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A Pleading for Ship Manned Models as a "Physical" Simulator in the Ship Handling Training Process

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Abstract

As almost everybody is aware, the seafaring as occupation is still a dangerous way of life. Despite the scientific and technological progresses, the casualties at sea are yet numerous and loss of human life is costly. The causes are pending on various domains such as the increased maritime traffic at often associated higher service speeds, the overconfidence in the navigation gear devices the lack of alternative navigational knowledge, bad team management, crew overstressing and unduly fatigue and so on.

Because most of the causes listed above are (more or less) directly linked to human error, a proper training will (at least) reduce the frequency of such obviously unwanted events, so any way to achieve this goal is a meaningful one. Among other approach directions, the manned models ship training method is a very interesting (at least from most trainee's points of view....) and therefore efficient and successful procedure.

The submitted paper presents briefly the *pros* & *cons* of the manned models ship handling training together, followed by some proposals resulted from a feasibility study (included in the RoNoMar project) for the establishment of a new such a training centre imbedded in the Constantza Maritime University's educational heritage, notably two manned models (an ULCC and a PCC) preliminary design specifications.

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Keywords: training; electronic bridge simulator; manned models; modelled vessel; GRP construction; DGPS transmitter; tug simulation system

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1. Preliminary considerations and grounds

1.1. Some reasons for a continuous ship handling training

The seafaring is still a risky business despite the high-tech navigation aids available and the progress in ship design and construction. The open sea might be sometimes a rough environment by itself and very often unforgivable to the slightest mistake or negligence, the countless wrecks or memorials being a grim proof to this. Moreover, the increased maritime traffic and the participant's often-associated high service speeds are adding an extra "weight" to an already complex and difficult human endeavor. Also in this respect, the harbor entrance and exit maneuvers became more and more difficult and demanding, regardless of weather conditions or the modern infrastructure now available.

All these are leading to increase the high already probability that marine casualties might continue to appear. One way to reduce the still large accidents number (high operating performance navigation gear and ship constructive seaworthiness aside) is to train as thoroughly as possible the personnel involved (deck crew and pilots). A well-trained crew will be able to avoid the dangerous situations (or react properly if case) thus, limiting the number of such events or reducing the damages occurred if the accident yet happens.

An even stronger argument to intense and continuous training in ship handling is the fact that human error, either individual or consequent to an improper team management, contributes to the initiation of a large proportion of marine casualties. In this respect, among other made up references, the USCG Report M8 – 81 (**Error! Reference source not found.**) firmly demonstrating this issue, the human error being a frequent casualty motive (33 %), second only to the so called unavoidable reasons (34 %), all other (weather, environment or technical related) having by comparison a significantly reduced statistical weight (Fig. **Error! Reference source not found.**.).

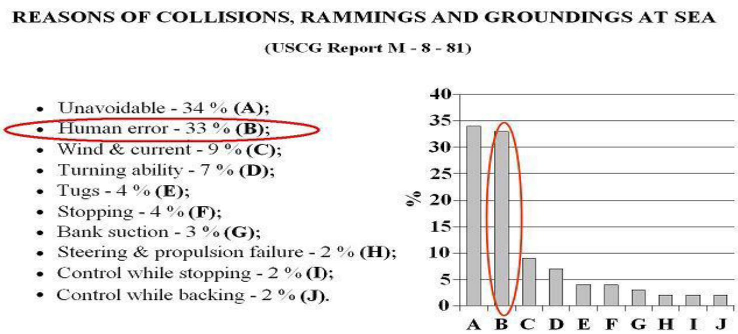


Fig. 1. Reasons of collisions, ramming and groundings at sea [1].

1.2. Means and modalities to perform ship handling training

Training on ship handling is largely recommended by IMO as one of the most effective method for improving the safety at sea, aiming by this to gain theoretical and practical knowledge about and thus being able to deal properly with a wide number of different practice situations. There are several possible ways to achieve an effective training in ship handling, each one with *pros* & *cons*, none of them having by itself the capacity to cover in all the various issues involved. Consequently, they have to be considered as complementary to each other and therefore implemented and conducted accordingly. The main directions followed for the ship handling training are:

- The real ship

The most straightforward and thus effective way of ship handling training wood be to use for this the real ship. In this "on job" training method, the inherent similitude or simulation-like feeling encountered when using other training modalities is totally absent, the ambient, ship behavior characteristics and associated operational events being at full scale (both as time and intensity). Consequently, the trainees (undergraduate cadets or cadet officers) have a full opportunity to complete their professional knowledge and to enhance the required specific skills and abilities.

