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AN ATTEMPT OF THE SPECIFICATION OF THE SHIP'S NAVIGATION PROCESS

ABSTRACT An attempt of the specification of main issues, such as the objectives, tasks, activities, etc. which are being solved and are being done while the ship is conducted at sea is undertaken in the paper. These issues constitute the substance of the ship's navigation process and all its sub process. The authors' belief is that the specification of these issues would enable the better understanding the matter of ship's navigation process. It could also facilitate the preparation of more precise algorithms of all navigation sub processes, i.e. even those which hardly could be expressed by the means of mathematical relations.

INTRODUCTION

The "integrated ship navigation systems" are composed of modules, such as navigation module, auto-sailing module and collision avoidance module. Many ships are also equipped with weather routing module. Each of theses modules fulfills one or several navigational functions, i.e. navigation's sub processes.
The heart of the navigation module, which realizes most of the navigational functions, will become soon the Electronic Chart Display and Information System (ECDIS).

The higher development's level of ship navigation systems constitute the "integrated ship's navigation and platform control systems", such as Integrated Bridge Systems. However the most advanced, although still being-under-development, are "the integrated ship's operation control systems"[Kopacz et al. 1998]. Probably the future intelligent and "almost unmanned" ships will be equipped with such system. Such systems will be composed of many expert systems which will control the realization of all ship's processes. Such system will be supervised by the captain-operator which can be situated at own ship, at shore, at accompanied ship, or his function can be performed by the properly programmed "computer-captain".
However, regardless of the advancement's degree of automation of ship's navigation system and integration with other ship's systems, i.e. platform control systems and command and combat management systems - the ship's navigation process and its sub processes remain almost unchanged. Therefore, the knowledge regarding the substance of ship's navigation process and its sub processes is getting more and more important.

This knowledge is essential:

- for educational process,
- for evaluation, approval and survey of navigational equipment and systems,
- for perfecting the above equipment and systems,

Below, there are presented two main issues:

- the ship's navigation process, its sub processes, phases and participants,
- the specification of all ship's navigation sub processes.

THE SHIP'S NAVIGATION PROCESS, ITS SUBPROCESSES, PHASES AND PARTICIPANTS

The term "ship's navigation process" means the process of safe and efficient conducting the ship at sea from one place to another.

The ship's navigational process (nav) is composed of several sub process, so-called also the "navigational functions" (Fig 1.) The ship's navigation process can be expressed as follows:

$$nav = [inf \wedge pln \wedge wea \wedge sta \wedge pos \wedge man \wedge col \wedge mco \wedge rec] \quad (1)$$

where: inf = information acquisition and storing,
pln = voyage planning,
wea = weather–damage minimizing,
sta = stabilizing ship's course or track,
pos = ship's positioning,
man = ship's maneuvering and handling,
col = collision avoidance,
mco = monitoring and controlling the ship's navigation process,
rec = ship- voyage/passage-data recording

While the passage preparation, there are activated and working three initial sub processes (Fig.1). Only while the voyage/passage execution, there are activated and performed all ship's navigation sub processes, i.e. only then the whole ship's navigation process is being performed.

The ship's navigation process can be expressed by the following transformation formula

$$nav: (Prin, Stpr) \rightarrow Napa \quad (2)$$

where [Prin] is the primary navigational information, [Stpr] are the standards and procedures concerning the ship's navigation process, and [Napa] are the navigational parameters.

