A Discussion on e-Navigation and Implementation in Turkey

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ABSTRACT: Electronic navigation, which has great important for ship management, has taken a step with technological improvements. In the result of these enhancements, new systems appeared as well as existing systems and these systems began to be integrated each other or used data of obtaining from the others like that AIS, Radar, ECDIS etc. All these and likely future systems have been put together under the roof of enhanced navigation (e-navigation) is defined by organizations such as International Maritime Organization (IMO), International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), General Lighthouse Authority (GLA) etc. Especially IALA guidelines serve as model future applications in Turkish waterways. In this study aim to redefine e-navigation concept based on maritime safety awareness, maritime service portfolio (MSC 85/26) and discuss possible applications.

1 INTRODUCTION

e-Navigation is defined by *International Maritime Organisation (IMO)* as: *"The harmonised collection, integration, exchange, presentation and analysis of maritime information on board and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment,"(IMO-MSC 85/26).* As it is well understood by above given definition, e-navigation is a very complex and overall concept that needs to be presented with its components deeply. If it is considered with the new international discussions on safety of navigation, e-navigation occupies more important role as well. Many of International and national organisations such as MSC subcommittee under IMO, IALA, GLA i.e., lead to determine how it should be regulate in national or international level. So that, we can say there are two dimensions of e-navigation, namely; technical dimension and legal dimension. Technical dimension of e-navigation

consists of mainly charting, navigation and communication. A navigator needs various types of information under all of these main topics. We can classify these information as; Electronic Chart Display and Information System (ECDIS) data, aids to navigation (Aton) data, satellite and terrestrial systems data and GMDSS data. etc. It is easier to use these several information in a common pool as much as possible. In order to provide such kind of pool, integrated bridge systems (IBS) is built up. Together with IBS, some new requirements came along as well. For instance, different types of information need to be available for same processes. At this point, it has to be determined that what are the using instructions and deadlines of these new technical improvements. From this perspective, discussions about such kind of new determinations can be listed under the legal dimension of e-navigation.

2 LITERATURE SURVEY

e-Navigation is a very broad issue, so that there have been several studies under different topics related with e-navigation. These are about both theoretical and technical background of e-navigation. Especially, existed studies focused on ECDIS. For instance; A.Norris tries to help new entrants and experienced navigators make ECDIS work for them using accepted navigational principles (A.Norris). Hauke L. Kite-Powell, Di Jin and Scott Farrow explain expected safety benefits and cost of new technologies, such as electronic charts and integrated navigation systems (Hauke L. Kite-Powell et al, 1997). Capt. Robert Mercer, M Blair Hong and Capt. Douglas Skinner compare ECDIS against paper chart navigations (Capt. Robert Mercer et al, 2004). As a similar study, Kristian S. Goulda, Bjarte K. Røedb, Evelyn-Rose Sausc, Vilhelm F. Koefoedd, Robert S. Bridgere and Bente E. Moena evaluates mental workload and performance in modelled high-speed ship navigation and has been compared based on an electronic chart display and information system and traditional system using paper charts (Kristian S. Goulda, et al, 2008). Z. Bradaric, Z. Grzetic, and Pejo Brocic define that "the concept of e-navigation" means integration of the existing navigational aids with the new ones – especially electronic ones, into an integral functionally organized system (Z. Bradaric et al, 2007). Toncho Hristov Papanchev considers an analysis of reliability of electronic systems with bridge structure in terms of reliability and models reliability parameters of a bridge structure (Toncho Hristov Papanchev, 2011). On the other hand, IMO Sub-Committee on Safety of Navigation has focused on Development of an e-Navigation Strategy in 53rd Session (IMO- NAV53/22, 2007). Also, IMO Sub-Committee on Standards of Training and Watchkeeping suggests an approach to e-navigation from a seafarer's perspective in the light of discussion of these issues at COMSAR and NAV Sub-Committees in 42nd session, (IMO-STW 42/14, 2011).

