Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Report Title:

Deliverable 3.2:

Review of existing training facilities and capacity

Contents

1 PUBLISHABLE EXECUTIVE SUMMARY

The aim of this task is to make a review of the existing training facilities and training programs and to evaluate both capacity and limitations respectively. The review focused on ship handling simulators, including DP training centres and manned-model training centres. The chosen data collection medium was by questionnaire, supported by secondary data, and the database contains entries under the headings:

- Types of ships in the facility;
- Types, number and locations of azimuthing control devices on ships in the facility;
- Types and makers of simulators (ships);
- Effects modelled for azimuthing control devices ships;
- Types of training prepared for azimuthing control device ships and the number of days training;
- Capacity at one time on azimuthing control devices ships;
- Training data gathering and analysing (debriefing, post-processing) capabilities;
- Accreditation and certification of the facility;
- Relation to host companies

Most of the Marine Schools or Academies and also some Harbours Authorities have Marine Simulators to provide training for Senior Mariners, Pilots and Tug's captains. The training requirements and constraints involve different programmes used in Manned Model Centres. The document investigates the limitations in the training programmes and also looks at the appropriate directions of possible remedies to the limitations. The document introduces the needs of standardisation and certification of the training programmes and to indicate the scope of standardisation, validation and certification of the programmes. The study shows the requirements of the training, the objectives and the implementations of training – for different types of simulation. The study will also show the training programmes used in training simulation centres. Specific actions performed include:

- Development and administration to the training providers and training customers, of a questionnaire regarding training for ships equipped with azimuthing control devices.
- Development of a standardised template to be used for rational training program description, specific to ships equipped with azimuthing control devices.
- Collection and presentation of data on training programmes specific to azimuthing control devices.
- Analysis of training programs to identify the best practices and limitations of the training programs.

The scope of the available information on the programmes of the azipod courses is really limited. The main training centres using Full Mission Bridge Simulators (FMBS) are already providing varieties of ACD training mostly for Pilots and Tug's Captains. The Programme of these training is based on individual demands from group of interest including specific ship's models. Also in Manned Model Centres training using ACD ship's models are very well established and organised and the document tries to prove the necessity to synchronise all trainings. The task culminates report that delineates the above aims and objectives.

2 INTRODUCTION.

The aim of this task is to review existing training facilities and programmes, and to evaluate capacity and limitations thereof. In order to facilitate this, a questionnaire was developed, and can be found in APPENDIX 12.3.
The next aim of this report is to focus on:

- Training requirements and constrains, on the defining training objectives and definitions of training programmes accounting for technology, human factors and training methods used in training centres
- Identification of origins of the limitations in the training programmes and on assessing severity of limitations and on indication the appropriate directions of possible remedies to the limitations
- The need to introduce of standardisation and certification of the training programmes and on indication of the scope of the standardisation, validation and certification of the programmes
- Showing the requirements of the training, of the objectives and of the implementations of training
- Showing training programmes used in training simulation centres.

3 DATA COLLECTION SOURCE

In order to perform an analysis for the objectives set out in the relative Work Packages, it was collectively decided, during the progress of Phase 1, that any questionnaires the different Work Packages produced, should be collated, and distributed to the appropriate organisations. A repository of these organisations/companies was produced, and can be found on the AziPilot Website, entitled “Basic Groups of Interest”.

The reasoning behind this method of questionnaire distribution was:

- It was considered that a higher yield of completed returns would result, due to the fact that the targeted organisations would receive one questionnaire instead of many,
- Organisation and administration would be simplified,
- The Organisation Repository would be useful for all Work Package Partners.

3.1 Composition and rationale of the Questionnaire

The primary objective of the questionnaire was to determine how effective simulator training centres are at representing different vessels equipped with azimuthing devices. The questionnaire itself can be found in APPENDIX 12.3.

The questionnaire gathers basic data for general analysis, and develops further into more in-depth examinations about azimuthing device specific capabilities and capacity.

Training centres may have the facilities to precisely reproduce the reactions of an azimuthing controlled device on a vessel, but how effective they are in practice is another matter entirely. For example, a training centre may be required by a client to simulate a certain vessel, which is not in the facilities database. This would require them to mock-up the vessel themselves on software designed for their simulators. The training facility may not have this capability, and if it does, then extremely detailed specifications are required to represent the azimuthing devices. These extremely detailed specifications are usually very hard to come by, as they are generally classified as extremely confidential. The model is only as accurate as the data that can be supplied to it, thus, although the facility may have the capability, it may be difficult to do so accurately in practice.

3.2 Other consideration trough developing the Questionare

The questionnaires supposed to be a lean and short - this way will enhance the possibility of a high return rate from respondents. However there are some ideas for further questions.

These are only ideas and may be not relevant to present questionnaire based through the description of objectives for W.P 3.2:

- Is it important to ask the respondents to describe specifically what types of vessels they can simulate at their facility and what type of vessels they simulate most often (and with the best results),
- Should the part "Types of bridge control levers for azimuth devices" include producers of levers such as, Kamewa, Aquamaster, Voith Schneider, Schottel, Lillaas, ABB, NIIGATA etc?

Maybe it is of interest to know if mathematically modelled vessels with one type of propulsion - say Rolls Royce - on the simulating bridges are most often operated for instance with a Kameva or Lillaas lever. Here at FORCE they have mounted Lillaas levers on some of the smaller simulation bridges. Seen from a human-machine interface perspective it is a good question if this has an influence on the perceived and actual handling of the vessel/means of propulsion compared with a situation where the azimuth propulsion system is operated with the actual handle/lever from the producer of the azipod/pulls (for instance Kameva levers for Kamewa pods).
One of the questions in the questionnaire could therefore be something like:

- Is it common practice to use levers for azimuth pods/pulls that are of a different brand than the producer of the propulsions system that is in the mathematical model? And if this is the case (that the same type of lever is used for vessels with different brand of propulsion system):

  - How often (percentage of simulations runs) does this happen?
  - What implication do you think this can have compared to operating azimuths in reality?

It could also be of interest to measure which brand of lever and/or azimuth producer/system is preferred in the simulators (and for different vessels?).
Also, how much does a specific model/lever require being handled/operated for the inexperienced to get to know it:

- Do you have any preferences for a certain brand of lever and why?
- What is most difficult to learn when training in the use of Azimuth control systems?
- Do your facilities have a procedure or best practice for this kind of teaching or is it more based on the personal experience of each instructor?
- Are there some aspects of the using of azimuth levers that can only be learned during a long experience period at sea/operation?
- Are there certain aspects of operating azimuth controllers that can only be safely done in a simulator/training facility?
- Do you have a certain method for teaching attendees at courses the "right" or "best" way to operate this lever/azimuth propulsion system?

It is interesting to get respondents to answer questions about how training facilities/instructors help/instruct in using handles of different make and model. (With the Schottel lever one should be aware of... It is possible to reverse in this azimuth without feeling tactile feedback from the handle that it is in reverse etc.).

- What is most difficult to learn when training in the use of Azimuth control systems?

Again - from a human machine interface perspective - it could be interesting to get an evaluation from training centres on how they see the usability e.g. the different propulsion systems and levers for different vessels. Interesting if they could rate them each on a scale (1-10)?
Maybe your last questions could have sub- questions like:
"What needs from the customers regarding the training with azimuth controllers have you experienced that you cannot or have a hard time to live up to"? - if this is to be negatively phrased - then something like:

"Have you experienced certain needs from customers you have difficulties to fulfil (- please indicate type of vessel/operation (and customer))?

Regarding the objectives in 3.2 about "types of training prepared for azimuth control devices, ships and the number of days for training" - maybe the respondents could list types of training/courses which are offer and number of days of these courses.

It could maybe also be of interest to ask respondents about how they systematically save information and data from training and courses and if this is used in the refinement/development of future training/courses.

3.3 Other informations available

It was assumed that parts of this task would be based on the responses to the questionnaire distributed to the training centres. Unfortunately, the responses to the questionnaire (the template of this questionnaire is attached to the deliverable report on task 3.2) are not available to the author at the time of writing of this report, and therefore those parts are based on the direct or indirect information on training courses realised in the following training centres:

- MITAGS- Maritime Institute of Technology & Graduate Studied Maryland USA
- TRANSAS Inc. Cork Ireland (and USA)
- Hochschule Bremen, Bremen, Germany (NS 5000 simulator by Defense Electronics)
- FORCE Technology, Lyngby, Denmark
- Australian Maritime College Launceston, Tasmania
- DST- Development Centre for Ship Technology and Transport Systems Germany
- STAR CENTER, Dania Beach, Florida USA
- ABB Marine Academy, Finland
- MARIN, Wageningen, The Netherlands
- TYNE -South Tyneside College
- CSMART- Center of Simulation and Maritime Training (Owner: Carnival), Netherlands.

Special simulation programs of azipod driven tugs are available in the majority of the above centers. On top of that, according to the information provided by TRANSAS and as reported by Sorensen (2006) at following simulator centers such programs are also available:

- MITAGS, Washington Di, USA: 2 Full-Bridge 360 degrees view Simulators and Tug simulator.
- Pacific Maritime Institute, PMI, Seattle, USA: 2 Full-Bridge Simulators and Tug Simulator
- Marine Engineering School, MEBA, Easton, Maryland, USA: 2 Full- Bridge Simulators and 2 Tug simulators
- STC B.V. Centre for Simulation, Maritime Research, STC Group Rotterdam, The Netherlands

- Georgian Great Lakes Maritime College, Canada, 4 Full-Scale Bridge Simulators in Network. Bridge layouts allow simulation of practically any ship types including tugs with all existing drives (FPP, CPP, Steering Nozzle, Pods, Voith – Schneider, etc.), tows, and many others.
- FORCE Technology, Denmark (a full bridge tug mock-up, two auxiliary tug cubicles, a vector tug station, an instructor/operator station).

The scope of the available information on the programmes of the azipod courses realised in the above training centres using Full Mission Bridge Simulators (FMBS) is widely different, in the majority of cases is rather scarce.

Detailed Information about training courses and programmes are available from two training centres using Manned Models Simulators (MMS):

- PRS -Port Revel, France
- SRTC – Ilawa, Poland

And some information about manned models training courses is available also from:

- Warsash Maritime Academy, Southampton UK
- Port Ash, Australia
- Massachusetts Institute of Technology USAT

In the last three centres apparently there are no models equipped with azimuthing propulsion units.

4 TYPES OF SHIPS MODELS AND SIMULATORS

The types of ships in a training facility depend upon the extent of the facilities database. Generally, these databases cover a wide variety of vessels. Azimuthing controlled device (ACD) vessels tend to be rarer but AZIPODs still may differ in most popular Simulators such as Kongsberg and Transas.
The most advantages technologies are used on the full mission bridges simulators.
Maritime – full mission Simulator delivers systems:

- bridge simulators
- dynamic positioning
- e-learning systems
- engine room simulators
- GMDSS simulator
- Liquid cargo simulator
- Offshore vessel simulator
- Thermal power plant simulator
- VTS simulator
- Crane simulator

Important markets include countries with large offshore and shipyard industries.

The types and numbers of ACD vessels available to simulator training facilities depend upon several factors. A training facility will have various ships in their database. A great deal of the work that simulator facilities do is that of manoeuvring in harbours. Tug handling courses are particularly popular, and as many tugs are azimuthing stern drive (ASD), then the training facility will usually have a variety of these ASD tugs available for simulation.

There are usually not many ACD vessels in the database that is obtained from the simulator manufacturer when it is first purchased. There may be a standard PANAMAX container ship and a cruise liner. Further ACD simulator models may be purchased, or the training facility may be able to develop their own models, using dedicated software from the simulator manufacturer.

4.1 Types, numbers and locations of azimuthing control devices

The types, number and location of azimuthing devices is almost without limits. It depends upon the how the device is being simulated with respect to the ship's hull and the environment. Different simulator manufacturers use different algorithms, but all the manufacturers claim that they can accurately simulate vessels with azimuthing devices. There are many types and configurations that azimuthing devices can be implemented. For example, contra-rotating Azipods, Shottel drives, Voith-Schneider, etc.

Not all simulators are capable of accurately simulating all azimuthing devices. The number and location of the azimuthing devices are limited to the limits of the software.
If the simulator facility has the capability of developing their own models, then they could theoretically develop a single Azipod cargo carrier, or nine tugs. Obviously, the more complex the vessel, the greater the time needed to develop the model, and thus there are usually not many unique vessels in the simulators database of ship models.

4.2 Types of simulators

Within the bridge-related simulator systems many types and levels of sophistication exist.

As there are many types of bridge simulators, in the requirements of DNV four categories were introduced:

Category 1: Full Mission
Category 2: Multi Task
Category 3: Limited Task
Category 4: Single Task.

Category	Class	Function
1 Full Mission	Class A.	Bridge Operation
2 Multi Task	Class B.	Machinery Operation
3 Limited Task	Class C.	Radio Communication
4 Single Task	Class X.	Cargo handling

- Category 1 - Full Mission. "Capable of simulating a total environment, including capability for advanced manoeuvring and pilotage training in restricted waterways." (This implies an interactive instructor facility connected to a fully equipped ship's bridge with high quality visuals, sophisticated mathematical ship and environment models, a sound system, numerous playing areas, multiple own and target ship models and possibly a motion system).
- Category 2 - Multi Task. "Capable of simulating a total navigation environment, but excluding the capability for advanced restricted-water manoeuvring." (This implies e.g. a radar simulator with navigation equipment and a simpler, limited visual system. The field of view of the visuals should preferably be at least the arc of the masthead and side navigation lights and an interactive instructor station).
- Category 3 - Limited Task. "Capable of simulating an environment for limited (blind) navigation and collision avoidance training." (This means what used to be designated as a radar simulator with for instance an instructor station and a number of own ship cubicles with radar and limited instrumentation).
- Category 4 - Single Task. "A desk-top simulator utilizing computer graphics to simulate particular instruments, or to simulate a limited navigation/manoeuvring environment but with the operator located outside (bird's-eye view) the environment." (This will mean for instance simulation on a pc of one instrument, such as is used in a navigation instrument lab. This type of system is particularly appropriate to provide multiple trainee stations for familiarisation training in preparation of a more comprehensive simulator).

Standards for certification of maritime simulator centres were adopted by Det Norske Veritas in 2005 (see reference). The scope of the standards is:

“This standard gives requirements for maritime simulator centres so as to ensure the quality of development and delivery of programmes. Programmes in this sense shall meet or exceed the customer’ expectations. This objective shall ensure that programmes being offered within the maritime simulator sector are properly designed, contain clear objectives as to results, are carried out by qualified instructors and are evaluated and improved in line with market demands and experience.”

Maritime simulator centres which comply with the requirements of this standard may receive a certificate for "Maritime Simulator Centre"

The STCW Code specified requirements as to the capabilities of simulators that must be satisfied. Those standards are repeated below:
"Section A-I/12 Standards governing the use of simulators
PART 1 – PERFORMANCE STANDARDS

4.3 General performance standards for simulators used in training

Each party shall ensure that any simulator used for mandatory simulator-based training shall:

.1 is suitable for the selected objectives and training tasks;

.2 be capable of simulating the operating capabilities of shipboard equipment concerned, to a level of physical realism appropriate to training objectives, and include the capabilities, limitations and possible errors of such equipment;

.3 has sufficient behavioural realism to allow a trainee to acquire the skills appropriate to the training objectives;

.4 provides a controlled operating environment, capable of producing a variety of conditions, which may include emergency, hazardous or unusual situations relevant to the training objectives;

.5 provide an interface through which a trainee can interact with the equipment, the simulated environment and, as appropriate, the instructor, and

.6 permits an instructor to control, monitor and record exercises for the effective debriefing of trainees.

General performance standards for simulators used in assessment of competence

2 Each party shall ensure that any simulator used for the assessment of competence required under the Convention or for any demonstration of continued proficiency so required, shall:

.1 be capable of satisfying the specified assessment objectives

.2 is capable of simulating the operating capabilities of shipboard equipment concerned, to a level of physical realism appropriate to the assessment objectives, and includes the capabilities, limitations and possible errors of such equipment

.3 has sufficient behavioural realism to allow a candidate to exhibit the skills appropriate to the assessment objectives;

.4 provides an interface through which a candidate can interact with the equipment, the simulated environment;

.5 provide a controlled operating environment, capable of producing a variety of conditions, which may include emergency, hazardous or unusual situations relevant to the assessment objectives, and

.6 permits an assessor to control, monitor and record exercises for the effective assessment of the performance of candidates."

In many countries sea pilots are required to attend special simulator courses either on FMBS or MMST every few (usually 5) years. Therefore there is certainly need for simulator training of ship masters and officers and also pilots in ship handling.

4.4 Marine Simulations Facilities and Makers of Simulators

AZIPILOT **Simulation Facilities** Sorted by country and town

Acronym	Company	Address	ZIP	Town	Country	Internet	Contact person	E-Mail	Manufacturer	Software	Year	Remarks	Equipment
HZS	Antwerp Maritime Academy (Hoogere Zeevaartschool Antwerpen)	Noordkasteel Oost 6	2030	Antwerpen	Belgium	http://www.hzs.be/		info@hzs.be	Flanders Hydraulics ???	**N/A**			**F M B Simulator**
	Flanders Hydraulic (Waterbouwkundig Laboratorium)	Berchemlei 115	2140	Antwerpen	Belgium	www.watlab.be	Katrien Eloot	waterbouwkundiglabo@vlaanderen.be	Flanders Hydraulics	**N/A**			2 **F M B** 360°+, 225°
	VDAB Maritieme Opleidingen	L Blondeellaan 9	8380	Zeebrugge	Belgium	http://www.users.skynet.be/vdab.maritiem		infomaritiem@vdab.be	Transas	**N/A**			Bridge without view, Cubicle without view
	Bulgarian Maritime Training Center	73 Vassil Drumev str.	9026	Varna	Bulgaria	http://www.bmtc-bg.com	Milcho Belchev	mbelchev@bmtc-bg.com	Kongsberg	**N/A**			Navigation Simulator
	University of Dubrovnik, Maritime Department	Branitelja Dubrovnika 29	20000	Dubrovnik	Croatia	http://www.unidu.hr/	Jelena Dubelj	jelena.dubelj@unidu.hr	**N/A**	**N/A**			Bridge with view

	University of Rijeka, Faculty of Maritime Studies	Studentska 2	51000	Rijeka	Croatia	http://www.pfri.hr	Prof. Dr. Pavao KOMADINA	komadina@pfri.hr	Transas, Transan, Kongsberg	Navi-Trainer Pro 3000, Navsim NMS 900			**F M B** 130°, PC-based navigation Simulator, Ship handling simulator
	AdriaMare Maritime Training Centre	Draga 2, P.O Box 109	22000	Sibenik	Croatia	http://www.adriamare.net		training@adriamare.net	Transas	Navi-Trainer Pro 4000, DP1/ DP2 cl.sim			
	BSM Marine Training Centre	7, Saafi Street	CY 3042	Limassol	Cyprus	http://www.hanseaticshipping.com **-> now:** http://www.bs-shipmanagement.com		management@hanseatic.com.cy **-> now:** cy-sdc-man@bs-shipmanagement.com	Kongsberg	**N/A**			
	Århus Maskinmesterskole	Borggade 6	8000	Århus C	Denmark	http://www.aams.dk	Mr. Niels Ole Birkelund	nob@aams.dk	**N/A**	**N/A**		<u>Approved</u> full mission simulator	

FORCE Technology DMI	FORCE Technology - Department for Maritime Industries	Hjortekaersvej 99 (Force: Park Allé)	2800 (FORCE: 2605)	Lyngby (FORCE: Brøndby)	Denmark	www.forcetechnology.com	Arne F. Mejer; Peter K Sørensen	afm@pc.dk; pks@force.dk	SimFlex	SimFlex	2008/ 2009	All bridges can simulate vessels with all kinds of azimuting propulsion with real handles	1 Bridge 360° visual view 2 Bridge 210° visual view 1 Bridge 120° visual view 1 Tug Bridge 360° visual view 2 Tug Cubicles 1 3D Steroscopic bridge
	Marstal Navigationsskole	10 Ellenet	DK-5960	Marstal	Denmark	http://www.marnav.dk/		kursus@marnav.dk	**N/A**	**N/A**		Simulation Bridges	
	Maersk Training Centre DK A/S	Dyrekredsen 4	5700	Svendborg	Denmark	http://www.mtc-maersk.com/		mtc@mtc-maersk.com	Kongsberg, D.P				1 **F M B**, 4 Cubicles
	Eesti Mereakadeemia	Mustakivi tee 25	13912	Tallinn	Estonia	http://www.emara.ee/		eesti.mereakadeemia@emara.ee	Transas	Navi-Trainer Pro 4000			Bridge with auxiliary bridge
	Føroya Sjomansskuli	Vinnuháskúlin, Boks 104	110	Tórshavn	Faroe Islands	http://www.vh.fo/		info@vh.fo	**N/A**	**N/A**			1 Bridge with view

	Yrkeshögskolan Sydväst	Nunnegatan 4	FI-20700	Åbo (Turku)	Finland	http://www.sydvast.fi/ TURKU, OTANIEMI		isabelle.bonnet@sydvast.fi	**N/A**	**N/A**		TURKU Sperry 2, Aspo Electronics 2, Furuno	OTANIEMI one 240° bridge + three 150 ° bridges
	Merituurva Maritime Safety Training Centre	Ship Simulation Unit, Merituurva, Tietotie 1 D	2150	Espoo	Finland	http://merituurva.fi/		laivasimulaattori@merituurva.fi	**N/A**	**N/A**			Bridge with view
	Sydväst Maritime [Wärtsilä Land and Sea Academy (WLSA)] / Aboa Mare	Malminkatu 5	20100	Turku	Finland	http://www.aboamare.fi/en/school	Per-Olof Karlsson	per-olof.karlsson@aboamare.fi	Sindel,Simulco-VTT and RDE	**N/A**			7 Bridges with view, different angles and size
	Ecole Nationale de la Marine	39 avenue du Corail	13285	Marseille Ceedex 8	France	http://www.hydro-marseille.com/v1/		enmm@hydro-marseille.com	Transas	**N/A**			Manoeuvring: 1 Bridge 270°, 5 Cubicles | Navigation 1 Bridge 150°, 3 Cubicles
TRANSAS	Transaas Mediterraneas SAS	Les 2 Arcs, 1800 Route des Cretes	6560	Valbonne	France	http://www.transas.com	Paul Dollery, 0033(0)489 864100	med-sales@transas.com	Transas	**N/A**			**Producer**

