Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Report Title:

Deliverable 3.3:

Review of the human physical and behavioural components

Contents

EXECUTIVE SUMMARY

In this report a task analysis is made for training requirements. Various types of ship handling situations during a voyage are analysed. The focus is on the tasks of the navigator with respect to the ACD (Azimuth Control Devices). Data is gathered from interviews with ACD users. The defined phases of the voyage include “steering and course alterations”, “crash stop”, “steering with low speed”, “manoeuvring”, “mooring”, “sidestepping”, “anchor area approach”, “narrow channel/river areas”, “port basin and terminal approach” and “manoeuvres with tug assistance”. The analysis forms a thorough background for understanding which training is needed and for the planning of such training. Impact of over and under-load working conditions are reviewed on the basic of available workload and fatigue studies plus interviews with relevant navigators. It is found that an under-load situation can create a relaxed situation with following risk of complacency, inattention and faulty assumptions. An average work load is found to keep the navigator engaged and alert – the optimal situation. Over-load working conditions can result in duplication of effort, overlooking of important information, bad temper, reduced listening and attention, tunnel vision. Individual differences in perception can be expected as real and experienced workload can differ. All mentioned undesirable effects can affect ability to analyze and make optimal decisions. Fatigue must also be considered and generally the voyage contains different phases with differing workloads. Following factors are found to affect the workload; management, voyage and schedule and ship specific factors. High stress situations are found to influence intuitive control. In the literature examples of the process of stress and how this affects human performance are abundant. Less is available regarding high stress on intuitive control. There is a general agreement that more intuitive control leads to better performance in high stress situations. The interface should help the user make optimal decisions and take appropriate actions. More research is needed regarding stress influence on intuitive control. More research is needed regarding perceptions of azimuthing control devices by new and young personnel. No indication is found however that young and new personnel differ from older and more experienced personnel in cognitive ability. No difference in the ability to learn to operate azimuthing controls between young versus old and inexperienced versus experienced navigators is found either – expect for handling experience of ACD´s of course. It is found that ASD tug handling can be defined as an over-load working condition. This has some implications compared to under load working conditions. Time is restricted, communication must be handled while constantly manoeuvring. Usual ASD tug handling often comes close to the human limits regarding perceptions, decision making, response selection and response execution – even for well trained and experienced navigators. This confirms the importance of training - both theoretically and practically.

Perception and feedback for course-stable and unstable vessels can be examined through observations, interviews, task analysis and questionnaires. Results are that even preferred controls are not perfect but could be improved ergonomically through extensive user studies and applied human factor methods. In simulator training level of fidelity must also be thoroughly considered and should generally be as high as possible. Continued development of the visual accessibility, sound quality and actual physical movement of/in the simulator should be considered when designing simulators for ASD tugs (the same goes for “ordinary” simulators). Certain pedagogical methods should be considered when designing the bridge layout. Training onboard or in simulator before handling ACD´s in real life should be thoroughly considered. Personality does not seem to influence the capability of learning to handle ACD´s. The most important findings might be that existing courses live up to expectations of learning to handle the ACD´s intuitively and that navigators are very assertive regarding receiving simulator training to optimize their professional performance onboard their vessels in real life. The quantitative and qualitative results of the work described in this report spur many questions for further research studies. It can generally be concluded that many factors contribute to successful training in intuitive use and control of ACD´s by affecting the perception and feedback of and to the navigator in the simulator.

INTRODUCTION TO THIS WP 3.3 REPORT

"Annex 1 – Description of Work" describes the work that the participating partners should do within the first 18 months of the EU 7th framework Azipilot project:

Review of the human physical and behavioural components

The aim of this task is to perform a 'Task Analysis' type review of the training needs and implementation specifically for ships equipped with azimuthing control devices. This will include a review of the specific need of new and young personnel. The objectives are firstly to assess the appropriateness of current techniques and provide feedback for new, more appropriate methods. Secondly, to explore issues specific to ships equipped with azimuthing control device including both training and perceptions The main areas will include:

3.3. 1 • *Conduct a Task Analysis for training requirements.*

3.3.2 • *Review impact of over-loaded and under-loaded working conditions.*

3.3.3 • *Review impact of high-stress situations on intuitive control.*

3.3.4 • *Survey of perceptions of azimuthing control devices by new and young personnel.*

3.3.5 • *Discuss implications of an over-loaded work environment.*

3.3.6 • *Discuss implications of an under-loaded work environment.*

3.3.7 • *Explore perception and feedback for both course-stable and unstable ship response.*

The task will culminate in a task report that will delineate the above aims and objectives and will constitute one deliverable.

Answering the WP 3.3 project questions

In 3.3.1 an analysis of various types of ship handling situations during the various phases of a voyage is performed and described. Each situation considers specific tasks in respect to ACD (Azimuth Control Devices). The work is focused on real life experience of masters on different type of vessels such as cruise vessels and gas carriers. Data is partly collected by interviews. A task analysis is performed for the different phases of a voyage.

In 3.3.2 an analysis of available workload and fatigue studies is performed. Interviews with navigators are also used as a thorough data source. Under loaded and over loaded working conditions in the different phases of a voyage are then discussed.

In 3.3.3 impact of high-stress situations on intuitive control is described and discussed. The question is answered with respect to influence of personality and on cognition. The human nervous system is briefly described followed by an explanation of the role of psychological factors, social, occupational and individual factors. The concept of stress, high-stress situations and intuitive control is defined. This is followed by theoretical perspectives on intuition, discussion of implementation of intuitive interfaces and what stress does to intuitive control, judgement and decision making.

In 3.3.4 data from an interview with an experienced instructor is used to look at possible differences between ACD trainees in different manoeuvring situations and tasks. Indications are that some trainees learn faster than others and that some young trainees are more capable of applying theoretical education in the practical use. This may be caused by experienced navigator's prior experience with conventional propulsion systems.

In 3.3.5 & 3.3.6 implications of over loaded and under loaded work environment are discussed. The variety of methods used in the project work is listed followed by the explained reason for focusing on ASD tugs. Examples of overload and under load environments on the navigational bridges of vessels are described. These scenarios are then explained on the basic of a classic information processing model.

In 3.3.7 Perceptions and feedback for course stable and unstable ship responses are explored. The main focus is on unstable ASD tugs but the data gathered through questionnaires prove to contain useful information for simulation of course stable azimuth propulsion vessels as well. Main findings from an interview with an expert tug master is gone through generally and in detail. Subjects dealt with include controllers, replication, physical movement of the simulator, sound quality, visual quality, instructors position on ASD tug simulation bridge, ideal number of trainees, experience prior to simulation training, individual differences of trainees, duration of courses and the question of examination at the end of the course.

Then the used questionnaire is described. And the results are provided, qualitatively and quantitatively. Results are discussed and a factor analysis is calculated and explained.

3.3.1 CONDUCT A TASK ANALYSES FOR TRAINING REQUIREMENT

Approach

Our strategy for this task has been to analyse the various types of ship handling situations during the various phases of a voyage. Each handling situation examines the tasks required with respect to ACD handling on behalf of the navigator.
Information has been gathered from interviews with ACD users and incorporated into this report. The task involved data gathering, analysis of relevant information.

Practical experience ship handling with ACD's

Information regarding practical experience was gathered by questionnaires and interviews. The following interviews were held:
Interview with Captain J. Bayens, experience as master on board of Cruise liners of the Holland America Line and equipped with AZIPULL systems.
Interview with Captain L. Toly, experience as master on board of gas carriers of Antony Veder and equipped with AZIPULL systems.

They both were able to deliver valuable information regarding the practical use and handling of ACD systems.

Steering and course alterations

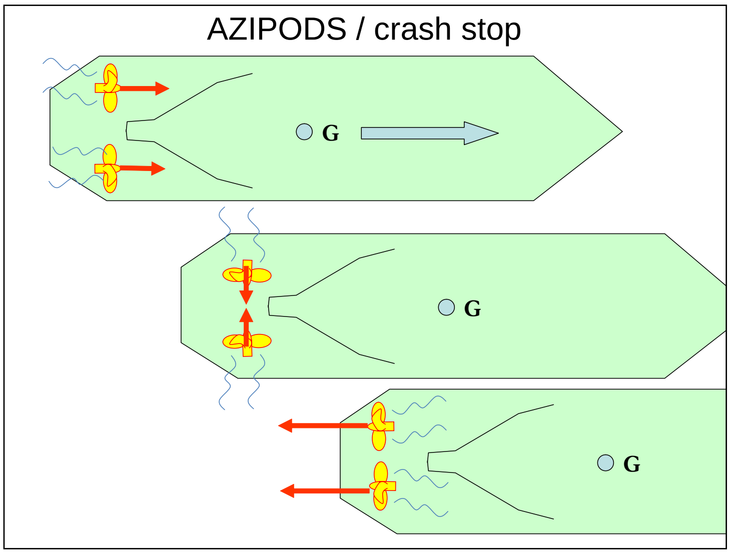
The course alterations with service speed normally are carried out by setting the autopilot or changing to manual steering.
The angle of the thrusters is limited to 35º when the system is in service speed mode.
One of the differences between conventional ship propulsion systems and the ACD system is that the ACD's can be rotated to a specific angle. This arrangement results in a stronger lateral force and when turning, a smaller turning circle but the kick (lateral movement of the centre of gravity of the vessel) will be larger.

The list during the turning is almost negligible, which is an advantage on passenger ships. Ships with power management control will experience an rpm reduction automatically should the weather deteriorate.

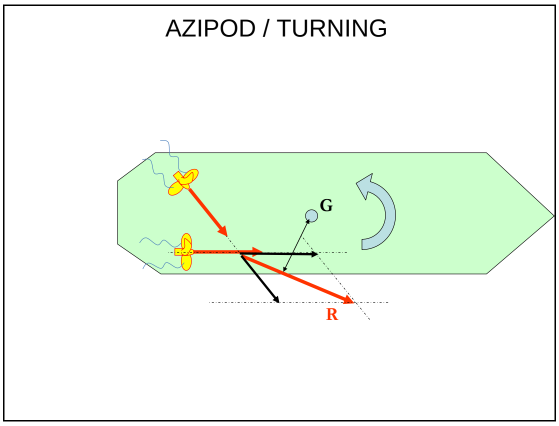
Crash stop

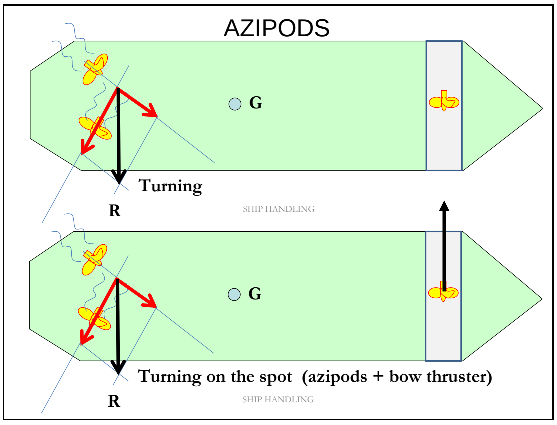
In this section a comparison has been made between a crash stop on conventional propulsion as compared to ACD propulsion. From full power the propulsion plant is set to full manoeuvring mode, which normally takes 10-15 min. To handle the thrusters the capacity further has to be reduced to about 60% of the total capacity.

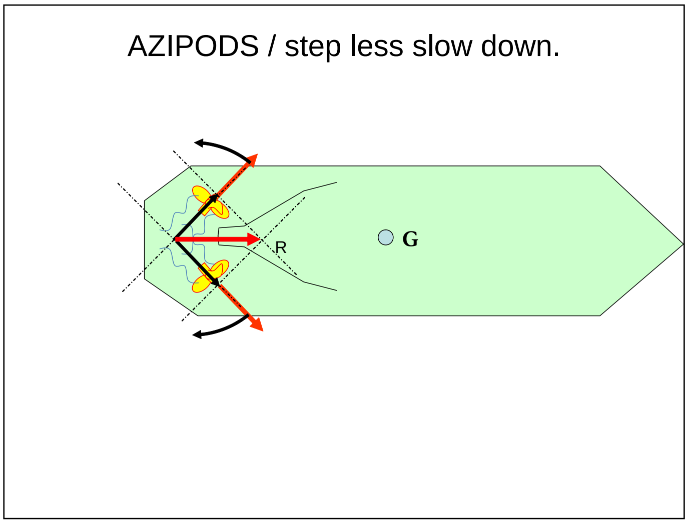
The most common action is to turn the thrusters from dead ahead to 90º outward thruster force and then 180º . For cruise liners with the option to reverse the rpm, the efficiency will be smaller that reversing the ACD thrusters (propellers are designed for forward thrust).
Ships can be equipped with power management systems where the change over to manoeuvring mode goes automatically. Then from full ahead the thrusters can be set to full astern. And the thruster power is dropped (by a reduction of rpm) while the angle goes to 90º and remains in this position until the ship speed is reduced to a certain value. Then the thrusters turn to 180º and full power is set automatically.



Steering with lower speed
In general, cruise liners may be steerable with stopped thrusters (wind milling propeller). The ship can be steered by adjusting the pod direction only at speeds up to 3 knots. The pods are couple for this steering operation.
Below this speed the heading can be controlled by using one or 2 thrusters in a certain direction. A common setting is one thruster ahead and the other having an inward angle. (see figure).





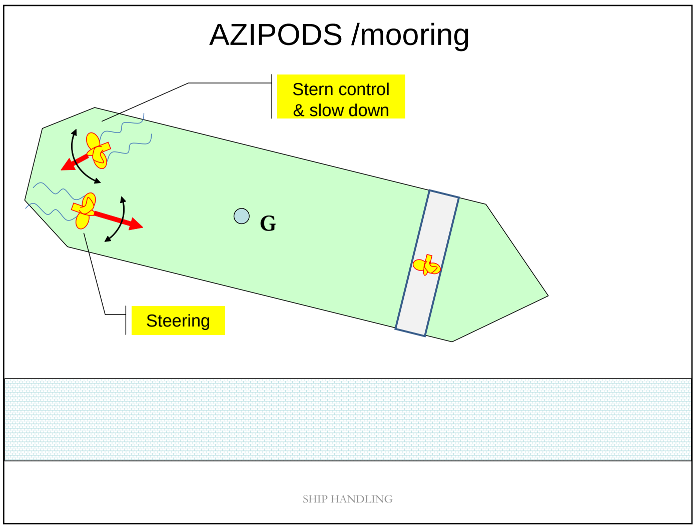


Manoeuvring

It is possible that the manufacturer advises minimum rpm for the thrusters. This affects the way of manoeuvring. To reach lower speeds the thrusters are set on mirroring angles creating step less longitudinal forces. (see figure). For full turning, the thrusters are set in a lateral direction with one a bit forward and the other a bit aft to avoid capacity reduction by water wash of one thruster against the other. For turning on the spot larger vessels will use a bow thruster to create a couple on the vessel.

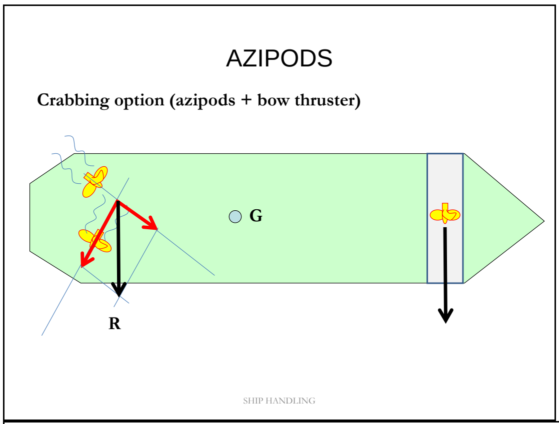
Mooring

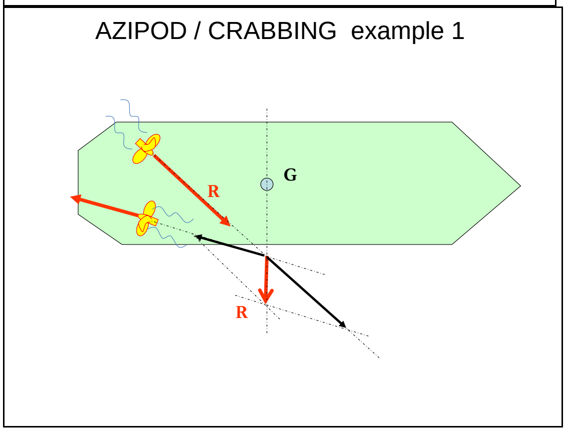
When executing a manoeuvre with bow in first, the user can control the approach speed and angle using one thruster while controlling the lateral movement of the stern with the other, including slowing down if necessary.



Side stepping

To approach terminals with a lateral speed, side stepping will be executed with the thrusters set in a lateral direction and the bow thruster(s) in the same direction. This is a common procedure with larger ships.
Smaller ship and in particular ASD tugs are able to side step by the bow thrusters set in the direction as shown in the figure below.
However, as long as a bow thruster is available the manoeuvre can be executed with greater control and this in turn requires a less complicated arrangement of the thrusters as depicted below.





Ship handling in ice.

Manoeuvres in areas with ice become more complicated by the restriction of setting the thrusters to avoid ice being sucked into the ACD's.

ACD's with reverse rpm.

ACD's with the option of reverse rpm have an extra possibility to slow down, stop or to move astern. This option should be compared to the feature of setting the thrusters in a reverse direction which will create the same effect. In particular for ships equipped with propellers designed for optimal efficiency with forward rpm, the turning of the thrusters is a better option than reversing the rpm.

Task analyses of ship handling by ACD's

Open sea, confined waters

With the vessel on a steady course and speed the navigator only monitors the correct ship heading speed, rpm, and alarms w.r.t. auto pilot and propulsion malfunctions.
During heavy weather the yawing is observed and possibly auto pilot settings are adjusted. The latter should be based on knowledge of feedback and control systems.
During course alterations and give way actions for other vessels, the auto pilot is set to a new course or set to manual steering,
In service speed the navigator must be aware of the possible limitations in changing rpm or direction.
In case of an emergency manoeuvre the thruster is stopped and reversed to stop the vessel or set ACD thrusters in order to turn away from the danger as fast as possible.
The correct change over procedure from auto to manual steering must be known by the navigator.

Data gathering	**Decision making & performance**	**Feed back on executed measures**
Traffic by RADAR/ARPA	Required course / speed alterations	Correction of course /speed alteration based on observed CPA
Time at way points by RADAR/ARPA position fix	Course alteration by auto pilot setting or manual steering Choice of R.O.T.	Course correction by off-track position.
Adverse weather steering	Adaption of auto pilot settings or manual steering	Fine tuning based on auto pilot performance
Need for emergency give way	Hand steering order / speed alteration	Correction of course /speed alteration based on observed CPA

Anchor area approach

The navigator will change the steering from auto pilot to manual by the helmsman.
However with systems without a steering console (only auto pilot or thruster handling) the manual steering is done by the navigator.
The navigator will reduce the speed of the ship by reducing rpm of the ACD's after appropriate notice to the engine room or automatic if a power management system is available.
The navigator should have knowledge of the reduction in speed by changing the rpm.
On ships equipped with a separate "reduced speed mode the ACD's thrusters are handled by normal telegraphs for each thruster and steering is done by the auto pilot or by the helmsman.
If the vessels receives an off track position this will be corrected by a steering order to the helmsman.
Observation of position is mainly done by RADAR/ARPA observations.
Speed is monitored by viewing the (Doppler) log , and GPS information.
In the last phase the ship is stopped by reverse thrust. The navigator must have knowledge how the ACD's are set to create efficient reverse thrust.
In the last phase of the manoeuvre the navigator will change from reduce speed mode to azimuth drive mode in accordance with required procedure. Then the ship is steered by uncoupled ACD thrusters and stopped by reverse thrust settings.
The navigator must know how the ship will react under various independent ACD settings.

Data gathering	**Decision making & performance**	**Feeed back on executed measures**

Position to slow down the ship speed	Notice to engine room, change over to reduced speed mode	Correct rpm settings
Control of required track to anchor position	Ascertain wheel over point. Course to steer order.	Correction of off track position by steering order to helmsman
Position to change over from reduced speed mode to azimuth drive mode	Follow correct change over procedure	Control of correct performance of thrusters
Control of planned track, speed and heading during anchor position approach	Settings of both ACD thrusters	Tuning of settings when diverting from plan
Ship position and speed to drop anchor	Settings of both ACD thrusters	Tuning of settings when diverting from required speed and heading

Narrow channel / river areas

Speed control and steering is done in the reduced speed mode.
Ships with a "reduced speed mode" are steered by the helmsman, ships with only an auto pilot and thruster handling system will be steered on the auto pilot or with the thrusters by the navigator.
In case of more drastic course alterations the navigator will use the uncoupled thrusters in the azimuth drive mode, but can only be done if the ACD thruster capacity is already reduced to the required value.
In the azimuth drive mode the navigator must have full knowledge of different turning options and behaviour by ACD's settings.
The navigator will control the speed by rpm settings on the ACD handles.

Data gathering	**Decision making & performance**	**Feeed back on executed measures**
Position to slow down the ship speed	Notice to engine room, change over to reduced speed mode	Correct rpm settings
Control of required track to anchor position	Ascertain wheel over point. Course to steer order.	Correction of off track position by steering order to helmsman
Position to change over from reduced speed mode to azimuth drive mode	Follow correct change over procedure	Control of correct performance of thrusters
Control of planned track, speed and heading during anchor position approach	Settings of both ACD thrusters	Tuning of settings when diverting from plan
Ship position and speed to drop anchor	Settings of both ACD thrusters	Tuning of settings when diverting from required speed and heading

Port basin and terminal approach

The navigator will change over the ACD's to the azimuth drive mode in order to move the vessel in all required directions and control the turning and speed.
Setting of the thruster is based on the knowledge of the resulting force of both thrusters with various settings in rpm and direction.
The setting of the ACD thrusters will de fine tuned by observing the environment, the Doppler log. Rate of Turn indicator and the RADAR/ARPA / ECDIS monitor.

The change over procedure from central console to bridge wing or from wing to wing will be executed in accordance with the required procedure. Also other navigational instruments near the ACD console will be set to the required presentation.
Theoretical knowledge of forces and moments created by the various components and the position of the pivot point must be known by the navigator.

Data gathering	Decision making & performance	Feeed back on executed measures
Position to stop, turn or reverse the ship. Wind and current condition	How to perform the manoeuvre under given wind and current circumstances and set the ACD thrusters	Fine tuning the ACD settings by diversions from planned track, longitudinal / lateral speed and turning.
Distance to terminal and other moored vessels	Required approach track and speed, settings of ACD thrusters, bow thrusters or orders to tugs	Fine tuning the ACD settings, bow thrusters, or tug orders by diversions from planned track, longitudinal / lateral speed and turning.

Manoeuvres with tug assistance

Manoeuvres where tugs will assist the ship during the manoeuvre may affect the use of ACD’s in 2 different aspects ;

- The use of ACD’s in such a way that the aft tug is not brought in a dangerous situation.
- The decisions made by the navigator when and how tug forces can be best introduced in combination with the settings of the ACD’s thrusters.

3.3.2 REVIEW OF OVER /UNDER LOADED WORKING CONDITIONS.

Approach

Analysis of available workload and fatigue studies on board of sea going vessels.
Interview navigators with experience on ACD ships.
Accumulate information to establish under/over workload on the navigation bridge affecting the ACD handling.

Results from workload and fatigue studies & interviews

General

Under load work loads as well as over load workloads can have an impact upon the navigator in a variety or undesirable ways. In general the under load workload will create a relaxed situation for the navigator with risk that he/she becomes complacent and can also fall into the trap of making assumptions. Complacency can easily lead to in-attentiveness which is undesirable in all situations of navigation.

As can be expected an average work load in which the navigator remains engaged and alert at his/her duties is an optimal situation.
Over load work loads can produce a number of undesired effects including, duplication of effort, errors, overlooking important items, bad temper, cessation of listening and tunnel vision. These effects naturally will affect the individual’s ability to analyse and make decisions and perform in an optimal manner.