To our knowledge there is not any review article on e-navigation concept that addresses current status include all components. In this study, authors aimed to summarize e-navigation related studies for better understanding and redefine e-navigation concept based on maritime safety awareness, maritime service portfolio and discuss possible implementation in Turkey.

3 DEFINITION OF E-NAVIGATION

A ship navigates for carrying cargo or passenger in oceans from one point to another challenging against natural or technical risks. During a voyage of a ship the safety of navigation is affected by several elements by means of either corresponding shareholders or technological events. As a result of the voyage an invaluable service is produced when it is considered that a navigator has to deal with a lot of essential risks. So that an "e-navigation concept" is developed and defined as "The harmonised collection, integration, exchange, presentation and analysis of maritime information on board and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment" by IMO.
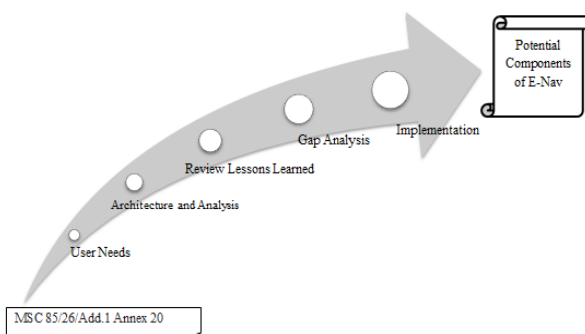

Figure 1. Potential components of an e-navigation implementation process

Together with this new concept IMO and IALA have been discussing about how an e-navigation implementation plan can be developed and used by shareholders. Potential components of an e-navigation implementation process are shown in figure 1, according to MSC 85/26/Add.1 ANNEX 20. But still there is a gap so that the components of e-navigation concept definition can be improved. In this study authors would like to redefine and illustrate the components of e-navigation concept as it is given in figure 2.

In addition to technical component of e-navigation in Figure 2, maritime service portfolio has placed to shore based technical e-navigation services and principle of an information/data flow in the e-navigation architecture (IMO-NAV 57, 2011). Therefore, maritime service portfolio has submitted different perspective for definition of e-navigation. e-Navigation concept not only includes mentioned factors but also it includes risk analysing and decision making process. In this point, we can address to "Maritime Domain Awareness". Maritime Domain Awareness is aim to supply safety, security, definition threats, common maritime data and early intervention against these threats in light of the foregoing (Maritime Domain Awereness, 2005).
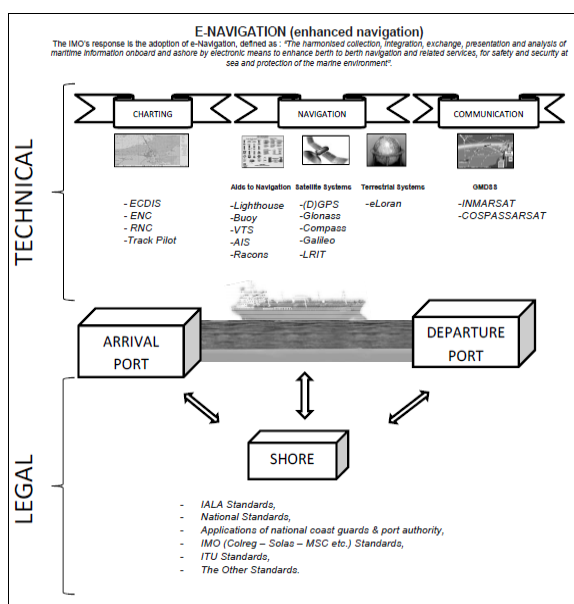

Figure 2. Technical and legal components of e-navigation.