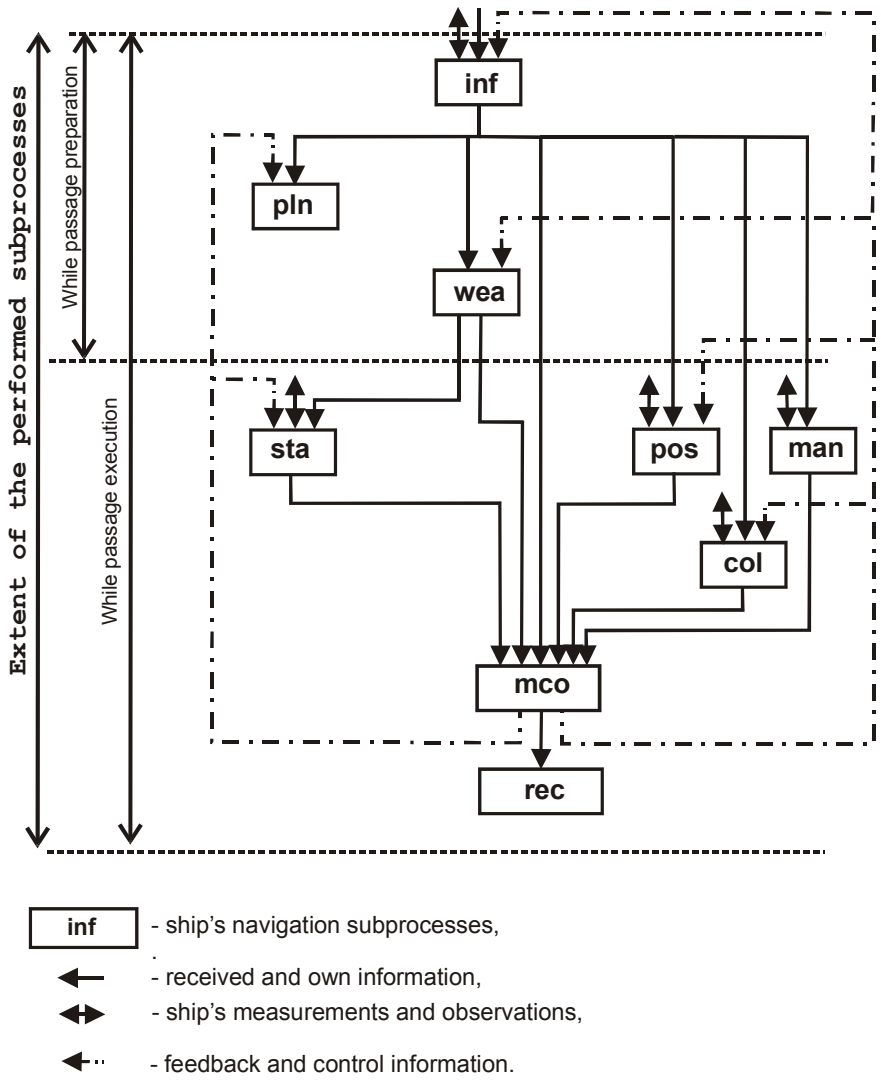

Fig. 1 The ship's navigation process and its subprocesses

Each ship's voyage (voya) include all or several of the following voyage phases:

- docking phases (dock),
- harbour phase(harb),
- restricted water phase (rest),
- ocean (open water) phase (ocea).

The ship's voyage (voya), which includes ocean phase (ocea), can be expressed as follows:

$$voya = [dock \wedge harb \wedge rest \wedge ocea \wedge rest \wedge harb \wedge dock] \quad (3)$$

The main participants of the ship's navigation process are (Fig. 2.):

- own ship and her navigation system,
- maritime geographical environment,
- other ships participating in the surrounding traffic,
- elements of the Maritime Navigation Safety System, i.e. the legal and operational ship's environment.