In addition we must also consider the individual and the difference in perception. There is a difference between real workload and perceived workload.

When we consider fatigue, many factors come into play from sleep disturbance, energy disturbance, mood disturbance. Both short and long term effects can be experienced affecting performance and general health.

Workload investigations on board of sea going vessels indicate significant different levels in various phases of an entire voyage from the terminal departure in a port until the arrival at the terminal in the port of destination.

In general the workload peaks occur during arrivals and departures, but differ for the various ranks of the navigation officers. During arrivals and departures the workload of the captain is the most over-loaded by navigation, communication with external bodies and administration tasks. Also the chief officer may have extra work to prepare the loading and discharging of the ship while also dealing with navigation tasks. On smaller ships with limited crew these phenomena are even stronger.
The following factors will affect the workload;

- Management factor
- Voyage and scheduling factors
- Ship specific factors

Management Factors aboard ship

The Management Factors relate to how ships are managed and operated. These factors can potentially cause stress and an increased workload, ultimately resulting in fatigue. These factors include:

- Administrative requirements
- Strict time schedules enforced by economics
- Work / rest schedules, overtime hours
- Compliance with Rules and Regulations
- Training and Selection of crew

Voyage and Scheduling Factors

- Frequency of port calls and duration of sea voyage
- Degree of navigation and traffic density by chosen routes
- Weather and Sea condition on route
- Nature of duties/workload while in port

Ship-specific Factors

These factors include ship design features that can affect/cause workload. (i.e. automation, equipment reliability), some affect the crew's ability to sleep, and

others affect the level of physical stress on the crew (i.e. noise, vibration, accommodation spaces, etc.). The following list details ship-specific factors:

- Level of Automation
- Level of Redundancy and equipment reliability
- Age of vessel and degree of maintenance to upkeep of vessel
- Physical comfort in work spaces and accommodation spaces
- Ship motion

Fatigue

Fatigue can be defined in many ways. However, it is generally described as a state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep.

The result of fatigue is impaired performance and diminished alertness.

The technical and specialized nature of this industry requires constant alertness and intense concentration from its workers.

Fatigue is also dangerous because it affects everyone regardless of skill, knowledge and training.

Effectively dealing with fatigue in the marine environment requires a holistic approach. There is no one-system approach to addressing fatigue, but there are certain principles (e.g., lifestyle habits, rest, medication and workload) that must be addressed in order to gain the knowledge and the understanding to manage this human element issue.

Under-loaded / over-loaded working condition on the bridge.

Open Sea areas

During sea voyage the navigator experiences a limited workload. The task is primarily controlling the traffic, position and the operation of the auto pilot. An extra task can be the observation of GMDSS messages/ alerts. Changes in weather conditions are followed, as are a low frequency of fire detection and some principle engine room alarms.

The ACD system will not be handled other than course alterations by setting the autopilot or manual steering.

During restricted visibility the RADAR/ARPA is monitored constantly increasing the workload of the navigator unless the master is attending the bridge.

In general the workload situation is average or under loaded .

Congested waters

The navigation intensified by more position and traffic control as well as more course alterations due to give way for other vessels and to follow planned tracks.
The ACD will be handled more frequently by setting the auto pilot or steering manually.
Communication with other vessels or shore authorities may increase.
In general the workload situation is average and does not affect the handling of the ACD system in a negative way.

Anchor area

The navigator will increase the position and speed control. Change over from service speed to reduced speed mode and later on to azimuth drive control will be executed.
Also traffic control will be highly frequent. The communication with shore authorities is increased.
ACD is changed over from reduced speed mode to azimuth drive mode in the last phase before dropping anchor. The navigator will handle the thrusters to stop the speed and control the heading.
In general the workload situation is average with sufficient time to handle the ACD system.

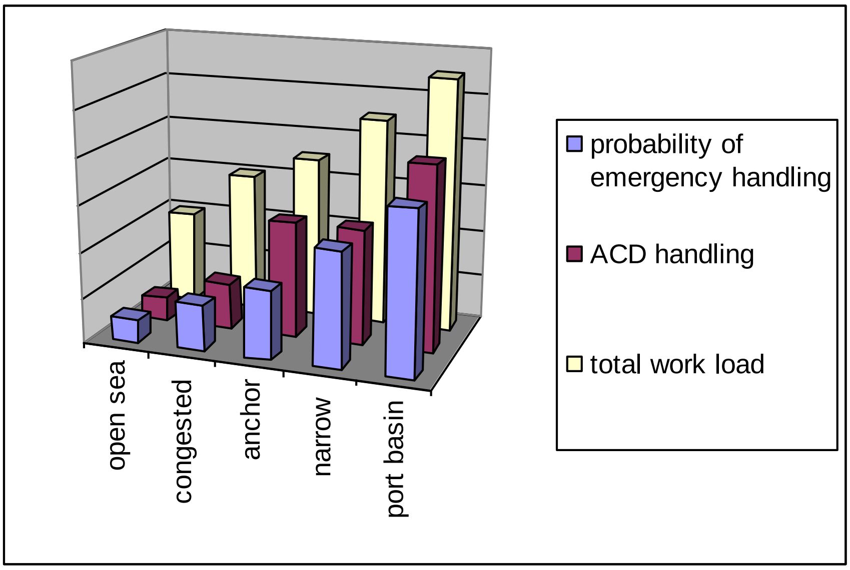
Narrow fairway / rivers

Full attention is given by the navigator to keep track, follow bends and to pass or overtake other vessels. Communication is increased to frequent by contact with other vessels and VTS.
A helmsman will steer the vessel manually. ACD is handled by the navigator to control the ship speed. Extra attention is given to wind and current conditions.
On larger ships the master and a navigating officer will attend the bridge dividing the tasks. In most of the circumstances a pilot is also on the bridge taking over the navigation. The master and /or officer will particularly have a controlling task, however if the master considered the manoeuvre to be unsafe, he will intervene by telegraph or steering order.
On smaller vessels the extra navigating officer will not be present increasing the workload of the master.
In general this situation is average to heavy loaded. However, the handling of the ACD system is simple and does not cause a heavy loaded situation. An over loaded situation may occur when the master has to intervene and change over to azimuth drive control.

Port basin / terminal approach.

The pilot, based on local knowledge, will give advice how to manoeuvre the ship.
The master will handle the ACD thrusters in the azimuth drive mode. The master will control and approve the manoeuvre by constant observation of the environment, speed, turning rates and distances to beacons, borders and other vessels. Also the weather circumstances are observed more or less constantly.
If the master considered the manoeuvre to be unsafe, he will intervene by handling the ACD thrusters.
At this moment many masters have more experience how to manoeuvre than the local pilot. Therefore the settings of the ACD thrusters will be executed by the master.

On larger vessels a 2nd navigation officer is present on the bridge. Tasks will be divided between the master and the navigation officer. A common division is that the master handles the ACD thrusters and the navigation officer does the communication with the crew fore and aft. As a back up they check each other performance.
In general this situation is average to heavy loaded. Handling of the propulsion / steering means are responsible for the lion share of the total workload. An over loaded situation may occur when the master has to intervene in the planned manoeuvre by the pilot.


open sea
congested
anchor
narrow
port basin
probability of emergency handling
ACD handling
total work load

3.3.3 REVIEW IMPACT OF HIGH-STRESS SITUATIONS ON INTUITIVE CONTROL

Introduction

The AZIPILOT project is researching ways of improving the interface between man and machine. The aim is to improve the safety and security of ships by taking into account the training of maritime pilots, specifically when operating ships equipped with azimuthing control devices. The project brings together the industry sectors responsible for design and testing, simulation and training, the pilots that operate these ships and the authorities that regulate them.
The aim of task 3.4 within the project is to review bridge systems and the human interface. The objectives are firstly to assess the appropriateness of current techniques and provide feedback for new, more appropriate methods. Secondly, to explore issues specific to ships equipped with azimuthing control device including both training and perceptions.
This document will try to give a review on the impact of high-stress situations on intuitive control.
Chapter 2 of this document will define the sub-research question for this part of task 3.4. In Chapter 3 definitions will be given to come to a mutual understanding of the concepts used in this document. Chapter 4 will go into more detail and Chapter 5 will describe the conclusions and recommendations for further research.

Models that describe stress, but are not included in this document, are the following:
Michigan Model (naar Kahn e.a., 1964)
Person-Environment Fit Model (naar French e.a., 1981)
Demand-Control Model (naar Karasek, 1979)
Demand-Control-Support Model (naar Johnson & Hall, 1988)
Vitaminemodel (naar Warr, 1987)
Efford-Reward Imbalance Model (naar Siegrist, 2001)
Job Demands-Resources model
Demand induced strain compensation model (DISC)

Research question

The following research questions are posed in this document:

- What is the impact of high-stress situations on intuitive control?
    - What is the influence of personality on coping with high stress situations?
    - What is the impact of high stress situations on cognition?

Definition

To give an answer to these research questions it is important to come to a definition of the concepts used in this document. In order to come to an agreement on the concepts used a definition of a high-stress situation and a definition of intuitive control will be given.

Before we start with defining a high-stress situation we will first give a description on the concept of stress. Within the occurrence of stress biological, psychological and social factors play an important role.

Looking at the biological factors, the nervous system, particularly the brain, controls the way we initiate behaviour and respond to events that happen in our world (Sarafino, 1994)
Sarafino (1994) describes the nervous system as having two major divisions; the central nervous system and the peripheral nervous system. The central nervous system consists of the brain and the spinal cord. The peripheral nervous system is composed of the remaining

network of neurons throughout the body. Areas toward the top and outer regions of the brain are involved in our perceptual, motor, learning, and conceptual activities.
Regions toward the center and bottom of the brain are involved mainly in controlling internal and automatic body functions and in the transmission of information.

The peripheral nervous system has two parts:

- the somatic nervous system and
- the autonomic nervous system

The somatic nervous system is involved in both sensory and motor functions. The autonomic nervous system activates internal organs and report to the brain about the current state of activity of these organs.
The autonomic nervous system has two divisions, the sympathetic and parasympathetic, which often act in opposite ways.
The sympathetic nervous system helps us mobilize and expend energy in responding to emergencies, expressing strong emotions and performing strenuous activity. It speeds up the heart, dilates certain arteries to increase blood flow to the heart and skeletal muscles, constricts other arteries to decrease blood flow to the skin and digestive organs, decreases salivation, and increases perspiration. These changes enable you to mobilize energy when you have to leap to safety.

The parasympathetic nervous system regulates calming processes, helping our individual organ systems to conserve and store energy. When an emergency has passed, the parasympathetic division helps restore your normal body state.

The endocrine system consists of a set of glands that often work in close association with the autonomic nervous system. It communicates with various parts of the body. At the same time that the sympathetic nervous system reacts to an emergency, the hypothalamus sends a hormone called corticotrophin-releasing factor to the pituitary gland. This causes the pituitary to release adrenocorticotropic hormone into the blood. This hormone stimulates the adrenal glands who release adrenaline. The hypothalamus is a small structure in the brain which plays an important role in people’s emotions and motivation, it also plays an important role in our reaction to stress. When the parasympathetic system does not work properly under situations of high or prolonged stress, the adrenaline level stays too high in our body, which can be harmful when this is taking to long. Hans Selye (1956) conceptualized the concept of stress around the 1950’s.

Role of Psychological factors

Transactions that lead to the condition of stress generally involve an assessment process that Richard Lazarus and his coworkers call cognitive appraisal. Cognitive appraisal is a mental process by which people assess:

- whether a demand threatens their well-being
- the resources available for meeting the demand.

Appraising events as stressful depends on two types of factors –those that relate to the person and those that relate to the situation (Cohen & Lazarus, 1983; Lazarus & Folkman, 1984b). How can personal factors affect appraisals of stress?
Personal factors include intellectual, motivational, and personality characteristics. One example has to do with self-esteem: people who have high self-esteem are likely to believe they have the resources to meet demands that require the strengths they possess. (Cohen & Lazarus, 1983). Another example relates to motivation: the more important a threatened goal, the more stress the person is likely to perceive (Paterson & Neufeld, 1987).

Role of Social factors and occupational factors

Another factor that influences stress appraisals is the desirability of the situation. One other aspect of the situation that affects the appraisal of stress is whether the situation is controllable –that is whether the person has the real or perceived ability to modify or terminate the stressor.

There are at least two types of control, behavioral and cognitive. In the case of behavioral control, we can affect the impact of the event by performing some action. Suppose, for example, you are experiencing intense pain. If you have the ability to reduce the pain, you are less likely to be stressed by the pain than if you do not have this ability. In the case of cognitive control, we can affect the impact of the event by using some mental strategy, such as by distracting our attention from the stressor or developing a plan to overcome a problem. Social support can also help to relieve the impact of stress.

Individual factors

Some types of personalities are more prone to stress than others. Persons with the so called type A personality are more prone to stress than others. These people have an intense, sustained drive to achieve self-selected but usually poorly defined goals, eagerness to compete, the desire for recognition, continuously involved in diverse functions subject to time restrictions etc…

What is stress?

Stress has been conceptualized in three ways (Baum, 1990; Coyne & Holroyd, 1982; Hobfoll, 1989).

One approach focuses on the environment, describing stress as a stimulus. In this approach events or circumstances that we perceive as threatening or harmful, thereby producing feelings of tension are called stressors.

The second approach treats stress as a response, focusing on people's reaction to stressors. The response has two components. The psychological component involves behavior, thought patterns, and emotions, as when you "feel nervous". The physiological component involves heightened body arousal. The person's psychological and physiological response to a stressor is called strain.

The third approach describes stress as a process that includes stressors and strains, but adds an important dimension: the relationship between the person and the environment (Cox, 1978; Lazarus & Folkman, 1984a, 1984b; Lazarus & Launier, 1978; Mechanic, 1976). According to this view, stress is a process in which the person is an active agent who can influence the impact of a stressor through behavioral, cognitive, and emotional strategies. People differ in the amount of strain they experience from the same stressor.

Stress is defined as the condition that results when person/environment transactions lead the individual to perceive a discrepancy –whether real or not- between the demands of a situation and the resources of the person's biological, psychological, or social systems.

Kowalski-Trakofler and Vaught use the definition in their research with respect to emergency management because in their opinion "demand exceeding resource" is a key factor in the management of an emergency or in the response of an individual to an emergency.

What is it about situations that make them stressful? First, events that involve very strong demands and are imminent tend to be seen as stressful (Cohen & Lazarus, 1983; Paterson & Neufeld, 1987). Also, life transitions tend to be stressful (Moos & Schaefer, 1986; Sarason & Sarason, 1984). Ambiguity –a lack of clarity in a situation- can have an effect on stress appraisals. But the effect seems to depend on the type of ambiguity that exists.

3.3 Review of the human physical and behavioural components

Defining high-stress situation

A high-stress situation describes a situation in which extra high demands are posed on the individual to cope with an unexpected situation. Emergency situations are examples of high stress situations. Especially in these kinds of situations making use of intuitive interfaces could be beneficial.

Defining intuitive control

The term “intuitive” is used more and more when talking about human machine interface requirements. The interface itself is called intuitive and refers to intuitive use that should not demand high cognitive resources. When defining the term intuitive interface, one faces some difficulties, because interfaces can not be intuitive. The people that interpret these interfaces are doing it in an intuitive manner.

When talking about intuitive control, we are actually talking about intuitively understandable user interfaces. Presentation of information on interfaces as scenes, objects and actors can call upon instinctive capacities for direct perceptual information pickup, intuitive cognitive functions and natural behavioral tendencies (Baerentsen, K.B., 2000).

Naumann et all use the following definition in their study:

“A technical system is, in the context of a certain task, intuitively usable while the particular user is able to interact effectively, not-consciously using previous knowledge”

In a psychological encyclopedia intuition is described as being:

…essentially arriving at decisions or conclusions without explicit or conscious processes of reasoned thinking.

Baerentsen (2000) gives the following definition of an intuitive interface:

“the availability of functions supporting learning of unknown functions and their operation, but in a way that is not perceived as “teaching” or “education”. Learning must be a spontaneous product of the activity.”

Empirical data support the hypothesis that the user’s understandings and intuitions about the behavior of the system are built by drawing analogies from the everyday experience of handling physical objects in the physical world. When confronted with something new, people will employ whatever experience they may have in their efforts to understand new phenomena (Baerentsen, 2000).

Psychological theories about intuition

The most fundamental characteristic of living organisms is their activity. In relation to the use of technology this implies that the use of devices serves to satisfy some kind of need on the part of the user, and that the fundamental trick in relation to the user’s learning of the device must be to get the user to do something with the equipment, and that the resulting effects should provide the user with information about the functions of the device (Baerentsen, 2000). Our perception of the world is not only based on vision but also on our other sensory modalities. When it is considered, that in order to support locomotion and object manipulation all this information must be processed in real time, it is evident, that the brain must have an immense processing capacity in order to accomplish these “simple” forms of behaviour. Immense amounts of processing power are available to the user’s cognitive system, and largely without the necessity of the user’s conscious effort.

In relation to development of interfaces, the hypothesis developed by Baerentsen is that much of the interaction with technology should be delegated to the level of non-symbolic processes of direct perception-action control drawing on evolutionary old “hard-wired” systems in the brain. These systems possess an immense processing power compared to symbolic information processing, and they are specially tailored for automatic control of many aspects of interaction that in current interfaces requires symbolic information processing and conscious efforts of the user.

Naumann states that if the user does not perceive objects and signs as attractive and usable, or at least familiar, then the application or product has almost no chance of being used intuitively.

Implementing Intuitive interfaces

What does it mean when a design is called intuitive?
In order to construct user interfaces that support the utilization of the general human cognitive and sensory-motor competencies for locomotion and object manipulation, it is necessary to analyze the various functions in the system for which the interface is constructed (Baerentsen, 2000). In most cases usability is a complementary goal in that a highly usable interface will make the operator more comfortable and reduce anxiety (Sheldon, 1999).

Stress and intuitive control

Stress is a part of everyday life and not necessarily a negative phenomenon, being a physiological stimulus usually connected with human-environment interactions. It can become a harmful risk factor when it is perceived as an imbalance between an excess of demands and the individual ability to meet these demands. This causes a disturbance in the psycho-physical equilibrium (adapted from Costa, 1995).

Costa describes occupational stress and stress prevention in air traffic controllers. As the workload of an Air Traffic Controller increases, the ATC tends to employ more procedures which are less time consuming, together with a progressive reduction to the minimum of flight information and the relaxation of certain self-imposed qualitative criteria. It is evident that the number of decisions to be made becomes a stressful condition when the controller's decision-making capacity is stretched to the maximum; this can lead to a loss of situational awareness. If we consider stress as the external demands upon an individual, it is clear that stress for air traffic controllers is connected with the intrinsic characteristics of the job and with the work organization and conditions in the workplace. It is important to bear in mind that the psycho-physical responses of individuals also depend on their resources, defined both in terms of personal characteristics and coping strategies.

According to the demand/control support model on stress at work from Karasek, R. (1978), high stress levels and consequent troubles and illnesses are more likely to develop in work activities where there is high psychological demand, but low decision latitude and inadequate social support at the workplace.

Implementing new methods of automation could change job demands and characteristics. One result of such changes could be a modification in conditions which are known to cause stress (Costa, 1995).

The passage from the old procedural methods to modern assistance is in aviation considered the main factor that enables a better quality, not only in terms of work efficiency, but also in terms of stress levels. By reducing cognitive, memory and communicative workload as well as reducing uncertainty and unforeseeability of the situations stress levels can be reduced and reliability will be increased. The goal of progressive automation is to maximize system safety and efficiency by reducing human workload and error. However, it can also increase some problems related to both cognitive processes and operative procedures. There is a concern for increased human boredom, decreased motivation, loss of situational awareness, over-reliance on and misuse of automated systems, and deterioration of skills. It is difficult to find the balance between the stress alleviation by increasing the security of the man/machine system, and the reduced involvement which reduces security through a drop in vigilance (Costa, 1995). The human machine interface should be relatively simple for the human operator due to intuitive controls and understandable output according to Shelton (1999). But making the interface simpler means the user will be performing more repetitive actions and this can lead to human mistakes and lead to a more unsafe situation. According to Shelton the human machine interface should be easy and intuitive for operators to use, but not so simple that it provokes a state of complacency and lowers the operator's responsiveness to emergency situations.

Information and controls must be easy to understand and input devices easy to operate, according to logical processes of mental reasoning: delays and errors may occur because of confusing, misleading or excessively confusing documentation and information, poorly located knobs and levers, or lack of proper coding causing mismatches and mistakes (Costa, 1995).
It is worth mentioning that drastic changes in design and man-machine interfaces should be adopted very carefully, as they can cause stress and decreased performance due to difficulties in the adaptation of mental processes and operating procedures.
When the input system is intuitive and logical, it makes it easy to use, easy to learn, and faster (Costa, 1995).

Short term critical incidents stress symptoms:
Physical reactions:
- exhaustion;
- nausea/vomiting;
- weakness
- difficulty breathing
- chest pains
- rapid heart rate
- elevated blood pressure
- fainting/dizziness

Cognitive reactions:
- confusion;
- reduced attention span
- poor concentration
- loss of confidence
- decreased awareness
- troubled thoughts
- easily distracted

Emotional reactions:
- anxiety;
- anger;
- sense of loss;
- numbness;
- guilt;
- fear of loss of control;
- agitation;
- feeling overwhelmed;
- feeling isolated;

Behavioural reactions:
- emotional outbursts;
- feeling hyperactive;

- easily distracted.

Judgment and decision making process under high stress

During an emergency situation, critical judgments are frequently made under conditions of acute stress. Often during a high stress situation decisions are being made without all necessary information available. This places an excessive demand on an individual's decision making process. Often the demands exceed the resources in these kinds of situations. Emergency decision makers under stress not only have the effects of their own stress response and its resulting consequences to consider, the information they must base their judgments on is often unclear, faulty and incomplete (Vaught et all. (2000). Not much research and only scattered research has been done with respect to the question how decisions are influenced by high-stress situations before September 11, 2001. After the attacks the interest in studying these factors has grown considerably. But studying these factors in real life-threatening situations is very difficult due to ethical considerations and harmful circumstances. These elements could be studied more comprehensively by means of simulators, making it a laboratory study.

The ability to cope with stress is dependent upon an individual's perception or interpretation of an event or situation. It is important to note that stress can both improve performance and decrease performance depending on the coping strategies and the perception of a person. An optimum stress level makes you alert and vigilant; a too high stress level has more negative influences on your performance. It depends on the person when and whether an individual perceives a situation as too stressful. It depends on the adaptability of a person to changing situations and circumstances.

From a few studies (Hammond, K.R. 2000 and Flanagan, J. (1954) experts conclude that during critical incidents the focus of attention shrinks and that the individual focuses just on critical issues and elements. This focused attention was assumed to be bad, but in some cases it actually may be good, because it can eliminate nonessential information and highlight the most important sources (Kowalski).

The decision making process can be determined by the following elements:

- detection of a problem
- definition or diagnosis of the problem at hand
- consideration of all available options
- choosing the best option
- execution of the chosen option.

This process is influenced by several factors that impact one's ability to solve complex problems in a limited time frame:

- psychomotor skills, knowledge and attitude
- Information quality and completeness
- Stress
- Complexity of elements.

Hammond posited that different situations demand different forms of cognitive activity, some calling for increased analytical cognition, and others calling for increased reliance on intuition. Both the environmental conditions and people's reactions to them are key.

Conclusions and recommendations

A lot of literature describes the process of stress and the causes and consequences of stress within human performance. Less literature has been found with respect to the impact of high stress situations on intuitive control. We can conclude from our previous findings that most literature refers to the fact that more intuitive control will lead to better performance in high stress situations. It is important that the interface should guide the user to take the appropriate actions and provide feedback to the user when the operation succeeds or fails.

More research is needed to study the effects of high stress situations on intuitive control. By making use of simulators the effects could be studied. The preferred method for ensuring usability of the intuitive interface during high stress situations is to test the actual users with the ACD (Azimuthing Control Devices). This can be done by asking the users to perform representative tasks with the design under high stress situations (or scenarios), observing what the users do, where they succeed and where they have difficulties and analyzing their decision-making process.