3.1 Charting

e-Navigation consists of units which can be integrated each other and enhance service efficiency of all components. Electronic Chart Display and Information System (ECDIS) is one of the most important unit within mentioned technical part in Figure 1. and defined as likely to bring major changes to the ways that vessels are navigated by IALA (IALA-Nav Guide, 2010) While the system carries out statements in its definition, generally High Definition Radars, DGPS, Gyro and Auto Pilot, Digital Charts i.e., are seen in combination. Digital charts are divided into two main categories as Electronic Navigational Chart (ENC) and Raster Navigational Chart (RNC) which are produced according to the standard of the International Hydrographic Organisation (IHO). They are used in the navigational integration under ECDIS system.

ENC comply with IHO chart data transfer standard S-57. RNC commonly is used, where ENC is not yet available, present large amounts of cultural information which require land-based data to update the information and obtain new editions (IMO- MSC 70, 1998). Both of these ECDIS systems can be integrated with auto pilot, thus a ship equipped with such kind of integration can navigate through the track without a human management. This is called as track pilot system.

Future of ECDIS system lies behind the theory of Cpt. Dave Gillard and CDR Paul K.(2002). They have implied the challenge and the future of charting in their article as "Today there are nautical charts, topographic charts and aero charts…Tomorrow there will be an integrated four-dimensional cube of digital data". Since e-navigation concept result from integration, exchange, harmonised collection according to IMO e-navigation definition, it will take place in future of e-navigation concept as well.

3.2 Navigation

3.2.1 Satellite Systems

As of history, navigation has key role for maritime transportation and related to the other structures and in this process, various alterations have occurred on the using navigation systems and technics. There is no doubt that one of the most important is GPS, which is called global navigation systems, consists of satellites which belong to U.S. military and it works principle as received position information by means of this satellite. GPS system competitive with the requirements for general navigation by accuracy of 15 to 25 metres (95% likelihood) (IALA-Nav Guide, 2001).The aim of navigation reaches to the high accuracy rates. For this purpose, GPS is used with corrections from Ground Based Augmentation Systems (GBAS) or Space Based Augmentation Systems (SBAS), it is called as Differential GPS (DGPS) (NATO Document, 2012).

IALA defines a typical mission statement for a DGPS system as a;

"to provide an unencrypted DGPS correction integrity warning service, covering at least the coastal zone, with an accuracy of better that 10m(95%) and a signal availability of 99,8%".

To obtain high availability from DGPS is to set up transmitter stations which provide overlapping coverage from at least two stations in all areas within the nominal DGPS service area. According to IALA Guideline 1037, therefore, "failure of one transmitter does not affect the service to the mariner because the mariner can receive DGPS signals from the overlapping station". As alternative to GPS, E.U has improved Galileo, Russia-GLONASS system and Chinese-Compass system etc. Galileo system provide horizontal and vertical positions measurements within 1 meter precision and a global Search and Rescue (SAR) function by transferring the distress signals from the user's transmitter to the Rescue Coordination Centre based on the operational Cospas-Sarsat System (European Space Agency, 2012). Global Navigation Satellite System (GLONASS) covers 100% of Russia's territory and full global coverage have been completed in December 2011 (Wikipedia-GLONASS, accessed on 2012). Chinese system to alternative GPS which is called Beidou or Compass, services at customes in China and neighbour country but its global coverage will have been completed by 2020 (BBC, 2011)

e-Navigation is to be collected of current technologies and likely new technologies under same roof. In the view of such information, Bonnor N. has gathered GNSS and its components as Figure 3 (Bonnor, 2012).

GNSS (GNSS 1 and GNSS 2)
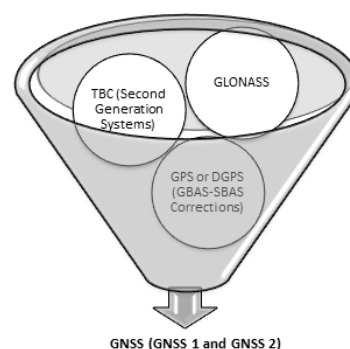
Note: TBC (Galileo, Compass like that systems) only refer to GNSS -2 and GNSS -2 under discussion

Figure 3. GNSS Relationships and terminology.

