The ECOTRAIN course

Planning, testing and evaluating a simulator based training course at Aboa Mare Training Center

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Examensarbete för Sjökapten (YH)-examen

Utbildning i sjöfart

Åbo 2016

BACHELOR'S THESIS

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Degree Programme: Degree Programme in Maritime Studies, Turku

Specialization: Bachelor of Marine Technology

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Title: The ECOTRAIN course – Planning, testing and evaluating a simulator-based training course at Aboa Mare Training Center

Date 20.3.2015 Number of pages 22 Appendices 3

Summary

In early 2012, Aboa Mare launched a study in energy efficiency training. The objective was to study the feasibility of introducing a training course in energy-efficient operation of ships, and, if this proved feasible, continue with planning, testing and evaluating such a course.

This thesis describes the procedures for planning, testing and evaluating the course. The theoretical parts explains the legislative background (Marpol) and principles for simulation, the background for the ECOTRAIN course and some information on Aboa Mare Simulation Center.

The practical part first describes the planning part, including building the training consortium and how the curriculum was developed. The consortium of partners ended up with ABB, Deltamarin, Eniram, Germanischer Lloyd, NAPA, VTT, Wärtsilä, and Aboa Mare, all of these providing lectures in their own special expertise areas.

The testing part describes the pilot course and its results. The main result was proving that significant fuel savings can be achieved by relatively small operational means.

The course was evaluated by the test trainees. The evaluation results showed overall high satisfaction, scoring around 8 points on a scale from 1-10.

The thesis was overall successful, documenting the procedures as planned.

Language: English

Key words: Ecotrain, simulator based, Aboa Mare, training course

EXAMENSARBETE

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Utbildning och ort: Utbildning i sjöfart, Åbo

Inriktningsalternativ/Fördjupning: Sjökapten YH

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Titel: The ECOTRAIN course – Planning, testing and evaluating a simulator-based training course at Aboa Mare Training Center

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Datum 20.3.2015 Sidantal 22 Bilagor 3

Abstrakt

År 2012 inledde Aboa Mare en studie gällande utbildning inom energieffektivitet. Målsättningen var att undersöka möjligheten att införa en kurs för energieffektivt handhavande av fartyg, och, såvida det visade sig vara möjligt, fortsätta med planering, testning och utvärdering av en dylik kurs.

Detta examensarbete beskriver procedurerna för planeringen, testningen och utvärderingen av kursen. Teoridelen beskriver den rättsliga bakgrunden (Marpol) och principer för simulation, bakgrunden till ECOTRAIN kursen och viss information om Aboa Mare Simulation Center.

Den praktiska delen inleds med en beskrivning av planeringsdelen, omfattande skapandet av utbildningskonsortiet och utvecklandet av kursbeskrivningen och –innehållet. Konsortiet kom slutligen att bestå av ABB, Deltamarin, Eniram, Germanischer Lloyd, NAPA, VTT, Wärtsilä and Aboa Mare, vilka alla deltar med föreläsningar inom sina egna specialområden.

Testkursen och dess resultat beskrivs. En betydande minskning av bränsleförbrukningen medelst relativt små operationella åtgärder kunde påvisas.

Kursen utvärderades av deltagarna i testkursen. Utvärderingsresultaten visade att deltagarna var mycket nöjda, med ett poängtal runt 8 på en skala från 0-10.

Examensarbetet lyckades och dokumenteringen av procedurerna förlöpte som planerat.

Språk: Engelska

Nyckelord: Ecotrain, simulator based, Aboa Mare, training course

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1 Introduction

The shipping business is very old, dating back in history for thousands of years and can arguably be considered one of the oldest businesses around today. The focus of interest in shipping has changed over time, but one of the main motivators, making a profit, is still around, as can be seen in the denomination “shipping business”. In other words, economical interests are important. No shipowner will run a deficit operation for very long.

Other motivators have also arisen over time. Of these we can easily identify safety, which arose mainly with the advent of the SOLAS and the COLREGs, and lately the STCW and ISM Codes. Safety was, and still is, seen as one of the leading lights in shipping, and this is easy to understand. Lately we have seen the rise of security thinking (the ISPS) and social sustainability (the MLC convention). In the past few years we have also seen the rise of environmentally sustainable and energy-efficient operation of ships, as exemplified by MARPOL Annex VI regulations.

Sustainable development is a common topic these days, but, unfortunately, we often tend to stress only the environmental sustainability, and then usually only in terms of garbage handling and emission reductions. However, as the most well- known and accepted definition by the “Brundtland Commission” (formally the World Commission on Environment and Development, WCED, 1987) states, the term “sustainable development” includes economic, environmental and social sustainability.

Based on this, we can thus state an ECO-thinking concept, combining economic and ecological benefits, which is, arguably, a win-win situation.

As MARPOL Annex VI sets new standards, new technology and new ship design is emerging, but technological advances are not the entire solution. Aboa Mare, being a maritime training provider, recognized the need for training programs in energy-efficiency and sustainability for the shipping industry. Aboa Mare is, among other, specialized in ship simulation and resource management training, which influences the contents of potential training programs.

1.1 Objective

The objective of the thesis is to document the procedure by which the ECOTRAIN course was planned, tested and evaluated.

1.2 Research questions

The research questions are:

- How was the course planned?
- How was the course tested and what were the results?
- How was the course evaluated and what were the results?

1.3 Delimitation

The thesis is limited to discussing only the ECOTRAIN course concept at Aboa Mare Training Center. No other courses of this type from other providers are discussed and no other Aboa Mare courses on other subjects are analyzed.

2 MARPOL 73/78 and annex VI

Energy efficiency is implemented in the shipping industry primarily via the MARPOL 73/78 convention. The MARPOL 73/78 is divided into six annexes designated I through VI. Annex VI, "Regulations for the Prevention of Air Pollution by Ships" is the one of consequence for this study. The MARPOL 73/78 Annex VI consists of 18 regulations as listed in table 1.

Table 1, Marpol Annex VI regulations (IMO, Marpol 73/78)

Regulation 1	Application
Regulation 2	Definitions
Regulation 3	Exceptions and Exemptions
Regulation 4	Equivalents
Regulation 5	Surveys
Regulation 6	Issue or endorsement of Certificate
Regulation 7	Issue of a Certificate by another Party
Regulation 8	Form of Certificate
Regulation 9	Duration and Validity of Certificate
Regulation 10	Port State Control on Operational Requirements
Regulation 11	Detection of Violations and Enforcement
Regulation 12	Ozone Depleting Substances
Regulation 13	Nitrogen Oxides (NOx)
Regulation 14	Sulphur Oxides (SOx) and Particulate Matter
Regulation 15	Volatile organic compounds (VOCs)
Regulation 16	Shipboard Incineration
Regulation 17	Reception Facilities
Regulation 18	Fuel Oil Availability and Quality

2.1 SEEMP

SEEMP stands for Ship Energy Efficiency Management Plan. This plan is mandatory for all ships of 500 GT and more from 1.1. 2013.