3.3.4 SURVEY OF PERCEPTIONS OF AZIMUTHING CONTROL DEVICES BY NEW AND YOUNG PERSONNEL

Approach

Focus of this work package element has been placed on an interview with an existing ASD user and the perceptions experienced when observing younger and newer users of the ASD system.

1.2 Interview with D. Braber

Q. With several ACD training executed so far you have gained quite a lot of information regarding the performance of the trainees in handling the system under various manoeuvring situations. Did you notice differences in performance between junior officers and senior officers?

R. In fact all of the trainees have none or limited experience with the ACD system and we can see that some trainees pick up the handling quicker than others, irrespective their time of experience on board of sea going ships.

Q. Can we say that younger people are more flexible to pick up new methods or procedures?

R. May be we can see in general a bid more capability with young people to make oneself familiar with the background theory and application of it in a practical situation.

Q. Can we say that younger people who used to play all kind of computer games pick up more easily the way the ACD thrusters should be handled?

R. Yes I did see a bit quicker learning path in handling the thrusters by younger people compared to those who have a longer experience period with conventional manoeuvring means like a fixed propeller and rudder lay out.

1.3 Summary

The initial interview clearly indicates more research is needed in this area. There is no indication of the cognitive ability of the young persons involved, background experience (other than less handling experience in general), nor even the validity of the observations in objective context. Work should be done to explore if the observations are indeed accurate and if so, what can we as educators do to help facilitate an optimal transfer of knowledge.

INTRODUCTION TO 3.3.5, 3.3.6 & 3.3.7

The work done in this project up until now by FORCE can be divided in:

- Meetings with partners in the Azipilot Project
- Discussions with partners in the project during meetings and at distance
- Observations made on board ASD tugs in operation
- Photos taken onboard ASD tugs in operation
- Interviews made onboard ASD tugs in operation
- Observations made in state-of-the-art 360 degree tug simulator at FORCE training facilities, Lyngby, Denmark
- Photos from the simulator
- Interview with expert tug captain and simulator instructor
- Task analysis of three scenarios
- Think aloud method while running examples of these three scenarios in the simulator
- Photos taken during the think aloud method

- Video recording of an experienced captain performing the tasks involved in these three scenarios in the simulator
- 42 returned questionnaires from pilots, captains and mates who have been trained in the 360 degree tug simulator at FORCE facilities, Lyngby.
- Qualitative and quantitative analysis of returned questionnaires.
- Studies of relevant literature
- Writing the report

In this report the background of information and data from which the project questions are answered comes from the above mentioned work. Knowledge from the theoretical and applied field of human factors in particular and basic and advanced theoretical and practical psychological psychology in general is also exploited.

3.3.5 & 3.3.6 Implications of over loaded and under loaded environment

Choosing focus

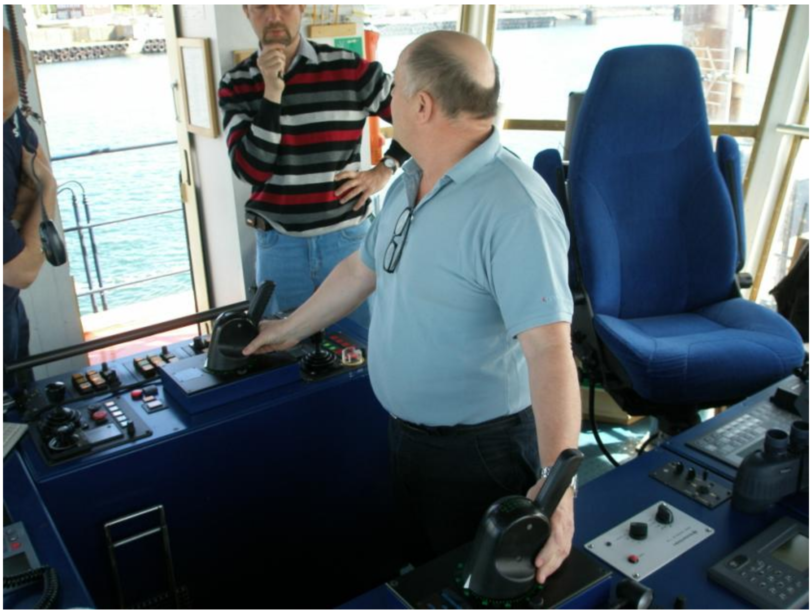
In this project our, FORCE, focus has mainly been on what we call over loaded work environment. We have chosen this perspective because we view ASD tug handling and ASD tug handling training in our simulator as a good example of an over loaded work environment. The fact that we have connections within the tug operating company Svitzer giving us the opportunity to make observations on their vessels has also been considered when choosing this perspective. Further more the availability of our 360 degree ASD tug simulator facility in- house has been considered. This facility have given us the opportunity to get 42 officers training at our facilities (mates captains and pilots) to fill out and return a questionnaire asking them about their experiences in the simulator.

Another reason for choice of perspective on this task is that STC in Rotterdam have had the opportunity to visit cruise vessels calling their port and interviewing cruise vessel captains with experience in handling azimuth propulsion systems onboard their vessels. The subtask of over- versus under- loaded work environment can thereby be approached from two sides, looking mainly at the over load environment by FORCE, and the under load environment by STC.

Over load and under load environments

We can construct examples of two different situations. One where the navigators (mate or captain physically handling the controls for the azimuth propulsion system) are in an over load working environment and one where they are in an under load working environment.

By under load working environment we do not mean that the master or mate handling the controls and thereby handling his vessel has to little to do or is getting bored or susceptible to for instance complacency. We simply argue that he is working less close to the limit of his human capabilities. This is primarily so because of the time factor being less restraint. When the tug master is ordered to deliver a particular force to the assisted vessel the force from the ordered manoeuvre is almost already needed (at least expected to take effect almost immediately). In this case the time factor is restraining the mate or captain performing the manoeuvre. But on a cruise vessel doing well planned harbour manoeuvres the captain at certain points in time positions his controls in a certain way that he knows will start to give him the needed movements of his vessels at a certain point in time ahead. He can then await the manoeuvre to take effect and make small adjustments for its optimization. The captain on the tug assisting another vessel must however constantly operate the controls changing angle, revolutions and pitch. If he does not do this the tug will in most cases not be in the correct position to supply the assisted vessels with the intended pushing or pulling force (angle and tonnes).



Observation onboard M Class Svitzer ASD tug. The captain is demonstrating the challenges of performing bow to bow operations.

In our simulator we often see very experienced and capable tug masters. When even they seem to be working at their limits doing “standard” ASD tug assisting manoeuvres such as the bow to bow operation it is clear evidence that they are close to what we call a general human capacity limit for handling azimuth propulsion systems manually.

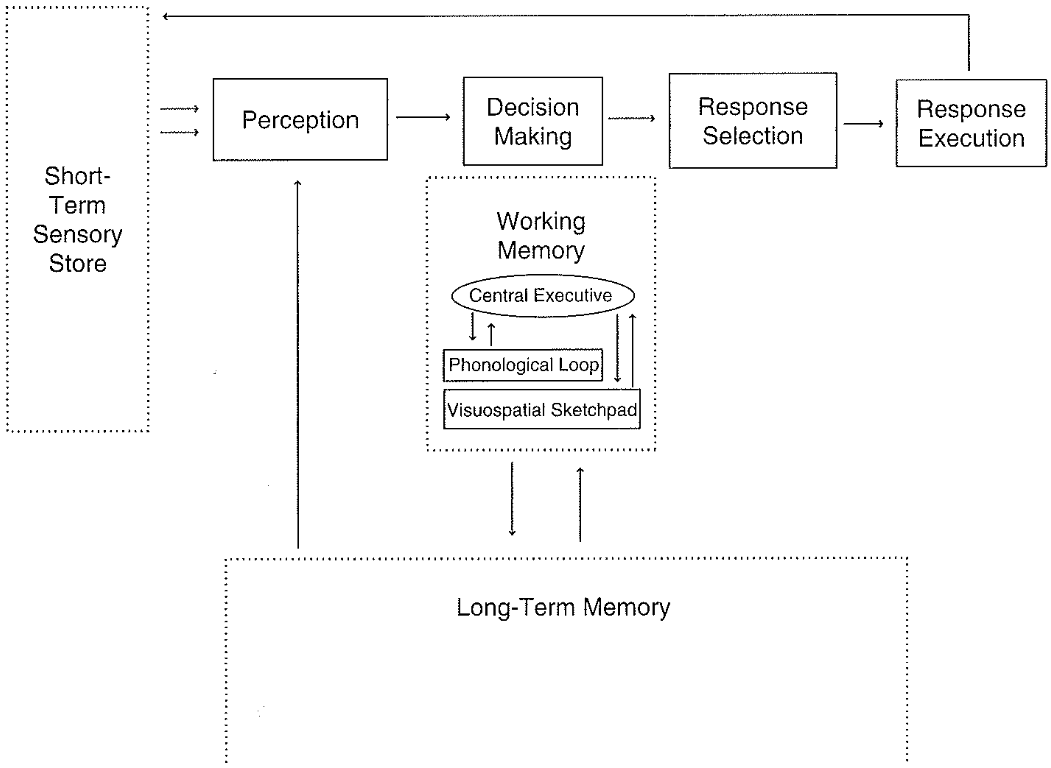
In the table below I have tried to describe main differences between the over load working environment and the under load working environment as we see it in the examples.

Over load environment	**Under load environment**
Ex A: *ASD tug assisting other vessel*	Ex B: *Large cruise vessel in harbour manoeuvre.*
Little time to do perform manoeuvre. Manoeuvre needed before it is started.	More time to do manoeuvre. Manoeuvre planned ahead and carried out before it is needed.
Constant adjustments and changes in control settings necessary. Large changes in settings (angle of thrust/pitch/revs) often necessary.	Few adjustments and changes in control settings necessary. Smaller changes in control settings (angle of thrust/pitch/revs) necessary.
Actions are more situational dependent and have to adapt dynamically. Situation changes quickly and often.	Actions are more systematically stringent (the same and done the same way). Situation changes slowly and not as often.
Fewer persons on bridge to share tasks between them and support decisions.	More persons on bridge to share tasks between them and support decisions.
External communication is of direct importance for the handling of the vessel and performed by the same person that simultaneously physically handles the controls.	The person handling the controls is shielded from most external communication. Staff captain handles a large deal of the communication.
External communication is both a primary and secondary task.	External communication is mostly a secondary task.
Most communication can not be postponed	Most communication can be postponed
Person handling the controls also communicates externally.	Staff captain or one of the officers is handling external communication.
Master or mate must have “mental picture” of assisted vessels intentions and movements as a result of combined forces including tugs influence on these resulting forces.	Master or mates “mental picture” consists for the largest part of the masters intentions of positioning his own vessel at certain points in time resulting mostly from forces applied by own vessels propulsion system.

3.3 Review of the human physical and behavioural components

Under load and over load of the human information processing system.

Another and more detailed way to distinguish between an under load and over load environment is to look at the impact on the human processing system and its capabilities. Below is a drawing of a classic model of human information processing.



The model is taken from Carswell (2006: 409) and is an example of a typical information processing model, combined from the work of Atkinson and Shiffrin (1969), Baddeley (1997) and Wickens (1992).

Let us consider an under load and an over load environment through the use of this model. In the under load environment the situation develops quite slowly. The cruise vessel making a controlled swing in the harbour is expected to make very little speed ahead or astern while swinging round. This means that the visual "picture" of the situation that the captain is monitoring is changing and developing quite slowly. Also other inputs such as sound (vibration or maybe engine noise) and movement of the vessel (for instance heel) are few.

Transferred to the model of information processing above, the under load environment therefore supplies the *Short –Term Sensory Store* with less stimuli than would be the case in an over load environment. For instance on the bridge of an ASD Svitzer M Class tug doing a fast 360 degrees turn. Here the visual input would be much more dynamic – change much faster. Also the heel of the tug would be faster. The noise heard from the engine and the changes in load on the engines and their revs and angle of the thrusters angle is much easier to see and feel and changes comes at a much faster rate.

3.3 Review of the human physical and behavioural components

Look out the side windows from the bridge of the ASD Svitzer M Class tug. The propellers are giving a lot of wash while the tug is doing a fast 360 degree swing. The engines noise, vibrations and heel can easily be heard and felt on the bridge.

Proceeding in the comparison of the two environments looking at the model is therefore clear that the *Short – Term Sensory Store* must be less challenged in the under load environment. Fewer stimuli is being presented to the operator.

This also means that *Perception* is less strained. Less stimuli input means less material to perceive. Another thing one can speculate about in this place in the model is whether less input or stimuli from the outside world actually means that the captain on the cruise vessel must make more use of his *Long Term Memory*? It could be argued that this is the case however on the ASD tug the captain is definitely challenged also at this point because he is getting a lot of stimuli he must perceive, sort out and give meaning. And for this he must compare each of them with material from his *Long Term Memory*.

The time factor restraint becomes increasingly important as we continue to the right in the model. In order to make optimal decisions, the captain must find the best fit between “schemata” existing in his memory and the present perceived situation. As a situation develops or changes faster this recognition and retrieval must operate at a faster speed. This process is for a large part dependant on the operation of the so called *Working Memory* which operates as the controlling or “executive” mechanism in the recognition and retrieval processes finding “schemata” for actions that meet criteria.

The *working memory* also works as the buffer in which obtained visual (input form surroundings, instruments, feedback instruments) and phonetic input (speech/communication) are held for a short time until it is either used, forgotten or stored in the *Long Term Memory*.

A dynamic situation which evolves and changes fast in an over load environment makes *decision making* more challenging than it would have been in the under loaded environment[1].

[1] Drawing up differences between over load and under load environments it is important to (at least theoretically) keep other influencing factors unchanged, for instance training and ability. It is clear that a poorly trained and inexperienced captain with poor manoeuvring abilities would experience the routine harbour manoeuvre of his cruise vessel as an over loaded situation and environment. It is also important to think of the two scenarios (over loaded and under loaded) as "normal" situations and not for instance emergency situations in which even simple routine manoeuvres has the potential to become over loaded situations and environments – even for the most able and experienced captain.

More perceived information (*perception*) must be processed and put together to form a “picture” of what is going on and more criteria and possible actions and their possible outcomes must be considered before the proper response (*Response Selection)* can be chosen and executed (*Response Execution*).

Finally the faster pace of sensing – perceiving – decision making – response selection and response execution also adds circularly to sensing again (see model above) since all new actions performed be the captain (orders given through the controls) changes the movement of the tug, assisted vessel and situation and thereby adds to the total amount of environmental stimuli for the operator.

Conclusion, tasks 3.3.5 & 3.3.6

Several human factors methods have been used in combination during the first 18 months of the Azipilot project to answer these questions. It has proven fruitful to focus on over load working condition and ASD tug handling and simulator courses and training. A lot of data has been obtained.

Viewing ASD tug handling from an information processing perspective it can be concluded that ASD tug handling is complex and very demanding to the master or mate operating the controls. Even when experienced and trained the manoeuvring of the tug quickly comes close to the limit of human capabilities. It confirms the importance of theoretical and practical education and training in a simulator as well as on board the tugs. The right training, education and experience enhances the possibility of the master being able to pull the right “schemata” from his memory in a dynamic and fast changing situation in order for him to make the right decisions swiftly and perform the right actions promptly. If he is not able to do this the tug work will not be safe or efficient.

3.3.7 Explore perception and feedback for both course- stable and unstable ship response.

Clarification of concepts and purpose

Answering this milestone, we have decided to focus on course unstable ships. More specifically we focus on the Svitzer M Class ASD tug and its simulation. The reason for this is that this vessel type has been available for us in our simulator and because we have had the opportunity to visit and do observations onboard this type of vessel in real life. The fact that we in our facilities have a state-of-the-art 360 degree full mission ASD tug simulator where many people get practical and theoretical training and education also gives us the possibility to asses in what way our simulator (and thereby other modern simulator for ASD tug manoeuvring training purposes) and courses are experienced by the navigators we train.

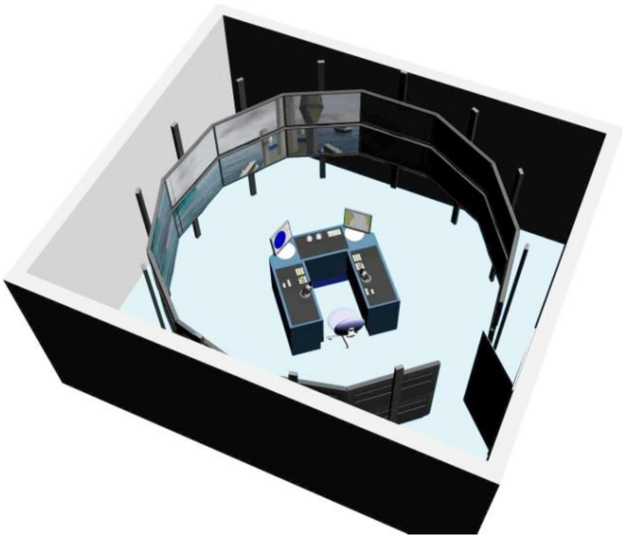
3.3 Review of the human physical and behavioural components

Ahead view of the ASD Svitzer M Class tug in simulator

Astern view of the ASD Svitzer M Class tug in simulator

In this way we live up to the important 3.3 task purpose to both *"...review the training needs and implementation specifically for ships equipped with azimuthing control devices..."* and *"... assess the appropriateness of current techniques..."* [2] in the training and education.

For this purpose we have developed a questionnaire[3] to hand out to mates, captains and pilots training at our facilities[4]. This questionnaire has been the most effective and efficient way we could think of to get knowledge from the "users" or customers if you like. It is our assumption that this feedback from true players is an important way to obtain knowledge of ASD tug simulation regarding needs and challenges.



Drawing of the 360 degree ASD tug simulator bridge at FORCE facilities.

[2] Purpose description task, 3.3, Annex 1 – description of work (October 10th, 2008), p. 42-43.
[3] Please see "Questionnaire" in Annex.
[4] Force Technology, Hjortekærsvej 99, 2800 Kgs. Lyngby, Denmark: http://www.force.dk/en

3.3 Review of the human physical and behavioural components

Interview with expert ASD tug captain

Choosing the informant

The interview was performed by the author of this text and conducted in the ASD tug simulator at FORCE facilities, Lyngby, Denmark. The interview was recorded on a Sony mp3 recorder and later fully transcribed. The full transcription is attached to this report in the annex.

The interviewed experienced captain also works part time as an instructor and teacher at our training facilities. There are of course pros and cons to be considered when choosing him as an informant for this project. On the pro side is his long practical (hands-on) experience (20 years on tugs), experience as training captain in Svitzer and the fact the he is still working as a captain on the newest ASD tugs – the M Class which our simulator is built to be a replica of.

His long practical experience and the fact that he has also been a training captain onboard the tug means that he has a lot of practical experience and expertise. But also that he has *thought* a lot about manoeuvring, how it works, why and what the most effective manoeuvres are. And he has been teaching and explaining this to others. This means that he is used to *communicate* about these issues and that we can expect that it will not be a problem for him to *verbalize* his knowledge and insights. This is a great advantage in regard to data that can later be drawn from the transcription of the interview. Working with people of different ages and levels of experience also gives him the opportunity to draw a picture for us about what the difficult parts of learning to handle an ASD tug manoeuvring are for experienced/inexperienced and young/old navigators respectively.

On the negative side, however, if you view data from the interview through a more scientific lens, is the fact that he is himself working as an instructor and teacher at the same facilities (simulator) that we interview him about. Here there is always a danger of subjectivity – a large bias. There is also a possibility that serious human factor problems with the construction, set-up or functioning of the simulator is overlooked by him because of "home blindness". Having worked many hours at the facilities could make him develop work-arounds and routines (more or less unknown to himself) that deal with problematic issues so well that he does not realize they even exist anymore.

This problem we have of course considered before we chose him as the subject for the interview. And part of the argument for choosing him as a subject anyway is that we are actually interested in his subjective opinion about the simulator because we believe it is the result of a thorough comparison with his practical experience onboard real life ASD tugs. In other words it is our belief that he knows what he is talking about!

Regarding the possible problems concerning his view of the simulator itself we think that this will steadily be adjusted and corrected by the people training at our facilities. The trainees are mostly experienced navigators and most of them have already tried to manoeuvre ASD tugs themselves and therefore expected to give good realistic and critical feedback to our captain/ instructor. And it is our actual experience that they actually do give this kind of critical and constructive feedback when they experience something in the simulator they think they miss or something that appears to be different in the simulator than on the real tug[5].

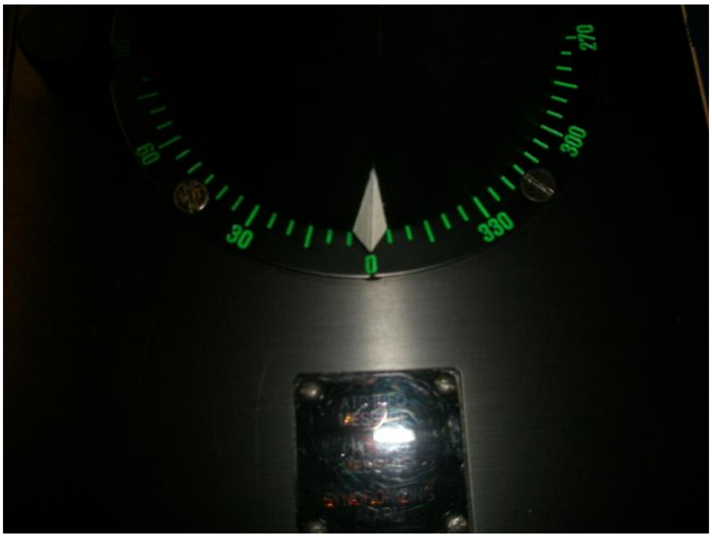
[5] Please see the paragraph "results from the questionnaires" where this kind of information is presented.

3.3 Review of the human physical and behavioural components

Main points from interview with the ASD tug captain[6]
In the following text main points from the interview data is extracted. Everything that is thought to be of relevance for simulator and course training for "course unstable" ASD tug handling is included. The order in which the issues are mentioned is not a prioritization of their importance. Such prioritization is out of the scope of the information gathering work in this Azipilot project and is therefore left to the reader.

Controls
The controls fitted in our simulator are made by *Aquamaster* and they are the type of controls most often fitted on the bridge if Rolls Royce is the producer of engines and azimuthing thrusters (propulsion system). It turns out that this particular type of controller is made in different "quality" having a more or less plastic-like feel. A problem with this particular set of controls is reported by the captain as well as some of our respondents through the questionnaires. Beside the fact that the cheaper version, fitted in our simulator, seems plastic like everyone more or less agrees that they are good controls. Some weaknesses are reported though. And as we know from experience; even good equipment and technology can be improved.

When the controls are positioned at the angle of 0 or 90 degrees the built in notches are difficult to feel. This will make some operators look down on the controls to check the correct angle[7]. Another problem is that the notches in the lever for adjusting revolutions and pitch are difficult to feel.



The controller is set at 0/90 degree angle – the notch is difficult to feel on the budget version of controller.

The problem with the feel of the notches is reported to become worse when the controller gets worn. One model of this controller is manufactured with a built in push button for the VHF radio on the very top of the starboard controller. This function is reported very useful in an overloaded environment (see above paragraph on this issue). The master or mate handling the tug usually has his hands on the controls all the time and is therefore reluctant to let go of one of the handles to grab the microphone or VHF radio handle to talk.

Whether controls with this function should be installed on an ASD tug simulation bridge surely rests on the purpose of the simulator. If it is mostly designed for training specifically

[6] For full transcription please see annex to this report.
[7] They are then in the unfortunate "head down mode".

for a certain type of tug where the button switch is then it can be rightfully argued that it should also be on the bridge of the ASD tug simulator.