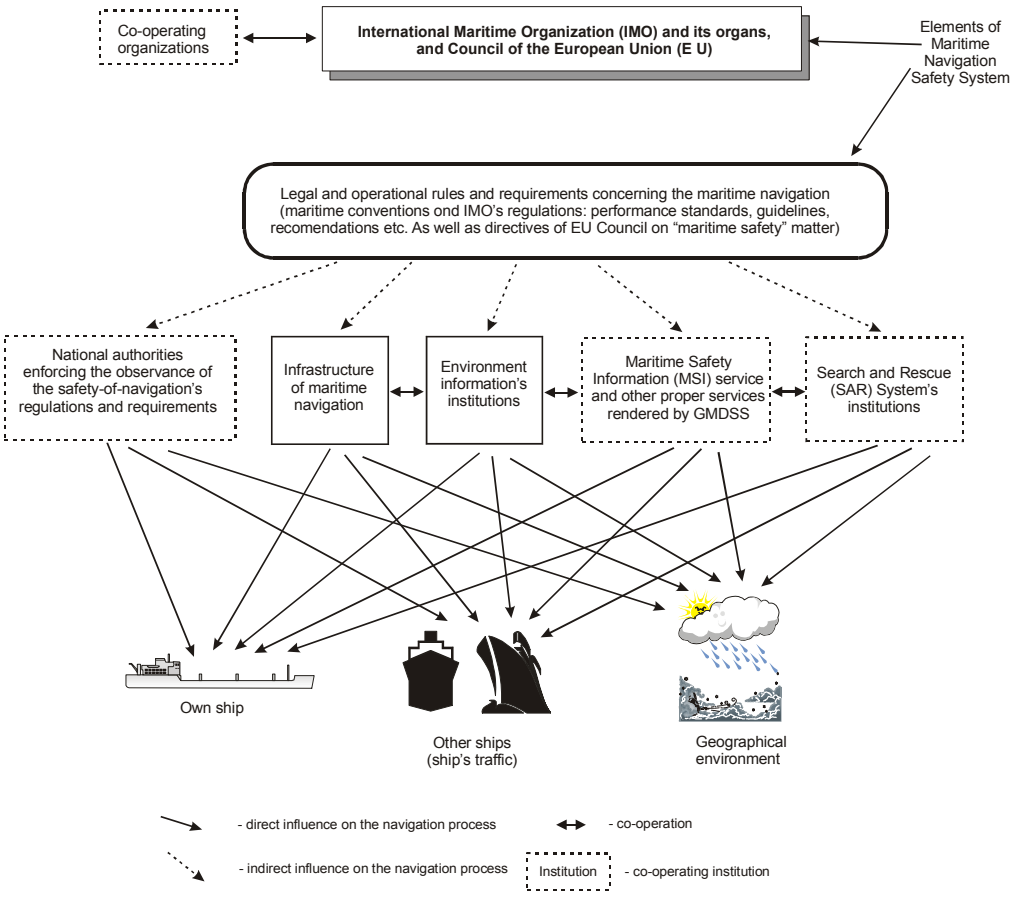

Fig. 2. The participants of the ship's navigation process.

THE SPECIFICATION OF THE SHIP'S "INFORMATION ACQUISITION AND STORING" SUBPROCESS

The ship's "information acquisition and storing" subprocess (inf), is the first navigation's subprocess (Fig.1).

The main subject of this subprocess is the ship - environment's information, i.e. geographic – environment's information and legal and operation-environment's information. The ship-environment's information must include also the information regarding ship's navigational characteristics and ship-tasks' characteristics.

The main objective of the ship's "information acquisition and storing" subprocess is to provide the ship timely with all kinds of necessary ship-environment's information, in proper amount, updated, and presented in suitable forms.

The first questions to answer is who and how are defined the kinds, forms of presentation, and amount of particular kinds of ship-environment's information.

The answer should be given taking into account the basic legal acts regarding the maritime navigation and its safety, i.e.:

- international maritime conventions such as SOLAS 74, COLREG 72, STCW 78/95 and SAR 79, but especially two chapters of SOLAS Convention, i.e. chapter IV: Radiocommunications, and chapter V: Safety of Navigation.,
- IMO's resolutions, i.e. General Assembly's resolutions and Maritime Safety Committee's resolutions regarding the "navigation's process", as well as directives of EU Council concerning navigation's matters,
- requirements of international institutions being responsible for supplying the ships with the maritime environmental information, i.e. World Meteorological Organization (WMO), International Hydrographic Organization (IHO), International Association of Lighthouse Authorities (IALA), and others,
- operational requirements concerning particular ship under discussion (merchant, naval or special ship) and the tasks performed by her (bulk goods or crude oil carriage; kind of performed warfare tasks, etc.).

The tasks to be realized by the "ship's information acquisition and storing "subprocess can be expressed as follows:

- give immediately the answer regarding the state of information being in ship's disposal,
- define what kinds and what amount of information is needed for realization of new ship's operational task,
- acquire the needed kinds and amounts of information (charts, nautical publications, etc.),
- store the whole necessary information at ship,
- ensure the up-dating the information stored at ship,
- retrieve the information without delay and in necessary forms of presentation.

The Main Kinds of Ship-Environment's Information.

The information regarding ship's environment contains the following kinds of information:

- information describing the navigational and operational characteristics of own ship [Ship],
- information describing the parameters of ship's task [Task],
- information describing the geographical (maritime) environment [Envi],
- information describing the legal and operational environment in which the navigation process is being realized (standards, procedures, etc.) [Loin].

The ship-environment's information [Senv] can be expressed as follows:

$$[Senv] = [Ship, Task, Envi, Loin] \tag{4}$$

Because the contents of information regarding own ship [Ship] and ship's tasks [Task] are rather obvious, only two last kinds of information are subject of further considerations.

The Geographic-Environment's Information.

The set of geographic-environment's information (Envi) contains the following sets of information

$$[Envi] = [Char, Msin, Fore] \tag{5}$$

where [Char] is the chart information, [Msin] is maritime safety information, and [Fore] is the long-term weather information.

The set of chart information [Char], i.e. the information which constitutes the content of paper charts and nautical publications, or content of the ECDIS data base, can be expressed as follows:

$$[Char] = [Hrol, Hgra, Infr] \tag{6}$$

where [Hrol] is the hyrometeorological information, [Hgra] is the hydrographical information, and [Infr] is the information describing the navigational infrastructure.

The set of the hydrometeorological information [Hrol] can be expressed as follows

$$[Hrol] = [Clim, Sesu, Sewa] \tag{7}$$

where [Clim] are the average values describing the sea climate, [Sesu] are the average values describing the sea surface, and [Sewa] are the average values describing the dynamic and static parameters of sea water being of importance for ship's navigation.