2.2 IMO SEEMP model course

IMO has published a draft version of a SEEMP model course,the IMO (draft) Model Course Energy Efficient Operation of Ships (MEPC62/Inf.39). This draft model course was used extensively as a basis in the ECOTRAIN course planning process. However, the entire model course was not incorporated in the ECOTRAIN course, mostly because of the three-day timespan of the course as compared to the 30 hours of the model course.

Incidentally, when this thesis was in an advanced stage in 2014, IMO published a new Model Course 4.05 on Energy Efficient Operation of Ships. This model course is not taken into account in this thesis because it arrived at a very late stage of the thesis process.

3 Using simulators for learning

Today, simulators are used extensively in many different contexts, perhaps the most well-known being the flight simulators used in airline pilot training. However, simulators are used in many other contexts as well, for example power plants, forest harvesting, medical and, most important in the present context, ship operations.

3.1 Definition of simulation

Simulation can be defined in many ways, such *as "acting out or mimicking an actual or probable real life condition, event or situation to find a cause of a past occurrence, or to forecast future effects of assumed circumstances or factors "*(Businessdictionary) or "*the act or process of simulating"* (Merriam-Webster).

For the purpose of this study the best definition could perhaps be *"the imitation of the operation of a real – world process or system over time". (Wikipedia).* Although this is a Wikipedia quote and, as such should be treated carefully, it is quite close to the definition needed in a ship operations context.

In the following discussion "simulation" is limited to the use of computer-based equipment in specific setups being then named "simulators".

3.2 Use of simulator in the ECOTRAIN course

In the ECOTRAIN course, the ship simulator was used for two different purposes; primarily to train officers in energy- efficient procedures but secondarily, to, simultaneously, collect data for research purposes.

Generally, simulators are, at least in the shipping industry, regarded as training-oriented equipment, but the dual use of simulators in training and research is not a new concept.

Perhaps one of the most significant early use of simulators in this way was in the US X-15 research rocket plane program in the 1950s and 1960s. The X -15 program used simulators for the dual purpose of training the pilots and other personnel involved and also for research purposes, mainly in predicting the behavior of the airplane at speeds and altitudes never before attained. The simulators were also used for troubleshooting and correcting equipment malfunctions (Thompson 1992).

Thus, the X-15 program depended heavily on the simulators and it has been argued that the program would not have succeeded without the use of simulators, or, at least, would have been significantly less efficient. As X-15 pilot Milton Thompson said*: "We were able to avoid many pitfalls because of the simulation. It really paid off. I personally do not believe we could have successfully flown the aircraft without a simulation*" (Thompson 1992, p.70).

This quote is a good description of the reasons why the ECOTRAIN course can be considered very significant training. Avoiding pitfalls, using training to gain significant pay-offs and developing operations successfully is, or should be, vital to each and every responsible shipowner.

3.3 Azipod workshop (H885) and the TRANSAS Navitrainer 5000 Ecofunctionality module

One very important fact in the development process was the experience on energy consumption measurements and other information gathered during Azipod (H885) workshops delivered at Aboa Mare Simulation Center Espoo by ABB Marine Academy. This information was used for conducting a joint ABB/ Aboa Mare study designated "Vessel handling with Azipod® Propulsion - Techno-economical and simulator -pedagogical observations from high-level cruise ship captain training", which was published in August 2013.

These Azipod workshops are continuing to be delivered and Aboa Mare delivers the simulator knowledge and maritime expertise for the workshop.

The experience gained in these workshops led to checking out the possibilities for using the TRANSAS Navitrainer for a more generic approach to energy-efficient training. It was quickly established that the Navitrainer 5000 includes an optional Ecofunctionality module. This module enables the measurement of 12 different parameters, incl. CO, CO2, NOx, SOx, soot, and fuel consumption.

3.4 Aboa Mare simulator centers Turku and Espoo

The ECOTRAIN course is delivered primarily at Aboa Mare Simulation Center in Espoo, Finland. Aboa Mare, the leading maritime training provider in Finland, runs two simulator centers, one in Turku and one in Espoo, and is, additionally, co-owner of Giga Mare Inc, which runs a simulator center in Subic Bay, the Philippines (Aboa Mare) As of March 2015, the Espoo simulator center is, however, slated for decommissioning during 2015.

Aboa Mare Simulator Center Espoo uses a Transas Navi-Trainer 5000 software being run on three simulator bridges, of which two were used in the ECOTRAIN course, as described in chapter 7.1.

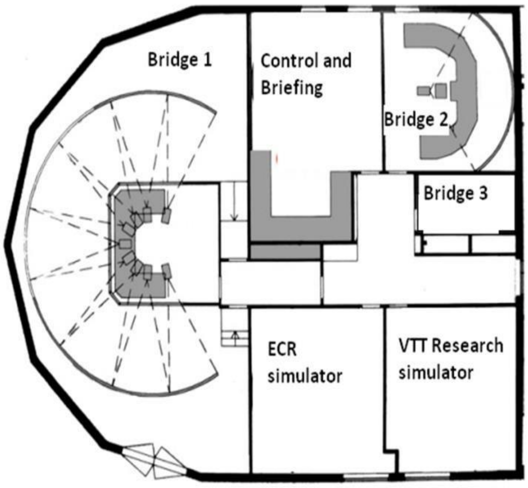


Figure 1 and 2, Aboa Mare Simulator Center Espoo, layout and external view (Aboa Mare)

Figure 3, Bridge No. 1 (Aboa Mare)

Figure 4, Bridge No. 2 (Aboa Mare)

4 Planning the course

The planning phase was initiated in February 2012. The interest from different actors in shipping was evident and the subject is very current. Aboa Mare decided to start the planning process and a course planner was appointed.

4.1 Basic information gathering

The first action was to start gathering the basic facts needed to build a basic framework for the course. It was from the start obvious and well-known that the scope for a course of this type is optimally three days. Less than three days makes it very difficult to include all the information needed and more than three days makes the course too long, making it tiresome and also raises the price too high. Thus, the three-day framework established the limits for the course content.

It was also quickly established that the training course was to be modeled on the ICETRAIN concept, in which Aboa Mare is a partner. This concept is on training for ice/winter conditions and has been run since 2007.

The Marpol 73/78, as amended, is the basic steering document and it quickly became clear that a thorough discussion of especially MARPOL chapter VII is essential.