Replication of real bridge or not

Something similar can be said about the type, make model and placing of the feedback instrument for the azimuth thrusters (indicating angle, revolution and pitch) and the other important nautical and communication equipment on the bridge. In our inquiries throughout this project we have generally come across two different views on the simulation being a replica of the real bridge or not. Agreement seems to centre on replication if the simulator primarily is to be used for detailed and specific high skilled training for a particular type of ASD tug while the opposite seems reasonable if the simulator is more often used for principal education in azimuth propulsion systems handling:

"I: If you have to prioritize how important it is that the setup is exactly the same in the simulator as in reality thinking of training… how important is it?

B: If we focus on training now for a specific vessel then I think it is a clear advantage that it resembles the specific vessel. Especially if the crew have already been on that specific vessel before and comes to our facilities and are able to recognize it. That is what makes it possible to almost jump pass the first day in the course where the familiarization is normally done.

I: It will in that case not be necessary to spend time on familiarization?

B: No, at least not to the same degree as one would normally do. "

(Interview, p. 3)

Choosing level of complexity and difficulty

Another issue is the problem of choosing the level of complexity of difficulty in the course. And advising companies if they should send their crew to the simulator before sailing on the ASD tug or do on the job training onboard the tug for some months effectively before attending the course at our facilities:

"B: It depend on what crew you have or what crew is available in the areas where the vessels are supposed to operate. We had some from South Africa that did not have any knowledge of ASD tugs whatsoever and they were to handle newly delivered ASD tugs. But they did not have any crew that could handle them at all. Seen from that perspective it is a really good idea that they come to us first. But then we just have to realize that what they are here for is to learn the absolute basic handling of the tug. That is to learn how to sail back and forth and turn.

I: But such knowledge and practice the crew that come here from Svitzer will already have?

B: Most often that would be the case, yes. You can easily spend two days with the basic stuff before people start to think in vectors in their heads and hands. That can be skipped if they have had the opportunity to try this in the real world first. And then a four day course will be 4 effective days of where you can train the actual purpose. We are able to deliver both services both it is a question of what the purpose of the course is. If the purpose is to push, tow and assist other vessels with the tug, then the better trained they are in the general handling when then come to the simulator the more time can be spend on the more difficult manoeuvres and operations."

(Interview, p. 3)

Physical movement of the simulator

Also the subject of physical movement in the simulator has been mentioned – both in the interview and in the questionnaires. In the questionnaires a few respondents discussed the possibility of a moving platform to be fitted underneath the simulation bridge to mimic movements, vibration or the like. These few respondents think it would be of great benefit to the experience of realism in the simulator if physical movement was in some way added to the floor on the simulation bridge. They speculate that this could be achieved even by small (centimetres) movements or simple vibrations in the floor or controls indicating for instance contact between tug fender and assisted vessel, quay or barge etc.

Data from the interview does not directly support the need for a moving platform but recognises the need for some kind of haptic/tactile feedback:

3.3 Review of the human physical and behavioural components

"…what could be an advantage is when we go alongside another vessel it would be useful with some kind of bumping feedback. That sensation is not offered for the operator in the simulator when he hits, actually physically hits, the vessel."

(Interview, p. 4)

Sound quality in the simulator

The quality of the sound in the simulator attracted a lot of attention. Sound is by many of the respondents considered a very important and powerful stimuli. They mention that they actively use sound (the revolutions, pitch and load on the engines) in their manoeuvring. For them it is important feedback from their manoeuvres and information about the remaining power and performance of the tug. The interview supports this perspective:

"B: Like old cars where you drive as much with your ears as you do with you with your eyes? Yeah – the effect could be turned up a bit, but we do have the sounds of the engine but we have turned them down because of the people working on in the offices on top of the simulator. But I think it is really good as it is. Something you could wish for that is a realistic stress factor is that combined with the engines power increases some kind of rattling sound on the bridge if you understand what I mean. Something in the vessel and on the bridge that starts vibrating when running at high revolutions on the engines and when the propellers are turned cross ways. Something that you maybe can not feel but is delivered as an input to the operator through sounds from the speakers.

I: Indicating some stress on the tug?

B: Yes – exactly.

I: Maybe indicating possible cavitations and so on?

B: Yes. "

(Interview, p. 4-5)

Visual quality

Concerning the visual quality in the simulator different aspects have been mentioned. Visual quality can on the background on the information we have gathered in this project be divided in several categories[8]:

- Brightness
- Realism of colours
- Realism of structure
- Update speed
- Update precision
- Update integration
- Viewing angle
- Visual accessibility

Visual quality in the simulator is not just visual quality. Within the simulation research literature the mentioned aspects of the visual quality would surely fall in the category of *simulation fidelity* in general and more specifically, *visual fidelity* (Vicenzi et al., 2009). Where fidelity means *"the degree of similarity between the simulation and reality"* (op. cit, p. 67).

Brightness

Starting with brightness a difference between brightness at night time in the simulator can be a little different from available light in the real world.

[8] In am not an expert in this matter so the description might look significantly different if it had been written by an engineer with special knowledge on flatbed screens!

3.3 Review of the human physical and behavioural components

Colour
Then there is the colour of navigations lights, lighthouses and background lights ashore etc. But also the colour of plane surfaces, for instance the side of the assisted vessel. Does that always look exactly right at every angle with the expected shadows induced by the angle of the sun and so on? I am sure that our simulator comes very close on all these aspects but is it ever going to be perfect and what meaning does the quality of these variables have? Research is needed to answer such questions.

View of surfaces - structure
Another issue of the surfaces viewed in the visual picture observed from the simulation bridge is structure. If real life photos are used to sculpture surfaces on building, quays, jetty's etc graphically – does it ever look quite right and what does this mean? The work in this project have not even come close to answering this question.

Picture update
Then there is the speed of the picture update. Can the graphics accelerator actually catch up with the heavy load from the visual data or is there a tiny lag? Even a tiny lag in the visual (meaning that the tug is actually a little closer to the assisted vessel right now than it is possible to see) can make a big difference if the exercise is to approach the vessel to be assisted vessel at high speed and stop the tug in such a way that it just lands gently with the fender on the ship side. The captain doing such a manoeuvre is "all in the visual" meaning that it is the interpreted distance from looking out the "windows" that enables him to break at exactly the right moment and not some readout of distance obtained from an instrument!

Update precision
Update precision is partly the same. By this aspect I mean for instance the total concordance between when a manoeuvre *should* take effect by moving the water (and then supplying a force to the tug) and the time until this can *actually* be observed as a movement of the visual field.

Being no expert in this matter I can see that in our simulator there seems to be no such delays or discrepancies but if I think logically I guess that there must be since the visual reactions to my adjustments of the controls must go through some kind of calculation before transformed into pixels forming before my eyes. To verify that our particular courses do not suffer from such problems our procedure is to invite expert captains before the courses are run to try out the simulator and critically comment on any experienced or felt discrepancy so that these can be corrected for in the simulation in the actual course.

Update integration
And when all the forces reacting on the tug in combination there is the issue I call update integration (including the timely precision of these). Factors such as current, drift, suction, push, pull, and drag etc.[9].

Viewing angles
Lastly there is the issue of viewing angle. Is the visual quality the same from different viewing angles? In the ASD tug simulator at our facilities the flatbed screens give very sharp and strong pictures of good quality but standing at certain positions on the bridge the way the screens are positioned (circular form) around the operator can sometimes give the visual impression that what is supposed to be a straight line or straight and flat surface (for instance the side of the assisted vessel) in the simulator looks as if it is rounding if you stand outside the focus point.

[9] If some of the words I use in this sections is not 100% correct please excuse me. I am a human factors specialist, not an engineer. It is my hope that the "meaning" of the text can still be transferred to the reader.

Visual accessibility

Finally the problem of what I call visual accessibility (being able to see from the bridge in the simulator what one knows can be seen and therefore expects to see from the real bridge) is very interesting. This is mentioned in the interview where the expert tug master misses perfect visual possibility (totally the same view from the bridge as on the real tug) to look down the side of the tug and up and out of windows in the ceiling in the bridge structure:

"I: I have personally been thinking about what kind of effect it has on the operators perception visually if the window bars are indicated by the edges of the flat screens as they are now or if they are made up by an exact visual model of the actual view though the windows on the bridge. Do you think that has an effect? Do you look for something through the windows and monitor that you can not monitor in the same way because the view is a little different – or things and objects you would like to monitor along the side of the tug that we can not see here?

B: Yes, there actually is. When we go alongside another vessel it is quite difficult to determine the distance to them. In the real world we can see more to the sides and downwards. We have actually discussed that the left and right bottom screens forward, could be replaced by still photos, and the screens moved to show a lower view at the sides. That would help a lot.

B: I suppose it is a question of money. Likewise it could also be beneficial – especially when we talk about tug escort training – you could wish for more screens upward. In the real world there are small slanting windows upward to the sides. When the tug is escorting it is so close to the other vessel is has problems seeing where it is positioned.

I: Is it an issue when the tug is below the bow of the big vessels where you have to make sure your mast does not come to close?

B: Well – under those circumstances the tug will be 60 to 70 meters form the bow – or the tug will be even further away – so that is not a problem.

I: The tug is not supposed to be so close to the bow at all?

B: No, not at all."

(Interview, p. 5)

Such problems can be identified by thorough analysis of user behaviour, context and needs[10] before building the simulator or during the iterative processes of improving existing bridge- or visual design (hardware or software).

Position for instructor on the simulation bridge

Another important issue regarding the training of captains, mates and pilots at our facilities in the handling of an ASD tug is the optimal place for the instructor to be during training. It is the experience of the instructor that novice or partly experienced navigators in the beginning of a basic course (or at intermediate level when doing difficult manoeuvres) can experience great problems on their own. This means in practice that the instructor literally has to stand close by (within reach of the controls) the navigator. On the simulation bridge no specific room is made for this since no room beside the navigator exists on the real tug.

Ideal number of crew on the simulator bridge

In the questionnaire we asked respondents for comments on the number of crew onboard the bridge at a time and it turns out that they prefer being there alone while training to get optimal hand on experience. But they also preferred the possibility to have personal assistance from the instructor in some instances while manoeuvring. This indicates that there is a need for at specific seat for the instructor besides (or maybe a little behind and to the side) of the training captain or mate. Beside this seating position (from which the instructor should ideally be able to reach the controls) should be a computer controlling the simulator so that the instructor can set and remove the towline. Often the critical moment in the manoeuvring is right before the line is to be set and in order to do this the instructor must leave the bridge and walk the 3

[10] Actually it is a classic human factor discipline to gain knowledge of the user. Always used to some degree in the human centered approach to the design process. Please see more in the ISO standard 13407:1999 Human-centered design processes for interactive systems.

meters to the control station "outside" the simulator. This only takes a few seconds but can be longer than the trainee is able to keep the tug under control:

I: The operator station for this particular simulator is situated right behind the screens here (behind the screen providing the visual effects for the captain manoeuvring on the simulator bridge). How does that work compared to what you are used to and think is optimal?

B: I must say that sometimes you could wish for the possibility for the operator to sit beside the captain manoeuvring – maybe with a laptop for the control of the simulator. When you sit inside the simulator – and especially when the totally inexperienced navigators are training you need to support them a lot in the beginning.

I: So in these situations the operator is supplying "standing next to – education"?

B: Yes. There are situations where you can not leave them for 10 seconds before it goes wrong. And that is often in the situation where they need to take the line from the other vessel, and therefore also the situation where the operator needs to set the line between the tug and other vessel from the desktop controlling the simulation programme. In these situations you as the operator have to leave the room. You could therefore benefit from having just some of the critical functions available for the operator within the simulator for instance to establish a towing line.

(Interview, p. 5-6)

More or less experience before they come to the simulator?

More interesting issues concerning the training and ASD tug handling courses were discussed in the interview. From the point of view of our experienced ASD tug master and instructor it is important to distinguish officers from captains. And also between those who have experience beforehand and those who do not (Interview, p. 9-14).

If they do not have any experience it is prioritized by the instructor that they simply learn how to handle the tug in simple harbour manoeuvres, approach and departure from quay, sailing straight ahead and so on. If they do have this kind of experience and training already the instructor will start to teach them basic tugging; setting lines fore and aft and repetitions of these manoeuvres.

If the company decides that their mates must come to the course before getting a new ASD tug the instructor will start from scratch. He will teach them how to think in vectors, how to sail in and out of harbour and to and from the quay.

Differences between individual trainees

In the interview we discussed if there are differences between the trainees; if some need more theoretical explanations before the practice or visa versa. The instructor thinks there are differences. A particular difference he has noticed is described below:

"B: That a highly individual question. Some people are enormously practical. They come here on the bridge and can almost feel what they have to do almost immediately. And we as instructors can feel that as well when we get people like that in the simulator. But it is not often. These people just "feel" the vectors in their body without thinking about it. And other people need thousands of explanations and some has to think and calculate all the time in their heads before they can do anything. Knowledge based…. There is a lot of difference in how people work. Some are good and some are not that good. Some will learn it and some will never learn it at all. "

(Interview, p. 9)

Certain personality to handle ASD?

In the interview it was also discussed if a certain "personality" thrives with ASD tug handling or is particular good at learning to handle such a tug. This was not the experience of the tug master. But a talent for a high degree of multitasking is thought to be an advantage.

Duration of the courses

Concerning the ideal duration of the course it is the captain's experience that it should last four days. Four days is considered best because it allows for a start that is not too demanding and a reasonable ending with to full days in between were they really get a lot of practical action. If the trainees do not have any experience their ideal education in the course should be divided in three 4 day courses that starts with a basic training course and then gradually increases in level.

Exam at the end of the course or not?

Some of the trainees miss some kind of examination following the ASD tug handling course. This can of course be arranged if the customer orders it. But normally examination is not done in this course even though some of the captains and mates actually ask for it in their responses to the questionnaires. The issue of examination or some kind of test was also discussed in the interview:

I: Can you think of a way to obtain or gather data for each of the pupils that can give some kind of objective measure of how good they are – or have become?

B: It is more my judgement. I see how much they sweat and shake and if they can actually do the manoeuvres. The time factors of course also plays a role here. Some of it is actually possible take time on.

I: Can you say – sail to this position, this way – and then you as instructor can monitor how long it takes for them and how safe the manoeuvre was?

B: Yes – we do have a small exercise we do from time to time. We call it tug race and the pupils are racing each other. They have to compete in time. They do not get any punishment if they hid something on the way to this particular defined destination. It gives us a quick picture of their understanding of the vectors and how the tug is basically operated. We can not use for much more than for themselves to decide who should by the first round in the evening! This exercise can be seen as a socialising event as well... Of course it would to some degree be possible to set criteria and exercises where the people could be objectively measured.

I: How do you measure – I know you use the Delphi method for evaluation where we get feed back – but how do you personally as an instructor measure the effect of their learning compared to what they could do when they came at first? – do you look for any particular markers or cues?

B: It is difficult to say. What I do is that I make some test runs with them individually – the go back and forth and get a feeling of what level there at. And if they are on equal level or close it is an advantage. We can then proceed faster.

I: You do this as the first part of the course?

B: Yes it is a part of the course. It is the first exercises we do. It is part of the familiarization we do. We go back and forth following a track – back and forth – looking aft – looking forward. That quickly gives me an impression of if they have the feeling for the vectors and what part of the tug they can actually control. And that gives a clear impression of their abilities and if they need more training on the cubicle bridges in specific issues before they can proceed in the programme.

(Interview, p. 12)

The Questionnaire

The questionnaire[11] we have developed and used consists of an introduction describing the AZIPILOT EU project under the EC seventh Framework programme and its overall purpose. In the introduction it is also made clear that any contribution is welcome and that answers will be treated anonymously.

The development of the questionnaire is partly inspired by data from the interview with the expert tug master and instructor, partly observations on board a tug in real life and comments and “complaints” heard around the simulation facilities when the courses run and the house is full of training captains, mates and pilots.

The initial version of the questionnaire has been changed after trail runs where maritime officers of different rank were given the opportunity to answer it and evaluated both the relevance of each question and perceived difficulty of understanding each question on a scale from 1 to 4. All questions with a lower rating of relevance at these trails runs than 3 and a higher rating of difficulty than 3 -4 (inclusive) have been amended or removed.

[11] Please see reference and Annex.

3.3 Review of the human physical and behavioural components

The final adapted questionnaire consists of a total of 53 questions where the first six questions concerns data of the respondent: Name of employer, present job position held, primary tasks, years of experience in present positions, age plus the name of the present course attended[12].

The questions 7 to 11 asks about duration of present course, if the respondent has attended other similar courses previously and which plus the name of vessel or vessels they are training to handle in real life.

Questions 12 asks for hands-on experience with manual control of azimuth propulsion in 4 categories; 1 month, 2 months, 6 months or "more than 6 months". Question 13 asks for the type of controller (make/model) if any prior experience with azimuth propulsion.

Q 14 and 15 are about motivational factors for attending course, personal and company.

Q 16 to 18 concerns believed ideal number on each course, the reason for this and ideal number on the bridge during exercises.

Q 19 is a likert scale type of question asking for general satisfaction regarding intuitive use of the controls. Q 20 has to do with course experience correspondence to expectations regarding intuitive use of the controls.

Q 21 is about impression of colleague's satisfaction with the course. Q 22 asks for opinion of overall realism of bridge setup in simulator. Q 23 is about which simulator bridges the trainee have been working/training on.

Q 24 asks if controls were found intuitive to use, Q 25 asks why this is so while Q 26 asks why not this is the case.

Starboard azimuth controller on the ASD tug simulator bridge.

Q 27 asks about the opinion of the feedback instruments on the simulator bridge, Q 28 asks for possible improvements of the simulator bridge setup and Q 29 asks for possible improvements of the design of the controls.

[12] Please see questionnaire while reading explanation of questions in this paragraph

Q 30 is a likert scaled question of how realistic the simulator feels compared to real life while Q 31 asks for things that the respondent misses regarding the "feeling" of the simulator compared to real life.

Q 32- 35 are likert scaled. Q 32 asks about the experienced visual realism in the simulator while Q 33 asks about the perceived importance of the visual quality. Q 34 is about the quality of the sound experience in the simulator while Q 35 is about the importance of the sound quality (sound experience). Q 36 asks for perceived shortcomings regarding sound capacity while Q 37 asks the respondents opinion about ideal effect and training outcome of course held and Q 38 is a likert scaled question of how the present course attended has lived up to these ideal parameters.

Feedback instrument for one of the two azimuth propellers showing present thrust angle and picth and revolutions applied. To the left the speed log. No log reading or applied pitch/revolutions because simulator is stopped when picture was taken.

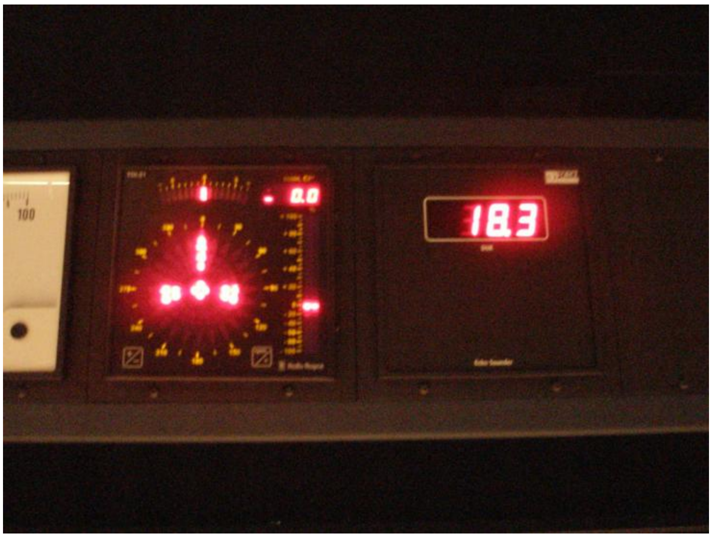


Photo of the other azimuth propeller feedback panel also showing depth indication data from the chosounder.

Q 39 asks if the respondents miss anything in particular regarding the instrumentation on the simulation bridge, Q 40 investigates possible missing important contents in course while Q 41 asks for respondents opinion about what is most important to learn on an ASD tug training course. Q 42 to 45 are likert scaled and asks for the importance of make, type and model of controls (Q 42), sameness of feedback instruments (Q 43), placing of feedback instruments (Q 44) and finally how important it is that the entire simulator setup is a replica of the real bridge on the vessel the respondent is training for to manoeuvre (Q 45).

Q 46 asks for the respondents assertiveness regarding willingness to asks for a course about azimuth propulsion handling if they had not been offered this by their company.

Q 47 and 48 asks for experience with automation feature onboard real life vessel regarding steering or propulsion control.

Q 49, 50 and 51 asks for the respondents opinion of safety and usability of the in Q 47 mentioned automation systems.

And finally Q 52 and 53 urges the respondent to think about a possible automation feature not already invented that could be an advantage in their manoeuvring.

Procedure for answering the questionnaire

The questionnaire has been handed out to captains, mates and pilots from different companies when they have been at FORCE facilities in Lyngby, Denmark. The instructors have during each course considered how good the trainees were at reading and understanding English. If they were considered at least reasonably good they where given the opportunity to fill out the questionnaire. Typically they were given the questionnaire in the final quarter of the course and often on day 3 of a 4 day course (most courses lasts four days). Time to answer the questions was given (app. 25 min) between practical exercises in the simulator. The trainees were encouraged to fill in as good as they could and instructed that few answers were better than none and that data would only be used and presented in an anonymous form. They where however encouraged to give their contact details in case questions about reading and understanding their answers would later become relevant. Most of them actually did but no further contact with respondents were later done or thought necessary.

Results from the returned questionnaires

In the following text some of the interesting results are presented. In the next section these results will be analysed quantitatively and I will try to give possible explanations for their outcome.

In total 42 respondents returned their questionnaires. It is not known to me how many questionnaires that have been handed out but not returned.

Most respondents are employed in the Svitzer organization. 14 are employed in the Danish part of Svitzer, 3 in Svitzer Australia, 3 in Svitzer Humber, 4 in Svitzer Immingham, 2 in Svitzer UK and 1 in Svitzer Chile.

5 of the respondents are employed in the Norwegian company Bukser og Berging, 7 in The British Ministry of Defence and 3 in Serco Denholm[13].

27 of the respondents are captains or masters (same meaning), 6 are chief officers (or mates), 7 are pilots and 1 is VTS[14] managers or operators. 1 respondent did not give his position details.

[13] An impression of each company can be obtained by visitig their web sites: http://www.serco.com/markets/defence/marineservices.asp , http://www.bube.no/index.aspx , http://www.mod.uk/DefenceInternet/Home/ , http://www.svitzer.com/Contact+Us/?regionid=2&countryid=16 , http://www.svitzer.com/About+Us/News/News+Archive/salvage+onego+merchant

3.3 Review of the human physical and behavioural components

In Q 3, 11 answered the question regarding their primary tasks. Not surprisingly they reported classical primary tasks for their position and type of job. Tug masters and mates reported primary tasks such as:

- handling and manoeuvring of ASD tug
- assisting, barge handling and offshore operation
- harbour towage
- assisting vessels into enclosed docks and riverside berths
- spot marked
- towage service for naval/RFA/commercial vessels

Pilots of course reported “pilotage” – in sea, harbour and docking areas while the VTS operator replied “ships movement and traffic management”.

41 answered the question of years of experience in present position. Min. experience for respondents was 0 (just promoted as captain with experience as mate but not captain – in “present” position). Max. experience was 30 years. The mean was 11 years of experience in present position. Almost all values from 0 to 30 are represented and the highest percentage was found (9,8 %) for 1 year experience.

Age was also almost equally distributed between 24 and 62 years. Peaks were found in the ages 48, 52 and 54 with 3, 4 and 4 respondents respectively. The average age was 46 years.

Most had participated in courses of 4 days duration (35 = 83 %), while 4 attended a 3 day course, 1 attended a 5 day course and 1 also attended an 8 day course.

