The coefficients D_i are obtained by the equation in (11) that it is reached from the fourth condition.

$$D_i = \frac{C_{i+1} - C_i}{3 \cdot (\varphi_{i+1} - \varphi_i)} \quad (11)$$

Once, all the coefficients have been obtained, the initial end of the curve has to be fixed by giving new values to B_0 and C_0. The coefficient B_0 will be equal to the slope at the first end and C_0 will be obtained from the equations in (10) and (11).

$$B_0 = \frac{GM}{57{,}3} \quad (12)$$

$$C_0 = \frac{3}{2 \cdot \varphi_1} \cdot \left[\frac{A_1 - A_0}{\varphi_1} - \frac{GM}{57.3} \right] - 0.5 \cdot C_1 \quad (13)$$

If these new coefficients B_0 and C_0 are applied to the first four conditions, the values of

$A_{1,1}$ and R_1 will also vary.

$$A_{1,1} = 2 \cdot \varphi_2 - 0.5 \tag{14}$$

$$R_1 = \frac{3\cdot(A_2 - A_1)}{(\varphi_2 - \varphi_1)} - \frac{3\cdot(A_1 - A_0)}{\varphi_1} + \frac{3}{2\cdot\varphi_1}\cdot\left[\frac{GM}{57.3} - \frac{A_1 - A_0}{\varphi_1}\right] \tag{15}$$

Taking into account the new values obtained from the formulae (9) to (15), the equation in (9) is applied again to calculate the values of C_i and the rest of coefficients. Thus, the first end of the static stability curve will be fixed.

3. Angle of loll determination by spline

As the angle of loll is usually small, it may be considered included within the first segment of the spline curve or, what is the same, within the first subfunction. Given that the GZ is equal to zero when the ship is up righted [$GZ_0(0^o)=0$] and when the ship is heeled the angle of loll [$GZ_0(\phi_{loll})=0$], the equation in (2) is applied to obtain the angle of loll as follows:

$$A_0 + B_0 \cdot \varphi + C_0 \cdot \varphi^2 + D_0 \cdot \varphi^3 = 0$$

As $GZ_0(0^o)=A_0=0$, then:

$$B_0 \cdot \varphi + C_0 \cdot \varphi^2 + D_0 \cdot \varphi^3 = 0$$

$$\varphi \cdot (B_0 + C_0 \cdot \varphi + D_0 \cdot \varphi^2) = 0$$

Bearing in mind that $\phi_0=0^o$, the angle of loll is obtained from the second grade equation:

$$B_0 + C_0 \cdot \varphi_{loll} + D_0 \cdot \varphi_{loll}^2 = 0 \tag{16}$$

The coefficients B_0, C_0 and D_0 are obtained from the equations in (11), (12) and (13).

In the improbable case that the angle of loll was located in the second subfunction, it will have to be calculated from the equation in (17).

$$A_1 + B_1 \cdot \varphi_{loll} + C_1 \cdot \varphi_{loll}^2 + D_1 \cdot \varphi_{loll}^3 = 0 \tag{17}$$

The coefficients A_1, B_1, C_1 and D_1 would be obtained from the equations in (3), (10), (9) and (11).

4. Practical application

In this chapter the angle of loll is calculated by means of the spline method for three different types of vessels. The values so obtained will be compared to those calculated by the approximate formula in (1). Obviously, the ships are unstable in all cases to get a negative GM. On the other hand, the static stability curve is drawn by cubic splines either fixing the ends or leaving them free.

FIRST CASE.- 16,600 dwt bulk-carrier (wall-sided).

Table 1: 16,600 dwt bulk-carrier hydrostatic data

Draft	10 meters
TKM (vertical distance from keel to transversal metacentre)	9.707 meters
GM (metacentric height)	0.043 (-)
VCB (vertical center of buoyance)	5,305 meters
BM (metacentric radious)	4.402 meters

Source: Authors.

Table 2: GZ arms for 16,600 dwt bulk-carrier, draft 10 meters and GM 0.043(-) meters.

ϕ	0°	10°	20	30°	40°	50°	60°	75°
GZ	0.000	0.003	0.028	0.089	0.262	0.263	0.020	-0.574

Source: Authors.

Taking into account the hydrostatic data and the GZ arms from the table 1 and 2, respectively, the coefficients are obtained for the first spline subfunction.

B_0 = -7.5044·10^-4^

C_0 = 6.7556·10^-5^

D_0 = 3.7487·10^-6^

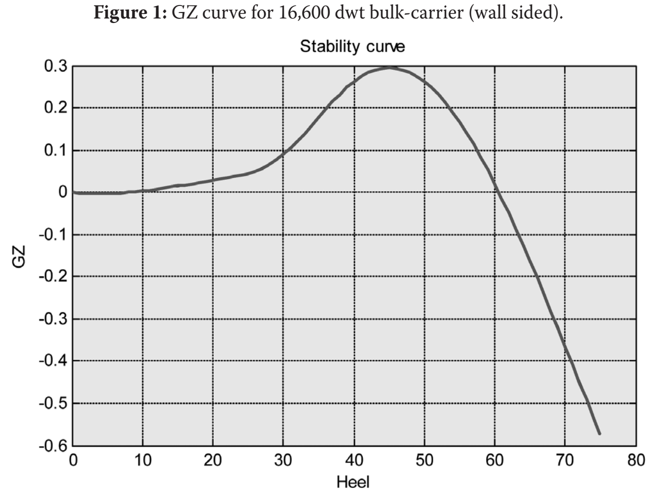
The angle of loll is thus calculated from the equation in (16).

ϕ_{loll} = 7.76°

On the other hand, the angle of loll is also obtained from the formula in (1).

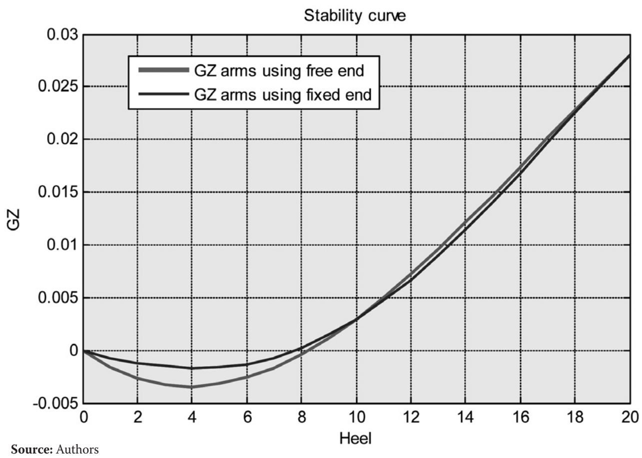
ϕ_{loll} = 7.96°

Figure 1: GZ curve for 16,600 dwt bulk-carrier (wall sided).



Source: Authors

Figure 2: Small angles' detail of the GZ curve for 16,600 dwt bulk-carrier (wall sided).



Source: Authors

SECOND CASE.- 150,000 dwt tanker (wall-sided)

Table 3: 150,000 dwt tanker hydrostatic data.

Draft	15.9 meters
TKM (vertical distance from keel to transversal metacentre)	20.08 meters
GM (metacentric height)	0.02 (-)
VCB (vertical center of buoyance)	8.25 meters
BM (metacentric radious)	11.83 meters

Source: Authors.

Table 4: GZ arms for 16,600 dwt bulk-carrier, draft 15.9 meters and GM 0.02(-) meters.

ϕ	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
GZ	0	0.023	0.055	-0.55	-1.52	-2.805	-4.239	-5.664	-6.979	-8.108

Source: Authors.

In case that the hydrostatic data and the GZ arms are those showed in table 3 and 4, respectively, the coefficients of first spline subfunction are expressed below.

B_0 = -3.4904·10^{-4}

C_0 = -2.4409·10^{-4}

D_0 = 5.0899·10^{-5}

The angle of loll is thus calculated from the equation in (16).

ϕ_{loll} = 5.95°

On the other hand, the angle of loll obtained from the formula in (1).

ϕ_{loll} = 3.33°

Table 5: Sailing yacht hydrostatic data.

Draft	2.71 meters
TKM (vertical distance from keel to transversal metacentre)	3.35 meters
GM (metacentric height)	0.05 m. (-)
VCB (vertical center of buoyance)	1.94 meters
BM (metacentric radious)	1.41 meters

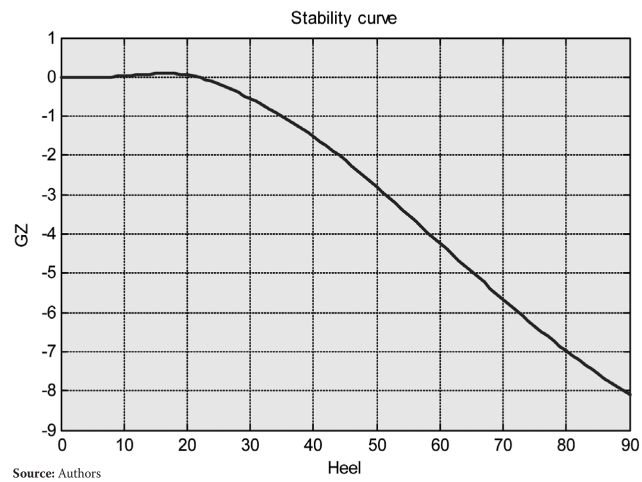
Source: Authors.

Table 6: GZ arms for sailing yacht, draft 2.71 meters and GM 0.05(-) meters.

ϕ	0°	10°	20°	30°	40°	50°	60°
GZ	0	0.0096	0.032	0.02	-0.015	-0.1246	-0.244

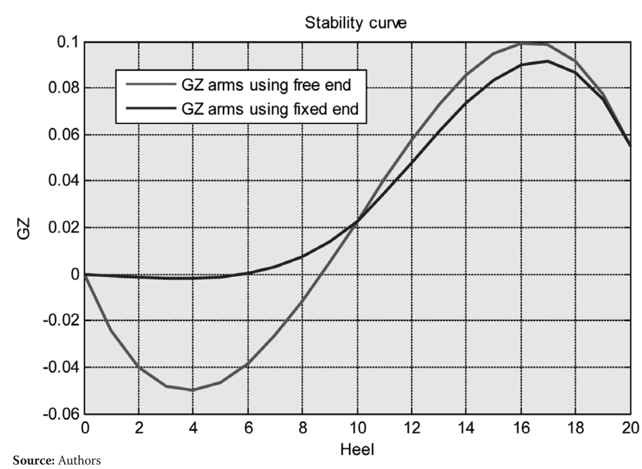
Source: Authors.

Figure 3: GZ curve for 150,000 dwt tanker (wall-sided).



Source: Authors

Figure 4: Small angles' detail of the GZ curve for 150,000 dwt tanker (wall-sided).



Source: Authors

THIRD CASE.- Sailing yacht (round-shaped)

The coefficients obtained from the hydrostatic data and the GZ arms from the table 5 and 6, respectively, are shown below:

B_0 = -8.7260·10^{-4}

C_0 = 1.9003·10^{-4}

D_0 = -6.7682·10^{-7}

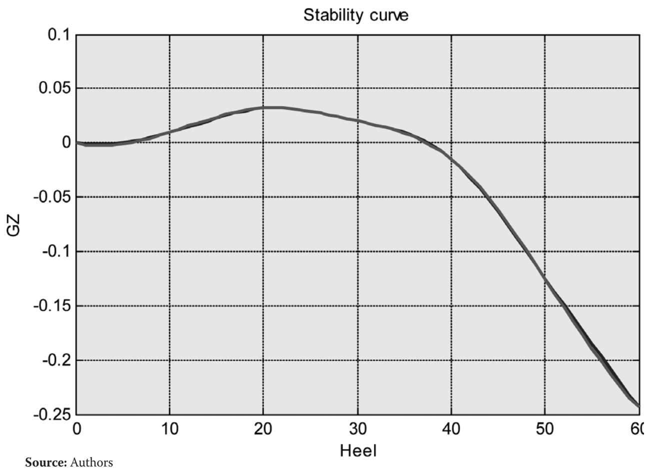
The angle of loll obtained from the equation in (16).

ϕ_{loll} = 4.67°

On the other hand, the angle of loll obtained from the formula in (1).

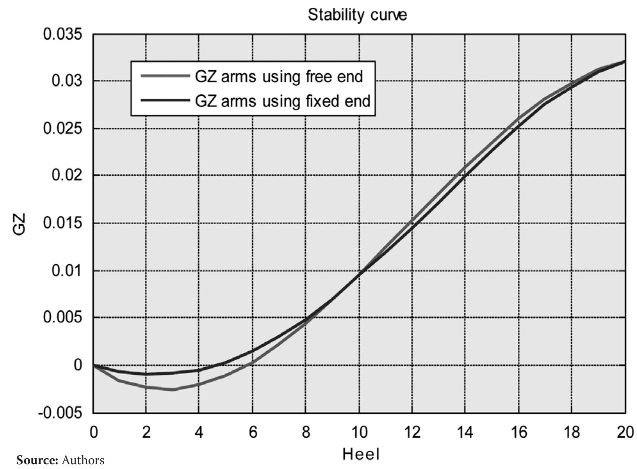
ϕ_{loll} = 14.9°

Figure 5: GZ curve for sailing yacht (round-shaped).



Source: Authors

Figure 6: Small angles' detail of the GZ curve for sailing yacht (round-shaped).



Source: Authors

5. Conclusions

The results obtained in the practical application show that the approximate formula is not accurate enough for round-shaped ships, although it may be useful for wall-sided ships. The results of the applications of both methods in the 16,600 dwt bulk-carrier In the case of the 150,000 dwt tanker, there is a difference of almost three degrees between both methods of calculation, which seems to be excessive for a box-shaped ship with small block coefficient; nevertheless, it must be taken into account that the ship's conditions to reach a negative metacentric height have been forced too much. This is due to the fact that the shape and hydrostatic particulars of that type of ship provide her with excessive stability. Therefore the height of the centre of gravity estimated for the tanker in the practical case is hypothetical and out of the possible stability criteria in the construction of this type of ships (Riola and Pérez, 2009). In the case of the sailing yacht, the difference of the results between both methods is bigger than ten degrees, which means that the approximate formula is not valid for non wall-sided ships.

The global cubic splines let us obtain graphically and analytically the angle of loll in an accurate way. However, it is essential to fix the end where the slope of the static stability curve is known. Otherwise, there may be an error of more than three degrees. Therefore, it is advisable to fix the end when a math program such as Matlab or Mathematica is used to define the static stability curve.

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The Development of China's Coastal Ports in the Era of Globalization.

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ABSTRACT

By the 21st century China's port logistics have been aligned fully with the country's global trade needs, in which the development of Chinese coastal ports is playing a very important role. In this article, we describe briefly the development process and current situation of China's coastal ports from a macro perspective. From the study and analysis of this process, a general picture can be gained of the evolution of China's port logistics, and suggestions can be made for their future development. The rate of increase seen recently in China's international trade volumes will slow; exports and imports will tend to balance; and the structure of trade will tend to stabilize, with the proportion of normal goods traded increasing. The proportion of intermediate products and materials for further processing traded will decrease; and the structure of foreign trade in commodities will gradually be regularized.

1. Introduction

Since the basic reform of China's[1] economy and its opening up as an emerging market-oriented country, China has gradually become more integrated with the g lobal economy. Numbers of ports and port production have undergone wide and substantial growth. Ranked by cargo throughput volumes, China now has 8 of the world's leading ports. In respect of container traffic, China accounts for 7 of the world's top 20 container ports. The cargo throughput of China's ports has been in the world top rank for 8 years continuously. This scale of port development is unique in the world.

With globalization companies organize their production and source their raw materials more and more internationally, and so a global trade and transport chain has gradually been formed. In every part of the world, coastal ports especially have become integral parts of the international logistic network. Port logistics plays an important role in most national economies and in international trade, which has become a primary indicator of the level of development reached by a national economy.

Considered by many as the manufacturing centre of the world, China supports a large proportion of total world construction of coastal ports. The logistics of some Chinese ports have reached the advanced level typical of the best international ports but on the whole, the level of port logistics is low because of China's late beginning. Moreover, there are still many problems associated with the infrastructure, technology and organization, which are restricting the development of ports. In view of this, it is of great importance to study the development of Port Logistics and to identify and resolve the problems existing in the context of continuing globalization.

1.1 Methodological aspects

The main research methods adopted for this study are as follows: a historical review has been carried out of the development of China's coastal ports and how they have changed; the case study method, considering a few influential cases, provides secondary evidence and descriptions, for the analysis of the strategy and summary of the process of evolution; lastly,

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[1] In this article refers to mainland China, excluding Hong Kong, Taiwan and Macao.

the relevant literature and documents have been reviewed and studied, for process summary and further analysis of the key points in the strategic research on port enterprises. This has enabled us to build up a comprehensive picture of national ports in China, and to put into perspective the modern port logistic process.

In a study of port logistics such as this, sometimes because of insufficient support data, measurements of efficiency made by previous scholars are very difficult to verify by empirical methods. Although the development of China's port logistics presents many similarities with that observed in the world's more developed countries, it is not possible to learn much of value from other countries that could be put into practice in China. There are only a few papers available for us to study on the theoretical aspects of Chinese port logistics. Our study and analysis of the development of China's port logistics and industry is therefore based on a macro perspective.

2. Recent history of port development

Since the founding of the "New China", there have been five distinguishable waves of intensive construction of Chinese ports Junfa (2004), Huosheng (2011). Hence the characteristics of the port system have undergone tremendous changes, and these changes, in turn, have played an important role in supporting the opening-up of China's economy and its rapid development.

a) The first of these waves can be dated from the 1950s to the early 1970s. After the founding of the New China, the economy remained focused mainly on domestic markets and industries, with exports and imports having relatively little importance. The transportation system relied mainly on road and rail connections. In the geopolitical context, the government still considered that a potential military threat, and specifically a possible sea blockade by Western powers, existed. China did not invest very much effort and resources in port construction.
b) During the 1970s, China's national economy achieved a certain degree of development; international communication was becoming easier, and the development of trade between countries began to be promoted. As maritime transportation was becoming more important for the economy, it became evident that the cargo handling capacity of the country's coastal ports was inadequate for the expected needs of international business. Therefore, Premier Zhou announced the need to "change the face of Chinese ports in three years".
c) The 1980s was the decade in which the global wave of economic integration took place; companies became multinational, competing in global markets, and the factors of production began to be managed on a worldwide basis. All countries grew closer together, economically if not politically. Development of China's foreign trade meant that the requirements for China's port construction were even more pressing. In the sixth Five-Year Plan (1981-1985), the construction and development of Chinese ports were regarded as a strategic focus of China's national economic development. In this decade, port construction played a crucial role in China's national economic development.
d) In the 1990s, the process of opening up and reform was continued and intensified. China participated more and more actively in the global economy and competed internationally. The promotion and development of international trade required Chinese ports to invest in the specialized construction of deep water berths for larger ocean-going vessels. This decade saw the third wave of major port construction, in accordance with the Port Development Framework, in which the main pivotal port is the backbone of the system; the major regional ports complement the main ports; and the medium-size and smaller ports are developed as appropriate.
e) From the early 21st century to the present, the modern port is no longer regarded as a place for the simple transfer of cargo to and from vessels. In order to respond to new needs, strategic research is undertaken for the construction and development of major ports, and substantial funds are allocated to the construction of related specialized infrastructure such as information systems and large-scale deep-water berths in the ports. As a result of this modernization, Chinese ports have been greatly improved, and the levels of efficiency and scale of operations of the major coastal ports are now close to those of the most advanced ports of the developed countries.

The port serves as a window between the nation's economy and the world; it is at the cutting edge of a country's external liberalization; and it is the node of a great network for the comprehensive transportation of commodities and manufactures. The modern port is an important hub that facilitates domestic and international economic exchanges (Ran, 2003). At the start of a new century, China started a new wave of port construction and development; the amount and scale of investment is unprecedented, and the throughput capacity of China's ports is increasing at an amazing rate. A new pattern of Chinese ports has been formed, and China has ascended in the ranking of the world's leading ports.

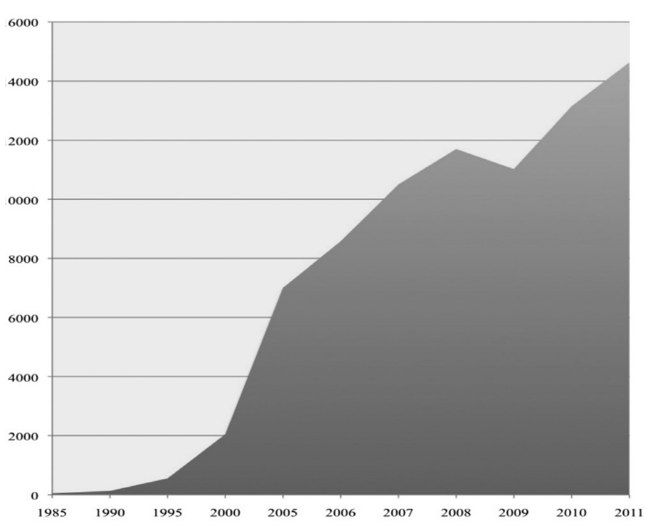
After more than 50 years of intensive construction in China, there are now 36 coastal ports, and the total cargo handled annually by these ports has reached more than 10 billion tons. At the end of 2010, Chinese coastal ports had a total of 5453 operational berths, and 1554 of these berths can accommodate vessels of more than 10,000 tons. In particular, since the start of the 21st century, the pace of China's port construction has been accelerating. New berths for vessels of more than 10,000 tons are added to the capacity of the coastal ports at an average rate of 78 per year.

This substantial increase in the number of port berths lays a solid foundation for large-scale port operation and productivity. The year 2003 was very significant for China's ports: nationally (excluding HK, Macau and Taiwan ports), all its ports taken together achieved a total throughput capacity of 2.6 billion tons per year, which moved China to the top of the world ranking (Nan et al., 2008). The rate of increase in port throughput capacity of containers is far in excess of any other country in the world. The total capacity has reached 48 million standard containers, which exceeds even that of the USA (Colas, 2008), and again has made China the world's leading country for container traffic.

In recent years, especially those covered by the 11th "Five Year Plan", the pace of construction of Chinese coastal ports is continuous and rapid; with each passing day there are changes in their quantity, scale and capacity (Shunquan, 2011). As reported by the State Statistical Bureau in 2010, ports of national and international scale have achieved a cargo throughput capacity of 8.02 billion tons, representing an increase of 15.0% over the preceding year; of this total capacity, the amount of foreign trade cargo was 2.46 billion tons, which increased by 13.6% over 2009. In standard containers, the annual throughput capacity of China's ports was 145 million TEUs, representing an increase of 18.8% over the preceding year.

In the present situation the export of goods by container is still the mainstream activity of port production and operation in China (TICMSR, 2008, 2011). Container handling is the main force driving port development, because of the joint effects of three major factors: first, the rapid growth of China's economy and foreign trade; second, the adaptation to containerization of products, packaging, handling and the transport structure; and third, improvement in the costs and prices of containerization. The container throughput capacity of China's coastal ports has been showing rapid and sustained growth of about 27% per year, and reached 146.32 billion TEUs in 2010.

Figure 1: Container throughput capacity of China's coastal ports.



Source: Authors' own elaboration from: Tung International Centre for Maritime Studies Research, China. (Tens of thousands of TEUs).

In the ranking of world ports by annual volume of container traffic, there are five Chinese ports in the top ten. China's two largest ports, Shanghai and Shenzhen, have consistently been the second and fourth largest container ports of the world, and in 2010 handled 29 million TEUs and 23 million TEUs, respectively, and are rivaled only by Singapore and Hong Kong. This illustrates that, overall, Chinese ports occupy a very important position among the world's ports. This achievement is the result of the substantial and comprehensive construction and development of China's coastal ports.

According to national statistics, in 2010, the cumulative throughput capacity of the first batch of national coastal cities and special economic zones reached 4,144.9 million tons (including Weihai, but excluding Rizhao). This represented a growth of 12.8% over 2009, and accounted for 51.7% of the total throughput capacity of all China's ports (and 75.8% of the total capacity of the 30 biggest national coastal ports and emerging ports). In respect of container traffic, the throughput capacity of the first batch of national coastal cities and special economic zones reached 121,304.43 million TEUs, representing an annual growth of 18.5%. These cities and zones accounted for 83.7% of the total containers capacity of all China's ports (and 94.3% of the total container capacity of the 28 biggest national coastal ports and emerging ports).

An annual throughput capacity of 100 million tons is taken as defining a great port, and China now has 16 such great ports. According to statistics, the port of Shanghai was the first to exceed 100 million tons. Since then more and more coastal ports of China reached the 100 million tons annual capacity level. In 1999 the ports group of Guangzhou became the second port in the Chinese mainland to move into the world class of a great port. of cargo in ports firstly, the began to be watched, they continuously breached barrier, The following year, in 2000, the port of Ningbo exceeded 100 million tons throughput capacity, followed in 2001 by the ports of Tianjin, Qinhuangdao, Qingdao and Dalian. The port of Shenzhen achieved this capacity in 2003, and the ports of Zhoushan and Rizhao followed in 2006. Between 2007 and 2009, another six ports reached the capacity of 100 million tons per year (Yantai and Yingkou in 2007; Tangshan and Lianyungang in 2008; and Zhanjiang and Xiamen in 2009). Thus, at the end of 2010, there were 16 Chinese ports (excluding Nantong) which could claim world class with an annual throughput capacity of over 100 million tons. China is now the country with the most ports of this capacity in the world. Among these ports there were 13 which now have an annual capacity of over 200 million tons, and 6 of them can boast over 300 million tons of annual throughput capacity.

According to C.Y. Tung´s port research report, in 2010, the cumulative throughput capacity of the 16 ports with a capacity of more than 100 million tons each had reached 4,589 million tons, which represented an increase of 15.6% over 2009, and was 0.6% higher than average national growth rate; these 16 ports accounted for 84.0% of the total throughput capacity of the 30 biggest coastal ports, and 57.4% of the total throughput capacity of all Chinese ports. In respect of containers, the cumulative throughput capacity of 15 national coastal ports (excluding Tangshan) has reached 120,929 million TEUs, which is an increase of 19.0% over the preceding year, and 0.2% higher than average national growth rate; These 15 ports accounted for 94.0% of the total throughput capacity of containers in the 28 biggest coastal ports, and 83.4% of the total throughput capacity of containers in all Chinese ports.

Shanghai: In respect of cargo throughput capacity, the ports of Shanghai (there are five major working zones) have held the top ranking in recent years, and have presented excellent scores on many parameters. After taking the lead by breaking through the 100 million ton annual capacity mark in China, it surpassed the 200 million ton mark in 2000, and one year later, in 2003, the port of Shanghai even exceeded the huge capacity of 300 million tons. By achieving a throughput of 316 million tons, it became the third largest port in the world, next only to the ports of Rotterdam and Singapore. By 2004, the throughput capacity of Shanghai reached 379 million tons, surpassing the port of Rotterdam in The Netherlands, which ranked second among the cargo ports of the world. In 2005, Shanghai made a further almost miraculous advance, not only exceeding the throughput capacity mark of 400 million tons by reaching 443 million tons, but also for the first time surpassing the port of Singapore, to become the No. 1 port of the world (Henan, 2009).

By 2010, the cargo handling operations of the port for the whole year amounted to 653 million tons. Shanghai remained at the top of the world's port ranking for 6 years continuously. By 2010, the container traffic handled by Shanghai ports reached the impressive figure of 29.069 million TEUs for the whole year, representing an increase of 16.3% over the previous year, and 0.669 million TEUs more than Singapore. Shanghai ranked as the No. 1 container port in the world for the first time. In 2011 Shanghai set a historic record by handling more than 30 million TEUs.

Tangshan: This port started with the building of a berth for vessels of 15,000 tons in 1988, and this has since been opened to navigation. The throughput capacity of cargos was increasing at an annual rate of 1 to 1.5 million tons. The annual throughput capacity first surpassed the 10 million tons level in 2001, and by 2008, it had exceeded 100 million tons. In October of 2010 it surpassed the 200 million tons mark, and reached 250.62 million tons for the year as a whole, thus becoming the tenth port nationally to exceed the annual throughput capacity of 200 million tons. Based on the official Annual Report on National Ports, 2011, during the period of the 11th Five Year Plan, the cargo throughput capacity of Tangshan was increasing at an annual growth rate of 40%, putting this port in top place nationally for the amount of increased throughput achieved each year.

This amazing rate of growth was outstanding not only among Chinese ports but also globally. Presently, Tangshan ports are divided into three areas: the Caofeidian, Jingtan and Fengnan port areas, which form a comprehensive development. By division of work, cooperation, coordination and interaction, these three ports go forward together. Specializing in the importation of bulk coal and iron ore from overseas, especially from Australia, for the development of the region's steel industry, the ports of Tangshan have become comprehensive ports associated with China's steel industry.

Lianyungang: One of the first batch of port cities of China, designated when further external liberalization was carried out, Lianyungang port opened in 1993, and since then it began to fulfill the dream of being a great oriental port with its practical activities. During the 11th Five Year Plan period, Lianyungang made great advances in strategic status; it presented a very fast rate of development and the results of this became very evident. In that period, Lianyungang won acclaim both in Jiangsu province and at the national level. The "National Coastal Ports Layout and Plan" clearly listed Lianyungang, together with the ports of Shanghai Ningbo, as the main ports of the Yangtze Delta ports group, and Lianyungang was designated as a major national coastal hinge port, and the important node of a comprehensive national transportation system. It was charged with the important task of serving the economic development of Yangtze Delta and Midwest areas of China. The central government approved the strategy for Jiangsu province to give top priority to the development of the port of Lianyungang.

According to official Annual Report on National Ports, 2011, in the whole period of the 11th Five Year Plan, particularly in 2008, Lianyungang suddenly moved up into the ranks of Chinese coastal ports with 100 million tons throughput capacity. By 2010, the throughput capacity of Lianyungang port reached 135.064 million tons, making it one of the 16 Chinese coastal ports with over 100 million tons annual throughput capacity. This represented an increase of 18.7% over 2009, and Lianyungang was ranked in tenth place among the 30 major national coastal ports (excluding Dandong and Nantong), and in sixth place among the 16 ports with over 100 million tons handled annually. Now it has became the only port of Jiangsu Province among the 12 Chinese coastal hinge ports. Since it started operations, the construction of a deep sea channel to accommodate vessels of 300,000 tons, has been a significant milestone for the port of Lianyungang. This indicates that Lianyungang has begun to move into the era of "ocean highway", and this has made its advantages as a strong port more evident after it ascended into the "national team".

Lianyungang started to handle containers in 1986, and during the 10 years to 1996, the annual throughput capacity had not exceeded the 100,000 TEUs level. However, in recent years, Lianyungang has begun to exert its unique location advantages; it responded fully to the directive spirit of Premier Wen Jiabao; it utilized fully the supportive measures available at national, provincial and city level; it has grasped the opportunities and fought well. In 2005, it generated an annual growth of over 100% in containers handled; throughput capacity jumped from only 500,000 TEUs to over 1 million TEUs, thereby taking Lianyungang into the ranks of the top ten national coastal ports and top 100 national container ports (Xian, 2010). In 2010, the throughput capacity of containers reached 3.871 million TEUs, which ranked it in ninth place nationally, and in the top place among the ports of Jiangsu Province; this was an increase of 27.7% over the preceding year. It now ranks just below Yingkou in the top 10 national container ports, and it has reached No. 1 place in the first batch of coastal cities and ports of special economic zones.

Suzhou: In June 2002, Jiangsu Province integrated the ports of Taicang, Changsu and Zhangjiagang into one, and introduced "Suzhou port" as the name of the ports group. The throughput capacity of Suzhou port as a whole reached 102.15 million tons in that year, making it the first national inland river port to surpass the 100 million tons mark. Later, in 2006, Nantong port achieved a throughput capacity of 103.862 million tons, and became the second national 100 million tons inland river port. In 2007, Nanjing port reached a throughput capacity of 108.59 million tons, and it thus became China's third inland river port of over 100 million tons throughput. In September 2009, the throughput capacity of Zhejiang's Huzhou port exceeded 100 million tons, while Jiangyin port reached a throughput capacity of 108.45 million tons in the same year, and Zhenjiang port achieved the throughput capacity of 122 million tons in 2009. All these inland river ports thus ascended to the rank of ports handling 100 million tons throughput (Fang, 2009).