The set of the hydrographical information [Hgra] contains the following types of information

$$[Hgra] = [Dept, Isob, Grou, Obst, Tide, Curr, Vari, Topo] \tag{8}$$

where [Dept] are the sea depths, [Isob] are isobaths, [Grou] are the kinds of sea bottom grounds, [Obst] are the ship wrecks and other kinds of fixed obstacles, [Tide] are the parameters of sea tides, [Curr] are the parameters of sea currents, [Vari] is the variation, and [Topo] are topographic elements and features being of importance for ship's navigation.

The set of information regarding the navigational infrastructure [Infr] can be expressed as follows

$$[Infr] = [Aids, Ways, Assi] \tag{9}$$

where [Aids] are aids to navigation (floating and fixed sea marks, electronic position-fixing systems, etc.), [Ways] are the sea ways (artificial canals, fairways, anchorages, passing areas, etc.), and [Assi] are the navigation assistance systems (pilotage services, traffic separation schemes, ship's reporting systems, Vessel Traffic Services, etc.).

The set of maritime safety information [Msin] contains the following types of information

$$[Msin] = [Warn, Weat, Sari] \tag{10}$$

where [Warn] are the navigational warnings, [Weat] is the weather-forecast information, and [Sari] is the SAR-system information.

Legal - and Operation – Environment's Information.

The set of information regarding the ship–legal and-operation's environment [Loin] should contain these kinds of legal and operational constrains which influence passage planning and passage correcting and safe and efficient conducting the ship at sea.

The set of [Loin] information can be expressed as follows

$$[Loin] = [Leco, Opco] \tag{11}$$

where [Leco] are the legal constraints regarding passage planning and monitoring, and [Opco] are the operational constraints regarding planning and execution of ship's navigation process.

The sources of the legal and operational constraints are given in subsection

THE SPECIFICATION OF THE "PASSAGE-PLANNING" SUBPROCESS

The problem of " voyage/passage-planning" subprocess are specified in two legal acts, i.e. (i) "Guide to the Planning and Conduct of the Passages" (IMO Circular SN/Circ. 92, 1978) and up-dating it: (ii) "Guidelines for voyage planning" (Resolution A.893 (21/1999). There are many elaboration's, also in Polish, regarding the voyage/passage planning and execution. The following considerations concern mainly the specification of this process and have rather the theoretical character.

They should be considered as an attempt to specify the logical sequence of consecutive items which could be used as the basis for preparation of algorithms and programs for ECDIS and which, consequently, could be used not only for rough but also for precise planning the ship's passage. Therefore, the authors present their own proposals regarding this question.
The main objective of the passage planning subprocess is:

- select, for given ship and her tasks, the most suitable route (passage) free from permanent navigational dangers,
- facilitate and make more effective the navigational watch process by preparing all necessary data, regarding navigational process, for use while the navigational watch is being performed.

The " voyage/passage planning" subprocess is being started and performed both before the ship's passage is begun and while ship's passage is performed (Fig.1). We constrain our considerations to the passage planning performed before passage execution.

The ship's "passage-planning" is being performed during two staged, i.e.:

- rough passage – planning stage,
- precise passage – planning stage.

The main aim of rough passage – planning is to select the safety ship's route, while the main aim of precise passage- planning is to prepare passage scenario, as the main aid for passage execution.

First Stage of Passage – Planning: Selection of Ship's Route.

The main aims to be achieved while performing this stage, are:

- select, for given ship and her tasks, the most suitable route free from permanent navigational dangers,
- obtain the rough data (times, distances, average speeds, etc.) for precise planning.

There are three kinds of constraints which should be taken into account while route selection:

- legal and operational constraints,
- own – ship characteristics' constraints,
- geographic – environment's constraints.

To the group of legal and operational constraints belong the following:

- prohibited areas,
- legal and operational constraints resulted from the kind of the ship and performed tasks (general cargo ship, crude oil tanker, fishery ship, naval ship, special ship, etc.), as well as estimated times of departure (ETDs) and arrivals (ETAs), and other.

To the group of constraints resulted from the own-ship characteristics belong ship's draught, horizontal dimensions of safety domain, speeds and ship's handling characteristics and seagoing characteristics,

To the group of geographic – environment's constraints belong areas with insufficient depths and other hazardous areas and areas where the hydrometeorological conditions, for given ship or her tasks, are (or could be) dangerous or highly unfavorable (ice, sea current, tides and tidal streams, sea state, wind parameters, etc.).

The selection of ship's route consists in choosing the successive route's legs - beginning from the position of unberthing, unmooring, or weighing anchor - and checking if the each route's leg is free from all of the above mentioned constraints. The selection of the ship's route is finished when all route's legs, between position of departure and arrival, had been chosen and each route's leg is free from constraints.