It also became clear that the course should be based on the IMO (draft) Model Course Energy Efficient Operation of Ships (MEPC62/Inf.39).

After establishing these basic facts, the planning crystallized into three different modules. The first module would consist of legislation and basics about energy efficiency and, additionally, basics about shipbuilding and ship design from the energy efficiency perspective. These basics are the facts an officer cannot influence, but he/she should nevertheless be aware of them in order to be able to take them into consideration in the everyday operation of the ship.

The second module would consist of the things that the officers onboard ships can influence. By discussing different methods of operation and also the technical equipment available, the trainees can be given a good picture of their own abilities to influence the operation of the ship.

The third module would consist of simulator exercises designed to clarify different phenomena and give the trainees the possibility to test out different actions and observe their impact on fuel consumption, and, consequently, the emissions.

4.2 Sounding out partners and building the consortium

After the basic framework was established, this influenced the potential partners to be approached.

Potential partners were charted and approached. As it turned out, the final consortium came to consist of the following partners:

- DNV-GL
- VTT
- Deltamarin
- Wärtsilä

- ABB
- Eniram
- NAPA
- Aboa Mare

4.3 The first meeting with the partners

After the potential partners were approached, a first meeting was proposed. This meeting was attended by representants from all the above mentioned partners. At the meeting, the basis was discussed as well as the economic considerations for the tentative course. This was established fairly easily. The details of these arrangements will not be made public in this thesis because they are considered business inside information.

Additionally, the basic framework was established and a working plan discussed. The partners agreed to proceed with the different subjects according to their own special areas.
It was furthermore agreed, that a second meeting will be called at a future date.

4.4 The second meeting with the partners

The second meeting was called and convened as planned. All the partners attended, and the main point was to study and discuss the lesson plans and material to be used. The main outcome was that the consortium can proceed with the planning procedure and a test course (pilot course) should be arranged to check out the feasibility of the program. At this second meeting an important development was that the title "ECOTRAIN" was proposed as the name for the training course.

4.5 The follow-up meeting with the partners

The pilot course referred to in chapter 5 led to some minor improvements being made to the lectures, but the main structure was found to be sound and needing no further development at the time. A follow-up meeting was convened in January 2013, at which the course was finalized and the consortium decided to proceed with the marketing of the course.

The course is now open for enrolment at the Aboa Mare website and the ECOTRAIN – course is presented in detail on the website www.ecotrain.fi .

5 Testing the course

At Aboa Mare the standard procedure for testing and evaluating courses being planned is to run a test course, usually referred to as the” pilot course”. In the case of ECOTRAIN, this procedure was implemented in the standard way.

5.1 The pilot course

The pilot course was arranged 27-29.11 2012 at Aboa Mare Simulation Center in Espoo. Five students from the degree programme in maritime management (Utbildningsprogrammet för sjöfart) attended the course. The students could use the course as an optional course in their curriculum. The scope of course was determined to be 1,5 ECTS points.

5.2 The program as planned and as amended at the pilot course

The planned program is described in appendix 1. The basic layout is, as described in chapter 4.1, one day of basics, shipbuilding and technical solutions, one day of discussing the possibilities open to the officers and one day of simulator exercises.

Unfortunately, the program had to be rescheduled due to problems in the timetables of the lecturers. As a result, the simulator exercises were all run one the third day, including the familiarization and pre-course run. This could influence the results to some degree, but on the other hand, the results were very clear nevertheless.

The program was thus run as shown in appendix 2.

5.4 Establishing a baseline, pre-course and post-course runs

In the ECOTRAIN course, the concept of running pre-course and post-course training sessions was used. This approach also originated in the previously mentioned Azipod workshop and also on the pre-course and post-course written questionnaire used in the ICETRAIN concept. The main idea is to establish a baseline for evaluating the learning achieved during the course. The trainees are asked to, in the pre-course run, just run the ship along the planned track as they would ordinarily do in real life. The trainees are then subjected to the theoretical lessons and run through a series of standardized simulator exercises. At the end of day three, the trainees are then asked to perform the same run as in the pre-course exercise, but this time using and implementing the knowledge achieved during the course. In this way, it is possible to see immediately the effectiveness of the training.

5.5 Briefing and debriefing

In simulator training, the procedure of using briefing- training session- debriefing methods is the commonly used method.

Aboa Mare has, over many years, made a big effort of developing methods for running simulator exercises in the most efficient manner possible. According to Westilä and Vuorio (2011), a simulator training session is composed of briefing, simulator exercise and debriefing. All three elements are crucial to enabling the learning process in a simulator environment (Westilä & Vuorio 2011, p. 1).

5.5.1 Aboa Mare standard form for briefing and debriefing

According to Westilä and Vuorio (2011) the standard Aboa Mare form for briefing and debriefing is to start the exercise session with a short briefing session including the following items:

> The objectives and main scenario of the exercise, the composition and roles of the bridge teams, exercise date and time, weather conditions including wind force and direction, wave height and direction, water temperature, visibility and speed and direction of the sea current, ship type and specification, passage plan and external and internal communications.

After completing the simulator session, the debriefing session is run, discussing at least the following items:

> Events during the exercise and reflections from real-life operations in order to verify correct transfer. What did we learn from our possible mistakes and which things went well? What were the strengths and weaknesses in the exercise and, finally, were the objectives reached?

5.5.3 Pilot course briefing and debriefing

In the ECOTRAIN pilot course the standard Aboa Mare briefing and debriefing was conducted. Some modifications and amendments/omissions from the standard form were made due to the specialized type of training conducted, mostly this included a more thorough debriefing than usual to study in detail the energy efficiency aspects.

5.6 Simulator software and bridges used

The simulator used in this research was the Transas Navi-Trainer Professional 5000 (NTPRO 5000). Two full mission command bridges, Bridge 1 and Bridge 2, were used, with viewing angles of 220 and 110 degrees, respectively.

5.7 Pre-course and post-course runs, operational area

The operational area used was north of Överö in the Sea of Archipelago, stretching along the 8,2 m fairway from a position just to the east of Enskär lighthouse and ending at the north cardinal mark northwest of Bredskärskobben. Environmental variables were minimal, involving no wind or current. Visibility was 10 nautical miles, and no other vessel traffic existed in the area.

Because the available simulator shipmodel had a maximum draft of 3.5 meters, it was decided to artificially adjust the depths of the fairway to achieve approximately the same relative ratio between ship draft and water depth. The area with planned track and adjusted water depth areas can be seen in figure 5.