According to provisional statistics, of the six national inland river ports of over 100 million tons throughput capacity, Jiangsu Province accounts for 5, and Zhejiang Province has 1. In 2010, the inland river ports with cumulative throughput capacity of over 600 million tons have actually achieved a total throughput of more than 1 billion tons, which represented an increase of 19.0% over the previous year; the contribution of these inland river ports accounted for 12.6% of the total throughput capacity of all the national ports, which had grown by only 0.4% over the previous year. Among the inland river ports, the 5 ports with over 100 million tons throughput each together reached a throughput capacity of 869.40 million tons, which accounted for 85.8% throughput capacity of the 6 ports of more than 100 million tons.

The container statistics are still incomplete, but in 4 of the inland river ports of more than 100 million tons each, the combined throughput capacity of containers reached 6.311,7 million TEUs, which represented an increase of 32.0% compared with the previous year. Within this total throughput capacity of containers, Suzhou accounted for 2.717,4 million TEUs, which put Suzhou top in the ranking of inland river ports, just ahead of Lianyungang and in the second position in Jiangsu; it increased by 34.1% over the previous year, making it also the fastest growing of all the inland river ports in container traffic.

3. The new regional pattern of national coastal ports.

In September 2006, the "National Coastal Ports Layout and Plan" was issued, which indicated that the construction and development of coastal ports has moved into a new stage. It determined that, in the Chinese coastal areas, five large-scale, intensive and modern groups or clusters of ports will be formed; these will be in the Bohai Economic Rim area, the Yangtze Delta, the Southeast Coastal Area, the Pearl River Delta and the Southwest Coastal Area. With the continuous enlargement of the operating scale of Chinese ports, a series of large-scale groups of ports, relatively concentrated geographically, has been gradually formed; and a rational national pattern and layout of China's ports has gradually emerged. This is intended to promote the better and faster development of China's port industry.

According to the National Bureau statistics of 2011, of throughput capacity of ports, and from Shi and Nan´s study in 2010 (Shi and Nan, 2010), among the recently-formed five areas of port groups, the "Yangtze Delta" and "Bohai Rim" are still the largest, followed by the "Great Pearl Delta", the Southeast Coastal Area and the Southwest Coastal Area.

(1) **"Yangtze Delta"**: this is the short name for the Changjiang Delta zone. In the narrow sense it is a city group consisting of 17 cities of the Suzhou, Zhejiang and Shanghai areas. Because of the expansion of China's economy and the needs of Jiangsu, Zhejiang, Anhui and other provinces, all the ports of Jiangsu, Zhejiang, Shanghai and Anhui have now been included in the Yangtze Delta cluster of ports (Huaping, 2010). According to incomplete statistics, there are now 6 major coastal ports and 6 inland river ports, each of more than 100 million tons capacity, in the Yangtze Delta. The cumulative throughput capacity of cargos has reached 2.5 billion tons in 2010, having increased by 14.2% over 2009. The ports of the Yangtze Delta accounted for 31.2% of the total throughput capacity of all China's national ports. Within this total, the cumulative throughput capacity of the 6 leading coastal ports, from Lianyungang to Wenzhou, was 1.49 billion tons, representing a growth of 11.1% compared with 2009, and these 6 ports accounted for 18.6% of the total throughput capacity of all China's national ports.

(2) **"Bohai Rim":** this is the short term for the Bohai Economic Rim zone, which refers specifically to the Liaotung Peninsula, Shandong Peninsula and Bohai Economic Rim zones encircling the Bohai Sea, in Northern China. The area includes Beijing, Tianjin and Hebei, and, at the same time, extends and radiates to Shanxi, Liaoning, Shandong and Mideast Neimenggu. The Bohai Rim is the most active economic area of Northern China. According to statistics, in 2010, the Bohai Rim area reached a total cumulative throughput capacity of 2.445 billion tons in 11 major ports from Dandong to Rizhao. These 11 ports accounted for 30.5% of total throughput capacity of cargos in all China's national ports - slightly less than the proportion of the Yangtze Delta. Compared with the year before, this was an increase of 18.8%; this rate of growth was 4.6% higher than that of the Yangtze Delta ports, and 3.8% higher than that of all China's national ports.

(3) **"Great Pearl Delta":** this is short-hand for the Zhujiang Delta, and originally consisted of 10 inshore cities of Guangdong Province which were mainly centered on Guangzhou, the so-called Guangdong Pearl Delta or "Little Pearl Delta". The area now referred to as the "Great Pearl Delta" consists of Guangdong, Hong Kong and Macau. In 2010, the five coastal ports of the "Little Pearl Delta" in onshore Guangdong, which are mainly based on Guangzhou, achieved a combined cargo throughput capacity of 876 million tons, which accounted for 10.9% of the total capacity of the nation's ports; this represented an increase of 14.9% over the previous year, greater than the growth of the "Yangtze Delta" ports, but less than the growth of the "Bohai Rim" ports, and also less than average growth of all national ports.

(4) **Southeast Coastal Area**: this refers mainly to Fujian Province and includes its surrounding areas, which link with the economic zones of the Pearl Delta and Yangtze Delta in the north and south, face Taiwan Island in the east, and are adjacent to the broad inland area of Jiangxi in the west. In recent years, this area is always referred to as the (Taiwan) Channel East Shore Economic Zone. In 2010, 3 major ports of the Fujian coastal area, Fuzhou, Xiamen and Quanzhou, achieved a cargo throughput capacity of 295.11 million tons; however, for all the ports of the Southeast Coastal Area the total amount is higher. The increase over the previous year was 12.5%, and this Area accounted for 3.7% of the total throughput capacity of all the national ports.

(5) **Southwest Coastal Area**: this refers to the Northern Guangxi Bay Economic Zone and comprises "4+2" zones of supervised administration, including 4 cities (Nanning, Beihai, Qinzhou and Fangchenggang) and two logistics cities (Yulin and Chongzuo). In January 2008, China put into practice the "Northern Guangxi Bay Economic Zone Development Programme". The National Development and Reform Commission has emphasized in its reports that the Northern Guangxi Bay Economic Zone is an important area for the development of Western China, and is a zone for the growing cooperation with ASEAN countries. The Area has major significance for China's implementation of its general strategy of regional development and its strategy of opening up the economy to international collaborations for potential mutual benefit, and with "win-win" results. China will develop the Northern Guangxi Bay Economic zone as the base for logistics, trade and manufacturing, and the information and communication centre which services the growing China-ASEAN cooperation. The strategy envisages this Coastal Area driving and supporting the development of all the hinterland of Western China. It will become the critical zone for global and regional economic cooperation with other countries, open to a high degree, radiating strong economic growth, promoting social harmony and protecting its ecosystems (Liehui, 2008). According to the statistics, in 2010, the cargo throughput capacity of the three ports, Beihai, Qinzhou and Fangcheng, located in the Northern Guangxi Bay Coastal Area reached 155.98 million tons. This represented an increase of 65.8% over the previous year, the fastest rate of growth in the five regional ports groups.

4. Conclusions

China is still in a period of social transition; the market economy has not completely developed; and the effect of the market on the basic distribution of resources is not yet evident. However, the development has not been incoherent, and the strategies adopted present strong local characteristics.

Considering the overall international and domestic situation facing Chinese ports in the future, it can be stated that both opportunities and challenges exist for the development of Chinese ports, at the same time as uncertainty and uncontrollable factors are increasing. Globally, the world economy is recovering only slowly after the financial crisis of 2008-10. Volatile situations in Western Asia and North Africa, and factors such as the Fukushima nuclear leak have increased the instability of the world economy. Affected by the situation on the Korea Peninsula, the process of economic integration in Northeast Asia has almost stopped. International competition has become more intense, new trade protectionism, including a low carbon tariff, and environmental protection, is popular. The strength of developing countries and emerging economies has further increased, and the tendency for world economic centers and international shipping centers to transfer to the Asia Pacific area has gradually become stronger. Judged from China, the country's comprehensive power and soft power will increase further in the 12th "Five Year Plan" period. The Chinese Yuan will not only face pressure to appreciate, but will also have the opportunity to become an international currency. The rate of growth of China's international trade volumes will decrease; exports and imports will tend to balance; the structure of trade will tend to stabilize, the proportion of trade in normal finished goods will increase, with the proportion of trade in intermediate products and materials for further processing decreasing, and the structure of foreign trade in commodities will gradually be regularized?? .

China has entered a new stage in which particular regions are opening up and developing. Each region is racing to develop as fast as possible, and advanced regions such as the Pearl Delta and Yangtze Delta are promoting a new wave of evolutionary development. The Bohai Rim area, including Tianjin, Bin Hai, Xin Qu, the Shandong Peninsula Blue Economic region, the Liaoning coastal economic region and others, are all growing fast. General regional development strategies such as the Western China Development Plan, the accelerating growth in the middle parts of China, and the encouragement of further growth in those eastern areas that were the first to develop, have been confirmed. Thus the regional development policy of China is being extended to cover the entire country completely.

All the ports of China will gradually modernize, but their transformation into powerful ports will only be achieved by courageously grasping opportunities, by boldly welcoming challenges, and generally by converting difficulties into opportunities. Existing advantages must be more fully exploited; the operational functioning of ports and services must be improved by changing practices and development modes. New thinking is required to explore how to accelerate the construction of ports, and new systems are required to accelerate further the development of all China's ports.

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Sea and Littoral Localities' Economy: Exploring Potentialities for a Maritime Cluster - An Integrated Analysis of Huelva, Spain and Algarve, Portugal.

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ABSTRACT

As a littoral territory with more than 120 km of coast, Huelva (Andalusia, Spain) is a province that gives to marine and maritime activities a relevant role in its regional economy. The Algarve, the most southern region of mainland Portugal, bounded north and east by the regions of Alentejo and Huelva, also gives to the Sea importance in the main regional economic activities. In this article, we compare the emergence of policies for maritime clustering in both regions due to their geographical proximity that stimulate highly levels of cooperation. The relevance of the different type of policies being implemented in Huelva and the Algarve are analysed to a better comprehension of the similarities and the differences between these cases. The analysis of innovation actors, creating linkages between firms and scientific communities, focusing in marine sciences in scientific and technological networks, is crucial to understand the potential for the emergence of a dynamic trans-border cluster.

1. Introduction

The study of the maritime clusters is still not mature. However an effort is being made to improve the quality and quantity of scientific research in this area. In the last decades we have assisted to the emergence of the concept and policies to support clustering dynamics in the territorial development and regional economies. In the case of maritime regions, the sea has proved to be a decisive factor in building regional clusters around the activities that depend on or explore the marine, maritime and coastal resources.

The performance of regions depends on the economic and social environment and on the strong relationships that their agents establish among themselves. So, it is crucial to develop regional clusters based on this, and this creation is made trough the increase of activities, the promotion of labour mobility, attracting talents and skills and valuing each other mutual assets (Guerreiro, 2011), and promoting the high density of relations between those members.

In spite of the fact that several inland territories can have a powerful marine economy (Rodríguez et al., 1998)[1], derived from aquiculture firms and other enterprises which manage fishing products, the maritime economy is mainly concentrated in littoral territories, being the essence of the economy in these regions. Even though these territories have a high level of implication in agricultural economies, sea and land are strongly connected and probably a coastal region might not be competitive if it has not developed the maritime economy. Whereas an interior province can survive exploiting the agricultural areas, a littoral one could not without exploiting at the same time the sea, just because most of the resources are marine ones.

The Spanish province of Huelva in Andalusia is located in the margins of Atlantic Area and often called the Atlantic Door. It has currently little more than 510,000 inhabitants (INEM, 2010), distributed in 10,148 Kilometres squared,

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1 Some provinces placed in areas with central markets, for instance Madrid, have a very important part of the demand concentrated in his hands, such Mercamadrid that commercialized a 50% of the fish and shellfish consumed in Spain. Madrid has a relatively short distance with the principal ports, that's why it is very close to the total fishing offer (Rodríguez, L. et. al., 1998)

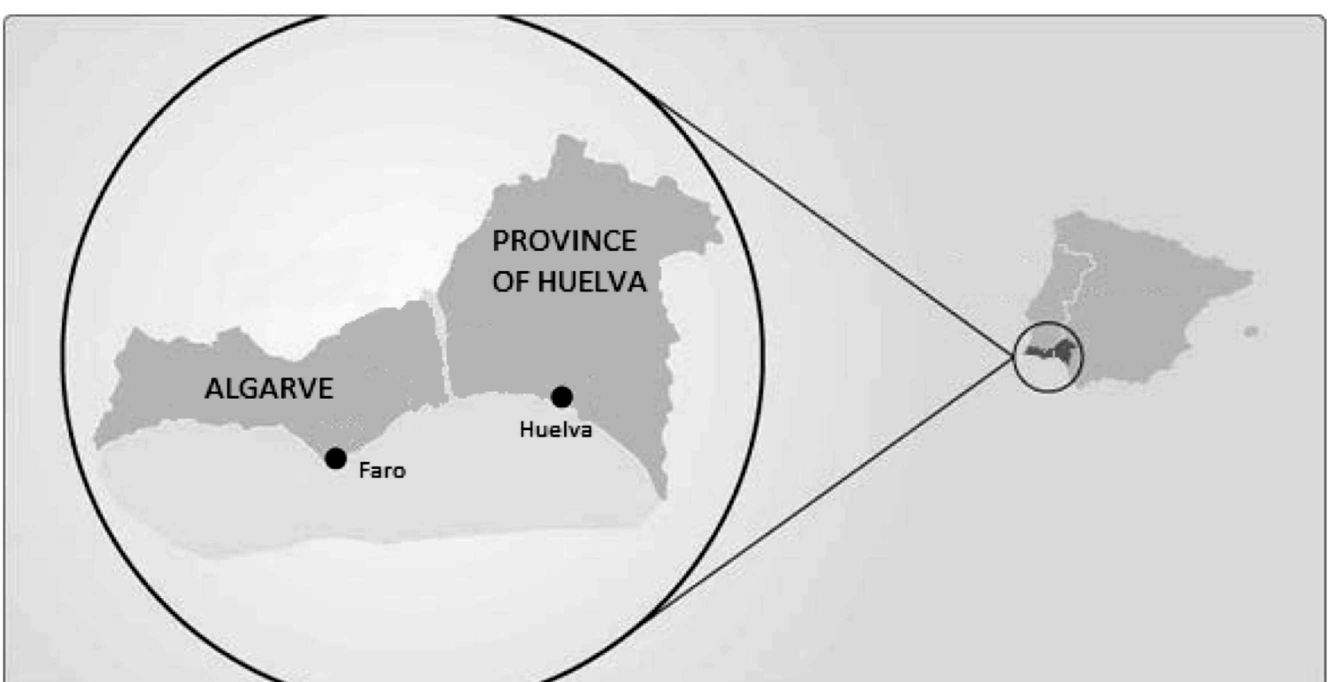
where more than 120 Kilometres are uninterrupted coast bathed by the Ocean. Huelva and the Atlantic Ocean and the maritime areas are currently much connected, even though the importance of the sea in Huelva comes since the Romans who were the first one that found in the Huelva's coasts the best place to enjoy with the sea (ABC, 2011), or after that, since the America discovery and trade in the XVI century. Huelva is the sea and lives to the sea. The sea is in his past, in his present and it will be in his future, and of course, the sea is in the province and capital shield. In both appears the text: "Portus maris et terrae custodia" that's mean Port of the Sea and Land Defence. In the province shields, appears the Atlantic Ocean, as a symbol of the American discovery, and the anchor, representing the maritime efforts (BOJA, 2004; Campos, 2002). The important role of the sea has had in Huelva's History and evolution is also present in its economy and in all sectors that are connected with the sea.

The region of the Algarve, with a coastline of approximately 220km has a particular affinity with the sea because of its excellence natural conditions. A famous example is the Nautical School of Sagres, created by Prince Henry, where the navigation pilots, who initiated Portugal´s Age of Discoveries, received instruction, became the core of the Portuguese maritime expansion during the first half of the XV century, the most advanced centre for studies and research worldwide; historically, the fisheries sector in the Algarve has always been an important economy activity with a strong tradition; and more recently nautical activities, such as tourism and recreational boating, have been gaining increasing importance (Monteiro et al., 2011). Portugal has the largest Exclusive Economic Zone (EEZ) of the European Union and the 11th worldwide, with more than 1,700,000km^2, which corresponds to about 18 times its land area. The Algarve is a region with a similar size of the province of Huelva, it is also a NUTS III level region in the EU context, having a equivalent population, reaching a little less than half million inhabitants.

Despite Huelva has developed some maritime activities more than other ones, it possesses a great range of activities related to the Sea, being each of them, independently, very strong, and turning the sea into an essential element of the Huelva's economy (Osuna, 1992). The Algarve regional economy is mainly based in coastal tourism, in particular "sun and sand". In the last years, after a convergence period to more developed EU regions, the GDP level has decreased and both regions are falling behind other comparable European and Portuguese regions. In the case of Algarve it is evident that the investments in traditional sectors like agriculture and fisheries, including aquiculture and agro-industry, were substituted in the region by investments linked with tourism with shorter economic return periods. Aligned with the National Strategy for the Sea, the region is trying to consolidate its maritime economy potential as a way to overcome the limitations of the few investments in the diversification of the regional economy (Pinto and Cruz, 2012).

The main aim of this article is to describe the marine sector in these coastal regions, emphasizing sea's importance for the local development, to corroborate the hypothesis of which in localities placed in coastal areas, the economy is based on the sea and on marine sector, and to show the important role the ocean plays in many territories and activities (Morrissey et al., 2011). The paper starts with

Figure 1: Huelva and the Algarve.



Source: Based in a Map of www.pidetrans.com a synthetic theoretical review, approaches to cluster theory and regional development. Then a reflection the national and regional contexts in which the maritime cluster emerge highlighting the main developed policy instruments, in both regions, Algarve and Huelva. Finally, the last section presents some concluding remarks.

2. Cluster theory and regional development

Cluster is a concept that has different meanings depending of the author and the sector where it has been analyzed; geography or new-geography perspectives, socio-cultural factors or territorial agglomeration (Chang, 2011). Focused in different aspects, it exist a large number of cluster's classifications and definitions. Clusters are geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities (Porter, 1998). In cluster theory, geographical proximity is the driving force for the creation of agglomeration and network economies even if it is accepted that other types of proximity are also relevant for inducing institutional and collective learning (Pinto and Cruz, 2012). These groups have four main elements that define a cluster: the cluster member, their interaction, the knowledge and innovation generated and the economical impact of the cluster activities (Rialland, 2009).

Clusters exist just because enterprises, like people, prefer to be physically close to other one whom, probably because are stronger, could help them in some concrete situations. When firms and institutions work together, the group can operate with a higher level of efficiency, react quicker, create more new ideas and innovative activities, share the clients and take the other enterprises like suppliers and not like competitors (Chang, 2011). Cluster exists because enterprises find beneficial their interaction, reducing the risk of failure.

To a better comprehension of the typology of this concept, it is possible to distinguish four types of clusters (Monteiro, 2011), namely:

— "Micro cluster" or "Local cluster" that is a set of geographically close companies and institutions, interrelated by common and complementary elements, that act in a specific field of activity, and are able to cooperate, although they compete in the market for products or services;

— "Industrial cluster" or simply "cluster" that is a set of interconnected companies that are active in different fields, using different but complementary technologies, and through the innovation that is generated by some, benefits are realized for the others and so all of them gain from improved global competitiveness;

— "Regional cluster" is essentially a industrial cluster, with the main joints functioning within a given regional area and these joints can be repeated in another place in a whole or in part of the same country, being important the effects of geographical proximity on the dynamics of interaction between actors and at the level of competitiveness and innovation of the set; and,

— "Mega cluster" that according to the OCDE definition is a dissimilar set of activities, whose goods or services meet the demand using basic skills and exploring the complementary advantages of networking between themselves and with other entities.

The concepts of networking and cluster have gained considerable interest in both academic and industrial worlds (Rialland, 2009). Networking has existed for a long time, although known with a different name. However, networks and cluster are not necessary linked to the extent that networks can take place between firms located at different points, while clusters are geographically located in a country or region. Although they represent different concepts, clusters and networks are inter-related and both refer to valuable relationships between companies, being networks the essence for the functioning of cluster (Monteiro, 2011). Therefore is possible to say that a cluster is a group of overlapping networks.

Cluster is a new concept although not networking, that has been studied as a type of association. As Richardson already said in 1972 "Firms are not islands but are linked together in patterns of co-operation and affiliation" (Richardson, 1972, pp. 895) and the only common thing in all the different definition is the geographical concentration of related companies and his interconnection (Reve, 2006). Clusters could be considered associations just because they both are a group of different enterprises, firms and institutions working together to interact and generate economical impact. Nevertheless, associations do not work together to create knowledge or innovation, they just work together to be stronger and due to members help each other, and innovation is one highly recognized outcome of clusters (Porter, 1990) stimulated by the cooperation and the competition, resulting new products or services, new technologies or competitive solutions, among others.

In some countries, like Spain, where the cluster theory is not completely consolidated, cluster refers commonly to specific economic sectors or enterprises linked by the industrial field, like Robles did in his study *"Key Sectors and Clusters in the Spanish Economy".* There are many associations and interactions in a field or a sector, and since in Spain there are no specific clusters, this paper refers a cluster like a concrete sector within the maritime sector in Spain (Robles and Sanjuán, 2008).

3. Maritime cluster emergence

3.1. National, Regional and Local Policies for Huelva Maritime Cluster

Despite the large number of enterprises that develop their activities in many different marine sectors in Huelva, like tourism, fishing, aquiculture, canned and salted fish industry, shipping or shipbuilding, there is not a maritime cluster recognised as an official cluster. There are many different associations constituted by a groups of interconnected companies and associated institutions in a particular field, like Porter established in 1998, but in Spain, and concretely in Andalusia, most of the groups are not considered Cluster association in the perspective showed by different theories.

There are no formal regional maritime clusters in the country, the only one is the Spanish Maritime Cluster, located in the capital (Madrid), which is an institution born by the collaboration and cooperation between all the Spanish activities-enterprises related to the sea (www.clustermaritimo.es). On the other hand there are many marine associations that include firms in concrete fields inside the marine activity, like for example Association of Shipbuilder of the Shell Fishing Fridge Ships, Shipbuilder Association, Aquiculture Association, Gatherers Shellfish Association, National Association of Fridge Ships of Shellfish Fishing, South Atlantic Shipbuilding Association of Siege Ships.

All these associations are not real clusters just because in relation to the four elements specified by Rialland, they do not focus specifically in innovation and knowledge, but mainly work together in concrete situations and have different initiatives to promote the collaboration between enterprises in each area. They join the enterprises' efforts to provide an environment in which the information and the common interests could be presented, discussed and transferred to benefit the members. Although there are more associations, which are including the innovation and education in their nature to improve their knowledge and actions, most of them are born from top-bottom approaches at the authorities' level or at the educational one. There exist a lot of research and educational centres connected with enterprises and organizations in marine, which aim is to develop and increase their knowledge and to share the results of the researches made in the heart of these educational centres to improve the competitiveness of the enterprises, improving the process production, creating new products and services and developing innovative actions. Most of these centres are part of the university or initiatives from regional authorities. The concept of cluster is extremely related to technological development, research and innovation, therefore, it has a direct relation with the research centres and institutions (ICEX, 2009).

At the local level, a high number of organizations and associations exist, an outcome of the large activity in marine issues, like for example the Trade, Industry and Navigation Chambers, private institutions that give services to enterprises from the maritime and other sectors, such as the creation of new companies, the management of funding, education activities, and in case of Huelva, it exists the Onubense Entrepreneurs Federation (*Federación Onubense de Empresarios* – FOE), a private organization created by businessmen to promote and defend business interests. They are neither cluster nor association but they work giving support to enterprises and offer some services like courses to improve innovation and knowledge.

The *Junta de Andalucía*, Regional Government, created other institutions to transfer the knowledge like the OTT-Technology Transfer Office, which promote the collaboration and the cooperation between public and private entities, nationals and internationals, to join the efforts in research. Andalusia is too a part of the Mobility Centres Network, trough the public enterprise Innovation and Technology Transfer Centre in Andalusia (CITAndalucía). It tries to create a net where the Andalusia residents and foreign people could move through different centres transferring the knowledge.

As Navarro Arancegui stressed the less accuracy there is in the definition of cluster, the less clear it is the existence of a cluster policy. He says that there is not any new policy dedicated to cluster, only a rewritten policy with technological and industrial policies based in previous mistakes like the not enough investment in knowledge (Navarro, 2003). A cluster policy must be affected by other different policies, related to the main things which define a cluster, like policies related to the education, innovation or competition, and affected by policies from different sectors, because each cluster has different needs in relation to the sector, although on the other hand, cluster are regulated in by the geography. So, the cluster policy is a decentralized one and has different actions and regulations at local, regional or national level (Navarro, 2003). Mixing policies is the best way to create positive conditions to develop clusters.

Although there are no direct policies relating to the creation of clusters in Spain or in relation to the marine economy, there are different initiatives in the creation of collaboration networks and in knowledge transfer, and many policies relating to the maritime sector and maritime activities. These policies are largely in the form of laws, focusing sectors such as fishing and shipping but also covering university involvement and networking. For the most part, these laws are at the regional, at Andalusia level.

At European level, regarding marine policies, the most important policies are the European Community ones, because if we go down in the levels, we cannot find any law that contradicts the articles of the highest-level policies. Besides, there is no special law in relation to the global marine sector at the national, regional or local level. In this case, there is the *Integrated Maritime Policy* (2007), which gives some tools to create strategies in maritime ordination, vigilance and new information systems to assure the navigation security, the protection of the frontiers, the control of the maritime pollution, the impel of the maritime research and which aimed to benefit the maritime economy, protect marine environment, strengthen research and innovation, foster development in coastal and outermost regions, address international maritime affairs, and raise the visibility of Europe's maritime dimension. The management of the fisheries in the European Union has a concrete policy tool, *The Common Fisheries Policy (CFP).* The EU countries have decided to manage their fisheries in collaboration through the CFP and this policy brings together a range of measures designed to achieve a thriving and sustainable European fishing industry, ensuring the sustainability and not damage of the marine environment, providing national authorities with the tools to monitoring the size of the European fishing fleet and preventing it from expanding further, providing funding and technical support for initiatives that can make the industry more sustainable and scientific research and data collection.

At national level, the Spanish Constitution (SC), in this 149.1.19 article, gives to the State (National Authority) the exclusive competences in maritime fishing, without affecting the competences given to the Regional Authorities (Autonomous Regions) in relation to the sector's regulation. There is no concrete policy in relation to the maritime cluster or marine economy but there are many policies related with the maritime sector or activities. It exists the Ministry of Industry, Tourism and Trade and the Directorate General for Small Medium Enterprise Policy (DGPYME), responsible for the implementation of an approximation of a "cluster" policy at national level (Müller, 2007). The DGPYME is a management centre, which promote and support business initiatives and the growth and competitiveness of the enterprise sector. This Directorate works with national and international institutions and agencies to improve business innovation and support some enterprise promotion and development programmes (Müller, 2007).

Moreover, in the frame of the *Junta de Andalucía*, is created in 2007 the Andalusia Research, Development and Innovation Plan 2007-2013, which aims to impulse the labour of the Andalusian universities and the access of the society to the knowledge, promoting the education and the technological infrastructures. It intends to create a new economy of the knowledge, innovation and human resources. Inside this plan, it was created the R&D knowledge system as the scenario of the interaction of different agents in the creation, planning and execution of research, technological development and innovation policies in this region.

At local scale, there are some rules that concrete the execution of the other laws, decrees and rules in a higher level, which gives specific regulations in relation to the concrete case of Huelva's areas.

3.2. National, Regional and Local Policies for Algarve Maritime Cluster

In the first quarter of the century XXI, there are five specific domains that Portugal can explore and develop according to the resources at its disposal: tourism, environment, enhancement of cities' role as centres of development, the value-added services and the economy of the Sea (SaeR/ACL, 2009). If these five domains were exploited in an integrated way, they have enough potential to constitute a platform of modernization that drag other more traditional sectors, through their interconnections and by the dissemination of good business practices and appropriate social behaviours. Moreover, they have a strong potential for job creation, viewed as a relevant condition to support the transition phase between the development model of the national economy and the development model of competitiveness (*ibidem*).

In fact, the strongly specialized development assumed in the Algarve region in recent decades, has led major regional traditional sectors, such as coastal fishing, canning industry, shipbuilding, and naval repair to a situation of general decline. This happens due to an inability in adapting to new operating logics of market, along with a deeply unbalanced territorial occupation. Algarve is currently the Portuguese region more penalized by the economical recession, and unemployment is the main social scourge affecting the region. In this context, based on a redefinition of priorities aiming the promotion of a more diversified and sustainable regional economy it is imperative exploring a new strategic plan, which is the strengthening of the association between the Region and the Sea. A maritime cluster may facilitate articulation, synergies and economies of scale, and at the same time contribute to build a sustainable and integrated view of the Algarve marine resources, of its assets and of the various activities associated with this, emphasizing its importance as one of our main economic resources and projecting it as an basilar engine for the economical development of the Algarve (Monteiro et al., 2011).

The study of the innovation actors and institutions in the Algarve (Cooke et al., 2011) revealed that the creation of a maritime cluster needs to be supported by a central actor, surrounded by public institutes, R&D centres from the University of Algarve, spin-offs and established companies. It is also crucial to create an association to structure and coordinate the activities. Moreover, a maritime cluster should focus economic activities and needs to anchor in a relevant knowledge base. It is crucial to highlight the relations between research centres and private companies. The role of research units is to produce new knowledge and translate this knowledge into action. Research must solve basic science problems to enlighten the possible interventions. It is fundamental to link sustainability and environmental quality with private preoccupations. More specifically in marine sciences, there is a relevant knowledge base but there is lack of firms that can valorise it. The potential exists and the territorial conditions are great and it is necessary to focus on sub sectors like offshore aquaculture, transformation of fishing products and energy. One first limitation is that this transfer is not being stimulated by the municipalities, another one is the limitation of funds due to the Algarve´s phasing-out status in European structural funds. The kinds of support are very limited, focusing training and completely constrained by the access to the European structural funds that co-finance the thematic operational programmes that the region cannot access (Cooke et al., 2011).

In a more general way, before the analysis of the policies being implemented, the ALGARVE 21 – Regional Operational Programme for 2007-2013, gives relevance to the marine cluster, highlighted by the 2007´s Regional Innovation Plan. There were three potentially relevant organizations in the linkages of the cluster emergence: CCDR

(*Regional Development and Coordinating Comission*), UAlg (*University of Algarve*) and IPMA *(Instituto Português do Mar e da Atmosfera),* and these three organizations must work together and build strong linkages with each others to increase the potential emergence of a maritime cluster in the region.

In a more specifically way, it is important to explain the policy framework in national and regional level. The Portuguese cluster policy is relatively new. The subject of Portugal´s potential for innovative development was particularly popular after Michael Porter´s study (1994). Nowadays, as the Portuguese economy aims for sustained growth and the capability to compete at international level - objectives which are reliable with the creation of added value, regional qualification and employment- it faces some challenges and constrains. This fact requires a strategy for acknowledging competitiveness as a systematic reality and required the State to play a dynamic and leadership role in creating business attitudes and behaviours that value innovation and knowledge. This strategy is reflected in the *National Strategic Reference Framework* 2007-2013, whose aim is the qualification of population through an emphasis on knowledge, science, technology and innovation, as well as the promotion of high and sustained levels of economic and social-cultural development and territorial qualification. The achievement of this strategic framework is ensured with the support of structural funds and Cohesion Fund by the concretisation by all Operational Programmes during the period previously referred (Cooke et al., 2011).

Clusters are specifically framed in the Operational Agenda for Competitiveness factors under the so-called "*Collective Actions – Collective Efficiency Strategies*". These strategies are presented in two different typologies: Clusters and Territorial based Economic Valorisation Strategies. Under the cluster typology exists a distinction between "Technology and Competiveness Centres" (TCC) and "Other clusters". TCC are partnerships that have national scope and value international projection of the projects, whilst Clusters and mainly regional partnerships, aggregating companies and other institutions that must share a common vision of territorial economy and show the key role of physical proximity in the innovation process (Cooke et al., 2011). A cluster emerges because there is an institutional context that creates advantages based on the physical proximity and created social capital (Pinto and Cruz, 2012). In the end of 2006 the *National Strategy for the Sea* became a central political instrument to permit Portugal to care for and make the better use of the invaluable resource of the sea. In defining for the first time priority strategic guidelines for the "Maritime Affairs" the Portuguese government dedicated in promoting novel ways to use the ocean resources in a sustainable way, contributing to the development of the maritime economy and industries. This recognition lined the way to the implementation of a new strategy for the Sea at regional level too (Cooke et al., 2011).