The content of the course is of course clear to the instructors and teachers at our facilities since most of them are directly involved in the planning and structuring of the courses but it is still interesting to look at respondents answer to Q 8 regarding the content of the course they have/are attending. Examples of answers are:

- ASD simulator training.
- Basic handling of the tug
- ASD tug handling and harbour and escort towing.
- Pod – manoeuvring theory, basic manoeuvring theory, advanced manoeuvring, towage, bow stern operations and bow to bow operations.
- Escort safety checklist
- Class room theory
- Enhance safety of life and property and effectiveness during operations
- Protection of environment, knowledge and skills enhancement

It must be mentioned here that some of the courses are tailor made to fit the wants and needs of the customer. And naturally the 1 and 8 days courses will be different from the “standard” 4 day course. Also it is worth mentioning that some of the subjects mentioned has to do with the theoretical, human factors and safety contents that are woven in to the practical training programme of the course and visa versa.

Q 9, about prior attendance at pod courses was answered by 36 (86 %[15]). 90% of those had not attended prior courses while 10% had.

[14] VTS stand for Vessel Traffic Service. The managers/operators role is further explained here: http://en.wikipedia.org/wiki/Vessel_traffic_service

[15] All percentages are valid percentages meaning percentages out of the respondents who have actually answered the question.

5 of those who had attended prior courses also answered the question of where they had trained. 1 had a 5 day training course in Rotterdam with the well known captain, Henrik Hensen, on the job training with another captain and then a 5 day course at Mitags, Baltimore. Another had trained 1 day at Faslane Naval Base. Still another had trained pod manoeuvring on a Mitags simulator in Chile, another tug handling on Mitags, Baltimore. The last had trained 5 days in Wallingford, England.

Q 12 asks respondents about their "hands-on-the-controls-experience". 41 answered this question. 61% have had 6 months or more experience, 5% 6 months, 10% 2 months and 24 % 1 month or less experience. The average centres around 6 months.

12 answered Q 13 about prior experiences with different sort/brand/type of controls. The answers included: Aquamaster (Rolls Royce), Lipps, Nihigata and Schottel. Most have experience with Aquamaster handles (Rolls Royce).

The personal motivation for attending courses, Q 14 was answered by 42. The text string answers includes subjects such as:

-career
-safety
-regulations
-operational advancement
-training
-economy
-experience
-personal knowledge
-try out new manoeuvres
-tug familiarization
-aspiration for knowledge of all system

etc.

A rough estimate reveals most answers in the career, safety and regulations categories. Regarding perceived company motivation for sending respondents on the courses, Q 15, similar answers are given, but more answers of "regulations", "safety", "insurance" and "economy" are given.

Q 16, ideal number attending each course/class[16] was answered by 41, 32 said 4 days was optimal while 5 said 5 days, and 2 said 3 and 6 days respectively.

Q 17, a text string question trying to get respondents explaining why this number is ideal, got mixed replies. Most frequent answers where:

- all get more hands on simulation
- all got optimal use of equipment
- better individual concentration
- ability to work in pairs

[16] Since we have only one strictly dedicated ASD tug simulator and therefore only one course at a time about ASD tug handling, course and class size is similar. It is not realistically possible for us to have more people attending pure ASD tug courses than the capacity the tug simulator can take. Mostly training is performed by trainees doing practical manoeuvring in the simulator on at a time while the rest of the "class" is taking a break, studying theory, monitoring, observing and evaluating the manoeuvring captain by camera or preparing for his own exercise.

- correct amount of time on pods
- everyone gets a turn
- instructors can concentrate more in each individual
- less time waiting
- simulator space
- teacher not over loaded and questions can be asked
- sociably comfortable
- you are able to learn from each other

Q 18, a text string question about ideal crew on the simulation bridge at a time was answered by 39. Min. is 1 and max. is 4. 74% said 2 persons is ideal, 13 % 3, 5 % 1, 5% 4 and 5 % said 1 person on the simulation bridge at a time. It is important to add that the usual set – up during exercises is that one of the trainees is on the ASD tug simulation bridge while the other is typically on the simulation bridge of the assisted vessel. These answers are thereby a bit unclear as to what is thought to be the optimal number on the bridge since respondent might have thought about both bridges or only the ASD tug bridge.

Q 19, a likert scaled (points from 1 to 7) question about how satisfied the trainee has been with the course in respect of learning to intuitively use the controls, all 42 have answered. The mean is 6,29 while min. is 5 and max. is 7. 43% answered 7, 43% answered 6 while 14% answered 5.

Q 20, likert scale, regarding if course lived up to expectation of intuitive use, gave quite similar answers to those of Q 19. On the 1 to seven scale where 1 is very little, and 7 is highly, 45% rated 7, 41% rated 6, 12% rated 5 and 2% 4. The mean is 6,3.

Q 21 also got high ratings. Here respondents were asked to rate colleagues perceived satisfaction of their colleagues with the course. To this question 41% rated 7, 43% 6 and 16% rated 5. 1 being not satisfied and 7 highly satisfied. Mean was 6,2.

In Q 22, rating of perceived overall realism in the simulator, was in average rated 6,2 on the 1 to 7 scale. 43% rated 7 being “very realistic”, 38% 6, 17% 5 and 2 % 4.

Q 23 about what bridge trainees had trained on, was not used to sum up any data, but simply to check if they had used the “standard” simulation bridges (we have 7 in all) which is normally used for a ASD tug handling course.

Q 24 asked if controls where found intuitive to use (yes or no). 39 answered this question. 90% percent of these replied yes, while 10% replied no.

Q 25 asked for elaboration on respondents answer to Q 24 in text string. 29 gave their answer. Key examples of answers to this question are:

- because equal to what is onboard the real tug
- easy to use
- good feedback panels
- have worked with them for 30 years
- intuitive to use as the throttle lever indicate direction of thrust
- very precise

The reason of sameness was clearly the most represented in the answers.

3.3 Review of the human physical and behavioural components

In Q 26 those few who had replied "no" to Q 24 were asked to elaborate. The few answers given can be summed up to:

- better if all controls are identical
- "feel" of controls not good enough
- astern pitch allowed
- throttles are far to sensitive
- "you can write a book on this!"

Q 27 asked for trainee's opinion of feedback instruments in text string. Answers were for example:

- displays should be better – nearer to the operator
- excellent
- computer screen is good – should be on real bridges!
- good and clear

Q 28 asks for possible improvements of the general simulator setup. 30 responded to this question and gave very different answers. Examples are:

- better seats
- better view of close quarters – last 1-2 meters when coming alongside
- engine noise and vibration
- force readings could be better
- monitors aloft enabling view to the side and upwards when tug is healing
- fixed VHF´s
- knee operation of radio
- "noise" from VHF radios should be made
- inclusion of realistic hook-up positions (eg. dutch bits hook up)

Q 29, what could be changed for the better regarding the controls gave many replies. 22 gave their reply. Following examples can be mentioned[17]:

- "click" sound is missing for the notches indicating position neutral, 0, 2, 10, 50 and 75%.
- controls should generally be made so that notches could be felt easily
- graduation on dials and clicks on revs
- helicopter controls could be used as inspiration in the design of azimuth propulsion controls
- thumb wheel could be used
- better sensory feed back to allow greater accuracy without constantly having to look down
- notches should generally be easier to feel
- controls should be smoother
- uniformity in design of controls is needed

Question 30 asks respondents how the tug "feels" when it is manoeuvred compared to their experience from the real ASD tug. All 42 answered this question. The average rating on the 1 (not realistic at all) to 7 (very realistic) scale was 5,8. 24% rated 7, 36% rated 6, 38% rated 5 and 2% rated 5.

In Q 31 respondents were asked about something missing in relation to the "feel" of the simulator. 22 answered in text. Examples of responses are:

[17] Here it is important to point out that the Aquamaster controller we have in the simulator is the standard controller made by Aquamaster.

- depth of field
- engine noise and vibration
- weather conditions
- hard to get a feel of the tow
- certain aspects of reaction (felt) when weight comes on towing line
- smell of the ocean
- more real hook up positions
- vibration when operating with full with turns
- better wire rope handling

In Q 32 respondents were asked about their visual experience in the simulator; on a scale from 1 (not realistic at all) to 7 (very realistic). All 42 answered this question. Mean was 6,2 and all ratings fell between 5 and 7 (inclusive). 43% rated 7, 36% rated 6 and 21% rated 5.

Q 33 then asked for perceived importance of the visual quality in the simulator also on a 1 to 7 scale. All 42 answered; 69% replied 7, 26% 6 and 5% 5. Mean= 6,6.

In Q 34 respondents were to scale the quality of the sound experience in the simulator. Here the answers were more dispersed. 40 replied to this question; 13% rated 7, 28% 6, 38% 5, 10% 4 and 13 % 3. Mean was 5,2.

Q 35 surveyed the importance of the sound quality in the simulator. 42 responses were received; 26% rated 7, 36% rated 6, 31% rated 5, 5% rated 4 and 2% rated 3. Mean: 5,8.

In the next question, Q 36, elaborations of what was missed regarding the sound experience was surveyed. 22 replied and there was different answers centring on the following issues:

- load on the engines
- differentiated engine noise
- radio communications (other vessels using VHF etc.)
- louder level
- bowthruster sound
- more wind sounds

Q 37 surveyed what a course about ASD tug handling should ideally give attendees. 34 replied. Following issues of perceived importance were mentioned:

- basic idea of handling ASD tug, then more hands on, then more advanced manoeuvring
- understanding and knowledge of own and tug's limitations, capabilities and weaknesses.
- how to do tug operation safely
- better knowledge of ASD tug handling in critical situations (conditions)
- confidence
- confidence across full spectrum of possible employment
- confidence and ability to carry out normal and emergency manoeuvres
- experience
- opportunity to try out new things and experiment
- practical and theoretical use of ASD tugs
- sense of security and assurance of job effectiveness due to quality and high maneuverability of the vessel
- time on pods

Q 38 then proceeds to survey the degree to which the actual course has lived up to these parameters given in Q 37. 41 replied; 39% rated 7, 51% rated 6 and 10% rated 5. Mean was 6,3.

Q 39 asks for particular instruments/equipment that respondents would like to have on the simulation bridge which is not already there. 28 answers were received. 22 out of these replied “no”. Among the received answers were:

- AIS display
- More real instruments instead of pc versions on flat screens
- Better winch panels with tension indication

Q 40, about respondent’s thoughts of missing subjects or issues in the course content on ASD tug handling, was answered in text by 24. 16 of these replied “no”. Examples from the remaining answers are:

- 4,5 days is to short
- assessment by tutor at the end of the course
- alongside towing as a composite unit
- impact of wash when assisting berthing and un-berthing smaller and lighter vessels
- working in fog

Q 41 is somewhat similar to the Q 37. 41 answers were received. Here respondents were asked for their opinion of what they think is most important to learn on and ASD tug handling course. I have therefore chosen to present examples different from those given in Q 37:

- bow to bow operations
- crisis management
- how to keep calm and in self control
- finding the safe zone in which the vessel can operate while providing the best service
- good towage practices
- gain knowledge and respect of the tug
- limits and power in different directions
- verification of the theoretical part
- safe handling
- situation awareness and to recognize when a towage operation might compromise the safety margin for the tug and crew
- what are the vectors/forces

Q 42 concerns the importance of the controls in the ASD tug simulator being exactly the same as on the tug the trainee is training for to handle in real life. On a 1 to 7 scale respondents were asked to rate this question; 42 replied, 33% rated 7, 31% 6, 19% 5, 12% 4 and 5% rated 3. The mean ending on 5,8.

A similar question was asked regarding the feed back instruments for the azimuth controls, Q 43. All responded to this question as well: 33% rated 7, 26% rated 6, 21% rated 5, 14% rated 4 and 5% rated 3.

Q 44 surveyed the perceived importance of replicated placement of the feedback instruments: 41 answered and quite dispersed answers were given. Mean was 5 and all the scale was used with most replies on 6 (27%), 7 (24%) and 4 (22%).

To Q 45, which rated the importance of bridge design being a precise replica of the real vessel, 41 responded. All the scale was used here as well - again with a mean around five (4,8). Most replies on 6, 7 and 4.

Q 46 is not a likert scaled question but had the different answering possibilities; “Yes”, “No” and “maybe”. 41 responded; 83% said yes and 17% maybe.

Q 47 had 21 responding to automation existing on their real tug. 67% replied yes and 33% replied no.

Q 48 had 14 responding, where 12 replied “autopilot” and the remaining two replied “joystick”.

To Q 49 12 responses were received. 5 rated 1 “safe” while 3 rated 2 and one respondent rated 3, 4, 5 and 6 respectively.

Q 50 about usability of the of the automation system in question, 11 replied, 36% “highly usable” (rating 1), 27% rating 2 while 18% (2 respondents) gave the rating 5 (the same respondents who had mentioned joystick as automation feature.

Q 51 then asked respondents to elaborate on this answer about usability of the mentioned automation feature. Just 4 replied to this question. One was talking about experiences with joystick onboard and said:

“…on a new bouy laying barge. When joystick was put to neutral wash pushed buoys and workboat away!”

The other three answers concerned autopilots and the replies were:

- the autopilot has worked well even in poor weather
- switching over to autopilot is not simple enough
- there are that many systems!

Q 52 and 53 together got 4 replies. The wishes for automation features that would be considered beneficial in connection with the ASD tug use/manoeuvring was:

- coupling of the pods for longer voyages
- every type of automation is very important if improved
- slow side step

Discussion of results

In this section the results are discussed focusing on issues thought to be of relevance to the challenges of ASD tug manoeuvring/handling and simulator teaching/training. During the discussion main points from the interview data and data gathered during the observations onboard the ASD tug in real life are drawn in as well.

Statistical analysis of data

A correlation analysis was made of the answers. This was done to get an overview of possible correlations between the answers given to the different questions. To check for inter reliability a test was run in SPSS. 26 of the variable scales were compared and the Cronbach Alpha coefficient was found to be 0,63. This value is not high though (high is usually between 0,75 and 1). But we still found it reasonable and high enough to draw meaning from the results (keeping in mind that this project is not research but basically gathering of information).

3.3 Review of the human physical and behavioural components

Pearson correlation was used on all relevant variables in the data set from the questionnaire to look for co-variation. It is important to remember that correlations do not tell us if there is any cause-relationship between variables; meaning one variable is causing the other to be high. But it does tell you if they are in some way connected. If there is a strong correlation between for instance ratings on two questions in the questionnaire across the total data this means that there is a tendency that respondents rating the one question highly also rated the other question highly. This can be interpreted as the high rating on one question having some influence on the high rating on the other. An example from our data set is the correlation between perceived collegial general satisfaction with the course and the perceived visual quality in the simulator. The correlation of 0,77 is highly significant (<0,01, N=42). From this we can interpret that there might be a connection. At least we can say that when visual experience is rated highly collegial satisfaction with course is also rated highly. But we can not say that the one is causing the other.

Since the Azipilot project is generally about *"the intuitive use of azimuth propulsion and the controls for the steering and control of the azimuthing propulsion system"* we can meaning fully look at correlation between the rating of Q 19:

"What is your general satisfaction with the actual course regarding intuitive use of the azimuth controls?"

and other relevant variables (answers to other questions which are not text string). In the table below the correlation results are listed. As you will notice not all correlations are significant but this in itself can still be discussed, and this is exactly what I will do in the table below.

	"What is your general satisfaction with the actual course regarding the intuitive use of azimuthing controls?"		
	Correlations	Significance (2-tailed)	N
Years of experience in present position?	0,172	0,283	41
Age?	-0,067	0,672	42
How much hands-on experience have you had with operation of azimuthing controls?	-0,009	0,957	41
Does the training experience correspond to your expectations of learning to intuitively use the controls?	0,826**	<0,01	42
What is your impression of your colleague's satisfaction with this training?	0,860**	<0,01	42
What is your opinion of the overall realism in the simulator?	0,654**	<0,01	42
How do you think the manoeuvring of the tug in the simulator "feels" compared to real life?	0,384*	0,012	42
How realistic is the visual experience in the simulator?	0,635**	<0,01	42
How important is the visual quality in the simulator?	0,316*	0,042	42
What do you think of the sound experience in the simulator?	0,463**	0,003	40
How important is the sound quality in the simulator?	0,302	0,052	42
To what degree has this course lived up to ideal expectations?	0,703**	<0,01	41
How important is it that the make, type and model of controller…is a replica of a real tug?	0,228	0,146	42
How important is sameness of feedback instruments?	0,472**	0,002	42
How important is replicating placing of feedback instruments in simulator?	0,219	0,169	41
How important is replication of general bridge design in the simulator?	0,216	0,175	41
Would you ask for azimuth operation course if not offered by employer?	-0,011	0,944	41

**significance <0,01

* significance <0,05

Table of correlation between Q 19 in the questionnaire about attendees' general satisfaction with present course regarding intuitive use of azimuth controls and some of the other relevant questions asked.

3.3 Review of the human physical and behavioural components

Before we try to interpret the correlations we must as previously mentioned remember not to treat them as cause-relationships but as indication of co-variation. My interpretations in the following are therefore somewhat speculative and could prove wrong or inconsistent during further analysis or research (more and differently designed returned questionnaires for instance). We must also remember that the measurement done with the questionnaire as a tool does not strictly differentiate between the simulator as such and the other training and education that is performed through instructor and classroom facilities etc. And factors such as instructors personality, personal attitude and weighing of issues during the training/course days are no doubt very powerful factors that must play a significant role. But these factors are not directly measured in this project.

Going through the results of the correlation analysis I will also draw upon the data obtained in the interview with the expert ASD tug master and instructor (see annex).

General satisfaction, age and years of experience

If we start from the top of the table no significant correlation is found between general satisfaction and years of experience in present position. This can be interpreted as meaning that the course in its total has a structure and a content that satisfies both experienced and less experienced captains, mates etc.

The non significant correlation between own age and general satisfaction[18] indicates that persons of different ages does not for any reason (maritime conservatism or old view on how training is supposed to be) view the course, its content, structure and the function and quality of the simulator differently. I did before analyzing the data speculate that older captains with more experience might believe that onboard training in real situations was the only way to intuitively train for ASD tug handling, but this does not seem to be the case.

This point is supported by data from the interview where the instructor has no experience of age or experience being a problem regarding simulator training for intuitive use of ASD tug control/handling/manoeuvring. The instructor has experienced some differences, but not in their attitude towards simulators as such:

"I: Is there any difference of age and ability to learn to operate the azimuths? Is there any difference in age of starting point for operating azimuths and how easy it is for them to learn?

B: That would be a guess from my side…

I: But if you think of your own experience regarding this issue…

B: Well – generally – the older the people the more experience they normally have. No matter what kind of experience they have beforehand some of it will be relevant and transferable to this way of manoevering. I would say that if you take experience and how fast they learn the older will probably learn a little slower but have more experience while the younger would learn a little faster but have less experience from earlier resulting in approximately the same total learning during the course. It is hard for me to say. But experience is an important factor. Yes – the younger probably learn a little faster.

I: I think maybe some of the experience could be that you should be a little more cautious. The more experienced might not "jump forward" without first being sure they know exactly what they are doing?

B: Yes – and the older are maybe a little to slow reacting sometimes in stressful situations. With this kind of tug you sometimes have to react swiftly and give full throttle to safely handle a situation. You can say that the older are a little more afraid to use the power at hand".

(Interview, p. 12-13)

[18] Whenever I write "general satisfaction" in the following text in this chapter I mean "general satisfaction with the actual course regarding the intuitive use of azimuthing controls".

Time of "hands on experience" before attending course and satisfaction
The next correlation not significant between hands on experience and satisfaction also gives the impression that the course offers what attendees need. Of course each course is to some degree structured to fit the actual needs of the individual trainees. On the first day their abilities and experience is evaluated by the instructor/instructors and content and issues gone through in the education and training is then adjusted accordingly. This can very well be the reason that the more experienced do not find for instance the difficulty level of the course too low or too high (which would have resulted in a significant negative correlation).

Intuitive learning and course living up to expectations
The significant correlation between satisfaction and to what degree the course has lived up to expectation of intuitively learning to use the controls, 0,83 (highest possible is 1,0) tells us that there might be a connection here. It is an indication that trainees at our facilities actually experience to learn what they are here for. In this case how to operate the controls intuitively. A high correlation could also be expected even though trainees had experienced low levels of satisfaction and experience of correspondence to expectations. But looking at the descriptive data; mean 6,3 for satisfaction and mean 6,3 for living up to expectations shows us they are both high. If they were both low high correlation could still have been calculated, but this is clearly not the case.

Intuitive learning and perceived satisfaction amongst colleagues
There is also a highly significant correlation, 0,86 (<0,01) between the satisfaction and perceived satisfaction among colleagues. Psychologically this is not surprising since we often form our own opinion and our perceived impression is partly based on that of the "group" in this case the fellow attendees. It is still useful knowledge because the instructor can then (at least in the case of the present structure and content of ASD tug course) "probe" the satisfaction among his trainees (by looking at their emotions and expressions verbally, facially and bodily) as an indication of "living up to" trainees' expectations and needs. The more the trainees "look" as if the course does not meet their expectations and needs the less the probability that individual expectations and needs are actually met.

Intuitive learning and perceived realism
There is in the data also a clear connection between general satisfaction and perceived realism in the simulator. This is not the same as saying that the realism in itself will control the satisfaction level, but is a clear indication that it might be a very important factor. This is also in line with the opinion among most trainers, educators and simulator manufacturers.

Intuitive learning and "feel"
The correlation between the experienced "feel" of the tug in the simulator and the satisfaction is a little lower, 0,38 (sign.: 0,012) though still clearly significant below the 0,05 level. This still means that 0,38*0,38= 14 % of the variance in one of the variables is explained by the other and visa versa. Looking at this result it is worth to remember that the "feel" of the manoeuvring in the simulator can be different for many reason – an obvious an important one being that there are only visual and sound stimuli available for the operator. Not as would be the case in real life where kinaesthetic stimuli are abundant. The movements in the simulator in our FORCE SIMFLEX simulator is actually based on true tests made in our tank facilities and are therefore very accurate. Still they can at times "feel" less accurate probably because of the missing stimuli mentioned above.

A plausible reason for the not "perfect" correlation between the "feel" and satisfaction is that it might simply not be the most important factor in the course. The course contains a lot of important stuff that also influences the experienced satisfaction. For instance thorough theory of ASD propulsion and the relation and interaction of forces when handling this propulsion system. But also theory and examples of important human factors issues. And the personality, ability and pedagogical abilities, motivation, experience and attitude of the instructor himself are important factors. The same is the case with the quality of education materials, information spreading technologies such as overhead and projectors, classroom facilities etc.

Intuitive learning and visual experience
The next pair of correlations in the table is between satisfaction and visual experience. Is the simulator realistic in its visual output to the navigator? As we already have seen in the paragraph describing the descriptive results the ranking on the visual quality was very good, mean 6,21 on the 1 to 7 scale, rated as being very realistic. In the highly significant correlation of 0,64 ($p<0,01$) there is indications of a connection between perceived visual quality and satisfaction of learning to use controls intuitively. This is not surprising keeping in mind our knowledge of how visually dependent captains are especially on tugs. They are extremely dependent on their sensing and perception to be able to make the right decisions and carry out their actions; adjusting and operating the controls in order to get the ASD tug moving in the right way. Things happen fast on a tug and the first indications of any changes in the movement and the position on a tug, changes in load on the line etc. comes to the navigator through his senses; visual, hearing, touch, haptic and kinaesthetic. But being a primary sense by which man adjusts his actions in his environment the visual sense is of immense importance. (Just try to close your eyes while keeping your balance standing on one leg!)

Intuitive learning and importance of visual quality
So naturally the importance of the visual quality must be expected to in some way influence the overall satisfaction. In other words we can say that all movements of the controls are “caused by” or done in “reaction to” visual and other stimuli. If the line is slacking adjustments to controls are made. If the tug is turning to the wrong side or not moving in the desired direction or delivering the expected pulling or pushing force the controls are adjusted etc. In this analysis 0,64*0,64= 40% of the variance seems to be explained by the perceived visual quality.