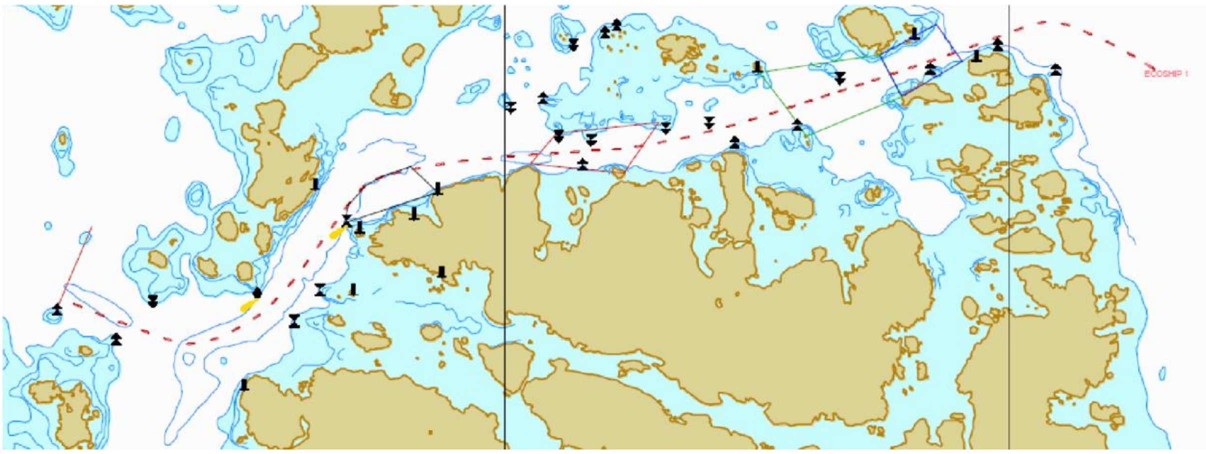


Figure 5, The exercise area (Transas 5000 screenshot)

5.8 Simulator shipmodel used

The model utilized was *Passengercarferry 3*, a car ferry modeled on the mv Daggri, in inter – island traffic in the Shetland Islands. Vessel dimensions are presented in Table 2.

Figure 6 , mv Daggri (macduffshipdesign)

Table 2, mv Daggri technical data (macduffshipdesign)

LOA	65.36 m
B	13.8 m
Draft	3.75 m
Propulsion system	Azimuthing
Propulsion power	2 x 370kW
Maximum speed	11 kts

5.9 Observations on the pre-course run

The pre-course runs were performed as planned. Both bridge teams ran the training session without any significant troubles and the results was found to be as shown in table 3.

Table 3, Pre-course run results

	Fuel consumed , kg	Time elapsed , s
Bridge 1	222,44	1 614
Bridge 2	221,33	1 599

The consumption was almost identical but the time elapsed was 15 seconds greater for bridge 1.

5.10 Observations on the squat runs

This exercise was conducted on a straight track. The water depth was basically 1000 m, but some shallow areas of 6 m were introduced so as to point out the effects caused by excessive squat. A screenshot of the track is shown in figure 4. The length of the run was 2,18 nautical miles.

The squat effects were studied doing two separate runs. The first run was straightforward; running due north on autopilot, with full power and no maneuvers during the run. The trainees were asked to observe the speed variations during the run when passing the shallows versus the deep water.

The second run was again to run straight ahead, due north on autopilot, but this time trying to adjust the engine power so as not to use unnecessary power in shallow water and anticipating the arrival to the shallows.

Table 4 ,Squat runs result

	Bridge 1	Bridge 2	Bridge 1	Bridge 2
	Fuel consumed, kg	Fuel consumed, kg	Time, s	Time, s
Run 1, no actions	96,56	96,56	697	697
Run 2, optimizing	72,15	74,05	738	731
Difference, absolute	-24,41 kg	-22,51 kg	+41 s	+34 s
Difference , %	-25,27 %	-23,31 %	+5,88 %	+4,88 %

The squat runs showed that optimizing the speed yielded a remarkable fuel consumption decrease of around 25 %, at the cost of an increased travel time of about 5-6 % (30-40 seconds).

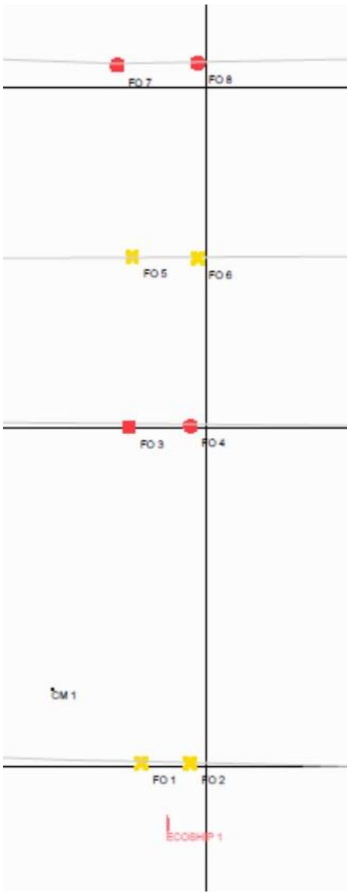


Figure 7, the squat run (Transas 5000 screenshot)

5.11 Observations on the turn runs

The effects of using different ways of doing turns were tested on a track with four 90 degree turns. The exact length of the track is not possible to determine because it varies according to the selected turn radii and wheel-over points. A screenshot of the track used and the two different turn radii is shown in figures 7 and 8.

Both runs were performed with engines full ahead and autopilot in use at all times. The first run was performed with turning radius 0,15 nm and the second run with turning radius 0,5 nm.

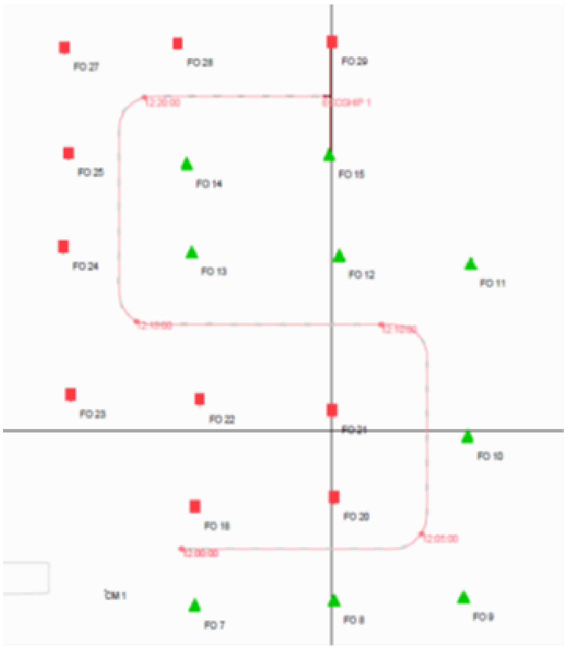


Figure 7, the turn run, radius 0,15 nm
(Transas 5000 screenshot)