At regional level, the ALGARVE 21 reinforces the necessitate to invest strategically in the Algarve Sea providing the opportunity to support specific projects or economic activities associated with it, or others that compete indirectly to consolidate the strategy around the Sea Algarve. Beyond this programme, the development of a Sea Regional Agenda, in December 2008, intended to optimize the use of resources linked to the sea, ensuring their protection, their linked operation with scientific research and innovation, ensure sustainable use of marine, coastal dynamics monitoring and diversify tourism products, combining all this in an integrated policy of governance. The top priorities of this Agenda were the bet on a network of efficient port infrastructure, support for the fishing, aquaculture and other economic activities linked to the assets of the sea, the fleet support and sustainability of resources, exploitation of sea products, training and research and innovation (Cooke et al., 2011).

At the clusters level, technology and knowledge transfer, innovation, networking and association activities are mostly seen as a transversal issue. This means that there are no explicit policies at cluster level on these topics. Although clusters conform to the national and regional policy guidelines, clusters define their own programmes of action, according to their activity sectors. Therefore, each specific programme of action may define a strategy concerning technology and knowledge transfer, innovation and networking issues according to their reality. Similar strategies are adopted by different clusters (Cooke et al., 2011).

4. Conclusions

Marine sector and maritime activities related to the sea are important in localities placed in coastal areas. In Huelva and in Algarve, the economical and regional development is based in the sea´s economy, so it is crucial to create dynamics in the sectors and economic activities related to it. This development will benefit from knowledge transfer of academic actors to the society, innovators actors and systems, with strong linkages between research centres, like universities, and corporations, specialized programmes, among others. Nevertheless, the analysis showed in this paper reinforces the hypothesis related to the linkage between the economy and the marine activities in coastal areas. Most of the economical activities in both regions are connected in almost one sense with the Atlantic Ocean, which has given to the region the opportunity to exploit some activities.

Many economical activities, with an important economic impact, have a direct connection to the sea and the marine resources, which are the base of the economy in littoral provinces. So naturally, in relation to policies, it´s vital to create some specific strategies based on the European policies to the cluster emergent. More than regional and national laws, the region of Huelva, need various policies that will be able to generate more efficiency and innovation and most of all, the capacity to increase and fortify the emergence of a maritime cluster. In fact, each State has to have his own marine strategies to each region and that strategies and policies must be linked to the European guidelines, for together develop the region economy based on the sea.

It is urgent to rethink the model for future development in both regions. Only the strengthening of the regional competitiveness will ensure its economic success in a society increasingly globalized and competitive. Making the Algarve and Huelva region an innovative community, respectful of the environment and socially cohesive, should form the main components of a strategy for sustainable regional progress.

Finally, in a context of global economic crisis, it is fundamental to provide the regions with competences to response to the global context, the regions should be resilient. 'Strategic resilience' refers to the continuous adaptation though proactive policy development and implementation to global drivers of change, enabling a region or another system to support crises and disturbances without collapsing. Resilient regions are less vulnerable and more prepared to deal with change, complexity, crises and multiples disturbances (economic, social, environmental, technological), being more sustainable in long term. In the current context of turbulence and uncertainty this may be a critical capacity for regions to face the future. A crisis is a period of time full of dangers, changes and perturbations; however these periods of crisis can also be an opportunity to modify renovate and reconsider a system, allowing reinforcing its resilience and the emergence of the maritime clusters in territories located at seaside can be a factor to improve the economical resilience of the regions. The regions that structure regional interconnected systems of dynamic innovation will be more competitive. However there are some structural limits for the innovation that can condition the sustainability of the region´s development and that´s the main aim of the emergence of a maritime cluster, endue the Huelva and Algarve regions with some tools to improve its economy and guarantee their sustainability.

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Failure Mode and Effects Analysis (FMEA) for Reducing the Delays of Cargo Handling Operations in Marine Bulk Terminals

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ABSTRACT

So far as dry bulk cargoes are concerned, million tones of different varieties of these cargoes being moved and handled in marine bulk terminals around the world every day. Undoubtedly, this massive movement can impose serious cargo handling issues for dry bulk terminals in seaport. The problems associated with handling of dry bulk cargo in marine terminals can be in terms of both infrastructure and superstructure.
This research attempts to use a combination method comprising Failure Mode and Effect Analysis (FMEA) in conjunction with the Cause and Effect Diagram and Pareto Analysis to firstly reduce the delays in cargo handling operations, and secondly to smooth the loading/unloading activities in marine bulk terminals.
To achieve these objectives, this paper also aims to initially surface the major factors causing delays in cargo handling operation by focusing on the quantification of risk assessment through determining the Risk Priority Numbers (RPN) per identified processing of cargo handling operation, and then suggest solutions to resolve the problems.

1. Introduction

Over the last decade, global economic developments have had an increasing influence on supply and demand trend in the dry bulk market. This increase has impacted on the shipping industry, dry cargo handling, bulk terminal operations and transportation industries (Schott and Lodewijks, 2007).

Capacity of dry bulk terminals generally depends on the number of berths available to ship traffic and cargo handling capacity. Occurring some natural phenomena such as heavy rains, stochastic changes in water and land transport, failure in the progress of loading/unloading mechanisation and other involved equipment (Bugaric and Petrovic, 2007), weak cooperation of ship's crew with port operators, weak documentations, wrong cargo stowage and problems with labours can be regarded as factors which affect the cargo handling capacity negatively.

Several reliability engineering approaches have been proposed to identify and recover from failures. A well-known and mature approach is the FMEA (Sozer et al., 2007), which was originally designed to address safety concerns. However, FMEA is now used throughout the industry to prevent a wide range of process and product problems and thereby making the system robust (Ookalkar et al., 2009).

This paper employs a novel model, based on the FMEA in conjunction with the Cause and Effect Diagram, aiming to assist marine bulk terminal operators in reduction of delays in cargo handling operations, and smoothing their loading/unloading activities.

To date, no study has adequately examined the philosophy of FMEA in marine bulk terminals as a decision-making optimisation tool at strategic/operational levels. The challenging issues inherent this problem, and the limitation of existing research, robustly motivates this study.

For the first time in the literature, this research provides a novel decision-making framework for port operators to smoothing the bulk terminal's cargo handling activities and reducing the delays inherent it.

2. FMEA

FMEA is known as a systematic procedure for the analysis of a system to identify the potential failure modes, their causes and effects on system performance. It is vitally important to

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know that a failure mode is not the cause of a failure, but the way in which a failure has occurred (Hoseynabadi et al., 2010).

Conducting a FMEA, the reviewed product/process/service/system is normally broken down into smaller items/subsystems. For each item, the following seven steps are performed:

1. Define the item being analysed.
2. Define the functions of the item being analysed.
3. Identify all potential failure modes for the item.
4. Determine the causes of each potential failure mode.
5. Identify the effects of each potential failure mode without consideration of current control.
6. Identify and list the current controls for each potential failure mode.
7. Determine the most appropriate corrective actions and recommendations based on the analysis of risk.

After going through all the items for each failure, a rating for severity, occurrence and detection are assigned. Severity, in this context, refers to the magnitude of the end effect of a system failure. Similarly, occurrence refers to the frequency that a root cause is likely to occur, described in a qualitative way. Finally, detection refers to the probability of detecting a root cause before a failure can occur (Hoseynabadi et al., 2010). The severity, occurrence and detection factors are rated using a numerical scale, typically ranging from 1 to 10.

After these steps, the RPN should be determined for prioritising the recommendations. The severity rating should be based on the worst effect of the potential failure mode. The RPN is the product of the failure mode severity, failure cause probability, and control detection effectiveness ratings.

3. Case study

The objective of this research is the reduction of delays in cargo work operation, loading/unloading operation in both the quayside and landside, in the dry bulk terminal of port of Imam Khomeini (BIK); the main Iranian marine bulk terminal.

Among Iranians commercial ports, BIK with its 11 million square meters area is one of the largest and leading port complexes of the country, particularly being active in bulk operation. The port handles the largest quantity of bulk cargo (in terms of import and export) amongst all Iranian commercial seaports. Statistics indicate that almost half of the country's non-oil exports are transported via this port annually.

4. Data analysis

When applying the FMEA, a cross-functional and multidisciplinary team identifies failure modes, evaluates their risks and prioritises them so that appropriate corrective actions can be taken (Chin et al., 2009). Following steps have been perused solutions for removing delays by empirical analysis methods.

4.1 Definition of Process

Dry bulk terminals are transshipment and transport systems, consisting of different subsystems that enable a division of functions according to place, time, personnel and means (Schott and Lodewijks, 2007).

Definition of process and data analysis was conducted in a workshop with operational managers of the BIK, wherein the analysis was based on the annual BIK reports gathered from July 2009 to July 2010.

4.2 Definition of Components Functions

Like all marine bulk terminals, the case study has the following three main components:

— Port: must be fit to load and discharge vessels, at all times, whenever they are berthed.
— Ship: must be fit to receive or deliver cargoes from/to the port.
— Cargo owner: must be fit to receive or deliver cargoes from/to vessels throughout the port, after completing all the port and custom formalities.

4.3 Identify all Failure Modes

Failure modes are conditions which each of components could not be fit with their tasks and thus operation is stopped or performed slowly (less than standard norms), and cause delays in cargo handling process.

4.4 Determining the Causes of each Failure Mode by Cause and Effect Diagram

Cause and effect diagram is an analysis tool that provides a systematic way of looking at the effects and at the causes that create or contribute to those effects (Kumar, 2006). The cause and effect diagram is used to explore all the potential or real causes that results in a single effect (Arvanitoyannis and Varzakas, 2009).

As shown in Figure 1, causes are arranged according to their level of importance or detail, resulting in a description of relationships and hierarchy of events.

As illustrated in the Figure, there are four main factors which cause delays in cargo handling operations in the BIK, including:

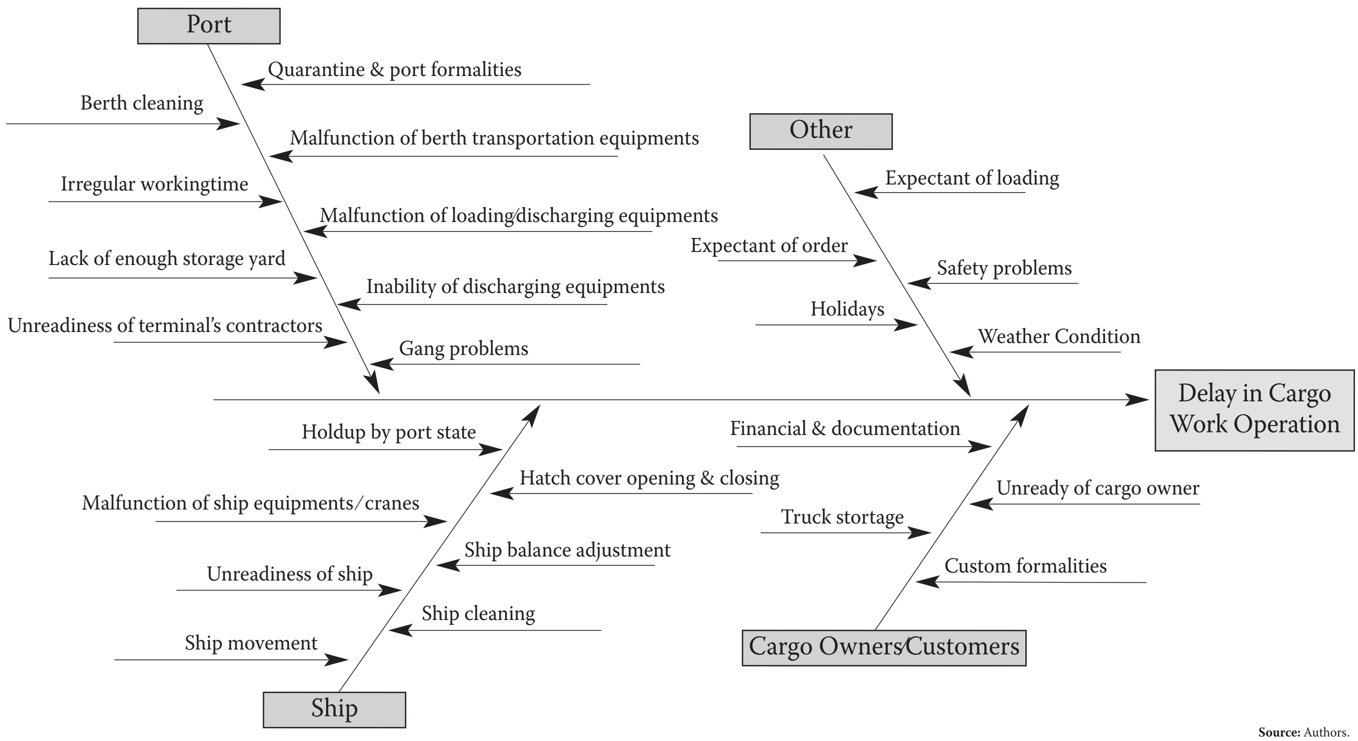
— Customers and cargo owners,
— Port and its operators,
— Ships, and
— Others.

Obviously, each of these factors has its own sub-factors which will be discussed in the next sections.

4.5 Identification of the Effects of each Failure Mode

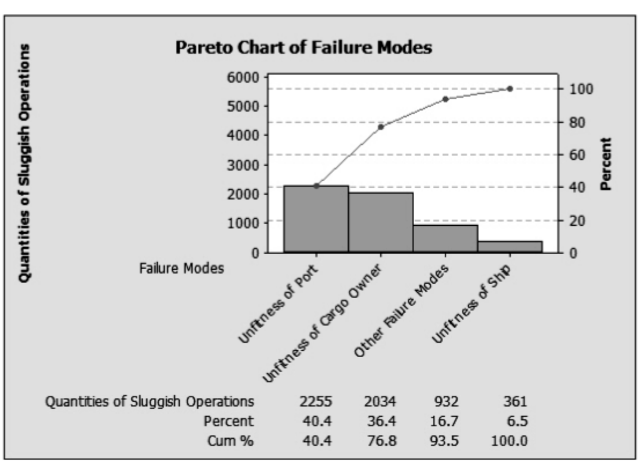
Pause in cargo handling operation and sluggish process are effects of failure modes; usually named delays. Pareto analysis is the process of ranking opportunities to determine which of many opportunities should be pursued first. It is also known as separating the vital few from the trivial many (Pyzdek, 2003). Pareto analysis is exploited to find what types of failure modes are effective.

Figure 1: Cause and effect diagram for the BIK problem.



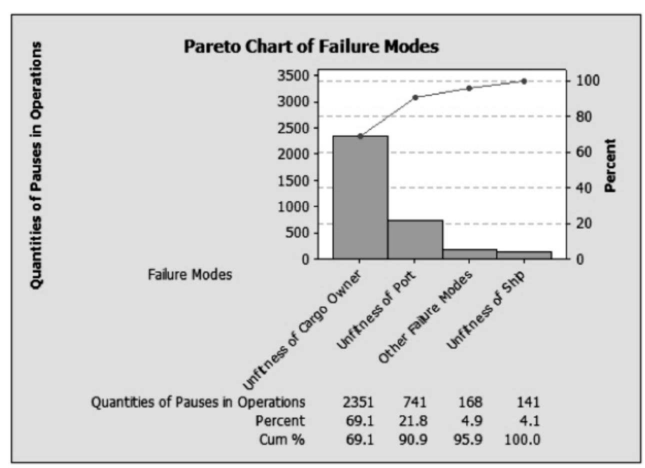
Source: Authors.

Figure 2: Pareto chart of failure modes and their roles at sluggish operation.



Source: Authors.

Figure 3: Pareto chart of failure modes and their roles at pauses in operations.



Source: Authors.

Evaluation and assessment of BIK performances by Pareto analysis, which is performed on the reports of delays at slow cargo work operation, indicated that more than 76% of failure modes are caused by unfitness among cargo owners and port. As illustrates in Figure 2, ships create failure modes only 6.5%.

Unfitness of cargo owner has also created more than 69% of total pauses in cargo handling operation (Figure 3).

According to both Figures above, it can be resulted that unfitness of cargo owner is the most important failure mode, and ship plays a minor role in creation of delays in cargo handling operations.

4.6 Identification the Current Controls for each Failure Mode

The first step in determining the current control of each failure mode is the identification of their causes. Table 1 extracts causes of each failure mode conducted from cause and effect diagram and, as well indicates the total and average quantity of delays as the results of both effects and number of occurrences in measured period of time. These help evaluating current controls and their effects for each failure modes.

There is no control on cargo owner to prevent the delays. High extent of delays confirms the coordination of cargo owner with port authority, and also ship owner and custom. In addition, inability for payments and truck preparation are very important issues that must be regarded.

Implementation of maintenance planning management programs is a sound method of controlling and preventing damage to port equipment. Cargo handling contractors are checked by daily statistics and statistical process control programs. Quarantine and port formalities need to be more and more in coordination with port authority, custom, agricultural and health organisations, wherein port authority plays more important role. Also gangs and working time should be supervised by operational employee.

Vessel is controlled by ship's chief officers and there is no special instruction for prevention of delays. Weather forecasting organisation helps port authorities to prepare requisite conditions for exceptional circumstances.

4.7 Analysis of Risk and Determination the most Appropriate Corrective Actions and Recommendations

As stated by Kumar (2006), FMEA is a structured and qualitative analysis of a system or function which identifies potential system failure modes, their causes, and the effects on the system operation associated with the failure mode's accuracy.

Table1: Causes of failure modes.

Failure	Effect of Failure	Cause of Failure	Tot.	Ave.	N
Unfitness of Ship	Pauses in Operations	Malfunction of ship's equipment	20.5	20.5	1
		Unreadiness of ship	24	24	1
		Holdup by Port State	85.5	14.25	6
		Ship cleaning	11.5	11.5	1
	Sluggish Operations	Malfunction of ship's equipment	231.75	5.4	43
		Unreadiness of ship	2	2	1
		Ship movement	32	6.4	5
		Ship balance adjustment	35	3.18	11
		Hatch cover opening and closing	60	7.5	8
Unfitness of Port	Pauses in Operations	Malfunction of loading and discharging equipment	48	24	2
		Movement of equipment	15	15	1
		Lack of enough storage yard	72	72	1
		Unreadiness of terminal's contractor	24	24	1
		Quarantine and port formalities	582	4.73	123
	Sluggish Operations	Malfunction of berth transportation equipment	241.5	3.05	79
		Malfunction of loading and discharging equipment	279	3.2	87
		Movement of equipment	20.5	0.89	23
		Inability of discharging equipment	121	2.47	49
		Berth cleaning	211.5	2.9	73
		Lack of enough storage yard	270.5	8.19	33
		Irregular working time	128	1.77	72
		Unreadiness of terminal's contractor	86.75	1.93	45
		Gang Problems	321.5	2.61	123
		Quarantine and port formalities	526	3.55	148
		Others	49	1.96	25
Unfitness of Cargo Owner	Pauses in Operations	Financial and documentation problems	1276	60.76	21
		Unreadiness of cargo owner	1064	11.44	93
		Custom formalities	11	11	1
	Sluggish Operations	Financial and documentation problems	690.5	14.09	49
		Unreadiness of cargo owner	628.5	5.56	113
		Truck shortage	662.5	12.74	52
		Others	53	6.62	8
Other Failure Modes	Pauses in Operations	Weather condition	120	24	5
		Expectant of order	24	24	1
		Expectant of loading	24	24	1
	Sluggish Operations	Weather condition	702.5	11	64
		Holidays	96	24	4
		Safety problems	44.5	11.12	4
		Others	89	6.36	14

Source: Authors.

The RPN is an important tool for ranking failure mode and their causes. Analysis of risk and determination of RPN need to rank severity, occurrence and detection, usually done in a 10-point scale. It is calculated for each failure mode by multiplying the severity times the occurrence time the detection ranking. Problem ranking system for each of the scales is provided in tables 2 to 4.

Table 2: Process FMEA severity evaluation criteria.

Rank	Effect	Criteria: severity of effect on process
10	Very Long delay	Period of stop is often more than 24 hours
9	Long delay	Period of stop is often less than 24 hours and more than 12 hours
8	Moderate delay	Period of stop is often less than 12 hours and more than 6 hours
7	Moderate delay	Period of stop is often less than 6 hours or period of sluggish operation is more than 18 hours
6	Moderate delay	Period of sluggish operation is often less than 18 hours and more than 12 hours
5	Minor delay	Period of sluggish operation is often less than 12 hours and more than 6 hours
4	Minor delay	Period of sluggish operation is often less than 6 hours and more than 3 hours
3	Slight delay	Period of sluggish operation is often less than 3 hours and more than 2 hours
2	Slight delay	Period of sluggish operation is often less than 2 hours
1	No delay	There is no stop or sluggish operation

Source: Authors.

Table 5 presents the FMEA of the BIK problems, obtained according to the results of group analysis of statistical performance of BIK and brainstorming among the experts and operational managers of the BIK.

Table 3: Process FMEA occurrence evaluation criteria.

Rank	Likelihood of failure	Criteria: occurrence of causes – incidents per items
10	Very high	> 36%
9		30 - 36%
8	High	24- 30%
7		18- 24%
6	Moderate	12 - 18%
5		6 - 12%
4		3 - 6%
3	Low	1.5 - 3%
2		< 1.5%
1	Very low	Failure is eliminated through preventive control

Source: Authors.

Table 4: Process FMEA detection evaluation criteria.

Rank	Effect	Criteria: severity of effect on process
10	Extremely unlikely	Controls will almost certainly not able to detect the existence of a defect
9	Remote likelihood	Defect is detectable after operation & port operators won't be able to correct it
8	Very low likelihood	Port operators will be able to correct the de fect with limitations after operation
7	Low likelihood	Port operators will be able to correct the defect after operation
6	Moderate low likelihood	Port operators will be able to correct the defect during operation
5	Medium likelihood	Controls have medium effectiveness for detection
4	Moderate high likelihood	Defect is detectable prior operation
3	High likelihood	Controls have high effectiveness for detection prior operation
2	Very high	Controls have a very high probability of detecting the existence of delay prior operation
1	Extremely likely	Controls will almost certainly detect the existence of the defect and correct it

Source: Authors.

Table 5: FMEA for the BIK problems.

Line	Component and Functions	Failure Mode	Effect(s) of Failure	Severity	Cause(s) of Failure	Occurrence	Current Controls, Detection	Detection	RPN
1	Cargo Owner; delivers or receives cargo to/from port	Unfitness of Cargo Owner to deliver or receive cargo from/to port	Pause of cargo work operation	10	Financial and documentation problems	5	None	10	500
2				8	Unreadiness of cargo owner	8	None	10	640
3			Sluggish cargo work operation	6	Financial and documentation problems	6	None	10	360
4				4	Unreadiness of cargo owner	9	None	10	540
5				6	Truck shortage	6	None	10	360

6	Port; transfers cargo from berth to ship or vice versa	Unfitness of Port to deliver or receive cargo from/to port	Pause of cargo work operation	7	Quarantine and port formalities	10	Coordination between responsible organisations by port authority	8	560
7			Sluggish cargo work operation	4	Malfunction of berth transportation equipment	7	Implementation of PM and CM programs	3	84
8				4	Malfunction of loading and discharging equipment	8	Implementation of PM and CM programs	3	96
9				3	Inability of discharging equipment	6	None	9	162
10				3	Berth cleaning	7	None	8	168
11				5	Lack of enough storage yard	5	Control by warehouse employees	6	150
12				2	Irregular working time	7	Check by operational section (visual)	7	98
13				2	Unreadiness of terminal's contractor	6	Check by statistical process control (SPC)	5	60
14				3	Gang Problems	10	Supervision	6	180
15				4	Quarantine and port formalities	10	Coordination between responsible organisations by port authority	8	320
16	Ship; carriages cargo from/to port	Unfitness of ship	Pause of cargo work operation	9	Holdup by Port State	3	Pteort sta	3	81
17			Sluggish cargo work operation	4	Malfunction of ship's equipment	6	None	6	144
18				4	Ship balance adjustment	4	None	6	96
19				5	Hatch cover opening and closing	3	None	7	105
20	Others	Cargo work operation is impossible	Pause of cargo work operation	10	Weather condition	3	Weather forecasting organisation	3	90
21			Sluggish cargo work operation	5	Weather condition	7	Weather forecasting organisation	3	105
22				10	Holidays	2	Annual holiday at calendar	3	50

Source: Authors.

According to the results of the FMEA, followings are the main roots of delays in cargo handling operations in the BIK:

— Unreadiness of cargo owners,
— Quarantine and port formalities,
— Financial and documentation problems, and
— Truck shortage.

A high RPN needs an immediate attention as it indicates that the failure mode can result in an enormous negative effect, its failure cause has a high probability of occurring and there are insufficient controls to catch it.

As stated above, RPNs obtained from the FMEA table, denote unreadiness of cargo owners, is the main factor increasing the delays within the cargo handling operations. Unfortunately, there is no control plan on the fore mentioned problem.

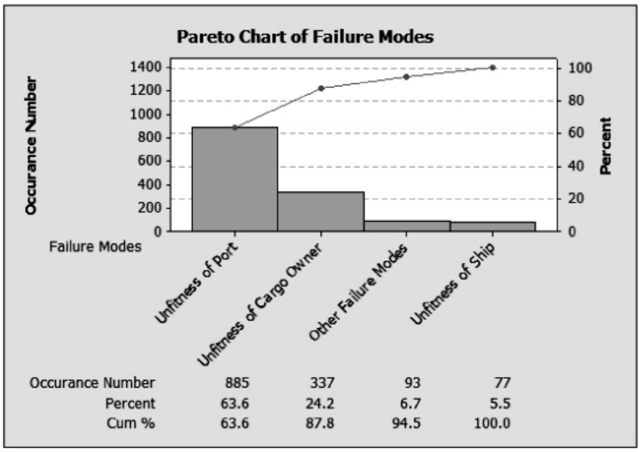
5. Failure mode and root cause hierarchy

A final useful analysis from the FMEA results is the occurrence frequency of the different failure modes and root causes (Hoseynabadi et al., 2010). As illustrated in previous tables, there are lots of failure modes and root causes. Counting these over the whole FMEA gives histograms for each, identifying the top failure modes and the same root causes shown in Figures 4 and 5, respectively.

Identifying the most frequent failure modes and root causes is a vital decision making tool, especially at improvement phase.

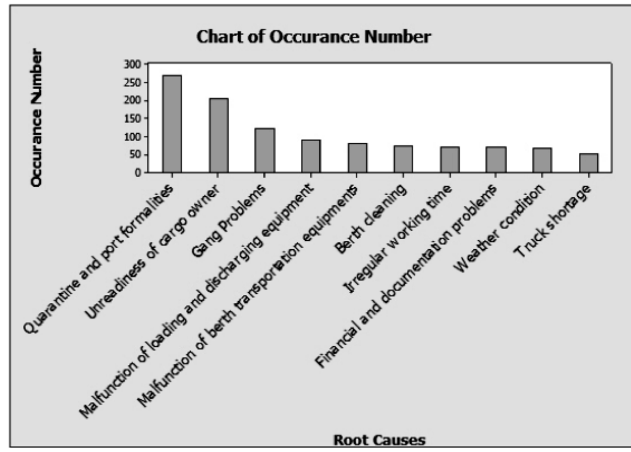
As it can be seen from Figure 4, the most significant failure modes are unfitness of port and that of cargo owner. Hence, improving the unfitness of both the port and cargo owner is the key point in implementing the strategy at improvement phase.

Figure 4: Pareto chart of top failure modes based on occurrence number.



Source: Authors.

Figure 5: Top 10 root causes.



Source: Authors.

Based on Figure 5, the most frequent root causes are quarantine and port formalities, and unreadiness of cargo owner. Both of these root causes are the results of weak cooperation among port authority, port contractors, cargo owner, and custom, which should be looked upon at the improvement phase.

6. Conclusions

FMEA is known as a systematic procedure for the analysis of a system to identify the potential failure modes, their causes and effects on system performance. Firstly, this paper discussed the FMEA and the Cause and Effect Diagram in the context cargo handling operation. Secondly, it attempted to draw links between cargo operation in a bulk terminal and other activities in port environment through utilisation of the FMEA in conjunction with the Cause and Effect Diagram, and Pareto analysis. The overall aim was to improve the efficiency and productivity a marine bulk terminals by reducing the delays of cargo handling operations, and smoothing their loading/unloading activities.

Based on the obtained results, followings should be taken into consideration for reducing the delays in loading/discharging operations in the BIK:

— Since unreadiness of cargo owners is one of the main causes of failure, there should be a plan for its reduction. Unfortunately, it is an external factor which is not directly related to port authorities, thus there is no control over it.

— Providing a systematic cooperation between contracting companies working in the port area and the port authorities is one of the solutions for reducing the port formalities via implementing standard documents.

— Since malfunctions of port equipments is one of the main root causes of failure, implementation of periodic maintenance planning management programs is a sensible process for monitoring and prevention of damage port equipment.

— Quarantine and port formalities are the two main root causes in bulk cargo work operation. Using standard and electronic documents and implementing Electronic Data Interchange (EDI) should be at the top of agenda, which definitely will reduce port formalities.

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European Maritime Safety Agency; Current Activities and Pending Tasks

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ABSTRACT

Maritime disasters that happened around the turn of the century led to the adoption of measures by the European Union in order to ensure a high, uniform and effective level of maritime safety and prevention of pollution by ships within the Community. Thus, the European Maritime Safety Agency (EMSA) was created, with headquarters in Lisbon (Portugal). It is comprised of members from all 27 states, being responsible for controlling 100,000 km of coastline and 1200 commercial ports. The control and identification work is done with the long tracking system (LRIT) which allows to evaluate and alert each EU Member State to the risk that each of the vessels leads to navigate international waters and jurisdictional European Space. Likewise the Automatic Identification System (AIS) recognizes the real time position of the vessels as they navigate the waters of the European Union. The agency is also responsible for monitoring fuel, for the supervision of ship dismantling (Control from the Cradle to the Grave), for the training of technical personnel, for the development of technical standards, for the advisory to Government Institutions (EU Member States), and Non-Governmental Organizations. This paper shows the main activities of EMSA and tasks for the future.

1. Introduction

The European Union (EU) is a continental organization dedicated to increasing economic and political integration and strengthening cooperation among its member states. The European Union was born on November 1st, 1993, when the Treaty of European Union entered into force, previously ratified by the twelve members of the European Community (EC), Belgium, Denmark, France, Germany, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. With the Treaty of the European Union, European citizenship was granted to citizens of all member states. Customs and immigration agreements were intensified in order to allow European citizens greater freedom to live, work or study in any of the member states.

The functioning of the Union is structured around different institutions, organizations and agencies. These agencies play an important role in the implementation of public policies and carry out certain functions, especially technical, scientific, regulatory and operational.

One of these 30 agencies is the European Maritime Safety Agency (EMSA), which provides technical assistance and support to the EU and its member countries in the development and implementation of standards for ship safety, pollution by vessels, protection of life and goods transported. It also has responsibilities in preventing and combating oil spills, monitoring and identifying vessels by vessel long distance monitoring (called LRIT).

The best way to implement security standards are comprehensive controls of the material conditions of the ships, carried out in EU ports. The new rules of the Union (Directive of port state control) involve a more rigorous and frequent inspections: of the 11,000 ships that are inspected on average every year, about 4,000, considered "dangerous", will be subject to rigorous inspections, compared to the 700 that are currently going through them. And ships carrying dangerous cargoes such as oil, gas or chemicals, will not be allowed to enter EU ports if sailing under the flag of a country appearing on a blacklist and have been arrested by port authorities more than twice in the past two years. Despite stiff resistance from the governments of the EU, MEPs managed to add a rule that requires ships to be equipped with a data crossing logger (or "black box"), which can provide usable information for accident research. These rules should be applied since July 2003.

Governments delegate the structural checks on vessel safety in companies known as "classification societies" that have the necessary technical skills. But the EU decided that

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these companies had to meet a stringent quality requirements. European and national authorities grant or revoke licenses to such companies after carefully examining his background in safety and pollution prevention. Under a proposal by Parliament, classification societies may not be in the hands of shipowners, shipbuilders or other organizations engaged in commercial shipping, to avoid conflicts of interest. Also those rules should be applied since July 2003.