Identification of an object or a ship is very important for future of e-navigation. For this, on the one hand as satellite technologies are used on the other hand identification and reporting systems do so. Identification and reporting systems generally work combination with satellite systems and the other units. Not only these systems can be within national concept but also they can be international concept such as Long-range Identification and Tracking (LRIT). LRIT system compose of communications service providers (CSPs), application service providers (ASPs), LRIT data distribution and international LRIT data exchange and LRIT data centres.

EU states have decided to set up LRIT Data Centre including SAR in charge of European Maritime Safety Agency (EMSA). Canada and U.S have a national data centre. Brazil has a national data centre (NDC). Venezuela has ASP and NDC etc. (Wikipedia - LRIT, accessed on 2012).

As result of developing these systems, e-navigation will be performed its' mission which take places within it's' definition by using data originated form information pool of systems. In the other words, satellite systems will be influenced the future of e-navigation.

3.2.2 *Aids to Navigation*

From time immemorial, lighthouse, buoy and racons have been used for navigation but with technological developments, new elements have been integrated to these equipments for obtaining more benefit and increased availability, reliability, continuity, redundancy, integrity and decreased mean time between failure and mean time to repair etc. (IALA, 2010).

IMO Resolution A.857 (20) Guidelines define a Vessel Traffic Services (VTS) as a *"Service implemented by a Component Authority, designed to improve the safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and to respond to traffic situations developing in the VTS area"*(IMO Resolution A.857, 1997). As is understood from the above definition, VTS address to heavy traffic area. Especially we can see importance of it in straits and narrow waterways. According to IALA Guideline 1068 (2009) is the aim of VTS as *"improving the safety and efficiency of navigation, safety of life at sea and protection of the marine environment and/or the adjacent shore area, worksites and offshore installations from possible adverse effects of maritime traffic"*. Also we can understand in here position of VTS in e-navigation concept. In the other words, VTS is navigational assistance service and it provides information, warning, advice and instruction in the relevant water. VTS provides these by using Automatic Identification System (AIS) of vessels. While AIS is still limited by the frequent absence of Radar/ECDIS overlay and the limitation of the Minimum Keyboard Display (GLA, 2007), vice-versa for the other areas, this system has developed rapidly and nowadays it is integrated to buoys as AIS-Aids to Navigation (AtoN) system. AtoN systems enable to remote control, monitoring and maintenance and testing of aids to navigation etc. These advances are very important for future of e-navigation because of eliminating human factors.

3.2.3 *Terrestrial Systems: e-Loran*

Basic principle of e-navigation is to obtain maximum performance from all components. For this aim, some elements to be improved or take over the other like that Long Range Navigation (Loran) works on land based in contrast to GPS (based on satellite) in time. e-Loran, which is new generation Loran system, supply coastal position-navigation-timing (PNT) necessity with the accuracy, availability, integrity and continuity performance as a substantive from GPS, GLONASS, Galileo or the other GNSS systems (ILA, 2007). Because of being independent towards the other factor, e-Loran can be used with high accuracy - especially such as in harbour entrance, manoeuvring, etc.- in maritime sector. Therefore, e-Loran can increase productivity of e-navigation concept especially in critical position by minimizing probable accidents & raising navigational safety.