PRL	SOGREAH - Port Revel Shiphandling Training Centre	3500 Route de Revel	38870	Saint-Pierre-de-Bressieux	France	www.portrevel.com	Arthur de Graauw	arthur.degraauw@sogreah.fr	Home made model ships	Home made GPS tracking system	1967	Manned model training of pilots, masters and officers. Instructors are former maritime pilots.	10 ships and 3 escort tugs on a 5 ha lake at scale 1:25. One podded ship.
	Staatliche Seefahrtschule Cuxhaven	Staatliche Seefahrtschule Cuxhaven, Am Seedeich 36	27472	Cuxhaven	Germany	http://www.seefahrtschule.homepage.t-online.de/	Mr. Görtz	goertz@seefahrtschule.de	Transas	**N/A**	2006		1 Bridge 120°
SANDRA	DST - Development Center for Ship Technology and Transport Systems	Oststrasse 77	47057	Duisburg	Germany	www.dst-org.de	Andreas Gronarz	gronarz@dst-org.de	RDE	ANS 5000	2008	Inland navigation / shallow water simulator	1 Bridge (projection 210°), 4 Cubicles (1 Monitor), 1 Experimental simulator (3 Monitors)
MTC	Marine Training Centre - Hamburg	Schnackenburgallee 149	22525	Hamburg	Germany	http://www.mtc-simulation.com/	Heinz Kuhlmann	info@mtc-simulation.de	RDE	ANS 5000	2009		1 **F M B** 360°, 2 Full mission bridges 120°
MSCW	Maritime Simulationszentrum Warnemünde (Hochschule Wismar, Bereich Seefahrt)	Richard-Wagner-Str. 31	18119	Rostock	Germany	http://www.sf.hs-wismar.de	Prof. Karsten Wehner PrKnud Benedikt	karsten.wehner@hs-wismar.de; knud.benedict@hs-*wismar.de*	RDE	ANS 5000			1 **F M B** 360°, 1 Bridge 270°, 2 Cub Cub 120°

	Fachhochschule Oldenburg/Ostfriesland/Wilhelmshaven, Department of Maritime Studies	Weserstrasse 4	26931	Elsfleth	Germany	http://www.fh-oldenburg.de/	Christoph Wand	Christoph.Wand@els.fh-oldenburg.de	Kongsberg	**N/A**			1 **F M B** 330°, 3 Bridges 150°,
SUSANNE	Maritime Education and Training Center Leer (Nautitec)	Am Emsdeich 33	26789	Leer	Germany	http://www.nautitec-leer.de/		info@nautitec-leer.de	RDE (ex SUSAN)	**N/A**	2007		1 **F M B** 360°
	Piraeus Maritime Training Centre	40, Leosthenous str.	18535	Piraeus	Greece	http://www.sranis.gr/		info@sranis.gr	Kongsberg				1 **F M B** with 7 projectors
	EPSILON HELLAS	42-44 Iroon Polytechniou Str.	18535	Pireaus	Greece	http://www.epsilonhellas.gr		crew@epsilonhellas.gr	Transas	Navi-Sailor 3000			1 Bridge with 5 projectors
	National Maritime College of Ireland	Ringaskiddy		Co. Cork	Ireland	http://www.nmci.ie/	John Clarence	john.clarence.nmci.ie	Kongsberg	**N/A**			1 **F M B** 360°, 1 **F M B** 270°, 3 Bridges 150°
	Ente Gestione Istituto Radar "G.Marconi" Genova	Via Nicolò Oderico 10	16145	Genova	Italy	http://www.enteradar.it/index.php		segreteria@enteradar.it	**N/A**	**N/A**			1 **F M B** 240°
	Italian Maritime Academy & Italian Maritime Academy Technologies	Via dei Mille 47	80121	Napoli	Italy	http://www.itma.it/index.htm		info@itma.it	Kongsberg	Polaris			1 **F M B** 360°
	VeMarS - Scuola marittima di Venezia	sezione portuale S.Marta, fabbricato 16	30123	Venezia	Italy	http://www.venicemaritimeschool.com/index.php?area=home		vemars@vemars.it	Transas	**N/A**			1 **F M B** 280°, 1 Cubicle 30°, 4 PC controlled ships

	Latvian Maritime Academy	5B Flotes Street	LV – 1016	Riga	Latvia	http://www.latja.lv/	Captain Gunars Steinerts	steinerts@latja.lv	**N/A**	**N/A**			Simulators
STC	STC-GROUP (Scheepvaart en Transport College)	Lloydstraat 300	3024 EA	Rotterdam	Netherlands	http://www.stc-group.nl	Jakob Pinkster	pinkster@stc-r.nl	STC	**N/A**		A number of dedicated simulators for vessels and harbour facilities	1 **F M B** 240°, 1 Inland bridge 120°, 5 other bridges, 4 Radar Cub
	Maritiem Instituut "Willem Barentsz"	Postbus 26	8880 AA	Terschelling West	Netherlands	http://www.miwb.nl/		miwb@mi.nhl.nl	Kongsberg	Polaris SBS2000			1 **F M B** 360°, 1 Bridge 300°
MSCN (MARIN)	Maritime Simulation Centre, The Netherlands B.V. (MARIN)	Haagsteeg 2	6708 PM	Wageningen	Netherlands	www.marin.nl	Frans Quadvlieg, Yvonne Koldenhof	quadvlieg@marin.nl mscn@marin.nl	MARIN	**N/A**			1 **F M B** 360°, 1 **F M B** 210°, 4 Cubicles
	Ålesund College	**Serviceboks 17**	**6025**	**Ålesund**	**Norway**	**http://www.hials.no/**		**postmottak@hials.no**	**Kongsberg**	**N/A**			**Several bridges with view**
	Fagskolen i Ålesund	Postboks 5077 Larsgården	6021	Ålesund	Norway	http://fials.no/		postmottak@fials.no	**N/A**	**N/A**			Bridge with view
	Konsberg Maritime	**Bekkajordet 6, 8A**	**NO-3194**	**Horten**	Norway	http://www.kongsberg.com	**0047(0)81573700**	km.simulation.sales@kongsberg.com	**N/A**	**N/A**			**Producer**

			NO-3189				Fax:0047(0)85028028	Solvi.opthun@kongsberg.com	**N/A**	**N/A**			
	OSM Ship Management AS	P.O. Box 1684	4857	Arendal	Norway	http://www.osm.no/		osm@osm.no	**N/A**	**N/A**			Bridge Simulator
	Bodin videregående skole og Maritim fagskole	Mørkvedtråkket 2	8026	Bodø	Norway	http://www.bodin.vgs.no		post.bodin@nfk.no	Kongsberg	**N/A**	2007		1 **FMB** 225°, 2 Bridge 120°, 12 PC-based stations
	Haugesund Simulatorsenter	Bjørnsonsgt. 45	5528	Haugesund	Norway	http://www.maritimeacademy.no/Side/Simulatorsenter http://www.hsh.no/	Martin Vold	martin.vold@hsh.no	**N/A**	**N/A**			Bridge with view
	Ship Manoeuvring Simulator Centre AS	Ladehammerveien 4	7041	Trondheim	Norway	http://www.smsc.no/	Gunnar Gudmundseth	gunnar@smsc.no	Kongsberg	**N/A**			2 **F M B**, 2 smaller bridge
	Polish Naval Academy	Smidowicza 69	81 - 127	Gdynia	Poland	http://www.amw.gdynia.pl/		jchar@amw.gdynia.pl	Kongsberg	**N/A**			3 small bridges
	Gdynia Maritime University, Department of ship operations	Aleja Jana Pawła II 3	81-345	Gdynia	Poland	http://www.am.gdynia.pl/html/wn/kes/?q=dydaktyka.pokaz&id=symman		sdk@am.gdynia.pl	Kongsberg	**N/A**			1 **F M B** 120°

	GDYNIA MARITIME SCHOOL LTD.	ul. Hryniewickiego 10	81-340	Gdynia	Poland	http://morska.edu.pl/		szkola@morska.edu.pl	Kongsberg	**N/A**	actualitzed 2009		Full mission bridge with view
SRTC	The Foundation for Safety of Navigation and Environment Protection	Ship Handling Centre	14-200	IŁAWA-KAMIONKA	Poland	http://www.ilawashiphandling.com.pl/		office@ilawashiphandling.com.pl	**N/A**	**N/A**		Training with manned models	
	Cernav Romanian Maritime Centre	Str. Pescarilor nr. 69A	900581	Constanţa	România	http://ceronav.ro/		office@ceronav.ro	**N/A**	**N/A**			1 **F M B** 360°, 4 Cubicles 30°
	NAFC Marine Centre	Port Arthur	ZE1 0UN	SCALLOWAY	Shetland	http://www.nafc.ac.uk/		info@nafc.uhi.ac.uk	**N/A**	**N/A**			3 Bridges
	Faculty for Maritime and Transport Studies - University of Ljubljana	Pot pomorščakov 4	6320	Portorož	Slovenia	http://www.fpp.uni-lj.si/	Dr. Jelenko Švetak	jelenko.svetak@fpp.uni-lj.si	**N/A**	**N/A**			1 Bridge 120°, 2 Cubicles
IMCO	International Maritime College Oman	po box 2954	pc111/cposeeb	Muskat	Sultanate of Oman	http://www.imcoman.net	W. de Vries		STC	**N/A**			14 Bridges
	Chalmers University of Technology	Department of Shipping and Marine Technologoy	SE-412 96	Göteborg	Sweden	http://www.chalmers.se/smt/	Lotta Olsson (admin)	lotta.olsson@chalmers.se	Transas, Kongsberg	Transas: NTPro 4000 Kongsberg :Polaris	2006	Contols for directional propellers and voight schnieider propulsion.	Transas: Horizontal field of view: 290° and 200°, Kongsberg: Hor field of view: one bridge 120°, 4 brid. 45°.

	Kalmar Maritime Academy	Sjöfartshögskolan	391 82	Kalmar	Sweden	http://www.hik.se/sjofart/		kma@hik.se	**N/A**	**N/A**			**F M B** with view
	Istanbul Technical University			Istanbul	Turkey	http://www.maritime.itu.edu.tr/		marsim@itu.edu.tr	**N/A**	**N/A**			1 **F M B** 240°, 1 Cubicle 42.5°
	Kherson Maritime centre	2, Komsomolskaya str., office 208	73000	Kherson	Ukraine	http://www.ship.gr/kherson.htm		kmc@public.kherson.ua	Transas	**N/A**			1 Bridge 120°
	Odessa National Maritime Academy	8, Didrikhson str.	65029	Odessa	Ukraine	http://www.onma.edu.ua/	Vadym Zakharchenko	zvn@onma.edu.ua	Transas, Kongsberg	**N/A**			Simulators
	Glasgow College of Nautical Studies	21 Thistle Street	G5 9XB	Glasgow	United Kingdom	http://www.glasgow-nautical.ac.uk/	Derek Robbie	dg.robbie@gcns.ac.uk	n	**N/A**	1998		**F M B** with view
	Warsash Maritime Academy	Newtown Road, Warsash, Southampton	SO31 9ZL	Hampshire	United Kingdom	http://www.warsashacademy.co.uk/	Annette Dymond	annette.dymond@solent.ac.uk	Kongsberg	**N/A**			1 **F M B** 270°
	Ship Safe Training Group Ltd	The Precinct, Rochester	ME1 1SR	Kent	United Kingdom	http://www.sstg.org/		info@sstg.org	**N/A**	**N/A**			**F M B** with view
	Fleetwood Nautical Campus	Blackpool & The Flyde College, Broadwater, Fleetwood	FY7 8JZ	Lancashire	United Kingdom	http://www.blackpool.ac.uk/	Mr. A. Dumbell	ad@blackpool.ac.uk	**N/A**	**N/A**			5 **F M B**
	Maritime Training (Plymouth) Ltd	Cumberland Road, Devonport	PL1 4HX	Plymouth	U. Kingdom	http://www.plymouthmaritimetraining.co.uk/		mtp@plymouthmaritimetraining.co.uk	**N/A**	**N/A**			no details

	Lowestoft College	Maritime and Offshore, St Peters Street, Lowestoft	NR32 2NB	Suffolk	United Kingdom	http://www.lowestoft.ac.uk/	Mr. G Horton	g.horton@lowestoft.ac.uk	**N/A**	**N/A**			1 **F M B** 150°, 2 secondary bridges
TYNE	South Tyneside College	St. George's Avenue, South Shields	NE34 6ET	Tyne & Wear	United Kingdom	http://www.stc.ac.uk/	Chris Thompson	Chris.Thompson@stc.ac.uk	Kongsberg, Transas	**N/A**			2 **F M B** 360°,4 120°, 8 Cubicles
	Lairdside Maritime Centre	3 Vanguard Way, Campbeltown Road, Birkenhead	CH41 9HX	Wirral	United Kingdom	http://www.lairdside-maritime.com/	0044(0)151164704	enquiries@lews.uhi.ac.uk	**N/A**	**N/A**			1 **F M B** 360°, 2 other bridges
	L3 Marine SYSTEMS	Innovation Drive, Burgess Hill	RH15 9TW	West Sussex	United Kingdom	http://www.L-3com.com	0044(0)1444247535	burgess.hill-office@L-3com.com	**N/A**	**N/A**			Producer of Bridges Controlers
	L3 Marine Products and Services	2961 West California Avenue	Utah 84104	Salt Lake City	USA	http://www.l-3marinesystems.co.uk/#/about-l-3/4541171848	888-259-4746		**N/A**	**N/A**			Producer of Bridges Controlers

5 RELATION TO HOST COMPANIES

South Tyneside College has been offering ship simulation training since the 1960s-and therefore has many years' experience of running successful simulations courses.

As the simulation marketplace becomes increasingly crowded - with shipping companies, consultants and even simulator manufacturers conducting their own training courses – in our Simulation Department we are constantly asked by others in the industry for information on how to run a successful simulation.

Although anyone can run a simulation with the correct training, there are hundreds of nuances, which we've developed over many years, to make the experience as realistic as possible. For example, ensuring that external visuals are aligned properly or providing realistic Port Authority announcements can make a big difference in how lifelike the simulation feels.

We are looking to share this type of knowledge and best practice to help the industry achieve the highest possible standards in Marine Simulation training and follow the industry progress for the control devices such an azimuthing control devices.
The more that the marine industry works together on sharing best practice then the higher we can set the bar on industry standards.

5.1 Marine Simulation, Ports and Harbour's Department of South Tyneside College.

The College's Marine Simulation, Ports and Harbour's Department features six simulated navigational bridges (including two full mission bridges), a full mission engine simulator, two VTS Simulation Suites, and a Radar Station featuring a navigational aids laboratory and a four bridge Transas Navy-Pro Simulator. There is also a four bridge Polaris desk-top simulator which is mainly used for ECDIS training and the Bridge Watch Keeping module of the NARAS (Ops) course. It also works regularly with many of the key industry players to develop bespoke courses.

Since its very inception, the Department has responded to the requirements of Maritime Training and Education. It boasts an impressive list of industry firsts – one of which is the introduction of IALA (International Association of Lighthouse Authorities) approved training for VTS (Vessel Traffic Services).

Pilots come to the College from all over the globe and it has been involved in some extremely high-profile training programmes including AziPod training.

When the King of Morocco wanted to divert commercial shipping traffic out of the Port of Tangier in order to develop tourism, Marine Simulation, Ports and Harbour's Department was instrumental in Pilot and VTS Training for the new Tangier-Med Port.
This contract once again confirms our reputation as a leading international Marine College with first class facilities and lecturing staff. It's fantastic that South Tyneside College's simulator team's knowledge and skills have been recognised on an international level.

Simulation Department provides the integrated courses which can vastly improve communication and understanding between the bridge and engine room and allow ship personnel to operate more effectively as one team. This new software will revolutionise operational training for the cruise industry, with some models of cruise ships equipped with AziPod devices. Although training programmes already exist for bridge and engine room cruise vessels separately, there really is no substitute for training exercises which simulate a real-life situation in real-time with the entire ship's staff working together.

This training will ensure that engine room and bridge personnel from cruise vessels learn to function more effectively as a cohesive team and gain a much greater understanding of the challenges and demands of each other's working areas.

5.2 Examples of models with Azimuthing Control devices using in Kongsberg Simulators in South Tyneside College

In our Simulator we have a group of computer programmers which are developing some ship's models (or adapted upon the customer demand) as required to fulfil demand for a particular training. For these reason we are already providing Azimuthing training for large group of Pilots and Tug's Captains.

Hopetoun

Goliath

Bison

Harald

Erlend

Integrated Exercise.

On our two full mission bridges simulators, run by professionals, we can provide all range of variety training including ship-handling based on models equipped with Azimuthing control devices. In response of the industry demand most of our Azimuthing models are tugs.

We can provide training using ship model base on "Independence of the Seas" – we call it "Freedom of the Seas".

6 TRAINING REQUIREMENTS AND CONSTRAINS, TRAINING OBJECTIVES

In this chapter there are discussed training requirements and constrains, training objectives are defined and training programmes defined accounting for technology, human factors and training methods used in training centres.

6.1 Training requirements and constrains

6.1.1 General

During last three decades attention of the maritime world has been focused on the increase of safety of shipping and on reduction of accidents at sea. Intensive activity of the International Maritime Organisation and other governmental and non-governmental organisations in this field has to be mentioned in this context.

Amongst other causes of accidents at sea casualties related to manoeuvrability happen quite often and analysis of casualties shows that CRG casualties (Collisions-Ramming-Groundings) constitute about 53% of all serious accidents leading to ship loss (Payer 1994). According to Lloyd's Register of Shipping statistics during last 10 years 2/3 of all accidents at sea were CRG casualties.

Data on casualties for the year 1982 analysed on the basis of sources provided by LRS and DnV revealed that the frequency of CRG casualties was rather high as it is seen from the Table 1.

The data showed that 1 ship in 22 took part in CRG casualty this year (Samuelides&Friese 1984). At present CRG casualties occur more often with increasing speed and size of vessels and such casualties may cause more serious consequences. Collisions may also happen more often in restricted waterways and canals and in particular in areas where additional external factors, as e.g. current, make handling of ships more difficult. Collisions, ramming and groundings are directly related to ship handling.This is important indication regarding training programmes.

Table 1. Data on CRG casualties

Source	Mean number of ships during the year	Number of CRG casualties	Frequency of casualties [%]
DnV	2816	120	4.3
LRS	3391	170	5.0

Increase safety at sea and reduction of the number of casualties, in particular CRG casualties is the main objective of the International Maritime Organization.

Specialized training in ship handling is required by the International Maritime Organisation. Seafarers' Training, Certification and Watch keeping (STCW) Convention. Also many governments, ship owners and pilot organisations require mariners to complete specialized training courses in ship handling.

Apart training onboard ships, approved simulator training or training on manned reduced scale ship models is mentioned there, as a method of demonstrating competence in ship manoeuvring and handling for various ranks, functions and subjects. However how this shall be achieved as well what type of simulator is required to achieve demonstrating competence is not mentioned.

In several places in the specifications of minimum standards of competence for ship officers as the method demonstrating competence use of simulators, either FMBS or MMS is mentioned Prospective masters and chief officers of large ships and ships with unusual maneuvering characteristics are recommended to attend training course of ship handling, either on FMBS or MMS. There are also specified certain requirements as to the capabilities of simulators that must be satisfied (see Chapter 3 of this report). IMO published also various Model Courses and one that refers to ship handling is Mode Course 1.22 “Ship Simulators and Bridge Teamwork”. However in the STCW Convention there are no requirements as to the training for ships equipped with azimuthing control devices. Azimuthing propelled ships are not specifically mentioned with the context of training.

Recently in many districts escorting of large vessels carrying dangerous goods - oil tankers, gas carriers and similar-is required. Escort tugs are almost always fitted with azimuthing propellers and escorting operations in case of emergency require greater skill from the tug masters and ship masters. Training in escorting operations is another fast developing area where azipod propelled vessels is involved and where special training is required by Port Authorities and National Administrations.

Main motivations for specialized training courses in handling of ships equipped with azimuthing control devices arise from the following prerequisites:

- Technology. Azimuthing control devices are novel types of propulsion units having characteristics and features that are widely different from conventional ship propulsion.
- Human factor. Different performance characteristics of ships equipped with azimuthing propulsion devices require different handling and skill in operating conventional ships may be inadequate.

The needs for specialized training for those ships are discussed in the reports on Task 3.1 and 3.5.

There are, however, strong links between human factor and technology. New technologies bring challenges to human performance. This is clear with regard to ships equipped with azimuthing propulsion devices. Novel type of ship control which is not intuitive for pilots accustomed on controlling conventional ships brings new demands on human performance when controlling those ships. Special training is then necessary. And vice versa, realisation that the majority of casualties are caused by human factor requires more study of the problem of man-machine interface that leads to new designs of bridge lay-out, new solutions of controls etc.

6.1.2 Effect of technology

Azimuthing propulsion units are well known for years. Such propulsion devices which at the same time are driving and steering the boat or ship were used for many years.

Classic example is outboard motor used for small motor boats, the other solutions comprise Voith-Schneider, Kirsten-Boeing (rather rare) and Z-drive Schottel propulsion units used for larger ships or as auxiliary control devices. Rotatable Kort nozzle may be also included in this category.

The real revolution in the last quarter of the last century was caused by the introduction of pod drives, where large electric motor was located inside rotatable housing under the ship's hull and the available power may reach 25MW or more. Those pod drives were used in large, ships, mainly cruise liners, but also in some other types of ships.

According to Rees (2010) vessels fitted with azimuthing propulsion constitute 6.9% of all vessels, the largest groups being tugs, off-shore vessels and cruise liners.

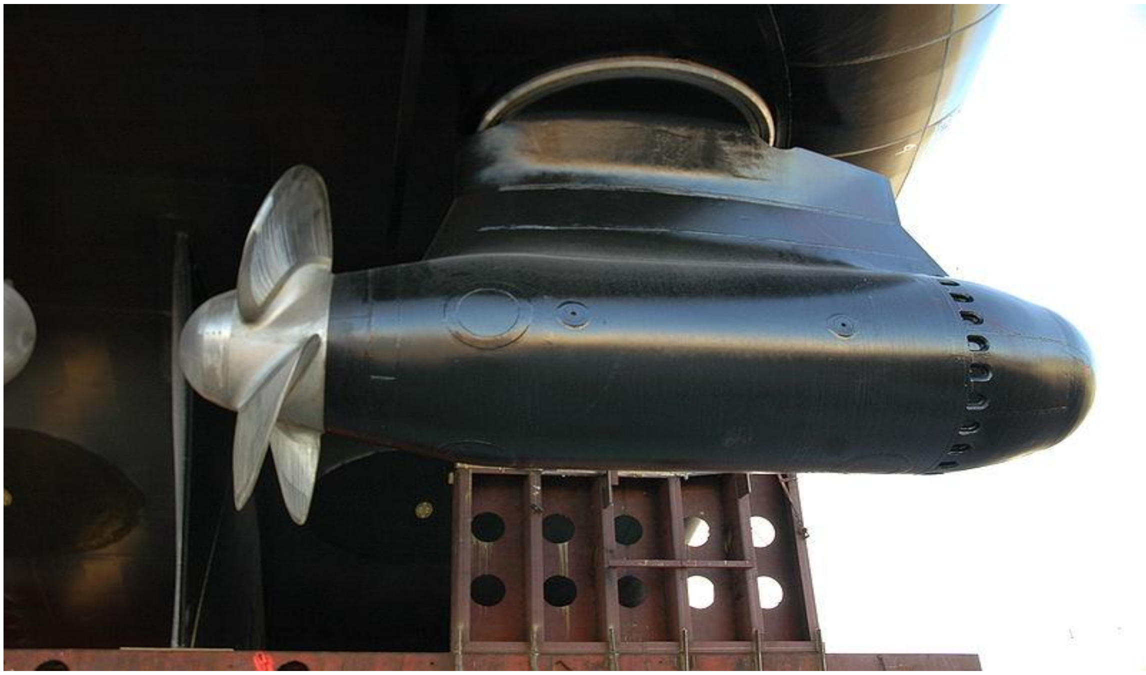

Fig. 1. Typical pod propulsion unit.