2. Materials and methods

In June 2002 two measures to improve maritime safety were approved. The Parliament supported with conviction the creation of a European Maritime Safety Agency, based in Lisbon, which will provide the member states with scientific and technical support to implement EU legislation and assess its impact on maritime safety. An information system that allows a more effective monitoring of maritime traffic was also established. Ships sailing in EU waters must have identification systems which allow them to be in communication with coastal authorities automatically. Data on hazardous transport will be more easily accessible and the Member States will have greater powers to intervene in the event of an accident or any risk of contamination.

The establishment of the European Maritime Safety Agency is structured around the Regulation (EC) No 1406/2002 of the European Parliament and Council, dated June 27 2002, which establishes a European Maritime Safety Agency. This regulation is structured in 4 chapters and 24 articles.

Chapter objectives, tasks, and I includes articles 1 to 4. Article 1 specifies in its 2 points the objectives of the Agency:

a) This Regulation establishes the European Maritime Safety Agency (hereinafter "the Agency"), in order to ensure a high, uniform and effective level of maritime safety and prevention of pollution from ships in the Community.
b) The Agency shall provide the Member States and the Commission with the necessary technical and scientific as support as well as with a high level of expertise, to assist them in the proper application of Community legislation in the field of maritime safety and prevention of pollution by ships within the Community, in monitoring its implementation and evaluating the effectiveness of existing measures.

Article 2 explains the tasks to be performed. In order to achieve the objectives set out in Article 1, the Agency shall perform the following tasks:

a) To assist the Commission, if necessary, in preparation for updating and developing Community legislation in the field of maritime safety and preventing pollution from ships, especially in relation to the evolution of international law in this area. This will include the analysis of projects in the field of maritime safety and preventing pollution from ships.
b) To assist the Commission in the effective application of community legislation on maritime safety and the prevention of pollution by ships within the Community. In particular, the Agency:
   — will monitor the overall functioning of the community port state control, which may include visits to the Member States, and suggest possible improvements to the Commission;
   — will provide the Commission with technical assistance necessary to participate in the work of the technical bodies of the Paris Memorandum of Understanding on the control of ships by the port State;
   — will assist the Commission in the performance of any task assigned to the Commission by the present and future Community legislation on maritime safety and the prevention of pollution from ships, especially the law applicable to the classification societies and safety passenger ships, as well as applicable to safety, training, certification and watchkeeping for seafarers;
c) Collaborate with the Member States to:
   — organize, where appropriate, relevant training in areas under the jurisdiction of the port State and flag State;
   — develop technical solutions and provide technical assistance related to the implementation of Community legislation;
d) Facilitate cooperation between Member States and the Commission within the scope of Directive 2002/59/EC. In particular the Agency: i) will promote cooperation between riparian States in the shipping areas concerned in the fields covered by this Directive; ii) will develop and operate any information system necessary to achieve the objectives of the Directive.
e) Facilitate the cooperation between Member States and the Commission in the development of a common methodology to investigate maritime accidents.
f) Provide the Commission and the Member States with objective, reliable and comparable information and data related to maritime safety and preventing pollution from ships so that they can take steps to increase safety at sea, prevent pollution from ships and evaluate the effectiveness of existing provisions. The Agency will also assist the Commission and the Member States to improve the mechanisms of identification and pursuit of ships making unlawful discharges.
g) In the course of negotiations with the candidate countries for accession, the Agency may provide technical assistance regarding the implementation of Community legislation in the field of maritime safety and preventing pollution from ships. This task will be coordinated with the existing regional cooperation programs and include, if applicable, the organization of relevant training activities.

Sections 3 and 4 cover the topics of visits to the Member States and other issues regarding transparency and protection of information.

Chapter II deals with the internal structure and operation. It consists of items 5 to 17. Article 5 deals with the legal status:

a) The Agency shall be a body of the Community and shall have legal personality.

b) In each of the Member States the Agency shall enjoy the most extensive legal capacity recognized in national laws to legal persons.
c) At the proposal of the Commission, the Board of Directors may decide, in agreement with the Member States concerned, the establishment of regional centers in order to carry out tasks related to the monitoring of navigation and maritime traffic, as provided Directive 2002/59/EC.

Article 10 onwards explains the constitution, powers and board members. For the operation a Board of Directors will be created, which will be composed of one representative from each Member State and four representatives of the Commission, as well as four professionals from the sectors most affected, appointed by the Commission, without voting rights. The Management Board shall elect from among its members a Chairman and a Vice President who shall have a term of three years renewable once. The Chairman shall convene meetings of the board of directors which shall normally be held 2 times a year but able to hold special sessions at the initiative of the president, the commission or one third of the Member States. The board's mission will:

a) Approve the report of the agency.
b) Prepare the work programs.
c) Adopt the budget of the Agency.
d) Appoint an executive director.
e) Define a policy of inspections.
f) Exert disciplinary authority over the Executive Director and the heads of unit.
g) Approve the rules of procedure.

Article 15 defines the functions and powers of the Executive Director, who shall be completely independent in the performance of his/her functions without prejudice to the respective competences of the Commission and the Board of Directors. The Executive Director may be assisted by one or more heads of unit. In case of absence or impediment, will be replaced by one of the heads of unit. The Executive Director shall have the following duties and powers:

a) To develop the work program and submit it to the Administrative Board after consultation with the Commission.
b) To decide, after consultation with the Commission, to conduct inspection visits.
c) To take the necessary measures to ensure the functioning of the Agency in accordance with the provisions of this Regulation.
d) To organize an effective monitoring system in order to confront the performance of the Agency with its operational objectives.
e) To exercise, in relation to staff, appointment of other agents.
f) To make an estimate of revenue and expenditure of the Agency.

Chapter III deals with the financial provisions organized around articles 18 to 21. Article 18 explains the sources of funding and expenditure that will be reflected in a budget that must be balanced:

a) The revenues of the Agency will come from:
— A contribution from the Community;
— From possible contributions from third countries participating in the work of the Agency pursuant to Article 17;
— Charges for publications, training and other services provided by the Agency;
b) The expenditure of the Agency shall cover staff, administration, infrastructure and operations.

Article 19 deals with the implementation of the budget delegated to the executive director and with the control of the payment commitments of all expenses in the Controller of the Commission.

Finally, Chapter IV (final provisions) undertakes independent external evaluation (within five years) of the application of this Regulation. Likewise, it is stated that, in the maximum period of 12 months from the entry into force of the regulation, activity is initiated by the Agency. The entry into force of the regulation is effective on the twentieth day following its publication in the Official Journal of the European Communities.

3. Operating structure of the agency

The agency is organized operationally with an executive director and the heads of its three departments. The Executive Director is in charge of decision-making with the assistance of an accountant, an internal auditor and chief executive office, which is responsible for external communications.

3.1.Department A: Corporate services (information)

The mission of the Department of A-Services for the company is to provide high quality and timely support to the operating businesses of EMSA, and to assist management and staff in the areas of human resources, legal and financial issues, information technology and logistics services, meeting and conference management, protocol, budget planning and monitoring.

3.2. Department B: Implementation (Planning)

Reporting to the Executive Director, this department is responsible for the verification and monitoring of the implementation of maritime safety legislation that falls within the competence of the Agency.

Support to the Head of Department involves two functions: to support the planning and monitoring of the budget, and to perform a horizontal analysis regarding the application of the relevant legislation, including information on the results of the visits and cycles of inspections carried out by the Agency.

3.3. Department C: Operations (execution)

This department provides operational assistance to Member States and the Commission in the field of preparedness and response to pollution at sea. In addition, the department C facilitates technical cooperation between Member States and the Commission to monitor the EU's maritime traffic, identification and long-range tracking of ships, and satellite tracking. The Department also offers a platform of integrated services adapted to the needs of users. The Department is comprised of three units, and also has a horizontal "coordination and support".

The Executive Director is assisted for decision-making by an accountant, an internal auditor and chief executive office itself that is responsible for external communications.

The establishment of a Community vessel traffic monitoring and information system for maritime traffic should contribute to the prevention of accidents and pollution at sea and to minimize their impact on the marine and coastal environment.

Along European coasts several mandatory reporting systems for ships have been established. Vessel traffic services and traffic organization have also been established, which played an important role in preventing accidents and pollution in certain areas or dangerous shipping lane for navigation. There have been technological advances in the field of onboard equipment allowing automatic identification of ships (AIS) to keep better track of them, and in the area of registration of the voyage data (VDR systems or "black boxes") in order to facilitate them post-accident investigations.

The Member State concerned shall monitor and take all necessary and appropriate measures to ensure that all ships entering the area of a mandatory ship reporting, comply with that system in reporting the information required without prejudice to any additional information a Member State may require.

The management and control tools of EMSA are:

1. Community monitoring and information system for maritime traffic
   - 1.1. Use of automatic identification systems (AIS)
   - 1.2 Voyage data registration (VDR) systems 'black boxes'
     - 1.2.1. Notification of dangerous or polluting goods carried on board
     - 1.2.2. Electronic exchange of data between Member States
     - 1.2.3. Monitoring of hazardous ships and intervention in case of incidents and accidents at sea
   - 1.3. Establishment of a Community vessel traffic monitoring and information system
     - 1.3.1. Information requirements for the transport of dangerous goods
     - 1.3.2. Electronic messages and SafeSeaNet
     - 1.3.3. Management, operation, development and maintenance of SafeSeaNet
     - 1.3.4. Data exchange through SafeSeaNet
     - 1.3.5. Security and access rights
   - 1.4. Identification System and Long Range Tracking (LRIT)
2. Visits and Inspections
   - 2.1. Monitoring and vessel traffic information systems

4. Conclusions

If we consider that we started from the need to protect the Environment / Human Beings and the potential damage that could be caused to continue with the methodologies of running after catastrophic events, beyond economic interests related to Naval Transportation, it is clear that much progress has been made in combating this scourge caused by the actions of man.

Evaluate the progress of the results shown by the actions of the EMSA, is based on correct operating distortions, whose detection is revealed through inspections carried out by technicians of the Agency to the Member States, by which chips are made containing data (statistical) that are used to draw conclusions on the effectiveness of the implementation of the tests. And from the analysis of data records received by satellites and processed with georeferenced information management tools and technical / commercial databases crosses.

The findings lead to perfect the system, within this continuous improvement actions, allowing prevention of potential current and future risks to the inhabitants in the area of competence (EU).

The correct application of new technologies, permanent technical/scientific training, earlier and effective intervention in the fight against disasters at sea, dissemination of knowledge, advice on building regulations of immediate applicability; all of them make this Agency a summary of the actions of the European Union.

The creation of EMSA marks a milestone, justified in the context of globalization. It is a clear example of a Continental Organization compliant with the lofty goal of working in an organized effort to improve people's life quality.

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Control of Maritime Traffic in the Canary Islands

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ABSTRACT

In the present article, we present the Paper corresponding to the research project, "Infrastructure for the Control of Maritime Traffic in the Canary Islands: Island of El Hierro, A Pilot Project".

We will analyse the existing means in the Canary Islands, we will make a forecast of the material and method necessary to pick up the signals from vessels transiting the Island waters, their consequent retransmission to a Control Centre away from the place or places where receptors and their corresponding antennas are installed, and the system we deem best for presenting the information.

1. Introduction

We have attempted to demonstrate the efficacy of the automatic transmission of data using the TDMA technique (Transmission/Reception of data using the multiple access by time division technique), in order to implant it in all the vessels and aircrafts that transit our geographic surrounding, with coverage in the Canarian Archipelago and adjacent oceanic and flight space.

This Ship-Shore-Ship data exchange will be possible in VHF, for which it would be necessary to install a certain number of antennae or make use of the existing network of antennas and radiolinks, given that, once the information has been captured, it could be sent to a Traffic Control Centre. These identification systems would allow to detect any given anomaly in the pre-established course of a vessel, in such a way that if it is not confirmed by the methods established for habitual communications, it could be understood that said situation has been provoked and not desired, for example, a high-jack, and, in turn, it would be necessary to respond accordingly.

By means of real observations, we have tested, with the aid of a mobile receptor, the need for installing antennas to guarantee the total coverage of our shores, including shadow zones. All of this has led us to propose an optimum antenna location map. Although it would be desirable to fulfil this fieldwork in all of the other islands, the budgetary limitations have impeded us from carrying it through. Nevertheless, we have intended with this project to demonstrate the viability of the system and put forth a proposal to our Autonomous Government of the Canary Islands (Spain) for its application.

This system, apart from seeking safety in navigation, can also be of use in commercial ambits, where it can be used for providing the ship owner with immediate data regarding the journey: state of the cargo, voyage, fuel, breakdowns, etc., which would result in a better exploitation of the company. We have installed equipments on shore and onboard a vessel to demonstrate the effectiveness of the system.

We will explain the difficulties that have arisen during the execution of the present Project, the strategies employed for the collection of data of the target vessels, and the factors that influence the functioning of the system we are proposing. We wish to highlight that the results attained, as will be seen, are easily applicable to any other coast, given that, the complex relief of the Island has served as the best test bench for the system at hand, which, if it has worked with efficacy in El Hierro, will do so with less difficulty in areas with less complex and more shelved shores.

2. The current state of identification and location of vessels in the Canary Islands

According to the Spanish National Society of Maritime Salvage and Safety: The Rescue Coordination Centres (RCC), are the

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Centres in charge of coordinating the execution of operations regarding search, rescue, salvage, and the fight against pollution in their assigned geographical sphere. The Rescue Coordination Centres existing in Bilbao, Gijon, Santander, A Coruña, Vigo, Huelva, Cadiz, Algeciras, Cartagena, Valencia, Tarragona, Barcelona, Palma de Mallorca, Las Palmas de Gran Canaria and Santa Cruz de Tenerife, fulfil in addition, tracking tasks of vessel traffic in their approaches to and exits from the ports where they are located. Therefore, in the specific case of just the Canary Islands, the ships controlled are only those navigating in the nearby areas of the two Capital ports, lacking the means to obtain information concerning the ships located in the rest of the Archipelago waters. When we talk about these *nearby areas*, we are referring to the waters covered by the range of the radars located in Montaña de La Altura (Santa Cruz de Tenerife), and La Isleta (Las Palmas de Gran Canaria). Given that the radar range is slightly superior to the visual one, the only vessels detected are those in the Channel Tenerife-Agaete and in a sector of around 35 miles south of Puerto de La Luz.

We should clarify that what is detected is a radar echo, having to recur to the communication via VHF in order to interrogate the ship with the aim of obtaining its identity and other useful data, hence, depending on the willingness of the watch officer to respond or not to the petitioned information, especially when it is situated at beyond 12 miles, limit of our territorial waters.

Each one of the AIS equipments have been recently installed in each one of the Regional RCCs, providing an important help for the controllers.

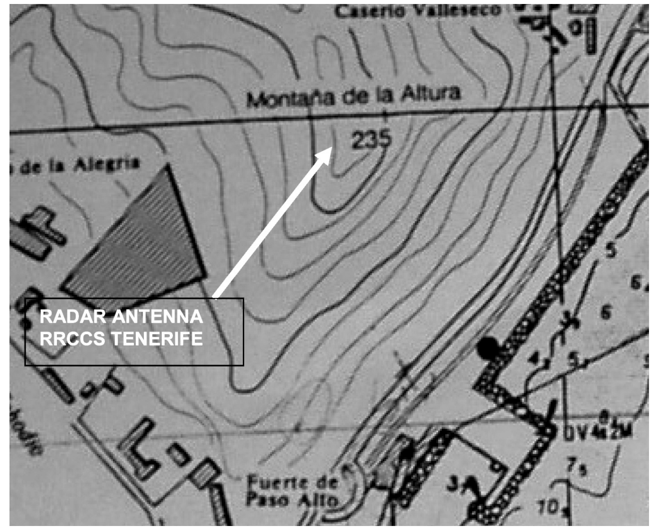
2.1. Equipment of the Tenerife RRCCS for location and identification:

— Radar: Approximate range: 34 miles; Orientation: E.
— Direction finder VHF.
— Identification Systems: AIS and interrogation via VHFRT.

Figure 1: VHF VHF-DF Direction finder (Antenna on cliff).

Source: Authors.

Figure 2. Tenerife's RRCC Radar Antenna. Located on the mountain of "La Altura" at 235 mts. altitude and communicated by radiolink with the control room.

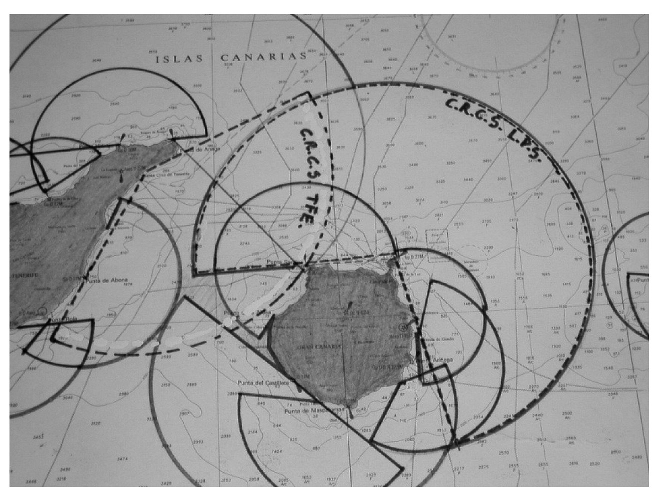


Source: Authors

2.2. Equipment of the RRCC of Las Palmas:

— Radar: Approximate range: 35 miles; Orientation: S
—VHF Direction finder
—Identification Systems: AIS and question via VHF-RT.

Figure 3: Zones with radar coverage of the RRCCs of Las Palmas and Santa Cruz de Tenerife (indicated by a dotted blue line). The antenna of Tenerife controls the Channel Tenerife-Agaete. The antenna of Las Palmas controls a minimum radius of around 35 miles around La Isleta from Pta.Sarrdina to Pta. Melenara.



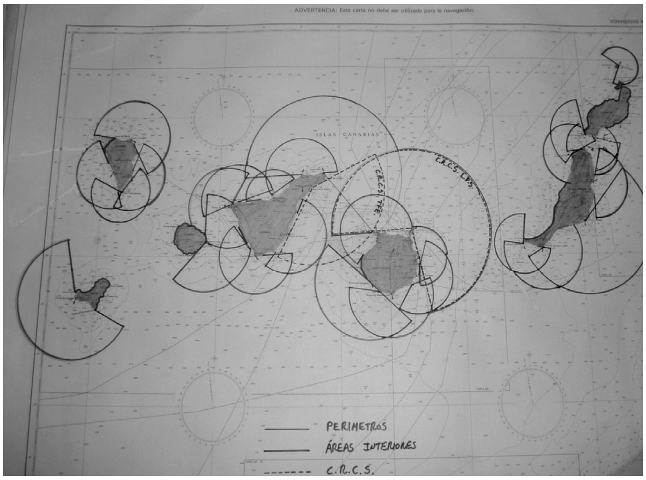
Source: Authors.

2.3. The current state of the identification and location of vessels on the island of El Hierro

The radio-electronic means of location and identification of vessels on the island of El Hierro are practically inexistent, limiting themselves to visual means carried out by the platform inspectors of the ports of La Estaca and La Restinga.

It is important to note the presence of the vessel belonging to the National Society of Rescue "Salvamar El Hierro" with

Figure 4: Lighthouses of the Canary Islands.



Source: Authors

base port in La Restinga, which will only be able to detect crafts during their sporadic exits from the ports.

3. Concrete aims of the project and their interest

We intend to test the effectiveness of the new system of vessel identification (Automatic Identification System – AIS), in the Canarian Archipelago which, as we know, has its implantation period between July 1st 2002 and July 1st 2008, and which intends to be a fundamental tool in navigation safety as it enables vessels or onshore stations to automatically "identify" all the vessels found in its surroundings, providing each station with valuable navigation safety information, such as the identification number of the vessel, type, position, course, speed, navigation status, dimensions, cargo, etc., ending, with this system, the uncertainty that has always existed at sea when interrogating another vessel.

We will install a receiver with its corresponding VHF antenna on the Island of el Hierro, we will pick up the information from the vessels close to the coast of the Island of El Hierro and, more specifically, the information transmitted by the Training Ship "Escuela Náutica Tenerife", which will make its way to El Hierro to fulfil the present work of research. We will send signals to a Control Centre located in the Town Council of the Island, to demonstrate the possibility of retransmitting the data from the receiver to any other desired place. We will extend the application of the system to small to urist and recreational boats, such as our apprentice sailing vessel, in order to test its effectiveness in areas close to the coast, attempting to detect the dark or no-coverage zones for recommending the installation of receivers in specific places as a guarantee of signal reception from vessels at all times.

The interest of this project lies in guaranteeing the location and identification of vessels and aircrafts navigating the coasts of El Hierro - this project being applicable to the rest of the Canary Islands -, and furthermore, in acquiring permanent information of their situation and navigation conditions, which will be advantageous for the safety of human life and the protection of the environment in our Islands.

4. Hypotheses, methodology and work scheme

Relying on two data transponder equipments, we will install one on board the vessel "Escuela Náutica Tenerife" (property of the University of La Laguna), and the other we will use as an onshore portable, focusing this pilot project on the Island of El Hierro, as it is the most exterior one bordering the Atlantic Ocean on its western end where there are no reference stations close-by.

We will pick up the signals and resend them via radiolink to a control station situated in the Island Council of El Hierro. We intend with this to demonstrate the possibility of implanting this system in the Canary Islands, as a means of centralizing all the information regarding the vessels and aircrafts transiting our Islands.

We will test ranges, interruptions in the transmission/reception, causes of the losses in remote and close-by targets, dysfunctions due to obstacles in the relief and meteorological phenomena, etc. We will study the ideal situation of the necessary receivers in different points of the Island. For this purpose, we require a sufficiently thorough format for data gathering, which will allow us to extract from it the necessary information to formulate a reliable hypothesis.

With the data of true ranges taken from the site of the ground equipment, we will extrapolate the conclusions arrived at to other geographic zones of the Island. With the previous data, we will initially study the theoretically ideal onshore location of the antennae. In order to test the former, we will situate the T/S "Escuela Náutica Tenerife" in different locations far from the coast and very close to it, behind headlands and capes, under cliffs, in different states of oceanic and atmospheric situations.

As former work to this project we count on the conclusions obtained in the one entitled, "location and identification of vessels and aircrafts in the canarian archipelago: a new proposal", with ending date January 2005, and in which the necessary observations were carried out, until the number of samples was considered to be abundantly significant leading to the instalment of the mobile station in different points of the island of Tenerife and a few others of the Canarian Archipelago. The system was tested at different altitudes and distances from the coast and the application of whose conclusions to the present project we will expose further on.

The identifying data of both stations are the following:
Boat Station:
Equipment: Furuno UAIS FA-100
Name: Escuela Náutica Tenerife
Call Sign: EA4450
Number of digital selective calling / MMSI:224090420
Height Of Antenna: 2.25 mts.
Ground Station:
Equipment: Furuno UAIS FA-100
Name: LAB COM
Call Sign: EON
Number of digital selective calling / MMSI:002241017
Experimental location on the island of El Hierro
In Geographic Coordinates:

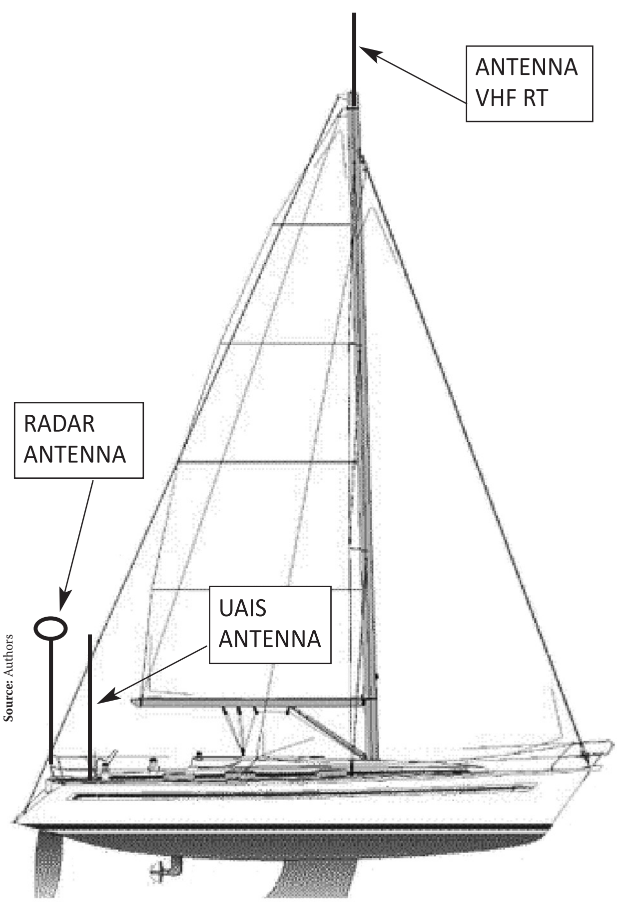
l= 27 48,2700 N L= 17 54,4835 W
H =545 mts. Above Average Sea Level
Datum: Pico De Las Nieves
In U.T.M Coordinates:
28 R 0213310
3079110
Z=545
Datum: WGS 84
Blind Sector: From 192º to 016º

4.1. Data taking

With the mobile ground station, we will pick up the signals and send them to a control station located in the Island Council of El Hierro. For this, we will have to experiment with different systems to determine the most appropriate technique.

5. Installations, instruments and available techniques

Figure 5: Bavaria Yacht 42 FEET YEAR: 1999.



Source: Authors

Source: Authors.

Basic Equipment
Navigation
Radiotelephone MF/HF, Echosounding, VHF RT, VHF DSC, 2 NAVTEX, Radar, GPS Plotter, AIS, SART, EPIRB406, INMARSAT NINI M.

Figure 6: Navigation Equipment: Radar, GPS Plotter, UAIS.

Source: Authors

2 VHF Radiotelephones for voice communication between onshore personnel and observers on board the vessel.

1 Portable GPS for the location of the observers onshore with the aim of comparing locations.

- 1 Compass with chronometer for orientation.
- 1 binocular to test the theoretically foreseen visual ranges.
- 2 Charts of the Islands of La Gomera and El Hierro (Scale 1:50.000).
- Military Geographical Service Map of the Island of El Hierro (Scale 1:50.000)

1 AIS Transceiver (Ground Station Equipment).

6. Data taking

During this experimental phase, observations were carried out both from the "Velero Escuela Tenerife" in navigations around the southern coast of the island of Tenerife and the island of El Hierro. Observations were also taken with the ground equipment initially installed in the Communications laboratory of the *Centro Superior de Náutica y Estudios de Mar* (Institute for Maritime and Nautical Studies), and consequently, from the Island of El Hierro, where the land station was transferred to.

Below is an example of the formats used for data gathering, which we will proceed to explain in detail.

Let us take the general form in sections, explaining each one of them:

DATE: **GEO POSITION: l=** **/ L=** **NO.:**
OWN SHIP STATIC DATA: NAME MMSI CAL L SIGN: TYPE:
ANTENNAS HaisO: HradarO: HvhfO: HbridgeO:
TARGET STATIC DATA: NAME MMSI CALL SIGN: TYPE:
ANTENNAS (EST):HaisT: HradarT: HvhfT: HbridgeT:

OWN SHIP DYNAMIC DATA	FIRST OBSERVATION	LAST OBSERVATION
TIME COG/SOG COW/SOW REMARKS (WEATHER, ROLL, PITCH, ETC.)		

AIS TARGET DATA TIME BEARING/RANGE CPA/TCPA COG/SOG REMARKS	FIRST OBSERVATION	LAST OBSERVATION
RAD/ARPA TARGET DATA TIME BEARING/RANGE CPA/TCPA COW/SOW COG/SOG REMARKS	FIRST OBSERVATION	LAST OBSERVATION
VISUAL TARGET DATA TIME BEARING DAY/NIGHT VSIBILITY (FAIR/REG/POOR) VISUAL TYPE REMARKS	FIRST OBSERVATION	LAST OBSERVATION
VHF COMMUNICATION TIME POSSIBLE (YES/NO) QUALITY (FAIR/REG/POOR)	FIRST OBSERVATION	LAST OBSERVATION
OBSTRUCTIONS (YES/NO) TYPE REMARKS	FIRST OBSERVATION	LAST OBSERVATION
A.-AIS THEORETICAL MAXIMUM RANGE:		ROLLING
B.-RADAR THEORETICAL MAXIMUN RANGE:		ROLLING
C.-VISUAL MAXIMUN RANGE:		ROLLING
D.-VHF THEORETICAL MAXIMUN RANGE:		ROLLING

A.– $R = 2.2048\ (HaisO)^{½} + 2.2048\ (HaisT)^{½}$
B.– $R = 2.2048\ (HradarO)^{½} + 2.2048\ (radarT)^{½}$
C.– $R = 2.08\ (HvisO)^{½} + 2.08\ (HvisT)^{½}$
D.– $R = 2.2048\ (HvhfO)^{½} + 2.2048\ (HvhfT)^{½}$

Where R = Range; For example: HaisT = Target AIS antenna Height; HvisO = Own Ship Estimated bridge Height; HradarT = medium Height of Target vessel.

GENERAL QUESTIONS:
— WAS RADAR OBSERVATION POSSIBLE AT THE FIRST AIS OBSERVATION TIME?
— ARE THERE BUILDINGS OR BIG WALLS NEAR OWN SHIP OR TARGETS?

GENERAL REMARKS:
— VHF COMMUNICATION DATA ONLY WHEN FEASIBLE
— OBSTRUCTION TYPES BETWEEN OWN SHIP AND TARGETS: PIER /CAPE/INLET/REEF ETC.

6.1. Vessel/own station

DATE: **GEO POSITION: l=** **/ L=** **NO.:**
OWN SHIP STATIC DATA: NAME MMSI CAL L SIGN: TYPE:
ANTENNAS HaisO: HradarO: HvhfO: HbridgeO:

TARGET STATIC DATA: NAME MMSI CALL SIGN: TYPE:

ANTENNAS (EST): HaisT: HradarT: HvhfT: HbridgeT:

OWN SHIP DYNAMIC DATA TIME COG/SOG COW/SOW REMARKS (WEATHER, ROLL, PITCH, ETC.)	FIRST OBSERVATION	LAST OBSERVATION

In this section we take down the static and dynamic data of the vessel or the onshore station from which the observations are fulfilled. In the same manner, we take down the useful static data of the target vessel. The meaning of the abbreviations used in this section and those below is the following:

DATE:	**FECHA**
GEO POSITION: l=	**/ L=Situation: latitude /Longitude**
NO.:	
OWN SHIP STATIC DATA: NAME	
MMSI	Number of digital selective calling
CAL L SIGN:	Distinctive or Indicative of call
TYPE:	Type of vessel (Tank, passenger, Sail, High Speed, etc.)
ANTENNAS HaisO	Antennas Height of AIS antenna (own vessel)
HradarO:	Height of RADAR antenna (own vessel)
HvhfO:	Height of RT VHF antenna (own vessel)
HbridgeO:	Height of bridge (own vessel)

TARGET STATIC DATA:	NAME MMSI CALL SIGN: TYPE:
ANTENNAS (EST):HaisT:	Antennas Height AIS antenna (observed vessel)
HradarT:	Average height RADAR eco (target vessel)
HvhfT:	Height of RT VHF antenna (target vessel)
HbridgeT	Height of bridge (target vessel)

OWN SHIP DYNAMIC DATA	
TIME	Time of observation
COG/SOG	Course Over Ground/ Speed Over Ground
COW/SOW	Course Over Surface/ Speed Over Surface
REMARKS (WEATHER, ROLL, PITCH, ETC.)	
FIRST OBSERVATION	Column corresponding to data from the 1st observation
LAST OBSERVATION	Column corresponding to data from the last observation. We refer to the moment in which the data from the observed vessel are starting to get lost.

6.2. Ais vessel/station target data

AIS TARGET DATA	
TIME	Hora
BEARING/RANGE	Demora / Distancia
CPA/TCPA	Time to closest point of approach
COG/SOG	Course and Speed over ground (effective)
REMARKS	(were there to be any)

6.3. Radar/Arpa Vessel/Station Target Data

RAD/ARPA TARGET DATA	
TIME	Hora

BEARING/RANGE	Demora / Distancia
CPA/TCPA	Time to closest point of approach
COW/SOW	Course and Speed over ground (effective)
COG/SOG	Course and Speed over water (surface)
REMARKS	(were there to be any)

Note: it must be taken into account that the ARPA systems initially give us the course and speed data with respect to the surface.