However, even if these aspects are conducting to a very realistic and thus effective training, it should not be ignored that this activity implies some quite delicate matters. As the ship's operational schedule is mandatory, the interference between must be totally absent, and above all, the ship must not be liable to any risk due to trainees' improper direct action or by overcrowding the crew's current duties and thus leading to consequent negligence. Moreover, learning "on job " by watching seasoned practitioner is a slow process and certain handling situations including critical ones may never occur and so no experience how to deal with such situations could be gained this way. Such training is considered by many people as very dangerous and is limited in use.

- The electronic bridge simulator

Other available option for ship handling training is to use the electronic bridge simulator. By itself, this complex equipment covers considerably more intended training events and is more ready to use than to resort to the services of a real ship, often unavailable now. The associated software is able to simulate various kinds of ships movements and maneuvers in different weather or sea state conditions. The electronic bridge simulator is very suitable for conducting especially teamwork training in relative short intense sessions. Moreover, a trainee wrong individual action or bridge team delayed decision is not subject to any ship real damage, the events as such being possible to be assessed and analyzed afterwards in order to establish the their causes and how to be avoided in the future. In addition, the bridge simulator can be connect to an electronic engine room simulator and so creating the possibility to train simultaneously and realistically trainee teams as a ship complete operating watch.

However, the mathematical equations which control the electronic bridge simulators are describing more or less approximately the ship's behavior in different maneuvering situations, a lot of situations being impossible to be properly numerically simulated because of the involved too complex hydrodynamic phenomena affecting the ship's maneuverability. Moreover, it worth noting that in this case the simulation accuracy is as realistic as one whishes to accept, the occurred sensations and "feeling " of the ship as a whole or the real life manoeuvres associated stresses being here a more or less an accepted convention and thus the actions to take are free of any responsibility.

- The *manned models* ship handling training

Finally, an other available mode to perform a ship handling practical training is to resort to the so-called *manned training models*, approach sometimes included [2] into the simulators category as MMS – ***M****anned* ***M****odels* ***S****imulators* as opposed to FMBS – ***F****ull* ***M****ission* ***B****ridge* ***S****imulators* (fully computer controlled). These are scale models of various ship types, able as such of independent navigation by autonomous systems of propulsion, orientation and steering and handled directly by a human crew (usually trainee and instructor) located on board.

1.3. Manned models ship handling training- a brief encounter

Manned models, although small, are ships by their very nature and same physical laws govern their behavior when maneuvering, thus representing realistically all involved hydrodynamic phenomena. These constructions are in fact scaled-down full ships operated directly by the trainee complement (usually pilot/master and tug master) located onboard. In this respect, the interior layout (unlike the real ship) is customarily structured in order to accommodate the necessary spaces.

The models are provided with all the required equipment such as propulsion system, steering gear, navigation aids & instruments and various controls for engine, rudder, bow thrusters & so. Also all internal controlling factors important from the ship handling point of view, such as the time for reversing engine and for deflecting rudder, are simulated properly and are controlled by computers installed onboard. The main wheelhouse controls duplicates the real ship one's and so allows the trainees to execute on the scaled training area the whole range of required maneuvers, the instrument gauges (wind speed indicator, speedometer in particular). Also, as the propulsion motor is electronically controlled, the main engine response can be modeled to mimic various power plant specific responses such as for Diesel engine or steam/gas turbines. Moreover, the as built models can be retrofitted with modular insertions (long/short superstructures) or even various propulsion systems (single/twin screw or AZIPOD-s) and so one basic model can simulate an extended range of vessels.