3.3 *Communications*

Global Maritime Distress and Safety System (GMDSS) is the international radio safety system. International Maritime Organization (IMO) mandates GMDSS for ships at sea. It was implemented on February 1 in 1999 through amendments to the Safety of Life At Sea (SOLAS) Convention as well. GMDSS mainly aims to automate and improve emergency communications for the world's shipping fleet (The Mercomms Group, 2012). Mainly two services are available that support GMDSS. First, International Mobile Satellite Organization (INMARSAT) is a British satellite telecommunications company which operates a system of geostationary satellites for world-wide mobile communications and which supports emergency communications systems as well. Second, Cospas-Sarsat is a system only detects and locates distress beacons transmitting on the frequencies 121.5 MHz and 406 MHz (International Aeronautical and Maritime Search and Rescue Manual, 2010). Inmarsat has a lot of subtitle such as Inmarsat A, B, C, Inmarsat Fleet service and FleetBroadband etc. The most important specifications of them are data transfer, internet, videoconferencing, remote monitoring, tracking, SafetyNET, FleetNET in addition to basic fax, telex, e-mail services (Korcz, 2008). Especially, internet networking can provide to us remote controlling mechanism via satellite. Fundamental aim of e-navigation which is controlling without human factor can be achieved by improvement of communication technologies. No doubt that GMDSS will be updated in parallel to e-navigation requirements and developments. Correspondingly, GMDSS modernization workshop has been generated and task force out of workshop has focused on modernization of GMDSS issues as given in figure 4. According to modernization workshop, Cospas-Sarsat system will be influenced from the GMDSS modernization as well. Because it uses EPIRB and its power budget is not economically support both homing signal in contrast with AIS (GMDSS Modernization Workshop, 2010). Finally, we can state that e-navigation will be on the agenda of GMDSS modernization quite a while and GMDSS will take place on ship to shore or ship to ship data communication network of e-navigation concept. Internet will play a vital role in process of GMDSS development. The new data exchange protocols enables to transfer big size sustainable data (Korcz, 2009). Due to such developments internet based data exchange from ship to shore and/or shore to shore became possible such as ship tracking, monitoring pollution, route planning. There is potential for the future to carry out remote repairing & maintenance of electronical equipment on board, intervene to operation or management of ship in case of need, remote company access, energy saving etc. besides of conventional operational function.
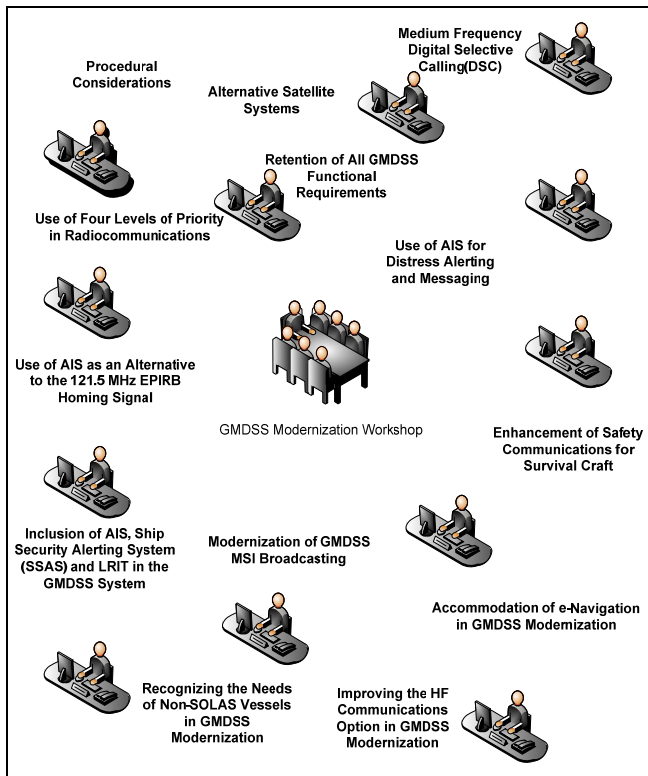
Figure 4. GMDSS modernization workshop general issues.