6.4. Visual data of the target vessel

VISUAL TARGET DATA

TIME	Hora
BEARING	Demora
DAY/NIGHT	Día / Noche
VSIBILITY (FAIR/ REG/POOR)	Visibilidad (Buena/Regular/Mala)
VISUAL TYPE	Type of vessel (appearance)
REMARKS	Observaciones

6.5. Communication by vhf radiotelephone

VHF COMMUNICATION

TIME	Hora
POSSIBLE (YES/NO)	Comunicación Posible (Sí/No)
QUALITY (FAIR/ REG/POOR)	Calidad de la señal (buena/regular/Mala)

6.6. Obstructions

OBSTRUCTIONS	Obstáculos entre estaciones receptora y transmisora
(YES/NO)	(SÍ / NO)
TYPE	Tipo (Cliffs, capes, inlets reefs etc.)
REMARKS	Observaciones

6.7. Table of theoretical ranges

Table 1. calculations of the theoretical ranges dependent on the heights of the antennae and/or of the observers, with the vessel righted and heeling

A.-AIS THEORETICAL MAXIMUM RANGE:		ROLLING
B.-RADAR THEORETICAL MAXIMUN RANGE:		ROLLING
C.-VISUAL MAXIMUN RANGE:		ROLLING
D.-VHF THEORETICAL MAXIMUN RANGE:		ROLLING

Source: Authors

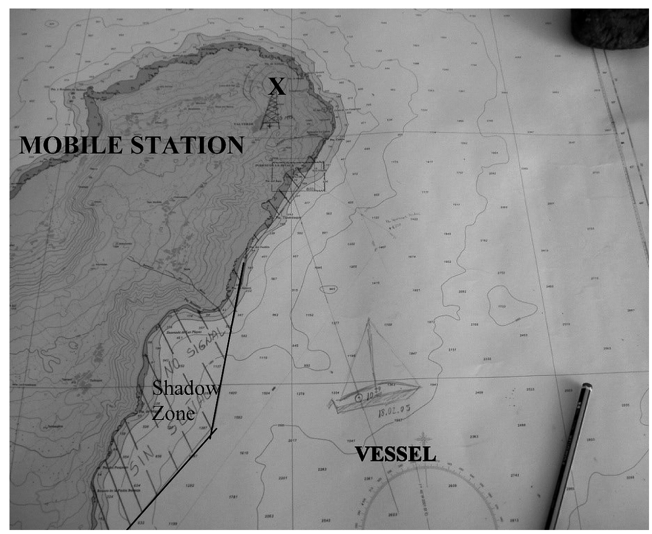
6.8. Observations taken from the portable station on the island of El Hierro.

58 observations were fulfilled onshore. The GPS and AIS antennas were transported in a cross-country vehicle and were installed on platforms designed to this effect in the following location.

6.8.1. Experimental location on the island of El Hierro in geographic coordinates:

l= 27 48,2700 N L= 17 54,4835 W
H =545 mts. Above Average Sea Level
Datum: Pico De Las Nieves
In U.T.M Coordinates:
28 R 0213310
3079110
Z=545
Datum: WGS 84
Theoretical Range: 51,47 Nautical Miles
Visible Sector: from **016º to 192º**
Blind Sector: from **192º to 016º**

Figure 7: Blind Sector.



Source: Authors

The main objective of these land observations was to attempt to receive signals from vessels found in the blind sector, that is, behind the coast and/or obstacles, or at a short angular distance of its limits. The Training Ship "Escuela Nautica Tenerife" was used for this purpose, navigating along the South, Southeast and Northeast coasts, from Puerto de La Restinga towards the northeast, navigating on occasions through the blind zone of Los Roques de Bonanza and La Restinga. Navigations were also carried out at different distances from the Coast, from and to Puerto de La Estaca.

At the same time, static related information to vessels was taken to analyse its correct introduction into the equipments.

7. Results

- All the vessels located within the theoretical visible sector and ranges, were satisfactorily observed with the AIS.
- Of the vessels observed, TWO were found outside the visible range.
- In situations of heavy rains and intense rainstorms, the dynamic data were received intermittently.

8. Conclusions

In an onshore station, such as the one installed, there is guarantee of receiving all the signals from transmitters found within the theoretical visible range and sector. This information leads us to a future determination of locations for antennas in order to implant the system at other points of the Island.

It has been demonstrated in practice that the ranges of the Automatic Identification Systems coincide and on occasions, surpass the foreseen theoretical ranges. The static data of the vessels are received in 100% of the cases.

The scarce angular sector outside the visual limits with which signals can be received, indicates that it is not necessary to overlap sectors between different antennas. This is one more data to determine the location of future antennas.

In specific occasions, the observed range of the system notably surpasses the theoretical range and, principally, that of the follow-up systems based on the RADAR technique.

The range of the system is limited by the visual range of antennas found behind land obstacles of great height. This range is always superior to that of the RADAR, whose echoes remain disguised behind land fixed features.

These results make the use of the system necessary in all types of vessels and onshore stations for traffic control and the fight against marine pollution.

In the case that the vessel initiates the navigation, fact which will be calculated by the internal GPS of the equipment, the information relative to the status of navigation should change automatically, without the need to introduce the information manually, proposing the transmission, by defect, of “machine navigation”.

The following parameters should be blocked using an access code, as is the case with the identification number and signal call of the vessel:

— Position of the antenna (this data will only change in the unlikely case of a change in position of the same)

— Type of vessel. We propose adding to the new equipments a new function in which only the information relative to the nature of the cargo can be introduced without an access code.

We suggest endowing the equipments with a keyboard similar to that of a computer for a faster manual introduction of data.

It is advisable to make the connection of the equipments to screens with larger dimensions compulsory in order to carry a clearer and safer tracking of the vessels detected, allowing the superposition of the images with those of other systems, such as a radar and chart display.

The strong meteorological disturbances may difficult the adequate continuous tracking of the vessels, given that the dynamic data can be received intermittently.

The ground stations should be provided with remote antennas allowing the reception of signals from vessels that are hidden by large land obstacles. This coverage would be guaranteed in 100% of the cases were they to be located in headlands, coastal geodetic apexes or lighthouses with a height superior to 200 meters, guaranteeing a coverage superior to the 31 nautical miles (around 57 kilometres), for objects at sea level.

The tracking of aircrafts would be guaranteed with a lesser number of antennas, as there are less land obstacles.

The locations suggested for the installation of AIS antennas in the Island of El Hierro or its proximities, are the following:

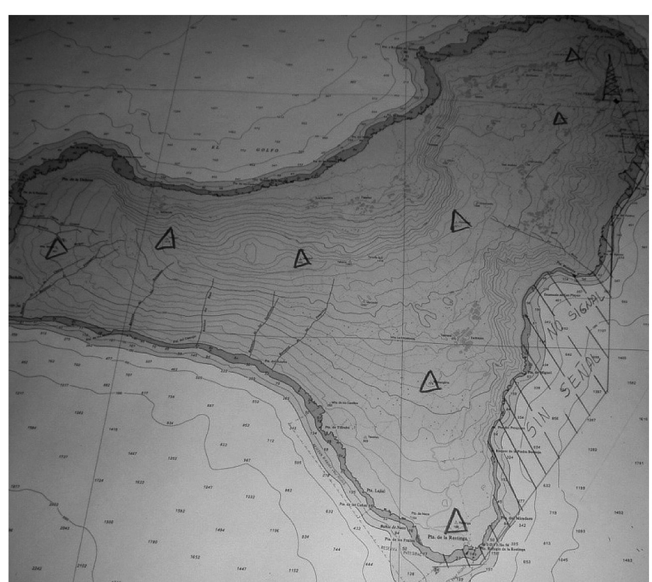
Table 2

No.	Denomination Place	Coordinates	Range (Miles)*
1	MONTAÑA TENACA	l: 27 43,70 N L: 18 08,00 W h: 615 mts	54,6
2	VENTEJEA (LOS HUMILADEROS)	l: 27 44,00 N L: 18 05,40 W h: 1.234 mts	77,4
3	MALPASO	l: 27 43,68 N L: 18 02,30 W h: 1.501 mts	85,4
4	TEMBARGENA (CERRAJA)	l: 27 41,23 N L: 17 59,40 W h: 774 mts	61,3
5	RESTINGA	l: 27 38,71 N L: 17 58,90 W h: 197 mts	30,9
6	ASOMADAS (LOS FRAILES)	l: 27 44,70 N L: 17 58,80 W h: 1.372 mts	81,7
7	VENTEJIS (LA PELOTA)	l: 27 47,60 N L: 17 56,08 W h: 1.138 mts	74,4
8	CUEVA DE LA PAJA	l: 27 49,65 N L: 17 55,50 W h: 539 mts	51,2

Source: Authors

* Objects with height=0 mts., that is, at sea level. The range would be greater the higher the object to be detected.

Figure 8: Suggested AIS Antennas (Mercator Chart).

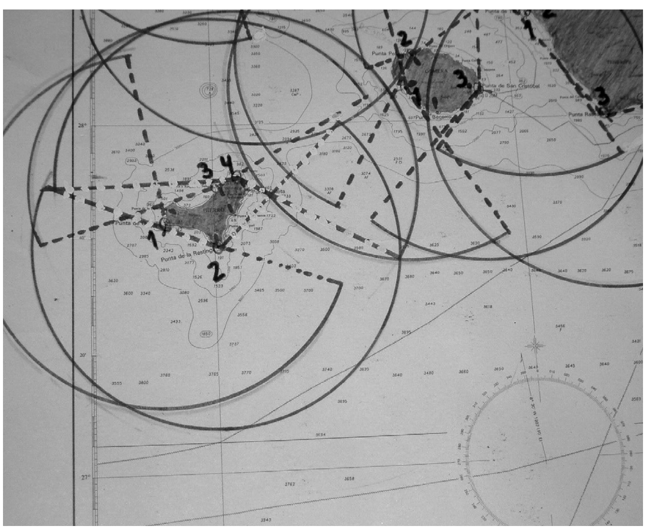


Source: Authors

The dependence of the system on the correct functioning of the satellite systems, together with the need to count on the collaboration of the transmitters as they have to keep their equipments functioning continuously, turn this system into a new navigation aid which, complemented with other systems, such as the radar (X band to detect SARTs), guarantee an effective tracking of vessels. This, together with the fact that dynamic data suffer from brief transmission/reception interruptions in situations of strong atmospheric disturbances due to rainstorms, reconfirms the need to contrast the data with those of other systems such as the Radar/Arpa.

In order to avoid these possible problems in the island of El Hierro, we suggest the location of four radar antennas, if possible in places of higher altitude (equal or above 200 metres), presenting small shadow zones, which do not affect tracking approaches to the island. It would be necessary to carry out a field study to determine the definitive location of the antennas. The antennas would be situated in the following places or their proximities:

Figure 9



Source: Authors

Table 3

No.	Denomination Place	Range (Miles)*	Shadow Zones
1	FARO DE ORCHILLA	31	SHORES FROM PTA. DE LA DEHESA TO PTA DE ORCHILLA
2	RESTINGA	31	ZONE OF LOS ROQUES DE BONANZA
3	SALMOR	31	EAST OF PTA. DEL NEGRO AND WEST OF PTA. DE LA SAL
4	PTA. NORTE	31	EAST OF PTA AMACAS AND WEST OF ROQUES DE SALMOR

* Objects with height=0 mts., that is, at sea level. The range would be greater the higher the object to be detected.

In this proposal a zone close to the Port of la Estaca would remain without coverage, at around 5 miles from the same. This problem would be resolved with the installation of a small port control radar with its antenna at a minimum sufficient height of 5 metres above sea level.

9. Final conclusion for the effective location and tracking of vessels and aircrafts in the island of El Hierro proposed for the rest of the archipelago

For tracking with coverage in the Island of El Hierro, it would be necessary to install the antennas/receivers suggested in the previous conclusions. These antennas would cause a minimum visual impact due to their reduced dimensions.

The signals received by the afore-mentioned antennas/receivers will have to be retransmitted to a Control Centre which will be provided globally and simultaneously with the static and dynamic data of the vessels and aircrafts transiting the waters of the Island from an average distance of 60 miles = 111 Km.

This system must be complemented with a series of low-level radar antennas to enable the confirmation of the dynamic data and of the effective presence of the echoes, in view of possible breakdowns or dysfunctions of the AIS system.

10. Proposal for the location of antennas in the Canary Islands

Following, we propose a model of ideal minimum network of AIS/RADAR antennas for the Canarian Archipelago. Logically, it would be necessary to carry through a field study, to confirm the hypothesis. The premises that have been taken into account have been:

— Height Of Antennas: 200 mts. Approx. RANGE: 31 Miles.
— Shadow Zones: small, do not affect tracking in approaches to the Island, only in coastal shores.
— Places: approximate, preferably in lighthouse proximities to make use of energy access and sources.

Figure 10

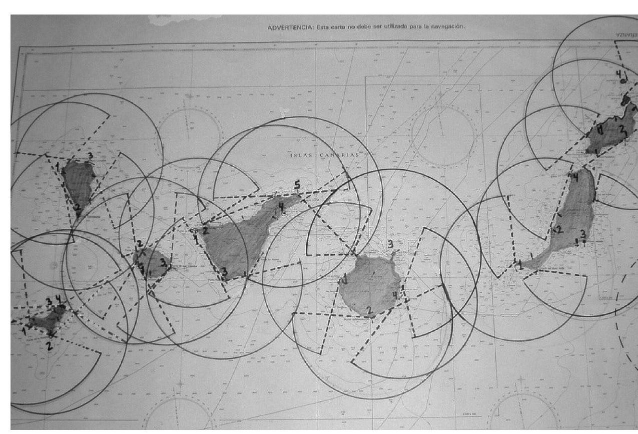


Table 4

	No.	Place	In Lighthouse
1	1	PTA. GAVIOTA	NO
2	2	ARRECIFE	NO
3	3	MOJON BLANCO	NO
4	4	ALEGRANZA	NO (Rise over the lighthouse)
5	1	JANDIA	YES
6	2	PTA. GUADALUPE	NO

7	3	LA ENTALLADA	YES
8	4	TOSTON	YES
9	1	PTA. DE LA ALDEA	NO
10	2	MASPALOMAS	YES
11	3	LA ISLETA	YES
12	4	ARINAGA	YES
13	1	PTA. TENO	YES
14	2	BUENAVISTA	YES
15	3	PTA. RASCA	YES
16	4	SANTA CRUZ DE TENERIFE	IN RRCC RADAR
17	5	PTA. ANAGA	YES
18	1	PTA. CALERA	NO
19	2	PTA. PELIGRO	NO
20	3	SAN CRISTÓBAL	YES
21	1	PTA. GORDA	NO
22	2	FUENCALIENTE	YES
23	3	PTA. CUMPLIDA	YES
24	1	ORCHILLA	YES
25	2	RESTINGA	NO
26	3	PTA. SALMOR	NO
27	4	PTA. NORTE	NO

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We would like to acknowledge the collaboration of the Local Government of El Hierro, without which this Project would have been hardly feasible.

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Speeds & Capacities Necessity of Boats for Improve the Competitiveness of the Short-Sea-Shipping in West Europe Respecting the Marine Environment

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ABSTRACT

This paper aims to contribute to highlight the main factors which determine the commercial success of Short-Sea-Shipping lines. As a part of complex topic of modal competition, we will focus on the ship's performances. The finality is to define the capacities and the speeds needed by ships for compete effectively with the services "all-by-road" of freight transport in West Europe. In fact, the flexibility is the main competitive advantage of road transport over the other modes as maritime, fluvial or railways, and the travel time is the second one. With exception of some cases which have ports as origin and destination, the transport "Door-to-Door" needs the participation of road transport ineluctably. So, the modal competition between the Short-Sea-Shipping and the road transport is in fact a problem of their complementarily. The really important matter is how to maximize the Short-Sea-Shipping' component into the travels which combine the maritime and the road transports. The main impediments for the SSS's component maximisation are the travel time of the boats and the ports passage time.

In continuity of our precedent researches, we use the results showing the more competitive SSS's lines (Martell Flores, 2007). On this base, we proposed the links between ports and the best operation way for each one, in "classical lines" of collecting & distribution or as "shuttle lines". All lines initially proposed are competitive with road transport under the costs criterion, but not always, even rarely, under the travel time criterion. We take the travel time by road as reference to define the travel time that the ships need to reach in order to be competitive. So, this analysis includes the cost & the travel time as criteria of comparison. We analyzed a network of the main 112 cities in West Europe, including 57 ports, which constitute our O-D matrix. For this analyse we use the DETCCM algorithm, it identified the differences between travel times of transports in "all-by-road" and in combined "maritime / road" for each possible link of the O-D matrix. The results show us a selected number of SSS's lines which are competitive in the current conditions of travel time. They show us the average speeds' necessaries to reach the competitive travel times for the rest of the lines. Finally, we made a performances' review of the more currents ships in order to propose the more adapted kind of ship to the SSS proposed lines. The results underline the necessity to make new naval engineering developments oriented to design a specific Short-Sea-Shipping' boat in the close future.

1. The factors of commercial success of the short-sea-shipping transport services

The particular characteristics of the different transport modes offer to shippers more or less advantages in function of the infrastructures capacities, vehicle's performances and the operating systems of each mode. The client point of view about the efficiency of a transport mode plays the most important roll in the modal choice. We have resumed the principal factors of the shippers' preferences as follow.

1.1. The cost of transport

Traditionally, the cost of freight transport was the principal criterion for shippers to choice between modes of transport. The majority of transports modal choice models was been designed in attention at this unique factor of choice. Today, the travel cost continues to lead the choice between modes. But in many cases, especially for medium and high value freight, the indirect costs of transhipments and/or of longer travel times push the shippers to prefer the road's transports even if they are expensive in comparison with other modes. In fact, the costs of Short-Sea-Shipping are attractive, and if we consider only this criterion, there are many maritime links with a high economics' potential of development (Table 1). But the other factors as the flexibility, the safety & security of freight, and travel time are more advantageous for the road transport.

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1.2. The safety and security of freight

The freight safety is a choice criterion which gives a great advantage to road transport in comparison with other modes and even in the case of combined transport (multimodal). One of the principal problems of the combined transport is the transhipment's handling between different vehicles from truck to boat, from truck to rail or other combinations. Each transhipment handling implies a "risk of damage" to freight. So, many shippers prefer to contract the transport services "all-by-road" to limit the number of transhipments handling and the risk's of freight damage.

The freight security is a choice criterion highly important but not really a discrimination factor between modes. Today, localisation by satellite and the tele-detection systems make possible to track vehicles, and containerized goods in an efficiently way and in real time. Thus, security level between transport modes is equivalent and it does not represent a disadvantage to Short-Sea-Shipping into the modal competition. Nevertheless, the shippers are more comforted with the idea of a "unique responsibi lity along the travel".

1.3. The flexibility of transport and the care of freight handling

The flexibility of a transport mode means the capacity of mode to link one origin and one destination everywhere and of the most directly way. The transport's services "door-to door" by the same vehicle represent the maximal flexibility. This is only the case of road transport because the truck may to go to any place communicated by the road network. For the others modes (maritime, railway, fluvial and aerial), the flexibility is reduced and represent a handicap, it make them dependent of the road transport to complete the services "door-to-door". In the case of the Short-Sea-Shipping, it is evident the necessity to find best compromises between maritime transport and the road transport to improve the offer of Short-Sea-Shipping's services. It is necessary to do the transport on the same contract and to find agreements between the road transport's operators and the Short-Sea-Shipping's operators with the finality to engage a unique responsibility in the contracts with the shippers.

1.4. The travel time

The travel time of freight transport becomes a very important criterion in modal choice, sometimes even in regard of the cost. The recent dynamics of the commerce as well as of the industrial's production and distribution has need of travel time reductions. The logistics exigencies derived of concepts as "just-on-time" pushed to reduce the travel times more and more. The "short travel time" becomes a key factor to the development of the Short-Sea-Shipping. The main objective of this paper is to demonstrate the necessity to improve the Short-Sea-Shipping boat's speed. Currently, the travel time reductions may to be done by the optimizing of the composition, rotations and itineraries of the fleet in service. Nevertheless, in the close future it will be necessary to design, to construct and to put in operation the adapted boats to the new necessities of speed. As well as more adapted to improve the freight safety and the handling care in order to increase their intermodal compatibility.

Table 1: The means of "Costs & Speeds" for the trucks and boats operation in Europe

Modal Choice Variable	Diffrents values for the same variable in fonction of sources	Mean Value considerto analyse (DETCCM)
Costs	[€/km]	[€/km]
Road Transport [Truck]	1,05 (b)	1,05
Short-Sea-Shipping [cont. 40']	0,75 (b)	0,75
Speeds	[km/h] (c)	[km/h]
Road Transport [Truck]	85 (c); 75 (a)	90
Short-Sea-Shipping [boat] 3	4 (18 Knot)	37 (20 knot)

Sources: (a) O bservatori de costos del transportde mercaderias per carretera a Cataluya
(b) SCEREN, Les ports maritimes français dans les échanges mondiaux
(c) Enquête de transit, Ministère de l'Équipement des transports et du logement

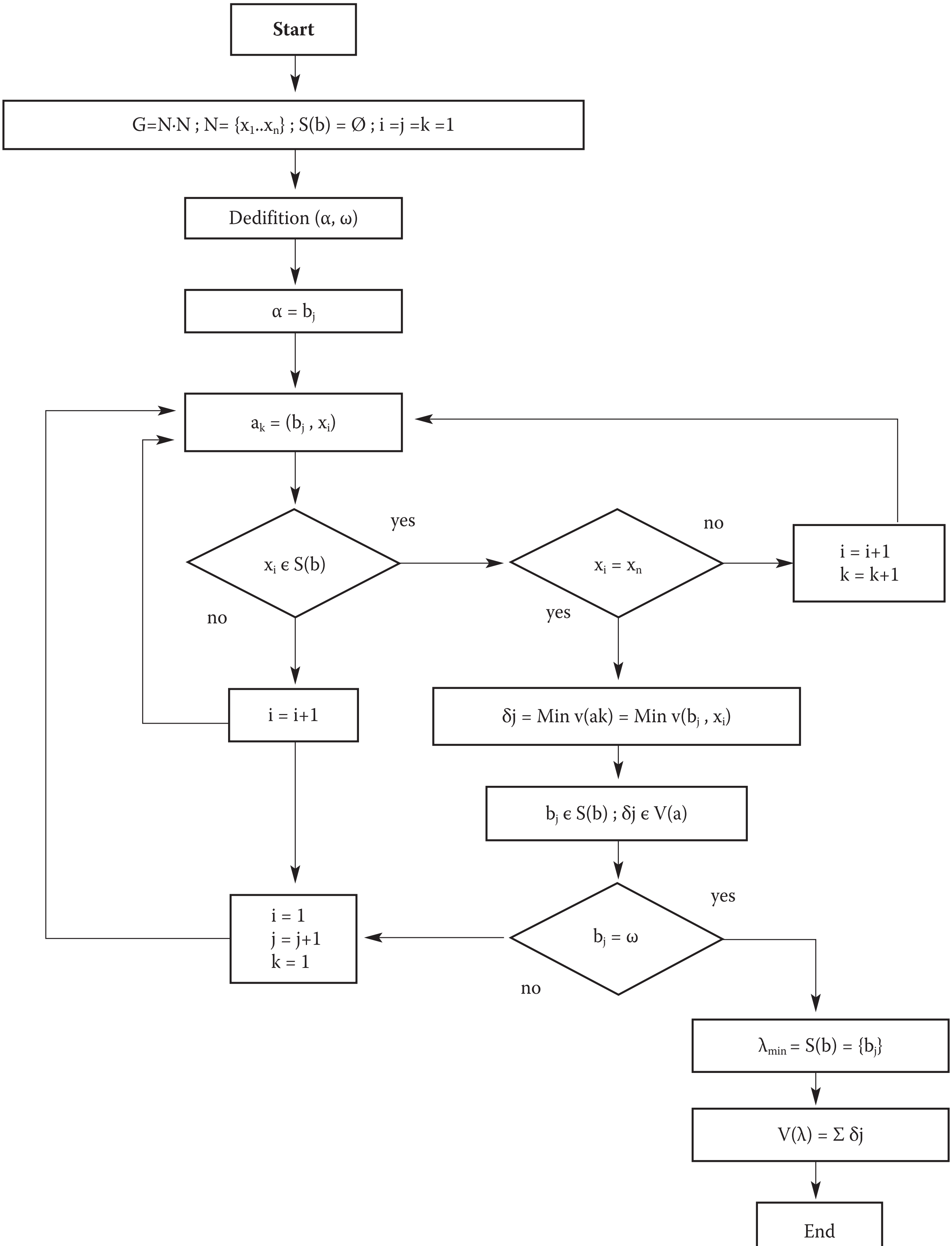
2. The more competitives links of the short-sea-shipping in Europe

To define the more competitive lines of Short-Sea-Shipping we can not forget the handicap caused by his lack of flexibility. So, we accepted his dependence of the road transport for complete the freight itineraries. Our analysis is based on the principle that Short-Sea-Shipping has to be considering not as an independent mode of transport in competition with the others modes, but as a part of a total transport chain. The real question is not how to do the maritime transport more competitive than road transport. But how to integrate the combined transport services "sea & road" to reach the performances of transports "all-road" with the largest component of Short-Sea-Shipping. Of course, a largest component of Short-Sea-Shipping means economies of costs, reduction of energy spent by cargo unit and reduction of pollution.

2.1. Evaluation of the Short-Sea-Shipping' competitiveness

As result of precedents works about competitive of short-sea-shipping to the transport of containerized general freight, we identified links between ports with high potential of development. This analyse was made on the base of a 112 European cities sample which 57 ports. We applied the algorithmic model DETCCM which is based on the Dijskstra's shortest way algorithm adapted to the case of combined transport services "Maritime & Road" (Martell Flores, 2007). This model finds and evaluates all possible combinations of transport "Maritime & Road" between the 112 cities. The principle of the algorithm is to superpose the maritime network onto the road network to analyse all possible combinations as only one network. Affecting the links of superposed networks by the different modal choice criteria we can evaluate the combined itineraries. The evaluation may to be done under different criteria of modal choice: the travel cost, the travel time, the energy spent or the travel pollution emission.

Figure 1: Flux diagram of DETCCM model "Optimized Detection of Combined Multimodal Chains".

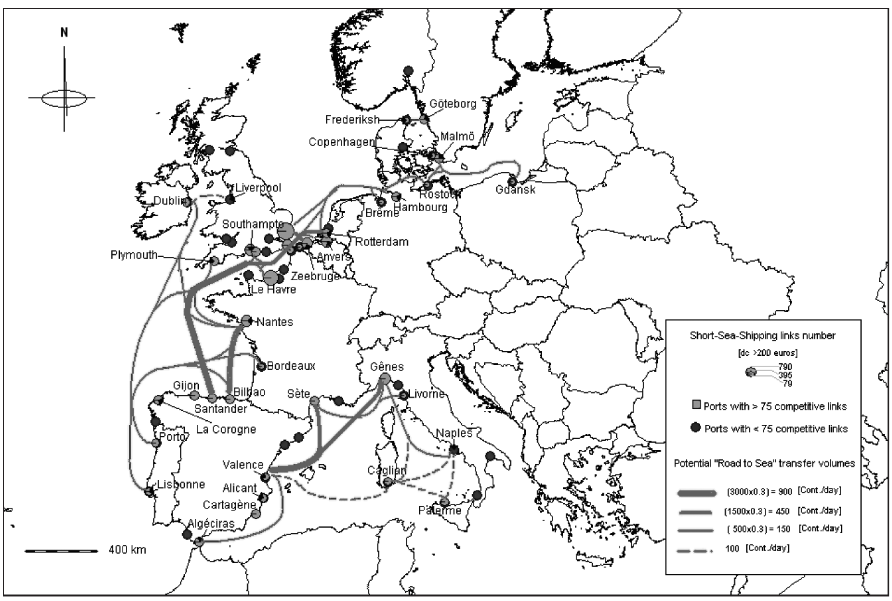


Source: © H. Martell, 2006, CIRTAI, UMR, I.D.E.E.S. du CNRS, University of Le Havre.

2.2. DETCCM's analysis results in the case of combined travels "road & sea"

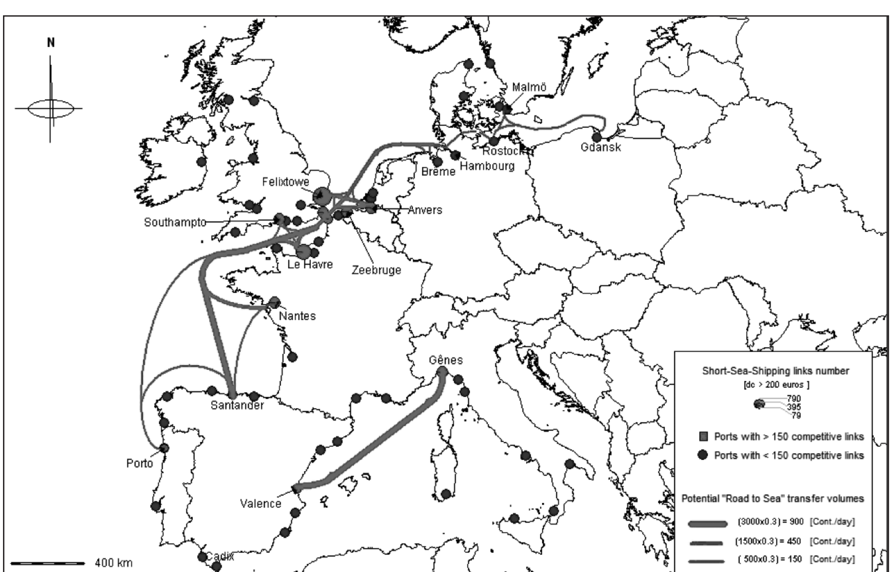
The model was applied to detect the combined transport optimal chains including the road transport and the Short-Sea-Shipping under costs criterion. To define the lines with high commercial potential we compared the "Road & Short-Sea-Shipping" combined chains between an origin city and a destination city, with the option of transport "All-by-Road" to the same couple of cities. The parameter of cost established for qualified links as "high competitive" is 200€. The freight's road to sea transfer was considered as the 30% of current road traffic. A systematically analysis was done for all the cities in our sample. The results show, in a first time, the ports' potential to absorb the freight flux currently transported by road. The ports with less than 75 potential links were considered as "not interesting", to develop the Short-Sea-Shipping lines. The ports with more than 75 links to develop the Short-Sea-Shipping appear in green colour. In a second time, we identified the more recurrent destinations from each "Highly potential port", in this way, we could defined the more interesting itineraries or "the lines of high development potential". The supposed transfer of 30%, give us a clearly idea of freight volumes to be absorb by the Short-Sea-Shipping lines proposed. In the next figure we can appreciate the global results of the analysis which demonstrate the viability of the lines in terms of costs.

Figure 2: The potential freight transfer from the road to the Short-Sea-Shipping in West Europe "Shuttle Lines of highly potential under the costs criterion".



Source: © H.Martell, CIRTAI, UMR 6063, CNRS, University of Le Havre, 2006.

Figure 3: The potential freight transfer from the road to the Short-Sea-Shipping in West Europe "Classical Short Lines with highly potential under the costs criterion".



Source: © H.Martell, CIRTAI, UMR 6063, CNRS, University of Le Havre, 2006.

The analysis of optimal transports chains or combined itineraries shows different results in function of the evaluation criterion. In the case of travel time criterion, we observed a several reduction of optimal itineraries in comparison with the cost criterion. As we said in 1.4, the travel time becomes a key factor to the development of the Short-Sea-Shipping. So, make improvements to diminish the maritime travel times are the priority for develop the Short-Sea-Shipping in a effectively way and to acheive the objectives of modal transfer of freight from the road to the sea. The precedent results were obtained considering the "ports passage". For that, we add twice the mean of 8h per port passage, and in the case of costs, the mean of 100€ /container 40' per passage. It is necessary to distinguish two kinds of Short-Sea-Shipping lines, the Roll-on/Roll-off for which the "truck" is the transport unit and the Lift-on/Lift-off for which the "container" is the transport unit. The Short-Sea-Shipping lines proposed in Fig.2 can to be developed in both modalities Roll-on/Roll-off or Lift-on/Lift-off, but it is recommended to use Roll-on/Roll-off in order to diminish the port's passage times, specially in the case of new lines.

3. The priority improvements for the short sea shipping

The Short-Sea-Shipping's activities need improvements in different aspects of the services. We consider that the main 4 improvements and their priority are: a) diminish the port passage costs and times; b) modernize the fleet; c) propose new services and differentiate them in function of shippers' need, and d) reduce the administration and the customs formalities. Each improvement needs special and more deep research works, in this paper we analysed the importance of the reduction the travel time as "the priority" to improve the competitiveness of the Short-Sea-Shipping services.