Data from the interview also supports the importance of the visual quality. Not just if the sea, buildings and so on looks just right, moves gently without flickering etc. The expert captain mentions two other examples where the visual information is of great importance in the simulator. One is the possibility to be able to look down the side of the tug while going alongside (the quay, assisted vessel or barge). The other is the possibility to see most of the side of the assisted vessel when the tug heels (this can be managed by installing flatbed screens on top of the others with some angle that can mimic the look out through top side windows on the bridge of the real tug). These are needs that concerns seeing what one is looking for. That means that visual quality as a factor is actually covering several aspects of the visual experience; visual accessibility, depth perception, pixel, update speed, details in the projected picture etc.

The next correlation, between satisfaction and the perceived importance on the visual quality in the simulator, is very interesting. This correlation is significant, 0,32 ($p<0,05$) but less significant and smaller than was the case for the experienced visual quality. Does this mean that the visual quality is more important for learning to intuitively handle the controls than the trainees think? We just can not say that on the basis of these data. But we can say that the perceived importance of the visual quality explains less of the variation in the data from the questionnaires; only one third, 10%.

Intuitive learning and sound experience
Correlation between satisfaction and the sound experience in the simulator is highly significant, 0,46 ($p<0,01$). It explains 21% of the variation. This means that the sound experience is potentially an important factor for the experienced satisfaction. This is supported by the many comments about the sound and its quality in the simulator. We are told by the respondents that they use the sound of the engines to estimate at what revolutions/pitch they run. They also listen for the "load" on the engines. This together with felt and heard vibration on the bridge gives them immediate feedback on how much more they have to work with (remaining power reserve on the engines). This is important information for instance in a bow to bow situation, where the captain must decide if the speed of the assisted vessel is to high for the tug to remain in the position forward of the bow safely or if he must let go the line or make the pilot reduce the speed of the assisted vessel.

This fact is also supported in the interview where the following is an example:

"I: What about vibrations and sounds? From the engines – regarding the revolutions of the engines? Our experience (as human factor specialists) is that it is not something you think of but something that still can play in important role in the perceived realism anyway. Because one instinctively can get an impression of what effect the engines are supplying.

B: Like old cars where you drive as much with your ears as you do with you with your eyes? Yeah – the effect could be turned up a bit, but we do have the sounds of the engine but we have turned them down because of the people working on in the offices on top of the simulator. But I think it is really good as it is. Something you could wish for that is a realistic stress factor is that combined with the engines power increases some kind of rattling sound on the bridge if you understand what I mean. Something in the vessel and on the bridge that starts vibrating when running at high revolutions on the engines and when the propellers are turned cross ways. Something that you maybe can not feel but is delivered as an input to the operator through sounds from the speakers.

I: Indicating some stress on the tug?

B: Yes – exactly.

I: Maybe indicating possible cavitations and so on?

B: Yes. "

(Interview, p. 4-5)

In the interview and from the questionnaire it was specifically communicated that the "singing" sound of the strain on the tow line was greatly missed.

Intuitive learning and perceived importance of sound quality
But even though the next correlated pair (satisfaction and perceived importance of the sound quality) is just not significantly at all 0,32 (p 0,052). This is perhaps surprising. But going through the individual answers in the questionnaires it turns out that answers are a lot more dispersed than answers for experienced sound quality. People have different opinion of this matter.

Taking a closer look at the data concerning the importance of sound quality in the ASD tug simulator reveals interesting information. The importance of the sound quality turns out to be significantly ($p<0,05$) correlated to six of the other questions:

- collegial satisfaction, 0,38 – explaining 14% of the variance
- importance of visual quality, 0,34 – explaining 11%
- sound experience, 0,39 – 15%
- placing of feedback instruments, 0,33 – 10%
- importance of replicated placement of feed back instruments, 0,35 – 12%
- general bridge setup is a replica, 0,33 – 10%

This can be interpreted as if the sound quality is an important factor that might have influence on six other factors which can therefore possibly be effected positively or negatively if the sound quality is changed for the better or worse.

Intuitive learning and course meeting ideal expectations

The correlation between satisfaction and the course meeting ideal expectations is highly significant, 0,70 ($p<0,01$) explaining 49% of the variance. In order to try to explain this result it is necessary to look at the other correlations to "meeting ideal expectations". Here we then find that question is highly significantly related to; expectation to learn intuitive use of controls (41%), collegial satisfaction (50%), overall realism (24%), "feel" (43%), visual experience (46%), sound experience (20%) and "real" and "same" feedback instruments (23%).

Intuitive learning and copy of controls

In this light the correlation between satisfaction and controls being an exact replica of the ones on the real bridge might be surprising to the observer. This correlation is both low and insignificant. Looking at the individual answers this comes as no surprise however. If we look at the other correlations we see that people that ranks high on importance of exact replica also gives high raking of: replica of feedback instruments 0,74 (correlation), placing of feedback instruments, 0,7, bridge design as replica of real bridge, 0,68 and finally assertiveness regarding asking for course if not offered, 0,61.

Looking at the individual answers it is clear that pilots express different wants and needs than ASD tug captains or mates. Pilots do not specifically wish for setup, instrumentation and layout to be a specific replica of real bridges in the same manner. They are used to operate on different bridges and may actually *prefer* to practice on different bridges with different instrumentation and setup. They are generalists not specialist in one type of vessel as the ASD tug captains are. The tug captains naturally want to be experts on the specific tug. They therefore want the specific instrumentation and a precisely replicated placing of such instrumentation and equipment to make the context a close copy of reality.

Intuitive learning and replication of feedback instruments

The correlation between satisfaction and sameness of feed back instruments are moderate but highly significant, 0,47 ($p<0,002$). This is opposite to the result above an indication that it is important that controls type make and model are corresponding to the make type and model of the feedback instruments. This of course makes sense for the ASD tug master since he is expected to want the whole thing to be the same as in real life but it is also important for the pilot that there is agreement between the controller and feed back instrument. On vessels in real life pilots would mostly expect to come aboard the bridge of vessels and find controls and feedback instruments of same type, make and model than the opposite. Therefore training in an ASD tug simulator most have controls and corresponding feedback instruments that is expected to be on the real tug. Everything else would not make sense. Unless of course the vessel trained for in the simulator actually *has* controls and feedback instruments of different type, make and model. In that case it *would* make perfectly sense to replicate this on the simulation bridge.

Intuitive learning and placing of feedback instruments

Low or non existing correlations between satisfaction and placing of feedback instruments, replication of general bridge design and assertiveness is calculated from the questionnaire data. This can be explained by the different needs of master (including mates) and pilots. And the last correlation, assertiveness regarding demanding an azimuthing course does naturally not necessarily have anything to do with satisfaction with the present course.

Importance of simulator training of captains and mates
The importance of ASD tug captains and mates being simulator trained is clearly shown if we consider the correlation between assertiveness (asking for ASD tug training) and the other questions. Here we find highly significant correlations between assertiveness and importance of controls being the same, feedback instruments being the same, replicated placement of feedback instruments and general bridge layout being the same.

ASD tug captains and mates need to be able to manoeuvre at a high performance and safety level and one of the important ways to gain this ability is to train in the ASD tug simulator. Since every type of vessel handles differently it is therefore of great importance that the ASD tug masters and captains train in a simulator. And it is important that this simulator is as close a replica of the real tug as possible. This means high correspondence between simulator-ship movements and those of the real tug (possible because of the precise mathematical model). But it also stresses the importance of replica of bridge layout (context correspondence), realistic visual and sound experience and fitting the simulator with exactly the same controls, type and placement of feedback instruments and other important nautical and communication equipment found on the bridge of the real tug they are training for to handle. It is a psychological proven fact that something learned at one point in time is most easy to recognize, recall or retrieve in an environment that is the same or close to the same as the environment in which is was originally learned (stored in memory).

Factor analysis of data from questionnaire
The many received questionnaires give a lot of data as we have seen. And we have used these data in the statistical method of correlation. The results of the correlation have been analysed in the above paragraph. Next I will use factor analysis to search for possible underlying factors that might explain the patterns of correlations. From the correlations mentioned earlier we can not meaningfully generate any hypotheses regarding the causal mechanism behind the answers. We will however have a better shot at that after we have applied the factor analysis method. A factor analysis therefore might cast more light on what the questionnaire is actually measuring (underneath the surface).

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6,215	36,557	36,557	6,215	36,557	36,557
2	2,773	16,309	52,866	2,773	16,309	52,866
3	1,631	9,593	62,460	1,631	9,593	62,460
4	1,442	8,480	70,940	1,442	8,480	70,940
5	1,217	7,161	78,100	1,217	7,161	78,100
6	,817	4,809	82,909			
7	,638	3,753	86,662			
8	,560	3,297	89,958			
9	,436	2,565	92,524			
10	,388	2,283	94,807			
11	,269	1,582	96,389			
12	,176	1,033	97,422			
13	,162	,950	98,372			
14	,121	,714	99,086			
15	,084	,492	99,579			
16	,056	,328	99,906			
17	,016	,094	100,000			

Extraction Method: Principal Component Analysis.

3.3 Review of the human physical and behavioural components

In the orthogonal rotation there is mediocre KMO (0,531), Bartlett's test is highly significant (p<0,001). Both tests indicate that factor analysis is appropriate. SPSS finds 5 factors with Eigenvalue >1. I have chosen to focus on the first 3 factors. Factor 1 explains app. 37% of the variance, factor 2 16% and factor 3 10%.

Factor 1
I will name the first factor *overall satisfaction with the course* since most of the responses that loads on this factors has something to do with the perceived, experienced or felt quality of the simulator and course.

In order of highest "loading" on this factor is:

1. Collegial satisfaction
2. General satisfaction regarding intuitive use
3. Visual experience in the simulator
4. How course lives up to ideal expectations
5. Importance of feedback instruments sameness
6. Expectations of intuitive learning

Factor 2
This factor I have chosen to call need for *realism in the simulator*

In order of highest "loading" on this factor is:

1. Importance of controls make, type and model
2. Importance of placing of feedback instruments
3. Importance bridge setup replication of reality
4. Importance of sameness of feedback instruments
5. Importance of overall realism
6. Expectations of learning of intuitive use of controls

Factor 3
I call this factor *Age and experience versus detail correctness*

In order of highest "loading" on this factor is:

1. Age
2. Years of experience
3. Low visual importance
4. Low rating of overall realism
5. Low rating of "feel"
6. Low rating of importance of make, type and model of controls

Discussion of factor analysis results (the three factors)
The factor analysis can be interpreted as an indication that responses given from navigators who have trained at our facilities basically are supplying their answers on the basis of three underlying factors that are different from each other (even though individual questions can load on more than one factor)[19].

[19] It is important to remember that the design of the questions in the questionnaire to a great deal guides the respondent to respond in a certain way.

3.3 Review of the human physical and behavioural components

These factors I have boldly named *"overall satisfaction with the course"*, *"realism in simulator"* and *"age and experience versus detail correctness"*.

Overall satisfaction in the course in this factor analysis explain 37% percent of the variation of the answers to the other questions in the questionnaire. This means that the questionnaire for a large part asks into basic satisfaction with the course. Satisfaction is a good aspect to measure since it is normally expected that satisfaction encompasses the more detailed positive and negative parts of the experience the individual has had during the course. Satisfaction can be seen as the individuals total evaluation of the course and its duration, contents, quality, effectiveness and efficiency. Weighed on an "inner scale" which is comprised of his prior knowledge, abilities, experiences and preferences?

Realism in the simulator as the second most important factors explains 16% of variation of the answers given in the questionnaire. We know realism is an important factor in simulator production and design and it therefore comes as no surprise that the questionnaire is probing into this issue. But we also know that realism is not enough in itself to produce a high level of satisfaction as an ASD tug handling course also contains important theory of manoeuvring and Human Factors and for a large part is also very dependent on the knowledge, experience and pedagogical capabilities and attitude of the instructor. And finally we also know that the building, classroom, and available education media and so on is important in order to support a satisfactory course.

Age and experience versus detail correctness turns out to be the third underlying factor measured by the questionnaire. It surely does not explain very much of the variation (10%). It is though still interesting because the result can be interpreted as (even if small) evidence that experience and older age has a tendency to make trainees at our facility focus less on the visual importance, overall realism, exact replica of bridge, controls and equipment and more on the principal learning and experience they can gain at the course. A speculative interpretation of this result can be that these very able, experienced and mature guys will easily feel whatever difference there will always be between the simulator and their real tug and difference in the sensory stimuli they get in the simulator compared to real life. But still they think the course is very valuable because they have the opportunity to train unusual complicated or even "at the limit" manoeuvres they would never risk in reality and also because they are given the opportunity to consolidate their theoretical knowledge and share their experiences with "colleagues".

Conclusion, task 3.3.7

A lot of data was extracted from the interview with the expert ASD tug master. It revealed specific ergonomic problems with a certain type of azimuth controller that should be considered in any future process of redesign. It also discussed the need to consider the level of replication (fidelity[20]) thoroughly. If the simulator is used for vessel type specific training it is surely important that the fidelity is as high as possible. This is true for stimuli for all the senses; seeing, hearing, touch (and in theory also smell!). Continued development of the visual accessibility, sound quality and possibility of actual physical movement of the simulator seems important.

The possibilities of certain pedagogical methods (for instance the instructor standing close to the trainee while still being able to operate the simulator steering system) proves valuable to consider when designing the simulator bridge – even though this can turn out to be in conflict with the aim for highest possible fidelity.

[20] The resemblance between the simulator bridge and the bridge on the real vessel regarding stimuli and perception.

3.3 Review of the human physical and behavioural components

Some training on board given to the mate by the experienced captain is in some situations viewed as an advantage. It decreases the duration of the familiarization and thereby maximizes the training effect in a 4 day course which is considered the optimal duration for an ASD tug handling course. However if the master or mate is expected to sail on an ASD tug with no prior experience or training in the operation of azimuth propulsion systems it is of course recommended that they train in the simulator first.
There are certain differences between the individual trainees. Some quickly become good while some never do. Some have a stronger need for a thorough theoretical understanding of the forces supplied by the propulsion system while some seem to “feel” these forces in their body. This calls for instructor and courses to try to comply with the individual needs of the trainees.

A certain kind of personality does not seem to be needed in order to become a capable ASD tug handler.

An exam at the end of the course is often discussed among companies, trainees, instructors and classification societies. There seems to be pros and cons in this matter. At FORCE Technology we can test and evaluate trainees if that is the company wish. Normally we do not. Instead the instructor from the first day of the course “probe” in to the capability of the individual in order to “frustrate” him optimally in his exercises throughout the course to ensure that he learns as much as he possible can in our course.

The for this project developed questionnaire proved to be a good source for collecting data. From these data it can be concluded that we offer education, training and facilities at a quality level that resembles the trainees’ expectations. This is the case among younger, older and more or less experienced trainees.

Just 10 % of our trainees did not have any hands on training before attending our course, while 60 % of them have had more than 6 month hands on experience at the controls on an ASD tug. This is an indication that most training is done on board. This is also the case when the navigators are completely inexperienced when it comes to ASD handling.

The trainees all seem very motivated and think that the course will enhance the safety and efficiency level in their tug work while giving them personal experience and enhance their career opportunities. Primary motivation for training ASD tug handling at our facilities seems to be “career”, “safety” and “regulations”.

The trainees think their companies’ motivation for their attendance at the course is mostly “regulations”, “safety”, “insurance” and “economy”.

As this project is about “intuitive training” is must be reported that the trainees answer on the question

“To what degree has this course lived up to expectations of intuitive use of controls?”

were average 6,3 on a 1 to 7 scale. This is of course a very good rating but there are still things in the simulator that according to the answers given in the questionnaires could be improved even though all trainees generally are very satisfied (please see mean scores on all questions in the “result” paragraph). For example it could be beneficial to install “ceiling windows” on the simulator bridge to give a better view of assisted vessel ship side when tug is heeling. A high fidelity visual look from the simulation bridge down towards the side of the tug could also be an advantage. The same goes for the quality of the sound and haptic feedback in the simulator where trainees for instance miss the possibility of hearing the load on the engines (not just the revs) and “feeling” the bumps when physically hitting quay, assisted vessel or other objects – or when the tow line is tightening up.

Another interesting conclusion is the need for simulation courses for ASD tug handling. Asked if they would ask for a simulation course if they had not been offered it by their employer, 83% replied “yes” while 17% replied “maybe” - nobody replied “no”. This clearly shows the need for simulation training and the assertiveness of the trainees. They are perfectly aware of the complexity and importance of learning to use the azimuth propulsion system safely and in an optimal way.

The correlation and factor analysis show interesting results that can be studied in detail in the respective paragraphs. But generally it can be concluded here that there are many factors that each contribute to a successful training course in intuitive use of an azimuth propulsion system. And it is definitely worthwhile to consider how well your organisation, facilities, simulator and instructors live up to each of these factors. The better they live up to each factor, the goal set by your organisation and the expectations of your customers the higher the possibility of successful training and transfer.

References

Atkinson, R. C & Shiffrin, R. M. (1968) Human memory: a proposed system and its control processes. In: Spence and Spence (eds.) *Advances in the Psychology of Learning and Motivation: Research and Theory, vol. 2.* Academic Press.

Baddeley, A. (1997) *Human Memory: Theory and Practice*. Psychology Press.

Carswell, C.M. & Stephens, E. C (2006) Information Processing. In: Karwowski, W. (eds.) (2006) *International Encyclopaedia of Ergonomics and Human Factors, vol. 1*. Taylor Francis.

Vicenzi, D. A., Wise, J.A., Mouloua, M & Hancock, P. A. (2009) Human Factors in Simulation and training. CRC Press.

Wickens, C.D. (1992) *Engineering Psychology and Human Performance* (2nd ed.). Harper Collins.

Woodward, Dr. M. D. (2008) Annex 1 - Description of Work. Azipilot Project. University of Newcastle.

Questionnaires (returned) Kept as confidential in FORCE filing system.

Baerentsen, K. B., 2000. *Intuitive user interface.* Scandinavian Journal of Information Systems, 12: 29-60.

Prof. Costa, G., Institute of Occupational Medicine University of Verona, 1995. *Occupational stress and stress prevention in air traffic control.* International Labour Office Geneva. Working paper CONDI/T/WP.6/1995.

Kowalski-Trakofler, K.M. and Vaught, C. *Judgment and decision making under stress: an overview for emergency managers.* National Institute for Occupational Safety and Health, Pittsburgh Research Laboratory.

Vaught, C., Brnich, M., Mallett, L., Cole, H., Wiehagen, W., conti, R., Kowalski, K and Litton, C. (2000). Behavioural and organizational dimensions of underground mine fires", Information Circular 9450, US Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH) Publication dissemination, Cincinatti, OH.

Selye, H. (1956). The stress of Life. New York: McGraw-Hill.

Shelton, C. P., 1999. Human Interface/Human Error. Carnegie Mellon University 18-849b Dependable Embedded Systems.

Naumann, A. Hurtienne, J. Israel, J.H., Mohs, C., Kindsmuller, M.C., Meyer, H.A., Huβlein, and the IUUI Research Group . *Intuitive Use of User Interfaces: Defining a Vague Concept.*

Annexes:

1) Questionnaire
2) Transcription of interview with expert ASD tug master and instructor

Questionnaire

Usability and intuitive control of azipod/-pull propulsion control systems:

- **to be filled in by bridge crew**

Introduction:

The rapid increase in the number of vessels being fitted with azimuth control devices has risen sharply in recent years and has rapidly established itself in the maritime industry. Azimuth control devices provide an innovative solution for ship propulsion and steering that offers significant economical and operational advantages when manoeuvring in close quarter situations within the confines of harbours and ports. However, these devices manoeuvring control can become complicated and counterintuitive. It is the assumption that the rapid evolution and introduction of azipod/-pull propulsion systems has not allowed sufficient time for the establishment of a proper training regime amongst bridge officers who are faced with the infinite number of control options azimuth devices offer.

The School of Marine Science and Technology at Newcastle University in the UK has put together a project, part funded by the European Commission, aimed at bringing together Naval Architects, Ship Owners, Simulator Manufacturers, Maritime Training Establishments and Marine Pilots. The project, entitled AZIPILOT, commenced in November 2008 and will run for three years during which time it will amass sufficient material appropriate for the formulation of a dedicated maritime training programme, make recommendations for specific regulations and criteria specifically related to the use of azimuth control devices, amass sufficient material appropriate for the formulation of a dedicated University level lecture series and finally to publish an ongoing dedicated technical journal to disseminate the findings of the project.

Force Technology is a partner in this EU project and one of our tasks is to gather further knowledge on the training, bridge officers undergo in the use of azipod/-pull propulsion systems.

Any contribution is welcome. You are welcome to answer the questionnaire anonymously. But please note company name and job title. The information from your particular answers will not be supplied to your company and will be used in a generalised and anonymous form only. Thank you very much for your contribution☺.

Please turn page to start answering the questions

→

3.3 Review of the human physical and behavioural components

(Please answer the following questions the best you can. If you are asked to scale your answers please mark the correct number/statement with a circle.)

Questions:

The name of your company:

Your position:

Your primary tasks:

Years of experience in present position:

Your age:

Name of present azipod/-pull course:

Duration of present course (days):

Content of present course:

Have you attended azipod/-pull courses before?

-if so, please note which, where, duration, and describe their contents briefly:

Type and name of vessels you are operating, supposed to operate on or training for in this course:

How much "hands-on" experience have you had with operation of azipod/-pull propulsion controls and systems in your maritime career (check √ best fit)?

- ☐ 1 month or less
- ☐ 2 months
- ☐ 6 months
- ☐ More than 6 months

3.3 Review of the human physical and behavioural components

If you have prior experience please note with which azipod/-pull systems and with which controller devices (Rolls Royce, ABB etc.):

What is your personal motivation for attending azipod/-pull courses (career, regulations, insurance, safety, economy, other)?

What do you think is your company's motivation for sending you on azipod/-pull courses (regulations, insurance, safety, economy, other)?

What do you think is the ideal number of crew to attend each course/class?

Why is that the ideal number?

What do you think is the ideal number of crew on the bridge during the exercises?

What is your general satisfaction with the actual course regarding intuitive use of azipod/-pull controls?

Low High
1 2 3 4 5 6 7

Does the course experience correspond to your expectations of learning to intuitively use azipod/-pull controls?

Very little Highly
1 2 3 4 5 6 7

What is your impression of your colleague's satisfaction with this azipod/-pull course?

Not satisfied Highly satisfied
1 2 3 4 5 6 7

What is your opinion of the overall realism of the bridge setup in the simulator?

Not realistic at all Very realistic
1 2 3 4 5 6 7

3.3 Review of the human physical and behavioural components

What simulation bridges have you trained on? (if you have attended courses at Force Technology, Lyngby)

A B C D F G H

(If you have trained on more than one bridge, please mark accordingly)

Are the controls for the pods easy and intuitive to use:

□ Yes □ No

If yes, why?

If no, why not?

What do you think of the simulators regarding the feedback instruments for the azipod/-pulls (instruments showing revolutions and angle of thrust- other)?

What could be changed for the better regarding the simulator bridge setup?

What could be better regarding the design of the azipod/-pull controls?

How do you think the manoeuvring of the vessel in the simulator "feels" compared to real life;

Not realistic at all Very realistic

1 2 3 4 5 6 7

Do you miss anything particular regarding the way the simulator "feels" compared to real life?

What do you think about the visual experience in the simulator;

Not realistic at all Very realistic

1 2 3 4 5 6 7

How important is the visual quality in the simulator;

Not important Extremely important
1 2 3 4 5 6 7

What do you think of the sound experience (sound) in the simulator;

Not realistic at all Very realistic
1 2 3 4 5 6 7

How important is the quality of the sound (sound) experience in the simulator;

Not important Extremely important
1 2 3 4 5 6 7

Do you miss anything particular regarding the sound (sound) capacity of the simulator?

What do you think a course about azipod/-pull propulsion should ideally give the attendants?

To what degree has this course lived up to these ideal parameters;

Not at all Highly
1 2 3 4 5 6 7

Do you miss anything particular regarding instrumentation on the simulator bridge, specifically or generally?