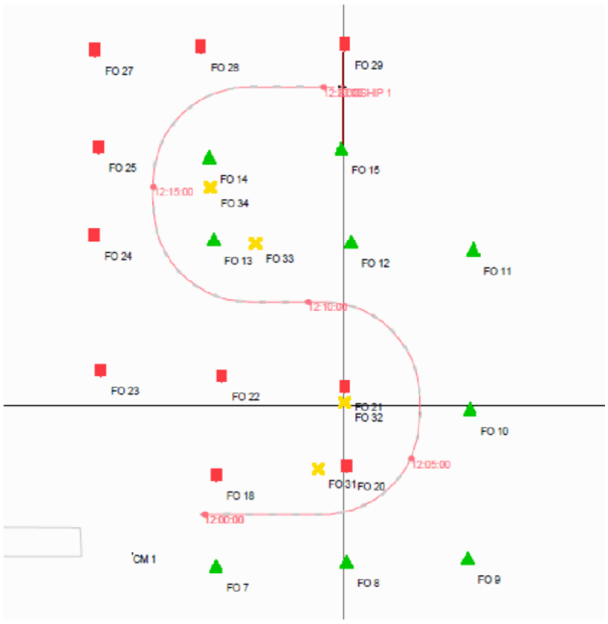


Figure 8, the turn run, radius 0,5 nm
(Transas 5000 screenshot)

Table 5, Turn runs results

	Bridge 1	Bridge 2	Bridge 1	Bridge 2
	Fuel consumed	Fuel consumed	Time	Time
Run 1,radius 0,15 nm	199,06 kg	197,12 kg	1438 s	1424 s
Run 2, radius 0,5 nm	171,22 kg	169,32 kg	1268 s	1223 s
Difference, absolute	-27,84 kg	-27,80 kg	-170 s	-201 s
Difference , %	-13,99 %	-14,10 %	-11,82 %	-14,12 %

The turn runs showed that using a larger turning radius of 0,5 nm instead of 0,15 nm yielded a fuel consumption decrease of around 14 %, and, simultaneously, the time used for the run decreased by 12-14 %. This is because when using a larger turning radius, the ship´s average speed is higher. Using smaller turning radiuses drops the ship´s speed and thus the time required increases.

5.12 Observations on the post-course runs

The post-course runs were performed as planned. Both bridge teams ran the training session without any significant troubles and the results was found to be as shown in table 6.

Table 6, Post-course run results

	Fuel consumed , kg	Time elapsed , s
Bridge 1	196,03	1 656
Bridge 2	195,34	1 681

The consumption was nearly identical but the time elapsed was 25 seconds greater for bridge B.

5.13 Comparison of the pre-course and post-course runs

The pre-course and post-course runs are compared in table 7.

Table 7, Pre-course and post-course run compared

	Bridge 1	Bridge 2	Bridge 1	Bridge 2
	Fuel consumed	Fuel consumed	Time	Time
Pre-course run	222,44 kg	221,33 kg	1 614 s	1 599 s
Post-course run	196,03 kg	195,34 kg	1 656 s	1 681 s
Difference, absolute	-26,41 kg	-25,99 kg	42	82
Difference , %	-11,87 %	-11,74 %	2,60 %	5,13 %

The fuel consumption was reduced by around 12 %, at the cost of an increase in travel time between 3- 5 %.

Finally, the effects of squat and turning radius during the post-course run was analyzed. For this purpose, the “ship-diagram” function in the simulator was used. It is possible to select a total of six parameters to be shown simultaneously.

In this case, the parameters selected were:

- Heading
- Longitudinal speed
- Rate of turn (RoT)
- Water depth
- Draft at bow
- Draft at stern

In figure 9 the effects of the rate of turn and in figure 10 the effects of the squat can be seen. When analyzing both figures, it becomes clear that the rate of turn has a minimal correlation to the longitudinal speed, as again, the draft has an exact correlation to the longitudinal speed, that is, the squat effects are the most important.