3.1. The currently status and the priority improvements

In the current conditions, the Short-Sea-Shipping transports of general freight have several unexploited potentials. In general, for the medium value cargo and the high value cargo, the Short-Sea-Shipping services are in fact condemned to stagnation in the modal split. As we saw the main solution to attract this kind of traffics is to diminish the travel times. What to do to diminish the travel times? What elements composed the travel? How to reduce the delays of these elements?

We consider that the Short-Sea-Shipping travel time is composed by the "Navigation time" and the "Port's passage time". So the reduction of travel times implies the reduction of both elements. We will focus on the navigation times and boats performances. The subject of "port's passage times" is another great problem for which the solution implies many factors as: labour laws in different countries, different labour costs between them, and the differences of cargo handling performances between ports in Europe. All mentioned aspects have to being the subject of future specific researches. We will continue with the definition of boat's performances necessities for emulate the road transport's performances about "travel times".

3. 2. The Short-Sea-Shipping' different services and the different needs of boats

The results of the highly potential lines were obtained in considering two kinds of services. The classical Short-Sea-Shipping service with rotations between many ports, and the shuttle services between two ports. In each case, the boat's needs are different. The classical service of Short-Sea-Shipping, needs ships with cargo's capacities of 500 -1000 TEU in order to transport and exchange the containers between all the ports of the rotation. The boats need to have an important stock capacity because more cargo capacity means more autonomy to serve a most important number of ports as well as the possibility of charging more goods in each rotation. But, more cargo capacity means less navigation speed and the more important travel times. About the boarding system, we find principally the boats Lift-on Lift-off (Lo-Lo) and rarely the boats Roll-on Roll-off (Ro-Ro) or with combined boarding systems.

In the case of shuttle modality the logic of operation is not the same. The principal interest is to serve the transport's demand between two ports in maintaining the frequency of the rotations in the shortness time. In the case of demand increase we can to affect another boat to the same line to double the capacity that we offer. In this case the cargo capacities may to be less important; the principal factor is ensuring a good the level of the service. It is the case of the ferries boats. Another case of the Short-sea-Shipping is the "dedicated services" as the case of "Airbus Maritime Logistics" between the different plane's factories along Europe. For this modality of shuttle, the fleet is principally composed of boats Ro-Ro and rarely of the ships with boarding' combined systems or of the ships Lo-Lo.

3.3. The necessity of "Fast-ships" to improve the competitiveness of Short-Sea-Shipping

The analyse results the transport chains "Road & Sea" in considering the travel time as comparison criterion, shows that the ports passage have an important impact in the total travel time. We consider the Short-Sea-Shipping total's travel time (SSS t) adding the navigation time between ports plus the ports passage's time.

$$SSS\ t = N\ t + 2\ PP\ t \quad [h]$$

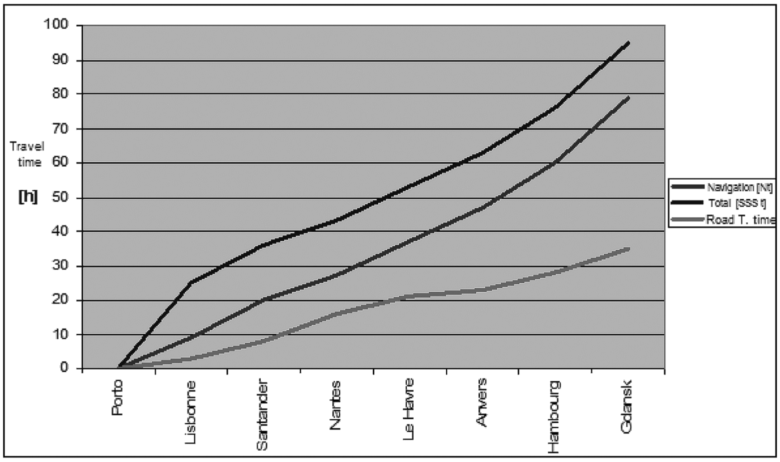
SSS t = Total travel time
Nt = Navigation's time
PPt = Port passage's time

For the navigation distances until 300 nm we have a mean navigation's time of 15h. The port passage in the case of containers on boats LO-LO has a mean time of 2x8=16h. In this condition the port passage represent 50% of total Short-Sea-Shipping travel time. As a first conclusion we can say that: "The Short-Sea- Shipping in the Lo-Lo modality is not really competitive for distances < 300 nm and only the Ro-Ro services will to be consider to develop lines to this very short distances. For the more important distances > 300 nm it become more competitive in function of the augmentation of distance. Nevertheless, even for the important navigation distances, the time of port passages represent a handicap to the Short-Sea-Shipping.

We can see on Figure 4 a comparative curve taking some representative ports in function of their distances to a hypothetical origin, we have chose "Porto" for appreciate the effect on the axis west-to-east. The two superior curves represented the time of navigation "Nt" and the port's passages "2xPPt". We can observe that with a speed of 20 knots, the competitivity of Short-Sea-Shipping decrease in proportional way of the distance increase. Otherwise, the increase of navigation distance reduces the negative effect of ports passage times into the total time of the travel "SSSt", but it rest no competitive.

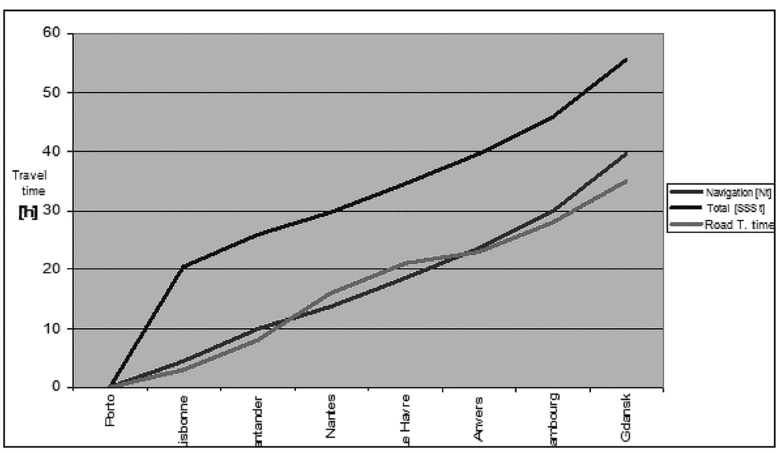
The Figure 5 show a curve which compares the Short-Sea-Shipping total travel time (SSSt), the navigation time (Nt) and the truck travel time (Rt). We can see the important delay of port passage in the Lo-Lo case. In the case of boats Ro-Ro the port's passage is reduced, we take a mean of 30min per passage. We can see that if the Short-Sea-Shipping' boats achieves the 40 knots as mean speed, the navigation times became almost similar than the truck travel times. In this condition, the Short-Sea-Shipping efficiency in terms of travel time is equivalent to the efficiency of road transport.

Figure 4. Comparative curve of travel times from Porto to some Ports in Europe in relation with navigation distances. With classical ships [mean speed = 20 knots]



Source: Authors.

Figure 5. Comparative curve of travel times from Porto to some ports in Europe in relation with the navigation distances. With high speed ships [mean speed = 40 knots]



Source: Authors.

If the Short-Sea-Shipping transport achieves the same levels of service, especially of the "travel time" than the road transport, the freight modal transfer from the road to the sea will have really chances to be done. In the opposite case, if the Short-Sea-Shipping boats continue to offer the current mean travel speed (20 knots) and the" total travel times" like at present, the freight modal transfer from the road to the sea is not really possible by lack of performance. We do not say that increase the travel speed of the boats is the magic solution to succeed the modal transfer because there are many factors involved, but we affirm that is a condition "without which the transfer is simply not possible".

The speed boat's improvements might to equalize the competition conditions between road and sea. The potential effects might to be highly positives on the development of Short-sea-Shipping in Europe. In regard of the shipper's interests, the Short-Sea-Shipping services will be absolutely competitive with "all-road" transport. In other words, it will be cheaper, with same travel times, trustable and regular. Of course, it will rest dependent of the port's passages, but boarding/disembark systems might to contribute to diminish this dependency of human and social factors.

In the next section we analyse the characteristics of the boats employed by the Short-Sea-Shipping services. This section shows the differences between boats' available and currently used in Europe. We will discuss about their capacities and the relation between the mean speeds, the load pay, the boat hull design and the energy consumption.

4. The boat capacities & the needs of speed

The majority of Short-Sea-Shipping boats operating in Europe are ferries aged of 10 - 20 years in the case of Ro-Ro services. In the case of Lo-Lo services the fleet is principally composed by port containers Panamax boats aged of 30 years or more. These Panamax boats are the recycled boats from the regular intercontinental lines. Today is necessary to ask us about the necessity of a new generation of boats specifically designed to the Short-Sea-Shipping. We go to begin by describe the characteristics of current fleet.

4.1. The boats characteristics of current Short-Sea-Shipping fleet in Europe

The ferry and "Roll On /Roll Off" services have an important role on the passenger and on a small amount of freight transport, such as the carriage of trailers, trucks and vehicles. The boats "Roll On /Roll Off" have the advantage of the fast loading /unloading and simple stowing and lashing. The only inconvenient is their need for more specific ship designs and the adapted port facilities. To this kind of boats, the ports need ramps to load the trucks or trains.

The general cargo boats with "Lift-on Lift-off" systems might to be classified in function of the kind of cargo, for example: palletized cargo, forest products, cars, bulks, liquid bulks or containers. These goods can be moved by units but the port' terminals need special docks and tools to handle them, warehouses, tractors, forklifts and trailers. In the case of containerized cargo, the port system should be capable to handle different units such as: containers ISO/UECI, cassettes, storage boxes (dedicated ports) and Roll trailers. A big inconvenient is the fact that with the exception to the first case, the named units are stored in the port because they cannot circulate outside it. Additionally, the terminal needs devices to board the goods from those units to a container or trailer and vice versa, e.g. cranes, straddle carriers, forklifts are some of these devices.

Table 2: The specialized boats adapted to the cargo.

Type of user	Ship Type
Containers	Cellular or multipurpose ship
Pallets	Conventional twin deck or multipurpose ship
Cargo on trailer	Ro/Ro or multipurpose ship
Big pieces	Heavy lift or multipurpose ship
Lighters	LASH ships
General cargo	Conventional twin deck or multipurpose ship
Perishable goods	Reefer ship

Source: "El transporte marítimo". R. Romero. Ed. Logisbook. 2002.

The Short-Sea-Ships are usually quite smaller than deep sea ones from aprox. 400 to 6,000 DWT. This is because the demand is weaker usually in short routes and the high number of short journeys requires smaller ships in order to reduce the port calls' time. There are several classifications regarding SSS ships reducing them to three main categories as: single-deck bulk carriers, container – feeder vessels and ferries. Further Marlow et al. (1997) proposed that specific size ships are the ones involved in the coastwise transport system, and even considering that things could change in the following years, they could be split in the following categories:

— Tankers and bulk carriers up to 13,000 GT and /or 20,000 GT
— General cargo or break bulk carriers up to 10,000 GT and / or 10,000 DWT
— Combined passenger / cargo ships and Ro/Ro between 1,000 GT and / or 500 DWT and 30,000 GT and /or 15,000 DWT.

4.1.2. Technical characteristics of the conventional ships Lo/Lo

This kind of ships can be used in SSS but also in pure feeder traffics. Their main characteristics from a global point of view are the small size, cellular holds, no derricks (gearless, but there are also geared units). The geared units use to have 2 turning derricks that could be an obstacle for the port operations and make the ship more expensive to build.

During the year 2000, there were 1050 Lo/Lo units within the feeder range (100 – 1050 TEU's) in the world.

The common speeds range from an average of 18 knots and exceeding the 20 knots with no operational or building costs, increase. A typical modern ship of these characteristics can be defined as follows:

— Capacity of around 500 TEU's.
— Hatch coverless and geared.
— 137 x 19,5 x 5 meters.
— 6,200 metric tonnes deadweight.
— Speed: 15 knots.
— 2 x 4,700 kW transmitted by 2 azipods.
— Consumption of 1.6 Tm per hour at 90% MCR.
— Building cost with derricks of around 25 M€.

Technical characteristics of the conventional ships Ro/Ro

The Ro/Ro or cargo ferries are units typically used for coastwise and island traffics, together with the SSS. The cargo handling in this type of ships is quicker than in Lo/Lo ships and thus cheaper. They require no derricks but only a ramp to easy the operative. These ships have shoal drafts in order to have no obstacles to sail through the channels. However, their capacity can be as far as half than other Lo/Lo ships of the same size, because cargo goes on wheels, losing space under and above those units. Additionally, some space is lost in the holds because their internal structures are thicker: frames, beams and webframes. Also, they need spaces to locate the internal ramps, lifters and accesses including the space between trailers. All these details make the Ro/Ro ships, a more expensive ship, as far as doubling the building costs per TEU unit of the Lo/Lo traditional ships. The short distance operation benefits Ro/Ro ships by lower port costs, compensating the higher constructive costs.

Figure 6: The Mono hull, Lo-Lo ship at Nantes.

Source: Gilbert Cailler.

Figure 7: Mono hull, Ro-Ro ship at Dunkirk.

Source: Acomimage.

The nowadays configuration of these ships, is based on a cargo space, distributed in 2 or 3 decks; to accept the trailers and rolling material. Their cargo capacity is measured in lineal meters to calculate the number of trailers to be carried (among 13, 14.5 or 16 meters long each). It is desirable that the cargo garage be squared with parallel rows to park the vehicles. They are equipped with ramps astern and sometimes ahead. The biggest ships have side ramps or even in the quarter, which allows them to be operated in the so called Mediterranean disposition. The port operation is carried out through tractors that can handle easily the rolling cargoes like trailers or roll trailers.

Figure 8: Mono hull, combined Ro-Ro/Lo-Lo ship at Le Havre.

Source: Agencies.

An example of modern Ro/Ro ship can be seen in the STENA RUNNER:

— 184 x 28 x 6,6 meters (only loading in the hold).
— Capacity of 370 TEU's or 2,700 lineal meters (185 trailers x 15 m.).
— Up to 1,000 TEU's on deck.
— Speed of 22 knots.
— 4 x 5.760 kW (23.000 kW) engines output connected to 2 shafts with variable pitch propellers.
— Flap rudders.
— 2 x bow thrusters of 1,000 kW each.
Hourly consumption of 4.6 tm at 90 % MCR.
— Cabins for up to 12 drivers.
— Building cost in 1998 of around 35 M€ (100,000 € / TEU).

The Ro/Ro–Ro/Pax series STENA TRANSFER (1977-1981):

— Length 151.9 / 184.6 meters.
— Beam 23.58 / 25.28 meters.
— Draft 6.37 meters.
— GRT between 16,776 to 21.162 LT
— Passenger capacity between 12 to 166 .
— Capacity of 2,500 lineal meters.
— Speed of 17 knots.

The Ro/Ro series MERCHANT (2002-2007):

— Length 180 meters.
— Beam 24.3 meters.
— Draft 6.5 meters.

— GRT 25,028 GT
— Capacity of 2,196 lineal meters.
— Passenger capacity 210 up to 550.
— Speed of 22.8 knots.

We are going to specify up to 5 different types of ships, susceptible to be used in SSS:

1) Barges of around 500 TEU's, sailing at 8-10 knots.
2) Conventional Lo/Lo of around 500 TEU's of capacity and 15-20 knots.
3) Ro/Ro (Ro/Lo or Ro/Pax) of around 250 TEU's and 18-24 knots.
4) Fast monohull Ro/Ro (Ro/Pax) of around 200 TEU's and ≥ 28 knots.
5) High speed catamaran Ro/Pax of around 100 TEU's and ≥ 28 knots.

4.2. The constraints of the relation between and payload capacities & speeds

A transport operator has the option of choosing between different types of ships to operate a Short-Sea-Shipping service, each of which has specific transport characteristics. The operator's choice is based on the type of cargo to be transported and on market demand. The maximum average speed of the ships that work on SSS services is 20 knots for conventional container ships and 23 knots for conventional Ro-Ro ships.

Table 3: The speeds according to the type of ship and the line.

Type of transport	Type of network	Type of ship	Speed
Interior maritime transport	Intra-European Net	Sea/river ships	10-12 knots
Conventional	Intra-European Net	Conventional (multipurpose, small oil tankers among others)	12-15 knots
Container	Fedder Net Intra-European Net	Conventional container	12-20 knots
Ro-Ro	Intra-European Net	Conventional ro-ro Fast ship (ro-pax) High-speed vessel (ro-pax)	15-23 knots 23-30 knots 30-40 knots

Source: Becker et al., 2004.

High-speed vessels are mainly used for passenger transport. Around 92% of the 1,600 high-speed European vessels only transport passengers. The remaining 8% are used to transport goods (in closed waters). The ships that combine passengers and vehicles include a space for cars and trucks which can also be used for the transport of goods (called Ro-Pax). To absorb an increase of goods in maritime transport, big ships could increase their cargo capacity even if this implies more time at port. The frequency of the service could be increased through new propulsion systems, new ship designs or more effective cargo handling. The main ships used in Short-Sea-Shipping are Ro/Ro, and have either passengers and cargo or only cargo. On short-distance routes, cargo and passengers are usually combined on ships, including transport vehicles with frozen cargo for which speed is the most important factor. For this reason, in recent years various HSC modes have been developed, above the cost criteria, which reduce the length of the trip by up to a quarter. The Ro-Ro ships have been characterized as having speeds greater than other types of ships. They usually cover relatively short distances on trips that take less than 24-30 hours. Most HSC have a tonnage up to 500 GT, some have over 2000 GT. This shows that HSC are not designed to transport heavy cargo loads. They are more appropriate for the transport of passengers and cars, due to their reduced cargo capacity. However, the most valid option for specific routes is that of combining passengers and cargo.

4.3. The high performances and more adapted boats

In this section we described some boats with the more adapted characteristics to put in operation on the Short-Sea-Shipping services.

4.3.1. The Fast Mono-hull Ro/Ro

The fast Ro/Ro ships, are generally ships developing speeds in above 28 knots and are becoming popular to be considered in coastwise and trans oceanic passages. Some of the main operational aspects are the increase in the hydrodynamic resistance and the generated height wave, as the ship's speed increases. The resistance depends on the wet surface size and shape. In order to reduce the resistance, the solution is to reduce the wet surface in the early stages of the ship's design, by means of different techniques. The displacement might be improved in modifying the hull shape like in the multi hull ships and using lighter materials and engines. The hydrodynamic elevation is another characteristic which is capable to improve the speed, the hull elevates slightly on the sea surface thanks to the air pressure or hydrodynamic forces. Within this category we can find the hydrofoils, hovercrafts or SES and WIG designs. These ships may reach the 50 knots even more in the hovercrafts case. However, these types of ships are limited by its operational cost to low deadweight, passengers and short distances. From the freight point of view, we only consider the displacement ships. As example we have:

The Blohm & Voss FM 147 Trailer Ferry (EMMA):

— Hull design in deep V, combining stability at high speeds and more width and space on the higher decks.
— 162 x 26 x 7 meters.
— GRT 17,300 LT.
— Deadweight 4,000 Tm.
— 2 engines x 16,800 kW in a single shaft.
— Maximum speed of 28 knots, but 25 knots at 90% MCR.
— 1,460 lineal meters or 100 trailers of 15 meters in 2 different beam decks. Single ramp astern.

— Cabins for 100 passengers.
— Consumption of 6.0 Tm / Hour.
— Building costs 49 M€ or 245,000 € / TEU (2.5 times the previous example).

4.3.2. High speed Catamaran Ro/Ro

The catamaran ships offer an ideal platform to build a Ro/Ro ship, because they are wide, relatively short and the deck is over the sea. The only major inconvenient is the fact that high speed is mainly efficient on passenger ships with a small capacity for freight. One of the most innovative design at their time were the STENA HSS 1500, based on the wave piercing designs during the nineties from INCAT builders, that in 1999 was selling the INCAT 96 (96 meters length) like the Millenium I and Alborán. As example we have:

The AUSTAL 112 TE freight – only hull catamaran:
— 112 x 25 x 3.6 meters.
— Deadweight 1,400 metric tonnes.
— GRT: 6,000 LT
— Capacity for up to 44 trailers or around 660 lineal meters.
— 2 x turbines developing 45,000 kW and water jets.
— Speed of up to 40 knots.
— Consumption of up to 9.9 Tm (hour).
— Accommodation for up to 48 passengers

Building cost of 45 M€ or about 500,000 € per TEU (ten more times than the Lo/Lo ship, 5 more times the fast Ro/Ro and double than mono hull).

The AUSTAL BENCHIJIGUA EXPRESS:
— 126.7 x 30.4 x 4 meters.
— Deadweight 1,000 metric tonnes.
— Capacity for up to 1,350 passengers and 727 lineal meters or 450 l.m. for trucks and 123 cars.
— 4 x 8,200 kW MTU 20V engines, totalling 32,800 kW.
— Speed of up to 40.4 knots with only 500 metric tonnes of freight.
— Propelled by three water jets and 2 bow azimuthally thrusters

4.3.3. The High Speed Craft as a best choice on the Short-Sea-Shipping

It could be considered that small ships operated at high speeds are less attractive than big ships that navigate at conventional speeds, due to the high cost of fuel and the construction costs. During the 20th century, the average speed of services has increased gradually. In fact, it has been shown that high-speed vessels can reduce loading costs. Speed minimises the storage time, which greatly decreases the total cost of the logistic chain, particularly for goods that must be delivered "just on time". In these cases, speed is an aspect of the quality of service. There are certain commodities and routes for which the higher cost of sea transport within an intermodal transport chain (due to legal systems, infrastructure differences or less developed transport vehicles) could be assumed by using more expensive transportation units such as high-speed vessels.

To define high-speed maritime transport we should consider all of the options for increasing the overall speed of transport. These options include higher speeds at sea, quicker operations and increased service frequency. In general, high-speed transport is basically undertaken with the high-speed craft (HSC) defined in the HSC Code. The introduction of high-speed ferries has created enormous market opportunities for vessel operators, designers and shipbuilders. An increasing number of ferry routes are served by high-speed craft, and new and larger HSC are expected to replace some of the existing conventional ferry capacity. Although these new routes can offer transportation benefits, they can also generate conflicts between the ferries and environmental and recreational interests. The advantages of the HSC are the increase in speed which reduces travel times, and the high frequency can minimise waiting times to users. The HSC may reach service speeds of 30 knots (56 km/h). The average speed of cargo trains into the European Union or long-distance road vehicles (considering the limits with respect to driving hours) is lower. The sea highway is free, while the road highways and the railroad need funding for construction and maintenance.

The disadvantages of the HSC are the delays at ports which are very frequent in many terminals, due to bad organisation and to the lack of appropriate equipment and installations. But this is an external problem depend of each port authorities. To develop successful high-speed maritime transport, appropriate port infrastructure is required to load and unload cargo rapidly. Other inconvenient is the cost of fuel used for this type of ships. In comparison with classical boats HSC are consume more energy and are responsible for highly pollutant gas emissions. They behave worse on the deep sea than conventional ships. High-speed ferries on many routes throughout the world have sparked numerous conflicts between ferry operators and environmental, coastal and maritime authorities. Conflicts have led authorities in many countries to require high-speed vessel operators to include in their operation permits an assessment of the effect of their navigation on the health of people and the safety of small vessels.

4.3.4. The More Recent High-Speed Ship Concepts

We will now describe the following concepts that have been designed for freight transport:
— PACSCAT
— Easyshift
— EHSVC
— FastShip

The PACSCAT design is a flat bottom (slender) catamaran that is suitable for high speeds and partly supported by an air cushion. It has a reduced draft, which supports a set of fans that enable it to approach the shore. The operational speeds are up to 40 Km/h (22 knots). This European project was initially developed by IMMA (UK). The hull is made of welded steel and connected to ducted propellers. No specific berth infrastructure is required. It is connected to ducted propellers. No specific berth infrastructure is required. It is sized of 135 x 22.8 meters. The dead weight is 2,200 metric tonnes and his loading system is combined Ro/Lo up to 160 TEU's

The EASYSHIFT® is an intermodal transport concept, using the existing port and river infrastructures. It have a Semi-submersible concept (sail on/sail off, so-so). This system avoids the shift from barges to ship, as it is a multipurpose ship that admits whatever type of cargo that would be contained on barges. The time of loading/discharge is relatively short (< 4 hours). The length needed is 15–18 meters. This catamaran design with 4.5 meters of draft and up to 6 big barges (2,000 to 2,400 TEU's) or 38,000 Tm of dead weight. The mean travel speed is around 20 knots.

The European High-Speed Cargo Vessel was developed by NAVANTIA (ex-IZAR) and Rolls Royce. The aim was to design a commercially viable ship for short distances. It is considered that HSC will gain market share due to the advantages in terms of costs, speed, service and reliability. The ship's operational cost on different routes with varying cargoes needs to be assessed in order to verify its commercial viability. However, the current cost of fuel has halted the project. It is considered that this vessel would be viable on routes between 300' and 800' with an 80% occupation rate and an average speed of 37 knots. The port operations could be undertaken on several decks at the same time. The ships shall have the following characteristics:

— High hydrodynamic and seaworthy performances.
— Garage: 1,700 lineal meters or 113 trailers of 15 meters.
— Dead weight: 3,000 metric tonnes.
— Service speed of up to 38 knots and 750' of range.
— Port operative time of only 3 hours.

The "Fastship" was designed to linking North America and Europe. This port gate-to-port gate service will enable door-to-door delivery times that are comparable to standard air-freight at half the cost. FastShip's initial North Atlantic service will operate between Philadelphia and Cherbourg, France. A commercial service on the North Atlantic is expected to begin in 2011. The "Fastships" have a capacity of 10,000 tonnes each. The ship will be capable of carrying container loads across the North Atlantic at 38 knots. It ensures a high degree of service reliability (98% on-hour port arrival). It needs a specialised terminal operation. This is the place where ship operations and inland transportation come together to create unparalleled savings in both time and cost.

4.4. The new generation of Short-Sea-Shipping' boats

Regarding the boat for Short-Sea Shipping, new generations talking about we must have in mind Requirement tat the customer demand for speed & Their volume charges. In fact, as commented previously, two types of high-speed transport ships for maritime Have Been Analyser:

— Container ships
— Ro-Ro and Ro-Pax ships with speeds of over 25 knots.

For this selection, after comparing the different types of vessels that are currently used, and criteria required by customers, we believe that the best option is to high-speed vessels applied for this type of traffic. However, in choosing a ship really effective for short sea shipping, we must recognize that depends largely on the volume of traffic related. In an era of cost reduction, implemented in all sectors, the shipping is no exception; the fall in traffic has been experienced in the last three years, and leaves us in serious commitment to these new challenges. This, once the current economic plight, perhaps make us thoroughly rethink the way we do this business, both to design efficient business model in all areas, among them the ability to adapt ships existing, or perhaps the need for new designs that meet the requirements of the shipping market. But we know that speed is not the only factor to consider, having studied the advantages and disadvantages of this type of vessel, it is very important capacity you have, and all the time in operations, and the ability port to handle this type of traffic, the speed for uploads and downloads, and the updating and standardization in document processes that facilitate the operations at ports and allow, that the time has earned in navigation, not congestion closed see only bring increased supply chain costs.

Given all these considerations, we find that a model ship and the European High-Speed Cargo Vessel, is one of the most suitable for these routes, as it is specially designed to cover short distances carrying large volumes. It's a good bet not only for its port operations in time (only three hours) but by its design, which blends the concepts of high speed, high load capacity and easily give services, for example, you can perform operations in several decks at once. It should be borne in mind that It is Considered That Would Be this vessel on routes viable Between 300 'and 800' with an 80% occupancy rate and an average speed of 37 knots, so as mentioned above, it is necessary to study economic viability of this project.

The new generations of ships, should be as similar, at least for now, this model explained, as it helps us to take into account many factors that have been identified as obstacles or disadvantages in previous models of ships, or the recent experience of short sea shipping and that are obtained from future studies. Standing in a changing market, as in the maritime business, and the evolution of naval and nautical engineering, any new development must be adapted to the demands of modern times, the requirements of each route in order to meet the expectations customers and keep up the circumstances, respecting the factors of sustainability and environmental friendliness, which are essential for sustainable development and sustainable development of a system. Perhaps these new designs will light we now consider alternative bio-fuels, to achieve ultimate combat to the emissions' problem, major reason for this type of transport, achieving efficient development of a transportation system that allows the benefit of all stakeholders, including in the main: The environment & the respect to the planet.

5. Conclusions

The Short-Sea-Shipping is a competitive mode of transport and it can to take a more important place in the European modal split. It can to take an important part of fluxes currently transported by the road transport. But it is not really competitive anywhere. The highly potential links of Short-Sea-Shipping have to be more studied and to exploit in function of their own particularities of potential demand. In fact, the real success of the Short-Sea-Shipping consists in taking more flux from the road transport. Principally of “more elaborated” and “high valued” goods’ traffics, and not only the traffics of bulks. The Short-Sea-Shipping services for special industries and the Ro-Ro services, have a good progression, but if the Lo-Lo traffics are not developed, the modal transfer “from the road to the sea” at the European scale is simply not possible. The Ro-Ro modality has more success than Lo-Lo services because the travel speed is higher and the port passage is quickly. This conditions need to be equalized, or at least, their differences have to be diminished.

As a first conclusion about the kind of boats the best adapted for Short-Sea-Shipping services, we can say that for the distances of less than 300nm is not really useful to employ the Lo-Lo boats. In this case the configuration Ro-Ro is the more adapted. Of course, the utilisation of the Ro-Ro boats for distances > 300 n.m. is recommended too, but the operation costs are more important than the same services with Lo-Lo boats. About the operation of the service, the shuttle modality is recommended for increase the competitively of the services. For the nautical distances of more than 300nm the Lo-Lo boats are in general more appropriate. Nevertheless, the port’s passage times may put the Lo-Lo services “out of competition” against the road transport; it is a problem to solve in local way. So the utilisation of Ro-Ro boats may to be better on some highly potential links with important distances between ports but with the disadvantage of diminish the load pay in comparison with the Lo-Lo boats. The highly potential shuttle links and the classical lines were defined in this work. The next step before the implantation of new lines or new services is to study the particular conditions of ports in each case.

The utilisation the most convenient of the Lo-Lo boats is on the classical lines modality of the Short-Sea-Shipping, touching several ports and covering great distances into a rotation. For this modality of services, the port passages diminish in highly important way the competitive of the boats in terms of the travel time (until 100% of navigation time for the 300nm distances). But a mean speed increase at 40 knots can relieve this external disadvantage of the Short-Sea-Shipping. Finally, if we accept the necessity of the travel time reduction and the increase of the boat’s mean speeds, there are two ways to succeed the diminution of “travel time” and the competitiveness improvement. The first way is to affect the more adapted kind of boat to the specific link of Short-Sea-Shipping in function of their own potential demand, their distance between ports and their modality of operation (shuttle or classical line). The second way is to renew the fleet with boats specifically designed to the Short-Sea-Shipping. Why not to think to the design of the new generation of Short-Sea-Shipping’s fast ships?

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Nautical Web-Based Asynchronous Training Environments: Student Motivators

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ABSTRACT

This study examined the relationships between various characteristics college student, and the ones from Nautical in particular, against the advantages and disadvantages perceived by the students, to access an online course. We have been trying to find indicators that allow us to help those nautical students who are not able to face courses and their only alternative is to make distance learning in the form of online courses.

In this paper we propose asynchronous format courses, successfully tested at the University of Texas at Arlington. This University has worked with the University of La Laguna to try this kind of on-line course in the teaching of postgraduate scope of the simulation.

Students have accessed to course materials of theoretical presentations in classes, practical exercises of the engine room and cargo handling simulator which are installed at the ETS Nautica, Máquinas and Radioelectrónica Naval of the University of La Laguna. Those are stored on the server school, with the advantage that students can access them anytime and anywhere.

The data presented in this study provides supporting evidence of support online courses applied to both Graduate and Master studies and research, but especially for those professionals who have to perform, in Spain, the professional training and update business cards, and who obviously for the reasons of working in the world of the merchant marine, away from the inflexible schedules classes, would be the ideal profile of the students who could perform this type of course. And, points to attitude as a possible predictor of student success in this environment.