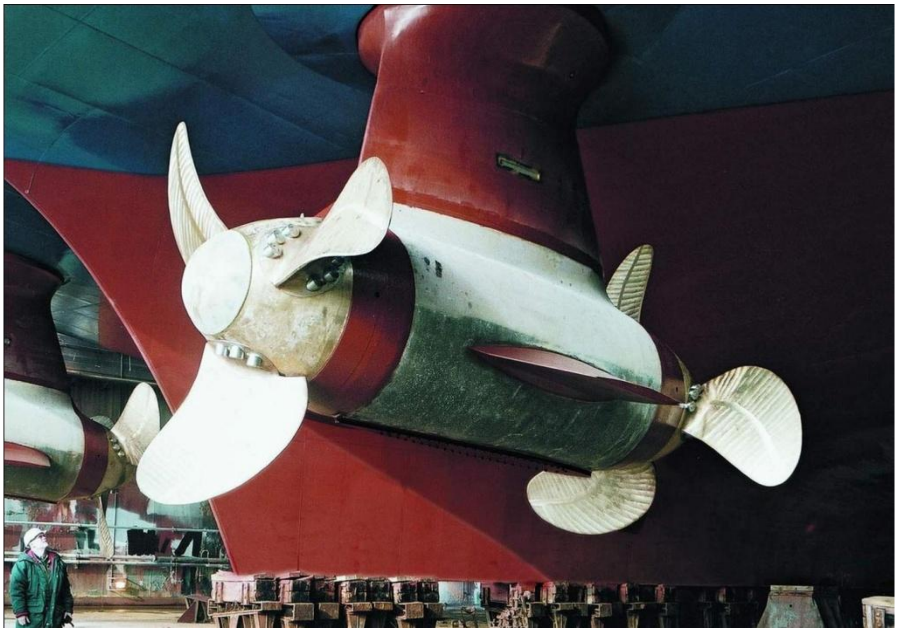

Fig.2. Siemens-Schottel arrangement of pod drive

Apart of the classical pod drive shown in fig 1, there are many other variants of pod propulsion where propellers may be pushing or pulling type or there may be two propellers contra-rotating or with the same direction of rotation on each pod as shown in fig 2. There are also some hybrid solutions where conventional propeller in combination with pod drives is installed, for example as shown in fig 3.

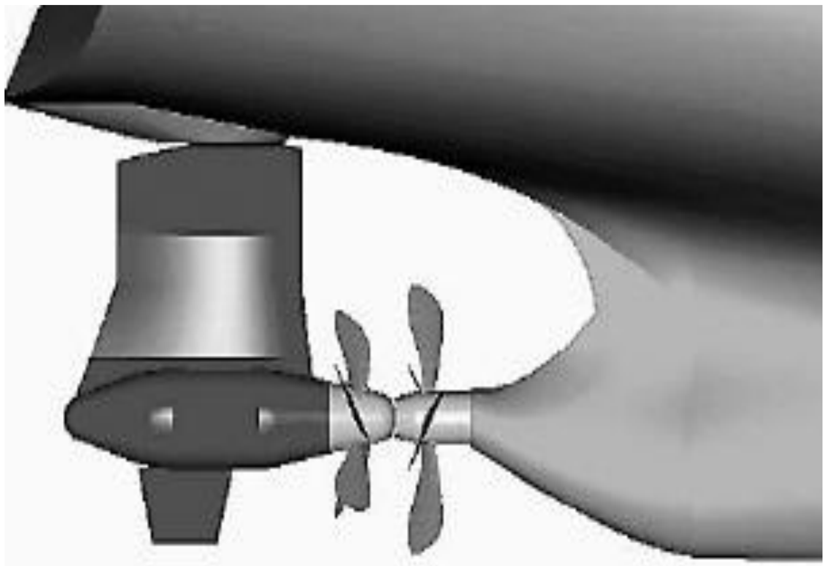

Fig.3. Hybrid arrangement of pod and conventional (fixed) propeller

Podded drives are installed usually in pairs, because ships with one pod drive are usually directionally unstable and difficult to control (report on Task 3.5, see references).

As the manoeuvring characteristics of pod driven ships differ substantially from those of conventional ships and pods are controlled in the different ways, helmsman at the controls may not intuitively handle motions of the ship without previous training and experience and he may be not fully aware of the results of settlings of the pods. In particular handling two pods independently may be confusing as to the effect of settlings on ship movements.

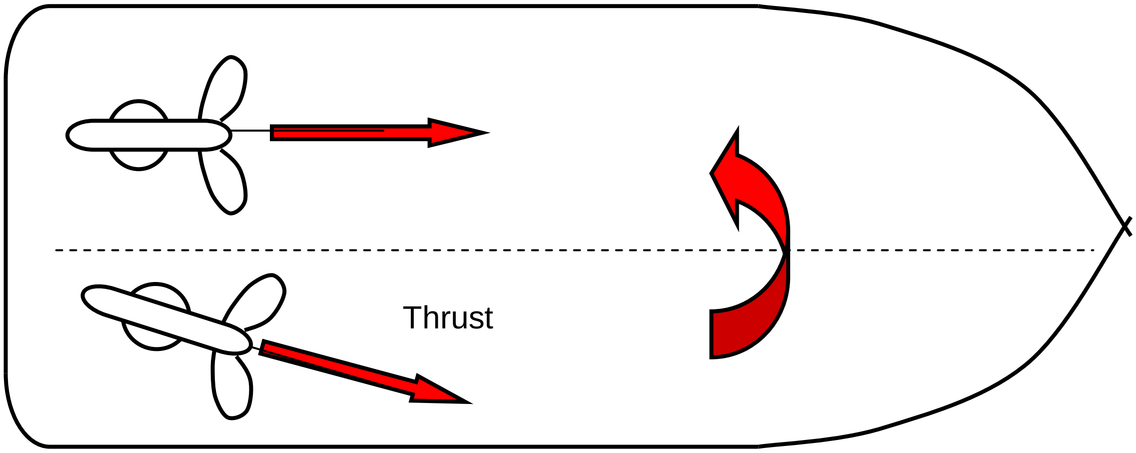

Fig. 4. Sketch showing direction of thrust

Controls on azipod propelled vessels are generally quite different from controls in conventional vessel and they are not intuitive. Usually controls show the direction of the thrust (fig.4.)

A typical control panel in pod driven ships is shown in fig .5. Indicators on the panel show direction of the thrust of pods. With the pod directed to starboard and the direction of thrustas as shown in fig.4 the ship will turn to port. (The opposite is with the conventional steering wheel 4)

Fig. 5. Typical control Panel on board pod driven ship

It must be taken also into account that because of the possibility to reverse the direction of rotation of the propeller, pulling propeller as shown in fig 1, will change to pushing propeller and that may be confusing to the helmsman especially when both pods are operated at the same time. The different modes of pod operation are discussed in the report on Task 3.5 (see references).

6.1.3 Effect of human factor

The prevailing majority of collisions, ramming and groundings (CRG casualties) could be attributed to failure in decision making and wrong reaction during navigation, in other words to human factor.

The effect of human factor on the training requirements, objectives and programmes is a very important one if we take into account that, according to general opinion, in about 80% or more marine casualties' human factor is prime and most important cause of accident. More detailed data on the effect of human factor on the percentage of casualties published by US Coast Guard (1995) reveal that about 80% of CRG casualties may be attributed to human failure. The alarming fact is that many of ships suffering casualties were equipped with the most modern state-of-art navigational aids and type approved bridges (Ehrke 2009).

In order to analyse the effect of training on safety, in particular safety from the point of view of avoiding CRG casualties, it would be useful to look at possible sources of human errors. The classification of human errors is shown in fig. 6 (after [3]).

Training affects all the above factors in a positive way. Kobayashi (2003) pointed out that human is one kind of control system revealing output (behaviour) to certain input (situation). This is shown in fig. 7 (from: Kobayashi 2003).

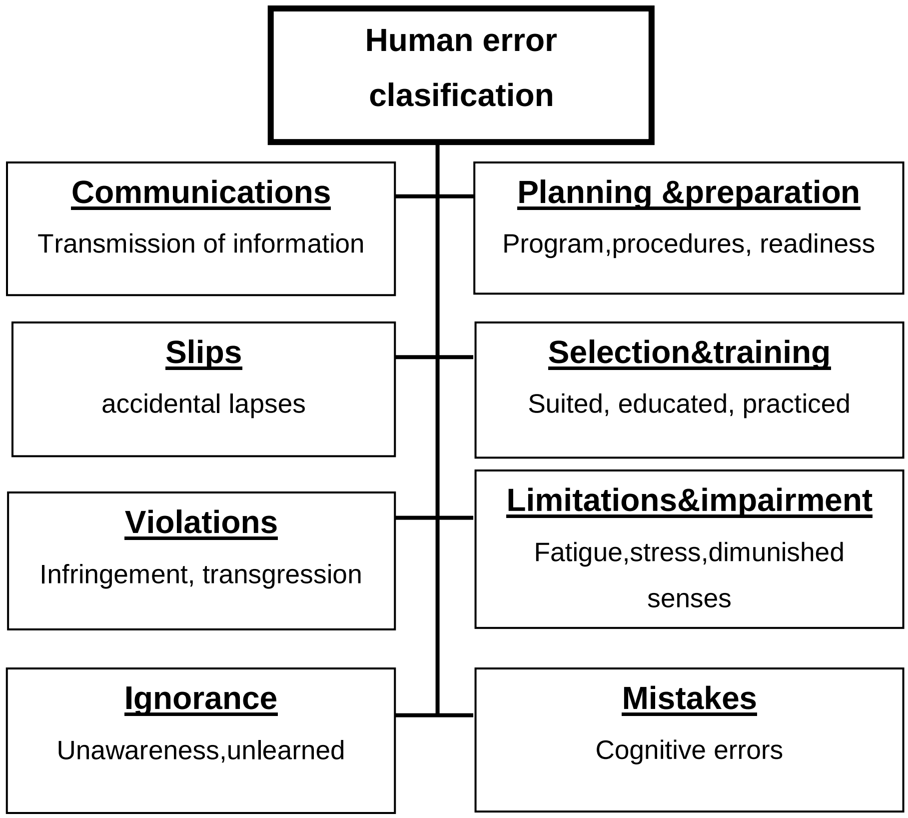

Fig.6.Human error classification (Bea, 1994)

He observed that mariner not having sufficient competency due to lack of training shows wide variety of behaviour, whether mariner having sufficient competency react to the same situation without such variety of behaviour. This effect is shown in fig. 8 (from Kobayashi 2003). This is clearly demonstrating effect of training on mariner’s behaviour.

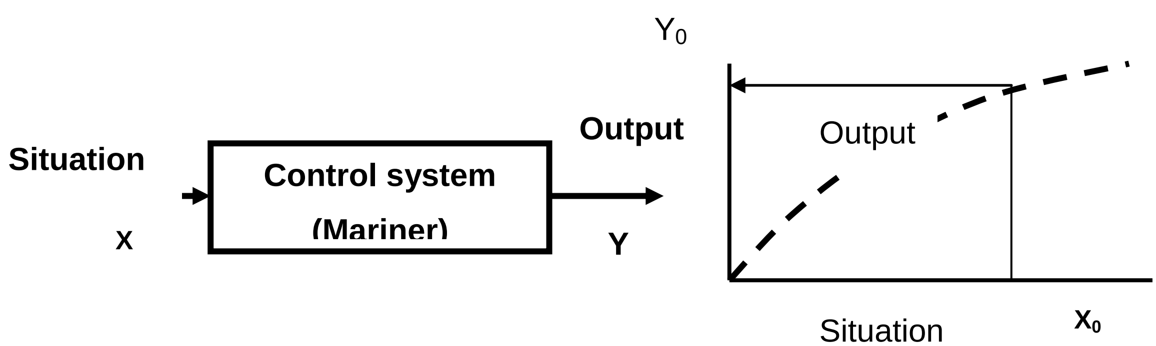

Fig. 7. Relation between condition (situation) and output (reaction) of the mariner treated as control system

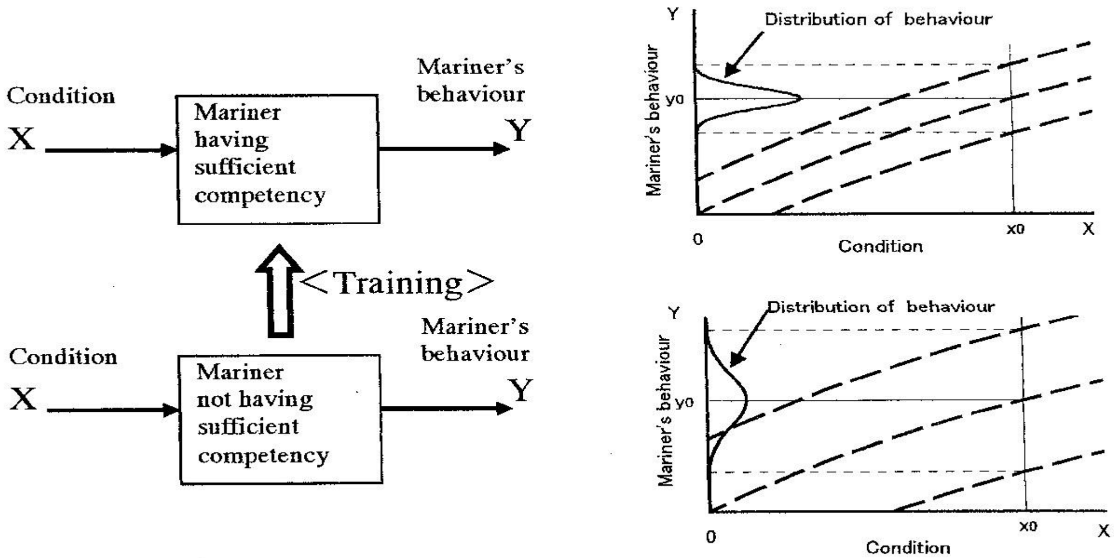

Fig. 8. The meaning of training concerning change of mariner's competency

Another important effect of training is the mariner's behaviour in emergency situation. This effect is illustrated in fig. 9 (from: Bea 1994).

A mishap is differentiated into three psychological stages: perceiving, thinking and acting. Fig 9 shows how training could influence way of handling a critical situation.

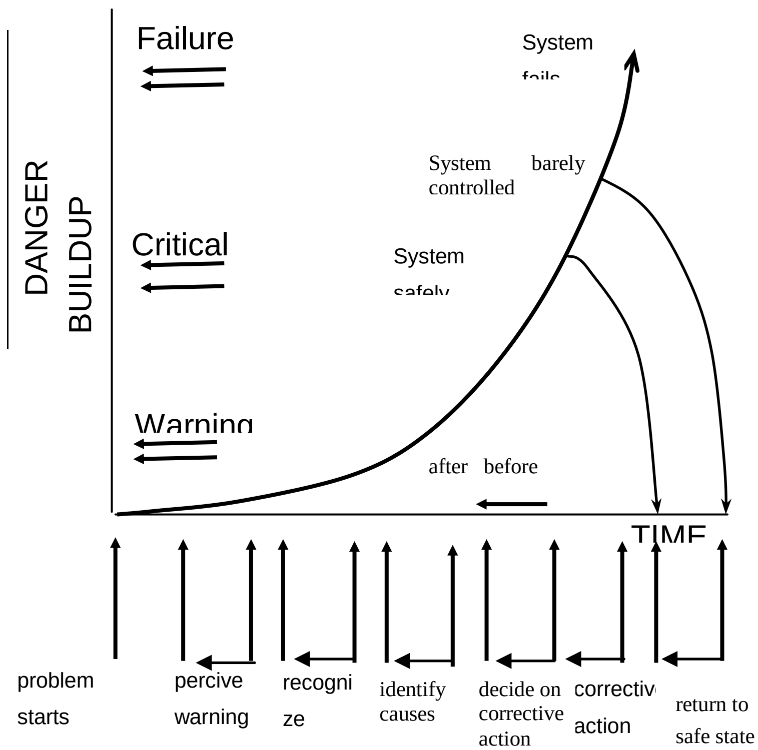

Fig.9. Effect of crisis training

The perception stage starts with a mishap and is followed by warning. The warning is recognised and mishap source is discovered. Then the thinking stage begins, problem is identified and decision taken. Action is planned and executed and the system is returned to normal operating status if the action is taken in time, otherwise system fails. The above figure shows how training may affect safety. It underlines also the necessity to training for critical situations. Once people were faced with critical situation during the training they will react quicker when such situation appears in reality. This is very important conclusion for the programming of training.

6.1.4 Training methods used in training centres

Obviously the best way to train ship officers and pilots in ship handling and manoeuvring is to perform training onboard real ships. Any use of simulators should be in addition to training onboard ships. However, gaining skill "on job" watching experienced practitioner working is a long and tedious process. Moreover certain handling situations including some critical ones may never occur during the training period and no experience how to deal with such situations could be gained this way. When serving on ships engaged in regular service between ports there is no possibility to learn about their real manoeuvring characteristics.

There are two ways of training ship officers and pilots in manoeuvring and ship handling, apart on-board training: to use electronic full mission bridge simulators or scale manned ship models.

Full Mission Bridge Simulators

Full Mission Bridge simulators are widely used for training of ship officers, pilots and students of marine schools and also for studying various manoeuvring problems, first of all problems associated with the design of ports and harbours. There is at present a considerable number of such simulators of different types operating throughout the world, starting from desk simulators to sophisticated full mission bridge simulators where the trainee is placed inside a bridge mock-up with actual bridge equipment, realistic visual scene, rolling and pitching motions and engine noise.

Full mission bridge simulators are working in the real time and are controlled by computers programmed to simulate ship motion controlled by rudder and engine (and thrusters or tugs) in different environmental conditions.

Because there is a mathematical model of ship motion on which computer programmes are based it is important that this mathematical model represents properly behaviour of the real ship. The theory of manoeuvring ship is, however, at present far from perfection.

The most useful mathematical model of a manoeuvring ship is so called modular model, which takes account of various hydrodynamic forces acting on hull, rudder, propeller and thruster separately. Those forces are expressed by hydrodynamic coefficients included in the equations of motions.

External effects, such as wind, restricted water, proximity of banks etc. could be also included. Hydrodynamic coefficients in curvilinear motion could be estimated using direct (model experiments in a towing tank equipped with planar motion mechanism - PMM) or indirect (identification method based on measurements input and output data of free-running model or full scale ship).

Both methods are expensive and time consuming and, moreover, indirect identification is rather difficult because of great accuracy of measurements required. Hydrodynamic coefficients could also be calculated by different methods such as theory of slender body, lifting line theory, panel method or most advanced method of finite volumetric elements and Navier -Stokes equations.

There are also available approximate regression formulae for calculation of hydrodynamic coefficients (Oltman et al 1999; Kijima 1993 and others). However, for pod propelled ships those approximate formulae may not be applicable.

Unfortunately, because of extremely complex flow phenomena around the manoeuvring ship, application of theoretical methods available cannot provide accurate results for more complicated manoeuvres.

With a ship in ahead motion and not to large deviations from the original course the numerical methods provide results which in many cases are within acceptable 20 per cent error in estimation of tactical diameter or overshoot angles in comparison with results of model tests or ship trials. However, when the ship is manoeuvring using often ahead and astern engine and rudder, and perhaps also thrusters at the same time and if, , manoeuvres are performed in the vicinity of piers or quays, in docks or in proximity of other manoeuvring ships, those methods are not accurate enough.

In particular with often changing direction of rotation of the propeller or often changing direction of pod drive what happens in manoeuvring i confined areas, the memory effects in the flow are hardly taken into account. In order to achieve accurate prediction of such manoeuvres it would be necessary to know propeller and rudder characteristics in four quadrants and the flow pattern induced and those could be estimated only on the basis of elaborate model tests which are exceptionally difficult and rarely performed. Moreover, the proper mathematical simulation of rapidly changing flow pattern around the ship hull, propeller and rudder taking into account external restrictions such as shallow water and bank effects is not possible.

Study performed by Gronarz (2010) where results of simulation of shallow water and bank effect in four advanced FBMS were compared did show that those effects not in all simulators were simulated correctly.

As manoeuvring full mission bridge simulators are working "on line" there is no possibility to use very sophisticated computer programmes which include calculations of hydrodynamic coefficients using advanced methods requiring powerful computers and extreme large memory. The computer programmes used are simplified and this is causing that the reality is not always simulated properly. This happens mostly when harbour manoeuvres are performed. But even simple manoeuvres such as turning circle manoeuvre or zigzag manoeuvre are often simulated not accurately. Gofman &Minin (1999, 2000) showed several cases where results of simulation differed considerably from results obtained during tests of full-scale ships.

According to those authors there are the following causes of this effect. When computer codes for the simulator are prepared some mathematical model elements are adjusted to provide minimal discrepancy between some given full-scale and simulated manoeuvres. Such adjustment of the mathematical model parameters can ensure satisfactory simulation only those manoeuvres it was performed for. As to the others, including many practical manoeuvres, it cannot guarantee satisfactory simulation.

On the other hand, for ships equipped with azimuthing propulsion devices advanced simulators simulate turning circles and zigzag manoeuvres in deep and shallow water accurately (Ankudinov 2010, de Mello Petey 2008).