Is there anything you would like azipod/-pull courses to offer that you do not think is already available (or not sufficiently covered)?

3.3 Review of the human physical and behavioural components

What do you think is the most important for you to learn while attending courses in azipod/-pull operation?

How important is it that the *make, type and model of the azipod/-pull controls is exactly the same* in the simulator as it is on the ship you are being trained to handle?

Not important at all Very important
1 2 3 4 5 6 7

How important is it that the feedback instruments (ex. angle of thrust and revolution indicators) *are exactly the same and shows exactly the same* in the simulator as they do on the vessel you are being trained to handle?

Not important at all Very important
1 2 3 4 5 6 7

How important is it that the controls and the feedback instruments are *placed exactly the same way* on the simulator bridge as they are on the vessel you are being trained to handle?

Not important at all Very important
1 2 3 4 5 6 7

How important is it that the general bridge design in the simulator is an exact copy of the bridge design on the vessel you are being trained to handle?

Not important at all Very important
1 2 3 4 5 6 7

If you were to function on a vessel with azipod/-pull propulsion systems, had no prior experience in operating such systems, and was not automatically offered a course by the company, would you ask your company for it?

Yes No Maybe

Does your vessel(s) have any kind of automation for the steering or propulsion controls of the pods/pulls?

If so – which?

3.3 Review of the human physical and behavioural components

What is your opinion of the safety and usability of these automation systems (answer only if you have experience with such system)?

Safety:
Safe Unsafe

1 2 3 4 5 6 7

Usability:
Highly usable Useless
1 2 3 4 5 6 7

-please explain further in a few words:

Can you think of an automation feature (ex. Coupling of pods, regulation of relative angle between pods) that could be beneficial to your specific vessels/operating conditions/situations?

If so – which?

Will it be possible for Force or another partner in the Azipilot EU-project to ask you for more information if needed?

If so, what are your contact details?
Mail:______________________________Phone: _____________________________

Thank you very much for your participation. You can follow the project on the web: http://pilot.ncl.ac.uk

Please return this questionnaire to:

Nikolaj Hyll, nnh@force.dk or:

Hjortekærsvej 99
2800 Kgs. Lyngby
Denmark

3.3 Review of the human physical and behavioural components

All replies will be treated in confidence. It would be helpful if the person completing this form provide his/her contact details so we may contact him/her directly for further information if required.

Transcription of interview with expert asd tug master and instructor

Interviewer: I Nikolaj Hyll, Force Technology, Hjortekærsvej 99, 2800 Kgs. Lyngby, +45 72 15 77 60, nnh@force.dk,
Interviewed: B Experienced instructor and captain on ASD tugs.
Interview date: 17.04.09
Interview place: Simulator Bridge H, Force Technology, Lyngby

I: I will start the interview now. I will start by asking you about your age.

B: I am 50 years old.

I: Your education – you are a master mariner, correct?

B: That is correct, yes

I: Have you been doing something else before starting your education and career as a mariner?

B: No, I started directly at the Sea Training School. I was hired by the company A.P. Moller as an apprentice.

I: What vessels have you been sailing?

B: After I finished my education as a master mariner I have been sailing on tanker vessels, mostly LPG, until I was hired by the company Svitzer. I was hired by Svitzer 20 years ago and have been sailing tugs ever since.

I: So in total – how many companies have you been employed in?

B: I have been employed in Maersk (A.P. Moller) and in Svitzer, That's it.

I: You mentioned the ship types before as well…. LPG?

B: Yes LPG, Liquefied Petroleum Gasses. That is gasses that are less volatile than the natural gasses. It is mainly butane and propane and gasses like that we can contain under low pressure, were the LNG have much higher pressure and much lower ?) temperature.

I: So all the vessels you have been on before you were employed in Svitzer had traditional propulsion systems?

B: Yes they had. One propeller, one rudder and fixed propeller – stop and start with air pressure when going from ahead to astern and so on.

I: Then at Svitzer, the first time you started sailing with azimuth –

B: Yes azimuth is the propulsion system fitted on Svitzer`s tugs. The abbreviation is ASD - tug. Azimuth Stern Drive Tug. This means that two azimuths are positioned at the aft end of the tug. That is different from azipods which are used primarily on the larger vessels. It is different from ship type to ship type on the larger vessels how the system is made up. Often they have one fixed propeller and one or more azipods that enhances their manoeuvrability considerably. In stead of fitting bow and stern thrusters it makes good sense to fit these propellers and make use of them when sailing ahead as well.

I: The controls – the handles for controlling the azimuths you have been using on the Svitzer tugs are made by Rolls Royce and exactly the same as the one we are standing next to here in the simulator, correct?

B: Yes they are from Aquamaster and are the one I have been using.

I: And Aquamaster – they are from Rolls Royce?

B: Yes, Rolls Royce is in charge of that.

I: There are no differences from these handles fitted in the simulator and the ones you have on Svitzers tugs? Have they changed during the last years? Are there different models? And what about the design?

B: The design when you just look at them is exactly the same in all the tugs Svitzer owns. But it is as if the ones we got in the beginning were of considerably better quality than the ones we got for the last tugs. Therefore as the controls we stand next to here in the simulator they are of lower quality.

I: When you say lower quality what exactly do you mean?

B: It means that they seem very plastic like in the hands and then the notches at 0 degrees and 90 degrees are very difficult to feel. And the notches in the lever for revolutions and pitch are very difficult to feel as well. And when the controls are used a lot and get worn this problem gets worse and worse. It is plastic like all the way trough. But I know that Aquamaster make one of another quality which is more expensive of course but where you get the sensation of quality when you handle them.

I: So different models are available that have the same functions but are made of different materials?

B: Yes. They also make some where there is a button in the handle for switching on the VHF radio. This is a smart solution as operating the radio can often be a problem when you are handling the tug. Both of your hands are busy handling the controls so it comes in very handy if you have a talk switch for the radio.

I: This possible function is something you have heard other captains and officers express a demand for?

B: I know of many colleagues that would like to have this function built into their controls – yes. But of course – it costs extra and is often not installed in order to save money.

I: This switch, if installed, where will it typically be sitting? – on the starboard controller?

B: I should think it most practical to fit it on the starboard controller as most of us are right handed.

3.3 Review of the human physical and behavioural components

I: I will now jump to talk about the equipment and set up we have in our simulators and especially in this bridge (H-bridge). If you look at this simulator critically how do you then think it works for education and use regarding training and handling of azimuth tugs?

B: This setup is made in cooperation with Svitzer and as a copy of one of their latest tug models. It has been made to come as close as possible to their M-class tugs. And it has been the goal from the beginning that it should be a replica. Therefore the setup is the same as on the real tugs. This is clever. Whether this setup is the best in the real world is another issue, but as for the simulator it resembles the real world the officer will find on the bridge. There are some differences visually though since the surroundings are shown on a number of widescreens. But as for the manoeuvrability it is exactly the same and all taken into consideration I find it very very good.

I: If you have to prioritize how important it is that the setup is exactly the same in the simulator as in reality thinking of training… how important is it?

B: If we focus on training now for a specific vessel then I think it is a clear advantage that it resembles the specific vessel. Especially if the crew have already been on that specific vessel before and comes to our facilities and are able to recognize it. That is what makes it possible to almost jump pass the first day in the course where the familiarization is normally done.

I: It will in that case not be necessary to spend time on familiarization?

B: No, at least not to the same degree as one would normally do.

I: What do you think there is generally the biggest marked for? As in Svitzer where the crew after they have been employed first are mustered on the vessels for some weeks and then comes to the simulator to train or that crew comes here to train before they are embarking the vessels?

B: It depend on what crew you have or what crew is available in the areas where the vessels are supposed to operate. We had some from South Africa that did not have any knowledge of ASD tugs whatsoever and they were to handle newly delivered ASD tugs. But they did not have any crew that could handle them at all. Seen from that perspective it is a really good idea that they come to us first. But then we just have to realize that what they are here for is to learn the absolute basic handling of the tug. That is to learn how to sail back and forth and turn.

I: But such knowledge and practice the crew that come here from Svitzer will already have?

B: Most often that would be the case, yes. You can easily spend two days with the basic stuff before people start to think in vectors in their heads and hands. That can be skipped if they have had the opportunity to try this in the real world first. And then a four day course will be 4 effective days of where you can train the actual purpose. We are able to deliver both services both it is a question of what the purpose of the course is. If the purpose is to push, tow and assist other vessels with the tug, then the better trained they are in the general handling when then come to the simulator the more time can be spend on the more difficult manouevers and operations.

I: Are there anything in this simulator that you would characterize as design flaws?

B: No I can think of any direct flaws.

I: If we focus on being able to deliver state of the art training in the future with a simulator like this one, and let us focus on the customer being Svitzer. If we try to think of what could be even better in the future in order for us to be a step forward of the second best what would you then say was necessary to do? That could be about extension, physical movement of the bridge platform, enhanced sound quality etc.

B: In that case I think the physical movement have been considered from time to time but I think it is totally unnecessary. When you look through the door to the simulator and see the people on the bridge leaning to the side almost falling it is obvious that the degree of realism from the visual feedback alone is enough. So I do not think physical movement is needed. At least not physical heel. But what could be an advantage is when we go alongside another vessel it would be useful with some kind of bumping feedback. That sensation is not offered for the operator in the simulator when he hits, actually physically hits, the vessel.

I: Some kind of realistic haptic feedback?

B: Yes. Something that could give at small push of some kind that indicate for the operator that now I hit it.

I: Could that be some kind of vibration or….?

B: Yes. I do not think it has to be very large. Maybe something like what you know from the joysticks used for flight simulator computer games where there is some kind of feedback in the joystick alone. That gives a completely different experience of…

I: What about vibrations and sounds? From the engines – regarding the revolutions of the engines? Our experience (as human factor specialists) is that it is not something you think of but something that still can play in important role in the perceived realism anyway. Because one instinctively can get an impression of what effect the engines are supplying.

B: Like old cars where you drive as much with your ears as you do with you with your eyes? Yeah – the effect could be turned up a bit, but we do have the sounds of the engine but we have turned them down because of the people working on in the offices on top of the simulator. But I think it is really good as it is. Something you could wish for that is a realistic stress factor is that combined with the engines power increases some kind of rattling sound on the bridge if you understand what I mean. Something in the vessel and on the bridge that starts vibrating when running at high revolutions on the engines and when the propellers are turned cross ways. Something that you maybe can not feel but is delivered as an input to the operator through sounds from the speakers.

I: Indicating some stress on the tug?

B: Yes – exactly.

I: Maybe indicating possible cavitation and so on?

B: Yes.

I: Do you have anything more to add to our discussion of the setup of the simulator?

B: No as long as the setup is as it is and we want to use it for training for a specific tug then it is perfect. You could imagine other tugs – if other types of tugs was modelled to fit this simulator and it was necessary to have both a for and aft bridge – if we can do that visually alone... that is a good question.

I: I have personally been thinking about what kind of effect it has on the operators perception visually if the window bars are indicated by the edges of the flat screens as they are now or if they are made up by an exact visual model of the actual view though the windows on the bridge. Do you think that has an effect? Do you look for something through the windows and monitor that you can not monitor in the same way because the view is a little different – or things and objects you would like to monitor along the side of the tug that we can not see here?

B: Yes, there actually is. When we go alongside another vessel it is quite difficult to determine the distance to them. In the real world we can see more to the sides and downwards. We have actually discussed that the left and right bottom screens forward, could be replaced by still photos, and the screens moved to show a lower view at the sides. That would help a lot.

B: I suppose it is a question of money. Likewise it could also be beneficial – especially when we talk about tug escort training – you could wish for more screens upward. In the real world there are small slanting windows upward to the sides. When the tug is escorting it is so close to the other vessel is has problems seeing where it is positioned.

I: Is it an issue when the tug is below the bow of the big vessels where you have to make sure your mast does not come to close?

B: Well – under those circumstances the tug will be 60 to 70 meters form the bow – or the tug will be even further away – so that is not a problem.

I: The tug is not supposed to be so close to the bow at all?

B: No, not at all.

I: The operator station for this particular simulator is situated right behind the screens here (behind the screen providing the visual effects for the captain manoeuvring on the simulator bridge). How does that work compared to what you are used to and think is optimal?

B: I must say that sometimes you could wish for the possibility for the operator to sit beside the captain manoeuvring – maybe with a laptop for the control of the simulator. When you sit inside the simulator – and especially when the totally inexperienced navigators are training you need to support them a lot in the beginning.

I: So in these situations the operator is supplying “standing next to – education”?

B: Yes. There are situations where you can not leave them for 10 seconds before it goes wrong. And that is often in the situation where they need to take the line from the other vessel, and therefore also the situation where the operator needs to set the line between the tug and other vessel from the desktop controlling the simulation programme. In these situations you as the operator have to leave the room. You could therefore benefit from having just some of the critical functions available for the operator within the simulator for instance to establish a towing line.

I: How about the sound and sound insulation – for instance if you call the simulator on the vhf radio from the operators station? Can it then be heard both on the radio and from behind the screens?

B: Yes it can. But it is generally not a problem.

I: But I think that when larger scenarios are played in the simulator and possibly with another type of vessel or towing/assisting operation it could be a distracting factor that the radio calls comes from different locations (analoque and digital) at the same time?

B: Yes in such scenarios it could be an advantage to have the operator control desktop further away – yes. But we do have the possibility of controlling the simulator on almost all of the other simulator bridges and control it from there.

I: What kind of podded vessels do you think can be realistically reproduced on a simulator bridge like this one?

B: Roughly any type of ASD tug. The tractor tugs with the propulsion positioned further toward the bow of the vessel I do not have very much experience with regarding how the manoeuvre and how the operating station should be for those vessels. But I will say – roughly all ASD tugs can be sailed on this bridge. But some of the realism of the setup disappears….

I: In order to realistically simulate another kind of tug do you think that the setup needs to be changed?

B: Not necessarily. It is possible to ignore the difference from a "wrong" setup and play along thinking the tug we are operating today is an imaginary one. How realistic the setup has to be for the simulator to work properly for training is a matter of discussion. In this simulator the setup was planned this way form the beginning because it is a direct agreement with the company who wanted this simulator facility (Svitzer M- class ASD tugs).

I: The most important instruments for controlling the azimuths in prioritized order – can you start going through them here?

B: The handles themselves where both pitch and revolutions are controlled. They are combined here. In principle there are two different ways of controlling pitch and revolutions. Given the Tug has pitch propellers of course. Normally when you are doing your manouvers and go to port and are assisting the vessels then we use towing – or combined mode. Where a predetermined proportion of pitch and revolutions is programmed. This is done in order to get the maximum effect of the engines. The way pitch and revolutions are combined when you increase power on your handle is pre-programmed. It is all in one lever. The same goes for turning. But if you are sailing solo and longer distances the fuel economy is better if you lock the propellers in full pitch and adjust the revolutions on another controller. And that is possible here.

I: Is that what you would call and automated function?

B: No. In real life this would just be called to operate in separate mode. It has more to do with economy.

I: The next important instrument is perhaps the feedback instruments?

B: Yes – correct. They are deeply connected. And the ones we have here are very good. And they are placed just right – they are clearly visible and you do not have to move your eyes much to read them. They are exactly where they should be and are placed in a way that even though you experience bright sunlight they are visible and easy to read.

I: What is this scale? (-pointing to the feedback instrument)

B: That is the load on one of the main engines. And that will vary as the controls are handled. In these ships we have to differentiate between where the load is. Is it on the line we assist with or is it the load on our engines? Imagine if we turn the engines against each other and order full power. That would give 100 percent load on the engines and 0 percent on the line we assist with. You can not get more than 100 percent out of your engines but you can maybe get more out of your line. The next instrument is the rev counter for the main engines. An the next is the azimuth indicator and it gives an indication of the angle the azimuth propeller is momentarily positioned in. You have to imagine that the line you see going from the propeller is the shaft or your rudder stick. That means that the way it is now positioned it will push the water astern and the tug will move forward.

I: And then there is an indicator up here…

B: Yes. That is an analogue indicator of the load on the engines or of how many revs you run your engine at. In the simulator here there is no coupling between the engine and the propeller. That means that what you see here is how many percent of your maximal revs on the propeller or you can change it to show how much pitch you are running with at this present time. And the digital readout on top of the scale that is now 0,0 and goes all the way up to approximately 26 degrees and the analogue simply shows where you are on the scale.

I: That is because you do not have any other indication of pitch in your controller or elsewhere since you are running in a combined mode?

B: No – correct. So that is actually the indicator of force – the read out of force. And next to that instrument – I must start the exercise to show you that (starts the exercise). Now the controls are adjusted so that the propellers are pointed sideways and the pitch is zero. If we then turn it – you see on the indicator – and that is of course controlled directly from the Aquamaster unit itself – so it shows how it is positioned. And not what your order for its position is. If there is some lag. So it is very important that when training in the simulator – navigators have to learn that they must always look at their feedback azimuth indicators because they are showing the real picture of what I going on with the azimuths at a given time while the controller is the medium through which you tell the engines what you want. An as it is showing here it is showing about 45 degrees to port. That means that if we put on some power the tug will start to turn to port. Now we can see that the pitch is increasing to 13 to 14 degrees which on a normal vessel will be approximately the same as hard port rudder.

I: Other instruments which are very important on this bridge?

B: Yes – now we have discussed propulsion – but we can also take a quick look on our bow thruster. It is a good example of a choice made (by Svitzer) the company that have had wishes for this simulation bridge. The cheapest solution has been chosen regarding the control of the thruster. They have bought what we call a non follow up system for rudder – emergency steering of the rudder. And that means that if we want to thrust to starboard and keep an eye of how much it increases to starboard and when we release it continues to run at – say 50 percent – where we left it. That means that when we try to use it you have to focus all your attention on this instrument and you have to watch all the time you adjust it back to zero again. And hold it with one of your hands while adjusting it. And when the instrument shows 0 again you can release the tiller.

I: What are the reasons for choosing such a system – it seems totally foolish to install something considerably worse than what you have on many leisure crafts?

B: Absolutely – I think the only reason is money and cost price.

I: I think it can have something to do with the way the guy ordering the equipment for the bridge on the tug thinks; now we are ordering a tug with two azimuth propellers so the thruster is just installed for looks and is basically superfluous.

B: That is also correct under many circumstances. What is the matter is that in Danish waters where we often have jobs in floating docks and precisely these types of tugs where you do not have winches on the aft deck, this means that you always have to tug over the bow and if the tug is lying in very narrow areas and only has a line it can be very difficult… And the bow thruster is the only force you can work with…

I: If you want to keep the tug in a certain position…

B: Yes – in the middle of a dock for instance and… you have to assist another vessel by holding it in the middle of the dock.

I: You mean that when you manoeuvre with the tug there is always a pivot point… and when your propellers are aft and you pull there will always be some swinging of the bow?

B: That is correct – yes. In open waters we do not need the thrusters that is true and that is also what we see – almost nobody used the thruster under such conditions. They even use it less than they actually want because they find out how much attention you need to focus on it in order to operate it. You simple choose not to use it. But if you had another controller for the thruster looking more like the "normal" where you can adjust it to 25 (percent) and leave it there or move it back to zero and you do not even need to look at it when you know the notches.

B: The next thing we have that is important is the operation panel for the towing winch.

I: We don't need to come closer to that subject. We will now talk about training and education – but first I need to ask you how many years you have sailed on tugs?

B: Twenty years on tugs and fifteen on ASD tugs. And twelve years as a captain.

I: Education and training. If you look from the outside at that training you give the officers here at this facility, and imagine that you are a captain on the tug in the real world what would you think is the most important the officers learn?

B: We need to distinguish officers from captains. We have also to differentiate between those with ASD experience and those without. Do they come here first or have they already been onboard and had the chance of being taught the standard harbour manoeuvres to and from quay etc. Sail straight ahead and so on. If they already have that kind of experience then the most important is of course to begin to learn them to do the most basic tugging. Setting lines aft and fore… And do repetitions of this until they can do this and avoid to make too difficult and too demanding. You can easily make it so difficult that they have a change to…. So the most basic tugging tasks and and if they can…

I: That was the officers…

B: That was for the mates yes – and if you deside that these mates must come here before they go on the tug, then we will start from schratch where they first have to learn to think in vectors, then in and out of port and to and from quay. And much more general manoeuvring.

Where the focus is on simply learning the positioning of your vessel, getting a feel for the tug and how it moves when you give different orders to the azimuths.

I: Is it your impression that it is an advantage to learn some basic theory beforehand about azimuth forces and vectors by manoeuvring this way or is it better to have practical knowledge first and learn the theory later on? Will you be able to detect differences in the ways people sail and manoeuver?

B: That a highly individual question. Some people are enormously practical. They come here on the bridge and can almost feel what they have to do almost immediately. And we as instructors can feel that as well when we get people like that in the simulator. But it is not often. These people just "feel" the vectors in their body without thinking about it. And other people need thousands of explanations and some has to think and calculate all the time in their heads before they can do anything. Knowledge based…. There is a lot of difference in how people work. Some are good and some are not that good. Some will learn it and some will never learn it at all.

I: Will you say that there – thinking about a learning curve – can be a difference regarding how fast you become super good – Can it have an effect for your pupils if they are able to combine your experience with the theoretical knowledge both for the more practical and theoretical "personalities".

B: Yes absolutely. If you can ad some physics to the practical experience at hand – that will be an obvious advantage.

I: Have you had some pupils with theoretical forehand knowledge that was as good as those who did not have any and they both had the same amount of practical experience – and when you see them in a critical situation here – have you then seen any differences in performance?

B: No – not directly. Of course there are differences in peoples capabilities but if we have two equally… then you would probably not see any big difference. Maybe one of them will think more about it and be better at explaining what he is doing while the other can not. He just does it. And that, I guess, is just as good? I really can not decide that but some are able to explain what they do and others can not.

I: Does operation of azimuths require a certain personality? Or said in another way – are there any personality characteristics that are an advantage when operating azimuths?

B: No – I won´t say that. I will say though that is important to be able to multitask to a certain degree. When handling azimuths you are controlling two engines with a lot of power you must be able to work independently and in combination at once while operating winch, talk on the radio and so on…. So you need to have a talent for a high degree of multitasking. And you need to be able to keep calm in stressful situations because the forces and the speed of what thing happens with you must be able to keep your awareness level up– if you can not you are bound to make mistakes and there is a high risk of incidents and accidents. A peaceful mind is an advantage together with the capability to do several things at once.

I: When you say multitasking – do you think that training specifically focussed on training the ability to multitask could be an advantage? In line with the though or assumption that people who are used to do several things at the same time will have an advantage when it comes to azimuth operation?

B: I would think that is possible yes.

I: Short questions next. What is the duration/length (how many days) of the ideal course – again differentiating those with pre – course practice and those without? The best course you can think of you can deliver – given all your experience and releasing all the potential of the programme and the simulator - how many days?

B: OK – if we start with those without knowledge of ASG tugs: I would then prefer to divide in three courses at different levels, where the first is a four days basic training course, and then again a four day – I believe strongly in the four days duration of a course because it gives enough space for a slow start, a reasonable ending and have two full days where they really get action.

I: And four days instead of for instance 5 – any particular reason for that?

B: Yes if the start day is slow and the ending day the same – then three days with intensive training that will probably be too much for most people. Then I think the learning curve will turn downwards.

I: Is it realistic to get the companies to pay for such courses and with that structure and setup?

B: Yes I think so. If the world economy is not all bad I think they would. The ship owning - and ship operating companies focus more and more on safety and larger demands are made for the operating crew regarding education. I am convinced this is the case – yes.

I: At our facility and in this one special tug simulator what is the ideal number of people attending the courses?

B: If we are just to run at the one simulator and then a bridge from where you can control the bigger vessel the tug is supposed to assist then maximum 4. We can have more attending the course but they will then experience considerable more waste time and watching which is not necessarily very good.

I: What is the ideal number of instructors for such a 4 person course. Ideally – what do you think?