1. Introduction

Major corporations and institutions responsible for professional training of Merchant Marine are rapidly developing Degree and Postgraduate programs in the virtual world of the Internet, that allow students Nautical Schools reconcile their academic studies with their professional skills.

The Superior Officer Training Merchant Marine in Spain has always been twofold, academic and professional. It is our duty to seek a balance between both aspects.

The first wave of courses was well received mainly by students limited by distance, work and life commitments to continue their studies. Most students in this category saw the possibilities of finishing their college degree or mandated professional training as the end that justified the means without truly assessing the prerequisites they needed to have to successfully "attend" classes in cyberspace, nor quite understanding the differences between the face-to-face courses and this new non-traditional approach to classes.

A couple of years after the newness of the concept wore off, educators, administrators and even students are starting to ask the right questions; how convenient, feasible and truly adequate is distance learning? Are online courses meeting the academic standards of the institution OMI? But even more importantly, in a perfectly designed and implemented online course, are all students equally able to successfully complete, enjoy and even thrive in this new course environment? This article presents the findings of a study that help answer some of these questions.

2. Development

2.1. Background

The Internet provides a viable medium for the delivery of course, curriculum to students and workers in need of contin-

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uing education or dated training that will keep them current in this competitive job market of the Marine Merchant. Internet's lower connection costs, faster speeds and higher data transfer rates, make textual and multimedia course content, delivery viable and accessible to more people than ever before. According to the Pew Research Center, 73% of American adults use a computer and of these 128 million use the Internet and the numbers are steadily increasing. In Spain, according to the new report '*Youth Portraits*' series, the Cabinet of Sociological Research of the Basque Government, regarding the use of youth to the media, 96 percent of young people use the Internet, the most daily and mainly for entertainment and training.

Distance education, as defined by the National Center for Education Statistics (NCES) (U.S. Department of Education, 2001), is instruction or training courses delivered to remote (off-campus) sites via audio, video (live or pre-recorded), or computer technologies, including both synchronous (simultaneous) and asynchronous (not simultaneous or delayed) instruction. And the Higher Education Act defines distance education as an educational process where the student is separated in time or place from the instructor. During the 2010-2011 academic year 56% of all 2 and 4 year degree-granting institutions offered distance courses.

And among these institutions, 90% offered asynchronous web-based courses. Furthermore, of these institutions and others planning to offer distance courses within the next 3 years, at least 88% are planning on increasing and/or offering for the first time asynchronous web-based courses as the primary mode for their distance education courses.

Distance education courses with hybrid modalities of content delivery are rapidly being developed at universities all over the world. Course content in textual and multimedia format can now be organized, stored and delivered over the Internet either: 1) synchronously – trainees/students and educators "meeting" in cyberspace at a pre-arranged time; 2) asynchronously – pre-recorded lecture videos and other materials being accessed at a time more convenient to the student; or, 3) hybrid – a mixture of synchronous and asynchronous delivery of text and multimedia where some of the lectures are delivered "live" and others "pre-recorded". Still, basic communication tools and other text media within all these online environments maintain their same synchronous "feel" in the chat-rooms and asynchronous "feel" in the bulletin boards, email, course notes, tests, and handouts.

Currently one of the biggest challenges educators and institutions face is determining the appropriate design and development of effective online courses. No data exists to unequivocally support the assumption that online courses are more effective than face-to-face instruction, nor that both environments are as effective. Still, the assumption that both environments are as effective is generally accepted as so (Wilson & Hood, 2000).

Given the lack of supporting data we set out to determine student characteristics and factors that could help determine and even predict students' preferred classroom environment between the face-to-face in the classroom, the web-based classroom environment classroom environment. Our study did not find any predictors in the demographics collected from the students but did find that attitude may yet be the key factor when predicting a student's preferred classroom environment.

2.2. Use of simulators in the training of Merchant Marine

The Spanish and international legislation on simulators and their use in the postgraduate training of Merchant Marine professionals is scarce and doing a brief review of the citations in the last ten years, we found only thirty references.

The FOM/1415/2003 order, in its Article 2.4.4., Relates the use of simulators and its reference to the International Convention on the International Maritime Organization STCW training and watchkeeping, in particular paragraph and AI/12 regarding trainers refers to paragraph AI / 6. Rule I/12 indicated the use of simulators for mandatory training of officers in the Merchant Navy simulator and the evaluation and demonstration of continued proficiency and simulator required by STCW code.

The Spanish law regulates, by Article 23 of RD 973/2009 of 12 June, the professional qualifications of the Merchant Marine, which states that to obtain them will need to pass a specific test of professional competence shall come well established for the exercise aboard the privileges of the regulating professional titles cited RD. The Spanish law regulates, by Article 23 of RD 973/2009 of 12 June, the professional qualifications of the Merchant Marine, which states that to obtain them will need to pass a specific test of professional competence shall come well established for the exercise aboard the privileges of the regulating professional titles cited RD. These tests of professional competence is limited to verify the exact and complete knowledge of the competences set out in Tables II / 1 and II / 2, III / 1 and III / 2 and watchkeeping standards contained in Chapter VIII the STCW Convention and the STCW Code, and ascertaining, through simulators of navigation, engineroom or SMSS, that the candidate provides the appropriate response to various situations that may arise in the course of watchkeeping.

The application of simulators in training graduate Merchant Marine, tries to mimic the behavior of a complex system or changes to certain stimuli. Therefore, currently this imitation of the real system is usually performed through digital simulation. Thus, we can define simulation as the technical development and implementation of a model of a real system to study their behavior, without breaking into the environment of the real system, namely simulation is the discipline of designing a model a real system, the implementation of that model, usually on a computer and analyzing the output produced during execution. A simulator is just the computer that simulates the system.

The concept of digital simulation and simulation capabilities have evolved in recent years in step with the evolution of both software and hardware of computers.

Regardless of the Spanish and international standards, simulation is essential because unless experimentation with a real system, simulation is the only way available to the Merchant

Marine Officer for the analysis of different complex systems with arbitrary conduct, where analytical techniques do not provide solutions.

Both in Nautical Engineering (Deck Officer) and the Marine Engineering (Officer Machines) simulation allows us to answer questions like What if? (Science: application of a direct problem) and what do I get? (engineering: application of an inverse problem), anticipating the behavior of the system under different situations, evaluation of performance and especially experience under conditions of operation, repair and maintenance that could be dangerous or high economic, social and environmental costs in the real system.

The usefulness of simulation in studying graduate of the Merchant Marine is useful because the real system can be dangerous, can be hardly available, the time constants of the system are not compatible with the professional. Simulation allows us to accelerate or retard the experiments as it suits us. It also allows us to access all the variables of the model and manipulate the model out of range safely.

Traditionally, simulation has been used in the design or improvement of systems and education, expanding and updating the knowledge of the system. In this case it has been used as a training room staff process control in nuclear power plants, thermal, petrochemical, paper, planes, bulldozers and of course as training complex systems of merchant ships: navigation, maneuvering, engine rooms, cargo handling, inert tank, and fire safety.

Thanks to simulation programs, students can not only receive knowledge passively, but above all, interact with models. For graduate studies and postgraduate Merchant Marine, we have commented that it seems clear that we must find a balance between the educational achievement of all media assets available in any medium and the use of materials of different nature, and the use of classroom virtual and conventional classroom learning, in one case as in the other, under the direction, guidance and expert teaching professionals and Merchant Marine supervision. In this project we considered that this balance to be maintained in graduate studies is not ideal to meet a professional postgraduate studies in the Merchant Marine way.

3. Methodology

This study was conducted on the students enrolled in a course at the Nautical School of the University of La Laguna. The course is taught over the Internet through a password protected site designed using Moodle platform (also known Learning Management System). Although students have the choice of meeting on campus 3 times during the semester for question-answer sessions, students still have to rely completely on the materials posted on-line to listen and view the professor's lectures and to complete the course requirements. For purposes of this study, the course is being taught completely as an Asynchronous Online Course.

In this study, data has been gathered for the past 3 long semesters, through surveys given to students at the end of every semester. All students in this study were enrolled in the same course with the same professors, the same class format and the same technologies. The professors have consistently received high marks in student evaluations for the past 10 years and are very highly regarded within the department. Careful planning went into minimizing the effects of "environmental" variables such as teaching quality, course being taught, and methodology, to ensure that the study results would be meaningful.

Semester after semester, students were given the same surveys to find out not only demography information, but also information on their learning styles, personality type, experience and attitude towards technology, and class format preference. Because of problems with missing data and invalid data being entered in the surveys, the study was extended past the initially intended semester.

With every semester new ideas were implemented to make the surveys more reliable. First, the paper-based surveys were converted to electronic format, posted online and directly connected to a database at a school website to minimize human error in the data tabulation process. The following semester, JavaScript code was added to key fields in the surveys (id, sex, age, computer experience and class format preference) to ensure a minimum of fields were filled before the surveys were submitted, and that crucial fields like id were available to link data collected in all 4 surveys.

Finally, in a subsequent semester, JavaScript code was added to all surveys' fields as the missing data problem was making other results highly unreliable. The whole site, where surveys were posted, was also made password protected to ensure only students enrolled in the course under study were able to access the surveys. After 3 semesters enough complete records were gathered to ensure reliable results would be reported.

The attitude towards technology (TAT) was measured using a modified version of Christensen's (1997) 10 paired-semantic differential items in 9 different areas of technology or subjects (computers, using computers for my professional productivity, using the World Wide Web, electronic mail, streaming video, V-Tel classes (All-In-One Telepresence Systems for Business and Education), on-line asynchronous classes, online synchronous classes, on-campus classes). Although the semantic scales were grammatically the same and also arranged the same as first designed, the topics were adapted to fit the needs of the researcher in the context of this study. From each attitude scale a single measure was created by computing the vertical mean response across the 10 pairs of semantic items for each subject. Cronbach Alphas computed on each measure ranged from 0.9228 to 0.9798 indicating reliable construct according to DeVellis (1991) proposed reliability guidelines for research instrument scales, and therefore legitimate to use these scales as predictors and measurements.

4. Population

The graduate level course under study enrolls an average of 30 students every semester. At this point of the study a total of 96 complete records from 96 students have been collected, over a period of 3 long semesters. All 96 students have been admitted to a graduate level program. 21 students are in a PhD program, 14 are in a Master's program and 61 is in a professional certification program. Students' age ranges from 22 years old to 56. They live anywhere between 1-2 miles to campus (live on city of the campus) to up to 60 miles from campus. There are 74 males and 22 females. 47 students work part-time and 49 full-time. Of the 96, 41 are part-time students and 55 are full-time students. 69 students are single and 27 are married. Of the 96 students, only 24 students reported having children still living at home. As far as dependents (elderly parents and/or children and excluding self or spouse), 50 students reported no dependents living at home, 16 reported 1 dependent, 17 reported 2 dependents, 7 reported 3 dependents and 3 reported having 4 dependents at home. Overall, for class format method: 60 students preferred the face-to-face in class format method, 30 students chose the online asynchronous class format as their preferred method, 5 students chose V-Tel and only 1 student chose the synchronous class format (after experiencing the environment very briefly in the semester).

5. Results

In this study, the measures created from each attitude scale were used to classify subjects as to their choice of preferred class instruction method between the face-to-face traditional class format (TF) and the asynchronous online class format (AF). An ANOVA (ANalysis Of VAriance) was performed on each measure to determine whether there was a difference in the mean of the measure on those subjects preferring TF and on those preferring AF. Three measures V-Tel classes (VT), online asynchronous classes (OAC), and on-campus classes (OCC) had significant ANOVA F-tests. These three measures were then used as independent variables in a discriminant analysis to predict preference between TF and AF. The analysis yielded a significant (Wilks' Lambda=0.547, p=0.000) canonical discriminant function:

$$f(x) = (0.343 \times VT)+(0.918 \times OAC)+(0.605 \times OCC)+0.150$$

The function was evaluated at the mean values of each of the independent variables, yielding the group centroids of –0.693 for AF and 1.163 for TF. These centroids were then averaged to produce the cut point, C=0.235, used in the classification process. If $f(x)>C$, then the subject was classified into TF as the preferred class format and if $f(x)<C$, the subject was classified into AF as the preferred class format. The discriminant function classified the subjects correctly 86.7% of the time.

6. Future works

Regarding at the Student Motivators, additional data collected will be used to test the validity of this discriminant function as a useful instrument for classifying subjects as to their preference in class format depending on their response to attitude measures. The function will also be refined using the additional data. Also, the authors will continue to explore other types of measures, which may prove useful in classifying subjects as to their class format preferences.

With further testing and data collection, shipping companies, business and institutions both higher education and Marine Merchant may use this function as a predictor to help choose the "right" employees and subjects who would benefit from the web-based training as opposed to the face-to-face training.

7. Conclusions

— Training in Merchant Navy graduate is largely governed by international law, so it is essential to find a balance between academic and working life of the marine.
— The variety and number of complex systems that exist in the different types of ships making training simulators indispensable, as the merchant marine graduate will not be able to access all the scenarios that can offer such a simulation.
— Student motivation versus asynchronous online course format is superior to traditional education.
— When assessing professional competence of graduate of the Merchant Marine simulators requires compatibility professional practices on board ships such training simulation. We propose that the best way are asynchronous web-based courses.

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Analysis and Calculation of The Magnetic Moment of a Magnet Compensation for Type "A" Magnetic Needle

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ABSTRACT

Our aim is to renew the compensation system, which is been used until now, and was depending of the compensation magnets got from the market. These magnets have a relative power noted by the manufacturer and we have to calculate how many correctors we go to use as well as where to place them according to the deviations we obtain from balanced ship. With this paper, we show a new system to calculate the place of the compensation magnets but in reference to the magnetic moment of four compensation magnets, which will be placed in a plate and then turned appropriately in order to generate a complex magnetic field, which is been used to compensate the deviations of the magnetic compass.

Having this idea in mind, by different experiments and measurements, we have calculated the magnetic moment of one compensation magnet, and thereinafter inserted in a complex formula to calculate the combined magnetic field generated by four magnets.

1. Introduction

The compensation of the magnetic needles or magnetic compasses has been always carried out in the same manner. First the ship is balanced to the different courses starting from the North, and taking the true course and magnetic course at different specified steered courses. With those different types of courses are calculated the different deviations of the magnetic compass and the deviation table is constructed.

In the compensation process, after calculated the deviations, these are used to try to compensate, not to eliminate, to the maximum possible the errors that appear in the deviation chart, for which certain types of compensating magnets are used and at specific positions of them in the binnacle.

We intend to modify, in principle, the compensation system that has been used, implementing another system based on the magnetic moments of the compensating magnets instead of the relative power of them used today. This then, explains the method for calculating of that magnetic moment which will be used to calculate the magnetic field generated by four compensation magnets and the combination of them into a corrector plate.

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2. Methodology

Until the present moment, all we have had clear that compensation had to be made with hard and soft magnets. The hard magnets are those that show a great retentivity, and that compensation magnets were from a defined size of 25 cm in length, which could be of two different diameters, the largest of 1 cm and 0.5 cm smallest. They could be used invariably in the compensation of both longitudinal and athwart deviations. The produced effect: one transverse compensation magnet 1 cm in diameter compensates a number of degrees equal to a half of the number of the cell where it will be placed, i.e., half of degrees of the cell number where is located the corrector magnet. A athwart magnet of 0.5 cm diameter compensates for a number of degrees equal to one eighth of the number of the cell wherein the corrector is located. Moreover, following the same rule, the longitudinal magnets 1 cm in diameter or also called large, corrected an equal number of degrees that the cell number where it is located, while small or 0.5 cm diameter do in a quarter of the number of the cell where it is located. Longitudinal magnets being two, they correct more degrees than the athwart one which is only one (García de Paredes y Castro, n.d.).

The cells are numbered from bottom to top with the numbers 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 20. The compensating magnets which will keep closer to the magnetic needle, at No.

20, will never be less than twice the length of the magnet that is used to compensate the deviations (Gea Vazquez, 2003).

This was the system that has been long used to empirically compensate somehow the deviation errors of the magnetic needle, caused by various factors.

Another way to perform the calculation of compensation is usually to calculate a relative power P_r of the magnet that we will use in that compensation, that will give us in terms of absolute power where:

$$P_r = \frac{P_a}{H} \tag{1}$$

Being P_a the absolute power of the compensation magnet and H the horizontal component in the place where we will make compensation. As well, it can be calculated by placing a magnet in a particular numbered cell, for example at 18. The compensation magnet generates a needle deviation of a certain number of degrees. Placed like that we take the bearing of a distant point with respect to a new Ra (compass course) which will give us a D_a (compass bearing) of that point. Once defined the 1st bearing, we change, in the same cell, the polarity of the same magnet, which will produce a new compass course R'_a with which we will take a new compass bearing D'_a of the same previous point. The deviation produced by the magnet in that cell will be:

$$\Delta^{º}_{18} = \frac{D_a - D'_a}{2} \tag{2}$$

Having this in mind usually we proceed in calculating the cell in which we will place the compensating magnets being *n* the location cell where:

$$n = \frac{\Delta_n}{P_r} = \frac{\Delta_n . H}{P_a} \tag{3}$$

From where:

$$P_r = \frac{\Delta^{º}_{18}}{18} \tag{4}$$

With this, it is enough to provide the place where we should locate the compensating magnet or magnets of a particular power to correct a determined deviation (Gaztelu-Iturri Leicea, 1998).

From the above, we are trying to vary the empirical calculation of the compensation used until now, and define it as a calculation, theoretical in the beginning, which defines us the most accurate place and as effective as possible for compensation.

We all know that our compensation never came to a complete correction of the errors of the magnetic needle, but the needle will be only compensated to minimize the deviation it has, so when we talk about adjusting a magnetic needle we never can say that we have corrected it but simply that we have compensated it.

3. Development

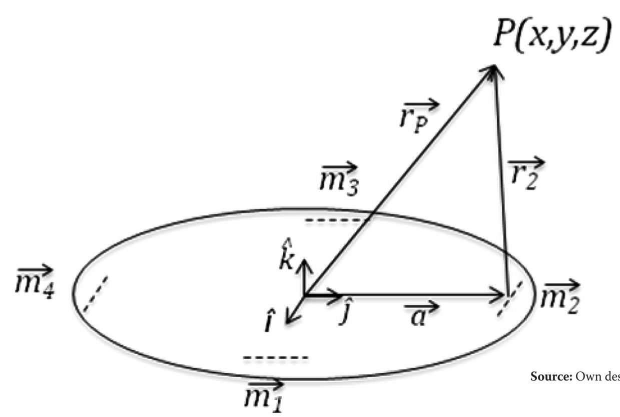
Therefore we have decided that perhaps we could define a more accurate system, and more in keeping with the times we live in, to determine the distance at which place the different compensation magnets. To do this we need to try to find a mathematical relationship that defines us that distance to magnetic compass and depending on what we will determine that.

After several readings of different bibliographies we have believed acceptable to use the formula which is written in the following paragraph (Reitz et al., 1996), which is defining that the magnetic field at a distant circuit depends only on the magnetic moment. This is clearly seen in the same book comparing the formula that will be used with other defined as (2-36) which is of the same form as (8-74) we use, where we can see that is of the same form as the electric field generated by an electric dipole, so named after magnetic dipole field.

$$\vec{B} = \frac{\mu_0}{4\pi}\left[\frac{\vec{m}}{r^3} + \frac{3(\vec{m}.\vec{r})\vec{r}}{r^5}\right] \tag{5}$$

To do this we look at what data we know $\frac{\mu_0}{4\pi}$ that have a value of 10^{-7} and other unknown data that are the magnetic moment *m* which is the magnetic dipole moment and radius *r* as the effective distance of the generated field. The new system that we go to study consists of 4 dipoles of the same size that will be used for compensation. So first we need to calculate the magnetic moment *m* of each of the magnets that we will use in the new prototype.

Figure 1 Schematic magnetic field calculation



Source: Own desing

We will use a cylindrical magnets which are made of AlNiCo alloy with specific dimensions of 40 mm length and 4 mm in diameter.

Now, instead of using the power to define the cell and thus compensate for the deviations of the needle, we will try to determine corrections depending on the magnetic moment of the compensation magnets and thus define at what distances these magnets can compensate the different deviations, and adjust the magnets to the compendium of compensation.

We define the magnetic moment of a single compensation magnet and determine the effect at different distances between compensation magnet, or dipole field, and the magnetic needle latter referred as another dipole. The determination of the straight magnetic moment can be performed in two ways: using a static method or by using the dynamic method.

The first method for determining the magnetic moment *m*, is based on the representation of the experimental values of the magnetic field created by the compensation magnet.

We perform different measurements of the basic magnet that we will use in the experience and we make it with a Hall sensor (Hall probe) by first performing transverse readings of the magnet in relation to its longitudinal position against the Hall probe.

We conducted a first approaching reading and give us the results expressed in the following table:

Table 1: 1st Test with 1 magnet. Longitudinal measurement.

d (cm)	B (μT)	
5	450	
7,5	135	
10	85	
12.5	95	
15	110	
17,5	130	

Source: Own source

We generate with this data and using a simple computer spreadsheet program, a graphic representation from which we deduce that in nearby and moderately distant magnet distances a distort is generated in the linearity of the readings that in principle is defined by excessive proximity, near magnet, and towards the end by excessive remoteness of it. Therefore, being able to be affected by an induced magnetism of metallic elements in the vicinity of the measurement.

We continue with a second measurement for better delineation and in an area were data shown more linear, as can be between 3 and 12 cm away.

Table 2: 2nd Test with 1 magnet. Longitudinal measurement.

	1ª lectura	2ª lectura	3ª lectura	
d (cm)	B (μT)	B (μT)	B (μT)	
3	3400	3350	3270	
4	1100	1100	1010	
5	450	450	430	
6	260	260	250	
7	170	175	163	
8	118	130	112	
9	95	100	87	
10	83	84	75	
11	80	81	70	
12	85	91	75	

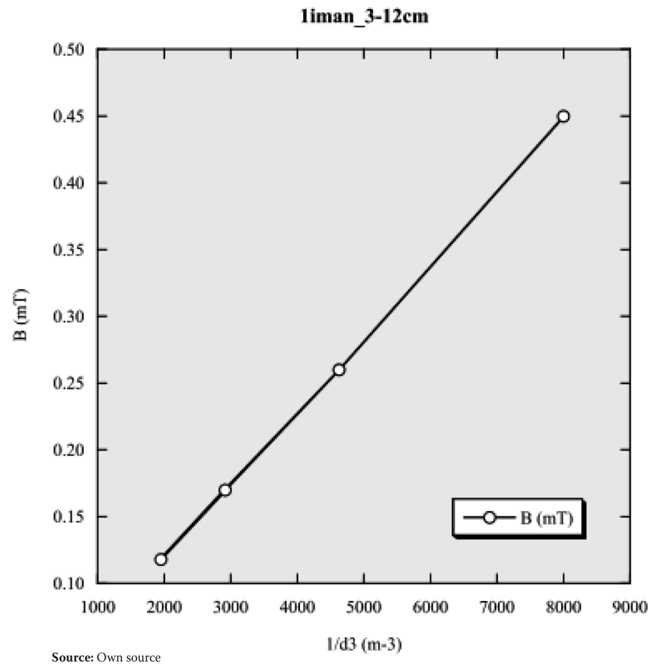
Source: Own source

From this second battery of measurements passed to the software to see its linearity and define the limits of the measurement were we found a higher linearity of the function.

Recorded the results, we see that has a higher linearity in a stretch between 5 and 10 cm of the measuring magnet, recording a more regular linearity than the values represented in other distances, closer and more distant, and be influenced by important factors of the linearity distortion.

All the readings are in nanotesla unit.

Figure 2: Graphic equivalent to Table 2.



Source: Own source

With the greater reliability section, defined between 5 and 10 cm, we proceed to make a new measurement every 1/2 cm and see the variation of the linearity in the sector defined as stable and linear.

Table 3: 3rd Test with 1 magnet. Longitudinal measurement.

	1ª lectura	2ª lectura	3ª lectura	4ª lectura	5ª lectura	
d (cm)	B (μT)	B (μT)	B (μT)	B (μT)	B (μT)	
5	457	450	450	452	450	
5,5	340	335	335	335	331	
6	282	280	260	252	264	
6,5	230	225	208	196	203	
7	180	190	165	170	173	
7,5	145	140	143	139	142	
8	120	120	127	120	123	
8,5	110	105	110	106	107	
9	98	95	101	96	98	
9,5	84	87	90	89	92	
10	—	83	83	84	85	

Source: Own source

From processed data transformed in graphical representation, the linearity in all of them is rather continuous, which shows that a general slope remains the same and of a value of 5.4×10^{-5} mT.m^{-3}, where the moment $m = 0.27\ Am^2$.

To verify that all this complimented may be correct, we decided to perform the same measurements at the previous distances but with 2 compensation magnet units to see if both, the linearity and the generation of the slope are common slope.

We conducted a test mode the next measurement with 2 magnets in the same values range previously determined ranging from 5 to 11 cm each half cm.

Table 4: 4th Test with 2 magnets. Longitudinal measurement.

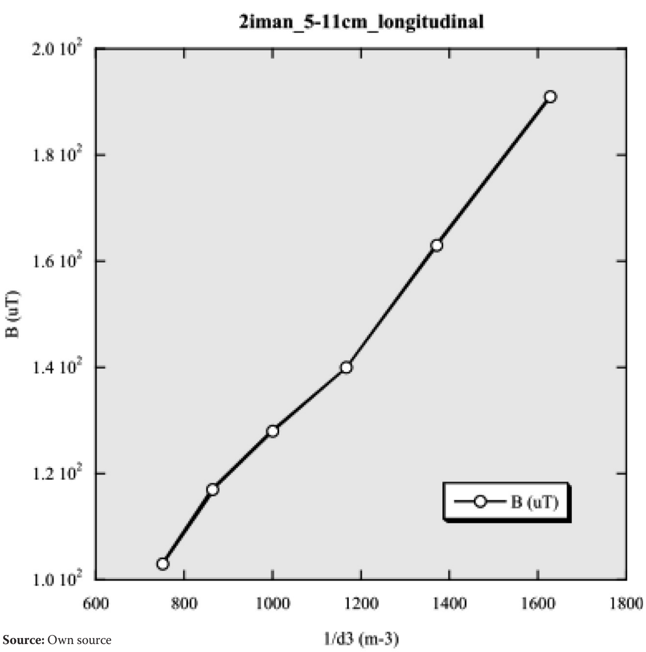
d (cm)	1ª lectura B (µT)	
5	1195	
5,5	830	
6	631	
6,5	475	
7	374	
7,5	284	
8	230	
8,5	191	
9	163	
9,5	140	
10	128	
10,5	117	
11	103	

Source: Own source

Having 2 compensating magnets, for measuring the field strength or what is the same the density of magnetic field, this is bigger, due to this we will take some additional measurement from further point defined in previous tests, i.e. from the maximum at 10 cm we go a little further and perform measurements up to 11 cm.

The first discrepancy we observe is that with a double magnet at the same distance, the reading doesn't indicate the double value of the measurement of a single magnet, a fact that leads us to doubt about the results. We can think that may be a displacement or off-set because the result is not linear in terms of measurement.

Figure 3: Graphic equivalent to Table 4.



Source: Own source

We proceed to the realization of the resulting graph with the data obtained and clearly see that movement is not an offset measurement but the measurements generate a different slope from the first comparison that has been done before with a compensation magnet. This recorded a value with a slope of 9.3 x10^{-5}mT.m^{-3} that indicates that it is more than double of the previous reading we have used as comparison, with what we believe the readings are affected by somehow environment in which we performed this measurements, by the effect of apparatus or by metal structures located in such an environment.

Anyway, to see if we are making measurement errors, we determined to make a new measurement with two compensating magnets but transversely, in which we assume that the measurement should be about half the value obtained in the previous measurement referred to as 4th measurement with two magnets.

In addition we define a distance reading between 4 and 10 cm every 1/2 cm.

Table 5: 5th Test with 2 magnets. Transverse measuring.

d (cm)	1ª lectura B (µT)	2ª lectura B (µT)	3ª lectura B (µT)	
4	617	654	630	
4,5	493	507	505	
5	387	389	410	
5,5	347	324	346	
6	300	280	298	
6,5	271	260	260	
7	243	234	230	
7,5	223	223	215	
8	218	202	200	
8,5	205	197	193	
9	198	185	193	
9,5	190	183	193	
10	187	190	180	

Source: Own source

We clearly see the results of the readings at the same distance, which should be about half value, no such relationship holds and makes us think without fear we are making measurement in a place with too much external magnetic influence, structures such as metallic tables, condition of electrical and electronic components near the measurement site etc. They are directly affecting the measurement readings.

We decided to carry out further tests in an environment where the external influence is zero talking about to the condition of the measurements. After several tests we decided that the triaxis utilization is expendable, so we proceed to make a measurement of one of the compensation magnets. For that, one of them is placed in the center of a goniometer (Figure 1), which is made of non-magnetic materials, by means of which the compensation magnet can rotate accurately on its center.

The goniometer has an angular resolution of 1 °, from 0 ° to 360 °. The field produced by the compensation magnet will be measured with a fluxgate magnetometer. The center of the goniometer, where the center of the magnet is placed, and the point of measurement have been placed from the point of measurement of the fluxgate at *r* distance. We have defined three distances *r* at what perform such measurements. These will be at distances of 164mm, 244mm and 325mm from the cen-

Figure 4: Fixing magnet on goniómeter.

Source: Own source

Figure 5: Positioning of the magnet relative to the fluxgate.

Source: Own source

ter of the compensation magnet or of the goniometer to the edge of fluxgate reader.

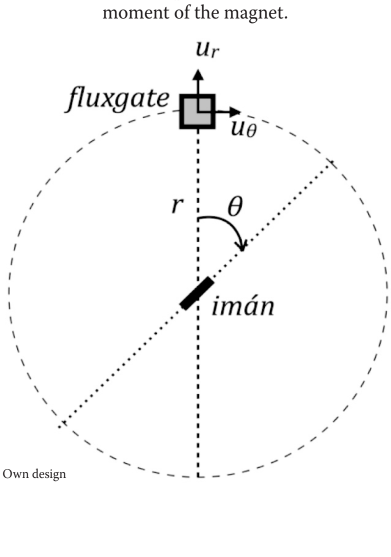
Initially we had planned; as we have indicated above, generate a cancellation of the ambient magnetic field surrounding, mainly terrestrial, but also any other that may be present in the test lab, using a triaxis Helmholtz coil system. Finally, and after considerable thought, it was decided that it would not be necessary, because we can consider the environment magnetic field as a constant and the information that matters most, and where the magnetic moment derived from, the various measures taken to make turn is obtained the magnet with the goniometer. Therefore, as shown in Figure 5, the Helmholtz coil system is not used more than for the fluxgate sensor placed in its center for measurement.

Moreover, we have that the components of the magnetic field *B* created by a moment *m* in a point (*r, θ*), in polar coordinates are:

$$B_r = \frac{\mu_0}{4\pi}\frac{m}{r^3}2\cos\theta \qquad (6)$$

$$B_\theta = \frac{\mu_0}{4\pi}\frac{m}{r^3}\sin\theta \qquad (7)$$

Figure 6: Calculation of the polar coordinates of the magnetic moment of the magnet.

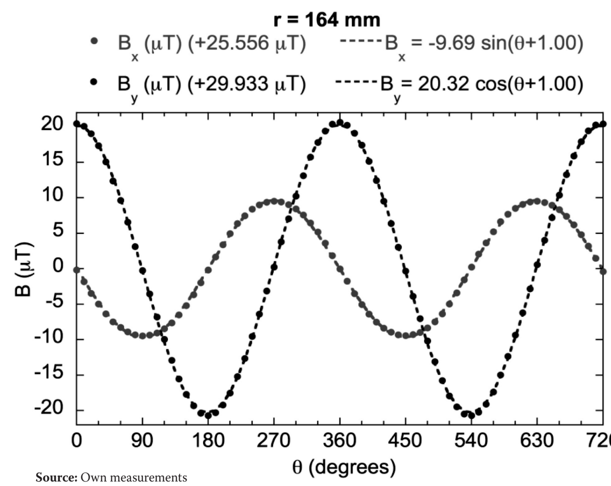


Source: Own design

In the approach of the experiment in the preceding figure (Figure 6) we can see the two components *B*, which are measured by the fluxgate in its *x* and *y* axes, for each angle of rotation of the magnet on the goniometer (considering their signs). A specific computer program was generated to collect data generated by the fluxgate.

We collect all the results obtained by placing the magnet at a distance of 164mm and translated with the program it will generate a diagram shown in Fig. 7.