The use of manned models for ship handling training allows to perform a wide extent of maneuvers, ranging from sailing in open water beacon marked areas, shallow water canals or rivers to more difficult ones such as dealing with specialized terminals, locks or over hanged bridges, all these in daytime or at night. The model specific motion control is achieved via a combination of scaled fin rudders, controlled pitch propellers or azimuth thrusters, bow thrusters also if case, their layout being issued from the particular characteristics of the vessel it replicates. Each such a motion control device is imputed from the wheelhouse in the same manner as on the real ship and generates a very realistic (time scale apart) model response, the rate of turn, acceleration and inertia leading to a very similar to full-scale perception of the action. Moreover, the manned models are also equipped with scaled fully functional mooring system, fitted out with anchors, chains and anchor windlasses, all the gear being remotely controlled from the wheelhouse and thus allowing the trainees to execute specific maneuvers such as anchor turning and stopping, berthing sideways with anchor aid or berthing stern first using both anchors. An essential aspect when berthing or sailing in close quarters such as straits and sounds is the tug assistance, especially for large vessels.

A relative recent but modern implementation is the GPS manned models on-line tracking system. A high accurate (DGPS) transmitter is located on each model, the signal being digitally processed and subsequently instantly displayed both on board model and on the shore based tracking centre. By doing this way, the instructor's presence on board is no longer necessary as a rule. An interesting feature is that, once implemented, the GPS on-line tracking system might used also as a radar system of some kind.

In order to be properly carried on, the manned models ship handling training process requires some basic arrangements, namely a dedicate training water area, several waterfront technical facilities and a close-by inland headquarters. The training water area should have enough surface area to accommodate the training mock-ups leaving also room to maneuver and, most of all needs to be a sheltered one.

2. Manned models ship handling training centers worldwide

2.1. Warsash maritime academy manned models ship handling centre (Southampton – U.K.)

General. The Warsash Maritime Academy Manned Models Ship Handling Centre (W.M.C.) is located in Marchwood, suburbia in the close vicinity of Southampton Harbor (Fig. 2.). The W.M.C. is part of *Warsash Maritime Academy* (W.M.A.), institution that provides first class education, training, consultancy and research to the international shipping and offshore oil industries. Furthermore, the W.M.A. is an integral part of Southampton Solent University a relationship that sets it apart from most competitors and constitutes a major strength when developing training programs.

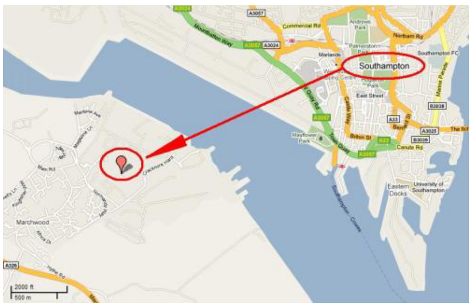


Fig. 2. The Marchwood *Manned Model Ship Handling Centre* location map [7].

Manned models fleet. W.M.C. has 7 training models, easily convertible to represent nine different vessel types, as well as three radio controlled tugs for use in berthing operations. The models each weigh around 6 ÷ 7 *t* have been specially developed in order to replicate the specifications of some real vessels by a team of dedicated Warsash Maritime Academy technicians. Some training models: *Progress,* Panamax bulk-carrier, 60,000 *dwt* (Scale 1:25, Fig.3-a); *Venture,* Very Large Crude Carrier (VLCC), 300,000 *dwt* (Scale 1:40); *Diligence*, 40,000 *dwt* product tanker (Scale 1:25), *Endeavour,* twin screw shuttle tanker, 141,000 *dwt* (Scale 1:30, Fig. 3. -b) etc.

a

b

Fig. 3. (a) *Progress,* 60,000 *dwt* Panamax bulk-carrier [3]; (b) *Endeavour,* 141,000 *dwt* twin screw shuttle tanker [3].

Training curricula. Standard ship handling course (36 *hours*), Advanced ship handling course (36*h*), Twin screw vessel ship handling course (20*h*), Pilots combined bridge simulator / *Manned model* course (40*h*), Pilots emergency procedures course (20*h*), Ship handling appreciation course (20*h*) and other Courses general outline and specific issues. The courses are operated on Marchwood Lake (Fig. 4. - a &. b), whose water surface is offering a variety of berths, basins and channels, including a canal. The Centre has three radio controlled model tugs (Azimuth Stern Drive, Voith Schneider and a steer-able Kort nozzle tug) which simulate tug assisted manoeuvres.

a

b

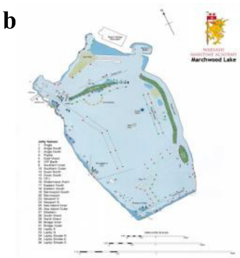


Fig. 4. (a) *Marchwood Lake* satellite view [7]; (b) *Marchwood Lake* training navigation map [3].