Second Stage of Passage – Planning: Passage Scenario Preparation.

The main aim to be achieved while performing this stage of passage – planning, is to prepare the passage scenario as reference data for using by the officers of navigational watch

The passage scenario should contain:

- graphical presentation, on charts, in proper scales, the whole ship's passage,
- timetable of all expected navigational events and relevant activities which should be performed by the officer of the watch.

The preparation of passage scenario should contain the realization of the following tasks (activities):

- exact outlying of the whole ship's track, having tacking into account the requirements of Traffic Separation Schemes (routes, recommended tracks, etc.),
- adjusting, if necessary and possible, the periods of passing the critical areas (restricted waters, straits, etc.) to the proper day's period (dark, day, twilight, etc.),
- adjusting, if necessary and possible, the moments of passing the important way points or hazardous areas (e.g. areas of excessive tidal effects, etc.),
- dividing the whole route into the proper voyage phases (docking phase, harbor phase, restricted-water phase, etc.), and division of each voyage phase into the day segments (day's segments, twilight's segments, etc.) and providing for each segment the proper positioning accuracy (and therefore method of positioning), way of steering, amount of bridge team, etc.,
- estimating the times of approaching all way points, values of course changes, as well as the time moment of beginning and ending of the turn,
- determining the times of passing, as well as the characteristics of all buoys and beacons,
- determining the times of approaching the ships reporting points and proper reporting procedures,
- determining the times of entering the vessel-traffic-vessels' zones, the proper communication procedures and ship's behavior,

- determining the times of approaching the points of pilot's call, embarking and disembarking, as well as communications procedures,
- checking the initial and final positions, times, courses, speeds and passage times of each route's leg,
- checking and determining the times of events, as well as proper activities of other important passage issues.

The passage scenario, besides the graphical presentation of the data on the charts of proper scales, should contain the time-table of all important navigation events, as well as activities (deeds, procedures) for the prospective realization by the officers of the watch.

THE SPECIFICATION OF THE "WEATHER - DAMAGE MINIMIZING" SUBPROCESS

Bad weather, including fog, was in the past one of the most important factors of ships wreckage. At the beginning of 19th century, bad weather was the reason of 46% ships catastrophes (collisions in foggy weather, grounding, beaching and foundering resulted from the heavy weather). Today, the situation changed dramatically. Nonetheless, even today, bad weather results in serious weather damages.

The term "weather damage" means all kinds of losses being the result of adverse weather conditions, i.e. from delays of ships arrivals or increased fuel consumption to damages of board equipment, hulls or even ships foundering.

The "weather - damage minimizing" subprocess is very mixed and complex. Therefore, only some it most general characteristics can here be mentioned.

There are two main ways of minimizing the weather damages, i.e. ships weather routing and proper maneuvering while in heavy weather.

The "ship weather routing" is much more effective, if the ship is equipped with Weather Routing System, or the ship is serviced by the "Ship Routing Agency". However, the deployment of the Global Maritime Distress and Safety System (GMDSS) and permanent progress in weather - forecast process make the weather - minimizing subprocess much more accessible and much more effective for each ship.

The second way of minimizing the weather damages, i.e. proper maneuvering while heavy weather, is the basic way of each ship's behavior while sailing in heavy weather. Therefore, our further considerations regard only the behavior of ships being endangered by heavy weather, or being in heavy weather.

The proper maneuvering the ship while in heavy weather can also be considered as an element of "ship's maneuvering and handling" subprocess.

There Exists the Danger of Tropical Storm

Below, there are given the successive steps which should be followed when in danger of tropical storm.

(i) if danger of tropical storm exists, then maneuvering to avoid eye of tropical storm,
(ii) if danger of encountering the eye of the tropical storm exists, then maneuvering to avoid the dangerous semicircle,
(iii) if danger of encountering the dangerous semicircle exists, then maneuvering to avoid the dangerous quarter,
(iv) if in dangerous quarter, then fighting against storm; however, most reasonable seams to be riding out the storm.

There Exists the Stormy Weather

Below, there are given the successive steps which should be followed when, for a given ship (because of her seagoing characteristics) the sea state is getting heavy weather, i.e. when occurs and persists a resonant rolling, heaving or slamming.

Then

(i) adjusting the ship's speed,
(ii) adjusting the ship's heading,
(iii) heaving to sea,
(iv) sterning the sea (if possible),
(v) riding out the sea,
(vi) using oil.

THE SPECIFICATION OF THE "STABILIZING THE SHIP'S COURSE OR TRACK" SUBPROCESS

By the term "course/track stabilizing" we understand keeping the established values of course/track, including course/track changes, without their fluctuating. Therefore, the term "course/track stabilizing" means such way of steering when established values of course/track including course/track changes, are being kept.

The term "course/track stabilizing" is used here to differ this way of steering from the way of steering when ship's maneuvers are being performed (collision avoidance maneuvers, search and rescue maneuvers, and many other kinds of maneuvers).

We assume that the whole ship's way at sea is composed of planned passage part or additional, i.e. unforeseen passage parts, performed while planned and unforeseen manoeuvres. We confine our further considerations only to the ship's planned passage. Each ship's passage i. e. each real ship's track is composed of straight segments (route's legs), and curve segments (the arcs of turn circles proceeded while changing the courses).

Each ship's passage can be performed in one of two stabilizing modes, i.e. stabilizing ship's course, or stabilizing ship's track. By the term "stabilizing the ship's track" we mean the conducting the ship at sea according to her planned courses.

Then the term "stabilization ship's/track" means the conducting the ships according to the planned track, i.e. strictly over the track line. The "course stabilization" can be realized either by the helmsman or by gyro-pilot. The "track stabilization" can be realized either by the helmsman (helped by the officer of the watch) or by the track control system.

The main objective of the "stabilizing ship's course or track" subprocess is to conduct the ship at sea according to her planned courses or strictly over the intendment-track's line. It should be stressed that the "stabilizing ship's course or track" subprocess is not an autonomous, i.e. self-contained subprocess. In respect of monitoring and controlling, this subprocess depends upon the subprocess of "monitoring and controlling the whole ship's navigation process", i.e. upon the subprocess (mco) (Fig.1).

The subprocess of "stabilizing ship's course or track" comprises the following activities:

- checking the readiness of ship's steering system and helmsmen's proficiencies concerning the changing procedures of ship's steering modes,
- transforming the speeds and courses made-good-values into the speeds and courses set values taking into account the actual hydrometeorological and hydrographical conditions,
- checking the set values of steering and propulsion systems, as well as, the work of these systems and work of the helmsman,
- matching the steering mode to the traffic conditions,
- maintaining and checking the dead-reckoning procedures.

THE SPECIFICATION OF THE "SHIP'S POSITIONING" SUBPROCESSS

The main objective of "ship-positioning" subprocess is to ensure the ship's safety against such dangers as grounding, beaching and colliding with fixed objects by the permanent checking ship positions against intendent track and against surrounding dangers, and by timely informing or alarming the imminent danger.

Ships positioning systems and, therefore, the ship-positioning subprocess were and are still the subject of very profound changes. The today's electronic position-fixing systems, esp. satellite position-fixing systems, enable the ship positioning in real time with relatively high accuracy. However, this accuracy does not fulfil still the ship accuracy requirements when in restricted waters and in harbour-phase of passage. Only the DGPSs fulfil these requirements when they are available.

Besides the electronic position-fixing systems, there are widely used piloting methods i.e. the terrestrial methods of positioning. In addition, in restricted waters, and while entering/leaving the harbours - there are used various danger - enclosing

and danger - delimiting position lines. The last ways of positioning, even in the future, will be and should be used as the back-up positioning methods.

The required positioning accuracy depends upon passage phase, as it is specified by IMO's resolutions, and upon kinds of positioning systems being in ships disposal. The last must satisfy the regulation 12/V of SOLAS 74 Convention (shipborne navigational equipment).

It should be stressed that just as the subprocess of "stabilizing ship's course or track", also the "ship-positioning" subprocess is not self-contained, i.e. an independent subprocess. In respect of monitoring and controlling this subprocess depends upon the subprocess of "monitoring and controlling the whole ship's navigation process", i.e. upon the subprocess (mco) (cf. Fig.1).

The "ship-positioning" subprocess includes the realization of the following activities:

- checking the proposals prepared while "passage-planning" subprocess, regarding necessary accuracy for given passage phase and period of day, as well as chosen positioning systems or positioning methods,
- starting and maintaining the positioning subprocess by the means of required systems or methods,
- checking, at the chart in the available largest scale, the actual ship track against the intendent track, as well as, against the surrounding dangers, and, if any doubt regarding ships safety, inducing the change of ship-movement's vector,
- checking periodically the performed positioning subprocess by the means of the back-up system or method,
- checking the conformity of positions and characters of the passed buoys and beacons and recording these events; in case of any inconsistency, notifying the proper authority.

THE SPECIFICATION OF THE "SHIP'S MANEUVRING AND HANDLING" SUBPROECESS

The actual passage of each ship consists of the planned passage and some or several manoeuvres, accordingly to ship's task, traffic density, etc.

The term "manoeuvring" means often and sudden changes of ship movements which effect in changing mainly the ship's headings and speeds. One of the manoeuvring forms is "handling". The term "handling" means also often and sudden movement changes with often reversing the movement and using not only the rudder but also propeller(s) and thruster(s) for heading changes. However, in practice the terms "manoeuvring" and "handling" are being used interchangeably. We treat also both terms as synonyms.

The most often kinds of ship's maneuvering/handling are the following:

- berthing/unberthing,
- mooring/unmooring,
- anchoring/weighing the anchor,

- responding to own ship's navigational emergencies (after grounding, collision, etc.),
- man overboard,
- searching ships and /or persons being in distress,
- taking the survivors and survival craft on board,
- assisting or towing the damaged ship,
- pilot approaching, embarking and disembarking,
- sailing in ice,
- and many other (e.g. determining ship's manoeuvring characteristics, and others.)

The other ship's activities, such as "collision avoidance" and methods of "fighting against storm" can also be considered as the specific kinds of "ship's manoeuvring and handling" subprocess. However, because of their specificities and importance for ship's navigation there are considered as separate subprocesses.

The main properties of "ship's manoeuvring and handling" subprocess are the following:

- each kind of ship's manoeuvring/handling is strictly connected with the kind of ship's task being achieved trough this kind of handling. Therefore, each kind of manoeuvring/handling is different, i.e. adjusted to the aim of that maneuver,
- ship's maneuvering/handling is performed towards the object being the subject, substance, or task of this kind of maneuvering/handling,
- the sequence, and kind of successive movement changes are very often the result of achieved effects while preceding kind of movement.

The main objective of the "ship's manoeuvring and handling" subprocess is:

- enabling the realization of the task being the subject of this kind of ship's manoeuvring/handling.

The "ship's manoeuvring/handling" subprocess includes the following activities:

- checking the validities and up - dateness of particular maneuvring's/handling's procedures,
- activating, when necessary, the particular written or memorized maneuvering/handling procedure and acting according to it,
- steering the ship's courses and maintaining speeds according to master (first mate) orders,
- making allowances for the wind, current and tides while maneuvering/handling,
- keeping watch over surrounding traffic, as well as fixed navigational obstacles, and preventing and avoiding dangers,
- positioning the ship's movement at chart and alarming the master when actual movement can result in ship's accident,
- recording most important navigational events (times of changing the movement's elements, their values, etc.)

THE SPECIFICATION OF THE "COLLISION-AVOIDANCE" SUBPROCESS

The collision-danger, esp. in foggy weather, was in the past the seamen's nightmare. Even the employment of radars, in the past-World-War II period, did not diminish the amount of ships collisions, because in the same period the ships traffic grew permanently. Most of the collisions occurred in the restricted waters. Only deployment of the elements of ship-traffic control, such as "traffic separation schemes", and later, Vessel Traffic Services, as well as permanent perfection of radars use for collision avoidance – began to result in rush decreasing ships collisions.

Below, only some of very many factors influencing the state of collision-danger at sea are discussed, i.e. preventing collisions by following the rules of COLREG 72 Convention by ships, esp. rules regarding the use of radar for collision avoidance.

The main legal act regarding the prevention of collision at sea is the above-mentioned COLREG Convention. The requirements regarding ships equipment with radars and automatic radar plotting aids are specified by regulation 12/V of SOLAS 74 Convention, whereas the necessary competences of deck officers concerning collision avoidance, are specified with full particulars, in the STCW 78/95 Convention.

The main objective of "collision-avoidance" subprocess is ensuring the ship's safety against collision-danger. The main way of collision prevention, besides the strict following the rules and requirements provided by COLREG 72 Convention, such as light, shapes, conducting the ships in different visibility's conditions – is avoiding close-quarter situation and, therefore, collision of ships.

It should be remembered that the "collision-avoidance" subprocess, likewise the other navigation's subprocess, is not autonomous subprocess. In respect of monitoring and controlling, this subprocess depends upon the subprocess of "monitoring and controlling of the whole navigation process", i.e. upon the subprocess (mco) (Fig.1)

The "collision-avoiding' subprocess includes mainly the following activities:

- checking the fulfilment of COLREG 72 rules regarding lights, shapes, sound signals, distress signals, etc,
- following the COLREG 72 rules regarding the ship conduct in various visibility conditions and various states and conditions of ship's movement,
- maintaining the permanent observation of surrounding ships traffic,
- identifying the collision dangers,
- choosing proper avoidance maneuvers,
- fulfilling the avoidance maneuvers.

THE SPECIFICATION OF THE SUBPROCESS OF "MONITORING AND CONTROLLING THE SHIP'S NAVIGATION PROCESS"

The subprocess of "monitoring and controlling the ship's navigation process" is a special subprocess because it deals with all other subprocess, i.e. monitoring and controlling all other navigation's subprocesses (cf. Fig.1)

The main objective of this subprocess is monitor and control all navigation's subprocesses being realized in accordance with the ship's passage plan, her tasks, and actual situations, as well as in accordance with general safety requirements regarding the ships and their environment.