4 LEGAL STRUCTURE OF E-NAVIGATION

e-Navigation can not achieve its' purpose only with technical advances. For accomplishment aim of e-navigation, it should be improved as both technical and legal. Technical infrastructure of e-navigation enhances quickly but this should be done legally so. In this outline IMO legislation and IALA recommendations are available but these haven't responded absolutely to necessity yet. Especially, in case that occur any accident is still not clear what will be? This part explains legal status of e-navigation based on national, regional and international. Legal status of e-navigation has to be fulfilled with IMO legislations and IALA requirements in the international level; with EU arrangements with domestic rule in the national level; with EU standards, Paris Mou, Black sea Mou etc. national arrangements in the regional level. While IMO provides these legislations via Maritime Safety Committee (MSC), IALA does guidelines so. IMO - MSC 85 Annex 20 have defined legal status of e-navigation according to developments on board, ashore, communication area, basic requirements for the implementation and operation of e-navigation, potential user of e-navigation and their high level needs, key strategy elements and implementation. IALA have determined responsibilities one by one with guidelines for each elements after being summarized under title in master formal responsibilities on board", pilot's responsibilities, functions related to tug services, functions carried out on-shore (IALA-Nav 56, 2010).

As for national arrangements are either roughcast or cannot be applied to municipal law or integrated to international law yet. National arrangements usually made by leading main units of country to e-navigation such as General Lighthouse Authorities-The United Kingdom and Republic of Ireland (GLA), Canadian Coast Guard, U.S. Coast Guard, etc.

General Lighthouse Authorities The United Kingdom and Republic of Ireland (GLA), have been applying integration of DGPS, AtoN, AIS, eLoran, for broadcast availability, continuity, accuracy and integrity to agreed IALA standards. GLA have also planned their policies & strategies with their perspective beyond 2025 and international applications and this plan include radio navigation plan, joint navigation requirements policies and visual AtoN plan (GLA, 2011).As all have been controlled, it can be seen clearly these plans together with international regulations and recommendations give form to national e-navigation policies.

Canadian Coast Guard have improved their e-navigation model based on IALA e-Navigation Subcommittee and they have applied LRIT, AIS, AtoN program, Electronic transmission of strategic maritime information to assist navigation planning and e-navigation pilot project on the St. Lawrence River and nowadays examines how e-navigation will affect current regulations (Canadian Coast Guard, 2008)?

U.S. is an position where shape destiny of e-navigation as both technical and legal because of developing technological systems and approaching while international regulations are arranged. For instance, LRIT coverage areas rely on U.S. and Chinese authorities and finally it is decided as 1000 nautical miles. In technical respect, U.S. improved GPS systems and then alternative system e-Loran has been improved. "At Committee on the Marine Transportation System (CMTS) April 2010 meeting, the coordinating board has accepted an interagency e-navigation task team to be led by the U.S. in order to make up an e-navigation national strategy suitable for federal e-navigation services and this strategy defines how the U.S. e-navigation applications are organized" (Cairns, 2011).

Regional arrangements lead to e-navigation policies as well as national and international arrangements such as E.U Maritime Navigation Information Services (MarNIS). MarNIS systems have extended the basic concept of e-navigation to e-maritime with improving projects parallel with e-Navigation of IALA (Pillich, 2007).

As conclusion, all these arrangements consist of draft of e-navigation legal substructure. IMO and IALA have started to prepare this draft but both keep going on technical and legal working on e-navigation and E.U. e-maritime studies will result in take up time for ultimate arrangements and e-navigation perspective will be leapt to superstructure.

5 E-NAVIGATION IN TURKEY

In Turkey, a great majority of population is situated around seas. Maritime facilities are important vitally for both security of this population and navigating vessel in this area. This security may be provided cooperation of states and subsidiaries of private sector

as owners, shipyards, management and insurance companies. State applications commonly are appeared in accordance with international regulations or recommendations such as IMO, IALA etc. As state applications, Turkey set up Vessel Traffic Service (VTS) system in 2003, availability of beacons have been set at 99,79% and fixing time the failure have been reduced to 1,79 days.