2.2. Port revel ship handling centre (Grenoble – France)

General. The *Port Revel Ship Handling Centre* (P.R.C.) is located near Revel, a small village in the vicinity of Saint-Pierre de Bressieux, some 50*km* of Grenoble (Fig. 5.). P.R.C. is a private training institution as being owned by SOGREAH, the French acronym for **So**ciété **Gr**enobloise d'**É**tudes et d'**A**pplications **H**ydrauliques. The group now has an activity spread throughout France (in some 30 offices) and abroad (with some 20 subsidiaries).

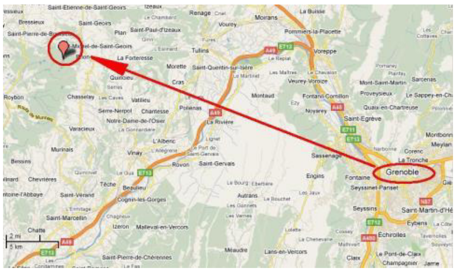


Fig. 5. The *Port Revel Ship Handling Centre* location map [7].

Manned models fleet. The P.R.C. has 10 scale model vessels ranging from *Berlin* (a 38,000 *dwt* tanker, Fig. 6. -a) to *Othello* (a large 8,500 *TEU* container ship, Fig. 6. -b). All models can be either controlled from the rear or the front wheelhouse, so in fact the fleet reproduces twenty different vessels. Moreover, since 2006, the Normandie (4,400 *TEU* container carrier) is fitted with optional AZIPODS which can be easily fitted in order to further reproduce the maneuvering behavior of a cruise ship. The training models weight range is around 3.5 ÷ 30 *t*, in order to replicate the specifications of some real vessels, the construction scale being 1:25 for all. Most of the models are equipped with bow and stern thrusters.

Fig. 6. (a) *Berlin,* 38,000 *dwt* tanker [4]; (b) *Othello*, 8,500 *TEU* container ship [4].

Training curricula. Pilot & Master ship handling course (43 *hours*), Advanced ship handling course (43 *h*), Emergency ship handling (43 *h*), Experimenting with pods & emergency ship handling (43 *h*), Specialized ship handling courses (43 *h*) and other. The courses are operated on 5 hectares purposely-remodeled lake (Fig. 7. -a &. b) feature that offers a variety of moorings, basins and buoyed channels, including a *Suez Canal* bend mock – up.

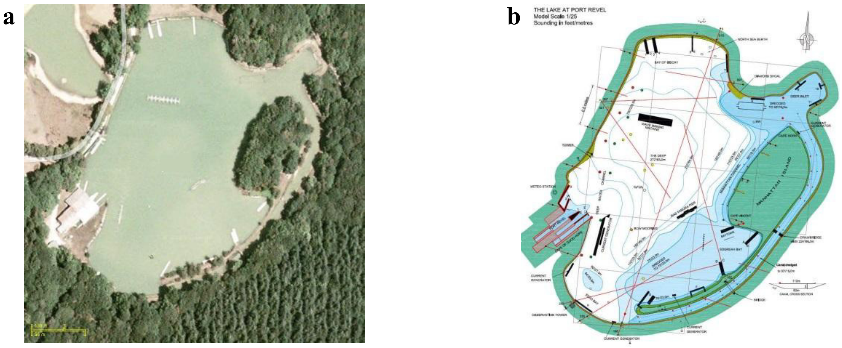


Fig. 7. (a) *Port Revel* training lake satellite view [7]; (b) *Port Revel* training lake navigation exercise map [4].

Also, the models are equipped with a tracking and plotting system using the latest *DGPS* techniques, feature enabling to record the model's track and to use it for afterwards exercise debriefings. This tracking equipment is supplemented by a number of leading marks on land and an observation tower.

2.3. Ship handling research and training centre at Ilawa (Poland)

General. The *Ship Handling Research/Training Centre* at Ilawa is owned by the Foundation for Safety of Navigation and Environment Protection, which is a joint venture between the Gdynia Maritime University, the Technical University of Gdansk and the City of Ilawa (some 130 *km* SE of Gdansk in the *Mazowian* hills area). Two main fields of activity of the Foundation are research on ship's manoeuvrability and training on ship handling. Since 1980, more than 2500 ship masters and pilots from 35 countries were trained at Iława Centre. The Foundation possesses ISO 9001 quality certificate. As far as the functional set up is concerned, the *Iława Ship Handling Research and Training Centre* is structured in two major operational compartments, namely *The General Headquarters* (located in the city of Gdansk) and *The Training Centre* as such (located on the *Silm* Lake, about 5 *km* from the city of *Iława* –Fig. 8.).

Fig. 8. The *Iława Ship Handling Research and Training Centre* access road map [7].

Manned models fleet. Currently, seven models representing a wide spectrum of ship types are available at the Centre for training purposes, ranging from *Szczecin* (60,000 *dwt* PANAMAX bulk carrier, Scale 1:24 – Fig. 9. - a) to *Blue Lady* (235,000 *dwt* VLCC tanker, Scale 1:24 –Fig. 9. - b).

a b

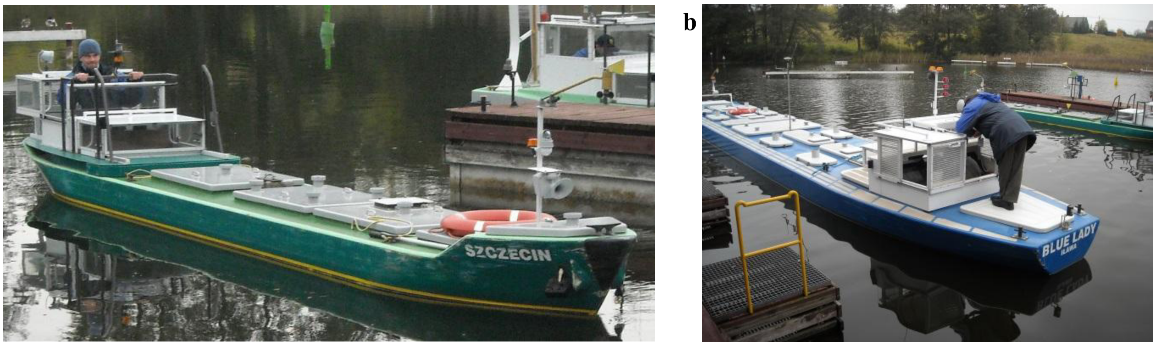


Fig. 9. (a) *Szczecin*: 60,000 *dwt* PANAMAX bulk carrier [5]; (b) *Blue Lady:* 235,000 *dwt* VLCC tanker [7].

The models are equipped with all necessary devices simulating a ship's systems: main engine (motor or turbine), propellers (single and twin, fixed and variable pitch), bow and stern thrusters, conventional and high lift rudders, anchors. On all models the basic navigational aids (gyro, log, navigational lights, wind velocity and direction measurer, etc.) are also installed. All manned models are equipped with the system allowing the simulation of tug-ship co-operation. Since 2006 the tug-ship cooperation is also simulated using a new manned model of an escort tug. Thus the two basic methods of tug assistance: direct and indirect are possible to train. Since summer 2000 the Training Centre is equipped with high precision tracking system based on GPS technology.

Training curricula. The lake training areas were selected so that the intended training fit-outs merge easily into the banks shape and open water existing geometry. The allotted training water area (Fig. 10. - a &. b) is fairly large (about 22 *ha* – 54.36 *acres*) and thus the reproduction of various and numerous sailing conditions and training scenarios implementation was easily achievable. All training areas as a rule do not repeat actual situations in various geographical areas, but are combinations of difficult situations, which could be met by the trainee. There is a possibility to adjust the programme of exercises and to arrange any special situation by constructing special mock-ups of floating structures, bridges, locks etc., or mark particular harbour entrances according to requirements. Actually, various manned model courses (for Pilots and Masters) are available at Ilawa Training Centre, ranging from usual ones (handling of large ships-standard level) to some more specific ones (ships with unusual manoeuvring characteristics or ships equipped with azipods).

a

b

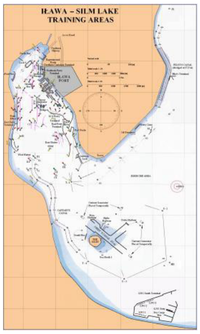


Fig. 10. (a) *The Iława Ship Handling Research and Training Centre* training areas aerial view [5];
(b) *Iława Ship Handling Research and Training Centre* exercise navigation map [5].

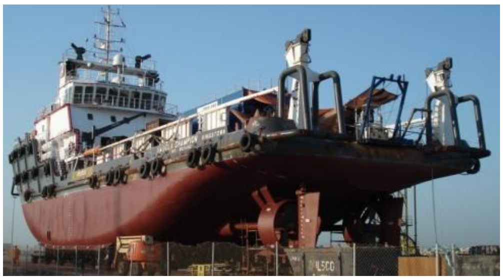
3. Future "*Constantza Complex Ship Handling Training Centre*" (Romania): feasibility and prime directions

As stated in the beginning, none of the mentioned training modalities does cover alone the whole range of various encountered aspects. One way to overtake this situation is to try to combine some of them, the most at hand being the reunion of the manned models with the electronic bridge simulator in a common ship handling training session. By making this way, one can benefit from both the high degree of manoeuvre and overall ambient realism proper to the manned models and the more alike navigation bridge ambient, teamwork conditions, readiness and the events repeatability of the electronic bridge simulator.

Also not in the last turn, despite the apparent high costs of implementation and initial development of a manned models training facility, once the activity starts the expenses will be relatively easy to recover. Some reasons for that might be the increasing demand (either from individuals or as employees) together with the reduced number of such locations worldwide (just three operating at present day: *Warsash Maritime Academy Manned Models Ship Handling Centre* at Southampton – U.K., *Port Revel Ship Handling* at Grenoble – France and *Iława Ship Handling Research & Training Centre* at Iława – Poland).

Therefore, the *Constantza Maritime University*, apart some individual achievements [6] in this direction already existents as a PhD. Thesis (Fig. 11. - a &.b), has recently initiated (as part of the RONOMAR project – [7]) a vast undertaking which will lead to the set up of a new so called *Constantza Complex Ship Handling Training Centre*.

a



b

Fig. 11. (a) The *1450 dwt* modelled supply vessel **Error! Reference source not found.**; (b) *PIVOT POINT:* the 1/12 manned model **Error! Reference source not found.**.

This establishment, intended to be brought into being as a Foundation, will link together the *Constantza Maritime University* as main educational factor (teaching personnel and learning spaces, including the proprietary electronic simulators – therefore the "complex" assignation in the name) and the *Constantza City Hall* as partner providing mainly the water training areas.

General. The *Constantza Complex Ship Handling Training Centre* should be located at the University's Nautical Base, situated on the Siutghiol Lake, in the NW suburbs of the city (Fig. 11. – a &. b). By doing so, one can take advantage of the already built learning facilities (including the main electrical and other domestic features as water supply, waste management and easy access).

Fig. 12. (a) *Siutghiol Lake* detailed access road map [7]; (b) *Constantza Maritime University* Nautical Base detailed satellite view [7].

The selected interest section convex shape (see again Fig. 12.) and the appropriate depth (0.50÷4.50 *m*) might lead to an easy training infrastructure implementation (the fish farm activity areas being rather distant). Also, the hilly, scarcely forested and housed banks may provide a good shelter (some floating wind barriers on the N – E bay opening might be eventually needed). As stated above, the biggest advantage of this location is the nearby presence of the ***Constantza Maritime University*** *Nautical Base* (whom assets and endowments can be easily and inexpensively converted to the new job).

Manned models fleet. The training fleet range essentially affects both the training process efficiency and the involved implementing costs. As far as the manned models fleet make – up is concerned, the selected vessel types should cover the widest area, ranging from the rather usual ones such as tankers or bulk – carriers with different significant sizes – PANAMAX, Post PANAMAX, SUEZMAX, VLCC, ULCC (Fig. 14.) & so, to the more special ones such as RO – RO vessels (Fig. 13.), passenger / car ferries or large fast container carriers. Subsequently, a detailed manned models fleet range is proposed, realized by using a unique construction scale, namely the *scale **1:25*** which might be considered as an optimum for this matter.