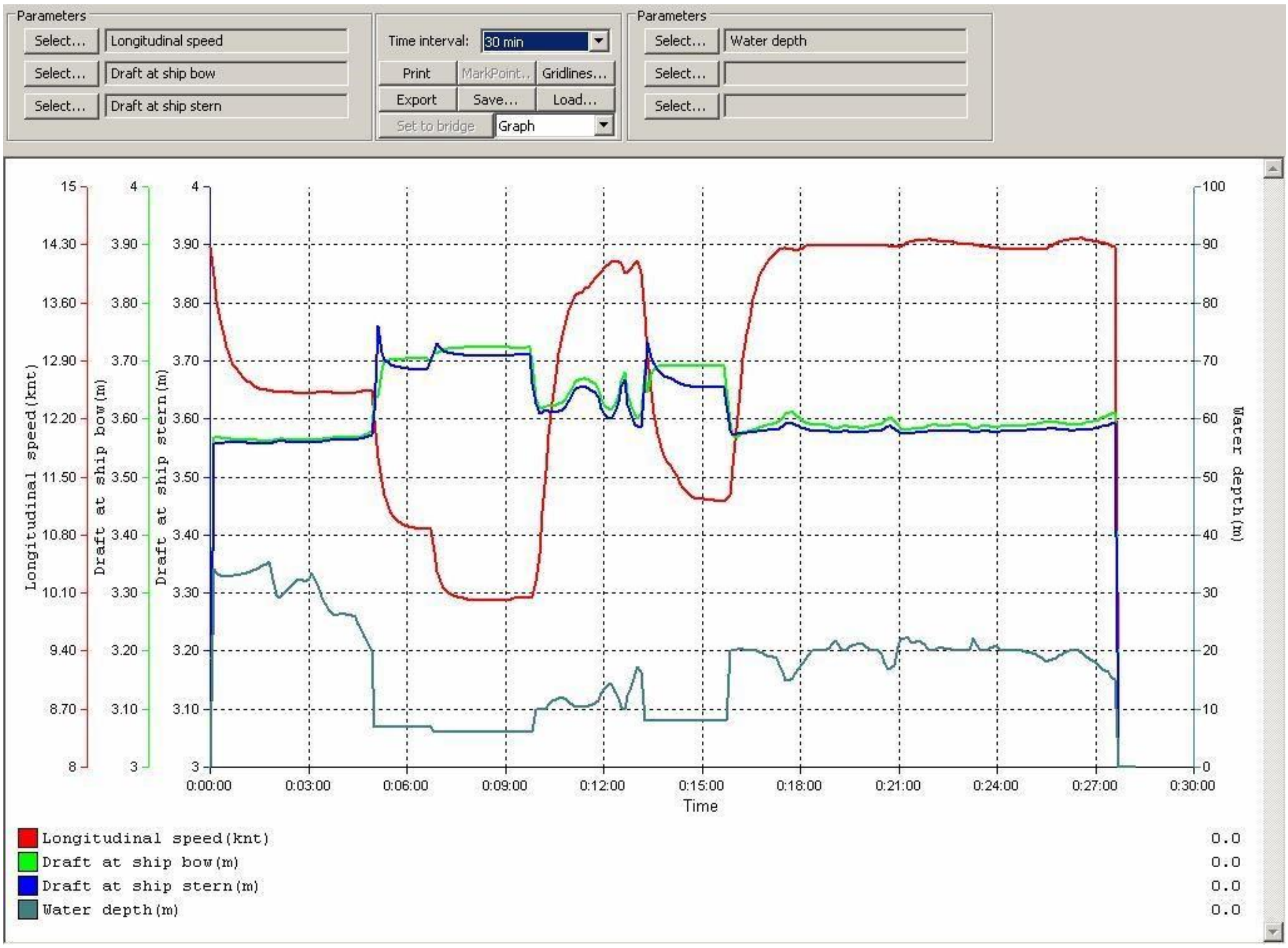


Figure 9, the squat effects

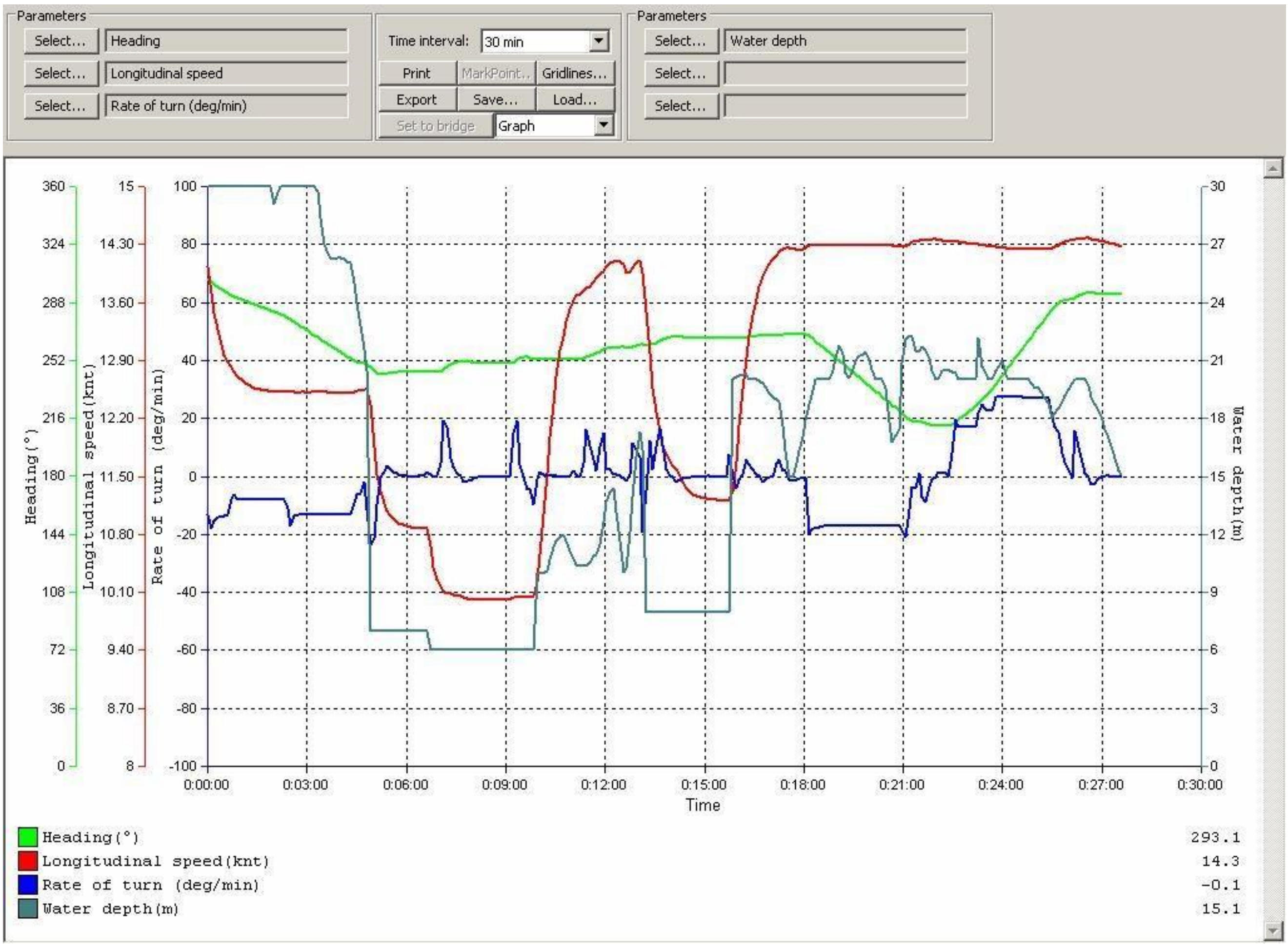


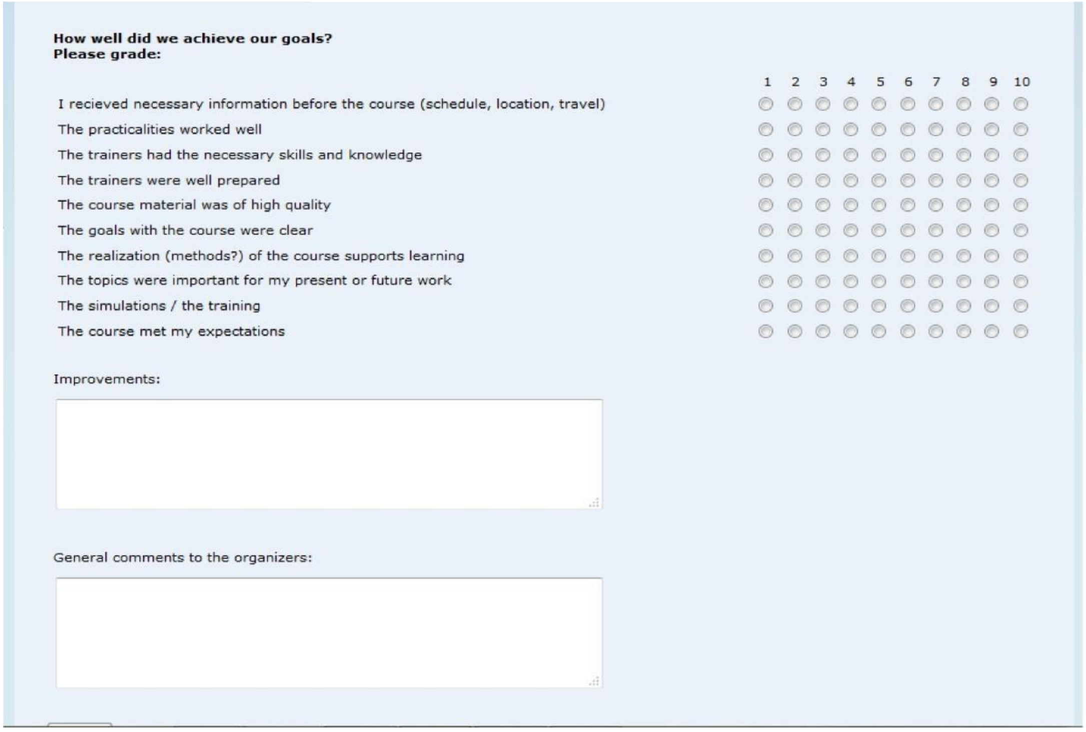
Figure 10, the turn radius effects

6 Evaluating the course

The course was evaluated using a standard Aboa Mare evaluation form as model. This form was then amended somewhat so as to acquire more information than the standard form yields.

6.1 Aboa Mare standard evaluation form

At Aboa Mare, a standard evaluation form is in use for commercial courses. Mainly, an online evaluation form is used, but occasionally a paper version is used for various reasons. A screenshot of the online evaluation form is presented in figure 11.



How well did we achieve our goals?
Please grade:

	1	2	3	4	5	6	7	8	9	10
I recieved necessary information before the course (schedule, location, travel)										
The practicalities worked well										
The trainers had the necessary skills and knowledge										
The trainers were well prepared										
The course material was of high quality										
The goals with the course were clear										
The realization (methods?) of the course supports learning										
The topics were important for my present or future work										
The simulations / the training										
The course met my expectations										

Improvements:

General comments to the organizers:

Figure 11, the standard Aboa Mare evaluation form (screenshot)

6.2 The evaluation by the students

The evaluation by the students was in two parts, A and B. The first part (Part A) was based on the standard Aboa Mare evaluation form, but amended by a minimum 50 - word comment on each of the standard points.

The second part (Part B) was also based on the same evaluation form but in this case the students were asked to grade each individual lesson and exercise, and also give a minimum 20 - word comment on each lesson or exercise.

The questionnaire can be found as appendix 3.

For some reason that was never fully resolved, one of the students did not submit the evaluation, and the evaluation is thus based on the four remaining student´s views.

6.3 The results of the evaluation

The numeric results of the evaluation are presented below in tables 8 and 9. Table 8 comprises part A and table 9 part B. The written comments are not presented in original form because of personal integrity considerations for the participants. They are only addressed on a general level to give an idea of the views of the participants.

6.3.1 The numerical results of the evaluation

Table 8, Evaluation results, part A

Part A					
Student	1	2	3	4	
Question no.					Average
1	9	8	8	6	**7,75**
2	8	9	8	9	**8,5**
3	7	9	9	9	**8,5**
4	7	7	8	10	**8**
5	8	7	8	8	**7,75**
6	5	8	9	7	**7,25**
7	7	8	7	9	**7,75**
8	8	9	8	10	**8,75**
9	9	9	8	10	**9**
10	8	9	9	8	**8,5**
				Average, all questions	**8,175**

The result for part A is an average of 8,175 on a scale from 1-10 and thus it can be concluded that the participants were quite satisfied with the training.

Table 9, Evaluation results, part B

Part B					
Student	1	2	3	4	
					Average
1	7	9	8	10	**8,5**
2	7	8	7	8	**7,5**
3	9	9	8	6	**8**
4	8	8	8	8	**8**
5	8	9	9	8	**8,5**
6	6	7	7	10	**7,5**