Manned Models Simulators

Manned scale models are used for training purposes in open water areas. Models are sufficiently large in order to accommodate 2-4 people (students and instructors) and are constructed according to laws of similitude. The governing law of similitude is Froude's law and all quantities for models are calculated according to the requirements of this law

This means that not only geometry of the ship hull is properly reproduced according to chosen scale, but also dynamic characteristics of the ship such as speed, centre of mass, mass moments of inertia are correctly reproduced in the model. Also characteristics of the propeller (thrust, revolutions) rudder engine (time from hard over to hard over) and main engine (power, time of reversing etc.) are reproduced according to the scale. .
However, as it is well known, the requirements of second law of similitude which is relevant to ship motion, Reynolds law, cannot be met. This means that the flow around the ship hull and appendages and in particular separation phenomena might be not reproduced correctly in the model scale. Fortunately those effects are important when the models are small. With models 8 to 15 m long the Reynolds number is sufficiently high for avoiding such effects.

Models are fitted with anchors, thrusters and tug simulators where appropriate.

Models are controlled by the helmsman and are manoeuvring in the areas where mock-up of ports and harbours. locks, canals, bridges piers and quays, shallow water areas and other facilities are constructed and where also routes marked by leading marks or lights (for night exercises) are laid out all in the same reduced scale as the models. Also in certain areas current is generated.

One important difficulty with manned models is impossibility to reproduce wind effect. Wind is a natural phenomenon and according to laws of similitude wind force should be reduced by factor $\lambda 3$ (λ - model scale). Wind force is proportional to the wind age area and to the wind velocity squared. Wind age area is reduced automatically by factor $\lambda 2$ but wind velocity apparently cannot be reduced. However, actually wind age area in models is usually reduced more than by factor $\lambda 2$, and wind velocity. Due to sheltered training area and low position of the wind age area in the model in comparison with the full-scale ship is considerably reduced. Still usually wind force is larger than it should be.

Capability of manned models to simulate shallow water, bank, and submerged and surface canal effects, effect of current, close proximity of other stationary or moving objects is automatically assured and is practically unlimited, restricted only by local conditions in the training area.

In manned models training as a result of using Froude's law of similitude all manoeuvres are performed not in the real time, but in model time, that is accelerated proportionally to the factor $\lambda 1/2$. In consequence trainees when performing manoeuvres have less time for mental preparation of action and must adjust to rapid changing situation. This, as pointed out by Kobayashi (2003) may have some effect in emergency training, because having about 5 times less time for perception of the situation trainee may not have enough time to perceive and assess this situation and consequently may execute wrong action.

6.2 Defining training objectives and programmes

In this chapter training objectives and programmes are defined for ships equipped with azimuthing propulsion units.

As there are two different methods of training using simulators, namely FMBS and MMS that use different technology, the objectives and programmes defined for these two types of simulators are not the same and must be geared to the capabilities of both types of simulators.

Comparison of capabilities and related objectives of programmes for both types of simulators is shown in Table 2.

Table 2.

FMBS	MMS
Capabilities-objectives - programs	
• Scenarios may be reproduced where full Scale Bridge with all its equipment and corresponding illusion of surrounding world is required. • They are suitable for actual handling of ships using rudder, engine, thrusters, anchors, tugs and other equipment. In particular positioning and control of tugs, anchoring in crowded anchorages, steering according to leading marks or lights. • Familiarisation with specific pilotage areas which could be simulated visually • Bridge team management and master-pilot interaction. Full mission bridge simulators allow creating integrated team on the bridge including pilot. • Exercises performed involve pilot working with the bridge team in different situations. • Emergency procedures could be simulated, such as machinery breakdown, disabled vessel. Various rudder problems, man overboard etc. • Blind pilotage, use of radar navigation, and use of electronic charts	• Proper representation of hydrodynamic forces. There are physical phenomena governing model motions, not mathematical simulation which is always approximate and sometimes incorrect. • Close proximity realism. There is complete realism when two models are meeting or overtaking in close proximity, when the model is in the final stage of berthing or when negotiating very narrow passages. All physical phenomena in those situations are reproduced properly and the model is behaving naturally. • Realism in emergency situations. Training on manned models assures psychological effects by better feeling of effects of groundings, ramming and collisions which, if they happen, are very realistic. • Possibility to exercise anchoring and other special manoeuvres. Manned models are specifically advantageous for performing exercises with dredging anchor, anchoring in wind and tide and single point mooring. • Possibility to perform manoeuvres in current and tide. Effects of wind and current are clearly visible and realistic. Current generators may create non-uniform current and river estuaries could be modelled. Such environment allows learning quickly influence of changing hydrodynamic forces on model behaviour and influence of momentum when manoeuvring in current. • Effective use of time. As models are working in accelerated time scale, one week training on models corresponds approximately five weeks training on electronic real-time simulators. • Understanding physical phenomena. When performing specific manoeuvres something goes wrong the trainee immediately see that the result is wrong and with the help of instructor he may easily understand physical phenomena playing part in this manoeuvre.

7 LIMITATIONS IN THE TRAINING PROGRAMMES, THEIR ORIGINS AND REMEDIES TO THE LIMITATIONS

In this chapter of origins of the limitations in the training programmes are identified and severity of limitations are assessed with indication of possible remedies to the limitations

7.1 Limitations to the training programmes in FMBS

FMBS are based on mathematical algorithms describing ship's motions in the water areas in different environmental conditions. Those algorithms may take into account effect of shallow water and canal, surface or submerged, of restricted width and effect of banks with different inclination of slopes, effect of wind and current, effect of proximity of other objects or ships, moving or stationary etc. Forces created by the fixed propellers or podded drives, by thrusters, rudders, anchors, towing cables may also be accounted for.

Computer codes were then developed on the basis of those algorithms that must, however, work on line. This condition limits possibility to use very complex codes that must be solved in time domain and requiring much computer time. Simplified approaches are sought causing, however, reduced accuracy.

Sörensen (2006) considering simulation of tugs action stressed the need for realism when training tug masters, in particular masters of tugs equipped with azimuthing drives (ASD tugs, tractor tugs). This is not an easy task and it seems that only few training centres developed simulation technology and acquired necessary hardware and software meeting this requirement.

De Graauw (2010) points out that in FMBS when the model for a ship have to be developed for use in the simulator, extremely detailed information is needed about real vessel including all hydrodynamic coefficients needed in manoeuvring mathematical model equations together with many operational data on rudder, engine and other characteristics. This information is usually exceedingly difficult to obtain, due to the fact that it is confidential or not available at all, because hydrodynamic coefficients may be obtained only by specially arranged model tests in towing tanks (planar motion mechanism). After the model has been developed with the information that is available, it is then rigorously tested and tweaked. This tweaking, however, is not usually how the mathematical algorithms in the software are intended or designed to be used, leading occasionally to unexpected results
Development of the new ship model and the environment view is always costly enterprise and if the financial means are limited, this is not possible.

All these factors limit scope and programs of training. How severe those limitations are depends on the objectives of training. If the objective of training is to train ship master or pilot for specific ship or ship type in defined environment (for example for specific port) then those limitations may be severe if this port or this particular ship are not simulated and the training is performed using different ship and different environment. But if training objective is set as to help the trainee to understand various effects, such as manoeuvring characteristics of the ship (own ship and/or tug), the effect of environment like wind, water depth, locks, harbour basins etc and human factors such as human errors, communications, teamwork etc, such limitations may be considered not to severe.

It must be noted, that over the year's simulation technology was developing rather rapidly and further development may be expected in the future. A good example is FORCE Technology training centre as described by Sörensen (2006).

7.2 Limitations to the training programmes in MMS

Limitations regarding MMS are related to the objectives of the training as specified in. paragraph 1.2.

In the training centres using manned models technique usually up to 10 large scale (λ = 24 or λ=25) ship models of different types are operated. Some of these models might be used in different variants, changing for example stern part of the model (SRTC Ilawa – gas carrier conversion from single screw to twin screw propulsion or azipod drive – Fig.10), conversion from conventional propulsion to azipod drive (SRTC Ilawa and PRL Port Revel), conversion from diesel engine to turbine propulsion, use the model in full-load or in ballast condition etc. This procedure may substantially increase the number of models used for training up to about 20 (SRTC, PRL)

Fig.10. Gas carrier model converted from twin-screw to azipod drive (SRTC)

If in a training centre using manned models technique there is a need to simulate a particular port or route and train pilots or masters using particular ship then new ship model must be built and mock-up of the particular port of route arranged. This may require large investment and quite often is impracticable. However, data on hydrodynamic coefficients are not needed in this case, although other data on engine and rudder characteristics and operational data are still necessary.

This is a serious limitation when the objective is to train pilots and masters for ship handling in a particular area. However in many cases this could be done at reasonable cost and if there is a number of trainees interested this effort may be substantiated as an example from SRTC shows.

This example shows prepared at SRTC mock-up of several nautical miles long approach route to Goteborg oil terminal. On this route escorting large tanker using two tugs equipped with azimuthing propulsion units was trained. (Fig.11). Similar exercises were arranged for British Columbia pilots. This, however, requires to use large water area and this may be limitation factor for other centres using MMS. It may be noted, that there is currently the tendency to expand water areas for exercises as far as possible (PRL, Warsasch)

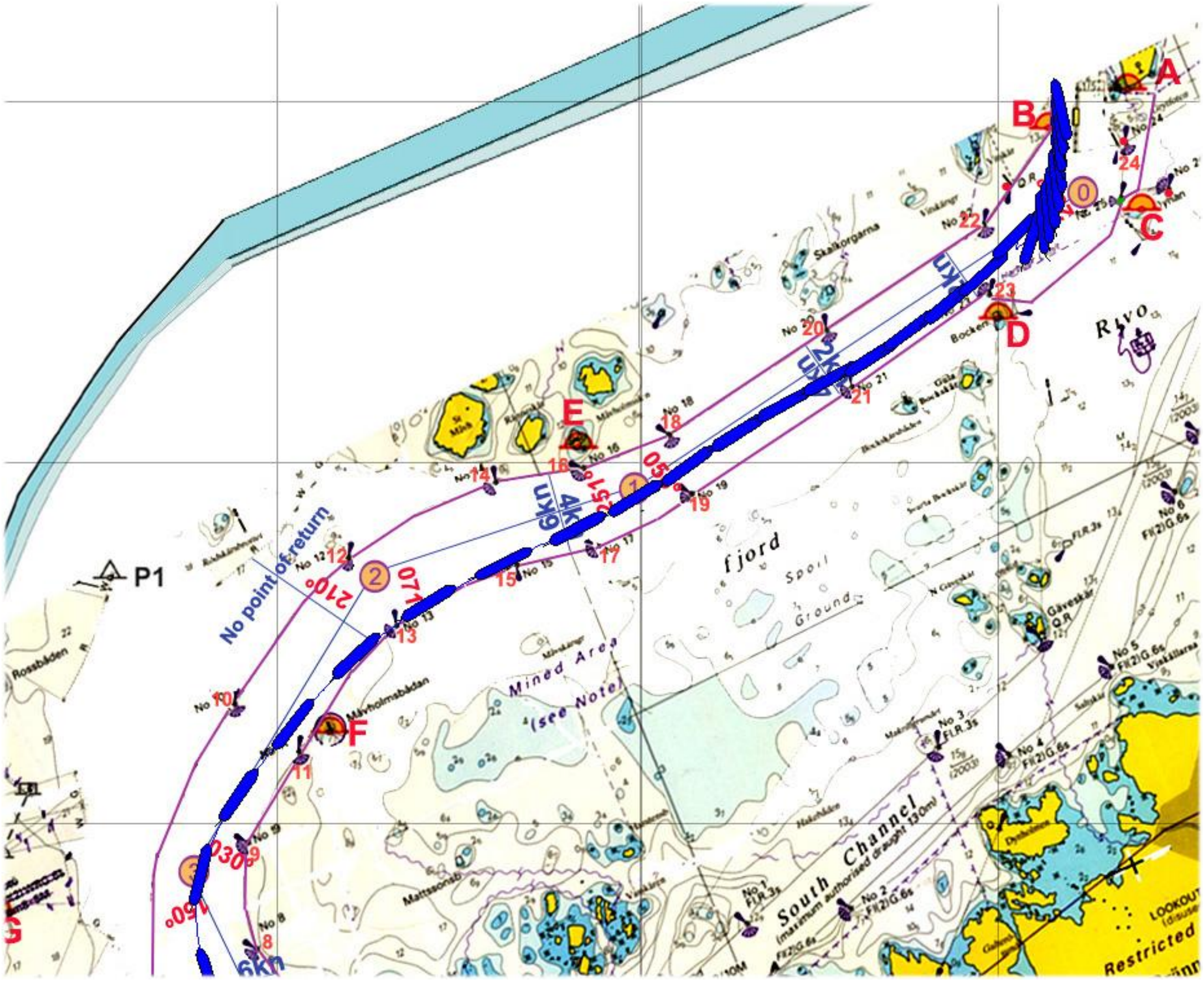

Fig.11. Mock-up of the approaches to Goteborg oil terminal –escorting large lanker (tugs operating are not shown)

First centre (PRL) using manned models technique was installed in early sixties of the last century. The models at that time were quite primitive. Since then great progress has been made. Models now simulate properly all geometrical and dynamic characteristics of the full-scale ship, but they are also fitted with accurate monitoring system showing on-line position of the model on the water area and its path including heading, speed, engine settlings, rudder (or azipod) position and other quantities. Tugs simulators and/or tugs models are also employed. Exercise areas include deep and shallow water areas, canals, locks, harbour basins, piers and quays of different configuration, current generators creating current, wave makers and other facilities. There is tendency to expand those facilities in the future creating new possibilities for performing handling exercises.

7.3 Possible remedies to the training programmes

It is very little to say about possible remedies to the limitations to the programmes of training either on FMBS or MMS. Progress in simulation technology over the years tends to reduce their limitations and in particular:

In FMBS training programmes – accuracy and realism of simulation, factors that extremely important from the point of view of successful training should be improved. This relates to software used in simulators as well as hardware. There is a lot of work in progress regarding mathematical models based on manoeuvrability theory in the world as reported in the proceeding of subsequent MARSIM Conferences. The International Towing Tank Conference created Manoeuvrability Committee that works on development and validation of mathematical models for ship manoeuvrability and initiating also benchmark study on computer codes.

Development of sophisticated software, methods of visualisation of the environment and in general progress in manufacturing of electronic equipment contributed also to better realism of simulation and faster and more accurate simulation of ship handling.

Without doubts in coming years further progress in this respect will be achieved and this will result in removal of some current limitations

In MMS technological progress materialized during recent years in better construction of manned models, simulating more accurately real ships characteristics. Effective monitoring on line movements and parameters of models in water areas is another compulsory requirement for the effective realization of training programmes. There is also the real need for expansion of water areas available in order to accommodate more mock-up harbour and other facilities and enabling to perform exercises requiring large area such as escorting operations on long routes, ship-to-ship exercises and many others.

8 STANDARISATION AND CERTIFICATION PROBLEM

In this chapter the need to introduce of standardisation and certification of the training programmes and on indication of the scope of the standardisation, validation and certification of the programmes is discussed.

Approved simulator training in ship handling is required by the International Maritime Organisation.

Seafarers' Training, Certification and Watch keeping Convention (STCW) STCW Code, Part A, being attachment 2 to the Final Act of the STCW 1995 Conference includes mandatory standards regarding provisions of the Annex to the STCW Convention. Apart training onboard ships, approved simulator training or training on manned reduced scale ship models is mentioned there, as a method of demonstrating competence in ship manoeuvring and handling for various ranks, functions and subjects. However how this shall be achieved as well what type of simulator is required to achieve demonstrating competence is not mentioned.

It is obvious that in view of IMO requirements and need of approval of simulator training by National Authorities and in order to satisfy the main requirement regarding simulators, i.e. accuracy and realism, some standardisation and classification of simulators is necessary. International Maritime Simulation Forum made many attempts at MARSIM conferences to come to an agreement on how this classification could be however no final agreement has been reached. (Cross&Olofson 2000).

Approved training mentioned in the Convention means that the training courses have to be approved by the Governments contracting to the convention and practically, on their behalf, by Maritime Authorities. It is possible that Maritime Authorities may authorise Classification Society to approve the training course on the basis of their own requirements. This is the case with Det Norske Veritas (DNV 2005).

Another problem related to standardization and certification of simulator training is development of criteria for certification of the mathematical models used by marine simulators. This problem was discussed by Lebedeva et al (2006). The need to assess validity of mathematical models used in training simulators was recognized quite long ago, as in view of requirement of the STCW convention adequacy of various simulators for training must be assessed. At present the quality of mathematical models is assessed by the simulator manufacturers and their adequacy for training and validation is made on subjective manner.

Lebedeva et al (2006) proposed the following main principles to be used as a base for the assessment criteria system:

- Decomposition principle:- simulated ship motion is considered as a set of particular tasks and for each task separately assessment of its reliability s made
- Comparison principle: –the adequacy of the mathematical model is assessed by comparison kinematic parameters from simulation with full scale tests
- Step estimation principle: - mathematical models are subdivided according to adequacy level which is directly related to the requirements of the simulator and with the available information about the ship.

In order to form the manoeuvring test programme the authors proposed to divide parameters to be tested in three sub-ranges:

- Sub-region 1 –extremely small parameters values
- Sub-region 2- small parameter values
- Sub-region 3 –extreme parameter values.

An example of this approach is given for the sub-region 2 – small parameter values. Adequacy of the mathematical model within this sub-region is assessed by the manoeuvre when the ship is steered with large rudder angles outside of the instability region (outside of the hysteresis loop). This includes zigzag manoeuvre, spiral test, pull-out test and also man overboard manoeuvre etc.

Fig. 12 shows results of calculations for 160 000 dwt tanker as an example (Lebedeva et al 2006). The dots show the value of kinematic parameters of the turning with different angles of rudder (spiral test), the lines show values of kinematic parameters from zigzag manoeuvre, and the dotted line show parameters from man-overboard manoeuvre. If the kinematic parameters are close, then the relevant values of hydrodynamic characteristics are close also. Thus the adequacy of the mathematical model for the selected manoeuvres is confirmed.

Accuracy of the mathematical model could be assessed by direct comparison of the relevant parameters of the path measured both for the ship and calculated by the mathematical model if the relevant points are within admissible error. This shown in fig. 13. (Lebedeva et al 2006):

The area of admissible error can take different shapes on the depending kind of parameters compared. To assess the error in motion trajectory, the area of admissible error limited by a circle formed around a given point corresponding to the instant position of the vessel's centre of gravity can be used. This is shown in fig.13. (Lebedeva et al 2006).

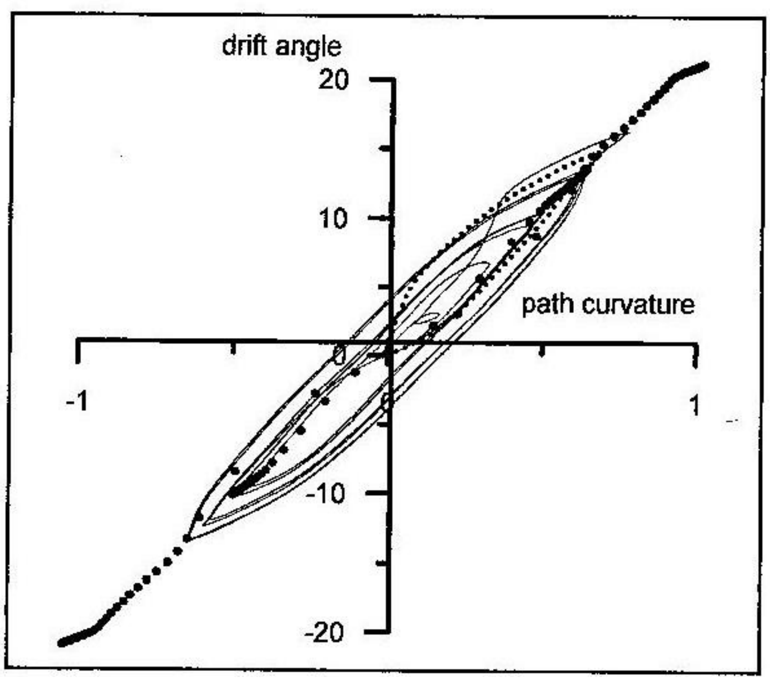

Fig.12. The kinematic parameters of different manoeuvres in sub-region 2.

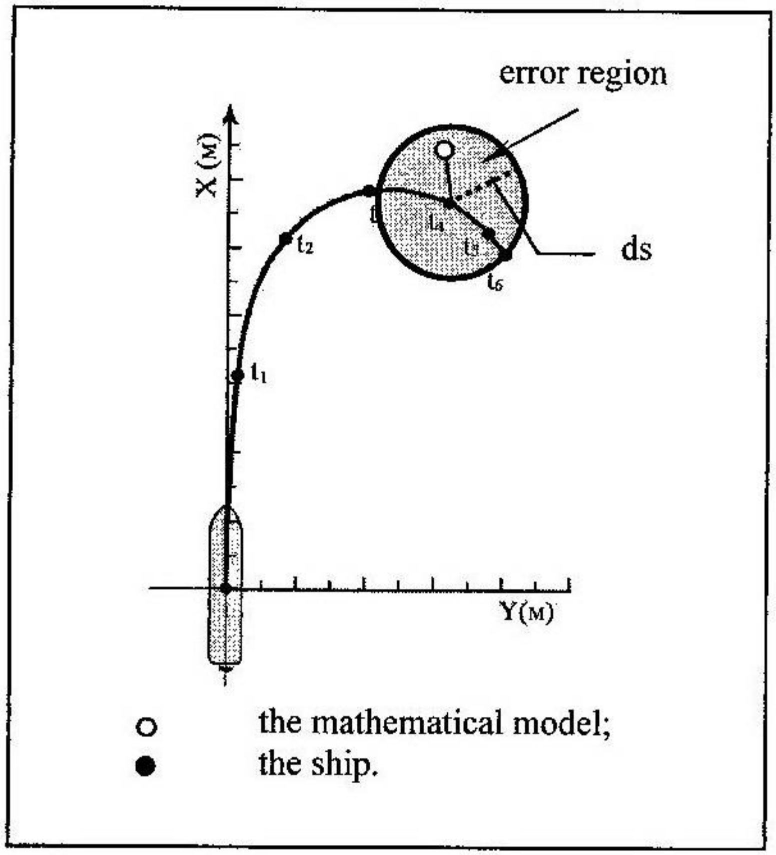

Fig. 13. The error region for ship model path correlation

As the adequacy level could be understood differently the authors introduced also three qualifications levels for the adequacy concept. This qualification may be used for assessment of adequacy of mathematical models used in simulators but at present the proposed system of assessment of the mathematical models used in simulators still has the proposal status and it was not introduced officially.

Regarding MMS there is a motion to introduce some king of standardisation and certification of training courses and training centres in general, as proposed at International Marine Simulator Forum, however at present nothing was introduced in this respect.

9 OBJECTIVES AND IMPLEMENTATION OF THE TRAINING

In this chapter the objectives and of the implementations of training are shown.

9.1 Objectives of the courses

The general objective of ship handling training is to improve safety at sea by providing participants with the knowledge and skill in safe operating of ships equipped with azimuthing propulsion units in different environmental conditions.

List of objectives of training courses for ships equipped with azimuthing control devices is given below (from SMART training centre)

- Enable participants to understand importance to safety by making a risk assessment and to develop a strategy for the operation
- Enable participants to demonstrate competence in how to execute and monitor a planned operation making best use of available resources
- Enable participants to counteract complacency by exposing them to unique and unusual situations relevant to maritime environment
- Enable participants to demonstrate competence in developing an operational strategy to be included in a detailed plan for the berthing/unearthing operation
- Enable participants to understand the effect of the ship's behaviour when exposed to wind, current, shallow water, bank and interaction effect

STC provided the following list of objectives:

- Teach the participant the art of ship handling in a number of normal and abnormal conditions. By way of the theory lesson and hand-on training during the course, the knowledge of each course participant regarding safe ship operation under diverse manoeuvring conditions reaches a sufficient level whereby the required ship handling skills are met
- Teach the participants to make a risk analysis as well as a planning to avoid any of these risks from occurring
- Teach the participants how to handle in cases of failure on board by giving a number of contingency cases during the course
- Improve the safety at sea and in the harbours etc. By being able to carry out proper ship handling under different conditions.

FORCE Technology provided objectives of the ASD tugs handling courses as follows:

During the theoretical lessons and practical simulator exercises the participants shall:

- Enhance their knowledge of and skills in- ASD tug manoeuvring
- Enhance their knowledge of Human Factor Issues and skills in the use of Human Factor Issues, such as communication, planning, briefing and situation awareness
- Enhance safety by applying the proper procedures for conducting safe tug operations.

In the report on Task 3.5. the objectives of the training in FMBS are summarized as follows:

- Improve safety at sea by providing participants with knowledge and skill about methods of safe operation of ships driven with azimuthing propulsion devices in different situations, including harbour approaches, berthing and unberthing, docking, negotiating narrow passages, in wind and current conditions.
- Help participants to understand interaction effects, such as effect of shallow water and canal effect, bank effect, interaction between two ships when passing or meeting.
- Counteract complacency by exposing participants to unique and unusual situations relevant to marine environment.
- Provide experience in full bridge team participation using procedures for error management combined with safe and efficient communication.
- Conduct training during critical stage of transferring controls from the centre console to the bridge wings.

And for MMS training as follows:

- Enhance the knowledge of and skills in handling azipod propelled ships. In particular enhance the knowledge of manoeuvring characteristics and specifics of operation of azimuth propelled ships, various factors affecting their manoeuvrability including environment.
- Help the participants to understand the importance of safety by showing the effects of handling errors.
- Show the participants the ways to handle critical situations. Enhance safety by applying the proper procedures

Objectives of special course for tug masters are as follows:

- Gain more detailed theoretical and practical knowledge of handling ASD and tractor tugs.
- Enhance knowledge and skill in handling large ships using conventional tugs and tugs driven with azimuth propulsion devices.
- Enhance knowledge and skill in tug manoeuvring in escorting operations with the use of escort tugs including handling of emergency situations.

- Enhance knowledge of human factor issues and skills in human factor issues such as communication, planning, briefing and situation awareness
- Improve safety at sea by applying the proper procedures for conducting safe escorting operations

9.2 Implementation of the objetives

It is impossible to assess in how many training centres the objectives of the courses as summarized above and in paragraph 1.2 (Table 2) were implemented. As far as it is known tug masters course arranged by FORCE technology meets all the above stated objectives. (APPENDIX 12.5 - the paper by Sorensen 2006).

Courses for azimuthing propelled vessels organized in both PRL an SRTC centres using manned models technique meet the majority of objectives shown above.

9.3 Training Programmes used in Training Simulation Centres

Data on programmes of training for ships equipped with azimuthing propulsion units used in training centres are scarce. The available data from few centres were summarised in the reports on Task 3.1 (de Graauw 2010) and on task 3.5 (Kobylinski 2010) (see references)

Those data are not repeated here.

Standardised template to be used for rational training programme description specific to ships equipped with azimuthing control devices.

If five days course is assumed, for each day there have to be specified lectures, practical exercises, their duration, description, briefing and debriefing. Also names of lecturers/instructors have to be included in the specification. Example template is shown below:

Day	Hours	Lecture Description	Objective	Practical exercises Description	Lecturer/ Instructors	Duration hours
1	8.00-9.00	Principles of simulation	Familiarisation with the simulation centre		Mr. Xy	1
1	9.00-9.30	Briefing		Explanations to the day	Mr. Yx	0.5

				exercises		
1	9.30-12.00			Unberthing, leave the quay, make a turn using different modes ...	Mr. Yz and Mr. zy	2.5

As an example model training course for MMS developed included in the report on Task 3.5 is shown below:

Model Training Programme for Ship Masters and Pilots on AZIPODS driven ship Models on Manned Models Simulators

Objectives of training
Enhance the knowledge of and skills in handling azipod propelled ships. In particular enhance the knowledge of manoeuvring characteristics and specifics of operation of azimuth propelled ships, various factors affecting their manoeuvrability including environment. Help the participants to understand the importance of safety by showing the effects of handling errors. Show the participants the ways to handle critical situations. Enhance safety by applying the proper procedures
Lectures
General information on the simulator facility. Principles of manned models technique. Similitude laws. Characteristics and types of azipod driven ships and azimuthing propulsion. Principles of work and operation of azimuthing propulsion devices. Forces acting on the manoeuvring ship. Manoeuvring characteristics of ships equipped with azimuthing propulsion devices. Pivot point. Basic manoeuvres. IMO requirements related to manoeuvrability. Operation modes of azipod driven ships. Various modes of stopping. Slow speed manoeuvring. Harbour manoeuvres. Tugs action. Operational restrictions related to azimuth propulsion. Principles of interaction effects – bank effect, shallow water effect, canal effect, ship/ship interaction effect. Sailing in current. Current forces. Manoeuvring principles in current from different directions. Inertia effects in current. Effect of wind. Wind force. Manoeuvring principles under wind effect. Human factor issues contributing to safe operation. Handling emergency situations.

Practical exercises
Familiarization with the simulator. Procedures for start-up and stop. Familiarization with controls and equipment. Unberthing and berthing; crabbing towards the jetty or away from the jetty without or with bow thruster use. Leaving the harbor basin making turns with different modes, pods coupled or independent, steering in different modes, cruise soft and strong. Steering onto navigational marks. Executing standards manoeuvres: turning circle and zigzag manoeuvres. Slow speed manoeuvring in different modes. Stopping in different modes Negotiating narrow passages and entering locks, bow first or stern first. Steering in narrow fairway with several bends. Manoeuvring feeling interaction effects - shallow water, bank effect and canal effect. Meeting and overtaking other ship in a narrow canal feeling interaction effects between two ships. Manoeuvring in current, steering with or against current, entering dock with current, from different directions, bow or stern first, turning in current, feeling inertia effects in non-uniform current, entering lock with or against weak current. Emergency manoeuvres involving engine failure forcing to steer with one pod only, the other blocked in different positions.

10 CONCLUSION.

AZIPOD research, an in-depth research project to look at training requirements for AZIPOD propulsion units, has powered into action. South Tyneside College is one of the organisations involved in the project to map current training provision for AZIPOD against future needs so that the training needs for the industry can be determined.
As a part of conclusion they are two short interviews with the aspect of:

- Maritime Training,
- Technical aspects of simulators.
- Trainees' opinion – taken from Course evaluation sheet.

There is the obvious need for specialized training of pilots and ship masters, including tug masters for ships equipped with azimuthing propulsion devices. This could be accomplished either in Full Mission Bridge Simulators or Manned Models Simulators, although objective of training courses performed in those simulators are partially different. Both types of advanced simulators are capable of simulating azimuthing propelled ships and tugs although there are some limitations regarding simulation in both types of simulators. Those limitations will be, however, mitigated with the development of technology. Sample template for specialized training courses for ships fitted with azimuthing control devices was proposed.

10.1 Chris Thompson, Head of Department – Marine Simulation Ports and Harbours. - Marine Training – Azimuthing Control Devices – Interview:

"Ship handling training at South Tyneside College has been on the curriculum plan for many years. The training helps both mariners at sea and professional pilots who board a ship. It also complies with the requirements under STCW95 for handling vessels particularly ships 'having unusual manoeuvring and handling characteristics'. When Azipod passenger ships come along there was an incentive to look at training programs which would apply to those vessels. STC for many years has been training seafarers in the use of azimuthing thruster devices that could be found on offshore supply vessels. In recent years we provide training for tug crews in handling of tugs which included those fitted with azimuthing stern drive propulsion systems. We have lots of interactive training on our databases using full mission bridges with tug crews, ASD tugs and pilots on board the bridge bringing a ship into the river. The training is very effective because it has interaction with the tug crew and ships pilots. To enable this sort of training ideally full mission bridges are needed with the good visual systems. The bridge must be fitted with control handles that will be the same or similar to the control handles found on the Azipod ships or tugs.

The Simulator system needs an azipod mathematical model to enable the bridge handles to interact with the software producing the results and movements of the ships and tugs.
At South Tyneside College we have several vessels fitted with azipods which include double azipods or triple azipods systems found on passenger ships, supply ships, tugs and tankers.
The simulator system can be used for training both Masters and Officers they would be sailing on these types of ships. Tug Masters and Pilots which will meet their ships in the harbours but also, of course, Senior Marine students at the College can be part of the training."

10.2 Paul Hodgson, Marine Technical Resource Manager in South Tyneside College, Marine Simulation Department - interview:

"In the two full mission bridges, we have got a pair of azimuth handles on each bridge, provided by Kongsberg Maritime AS, Norway. The left hand handle, can be switched to act on its own as a master control, controlling both pods at once. Alternatively the two together can then act as independent port and starboard handles. The hardware, the handles themselves, providing the turning and thrust power are designed by Lillaas. These standard handles also are used on real ships. Similar handles are used by Transas simulators and on the man-model manoeuvring Azimuthing models.

The system will allow other makes of handles to be connected (hardware). Handles can be mounted or connected by using mechanical means to the console. All manufacturers have software to allow different handles from different companies to be connected; all use the same protocols to achieve the same goals."

Bridge A.

Bridge F.

We can use our handles for different ship models, most of them are tugs (10 – 12 models). Also we have a model of cruise ship with azimuthing devices, similar to “INDEPENDENCE OF THE SEAS” (APPENDIX 12.1)

The modelling software should recognise if the handles are connected or not and what handles we are using on the bridge. The system knows that handles exist and what type of handles are used.

The simulation system knows we are using hardware handles or software version of the same handles on the bridge. Running the hydrodynamic mathematical model system will recognise if theses handles exists so it can control the handles.”

10.3 PLA - Port of London Authority - Pilot comment:

‘Azipod, ASD and Voith day was excellent. The College could have contacted the PLA for more content. Some documentation about Azipods, ASD’s and Voith’s would have been good.’
STC comment: The attendees were more than happy with the content of the training and requested more.

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12 APPENDIX

12.1 Polaris, Technical Mannual, Section 7,8 & 6.

Kongsberg Maritime
Doc.no.: SO-0613-P / 26-Jan-10

KONGSBERG

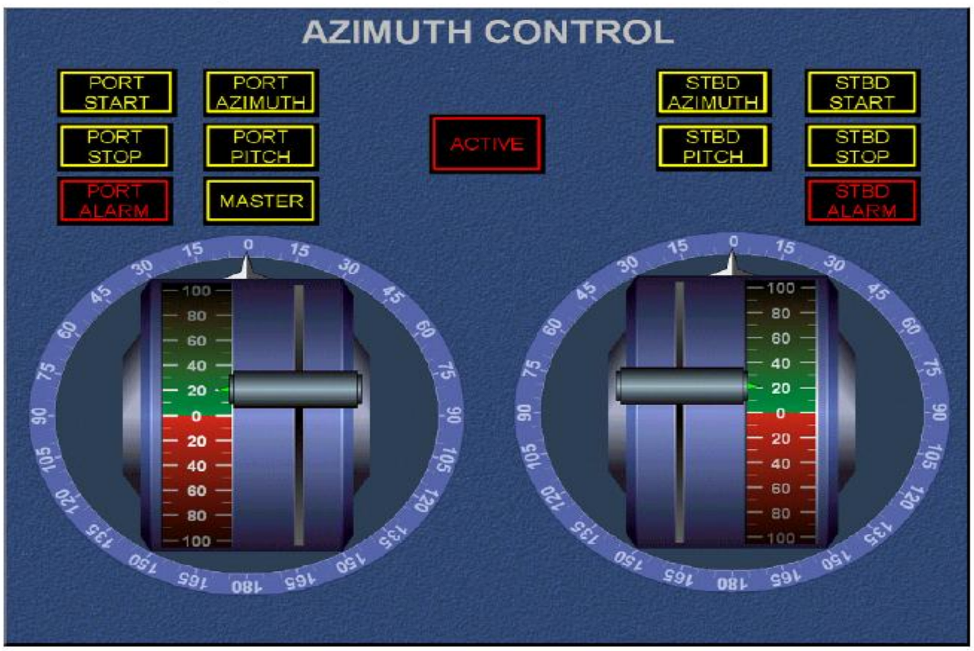
7 AZIMUTH CONTROL

The AZIMUTH CONTROL Icon

7.1 Purpose

The purpose of the Azimuth control is to control all Port and STBD azimuth thrusters RPM and azimuth (direction) orders.

7.2 Description



7.2.1 Keys and controls

When illuminated indication that the panel is activated/ power on

STOP button and indicates that PORT/STBD Azimuth propulsion is stopped

Start button and indication that PORT/STBD Azimuth propulsion in activated-

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KONGSBERG

Kongsberg Maritime
Doc.no.: SO-0613-P / 26-Jan-10

PORT AZIMUTH	STBD AZIMUTH	When flashing: When illuminated:	Azimuth rotating to ordered direction Azimuth in set direction
PORT PITCH	STBD PITCH	When flashing: When illuminated:	Increasing/de-creasing pitch to ordered Pitch Running with set pitch
MASTER		Activation and indication button that PORT Azimuth control also control STBD Azimuth	
PORT ALARM	STBD ALARM	When flashing: When illuminated:	An fault condition has occurred A fault condition is acknowledged

7.3 Operation

- Click ACTIVE if not already illuminated
- Click PORT START and STBD START to activate the PORT and STBD Azimuth
  - *Speed*
    - When the cursor is over the respective combilever handle the hand symbol will appear.
    - Press down the left mouse button to drag/move the combilever forward and astern. Release the mouse button when the combilever is in desired position.
  - *Direction*
    - When the cursor is on the azimuth indication ring the hand symbol will appear.
    - Click and drag the combilever to Stbd or Port. Release the mouse button when the combilever is in desired direction.
- The PORT or STBD PORT AZIMUTH and PORT PITCH will start flashing until they are in ordered direction/pitch

MASTER — Used for master/slave operation. When MASTER is activated the *port* combilever controls both combilevers simultaneously in azimuth and RPM. The STBD Azimuth control buttons are turned off

PORT ALARM — When a fault condition occurs the PORT ALARM button begins flashing and a buzzer is sounded. Click the button to stop the buzzer. The PORT ALARM gets a steady light

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Kongsberg Maritime
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KONGSBERG

8 AZIMUTH CONNING

The Azimuth Conning Icon

8.1 Purpose

This panel is used for viewing only and has no user interaction.

8.2 Information

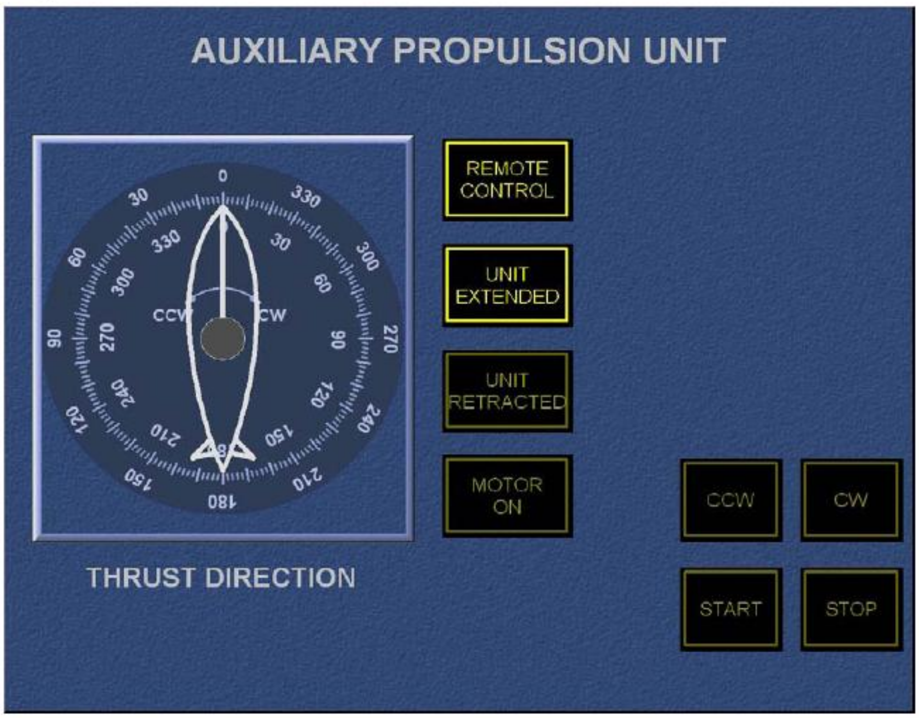
RPM:	The two bar graphs show port and starboard propeller speed order in RPM. On top of the two bars digital readouts indicates port and starboard propeller speed in RPM.
Speed	Readout from vessel log
Azimuth Direction:	Two indicators, starboard and port shows propeller thrust direction achieved in degrees.
Rate of Turn:	A horizontal bar graph shows the ships rate of turn in degrees per minute. A digital readout is above the bar graph.
Gyro Repeater:	The ships heading is displayed in degrees as rotating gyro repeater and digital readout.

6 AUXILIARY PROPULSION UNIT

The Auxiliary Propulsion Unit Icon (APU)

6.1 Purpose

The purpose of the Auxiliary Propulsion Unit is to allow operation of auxiliary thrusters on Ownship.



6.2 Keys and controls

The "CW" button rotates the APU in a Clockwise direction.

The "CCW" button rotates the APU in a Counter Clockwise direction.

The START button starts the APU. There is no speed control for the APU motor, it is simply started or stopped. Once started the APU is thrusting at 100% power. The "Start" and "Stop" buttons control this function for each APU

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KONGSBERG

The STOP button stops the APU. There is no speed control for the APU motor, it is simply started or stopped. Once started the APU is thrusting at 100% power. The "Start" and "Stop" buttons control this function for each APU

The UNIT EXTENDED indicator. If the APU is submerged and in use, the "UNIT EXTENDED" indicator lamps illuminate.
The raise/submerge operation is done by the engine room (instructor).

Note! In e-learning mode, the student can submerge the APU by pushing the "UNIT EXTENDED" button.

The UNIT RETRACTED indicator. If the APU is not in use and raised, the "UNIT RETRACTED" indicator lamp is illuminated. This is the default status of the panel. None of the functions described above are available. The raise/submerge operation is done by the engine room (instructor).

Note! In e-learning mode, the student can raise the APU by pushing the "UNIT RETRACTED" button.

The REMOTE CONTROL indicator indicates if the engine room (instructor) or the student has the control of the operation. When the remote control indicator lamp is illuminated the student has control

The MOTOR ON indicator indicates if the engine is running or not. This is controlled by the engine room (instructor).

KONGSBERG

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6.2.1 Display data and limitations

Display	Explanation	Range	Step	Unit
THRUST DIRECTON	Indication of APU direction	0-360	2	degrees.

6.3 Operation

1. The Thrust Direction indicates the direction of the APU. The APU will move the ship forward if energized. The direction of the indicator is always the direction that the bow will move when the APU is started.

2. The direction of the APU is controlled independently by the "CW" and "CCW" buttons. To rotate an APU the button must be depressed and held down, (the button is illuminated while depressed). To stop the rotation of the APU, the button is released and the light will be extinguished. The "CW" button rotates the APU in a Clockwise direction, the "CCW" button in a Counter Clockwise direction.

3. There is no speed control for the APU motor, it is simply started or stopped. Once started the APU is thrusting at 100% power. The "Start" and "Stop" buttons control this function for each APU.

4. There are also status buttons for the condition of the APU units. When they are not in use, the "UNIT RETRACTED" button is illuminated. This should be the default status of the panel. None of the functions described above are available when the units are in the retracted condition.

   Note! In e-learning mode, the "UNIT EXTENDED" and the "UNIT RETRACTED" indicators are action buttons that can be operated by the student.

12.2 Hudersfield University – Conference Paper and Presentation: Simulation as a tool for learning/teaching

. . . for Distinction Sake, a Deceiving by Words, is commonly called a Lye, and a Deceiving by Actions, Gestures, or Behavior, is called Simulation . . .

Robert South (1643-1716)

Simulation as a tool for learning/teaching.

By Stephanie Short

Introduction.

"Simulation is an act or process of simulating. It is an imitation or representation, as of a potential situation or in experimental testing." You might simulate event which already happened to find why it happened. There are more definitions about the simulation in different domains. I think that first we start to use simulation in mathematics don't even know that is a simulation. In simple equation:

$x + y = z$

changing ***x*** shows every time a different solution. The comparison of these answers helps to match required outcome. That is known as "Symbolic simulation" - uses variables to stand for unknown values.

Simulation could be a type of ***statistical modelling***, using a computer, that attempts to mathematically predict the results of an action or series of actions, based on assumptions about how different variables affect each other. The values of certain variables are set to simulate a particular circumstance, so that the effect on the variable of interest can be measured. For example, the effect of a price change on a market can be simulated by making assumptions about the behaviour of competitors and consumers in response to a price change.

In medicine the first simulators were simple models of human patients. Since antiquity, these representations in clay and stone were used to demonstrate clinical features of disease states and their effects on humans. Models have been found from many cultures and continents. These models have been used in some cultures (e.g., Chinese culture) as a "***diagnostic***" instrument, allowing women to consult male physicians while maintaining social laws of modesty. Models are used today to help students learn the anatomy of the musculoskeletal system and organ systems.

Simulation attempts to represent a real-life system with a ***Model*** to determine how a change in one or more variables affects the rest of the system, also called ***what-if analysis*****.** Simulation will not provide enhancement of effectiveness (optimization) except by trial and error. It will provide comparisons of alternative systems or how a particular system works under specified conditions. It is a technique used for **what-if scenarios**.

Necessity is being the mother of invention therefore the greatest advances in simulation have been linked to warfare. The earliest mechanical simulators were built to train pilots in the First World War, so that the pilots would have a better idea of aerodynamics.

During the Second World War this was extended so that a full bomber crew could be trained on a simulator, the Pilot, Navigator and bomb aimer would be put in mock up of a link simulator.

Historically, simulations used in different fields developed largely independently, but 20th century studies of Systems theory and Cybernetics combined with spreading use of computers across all those fields have led to some unification and a more systematic view of the concept.

Examples of Simulation in different areas:

- City simulators / urban simulation,
- Classroom of the future,
- Digital Lifecycle Simulation,
- Engineering, technology or process simulation,
- Finance/business,
- Flight simulators, truck simulators,
- Marine simulators,
- Military simulations,
- Robotics simulators,
- Computer games.

Marine simulators.

Bearing resemblance to flight simulators, purpose for Marine Simulators is to train ships' personnel. The most common marine simulators include:

- Ship's bridge simulators,
- Engine room simulators,
- Cargo handling simulators,

- Communication / GMDSS simulators.

Simulators like these are mostly used within maritime colleges, training institutions and navies. They often consist of a replication of a ships' bridge with operating desk(s), and a number of screens on which the virtual surroundings are projected.

The need for simulation for training Mariners was really kick started by a number of high profile major marine accidents which resulted in loss of life, oil spills and damage to marine ecosystems, namely the Exxon Valdez in Alaska, and the grounding of the QE2, these were the well-known incidents, but there have been other less known incidents.

The US Government held an inquiry into some of these cases and one of the recommendations was more simulation in training before an officer was considered to be competent.

The advantages of simulation in education:

At the moment computerised simulation models are increasing being used as teaching/learning tools as a replacement for, or adjunct to traditional field or laboratory exercises. Many benefits have been cited:

- Substituting for physical resources and tutor’s time.
- Speed.
- Performing impossible or undesirable experiments.
- Observing obscure processes.
- Controlling the ‘environment’.
- Synthesising expertise.
- Gaming and sensitivity analysis.
- Distance and self-learning.

There are very many simulation models commonly used world-wide which benefit from many years of development and validation. Studies suggest that computer aided learning is at least as effective as traditional methods, and in many cases has positive benefits in terms of motivation and retention.

Marine Simulation as a learning/teaching Tool.

Safety.

Risks associated with training on operational equipment are a concern in the marine industry, especially if there is a risk of collision, loss of life and damage to the marine environment, the use of simulators has reduced on the job training accidents. Simulators allow students to repeat risky operations several times if need be .Unlike learning on training on operational equipment where an instructor must be ready to intervene at all times, risky manoeuvres can be safely practiced.

Simulation allows the full placement of responsibility on the prospective Officer of the watch before that officer actually assumes the duties of a certified Officer of the Watch. In on the job training, concern for the safety of the vessel may cause an instructor to intervene earlier than is desirable for efficient progress of learning, and consequently the students training is cut short and in effect will be less proficient and confidence could be knocked.

In simulator training the instructor can allow students to make mistakes, and even sometimes encourage it, so that the consequences of that mistake can become apparent and possibly to allow a recovery or damage limitation exercise.

Lesson Repetition.

Using simulation, the instructor can terminate a training scenario as soon as its point has been made or repeat it until a lesson has been learned. In contrast, opportunities for repetition are very limited during actual at sea operations, the opportunity to repeat an exercise in on the job training aboard ship may not occur for weeks or months.

Recording and Playback.

Another feature of simulator training is the ability to record and playback the just completed exercise for review, evaluation and debriefing purposes. As a teaching tool, recording and playback empower the instructor to allow mistakes and accidents to happen for instructional emphasis and allow students to review their actions and correct and incorrect decisions and experience the results of their performance after the exercise is completed.

As an assessment tool, recording and playback can provide a history of performance that serve as a second opinion if a candidate challenges an assessors opinion, thereby minimising what might otherwise be a subjective assessment.

Flexibility.

Simulator training permits systematic scheduling of instructional conditions, as desired by the training syllabus. Simulation permits the use of innovative instructional strategies that may speed learning, enhance retention or build resistance to the stress level of the Officer of the Watch keeping his first real watch.

Multiple Task and Prioritisation

Deck Officers at all levels of responsibility must continually decide at any given time, and in any given situation, which among a number of tasks are more important. Before simulation training new officers initial training often consisted of a range of skills that were taught, practiced and examined separately. Use of simulation in training makes it possible to transfer classroom knowledge and to practice and prioritise multiple tasks simultaneously.

Simulation training enhances development of skills and provides the opportunity to exercise judgement in prioritising tasks.

Training on New Technologies.

By employing features such as the ability to repeat training exercises and to record and play back exercises, simulators can provide a safe environment for training Mariners in the use of new equipment. For some new equipment it is possible to place desktop computers on board ships to provide an opportunity for independent training.

Peer Interactions.

Simulator training can provide a forum for peer interactions and evaluations that might not otherwise occur. Because of the often solitary nature of their work, masters and pilots can routinely serve for years without having their work observed by their peers or professional bodies.

Simulator based training can provide an opportunity for these Mariners to improve their competency and learn new techniques by having old habits challenged and corrected in a safe environment.

Cost Effectiveness.

Although the most obvious goal of using simulation is improving performance, cost effectiveness is important. Simulators cost less to build and operate than the operational equipment on a ship. The commercial air industry is able to conduct transition to a new aircraft through simulation; this is a massive saving on actually training on the new aircraft.

In the marine industry training on board ships can be difficult and in some cases impractical because of risk, operating practices and schedules. Mandatory training is now a requirement for all deck officers before they can become certified and take over a watch at sea, in addition Lloyds of London and other certification societies require on-going simulation training, in return the Classification societies give cheaper insurance to those ships and shipping companies who take simulation training on a regular basis.

SURVEY OF SIMULATION RESOURSES AT SOUTH SHIELDS

The Marine College resources are very good, at the moment I teach in the marine simulation department and the major resources are the Marine Simulation Centre and the Radar Station, both are purpose built buildings and house high tech simulators.

The Marine Simulation Department has a total of fourteen simulated ships bridges in three different locations. There is also an engine room simulator that is capable of being connected to the bridge simulators.
These bridges can be modelled on any type of vessel from Tugs to Super tankers with actual ships being used as a model. The students can be put in various scenarios depending on the training required and the experience that is expected to that person’s certification.

The courses are structured to be progressive and cover:

- Ship handling
- Port operations
- Pilotage
- Navigation
- International regulations of preventing collisions at Sea
- Search and Rescue

Use of bridge equipment.

- Vessel Traffic Services (VTS)
- Used for training shore based personnel in the use of port operations.
- Cargo Handling Simulation
- Simulated so that students can load and discharge a cargo of oil from a tanker and gas from LPG tankers.

As a training tool, marine simulators have a number of significant advantages:

- Simulators can be used regardless of weather,
- Instructors can terminate training scenarios at any time,
- When a model has been constructed, it may be used over and over to analyze different kinds of situations; training scenarios can be repeated,
- Training scenarios can be recorded and played back in real or fast time,
- Training is relatively cheap,
- No risk to environment or students i.e. safe environment,
- Time is spent learning valuable lessons,
- Convenient to make mistakes in a virtual world so that they are not repeated in the real world,
- It allows modelling of systems whose solutions are too complex to express by one or several mathematical relationships,
- It requires a much lower level of mathematical skill than do Optimization Models.

The disadvantages of simulation:

Many of the existing models were developed for research use where the emphasis is on the validity of the output and rigour in the scientific understanding.

- Packages for educational use have a much greater demand on the ease of use of the interface and less on the accuracy of the prediction.
- Sometimes a model responds to simulated conditions not in the right direction and the correct order of magnitude.
- Many of the existing models therefore are unsuitable for educational use, or can only be used once extensive training in the use of the software has been completed.
- Too many minimal data required or to high level of accuracy.
- Some of the simulations are expensive and for that reason it is a lack of reproducibility.

Conclusion

Marine Simulator provides activities in which participants work through real-world scenarios. These activities can enhance their ability to manage complex situations and can encourage implementation of risk management strategies and adoption of safety practices. Practical and credible information presented in a "hands-on" setting is engaging and memorable. Also all exercises or just part of it can be repeated many times as required.

At South Shields College the upgrading of equipment is an annual event and expense, it is down to cost and training requirements. There is no doubt that students react better to simulation than any other type of training.

The next step in Marine Simulation is a bridge simulator built on a full motion platform. The first modern simulator has been built for the brand new campus of the Maritime Academy of Asia at Kamaya Point, Philippines. It also connected and integrated with a Neptune Engine Room simulator. It is a plan that the new simulator will be in full operation by June 2009.
(http://www.km.kongsberg.com/ks/web/nokbg0238.nsf/AllWeb/EEC90CB56B0EAF58C12575A6002FB01D?OpenDocument)

"The 360° full motion Polaris ship's bridge simulator is one of the most sophisticated of its kind in the world and at $50m^2$ it features one of, if not the largest simulated ship's bridge in the world." – Mark Stuart Treen – Sales and Marketing Manager for Simulation (Kongsberg).

The Polaris ship's bridge simulator with 360° visual screen on a pneumatic electric motion platform.

12.3 Questionnaries

South Tyneside College

Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships) Examples			
Simulator Type	Full mission bridge simulator		
Simulator Manufacture	NorControl		
Vessel type	Escort Tug		
Vessel name	Gertie		
Lever manufacturer	Kamewa		
Azimuthing device	Voith Schneider		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:** 65 tonnes	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**
Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Desktop simulator		
Simulator Manufacture	SimFlex		
Vessel type	RoPaX Ferry		
Vessel name	Queen Zelda		
Lever manufacturer	Aquamaster		
Azimuthing device	Twin Mermaids		
Is a Joystick/UniLever present? (yes/no)	Yes		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:** 210 m

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South Tyneside College

Intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Cruise Ship		
Vessel name	Freedom of the Seas		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Three ABB Azipod podded (fixed pitch) electric propulsion units, two of them azimuthing, one fixed.		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:** 338.7 metres

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Cruise Ship		
Vessel name	Constellation		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Two Rolls Royce Mermaid pods (fixed pitch)		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:** 294 metres

South Tyneside College

Intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Platform Supply Vessel		
Vessel name	Far Splendour		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Two fixed pitch propellers azimuthing at 18 deg/s.		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:** 86.2 metres
Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Advanced Platform Supply Vessel		
Vessel name	Maersk F-Class		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Thruster		
Is a Joystick/UniLever present? (yes/no)	Yes		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:** 82.5 metres

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South Tyneside College

Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Harbour Class Tug		
Vessel name	TUG05A		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Voith-Schneider		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	ASD Tug		
Vessel name	TUG08 (TG_5)		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Two Aquamaster thrusters (propeller in nozzle)		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

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AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Escort Tug		
Vessel name	Cocle (TUG10)		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Two Aquamaster thrusters (propeller in nozzle)		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type	Full Mission Bridge Simulator		
Simulator Manufacture	Kongsberg - Polaris		
Vessel type	Prevention Response Tug		
Vessel name	Alert (TUG06)		
Lever manufacturer	Generic Kongsberg		
Azimuthing device	Two Z-Drives (propeller in nozzle)		
Is a Joystick/UniLever present? (yes/no)	No		
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**
Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

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AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	If Tug, Bollard Pull:	If Cargo ship, Deadweight:	Other vessel type, Loa:

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	If Tug, Bollard Pull:	If Cargo ship, Deadweight:	Other vessel type, Loa:

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AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**
Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	**If Tug, Bollard Pull:**	**If Cargo ship, Deadweight:**	**Other vessel type, Loa:**

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AZIPILOT

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	If Tug, Bollard Pull:	If Cargo ship, Deadweight:	Other vessel type, Loa:

Types of vessel equipped with Azimuthing devices that are simulated. (including tugs and cargo ships)			
Simulator Type			
Simulator Manufacture			
Vessel type			
Vessel name			
Lever manufacturer			
Azimuthing device			
Is a Joystick/UniLever present? (yes/no)			
Dimensions of simulated vessel	If Tug, Bollard Pull:	If Cargo ship, Deadweight:	Other vessel type, Loa:

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Are simulated models realistic? If not, can the training centre:

a) Change the mathematical model?

b) Change the operating System?

If the mathematical model has not been encrypted, then parameters can be altered to achieve a more realistically performing vessel.

There is only one operating system, and thus cannot be changed.

On ship simulators equipped with azimuthing control devices, indicate a preference for:

a) Propulsors

b) Controls

Very briefly please explain your preferences.

As far as propulsors are concerned, there is no particular preference. So long as the propulsor gets the job done effectively for the particular task in hand, then the result is good. There are, however, very different mechanical implications for using differing types of propulsors, which operators need to be aware of. Some of these implications can be grasped more easily than others.

With regard to controls: Manually controlled devices are perceived to be better than automatically controlled ones. Automatically controlled devices are regarded as less reliable and too complicated.

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AZIPILOT

Is any training done for mismatches of controls and Machinery? E.g. Different manufacturers of lever and propulsor. **If so, what percentage of simulation runs, and what implication do you think this can have compared to operating azimuths in reality?**
Not Applicable. The only control handles available at present are the ones supplied by the simulator manufacturer. Ie Kongsberg generic ones.
Does the training vary depending on the type of control lever used? **If so, in what way?**
Not Applicable. The only control handles available at present are the ones supplied by the simulator manufacturer. Ie Kongsberg generic ones.

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Intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Does the facility realistically model: (Tick boxes that apply)	
Propeller/Hull interaction	☒
Propeller/Propeller interaction	☐
Propeller/Quay Wall interaction	☐
Propeller/Depth of water	☒
Vibration & adverse reactions	☐
Ship/Bank interaction	☒
Ship/Ship interaction	☒
Please state any other you think is important and whether it is modelled or not :	

Types of training available for ships with Azimuthing control devices.
Has the course content originated from a Lead Body? E.g. North Sea Safety Forum. Please state: No. The only influence a Lead Body has is on the Offshore Bridge Course, from the North Sea Safety Forum.
Other – please list where the course content originated. Course content generally originates from IMO Model Courses, and advice from Shipping Companies, Masters and Pilots.

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intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Has any of the training been accredited?
A National Training Organisation (please specify): No.
A National Safety Agency (please specify): No.
Do simulators/models meet STCW standards? (Yes/No) Yes
Do simulators/models meet DNV standards? (Yes/No) Yes
Other (Please specify) The Navigation and Radar simulation meets with the Maritime Coastguard Agency standards.
Does the facility have a procedure of best practice in training, or is it based more on the personal experience of each instructor?
Both, but this is very subjective. The procedure tends to be the best practice for the area of operation.

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intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Are there methods in place for monitoring and developing training courses. Please explain.
Yes. Working with customers and their feedback is the main source of inspiration for developing, monitoring and maintaining training courses. Customer liaison, with no direction from The State tends to be the method used. Different customers have different requirements, so there is differing content depending on what a particular customer wants.
Capacity of facility.
How may people can attend at once a simulator course on azimuthing devices? 5 persons can be accommodated per simulated bridge. (Full Mission Bridges only are used as a bridge with lesser visuals is considered inadequate for these devices)
How many simulator courses can be run simultaneously for azimuthing devices? Two courses can be run simultaneously. (There are two Full Mission Bridge simulators)
With respect to azimuthing devices, what percentage of time does the training centre run at full capacity? 25%

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intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Types of training courses and duration.			
Title of course	Brief Description	Clients (E.g. Masters or River Pilots)	Duration of course (days)
Offshore Bridge Simulator	Platform supply vessel handling.	Staff	21 Hours
Ship Handling	Dependent on the customer. Covers Tankers/Passenger/Container vessels	Staff	4 Days
Tug Handling	ASD handling	Staff	2 Days
Pilot Training	Ship handling and Tug awareness	River Pilots	2 Days

Training Facilities Name Page 16 of 20

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intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Types of training courses and duration.			
Title of course	Brief Description	Clients (E.g. Masters or River Pilots)	Duration of course (days)

Training Facilities Name Page 17 of 20

Relation to host company.
Is the training centre part of a maritime college?(Yes/No) Yes
Is the training centre part of a shipping company?(Yes/No) No
Is the training centre independent?(Yes/No) Yes
Other. (Please specify)

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Intuitive operation and pilot training when using marine azimuthing control devices AZIPILOT

Does the training facility fill the training needs and requirements of azimuthing control devices?

Please briefly discuss the limitations of the centre in this area. E.g. Has the training facility experienced certain needs from customers that are difficult to fulfil?

Yes, with specific models of ships in use.

The lack of specific controls and equipment that match exactly to the vessel being simulated can be a limitation.

Please list the most frequent obstructions to training.

Cost is an obstruction, and also companies being able to release staff from their jobs to attend the courses.

Instructor expertise for a particular vessel can sometimes be hard to find.

Are there some aspects of using azimuthing controlled devices that can only be learned during a period at sea?

Yes. An example would be for small vessels, the boats own inertia cannot be felt realistically, the movement of it heeling over cannot be felt.

The raw fear that certain events generate cannot be related to in a simulator, and staff may react in different ways when operating under such stressful conditions.

Specific operations to a particular port may only be mastered after “learning the district”.

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Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Are there certain aspects of operating azimuthing controlled devices that can only be safely done in a simulator/training facility?
Yes. Emergency scenarios, such as equipment failures, Man Overboard and very adverse weather conditions can be safely conducted. These scenarios can be repeated over and over again when using a simulator.
Can you think of any improvements that would increase the operators awareness of the ships handling? **E.g. Standardisation of symbols?**
Standardisation of control symbols, acronyms and terminology would be an improvement. A set of standard English command phrases would help in handing over control to another operator.

The End

Thank you very much for your time and cooperation.

Please return (by mail or e-mail) to:

By David Trodden.

12.4 ABB – Azipod CZ 1400 Product Introduction.

Preface

This Product Introduction provides system data and information for preliminary project planning of Azipod podded propulsion and steering system outfit. Furthermore, our project and sales departments are available to advise on more specific questions concerning our products and regarding the installation of the system components.

Our product is constantly reviewed and redesigned according to the technology development and needs of our customers. Therefore, we reserve the right to make changes to any data and information herein without notice.

All information provided by this publication is meant to be informative only. All project specific issues shall be agreed separately and therefore any information given in this publication shall not be used as part of agreement or contract.

Helsinki, November 2009

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Index of items

1 General

The first original Azipod® installation onboard was commissioned in 1990. By November 2009, the milestone of five million cumulated operating machinery hours has been reached. This is the total figure obtained with the various product variants of which the Azipod CZ is one particular application.

1.1 Azipod Propulsion and Steering

The Azipod CZ main propulsion and steering system was originally developed with the experiences gained from the already existing family of larger Azipod products. Azipod is a podded electric main propulsion and steering device driving a fixed-pitch propeller at a variable speed setting.

Azipod CZ propulsion is designed for preferential use in e.g. oil rigs. The Azipod CZ is azimuthing (steering around its vertical axis) infinitely by 360° and is available generally for propeller power ratings of up to 3,3 MW. The available static thrust is approximately 63 metric tons.

The full ship system consists of the required number of Azipod CZ steering propulsors, plus the delivery of an "ACS" series marine Propulsion Power Drive per each Azipod. Additionally propulsion supply transformers (if needed), and the power plant (generators, switchboards) are usually included in the scope of the delivery.

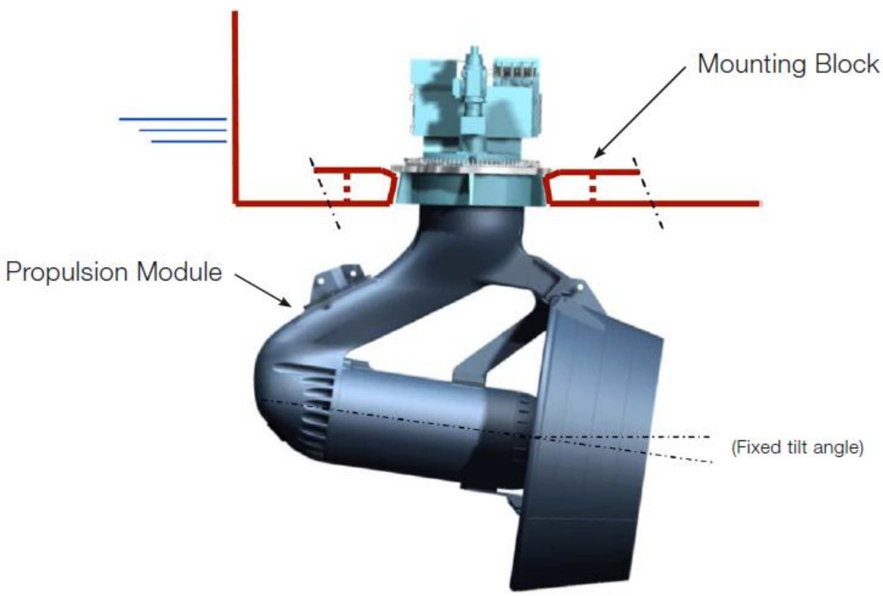

Figure 1-1 Basic arrangement of the Azipod CZ1400

4 General | **Azipod® CZ1400 Product Introduction**

1.2 Type designation for the Azipod product

In the ship concept design stage, the following main designation is used. (A more specific type code will be allocated for the product during the advanced design stage).

C = Compact Azipod
X = Next generation Azipod (in dedicated publications)
V = "Classic" Azipod (in dedicated publications)

O = Product with open propeller for free water operated ships
Z = Product with Kaplan propeller and nozzle for utility vessels

Diameter of the propulsion motor (mm)

Azipod® □□ xxxx

Azipod® CZ1400 Product Introduction | General 5

1.3 Electric propulsion and power plant

In order to drive the Azipod propulsion system the ship needs an electric power plant (not specifically presented on this document). Alternator sets supply power to the 50 or 60 Hz installation of electric switchboards for distribution to all consumers onboard, including Azipod propulsion.

Generally, ABB would aim to deliver the power plant as well as the Azipod system. Our mechanical interface to the engine maker is basically standard, although dependant on the delivery of engines or e.g. gas turbines from the contractors.

During the whole project the basic tool for power plant design is the so-called single line diagram. The actual onboard configuration can be efficiently discussed already in the early stages of work by using this clear visual representation.