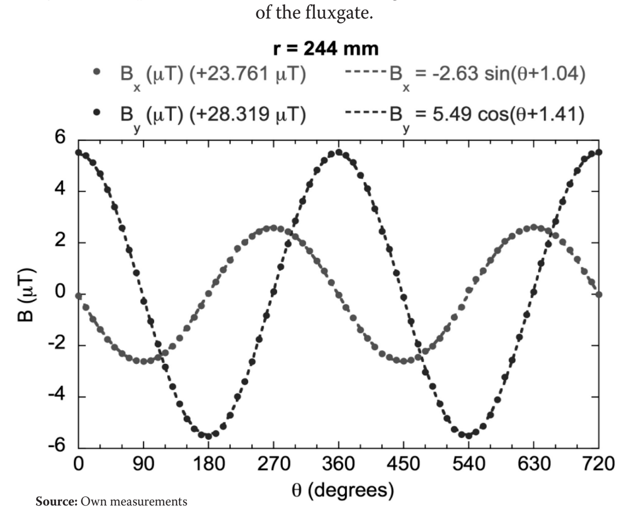
Figure 7: Graphic of measurements of the magnetic moment at 164mm from the fluxgate.



Source: Own measurements

Constant contribution is subtracted in both components. On one hand are represented the values from measurements at different angles of positioning the magnet with a certain symbol, represented by point. Moreover, the adjustment is made that

Figure 8: Graphic of measurements of the magnetic moment at 244 mm of the fluxgate.



Source: Own measurements

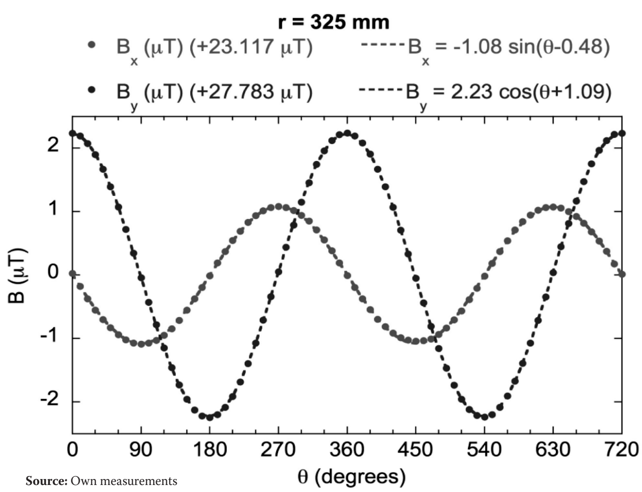
function generates a more homogeneous and lineal, for both sin and cos functions, shown in dashed lines. It is seen that the amplitudes of the field components are not exactly the double one of the other, as they should be according to the equations we handle (6) and (7). Calculating m with both expressions, and then calculating its mean value we obtain that $m = 0.44 Am^2$.

In the second measurement made at a greater distance, 244mm, we perform the corresponding readings, ensuring that the new situation improve over the previous one.

Making the necessary adjustments as in the previous graph and symbolizing the results in the same way, and calculating the mean value obtained for m we can see that the solution is $m = 0.39 Am^2$.

We conducted a third measurement for a refinement of the results, with which distance of 325mm from a meter of fluxgate we get the following chart:

Figure 9: Graphic of measurements of the magnetic moment at 325mm of the fluxgate.



Source: Own measurements

Performing as in previous measurements, adjusted, and finally calculated the mean value, gives us the result that the value of $m = 0.38 Am^2$.

With this final value we complete the measurement of the magnetic moment of the standard magnet that we will use to perform the compensation of magnetic needle that we will use for the prototype binnacle. We could further refine the distance, and therefore the moment of the magnet, but the variation from this point would be so small that we would enter the thousandths, which does little to adjust compensation.

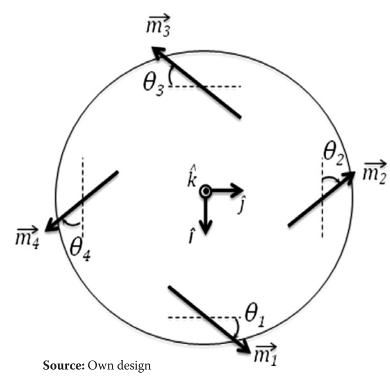
From this value we will calculate in the general formula of composition of the magnetic field generated by the combination of positions of four corrector magnets in a compensator plate.

$$\vec{B} = \vec{B_1} + \vec{B_2} + \vec{B_3} + \vec{B_4} \tag{8}$$

By having the single spin dipoles in the horizontal plane, we define the angles of the dipole relative to its initial rest position or all of them.

Finally if we calculate $\vec{B}$ Total magnetic field, according to the formula (8) we have the final equation of the total field generated by 4 dipoles:

Figure 10: Schematic of the initial position of the magnets and the turning of them.



Source: Own design

$$\vec{B} = \vec{B_1} + \vec{B_2} + \vec{B_3} + \vec{B_4} =$$

$$= \frac{\mu_0}{4\pi}\left\{\frac{m \sin\vartheta_1}{[(x-a)^2+y^2+z^2]^{3/2}} + \frac{3[m(x-a)\sin\vartheta_1 + my\cos\vartheta_1](x-a)}{[(x-a)^2+y^2+z^2]^{5/2}}\right\}\hat{\imath} +$$

$$+ \frac{\mu_0}{4\pi}\left\{\frac{m \cos\vartheta_1}{[(x-a)^2+y^2+z^2]^{3/2}} + \frac{3[m(x-a)\sin\vartheta_1 + my\cos\vartheta_1]y}{[(x-a)^2+y^2+z^2]^{5/2}}\right\}\hat{\jmath} +$$

$$+ \frac{\mu_0}{4\pi}\left\{\frac{3[m(x-a)\sin\vartheta_1 + my\cos\vartheta_1]z}{[(x-a)^2+y^2+z^2]^{5/2}}\right\}\hat{k} +$$

$$+ \frac{\mu_0}{4\pi}\left\{\frac{m \cos\vartheta_2}{[x^2+(y-a)^2+z^2]^{3/2}} + \frac{3[-mx\cos\vartheta_2 + m(y-a)\sin\vartheta_2]x}{[x^2+(y-a)^2+z^2]^{5/2}}\right\}\hat{\imath} +$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{m\sin\vartheta_2}{[x^2+(y-a)^2+z^2]^{3/2}}+\frac{3[-mx\cos\vartheta_2+m(y-a)\sin\vartheta_2]y}{[x^2+(y-a)^2+z^2]^{5/2}}\right\}\hat{\jmath}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{3[-mx\cos\vartheta_2+m(y-a)\sin\vartheta_2]z}{[x^2+(y-a)^2+z^2]^{5/2}}\right\}\hat{k}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{m\sin\vartheta_3}{[(x+a)^2+y^2+z^2]^{3/2}}+\frac{3[-m(x+a)\sin\vartheta_3-my\cos\vartheta_3]x}{[(x+a)^2+y^2+z^2]^{5/2}}\right\}\hat{\imath}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{-m\cos\vartheta_3}{[(x+a)^2+y^2+z^2]^{3/2}}+\frac{3[-m(x+a)\sin\vartheta_3-my\cos\vartheta_3]y}{[(x+a)^2+y^2+z^2]^{5/2}}\right\}\hat{\jmath}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{3[-m(x+a)\sin\vartheta_3-my\cos\vartheta_3]}{[(x+a)^2+y^2+z^2]^{5/2}}\right\}\hat{k}+$$

$$+\frac{\mu_0}{4\pi}\left\{-\frac{m\cos\vartheta_4}{[x^2+(y+a)^2+z^2]^{3/2}}+\frac{3[mx\cos\vartheta_4-m(y+a)\sin\vartheta_4]x}{[x^2+(y+a)^2+z^2]^{5/2}}\right\}\hat{\imath}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{m\sin\vartheta_4}{[x^2+(y+a)^2+z^2]^{3/2}}+\frac{3[mx\cos\vartheta_4-m(y+a)\sin\vartheta_4]y}{[x^2+(y+a)^2+z^2]^{5/2}}\right\}\hat{\jmath}+$$

$$+\frac{\mu_0}{4\pi}\left\{\frac{3[mx\cos\vartheta_4-m(y+a)\sin\vartheta_4]z}{[x^2+(y+a)^2+z^2]^{5/2}}\right\}\hat{k} \qquad (9)$$

4. Conclusions

Once calculated the field generated by the 4 magnets, we will calculate from what distance will begun to make effect, and therefore, from that point of initial effect, study how to combine the position of the 4 magnets with respect to its axis of rotation, we compensate for the different errors that appear in the previous study of the deviations of the magnetic needle.

The maximum effect of each magnet is when the magnet is perpendicular to the course at which we have to correct the deviation. Turning different angles of each magnet, the effect will be different, and as we know how the corrector magnet will affect to the magnetic compass needle, we can correct the different deviations at different courses.

This will be done, previously in a computer program designed for that porpoise with the formulae calculated above, and we can simulate the different combinations of the 4 corrector magnets till get the proper action against the magnetic compass. With this we will see the equivalent amount of degrees of angle is necessary to compensate each degree of deviation and what will be the effect over the deviations at other different courses.

The final interest is to facilitate to the seamen the compensation operation, with reliability to trust in the magnetic compass as a very effective navigational instrument.

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Positioning of Galician's Seaports Depending on Their Perceived Innovative Effort

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ABSTRACT

Since the introduction of competition and the application of the principle of financial sufficiency, Spanish Port Authorities have developed their business in a highly competitive environment. Against this background, and considering that the Spanish Port System may be oversized, it seems interesting to know the position of each Port Authority by analyzing its strengths and weaknesses. The objective of this study is to conduct a comparative analysis of the Galician Port Authorities in terms of the variable "innovative effort". First we analyze its strengths and weaknesses compared to the national situation and then we carry out a comparative analysis and benchmarking between the mentioned authorities

1. Introduction

Globalization has resulted in a spectacular increase in international transactions and freight. It has also required increases in the capacity and speed of the movement of goods, accompanied by a need for lower unit costs of transport. As a result, there has been a steady increase in the international merchant fleet, both in terms of the number and the size of vessels.

Additionally, the European Transport Policy has been committed to get freight off the road encouraging, as well as the rail transport, the Short Sea Shipping (further information is available in the Marco Polo Project).

All of the above calls for the emergence of new requirements for ports, raising the need to innovate. Therefore ports, if they are to be competitive, must be able to handle (process / load / unload / transfer) large quantities of merchandise quickly, to incorporate new activities and logistic services that add value and to adopt the new requirements. In addition, they must be able to incorporate other value adding activities and logistical services.

If countries wish to be competitive, they must have a port system that allows them to be part of international supply chains. In addition, each individual port must be competitive with the other ports operating within their national port system. Therefore, competitiveness and competition must be understood from two perspectives, international and national.

In Spain, the port system is state-owned. It comprises of 44 General Interest Ports, managed by 28 Port Authorities, dependent in turn on the Public Authority of State Ports within the Ministry of Development. Since the introduction of competition and the application of the principle of financial sufficiency, Spanish Port Authorities have developed their business in a highly competitive environment. Internal competition is mainly located within the same geographical zones (North coast, Mediterranean, etc.).

Furthermore, in the Spanish case, there is another factor which introduces an additional type of competition: the concession of competences by the State to the Spanish Autonomous Communities. This concession, together with the corresponding decentralisation of decision-making, generates competition for the institutional support within each of the Autonomous Communities. Facing that situation, and consid-

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ering that the Spanish port system could be oversized, knowing the position of commercial ports and their strengths and weaknesses may be interesting.

Ideally, the best option would be to do this analysis for each of the Spanish Port Authorities and based on different positioning variables. However, this is an ambitious goal that exceeds the scope of this study.

In this case, due to innovation is said to be one of the key drivers in improving social welfare and a crucial factor in the growth and survival of long-term business (Schumpeter, 1939; Baumol 2002), the variable "perceived innovative effort of the Port Authority" will be used for positioning.

Innovation, as it was stated in previous studies, is a highly important factor for port operations (Serrano et al., 2009; Blanco et al. 2010, p.72). Therefore, we consider innovation an important factor to analyse when positioning the ports. So, if it was necessary to select which Port Authorities should "survive" considering this variable, the most innovative Port Authorities or, what is the same, those who have made a greater innovative effort would be selected.

Moreover, due to internal competition mainly appears among ports that are geographically proximate, Galician Port Authorities have been chosen for the analysis. Selection of the Port Authorities analysed has been based on geographical proximity (they are located in the same watershed) and on their belonging to the same Autonomous Community. As a result they are potential competitors, even regarding the resources of their region.

Overall, the aim of this paper is to make a comparative analysis of the five Galician Port Authorities based on their perception of their "innovative effort". First we analyse its strengths and weaknesses compared to the national situation and then we carry out a comparative analysis and benchmarking between the mentioned authorities

In order to achieve the mentioned objectives, Rasch methodology will be applied to the data obtained from a survey conducted in 2009. Specifically, PKMAPs and Guttman Scalogram will be used. Further information about these techniques could be found in the previous study of Sánchez et al. (2012) that includes a brief explanation about these tools. The computer software used to process the data was Winsteps in version 3.75 (Linacre, 2012).

2. Strengths and weaknesses analysis

This paper is based on the findings of a previous study (Sanchez et al., 2010) in which a survey was conducted among the 28 Spanish Port Authorities, having response from 25 of them. Among other aspects, Spanish Port Authorities were asked about their perception about the innovative effort they had made in each of the areas included in the question (see Appendix I).

In the above-mentioned research, as well as checking the reliability and validity of the measures related to the construct "innovative effort of Port Authorities", items were ranked. Thus, the resulting list of items ordered from highest to lowest importance was as follows (Table 1):

Table1: Item hierarchy.

Position	Item Number	Item
1	P10-1	Strategic planning
2	P10-13	Contingency plans and security systems for protecting infrastructure and the environment
3	P10-11	Information systems and certifications
4	P10-12	Plans and Protection systems
5	P10-14	Projects and construction
6	P10-3	Port services
7	P10-15	Maintenance
8	P10-10	Environmental issues
9	P10-9	Quality
10	P10-16	Promotion and Sponsorship of scientific and technological R&D
11	P10-2	Human Resources
12	P10-4	Management of concessions and authorizations
13	P10-5	Sales and marketing
14	P10-8	External relationships
15	P10-6	Finance and economics
16	P10-7	Legal services and adminitrative management

Source: Adapted from Blanco et al. (2010).

Building on this previous paper, the current objective is to know what the main strengths and weaknesses from the five Galician Port Authorities are, in comparison with the Spanish total. It is based on their perception of the effort they have made.

One of the most interesting applications offered by the Rasch methodology is the PKMAP (diagnosis map) with identifies the strengths and weaknesses of a subject based on the hierarchy made by the total sample of subjects. The program performs a comparison between the individual assessment of each item and the general assessment of items made for all subjects, see (González Aponcio et al., 2012; Oreja-Rodriguez and Montero-Muradas, 2012). The five PKMAPs from the five Galician Port Authorities (A Coruña, Ferrol, Marín-Ría de Pontevedra, Vigo and Vilagarcía) are shown in Figures 1 to 5 which are included in Appendix II.

In the present case, the program will compare the scores that each subject (Port Authority) has given to each of the 16 items that make up the construct "innovative effort made by the Spanish Port Authorities" (see Table 1), with the average score given by the 25 Port Authority to each of items. For instance, if a Port Authority scored 5 to item P10-7, it would have a strength due to the innovative effort made by this Authority in that item is much higher than the effort made by the whole set of Port Authorities. By contrast, if a Port Authority scored 1 to the item P10-1, it would have a weakness, as its innovative effort is too small in an item in which, generally, the innovative effort made is larger.

The diagnosis map is divided into six quadrants in which different items are distributed depending on the response of the subject to each of them. The intermediate area represents the level of the subject. Items which are above that level are difficult for the subject. Those who are below that level are easy items. And finally, those in the shaded area are items placed in the subject's level.

Strengths are included in the upper-left quadrant. Moved to the current study would be activities in which the Port Authority makes a larger innovative effort than the average. Weaknesses, on the contrary, are included in the bottom-right quadrant. In the present study it would contain activities in which the subject is not doing enough innovative effort.

The five PKMAPs from the five Galician Port Authorities (A Coruña, Ferrol, Marín- Ría de Pontevedra, Vigo y Vilagarcía) are shown in Figures 1 to 5 included in Appendix II. In each PKMAP, strengths are in the upper-left quadrant and weaknesses in the bottom-right quadrant, as mentioned above. Results are summarised in Table 2 which includes those ítems which are strengths and weaknesses for the Galician Ports with respect to the national result.

Table 2: Galician Ports' Strengths and weaknesses with respect to the national result according to the PKMAPs.

Ports	Strengths	Weaknesses
A Coruña	Items: 1-5-7-8-13-14-16	Items 3-4-6-9-12-15
Ferrol	Items 2-3-5-8-13-16	Items 1-6-7-9-10
Marín-Ría de Pontevedra	Items 1-3-4-8-9-12-15	Items 10-13-14-16
Vigo	Items: 2-3-4-5-9-15-16	Items 7-10-11-13
Vilagarcía	Items: 1-4-7-14-16	Items 2-5-9

Source: Authors.

Additionaly, Table 3 includes, for each of the Port Authorities, the following three data:

— Measure: It represents the average value of the distribution (the three "x" which are in the PKMAP).
— Standard deviation (S.E.): the horizontal lines represent the average value plus or minus one standard deviation, showing the level of the subject (central strip).
— And score: it is the sum of the scores given by the Port Authority to all the items. The higher the value, the better position of the Port Authority.

Table 3: PKMAP information summary.

Ports	Measure	S.E.	Score
A Coruña	1.73	0.34	61
Ferrol	1.39	0.33	58
Marín-Ría de Pontevedra	1.06	0.33	55
Vigo	0.26	0.34	48
Vilagarcía	2.09	0.35	64

Source: Authors. From the "measure" values it can be seen that the best positioned Port Authority is Vilagarcía, followed by A Coruña, Ferrol, Marín and finally, Vigo.

However, we must be careful. We should not forget that the question is about "perception" of the innovative effort made in the last previous years (2004-2008) and, as a result, subjectivity exists. Therefore, results may be influenced by company size: a lower investment in a small port may be perceived as a big effort compared to another investment which is higher is absolute terms but relatively less important. Moreover the initial situation, which may be different in every port, is not analysed. Thus, a port which had previously done a big innovative effort has to do a lower effort and this is not detected in the analysis.

3. Benchmarking analysis

Once we had analyzed the strengths and the weaknesses of the five Port Authorities regarding the overall national situation, we will compare them directly among them. We will use the information provided by the Guttman Scalogram, another tool offered by Rasch Model.

Guttman Scalogram is a two-way table: each row represents the responses of one Port Authority and the columns represent the responses to each item.

Items are listed from left to right according to their global score, being the most important item in the left. Subjects, however, are listed from top to bottom, beind the best positioned Authority located on the top. After taking the data from the Guttman Scalogram, a benchmarking analysis was done.

In table 4, taking into consideration the scores given by the five Galician Port Authorities to each of the 16 items, which integrate the construct "Innovative Effort made" (data are not included due to confidentiality) and the information from the PKMAPs, the different strengths (S) and weaknesses (W) for each Port Authority are shown. In describing the results rows and columns from the Guttman Scalogram have been reversed. As a result the most important ítem is in the first row and the best positioned Port Authority is in the left column.

Table 4: Scores given to the items by Galicians Port Authorities. Stregthns (S) and weaknesses (W) with respect to the national result.

Items' hierarchy	ITEMS	VILAGARCÍA (3)	CORUÑA (6)	FERROL (7)	PONTEVEDRA (11)	VIGO (18)
1	P10-1. Strategic planning	S	S	W	S	
2	P10-13. Contingency plans and securitysystems for protecting infrastructureand the environment		S	S	W	W
3	P10-11. Information systems and certifications					W
4	P10-12. Plans and Protection systems		W		S	
5	P10-14. Projects and construction	S	S		W	
6	P10-3. Port services		W	S	S	S
7	P10-15. Maintenance		W		S	S
8	P10-10. Environmental issues			W	W	W
9	P10-9. Quality	W	W	W	S	S
10	P10-16. Promotion and Sponsorship of scientific and technological R&D	S	S	S	W	S
11	P10-2. Human Resources	W		S		S
12	P10-4. Management of concessions and authorizations	S	W		S	S
13	P10-5. Sales and marketing	W	S	S		S
14	P10-8. External relationships		S	S	S	
15	P10-6. Finance and economics		W	W		
16	P10-7. Legal services and adminitrative management	S	S	W		W

Source: Authors.

Overall, it can be concluded that Galician Ports are not bad positioned with respect to the national total. If we analyse the data, from the 80 scores (16 scores for each of the five ports) included in Table 4, there are 32 strengths (40%); 22 weaknesses (30%); and 26 cases (30%) which are not strengths neither weaknesses.

It can be highlighted that four of the Galician Ports have a strength in the item "Promotion and Sponsorship of scientific and technological R&D" (item 16). They are also well positioned concerning the item "External relationships" (Item 8). On the contrary, on the whole they are not well positioned regarding the item "Environmental issues" (Item 10) and they are even worse positioned concerning the item "Finance and economics" (Item 6). See Tables 2 and 4.

In addition, differences between the score of each Port Authority and the average Galician score have been calculated (Table 5). Positive values, which are shaded in green, mean that the Port Authority value is higher than the average. Negative values, which are shaded in pink, mean that the Port Authority value is lower than the average. The absolute maximum and minimun values for each item are written with a larger font size. Moreover, items are ordered according to the national hierarchy from the highest to the lowest importance.

Table 5: Score differences with respect to the Galician average.

	ITEMS	VILAGARCÍA (3)	CORUÑA (6)	FERROL (7)	PONTEVEDRA (11)	VIGO (18)
1	P10-1. Strategic planning	0.8	0.8	-1.2	0.8	-1.2
2	P10-13. Contingency plans and securitysystems for protecting infrastructureand the environment	0.4	1.4	1.4	-1.6	-1.6
3	P10-11. Information systems and certifications	0.6	0.6	0.6	-0.4	**-1.4**
4	P10-12. Plans and Protection systems	0.4	-0.6	0.4	0.4	-0.6
5	P10-14. Projects and construction	1.0	1.0	0.0	-1.0	-1.0
6	P10-3. Port services	0.0	**-1.0**	**1.0**	0.0	0.0
7	P10-15. Maintenance	0.2	**-0.8**	0.2	0.2	0.2
8	P10-10. Environmental issues	0.6	**1.6**	**-1.4**	-0.4	-0.4
9	P10-9. Quality	-0.4	**-1.4**	-0.4	**1.6**	0.6
10	P10-16. Promotion and Sponsorship of scientific and technological R&D	0.8	0.8	-0.2	**-1.2**	-0.2
11	P10-2. Human Resources	-0.4	-0.4	**1.6**	-0.4	-0.4
12	P10-4. Management of concessions and authorizations	0.6	-0.4	-0.4	0.6	-0.4
13	P10-5. Sales and marketing	-0.4	0.6	0.6	-0.4	-0.4
14	P10-8. External relationships	-0.2	0.8	0.8	-0.2	**-1.2**
15	P10-6. Finance and economics	**1.0**	0.0	**-1.0**	0.0	0.0
16	P10-7. Legal services and adminitrative management	**1.8**	0.8	-1.2	-0.2	-1.2

Source: Authors.

From the results included in Table 5, it may be concluded that Vilagarcía is the best positioned, followed by A Coruña, Ferrol, Marín and Vigo, as we already concluded with the PKMAP analysis.

Taking into consideration the five Galician ports, it is concluded that:

— Vilagarcía is the best positioned concerning items 6 (Finance and economics) and 7 (Legal services and administrative management) and it does not have any weaknesses. It scores above the average in 11 items and below the average in 4 items.

— A Coruña is the best positioned concerning item 10 (Environmental issues) and it is the worst positioned in items 3 (Port Services), 9 (Quality) and 15 (Maintenance). It scores above the average in 9 items and below the average in 6 items.

— Ferrol is the best positioned in items 2 (Human resources) and 3 (Port services) and the worst positioned in items 6 (Finance and economics) and 10 (Environmental issues). It scores above the average in 7 items and below the average in the other 7 items.

— Marín- Ría de Pontevedra is the best positioned in item 9 (Quality) and the worst positioned in item 16 (Promotion and Sponsorship of scientific and technological R&D). It scores above the average in 5 items and below the average in the other 9 items.

— Finally, Vigo is the worst positioned in items 8 (External relationships) and 11 (Information systems and certifications). It scores above the average in 2 items and below the average in 11 items.

The position of Vilagarcía, A Coruña and Ferrol is better in the Galician comparison (they have more strengths); whereas Pontevedra and Vigo worsen their strategic position with respect to the national comparison.

4. Conclusions

The present study analyses the positioning of five Galician Port Authorities: A Coruña, Ferrol, Marín- Ría de Pontevedra, Vigo y Vilagarcía. First the strengths and weaknesses of each authority over the whole of Spanish Port Authorities have been identified. Secondly, a benchmarking analysis was performed among the five Galician Port Authorities.

Overall the positioning of the Galician ports with respect to the other national Port Authorities is not bad, having strengths in 40% of the cases and weaknesses in 30% of the cases.

The best positioned is Vilagarcía, followed by A Coruña, Ferrol, Marín and, finally, Vigo. This classification is maintained both in the national and in the Galician comparison.

Vilagarcía, A Coruña and Ferrol are better positioned in Galicia than in the Spanish case, whereas Marín and Vigo are worse in Galicia than in the Spanish case, that is they are better positioned in Spain than in Galicia.

Overall, the Galician ports have strengths in "Promotion and Sponsorship of scientific and technological R&D" and "External relationships". On the contrary, they could have a weakness in "Environmental issues" and "Finance and economics".

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APPENDIX 1: Question 10

According to your point of view, and with reference to the last five years (2004-08), give a score between 1 (no effort) and 5 (extremely high level of effort) for the degree of effort to innovate that has been developed within the Port Authority in the following areas:

1	Strategic planning (business plan development, annual reports, planning for the use of port areas, objective monitoring, etc.)
2	Human resources (selection, training, internal promotion, labor relations, etc.)
3	Port services (the control of operations, the regulation of services, etc.)
4	Management of concessions and authorizations
5	Sales and marketing (Searching for new traffic, relationships with clients, carrying out studies, etc.)
6	Finance and economics (economic management, coordination and budgeting, internal financial control, etc.)
7	Legal services and administrative management (e-administration)
8	External relationships (corporate image, web, community relationships with the port and city communities).
9	Quality (quality systems and certifications, etc.)
10	Environmental issues (environmental impact, sustainability, waste management, certifications, etc.)
11	Information systems, communication and control systems (IT, telematics, cameras and sensors, etc.)
12	Plans and Protection systems (ships and port facilities)
13	Contingency plans and security systems for protecting infrastructure and the environment (port operations and services, monitoring and forecasting of environmental effects).
14	Projects and construction (the design and development of new infrastructure and port facilities).
15	Maintenance (the management of a preventive maintenance plan and a plan for the maintenance of infrastructure)
16	Promotion and Sponsorship of scientific and technological R & D within the port (agreements with universities or research centers, research grants and doctoral programs and the development of patents, etc.)

Source: Authors.

APPENDIX 2: Galicians Seaports Pkmaps

Figure 1: A Coruña Pkmap.

```
       Hard levels reached        -Higher-      Hard levels not reached
-----------------------------------------------------------------------------
|                                     4                                     |
|                                     |                                     |
|                                     |                                     |
| 16.4                                |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     3                                     |
| 14.5                                |                                     |
|                                     |                                     |
| 8.5                                 |                                     |
| 1.5  7.4  13.5                      |                                     |
| 5.4                                 |                                     |
|                                     |                                     |
|-10.5--------------------------------|-------------------------------------|
|                                     2                                     |
|                                     |                                     |
| 11.5                               XXX                                    |
|                                     |                                     |
|                                     |                                     |
|-------------------------------------|-------------------------------------|
|                                     |                                     |
|                                     |                                     |
| 2.3                                 1                                     |
|                                     | 4.3                                 |
|                                     |                                     |
|                                     | 6.3                                 |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     0                                     |
|                                     | 3.3  12.3                           |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 15.2                                |
|                                     |                                     |
|                                    -1                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -2                                     |
|                                     | 9.2                                 |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -3                                     |
-----------------------------------------------------------------------------
        Easy levels reached        -Lower-      Easy levels not reached

                         Each row is .13 logits
```

Source: Authors.

Figure 2: Ferrol Pkmap.

```
       Hard levels reached        -Higher-      Hard levels not reached
-----------------------------------------------------------------------------
|                                     4                                     |
|                                     |                                     |
| 2.5                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     3                                     |
|                                     |                                     |
|                                     |                                     |
| 3.5  8.5                            |                                     |
| 13.5                                |                                     |
| 5.4                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     2                                     |
| 16.3                                |                                     |
|-11.5--14.4--------------------------|-------------------------------------|
| 15.3                                |                                     |
| 12.4                                |                                     |
|                                    XXX                                    |
|                                     |                                     |
|                                     |                                     |
|-------------------------------------1-------------------------------------|
| 4.3                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 9.3                                 |
|                                     |                                     |
|                                     0                                     |
|                                     |                                     |
|                                     | 1.3                                 |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -1                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 7.2                                 |
|                                     |                                     |
|                                     | 6.2                                 |
|                                     |                                     |
|                                    -2                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -3 10.2                                |
-----------------------------------------------------------------------------
        Easy levels reached        -Lower-      Easy levels not reached

                           Each row is .13 logits
```

Source: Authors.

Figure 3: Marin - Pontevedra Pkmap.

```
      Hard levels reached        -Higher-      Hard levels not reached
-----------------------------------------------------------------------------
| 9.5                                 3                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
| 4.4                                 |                                     |
| 1.5                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     2                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
| 3.4  8.4  12.4  15.3                |                                     |
|                                     |                                     |
|-------------------------------------|-------------------------------------|
|                                     |                                     |
|                                     |                                     |
|                                    XXX                                    |
| 2.3                                 1                                     |
|                                     |                                     |
| 7.3                                 |                                     |
|-5.3--11.4---------------------------|-------------------------------------|
| 6.3                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     0 14.3                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 16.2                                |
|                                     | 10.3                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -1                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -2                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 13.2                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -3                                     |
-----------------------------------------------------------------------------
        Easy levels reached        -Lower-      Easy levels not reached

                                Each row is .1 logits
```

Source: Authors.

Figure 4: Vigo Pkmap.

```
      Hard levels reached        -Higher-      Hard levels not reached
-----------------------------------------------------------------------------
|                                     2                                     |
| 9.4                                 |                                     |
| 16.3                                |                                     |
|                                     |                                     |
| 3.4                                 |                                     |
| 15.3                                |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
| 2.3                                 1                                     |
|                                     |                                     |
| 4.3                                 |                                     |
|                                     |                                     |
| 5.3                                 |                                     |
|-6.3---------------------------------|-------------------------------------|
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    XXX                                    |
|                                     |                                     |
| 14.3                                |                                     |
|                                     0                                     |
|-8.3---------------------------------|-------------------------------------|
| 12.3                                |                                     |
| 1.3                                 |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 10.3                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -1                                     |
|                                     | 11.3                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 7.2                                 |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -2                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     | 13.2                                |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                     |                                     |
|                                    -3                                     |
-----------------------------------------------------------------------------
       Easy levels reached        -Lower-      Easy levels not reached

                          Each row is .08 logits
```

Source: Authors.

Figure 5: Villagarcía Pkmap.

```
       Hard levels reached        -Higher-      Hard levels not reached
------------------------------------------------------------------------------
|                                     4                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
| 7.5  16.4                           |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     3                                      |
|                                     |                                      |
| 14.5                                |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
| 1.5  4.4                            |                                      |
|-------------------------------------|--------------------------------------|
|                                     |                                      |
| 6.4                                 |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                    XXX                                     |
|                                     2                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|-11.5--------------------------------|--------------------------------------|
|                                     |                                      |
| 3.4  8.4                            |                                      |
| 12.4  15.3                          |                                      |
| 13.4                                |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
| 10.4                                |                                      |
|                                     1 2.3                                  |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     | 5.3                                  |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     |                                      |
|                                     | 9.3                                  |
|                                     |                                      |
|                                     |                                      |
|                                     0                                      |
------------------------------------------------------------------------------
        Easy levels reached        -Lower-      Easy levels not reached

                           Each row is .07 logits
```

Source: Authors.

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