7	8	8	9	10	**8,75**
8	9	9	9	10	**9,25**
9	8	9	9	10	**9**
10	9	8	7	10	**8,5**

11	8	8	8	10	**8,5**
12	8		8		**4**
13	9	8	9	10	**9**
14	8	9	10	10	**9,25**
				Average, all questions	**8,5**

In table 9, question 12 had to be omitted because two students did not submit a grade on the question, making the average slightly unreliable. However, the two grades given were grade 8, so, presumably, this question did not vary significantly from the others.

The average reached 8,5, even higher than part A. It can be concluded that the individual lectures and exercises were all very satisfying, but nevertheless there is room for improvement.

6.3.2 The written results of the evaluation

As said earlier, the written comments are not reproduced as such for personal integrity reasons. The main comments in form A was of the following nature:

- The course content was seen as very “heavy” and going somewhat higher than the knowledge basis of the students, which was acknowledged and understood
- Some of the lecturers were not as well prepared as others
- The practical arrangements were seen as adequate
- The course material was seen as high standard
- The objective of the course was not very clear before staring the course
- A closer linking of theory and simulator exercises would be nice
- More in-depth analysis of the simulator runs
- The course makes you think and supports your coming career
- Keep it simple
- The course would be of interest to all students.

The main comments in form B was of the following nature:

- Some of the lectures were very good and informative, some were seen as somewhat over-technical and some as being not properly prepared. All in all nevertheless very informative and thought-provoking.
- The simulator exercises were seen as very interesting and informative, only the shipmodel used could have been closer to ordinary shiptypes.
- The examination was not very difficult but made you think anyway.

7 Findings

The planning process was carried through successfully and it is now documented in some detail. This information can be used in the development of other courses at Aboa Mare in the future.

The testing during the pilot course was also successful. The concept proved workable and no special problems arose. The most interesting part was the numerical results from the test runs.

It was shown, that the fuel consumption on the squat runs decreased by around 25 %, at the cost of an increased travel time of about 5-6 %.

The fuel consumption using different turn radii showed a decrease in fuel consumption of about 14 %, and the time used for the run also decreased, by 12-14 %. This is clearly a win-win situation.

The combined run, the pre-course and post-course runs finally showed a decrease in consumption of about 12 %, at the cost of an increased travel time of 3-5 %. These runs were close to reality and it can thus be concluded that in real life, significant savings can be achieved but the travel time will increase slightly. The comparison of ship diagrams also showed that in this case, the main saving effect was due to taking squat effects into account. The turning radius affected the performance insignificantly.