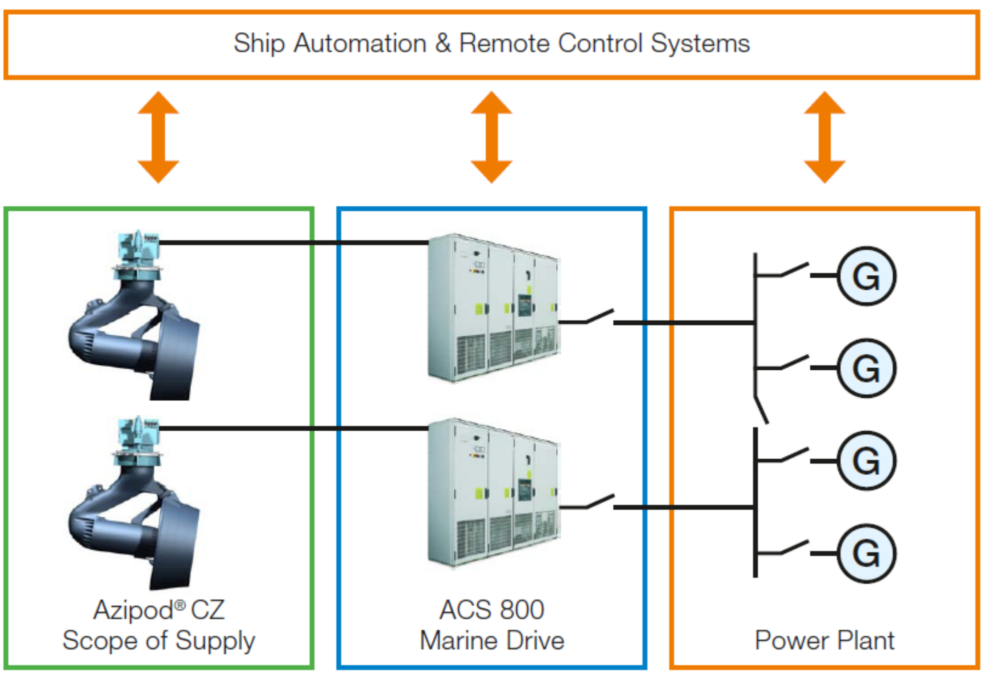

Figure 1-2 Simplified single line diagram of the power plant with a propulsion system.

6 General | **Azipod® CZ1400 Product Introduction**

2 Scope of Supply

2.1 General

The **Propulsion Module** of the Azipod CZ uses a permanent magnet synchronous motor to drive a fixed-pitch propeller that is mounted directly onto the motor shaft and runs inside a streamlined nozzle. The motor is directly cooled via convection to the surrounding seawater without using any additional cooling media. The motor is pressurized by air. The Propulsion Module incorporates the steering mechanics that also act as the mechanical interface with the so-called Mounting Block in the hull of the vessel.

2.2 Azipod Specific Basic Items for Delivery

Each Azipod CZ consists of twelve (12) separate packages with the equipment for installation into the ship:

One (1)	Propulsion Module (Steering mechanics, strut, nozzle, motor, propeller and inner installation dome)
One (1)	Slipring Unit
Two (2)	Gearboxes for steering
Two (2)	Motors for steering
One (1)	Connection box extension
One (1)	Local Backup Unit (for local emergency control)
One (1)	Installation fittings' kit
Two (2)	Steering Drive Units (Power electronic cubicle)
Two (2)	Brake Resistor Units (Steering gear accessory)

2.3 Azipod Specific or Contract Specific Optional items

In addition to the above listed basic Azipod hardware delivery, the following items may also be delivered when ordered, to assist the Shipyard in the installation work:

A. An Azipod-specific Mounting Block with the outer installation dome

B. Contract-specific Lifting and installation kit (Spreader beam, wires, jacks)

C. Contract-specific Guide base welding Dummy

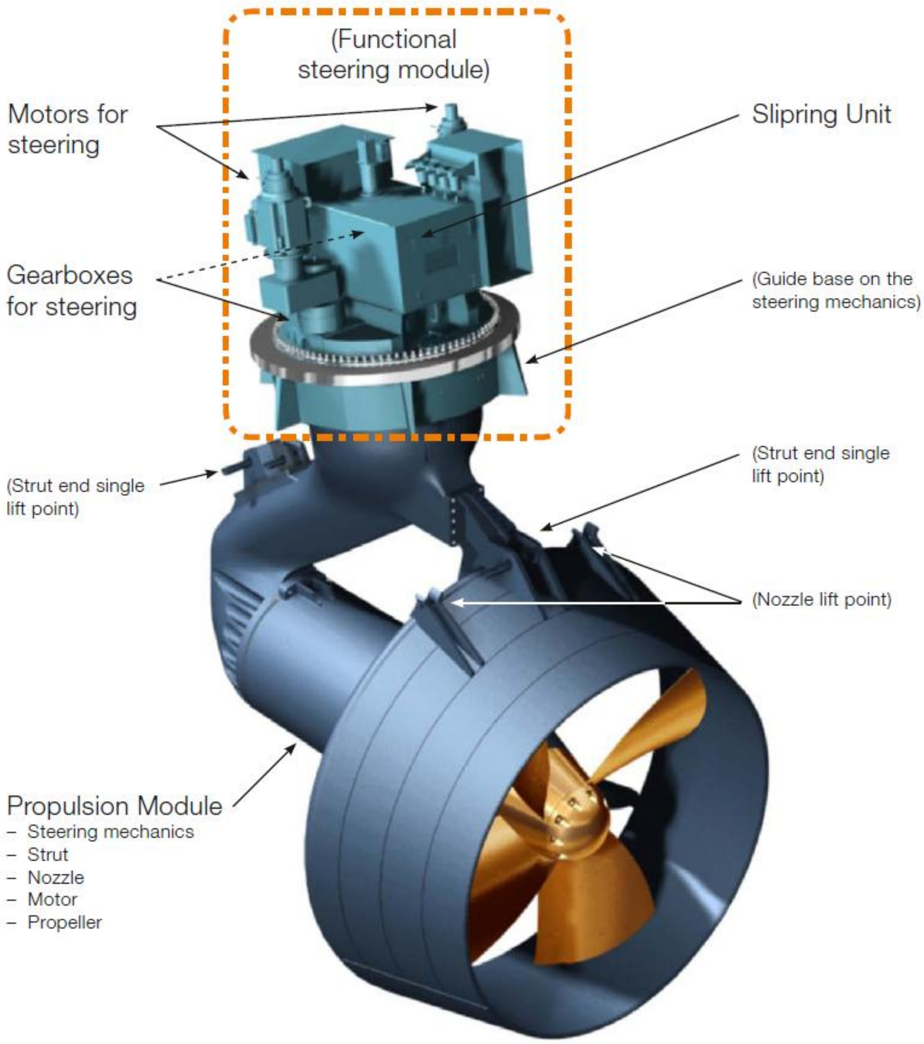

Figure 2-1 Functional elements of the Azipod CZ1400

2.4 Ship Specific Delivered Items

The ABB scope of supply would also typically include all or most of the following items:

A. One Propulsion Power Drive per each Azipod CZ

B. Remote Control System

C. The Generator and Switchboard power network outfit

8 Scope of supply | **Azipod® CZ1400 Product Introduction**

2.5 Propulsion Module

The motor, nozzle, strut and the steering mechanics are mounted together with the propeller at ABB, to form the Propulsion Module. The Propulsion Module is to be bolted into the Mounting Block by the shipyard.

The Propulsion Module incorporates a permanent magnet synchronous motor with a fixed-pitch propeller that is mounted directly onto the motor shaft. The motor section of the Propulsion Module therefore includes the complete electric motor with bearings, shaft seals, and a maintenance brake.

Permanent magnet technology brings a number of benefits. The design enables the motor to be directly cooled via convection to the surrounding sea water without using any additional cooling media.

The propeller shaft seal assembly combines a water lubricated face type seal and two grease lubricated lip type seals running on a steel liner. The set air pressure inside the motor prevents sea water from entering into the Propulsion Module.

The Nozzle / Strut combination is designed to enhance hydrodynamic steering performance and acts also as a connective element in the Azipod CZ structure. Control cables, piping and power supply bus bars for the propulsion motor are located inside the single piece cast strut.

2.6 Main Dimensions and Weights

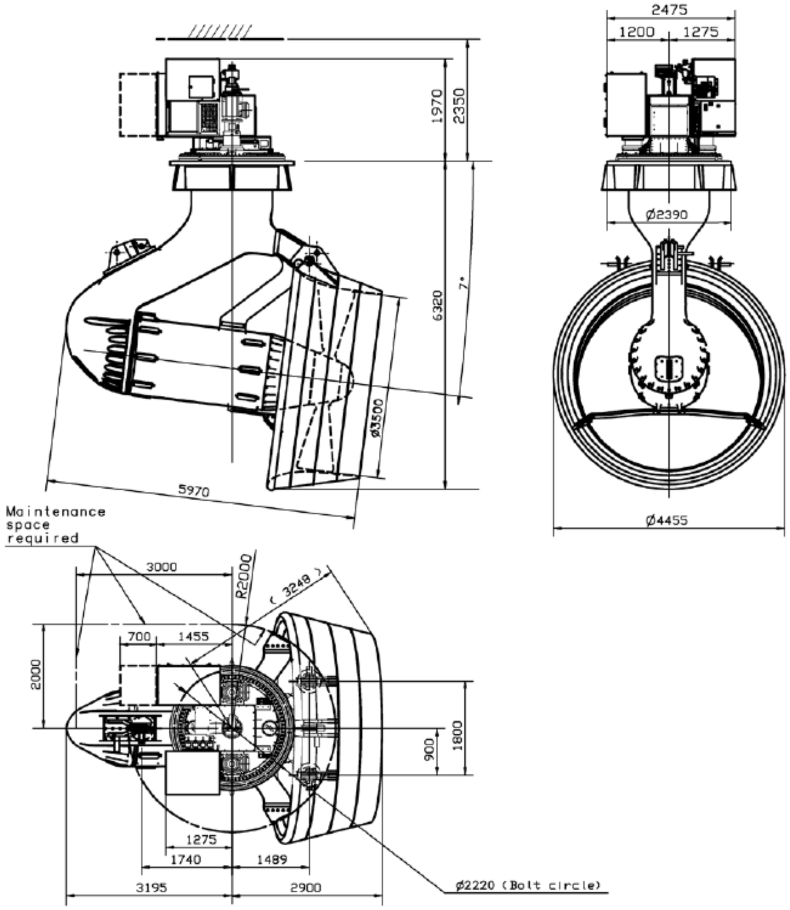

Figure 2-2 Dimensions for the Azipod CZ

Weights:

Propulsion Module	58 000 kg
Functional steering module	3 300 kg
Mounting Block (optional)	8 800 kg

10 Scope of supply | **Azipod® CZ1400 Product Introduction**

2.7 Steering Drive Units

The electric steering gear of the Azipod CZ is driven by two (2) Steering Drive Units of the ACS800 type. These two Steering Drive Units operate together by the master - follower closed control principle. In case of a malfunction to one of the units, the other can steer the Azipod with a lower helm torque.

The Steering Drive Units are typically located in the Azipod room.

The maximum available steering rate is 12 (twelve) degrees per second.

The weight of each Steering Drive Unit is approximately 400 kg.

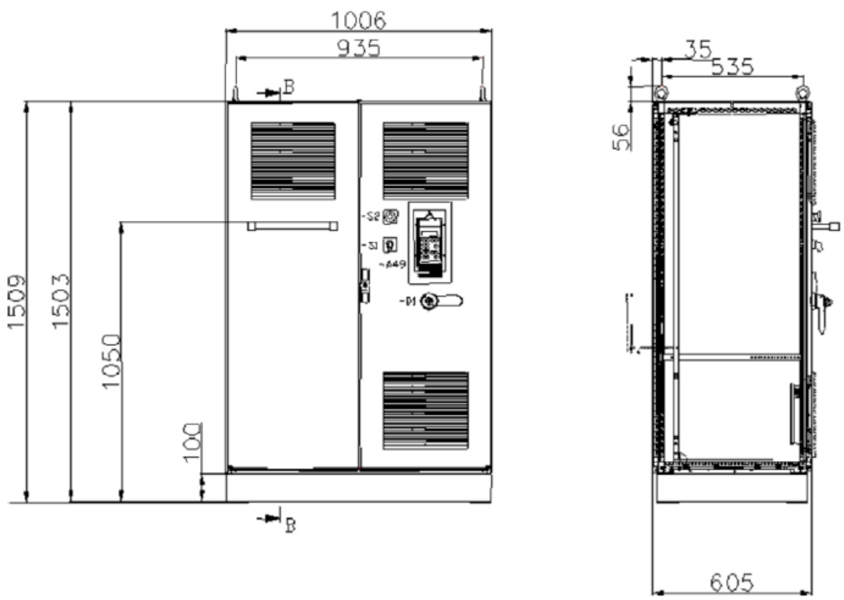

Figure 2-3 Typical dimensions of one Steering Drive Unit for Azipod CZ

2.8 Brake Resistor Units (for the steering gear)

Two (2) Brake Resistor Units are needed as accessories for each Azipod CZ steering gear. The resistor circuit absorbs functional reverse power from the respective electric steering motor. The Brake Resistor Units are to be normally installed in the Azipod room.

The weight of each Brake Resistor Unit is approximately 35 kg.

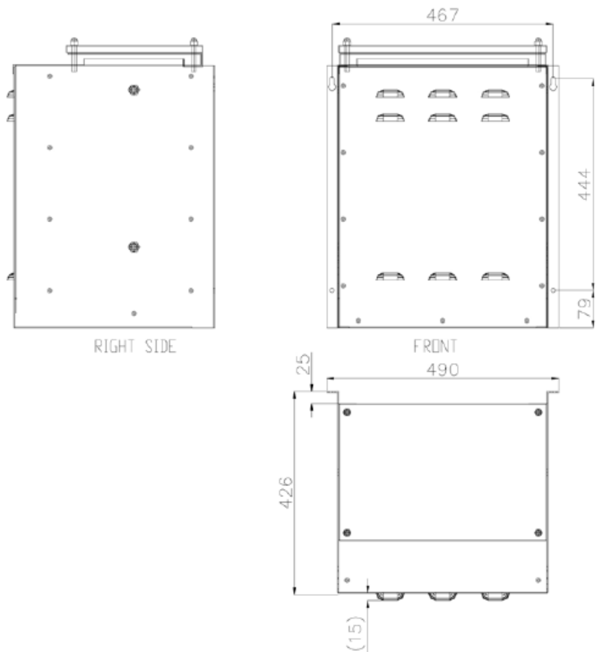

Figure 2-4 Typical dimensions of the steering brake resistor for Azipod CZ

12 Scope of supply | **Azipod® CZ1400 Product Introduction**

3 Ambient Reference Conditions, Weights and Speed

Azipod	
Sea water temperature	-2 ... +32 °C
Azipod room	
Maximum ambient temperature	+45 °C
Minimum ambient temperature	+2 °C
Relative humidity	95%, no condensation allowed
Propulsion Power Drives (ship specific item)	
Rated ambient temperature	+45 °C
Relative humidity	95%, no condensation allowed
Cooling fresh water inlet temperature	+2 ... +38 °C
Pressure	200 ... 600 kPa
Maximum speed	
Azipod water speed (max. allowed)	8 knots

4 Interface to the Ship

The Azipod CZ propulsion controls can be built to operate with or without a ship automation system. The ship automation system is needed for monitoring the propulsion system. It should also control the auxiliaries of the propulsion, e.g. the cooling water flow. The ship automation interface is to be carried out with a serial data link and by hard wired connections.

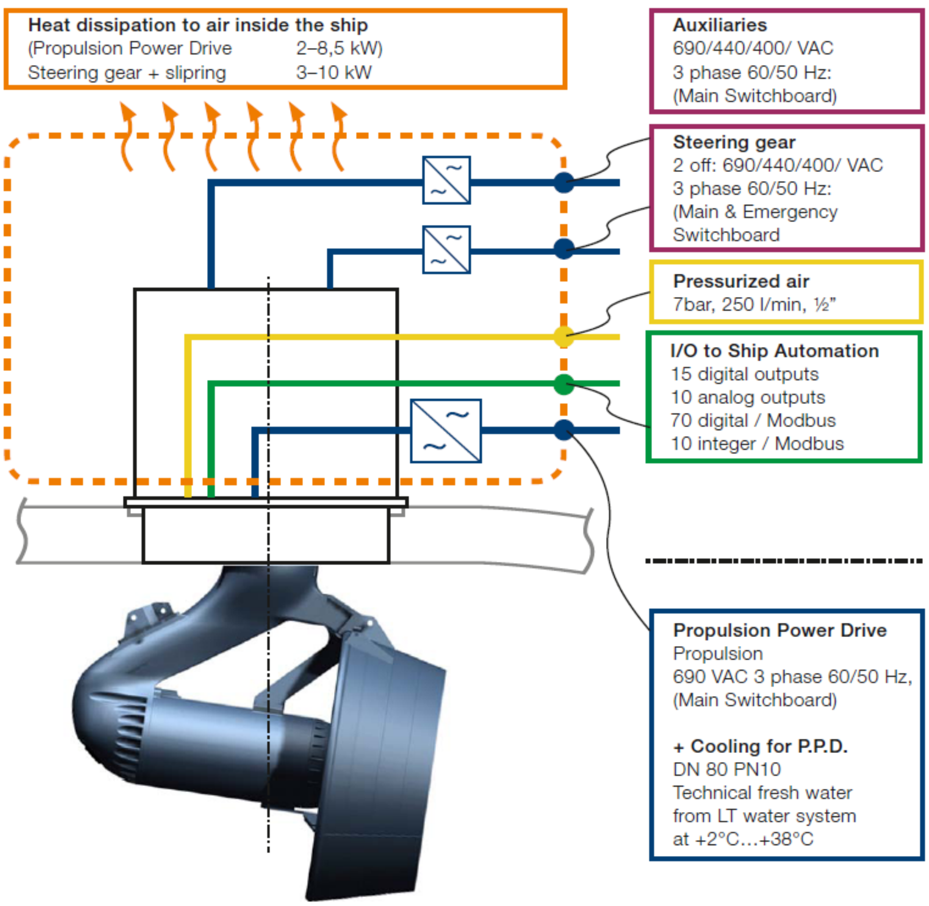

Figure 4-1 Azipod ship interface diagram in a preliminary project format

14 Interface to the Ship | **Azipod® CZ1400 Product Introduction**

5 Examples of Typical Installations

5.1 Power Plant Ship Example

In this typical onboard configuration three main generators are connected to the main switchboard, and the low voltage switchboard is supplied by two service transformers. The total harmonics' distortion (THD) is brought to the required level with the use of filters. The main switchboard can be divided into two separate networks by means of the tie breaker to increase the redundancy of the powerplant. A typical system configuration with Azipod CZ propulsion consists of the following components:

- Three main generators
- Propulsion switchboard 690 V with a tie breaker
- Two ACS 800 marine Propulsion Power Drive frequency converters
- Two Azipod CZ steering propulsors
- Bow thruster with electrically driven motor
- Two ship service transformers 690V/440V
- 440V switchboard
- Total Harmonics Distortion (THD) Filters
- UPS and UPS supply panel
- Two low voltage transformers 440V/220V
- 220V switchboard / panel
- Emergency generator
- Emergency switchboard

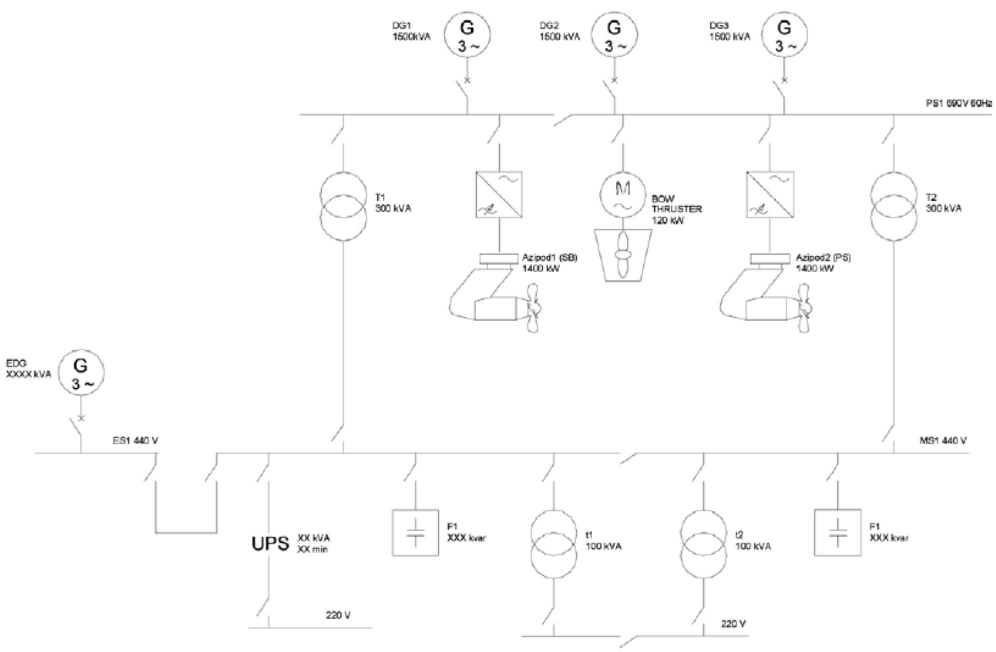

Figure 5-1 Example of a typical electrical power plant

5.2 Semisubmersible rigs for Global Santa Fe

CZ propulsors per rig	8 × 3200 kW
Rig deliveries	2003, 2004

Figure 5-2 The Global Santa Fe "Development Driller 1"

Figure 5-3 One of the eight Azipod propulsors being prepared for installation

16 Examples of Typical Installations | **Azipod® CZ1400 Product Introduction**

6 Azipod Questionnaire Sheet

PROJECT INFORMATION	
Company	
Contact person	
Project no.	
Tel. No.	
Fax. No.	
Ship type	
DESIGN DATA	
Ship main dimensions	L ~ _ _ _ _ _ _ m D ~ _ _ _ _ _ _ m B ~ _ _ _ _ _ _ m
Propulsion power	_ _ _ _ _ _ × _ _ _ _ _ _ kW
Main voltage	☐ 690 V / ☐ Other _ _ _ _ _ _ V
Generator power	_ _ _ _ _ _ × _ _ _ _ _ _ kVA
Max. vessel speed	_ _ _ _ _ _ _ _ _ _ _ _ knots
Bollard pull	_ _ _ _ _ _ _ _ _ _ _ _ kN _ _ _ _ _ _ _ _ _ _ _ _ metric tons
Classification society Class notation	_ _
Nozzle	☐ No (Azipod CO) / ☐ F Yes (Azipod CZ)
QUANTITY & APPLICATION INSTALLATION	
Number of vessels	_ _ _ _ _ _ _ _ _ _ _ _ pcs
Estimated time of delivery	_ _ _ _ _ _ _ _ _ _ _ _

Azipod® CZ1400 Product Introduction | Azipod Questionnaire Sheet 17

Contact us

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12.5 TUG SIMULATION TRAINING - REQUEST FOR REALISM AND ACCURACY

By Peter Kr. Sørensen FORCE Technology

TUG SIMULATION TRAINING - REQUEST FOR REALISM AND ACCURACY

Peter Kr. Sørensen, Head of Training, Ports and Human Factors Department, FORCE Technology, Division for Maritime Industry, Denmark.