Turkey committed to integration of navigational aids with new technologies. In this context, remote control system has been established to 85 beacons in Turkish straits in 2006 and to 185 beacons in West Black sea, Marmara, and Aegean region in 2008-2010 years. Authorities have appreciated necessity of improving coverage area in marine communication service in Aegean, Mediterranean, and Black sea region and to be used remote control system in South Aegean and Mediterranean Sea beacons within 2011-2012 years. As result of cooperation with Turkish General Directorate of Meteorology, meteorological information issues within every 5 minutes updating time for mariner in the around by using AIS-aton system in beacons. AIS-aton system consist of AIS, communication with vessels in different marine VHF bands, ECDIS, dGPS, meteorological and hydrographical sensors, data transferring service and the other hardware and software, electro-optic tracking, recording and rerunning system as well as radar equipments. According to Turkey AIS-aton system, remote control system will be established and this system will be integrated AIS-aton system. Therefore, aids to navigation systems which give service in Turkish straits, will be controlled from the centre.

Central controlling enable to ascertain promptly reason of failure, changing beacon bulb from remote and showing rate of battery charge, measuring light intensity, controlling position of buoys and intermeddle them immediately. According to Turkish Coast Guard performance plan, will be added to system total 485 aids to navigation as respects of end of 2012 and continued to suitable for IALA requirements in frame of availability 99,80 % and e-navigation concept. Additionally, 3 VHF stations having 25-30 miles service area will be built in Black sea, Aegean and Mediterranean Sea regions for improving coverage area and substructure of maritime distress and safety system in the end of 2014 (Turkish Coast Guard, 2012).

LRIT - national data centre installation is completed and 300 gross ton and above vessels are observed from 1000 miles distance by sending position information within min 6 hours-periods. AIS cover almost all Turkish seas and Turkey has set up VTS centre for regions in heavy traffic. Combination with these LRIT - AIS - VTS systems, Turkey has shown considerable improvement for safety navigation and maritime (Turkish Coast Guard, 2011). Especially in the LRIT system, Turkey have become one of the best in the world by applying in accordance with IMO regulations and establishing data centre through own capacity (Denizhaber, 2012).

Turkey Search and Rescue Co-ordination Centre has been equipped with COSPAS-SARSAT system and while Turkey take places ground segment provider until 11.06.2005, has qualified Turkish

Merchant Mariners Credential Full Operational Capability (TRMMC FOC) as of 17.01.2006 (Turkish Coast Guard, 2012).

Finally, as considered Turkish e-navigation programme, Turkey has made progress parallel with current world technical e-navigation improvements but there is not any legal arrangement related with e-navigation in Turkish law.

6 CONCLUSION

- GPS (dGPS) systems are used frequently in Turkish straits but new systems should be improved instead of GPS (dGPS). For instance, eLoran or similar systems, that have better accuracy, timing, availability etc. rates, can be preferred for obtaining alternative to GPS (dGPS). Otherwise existing systems should be developed according to e-navigation requirements.
- VTS cannot provide comprehensive information about course correction within enough time for safe manoeuvring. For this purpose, such as GPS (dGPS), Galileo, e-Loran etc. satellite systems should set in to supply this deficiency of VTS in Turkish waterways.
- In terms of aids to navigation, Turkey has been adopting systems rapidly in accordance with IMO regulations by integrating with AIS transmitter to all buoys.
- As Turkey develops own e-navigation system, will be need to an e-navigation committee consist of qualified personnel both technical and legal. Technical personnel should contribute on integration of components & update it with new technologies, legal unit should institute its' legal basis and case law according to such as IALA, IMO etc. arrangements and then integrate to Turkish municipal law.
- Weintrit (2010) state as a "e-navigation will be a living concept that will evolve and adapt over a long time scale to support this objective". In this time scale, this living concept should be approached as a whole and Turkish e-navigation strategy should be planned over the long term by considering e-navigation requirements.
- Ultimate goal of e-navigation is minimizing human errors which cause 80% of marine accidents. Human interface would be limited to observer on board ship and e-navigation tools will be used as decision support for control of ship on shore.

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