B: Yes – I will think that one instructor to 4 pupils – that would be a good setting. The instructor does not necessarily have to be physically the same person all through the four days and for the practical and the theoretical part. But I think it will be an advantage though if the instructor is the same throughout the course. When I started working here I was not very much into the human factor part of the theory so I had a more experienced colleague teach to do that part of the course. That is no problem.

I: How big a part does human factors play in the course?

B: Well – that part takes up approximately 1,5 to 2 hours on one of the days – that’s all. I must say that I have actually changed something along the courses. Situations occur naturally in the exercises and that makes it relevant an important to work with it… Especially when we talk about the SRK model then we can see clearly in some runs that you move from one area to another. And instead of boring theory on the Thursday of the week of the course. Then it may be better to take it as it shows up naturally and discuss it then.

3.3 Review of the human physical and behavioural components

I: I am thinking that if you like to sail the tug and love to do the practical side of the job then maybe you are even more hypersensitive to theory and power point slides?

B: I think you have a point there. It must be thoroughly considered what theoretical material you present on the courses and when. And it must be compressed a little. But often you adjust, divide and fit it into the exercises. The part of the theory that fits with the next exercise you are about to run and so on…

I: Can you think of a way to obtain or gather data for each of the pupils that can give some kind of objective measure of how good they are – or have become?

B: It is more my judgement. I see how much they sweat and shake and if they can actually do the manoeuvres. The time factors of course also plays a role here. Some of it is actually possible take time on.

I: Can you say – sail to this position, this way – and then you as instructor can monitor how long it takes for them and how safe the manoeuvre was?

B: Yes – we do have a small exercise we do from time to time. We call it tug race and the pupils are racing each other. They have to compete in time. They do not get any punishment if they hid something on the way to this particular defined destination. It gives us a quick picture of their understanding of the vectors and how the tug is basically operated. We can not use for much more than for themselves to decide who should by the first round in the evening! This exercise can be seen as a socialising event as well... Of course it would to some degree be possible to set criteria and excercises where the people could be objectively measured.

I: How do you measure – I know you use the Delphi method for evaluation where we get feed back – but how do you personally as an instructor measure the effect of their learning compared to what they could do when they came at first? – do you look for any particular markers or cues?

B: It is difficult to say. What I do is that I make some test runs with them individually – the go back and forth and get a feeling of what level there at. And if they are on equal level or close it is an advantage. We can then proceed faster.

I: You do this as the first part of the course?

B: Yes it is a part of the course. It is the first exercises we do. It is part of the familiarization we do. We go back and forth following a track – back and forth – looking aft – looking forward. That quickly gives me an impression of if they have the feeling for the vectors and what part of the tug they can actually control. And that gives a clear impression of their abilities and if they need more training on the cubicle bridges in specific issues before they can proceed in the programme.

I: Is there any difference of age and ability to learn to operate the azimuths? Is there any difference in age of starting point for operating azimuths and how easy it is for them to learn?

B: That would be a guess from my side…

I: But if you think of your own experience regarding this issue…

B: Well – generally – the older the people the more experience they normally have. No matter what kind of experience they have beforehand some of it will be relevant and transferable to this way of manoevering. I would say that if you take experience and how fast they learn the older will probably learn a little slower but have more experience while the younger would learn a little faster but have less experience from earlier resulting in approximately the same total learning during the course. It is hard for me to say. But experience is an important factor. Yes – the younger probably learn a little faster.

I: I think maybe some of the experience could be that you should be a little more cautious. The more experienced might not "jump forward" without first being sure they know exactly what they are doing?

B: Yes – and the older are maybe a little to slow reacting sometimes in stressful situations. With this kind of tug you sometimes have to react swiftly and give full throttle to safely handle a situation. You can say that the older are a little more afraid to use the power at hand.

I: You should think it is important… we have been discussing this a lot… A part of this project is also to consider different types of crash stop situations.. There is also being held interviews with pilots… and questionnaires are being forwarded to pilot associations. British and Danish in order to get some kind of measurement of just how good the pilots are at manoeuvring azimuth - like propulsion systems. Many pilots actually have not trained and can not maneouver these systems and one of the issues is that there are many different ways to stop the vessel and to turn the vessel. And maybe some of them are better than others in certain critical situations.

B: What is needed in order to use the tools at hand with a propulsion system like this one if firstly knowledge. My experience is that in order to get better and get better using the experience you already have is to eliminate some of your old habits and beliefs first. If we get people in this simulator that are used to handle two fixed propeller vessels then we would actually benefit from a psychologist that is waiting for them just before they enter the door to our facilities at their first entrance who can "reset" them before we start the course from scratch. We typically see that they do not know have to take advantage of all they can make use of. They think; backing or forward…

I: I have tried sailing vessels with waterjets myself and the first time I wanted to try this azimuth system here in the simulator I instinctively turned the azimuths to what I believed was toward each other but in reality the opposite happened. Then I started to mentally "rotate" my knowledge of the consequences of moving the handles which slowed my manoeuvres a lot. What was the must difficult for you to learn when you started sailing on ASD tugs?

B: The most difficult or maybe I should say what surprised me the most that was not exactly difficult as such – but positive – that was that you suddenly had 100 percent use of your forces and not just in forward or backward direction. It took some time to adjust to the reality that you had these forces at your disposal.

I: Can you say that you had to build up a repertoire of different manoeuvre possibilities?

B: That is totally correct. You suddenly have to get used to the fact that you are potentially much more capable as to manoeuvring than before. But you also had to be more cautious with your forces because they are so powerful, work 100 percent and immediately.

I: Was there anything contra intuitive when you started to use this propulsion system. Something that you thought was difficult… where you continued to do it the wrong way even though you knew it was wrong…where you kept thinking: this is strange how this works…? I know when I tried these aquamaster controls I was told to think about them as to outboard engines… which helped me immediately… But anyway – if I had to do a fast manoeuvre I fell back and handled the controls as if they it was Kamewa jets I was operating. You came from vessels with traditional propulsion - was there anything you thought was contra intuitive?

B: I do not think so. But sometimes I was as I said surprised about the sheer force and swiftness of how the forces was applied but besides from that I think the use of the system is in my head is intuitive.

I: What about the controls themselves. You have through many years gotten used to using these controls. But if you try to look at them objectively as if you did not know them; if I asked you to do an analysis of what your vessels should be able to do and how the controls (azimuth system) should be able to work ideally. And you where allowed to draw the handle form scratch – imagining that you did not already know what the controls normally looks like – that this I a good model – what can you then think of regarding size and ergonomy for instance?

B: I think they are good and feels good in the hand. I supposed the edges could be rounded a bit.

I: So that it fits the breadth of the palm of the hand better?

B: Yes – and if it was possible to get a better grip "underneath" the handle. It is like a square. You could imagine….?

I: Do you need to be able to hold on to the controller when the tug rolls or moves I rough weather? Does the tug roll that much at all?

B: That happens from time to time, yes. There are situations where you need to hold on to the handle.

I: Can they stand to be used in that way?

B: To this date yes. But I think – it is difficult for me to think how the controls could be different from this model. But I am of course affected by the amount of experience I have with this type of controls.

I: If it was me I would think that when the revolutions indicated on the handle are showed on this scale on top – it is hard to see the indications. And if I look at the controller I think it is thought from the producer that you would hold on to it in the top leaver and not at the base where I see most people hold on? If you held on to the leaver you could adjust the revs at once. But if you hold on to it as most people do you have to move your entire hand – change grip – and push the leaver for revs.

B: Some might have thought you were going to hold it like that – but you do not use it that way. You do hold it this way. Maybe you could imagine some kind of shape of this controller that was more natural considering its purpose. And maybe the other controls on the other bridges are preferred by some people who has not – as I – sailed on this kind of ASD tug for many years.

L: You mean the small Lillås controls? – or may be even Kamewa?

B: Yes Lillås – but not Kamewa. There are too clumsy and when you are sweating during stressful conditions your hands almost start to hurt. They are too broad. But maybe a combination of them – and they radiate considerable more quality than these from Aquamaster does. Clearly marked zero indicators and so on…

B: But surely they must not be too small. It should always be possible to feel what you have in your hands.

I: And there should be a certain feedback resistance?

B: Yes – there has to be that.

I: Would it be interesting to have other notches so that the operator can feel the angles the controller is positioned in… abeam and..?

B: There are some. But they are not clearly felt.

I: Could more of these notches be an advantage – more than abeam and aft as is the case now?

B: Yes maybe – it would be alright if there was a notch for 45 degrees as well. There are certain situations where you have angles where you are not supposed to operate your azimuths in and that could be a help. Obviously – the less you have to look at it the better. You must me able to feel where you are.

I: Could you imagine – there are some angles you should not put your azimuths in because of cavitations….

B: Yes it is basically about how the vessel acts …. It has of course something to do with the shape of the hull under water. It has for that reason nothing to do with the controller itself but is more vessel-specific. On these vessels - if you are pulling something you have the angle from forward to 45 degrees inward toward the hull where you are not supposed to operate the azimuths because the water from the propeller is sent directly onto the hull and the Skegg ?) that is there. So you must pass 45 degrees in order to get the planned effect. Otherwise something unforeseen happens.

I: Could it be of an advantage to have some sort of feed back tactically in the controller when operating certain revs and at certain angles?

B: Yes. But that would only be correct if this particular situation. This is some of the things you simply just have to learn. This has something to do with knowledge of your vessel. It will be slightly different from vessel to vessel where this unfortunate area is.

I: Do you have any idea of how Aquamaster get information about their equipment and controls from users? You have never had any contact with them?

B: No.

I: I don't think we have the time for discussing all the Aquamaster panels. But they seem difficult for me to understand…

B: I would like to say something about these Aquamaster switch panels anyway. They are very difficult to understand and get an overview of. And they have chosen to make all the buttons the same size and shape. Some of them are push buttons and others are indicator buttons and it is not possible to see the difference.

I: What do they mean then – these buttons (pointing to the panel)?

B: These ones here are perhaps the most easy to understand. They indicate if the Aguamaster unit is clutched in or not. And this one is the indicator for clutched in. So it is not all that easy! And this one here clutched out and this is clutched in and this is the indicator lamp. When this button is not lit the clutch is out. Here they could have had two buttons only. One for clutched out and one for clutched in.

I: I can see the point in that. What are the rest?

B: The one beneath indicate that we are in command mode here at the controller. That this controller is the one in command. The others are emergency steering indicators when they are emergency operated. You operate it by holding it down.

I: How do you see what way you are operating the azimuth then?

B: I was wrong just before. This is not for the angle adjustment but for adjusting the pitch. This way is increasing pitch and the other is decreasing pitch. Here you increase the pitch and here you decrease the pitch. And the same with the emergency steering of the azimuth angle. Here you turn. When you push to port side the azimuth turns to port and so on.

I: So the vessel then turns to port?

B: No, only the azimuth. And you then have to control the vessel…It is rather difficult but possible.

I: Okay. Here there are more?

B: Yes this is where you switch between the different modes; when it is in towing mode you have the optimized possibility of adjusting rev and angle of the propeller blades the pitch giving maximum amount of power. The other when you switch to free run that is when it is only pitch you are adjusting by the control. And the revs are set on the forward panel here. The last thing is the mode you use when you have fire pumps clutched in on the main engine. Then there are some area of revolutions you need to be within. That is then the only thing you can adjust. Still, on these – you can still manoeuvre your vessel.

B: But if you are fighting a fire and pumps water onto a large vessel this will be the way it works. We do have this fire fighting mode on the real ship as well. That makes it possible to manoeuvre the vessel but you do not have much force at your disposal of course. The pumps take their share – a quite big share.

I: Very interesting. The last thing I have to ask you is about automation. It is a difficult term – it is described in the project description and I do not know completely know what they mean. But I think what they mean is systems which can help in certain critical situations. For instance when a pilot has to do a crash stop – if he had a possible of using some kind of automated system that could control the azimuths in combination or some other way to give the must efficient stopping manoeuver under the current situations. Do you know of such automated systems?

B: I think that they mean joystick. Some systems have what you call a micropilot as they call it from Aquamaster – installed. You can with this system control it in different modes; if you are sailing back or forth and turn or sidestep. But we have had mechanics coming to adjust it all the time everyday and several days! And my experience is that a captain with just one year of experience is a lot better at handling the vessel than the aquapilot. As of yet anyway. I can also tell you that some come to us and say that they already have ASD experience because that is the propulsion system they have on their vessel. But as the ones we just had this week from Lissabon it turns out that they sail using the joystick and therefore they do not have the same control of their vessel at all.

I: What were the officers you just had on course this week?

B: Two of them were tug boat captains from Lissabon. They had been operating their azimuth tugs. But they do not have the individual control of each of the azimiuths. They have a joystick and some kind of combined system which means that they can not set the azimuths to each side. The system automatically reduces the revolutions when the azimuths are turned. This means that the very efficient method we use in transverse arrest where we put the propellers to each side 90 degrees from the moving direction can not be used on a tug like that. This way of stopping means that with a tug like this with 60 tonnes of bollard pull static. But if we make a transverse arrest we can come above 100 tonnes of brake power.

I: So that is very efficient in some situations when tugging?'

B: Absolutely. I have done that a lot.

I: When we talk about safety devices which could be some kind of combinated use of the azimuths. If you think about something that could be of an advantage regarding safe operation of azimuths what do you think of?

B: Well I think training is the one thing that can do the most for the safety. That is the most important. The next is the quick release mechanism on the winch where we can let go the line. And the other is the release hook after if we have something made fast aft. These are the two most important things.

I: Is it possible to imagine some combination of an automatic mechanism regarding the manoeuver of the tug or adjustment of the controls (some optimization)?

B: No – not really. What we must keep in mind is that we often have to give the maximum pull on the line that we possibly can. You can in fact say this is the criteria for success. Something that would release it at a certain force that would be completely opposite to what tug operation is all about. Much of the safety is build into the line you choose to fit on your tug. This line is calibrated to fit the effect of the tug and so on. If you are at the limit where the tug is in danger then the line must break. So the dimensions of the line is tailored to the limits of the tug. That may be from an economical perspective but it is some sort of a safety measure. It is generally very important in the tug business that you follow the procedures that exists. That you ensure watertightness and so on. So that the vessel actually can stand lying on its side – as it is supposed to be able to withstand and come back up again. Building in of any automatic measures is hard to imagine because the kind of work you have to do with the tug is about operating on the "crazy" side of what many would consider right. But that is what tugs are for.

I: I do not have any more questions. Thank you very much for your time.

Tug use case - Described by tug master and instructor, A. Mejer.

	Before towing operation commences – All cases
Plan	Assess the risks, plan of action and briefing. Defining areas of special attention
Starting up	• Starting up according to Start Up Procedure • Clutching in and testing all systems in normal/emergency mode according to procedures • Testing communication, internal/external • Unmooring/departing berth • Informing the port/VTS • Preparing for towing • Proceeding to the job in question
Sailing to the assisted vessel	VHF communication with the Pilot, getting information of connection point, speed & destination, (plan)

	Arriving vessel. Connecting point centerlead aft
Connecting	Closing up to the stern. • All watertight doors are closed • All crew informed of the plan • Deck crew wearing PPE (personal protection equipment) • Tow hawser prepared and ready • Controlling the speed to that of the vessel by a combination of reducing rev's/pitch and turning azimuths outwards.(Depending on engine/propeller characteristics and personal style) • Closing up to the stern in the propeller wash, monitoring the rudder movements and trying to maintain the position always in the center of the propeller wash. • When ½ to1 meter from the stern, maintaining this position receiving the heaving line and sending up the messenger line and the hawser. When the hawser is connected (indicated by the officer on the quarterdeck) the pilot is informed via VHF. • Falling back slowly, paying out on the hawser until a proper length is achieved. (25 to 75 meters) • Informing the pilot that the tug is ready to assist. • Standing by for orders.
Assisting	Braking: Speed more than 6 kts. Transverse arrest – ASD's perpendicular, increase thrust until requested force/effect is obtained. Speed 6 kts or less: Direct arrest - ASD's turned more than 90 & up to 180 degrees from ahead position. Increase thrust until requested force/effect is obtained. Steering: Direct steering - pulling the stern of the assisted vessel in the desired direction.

	Indirect steering - using the force of the passing water pushing on the hull of the tug to move the stern of the assisted vessel in the desired direction. Pushing: When the assisted vessel is almost stopped, the tug can slack out on the hawser and move to the assisted vessels quarter and push. This manoeuvre can damage the hawser due to chafing against the hull of the assisted vessel.

<table>
<tr><td></td><td>Arriving vessel. Connecting point starboard/port shoulder or amidships</td></tr>
<tr><td>Connecting</td><td>Closing up to the ships side on a parallel course.
All watertight doors are closed
All crew informed of the plan
Deck crew wearing PPE (personal protection equipment)
Tow hawser prepared and ready
Controlling the speed to that of the vessel by a combination of reducing rev's/pitch and turning azimuths outwards.(Depending on engine/propeller characteristics and personal style)
The speed should not be more than 5 knots.
Closing up easy to the ship side by small adjustments of one or both of the ASDs, maintaining the position relative to the point where it is planned to go alongside. Always land a little forward of-, and slide back to- the point where the tug are planned to work.
Be careful when negotiating the last ½metre, here the intershipaction works quite powerful and depending of many factors, the tugs bow or more often stern will tend to hit the vessel hard.
When alongside, turn both ASDs a little into the side of the vessel, lifting the tug's stern clear of the vessels side. The pressure from the passing water will keep the tug "glued" to the vessels side.
Receiving the heaving line and sending up the messenger line and the hawser. When the hawser is connected (indicated by the officer on the quarterdeck) the pilot is informed via VHF.
Informing the pilot that the tug is ready to assist.
Standing by for orders.</td></tr>
<tr><td>Assisting</td><td>If asked to push:
At very low speeds:
Increasing the power on both ASD's and use the ASD nearest to the assisted vessels hull to turn the tug and push with the other ASD

At higher speeds: Using both ASD's to lift the tugs stern off the vessels hull. This will force the passing water to push dynamically on the tugs hull and transferring this force to the vessels hull.

If asked to pull:
Lifting the tug off the vessels hull. Using both ASD's to back off, keeping the hawser slightly tight in order to control the bow. Slacking out hawser until a length of approximately 30 meters. Applying maintaining position perpendicular to the vessel with the aftermost ASD, pulling with the foremost ASD.
If told to be stand by to pull:
Maintaining position by slow or fast sidestep or turning the tugs stern into the direction of travel and maintain position stern first.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Arriving vessel. Connecting point starboard/port quarter (Usually just forward of the accommodation.</td></tr>
<tr><td>Connecting</td><td>Closing up to the quarter on a parallel course.
All watertight doors are closed
All crew informed of the plan
Deck crew wearing PPE (personal protection equipment)
Tow hawser prepared and ready</td></tr>
</table>

	• Controlling the speed to that of the vessel by a combination of reducing rev's/pitch and turning azimuths outwards.(Depending on engine/propeller characteristics and personal style) • The speed should not be more than 5 knots. • Closing up easy to the ship side by small adjustments of one or both of the ASDs, maintaining the position relative to the point where it is planned to go alongside. Always land well forward of the point where the vessels hull are starting to bend inwards towards the keel, and slide back to- the point where the tug are away from the danger of being sucked in under the flaring transom of the stern. • Be careful when negotiating the last ½metre, here the intershipaction works quite powerful and depending of many factors, the tugs bow or more often stern will tend to hit the vessel hard. • When alongside, turn both ASDs a little into the side of the vessel, lifting the tug's stern clear of the vessels side. The pressure from the passing water will keep the tug "glued" to the vessels side. • Receiving the heaving line and sending up the messenger line and the hawser. When the hawser is connected (indicated by the officer on the quarterdeck) the pilot is informed via VHF. • Informing the pilot that the tug is ready to assist. • Standing by for orders. • This manoeuvre can be carried out with the tugs sailing stern first, but only at very slow speed. This will make a safer approach in terms of not getting too close to the dangerous area aft of the parallel vessels sides.
Assisting	If asked to push: At very low speeds: Increasing the power on both ASD's and use the ASD nearest to the assisted vessels hull to turn the tug and push with the other ASD At higher speeds: Using both ASD's to lift the tugs stern off the vessels hull. This will force the passing water to push dynamically on the tugs hull and transferring this force to the vessels hull. If asked to pull: Lifting the tug off the vessels hull. Using both ASD's to back off, keeping the hawser slightly tight in order to control the bow. Slacking out hawser until a length of approximately 30 meters. Applying maintaining position perpendicular to the vessel with the aftermost ASD, pulling with the foremost ASD. If told to be stand by to pull: Maintaining position by slow or fast sidestep or turning the tugs stern into the direction of travel and maintain position stern first.
	Arriving vessel. Connecting point starboard/port shoulder or amidships
Connecting	Closing up to the ships side on a parallel course. • All watertight doors are closed • All crew informed of the plan • Deck crew wearing PPE (personal protection equipment) • Tow hawser prepared and ready • Controlling the speed to that of the vessel by a combination of reducing rev's/pitch and turning azimuths outwards.(Depending on engine/propeller characteristics and personal style) • The speed should not be more than 5 knots. • Closing up easy to the ship side by small adjustments of one or both of

	the ASDs, maintaining the position relative to the point where it is planned to go alongside. Always land a little forward of-, and slide back to- the point where the tug are planned to work. • Be careful when negotiating the last ½metre, here the intershipaction works quite powerful and depending of many factors, the tugs bow or more often stern will tend to hit the vessel hard. • When alongside, turn both ASDs a little into the side of the vessel, lifting the tug's stern clear of the vessels side. The pressure from the passing water will keep the tug "glued" to the vessels side. • Receiving the heaving line and sending up the messenger line and the hawser. When the hawser is connected (indicated by the officer on the quarterdeck) the pilot is informed via VHF. • Informing the pilot that the tug is ready to assist. • Standing by for orders.
Assisting	If asked to push: At very low speeds: Increasing the power on both ASD's and use the ASD nearest to the assisted vessels hull to turn the tug and push with the other ASD At higher speeds: Using both ASD's to lift the tugs stern off the vessels hull. This will force the passing water to push dynamically on the tugs hull and transferring this force to the vessels hull. If asked to pull: Lifting the tug off the vessels hull. Using both ASD's to back off, keeping the hawser slightly tight in order to control the bow. Slacking out hawser until a length of approximately 30 meters. Applying maintaining position perpendicular to the vessel with the aftermost ASD, pulling with the foremost ASD. If told to be stand by to pull: Maintaining position by slow or fast sidestep or turning the tugs stern into the direction of travel and maintain position stern first.
	Arriving vessel. Connecting point centerlead for, Bow to Bow
Connecting	Closing up to the bow on an opposite course. • All watertight doors are closed • All crew informed of the plan • Deck crew wearing PPE (personal protection equipment) • Tow hawser prepared and ready • Approach the vessel on a reciprocal heading or steaming sterns first up alongside the vessel and sail carefully in front of the vessels bow. • Controlling the speed to that of the vessel by a combination of reducing rev's/pitch and turning azimuths outwards/ sternvise.(Depending on engine/propeller characteristics and personal style) • The speed should not be more than 5 knots. • Closing up easy to the ship bow by small adjustments of one or both of the ASDs, maintaining the position in the centreline of the vessel. (some tug skippers prefer to line up in the line of the vessels parallel port or starboard side) • Be careful when negotiating close to the bow here the intershipaction works quite powerful. • Receiving the heaving line and sending up the messenger line and the

	hawser. When the hawser is connected (indicated by the officer on the quarterdeck) the pilot is informed via VHF. • Backing off, increasing the distance to the bow and paying out the hawser to a distance of approximately 40 meters or more. • Informing the pilot that the tug is ready to assist. • Standing by for orders.
Assisting	If asked to pull in any direction: At any speed above a few knots, the effect of the bow tug are neglible, so there should be no requests for anything but staying in a safe position at higher speeds. At very low speeds, the tug can turn carefully stern first to port or starboard side and apply some pulling power. Always be very careful not to turn too far from the centreline because this can cause the tug exceed the limit for being capable of recovering its position and make it collide with the assisted vessel.