Abstract

FORCE Technology has together with the global towage provider SvitzerWijsmuller developed a new tug simulator facility. The purpose of the facility is to train technical as well as human factor issues using a very realistic simulation tool. The paper presents the world's largest and most advanced full mission tug simulator and some of the features that are involved in the tug simulator training concept. A 360 degrees field of view full mission tug simulator with extended vertical view for monitoring of winch operations can be coupled to a part task simulator simulating the assisted ship and two or more tug cubicles. All ships involved in the simulation are fully interactive modelled 6 degrees of freedom ships. From a technical perspective this set-up has been a challenge in terms of ensuring that the simulations can be undertaken with a high update rate such that the size and rapid change in e.g. fender and line forces is taken into consideration. From a training point of view the idea is to reach a high level of realism such that the difference between simulation and real operations is minimal. This is amongst other achieved by installing the instrumentation and handles for the real tugs in the simulator and ensuring that the mathematical models behave accurately under the simulated environmental conditions. This is also a requirement when using the simulator facilities to evaluate size, type and strategies during engineering projects offshore and for ports. The tug models used in the simulators have been undergoing validations by experienced tug operators and tug captains.

1. INTRODUCTION

Simulation training is due to the increasing possibility of enhancing realism, which again is linked to the development in computer power, a cornerstone behind the development of a new full mission tug simulator at FORCE Technology in Denmark. Add to this, that there has been a continuous development in the mathematical model, DEN-Mark 1, which has been enhanced to fit the special requirements to tug simulation training.

Due to the fast movement of tugs in waves and under manoeuvres, variation in ship-ship interaction, influence of wash effects, response of fenders and towing lines etc. etc. the requirements for realism and accuracy can be said to be superior compared to the requirements when simulating larger vessels. In general there is a requirement for faster calculations and update rates when simulating tug operations.

The diversity of tug design (e.g. ASD, Voith, conventional) – even within the same type of tug (e.g. in relation to skeg placement and size), use of tugs in port and at offshore terminals, the variation in how such tugs are handled with different bridge equipment has lead to an increased focus on tug training and as such simulation with tugs for new port or offshore operations where determination of tug types, tug sizes and number of tugs for escort and berthing operations is in focus.

Simulation of tugs is not new. What is new is the increased emphasis on specialized training (versus generic training) where the tug masters and pilots can become familiarized with a specific tug equipped with specific instruments and handles. The available computer power and enhanced modelling of hydrodynamic forces has likewise added to the value and realism of today's tug training. Finally new ways of using tugs, such as escort towing, and development of new tug design is increasing and with this an extended demand for training.

In an article in Lloyds List 30 November 2005 it was mentioned that MAIB has noted several recent incidents over a period of four months in 2005 involving tugs. MAIB concluded that lack of training and familiarization by the tug skipper was the reason for these incidents. MAIB has therefore issued a safety bulletin highlighting the need for tug masters to be fully trained and an assessment made to ensure the tug and crews were suitable for each task.

The above issues have been some of the driving forces behind SvitzerWijsmuller's engagement in specialized tug simulation training. With the development of the M-class ASD tug design SwitzerWijsmuller is aiming at a high degree of standardization. During the development of the M-class ASD tug series SvitzerWijsmuller was considering the advantages of tug simulation.

2. THE FACILITIES

The full mission tug simulator system was operational in January 2005.
For the purpose of the simulator training a 100% SvitzerWijsmuller M-Class look-alike wheelhouse was constructed with all the real bridge equipment and electronics in place. Due to the flexibility of the in-house SimFlex Navigator simulation system and many years of experience with such integration tasks it was a relatively easy task to integrate all this real equipment and instrumentation.

FORCE Technology has together with SvitzerWijsmuller developed a new state-of-the-art interactive tug simulation facility with a very high degree of realism. Three fully modelled tugs and a number of additional vector tugs can be coupled to an assisted ship and escort and berthing operations can be tested with models of specific tugs.

The world's largest 360 deg. field of view bridge (denoted A) simulating a tug, is linked with a 120 deg. field of view bridge (denoted D) simulating the LNG-carrier. Furthermore, two auxiliary tug cubicles are added to the set-up as shown in Attachment 1. Fig. 1 shows the vector tug panel used for control of the vector tug.

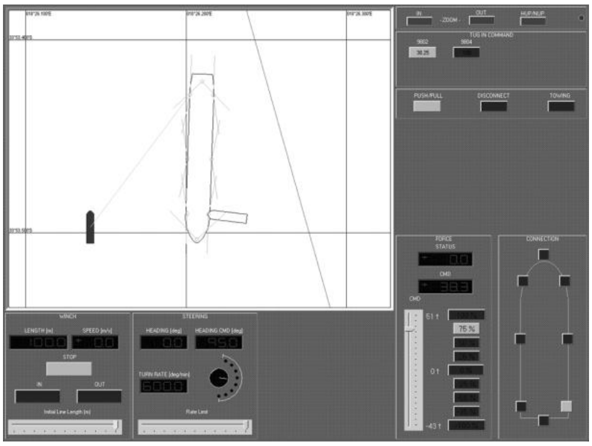

Figure 1 Tug control panel for vector tugs

The simulator is characterized by an own-ship (assisted vessel) interacting with three fully modelled tugs. This dedicated tug simulation facility will provide a very high degree of realism. A fourth tug can be operated as a vector tug that would be operated at the most non-critical position.

Mathematical and visual models of LNG carriers, tugs, terminals and the surroundings can be developed with emphasis on a level of details suitable for a given study.

2.1 Tug Simulator Set-up and Software

As depicted in attachment 1 the tug simulator set-up comprises of the following elements:

- A full bridge tug mock-up
- A full bridge LNG carrier mock-up
- Two auxiliary tug cubicles.
- A vector tug station.
- An Instructor/Operator station

Details of these elements are described in the sections below.

1.1. Full Bridge Tug Mock-up

The full bridge tug mock-up is installed in the simulator centre (Bridge A), which provides a 360º horizontal view from the tug wheelhouse.

Depending on the tug type to be simulated the bridge is equipped with the following propulsion controls:

1. Two handles for control of the azimuth propellers on ASD tugs.
2. One set of controls for speed pitch and steering pitch for VSP tugs.

For both types of tugs there is installed a winch control device. Control handles for other tug types can be integrated.

The two sets of controls are easily interchangeable, such that time delays are minimized when changing type of simulated tug.

The berthing display, Fig. 2, shows an overview of the berthing/unberthing situation with zooming functions. The grey area to the right displays details such as e.g. LNG carrier approach speed and angle of approach, towline forces and directions.

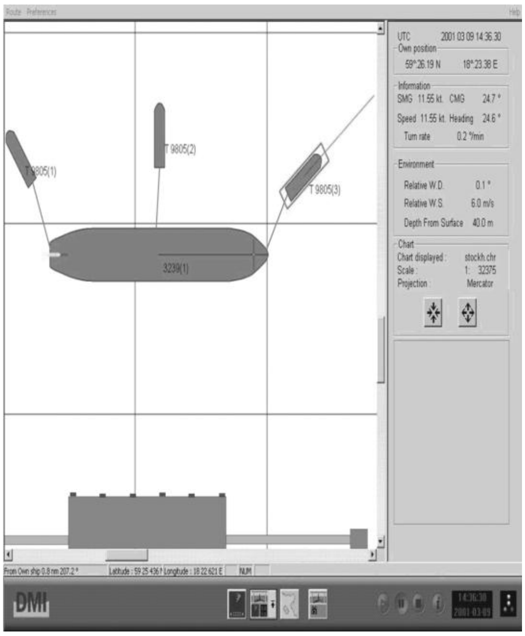

Figure 2 Berthing display

Figure 3. ASD tug full mission bridge layout. The VSP handles can be seen in front of the captain

2.3 Full Bridge LNG-carrier Mock-up

The bridge set-up for the assisted ship, e.g. a LNG carrier, is installed on the simulator bridge denoted D, which provides a 120º visual system. By means of a view-selection panel the line of sight can be changed to any direction and the eye-point can be changed from bridge centre to starboard or port bridge wing. The three fully interactive tugs and any possible vector tugs will be shown in the visual scene.

Figure 4. The assisted ship bridge (denoted D)

The equipment on the assisted ship bridge is:

- Engine control
- Rudder control
- Berthing display
- Radar
- VHF Radio
- Conning Display
- Electronic chart
- View selection panel

2.4 Tug Cubicles

The set-up for control of auxiliary tugs is shown in Fig. 5. The set-up includes ASD and VSP handles, winch control, visual view, conning display, electronic chart, a tug control panel operated by means of keyboard and mouse, and a VHF radio.
Other control handles can optionally be integrated.

Figure 5. Auxiliary tug control cubicle with ASD
and VSP handles and winch control.

From the tug control panel the tug master can:

- Connect/disconnect tugs in either pulling or pushing mode
- Control pulling pushing force and direction
- Control towline length in pulling mode
- Select constant tension mode

Same functionalities are available on the 360 degree field of view a bridge.

2.5 Tug Modelling

FORCE Technology possesses a profound knowledge in model testing and mathematical modelling of ships and offshore structures. The know-how is based upon more the 40 years of manoeuvring model tests. In the past almost any type of ship and offshore structure has been modelled in the towing tanks and in the ship simulators. Likewise FORCE Technology has been involved in tests and modelling of almost any propulsion system, including water jets, pod units, thruster units, Voith-Schneider units, CRP thruster units, etc.

FORCE Technology's tug models include various effects in order to obtain realistic and accurate interaction with the assisted vessel including but not limited to:

- Fender hull interaction (various fender types)
- Wake effect from assisted vessel
- Tug heel
- Interaction between tug's propulsion devices
- Wash effect in visual scene
- Specific towline elasticity and damping, break load, catenary curve

For further and more detailed information on tug modelling aspects please see the MARSIM 2006 paper by Kristian Agdrup and Anders S. Olsen, FORCE Technology, 'Development of a mathematical model of a Voith Schneider tug and experience from its application in an offshore simulation study'.

2.6 Visual Model of Ships

Visual models of e.g. the LNG carrier and the tugs have been generated based on photo texture techniques. The level of details is adequate for both engineering and training purposes. An example from the simulator is shown below.

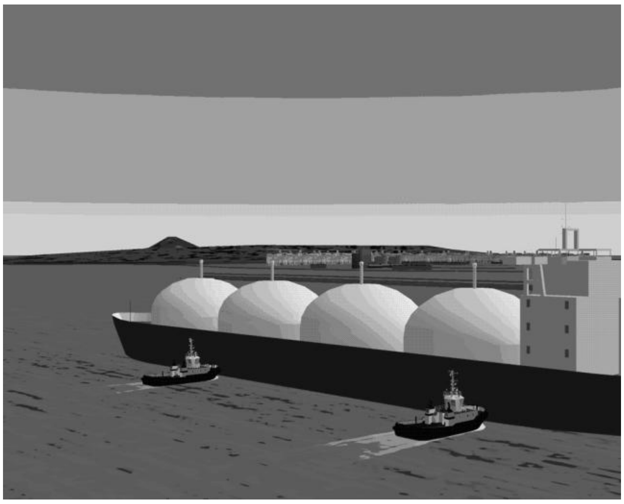

Figure 6. Illustration of LNG-carrier and tug models.

3. THE TRAINING

The new full mission tug simulator system can be used for a wide range of training activities including development of skills in ship handling and within human factors issues.

Initially the tug simulator serves two primary training objectives. First it is used to train tug masters at new terminal and port projects by familiarizing them with the terminal lay-out. Second, it is used for training of experienced masters and chief officers in tug handling, escort trails, bridge resource management and vessel handling in port and emergency situations at existing or modified ports.

Currently a tug handling course is a 4 days course including theory and simulation sessions for 4 participants. The training activities has expanded and includes training of pilots together with tug captains in order to enhance transfer of knowledge of the other groups domain and the challenges each group is meeting.

A more diversified training program using the advanced full mission tug simulator aiming at the participants' prior experience is under development and will result in three specific training levels: basic, advanced level 1, advanced level 2.

Basic Course: Designed for newly appointed tug chief officers and others with little or no experience of ASD tugs. Basically the same as the existing 4 days course.

Advanced 1: Designed for pilots and experienced tug chief officers and newly appointed tug masters. Less theory and shorter more intensive simulator exercise comprising arrivals and departures from specific ports and escort towing. Emphasis on tug master/pilot interaction and using various ship models. Two pilots and two tug officers participates. Focusing on either VSP or ASD tugs. 4 days course with half a day extra in advance for the pilots to be introduced to the tugs.

Advanced 2: State of the art. Designed for experienced tug masters with more than 3 year's experience with ASD or VSP tugs. Less theory and short intensive advanced tug simulator exercises in specific ports. Includes difficult emergency scenarios, escort towing, dock operations and towage in ice. Four participants, 3 days, focusing on either VSP or ASD tugs.

For all courses the objective is to transfer more technical ship handling skills as well as human factors skills.

The training can also include offshore Ship-to-ship (STS) and tandem mooring operations including use of DP systems.
Three main elements influence the way a tug is handled:

- the environment, like wind, waves, water depth, current, characteristics of the assisted ship and port lay-out
- the manoeuvrability of the tug and design of manoeuvring equipment
- human factors like teamwork, human errors, communication, stress control and situational awareness

If optimal performance of the crew is the overall target, training and bridge design should take all three elements above into consideration.

FORCE Technology has in close co-operation with the industry developed training programs that encompass all three elements above.

The program consists of three components:

- Ship Handling
- Crew Resource Management (Human Factors)
- Crisis and Emergency Management

The program contributes to an increase of safety and efficiency at sea. A well trained, professional and motivated crew that are continuously updated on manoeuvre theory, handling of specific vessels under normal and extreme conditions will in the long run reduce the incident and accident rate and enhance efficiency.

The advantage of the program is a very high degree of realism during the simulations. The course program includes exercises that would be very expensive to demonstrate in real life. In contradiction to on-the-job training simulator training can ensure that a given uniform high level of competence is achieved, as it can be guaranteed that the students have been through the same predefined curriculum.

3.1 Technical skill training

This element is focusing on the practical handling of specific tugs. If e.g. a tug master has many years of experience in handling of conventional tugs it will take an effort to get used to the handling of a VSP or ASD tug. There are several pedagogical aspects involved in this including a de-learning issue. As one of the course participants expressed it: "It is like learning to ride a bike again". After the training the participants should reach a level where they use less mental resources to think about how they control their actions – just like when you have learnt to ride a bike. The objective is also to experience the operational limitations for tug operations and how to apply different manoeuvre strategies including escort towing.

With the current set-up up three tug captains can be involved in one exercise and actually operating a fully modelled tug each.

3.2 Human Factors skill training

It is generally accepted that it important that the captain is able to “control” himself, his crew and his ship. Human Factors aspects are of course vital elements in that respect.

The following subjects are addressed: Human performance and limitations, mental abilities and limitations, decision making, stress handling, operational communication, use of new technology and human errors.

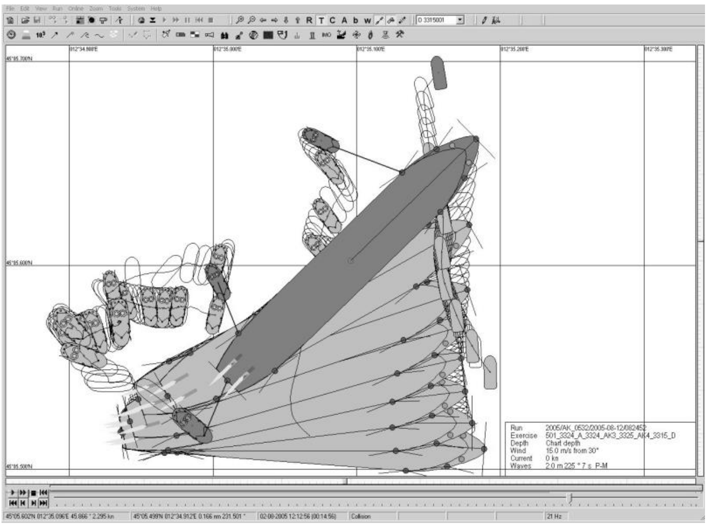

Figure 7. All involved Own Ships (tugs ad assisted ship) can be shown together in the Replay System.

Especially the communication element is emphasized where tug masters and pilots are trained in closed-loop communication.

3.3 Request for realism and accuracy

We could ask the question: Why is it important that simulation and simulators are as realistic is possible? One just has to look to the airline industry to see and understand that the highest level of realism should be the ultimate target. It is emphasized that the importance of tailor made courses meeting the requirements of the client to the highest possible standard is needed and will become more and more important in the future. Increasing realism in the mathematical ship model to obtain high accuracy is a time and cost consuming task. From a cost benefit point of view it is therefore important carefully to judge the required level of realism and accuracy against the training objectives. The trainees will always participate with a natural desire for maximum realism. It is the simulator instructor's task to design the training such that an efficient and maximum transfer of knowledge into skills is undertaken in a minimum of time and at minimum cost and risk – otherwise the trainees could just as well be put on-board real sophisticated ships and wait for bad weather - and a crisis situation.

Tug simulation training is an example where a high level of realism is required with simulation of various tug types equipped with e.g. Voith Schneider propellers, thrusters, azimuth propellers and operating close to ships in poor weather including waves, current and wind. Ship Handling, Human Factors and Emergency Management training simply cannot be accepted by the trainees to take place in generic full mission simulators. If the training takes place too far away from the trainees real working environment it will take too long time and require too many mental resources in a real situation to establish the connection from the skills acquired in the simulator to the exact skills required in a real situation. Simplification through use of generic simulators can lead to overconfidence and when the mariner discover that the distance between what he experienced in the simulator and the actions required in the real situation is too large the situation will be leading to stress and errors.

Full mission simulation of sophisticated tugs can be provided with a very high degree of realism if the real levers and instruments as well as engine control /alarm panels, winch control, conning displays and indicators are integrated to the simulator.

Another advantage of integration of real equipment and instruments in simulators is the reduction of instrument induced stress in real operations. This is a typical stressor that is very often seen amongst mariners joining or taking over new ships with instrumentation and equipment different from what they have previously been used to. When the majority of actions taken in relation to manoeuvring or conning the ship is changing from knowledge- or rule based actions into the much less mentally resource demanding skill based level, we see an increase in confidence as well as competence. This very important phase shift can only be carried out in a simulator where as much real instrumentation and equipment is integrated. The transition time leading up to where the majority of actions are skill based is the phase where most human errors are made. Part task simulators can be used to minimise the effect of instrument induced stress, but only in a full mission simulator a complexity close to the real world can be established where more perceptual cues and more stressors can be used. When manoeuvring a tug close to the assisted ship, the person in charge of the conning should spend as much time as possible in looking out the windows to monitor progress against plan and actions taken. It is desirable that the bridge is fitted with manoeuvring gear that is positioned and designed such that a minimum of time is spend in "head down mode". In other words it is preferable if the equipment is designed ergonomically and logically such that the person in charge of the conning after a certain initial training period does not have to move his sight from what is happening to concentrate (for a certain amount of time) on where to find the various handles, buttons and information. The closer the lay-out of the simulator matches the on-board lay-out the quicker the mariner gets familiar and gain confidence in the real world. If the simulator lay-out if too far away from the real thing we could end up in a situation where the mariner will have to de-learn methods and habits trained in the simulator.

3.4 Further developments

A number of advanced performance evaluation tools and methods are already in use such as event log registrations and the ComLog, where a team's communication profile is provided. It is the intention to develop a targeted assessment tool to be used for performance evaluation of tug masters including a measurement of ship handling as well as specific human factors skills.

The mathematical models of the tugs are already very sophisticated but further developments within complex ship-ship interaction between the assisted ship and the tug will be undertaken. Likewise the tug performance in waves and when interacting with fenders will be addressed in future development programs.

4. TUG SIMULATION IN ENGINEERING PROJECTS

The full mission tug simulation system has proven valuable during evaluation of tug types (e.g. VSP or ASD), tug sizes and number of tugs needed for a given operation at a terminal in a port or offshore. Obviously the realism and accuracy of the mathematical models and port databases are important as well as being able to provide valid output data such as tow line forces used, movement of the tugs, manoeuvring behaviour in order to assess if they can e.g. be safely maneuverer to the tug pushing points without overshoot, manoeuvrability during escort towing including shift time with full power on the towline etc.

Realistic full mission simulations has proved to be the most efficient and safe way to reach consensus on navigational issues, manoeuvring strategies and lay-out of ports and terminals as all relevant parties such as local pilots, tug masters, port authorities, port designers, port users etc. can be gathered and experience the complete complex array of problems and challenges that a future operation will meet.

When the final decision on which tugs to be used has been made such engineering studies are often follow-up by training of the tug masters and pilots involved in the new operation. Sometimes this involves introduction to use of a new type of tug and escort towing strategies.

5. CONCLUSION

Real-time tug simulation can be used for efficient training of tug crews in technical tug handling as well as human factors issues. It is also possible to use tug simulations in engineering projects where tug type and size is evaluated for specific port and offshore operations. When using simulators for training and engineering projects it is very important to ensure that the simulations are carried out at certain high level of realism and accuracy in order to avoid negative training effect and establishment of a poor decision-making basis for engineering projects.

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7. BIOGRAPHY

Peter Sorensen is head of the Training, Ports and Human Factors Department in FORCE Technology, Division of Maritime Industry (DMI), the former Danish Maritime Institute. He holds a B. Sc. in mechanical engineering and is a Master Mariner.

Has been 10 years with A.P.Moller-Maersk in the shipping company of which the last 5 years were with Maersk Oil and Gas as Offshore Mariner and Offshore Surveyor working in the North Sea, Arabian Gulf and Gulf of Thailand.

Came to the Danish Maritime Institute in 1994 and became head of the training department.

In 1998-1999 expatriated to Star Cruises as Manager of Star Cruises Ship Simulator Center in Port Klang.

Since 1999 with DMI (now FORCE Technology, Division for Maritime Industry) as head of the Training, Ports and Human Factors Department.

Chairman of Danish Human Factors Center since 2002, which is a cooperation between 18 Human Factors experts in FORCE Technology and The Danish National Research Laboratory, RISOE.

Attachment 1

Tug bridge, 360º HFOV.

LNG Bridge, 120º HFOV and pan function.

Auxiliary tug cubicles.

Instructor station.

Conceptual display of full mission tug simulator set-up.