The "monitoring and controlling" subprocess contains three levels of activities (Fig.1.):

- monitoring the realization of all ship's navigation subprocess by the means of bridge's monitors an indicators, and personal observation,
- situation evaluating and, if or when necessary, decision making,
- supervising the decisions' fulfilling.

Ship-navigation-process' proceeding is being supervised by the master (captain) or by the officer of the navigational watch (being supervised by the captain).

The STCW 78/95 Convention provides that the officer in charge of the watch is the master's representative and is primary responsible at all times for the safe navigation and for complying with the International Regulations for Preventing Collision at Sea, 1972.

The subprocess of "monitoring and controlling the ship's navigation process" includes the following activities assuming that this subprocess is supervised by the officer of the watch:

- keeping watch over ship's external dangers, i.e. over the other ships, floating and fixed objects (buoys, beacons, etc.) by means of the indicators, monitors (radars, etc.) and by personal observation and, if necessary, undertaking preventive actions,
- checking on the chart, or ECDIS's monitor, the ship's current positions and track against planned (intendent) track and against the surrounding dangers (shallow waters, shoals, wrecks, etc.) and, if necessary, undertaking proper actions,
- checking the set values pointed by the indicators of the steering and propulsion systems, as well as error-values of the magnetic - and gyro-compasses,
- checking the state of realization of the items provided by the time-table of passage scenario, and fulfilling the consecutive planned activities,
- responding properly to all alarms generated by the navigational equipment and systems, as well as to events notified by the look-out or other bridge-team member,
- checking the correctness of the work of the bridge equipment and systems and bridge team,

- responding to own ship's emergencies according to the proper procedures, and notifying the captain, i.e. when:
  - man overboard,
  - fire on board,
  - sudden water ingress,
  - serious breakdown of ship's equipment or systems,
  - serious accident of the crew members, and in any other serious emergencies,
- notifying the captain if other ships or persons are in distress, or the danger to own ship is being arisen, i.e. when
  - distress signals have been received,
  - visibility is getting restricted,
  - surrounding ships are causing concern,
  - worsening weather can produce weather damage,
  - radio equipment is out of order,
  - any of difficulties or doubts concerning ship's navigation process and safety of ship have been arisen.

THE SPECIFICATION OF THE "SHIP-VOYAGE-DATA RECORDING" SUBPROCESS

The "ship-passage-data recording" subprocess is the technical subprocess which consists in recording the determined data at the determined times, regarding the navigation process, in way enabling the reconstruction this process.

The obligations of the recording ship-passage data are being specified by the being amended chapter V of the by the SOLAS 74 Convention (regulation 20/V and 28/V) and by the IMO Performance Standards for ECDIS".

The main objective of the "ship-passage-data recording" is:

- to assist in casualty investigation,
- to assist in operational evaluation of performed ship's passage and tasks,
- to preserve basic data, during fixed period, for the subsequent needs.

There exists the obligation of recording the ship-passage data in following way

(i) for short protection period of time (e.g. for 12 hours in ECDIS)
  - all navigational data allowing the reconstruction of all particulars of the ship' navigation process (e.g. at one minute intervals should be recorded: times, positions, headings and speeds).

(ii) for the protection period of time not shorter than the passage time:
  - the complete track of the whole passage, with time marks at the intervals not longer than 4 hours,
  - times and orders while ship's manoeuvrings,
  - times of the most important ship's activities and incidents

(iii) for the archival purpose of ship's passage
  - track with time marks at interval of one day,

- times of harbours' entries and leaves,
- most important events (grounding, collision, fatal incident of crew member, etc.)

However, the data recording for archival purpose is not the ship's navigation activity and, therefore, it is not the subject of concern or considerations of this paper.

The data for short-protection time (e.g. 12 hours), being-recorded at very short intervals, besides the times, positions, headings, and speeds, should also contain the data regarding the quality of chart data, or there should be preserved the actual navigational plots, drawn at the paper charts.

The data, for period of protection not shorter than passage time, are being recorded in the following way:

- by ECDIS or manually made navigational plot, drawn on the charts in small scales,
- by Voyage Data Recorder, if available,
- recorded in the logbook or preserved in another form approved by Administration.

It ought to be remembered that the recorded information which to be stored and kept until the passage is finished - should not and could not be manipulated, changed or removed.

The authors' belief is that their attempt of specification of ship's navigation process, although very far from perfection and also far from completeness, can fulfil the authors' expectations expressed in abstract of this paper.

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