Besides the inherently accomplished geometrical similitude, the manned models general arrangement should comply also with the operational characteristics similarity such as steersman eyes location, wheelhouse outdoor view and operating controls layout. The manned models will be built in *GRP* construction (either solid laminate or sandwich where appropriate). The basic layout will include an adequately divided watertight hull which will locate the main equipments, water ballast tanks and the remaining void spaces, together with an enclosed wheelhouse where the crew (trainees and instructors) is performing the training specific duty. The wheelhouse is fitted with heating and ventilation systems (for an extended yearly training sequence and for summer comfort) and might be located either in a forward (see again Fig. 13.) or in a rear (again Fig. 14.) position, its construction and interior layout components and features being as standardized or typified as possible.

The entire fleet range shall be fitted with the proprietary designed and built *Tug Simulation System* (2 tugs as a standard and 4 tugs for bigger models such as ULCC or VLCC) together with the *GPS* based *On – Line Tracking System* (also a proprietary feature).

To summarize, a new manned models ship handling training centre is anyhow more than desirable to be created anywhere in the world, achievement which might have quite low implementation risks yet associated with high chances of operational success and a predictable financially self-supporting capability.

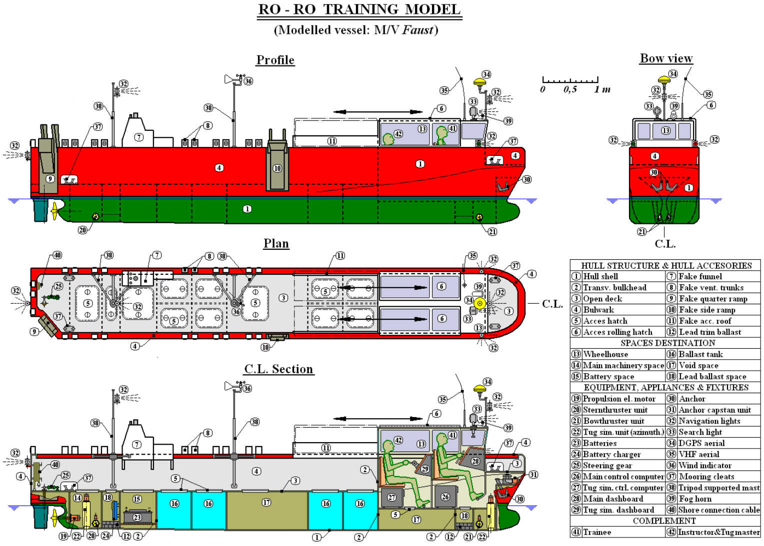


Fig. 13. Proposed RO – RO training model preliminary specification drawing [7].

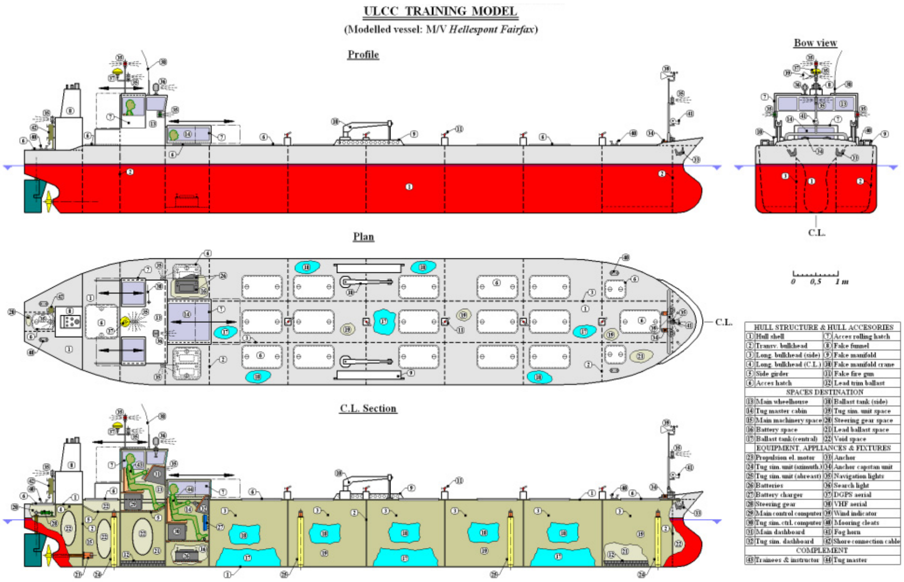


Fig. 14. Proposed ULCC training model preliminary specification drawing [7].

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