From these findings it can be concluded, that by taking into account squat factors and turning radius factors and adjusting the maneuvering of the ship according to these, fuel consumption, and thus also emissions to air, can be lowered significantly. These actions are purely operational and no technical solutions or alterations are necessary.

The evaluation of the course showed that he trainees were, generally, quite satisfied with the course, yielding numerical values of 8-8,5 on a scale from 1-10. This can be seen as proof that the course in present form is quite good, but there is room for some improvement as shown by the written comments.

8 Critical analysis and future development

The problem formulation questions have been answered in this thesis. The planning process is described, the testing procedure and the results are presented, as well as the evaluation procedure and results. The objective of documenting how the ECOTRAIN course was planned, tested and evaluated has been met and the thesis can thus be rated successful.

The fact that the original program was rescheduled and also that the ship model used was not optimal makes the results somewhat less reliable than the optimum level, but these facts could not be avoided at the time.

Future research could consist of gathering and analyzing information from the actual delivered courses and building a database from these results. At the moment of presentation of this thesis, two additional bachelor theses are underway discussing certain specific parts of the ECOTRAIN course.

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ECOTRAIN draft timetable **Appendix 1**

ECOTRAIN draft 8.1.2013

Day 1 0900-0915	Introduction to ECOTRAIN Aboa Mare
0915 -1045	Lesson 1. Rules and regulations. GL
1100- 1215	Lesson 2. Exhaust emissions from shipping and life cycle assessment (LCA)VTT
1230-1315	Lunch
1315-1345	Simulator exercise 1. Familiarization to the simulator environment and the bridge equipment used in the training. Aboa Mare
1345- 1445	Simulator exercise 2. Pre-course simulator run Aboa Mare
1500- 1700	Lesson 3. Ship design. Deltamarin
Day 2 0830-1015	Lesson 4. Saving fuel in operation. Wärtsilä
1030-1215	Lesson 5. Energy efficiency solutions.ABB
1215-1315	Lunch
1315-1500	Lesson 6. Trim and speed optimization, Eniram
1515-1700	Lesson 7. Voyage optimization, NAPA

Day 3

0830-1000	Simulator exercise 3 . Optimizing operation for squat and bankeffects Aboa Mare
1015-1145	Simulator exercise 4, Optimizing radius-controlled turns Aboa Mare
1145-1230	Lunch
1230 -1345	Simulator exercise 5, Optimizing use of autopilot Aboa Mare
1400- 1515	Simulator exercise 6. Post course simulator run Aboa Mare
1530-1700	Written examination, summary and wrapup. GL, Aboa Mare

ECOTRAIN pilot course timetable **Appendix 2**

ECOTRAIN 27-29.11. 2012

Day 1	1000-1100	Introduction to ECOTRAIN testcourse Aboa Mare
	1115-1215	Lesson 1. International and national legislation. GL
	1215-1300	Lunch
	1300-1345	Lesson 1 continues.GL
	1345- 1500	Lesson 2. –Climate change,LCA, fuels and consumption, emissions and measuring/modelling emissions, power-speed-resistance relationships.VTT
	1515- 1700	Lesson 3 . Voyage optimization, NAPA
Day 2	0830-1015	Lesson 4. Power production, engines. Wärtsilä
	1030-1215	Lesson 5. Energy distribution, frequencyconverters, sensors, ABB
	1215-1315	Lunch
	1315-1500	Lesson 6. Trim and speed optimization, Eniram
	1515-1700	Lesson 7. Ship design. Deltamarin

Day 3

0830-0900	Simulator exercise 1. Familiarization to the simulator environment and the bridge equipment used in the training. Aboa Mare
0900- 1000	Simulator exercise 2. Pre-course simulator run Aboa Mare
1015 -1145	Simulator exercise 3 . Basic runs , squat- and bankeffects Aboa Mare
1145-1230	Lunch
1230 -1400	Simulator exercise 4, Basic runs , radius controlled turns Aboa Mare
1415- 1500	Simulator exercise 5, Route planning and use of autopilot Aboa Mare
1500- 1600	Simulator exercise 6. Post course simulator run Aboa Mare
1600-1700	Written examination, summary and wrapup. GL, Aboa Mare

Student evaluation form **Appendix 3**

Course: ECOTRAIN
Date: 27-29.11.2012
Place: Espoo
Name (optional):

STUDENT´S EVALUATION

How well did we achieve our goals?

Part A : Please grade each point with a number on the following scale:

Bad		Weak		Average		Good		Excellent	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Please also elaborate your view with minimum 50 words on each point

1) **I received necessary information before the course (schedule, location, travel)**
   Grade:
   Comments:

2) **The practicalities worked well** Grade:
   Comments:

3) **The trainers had the necessary skills and knowledge** Grade:
   Comments:

4) **The trainers were well prepared** Grade:
   Comments:

5) **The course material was of high quality**
   Grade:
   Comments:

6) **The goals with the course were clear**
   Grade:
   Comments:

7) **The realization (methods?) of the course supports learning** Grade:
   Comments:

8) **The topics were important for my present or future work** Grade:
   Comments:

9) **The simulations / the training were** Grade:
   Comments:

10) **The course met my expectations** Grade:
    Comments:

General improvement suggestions:

General comments to the organizers:

Part B : Please grade each lesson or exercise with a number on the same 0-10 scale:

Please also elaborate your view with minimum 20 words on each point.

Lesson 1. International and national legislation. GL

Grade:
Comments:

Lesson 2. –Climate change,LCA, fuels and consumption, emissions and measuring/modelling emissions, power-speed-resistance relationships.VTT Grade:
Comments:

Lesson 3 (7). Voyage optimization, NAPA

Grade:
Comments:

Lesson 4. Power production, engines. Wärtsilä

Grade:
Comments:

Lesson 5. Energy distribution, frequencyconverters, sensors, ABB

Grade:
Comments:

Lesson 6. Trim and speed optimization, Eniram

Grade:
Comments:

Lesson 7(3). Ship design. Deltamarin

Grade:
Comments:

Simulator exercise 1. Familiarization to the simulator environment and the bridge equipment used in the training. Aboa Mare

Grade:
Comments:

Simulator exercise 2. Pre-course simulator run Aboa Mare

Grade:
Comments:

Simulator exercise 3 . Basic runs , squat- and bankeffects Aboa Mare

Grade:
Comments:

Simulator exercise 4, Basic runs , radius controlled turns Aboa Mare

Grade:
Comments:

Simulator exercise 5, Route planning and use of autopilot Aboa Mare

Grade:
Comments:

Simulator exercise 6. Post course simulator run Aboa Mare

Grade:
Comments:

Written examination, summary and wrapup. GL, Aboa Mare Grade:
Comments: