Escort Towing in Finland

Now and in the Future

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Thesis for Bachelor of Marine Technology

The Degree Programme of Maritime Management

Turku 2015

BACHELOR'S THESIS

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Degree Programme: Degree Programme in Maritime Studies, Turku

Specialization: Bachelor of Marine Technology

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Title: Escort towing in Finland – Now and in the Future

Date 2.12.2015 Number of pages 46 Appendices 1

Summary

In this bachelor thesis the state of escort towing in Finland at the moment and the prospects of escort towing in the future are introduced clearly and compactly. Also the regulations concerning escort towing in Finland are studied. The goal of the thesis is to collect knowledge and experience from experts working in the field and combine the information with literature references.

The collecting of information from experts was carried out by interviewing them. In the thesis the qualitative research method was used and the interviews were semi-structured.

The Finnish archipelago is a challenging environment for sea transportation; in a failure situation the space and time to react are limited. It is important to have a useful back up plan to be able to avoid accidents. Escort towing is used in Finland to ensure the safety of sea transportation.

As in the conclusion of the thesis is stated, the escort towing increases the safety of sea transportation. Also it is observed in the thesis that escort towing could be developed with specialized tugs and active training so that escort towing operations will succeed in the best possible ways.

Language: English

Key words: escort towing, escort tug, safety, sea transportation

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OPINNÄYTETYÖ

Tekijä: Eveliina Saari

Koulutusohjelma: Degree Programme in Maritime Studies, Turku

Suuntautumisvaihtoehto: Bachelor of Marine Technology

Ohjaaja: Captain Ossi Westilä

Nimike: Saattohinaus Suomessa – Nyt ja tulevaisuudessa

Päivämäärä 2.12.2015 Sivumäärä 46 Liitteet 1

Tiivistelmä

Opinnäytetyössä esitellään tiiviisti ja selkeästi saattohinauksen tila Suomessa tällä hetkellä ja sen tulevaisuudennäkymät. Myös saattohinausta koskevat säännöt Suomessa käydään työssä läpi. Opinnäytetyön päämäärä on kerätä tietoa ja kokemuksia ammattilaisilta, jotka työskentelevät alalla, ja yhdistää saatu tieto kirjallisuuslähteiden kanssa.

Tieto kerättiin ammattilaisilta tekemällä heille haastatteluja aiheesta. Työssä käytettiin laadullista tutkimusmenetelmää ja haastattelut olivat puoli-strukturoituja. Työn tukena käytettiin myös kirjallisuuslähteitä.

Suomalainen saaristo on haastava ympäristö meriliikenteelle; ongelmatilanteen sattuessa reagointiaika ja -tila ovat rajoitettuja. Toimiva varasuunnitelma on tärkeä onnettomuuksien välttämiseksi. Saattohinausta käytetään Suomessa meriliikenteen turvallisuuden parantamiseen.

Opinnäytetyön päätelmissä todetaan, että saattohinaus parantaa merikuljetusten turvallisuutta. Työssä kuitenkin havaittiin, että saattohinausta voidaan kehittää erityishinaajilla sekä aktiivisella harjoittelulla, jotta saattohinaukset onnisituisivat parhaalla mahdollisella tavalla.

Kieli: englanti

Avainsanat: saattohinaus, saattohinaaja, turvallisuus, meriliikenne

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Abbreviations

AFRAMAX An oil tanker that has deadweight tonnage between 80 000 and 120 000

ASD-tug Azimuth Steern Drive Tug, a tug with azimuth propulsors fitted under the stern

Bow thruster Tranversal propeller in bow for ships handling in mooring operation

CPP Controllable Pitch Propeller

DAT Double acting tanker, a tanker that can drive astern in ice conditions and act as an icebreaker

Deepwater route Fairway for deep draft vessels

DNV Det Norske Veritas; a Classification Society that integrated with Classification Society Germanischer Lloyd, their new name is DNV GL

DNV GL See DNV

DWT Deadweight tonnage

Knot A unit for speed, 1 knot = 1,852km/h

IMO International Maritime Organization, a agency of United Nations that is authority for safety and security of international shipping

LNG Liquefied Natural Gas

LPG Liquefied Petroleum Gas

MARIN Maritime Research Institute Netherlands

m/t Motor tanker

NM Nautical mile, 1,852km

OCIMF Oil Companies International Marine Forum, a association of oil companies that has an intrest on safe and environmental shipment and terminalling

SDWT Summer deadweight tonnage

Tanker A ship type used for oil transportation

Tractor tug A tug that has propulsion under the forebody

1 Introduction

The research for escort towing started worldwide in the 1990s after some big oil accidents had occurred (e.g. Exxon Valdes at 1989 and Sea Empress at 1996). In Finland the systematic escort towing in Porvoo and Naantali oil harbours started in the beginning of 2000s by Neste. The reason why Neste started to research and develop escort towing in their harbours was the grounding of m/t Natura in 1998. (Toivola, interview 2015)

Companies providing escort towing have studied the subject, but often the information stays with one operator, meaning that the knowledge is not generally available. The goal of the bachelor thesis was to create a document that presents escort towing clearly and comprehensively and speculates the future of escort towing in Finland.

I got interested in escort towing while I was working on board the oil tankers of Neste (nowadays operated by OSM Finland Ship Management). During my time on board I have noticed that countries and harbours have very different practices and regulations concerning escort towing. So, I thought that writing my bachelor thesis about escort towing was great opportunity to learn more about it.

The research was made by using qualitative research method; eight professionals were interviewed about their experiences and knowledge about escort towing. The research method is introduced more closely in chapter 2.1.

1.1 Objective

Over 80% of Finnish foreign trade is transported by seas. The maritime transport is increasing at Baltic sea continuously; behind this increase are new harbours and the extension of old ones. Expanding vessel sizes and increasing traffic volumes reflects the safety issues at Baltic sea. The special characteristics of Baltic sea are the shallow

waters, the high amount of rocks and islands, the narrow fairways, ice conditions and limited amount of day light. The sensitivity of the Baltic sea makes it even more important to concentrate to safety of sea transportation, because marine traffic accidents can make permanent damage to the Baltic sea. The Baltic sea may not recover from e.g. oil accident due to the shallow waters and the limited amount of water exchange. Oil accidents are seen as one of the biggest risk to the Baltic sea. (Haapasaari et al. 2015)

The main idea of escort towing is to secure oil transportation. Because of the importance of the subject, the goal is to conduct a research where the state of escort towing in Finland at the moment and the prospects of escort towing in the future are described. Also the regulations concerning escort towing in Finland are studied in the thesis. The idea of the thesis is to collect knowledge and experience from experts working on the field and combine the information with literature references.

1.2 Problem formulation

The aim of the thesis, presented in chapter 1.1, is carried out by answering to the following research questions. The thesis endeavours to collect information to one paper that is easy to access by everybody.

Research questions:

- What does escort towing mean and what is the difference comparing to other tug operations?
- Why escort tugs are used?
- Where is escort towing used in Finland?
- How does the future of escort towing in Finland look like?
- Is it profitable to escort tow also other vessel types, e.g. large cruise ships in Helsinki, ammonia tankers in Uusikaupunki or LNG-vessels in Tornio and in future in other harbours?

1.3 Delimitation

The thesis is concentrating only to escort towing in Finland. There are no international regulations ruling escort towing, so every country or port has their own way to execute it. It is nearly impossible to cover all of that information in one bachelor thesis. Also the special characteristics of Finnish Archipelago make it important to think ways to execute safe sea transportation and to protect the Baltic Sea. More importantly delimitation to Finnish escort towing is most interesting in Finnish opinion.

Other limitation in this thesis is to concentrate to tugs designed specially for escort services. Sometimes conventional tugs are used for escorting vessels, but it is not as efficient and safe than with special escort tugs. Escort tugs can be divided to several different designs; for example, Tractor Tug, Reverse Tractor Tug and Azimuth Stern Drive Tug (ASD) are tug types used for escorting vessels. All three Finnish escort tugs are ASD-tugs, so only that design is covered.

The chapter 2 is concentrating to the executing the research and to the references used in the research. In the chapter 3 the history of escort towing is enlightened briefly. The chapter 4 clarifies the theory of escort towing, also tugs used in escort towing operations are presented.

In the chapter 5 the class rules of escort tugs are presented. In the chapter the rules of only one Classification Society are presented, because class rules are not the main subject of this research and otherwise the chapter would get too extensive. The rules of DNV GL were chosen, because DNV GL is known as reliable operator in the field and they have an office in Finland.

In the chapter 6 the crew and training are presented; the chapter is concentrating to the training organized by Neste. The chapter 7 contains speculations about the future of escort towing. In the last chapter the results of the research are presented.

2 Executing the research

The research method used in this bachelor thesis is qualitative method. The research method was chosen due to the lack of material about escort towing in Finland. Escort towing is a rather new and small field compared to other towing operations and the operators working on the field make the researches by themselves. Usually the conclusions of researches are non-public information. All previous studies available were concentrating to the worldwide practise of escorting. This bachelor thesis is based on eight interviews made to experts on their fields; all of them are working with issues related to escort towing. The interviews are the main source of the material used.

Jani Huumonen has helped to choose the interviewees for the research. Six of the interviews were made by face to face discussions and two of the interviews were made by e-mail; all the interviews were made during the year 2015. The interviewees chosen to this work are working in different positions in the maritime field to ensure wide coverage about the subject. Operative perspective for escort towing were asked from OSM Finland Ship Management and Arctia Karhu. The view of oil company and Classification Society were found by interviewing Neste and DNV GL. Also persons from Finnpilot and Aboa Mare were interviewed. The persons interviewed are listed in References and the questions asked can be seen in Appendix I.

2.1 Research method

Qualitative method is used in studies that are aiming to find overall understanding on their subject. The research question in qualitative research can be e.g. "*what is this phenomenon?*" The qualitative method does not generalize the subject or collect statistic data like quantitative research method does. Usually the target group that is used in the qualitative research is relatively small, because the goal in this type of research is not to find out numerical regularity; also collecting the data in qualitative research is often time consuming. (Kananen 2014, p.16)

Qualitative research method can be used for example in cases where there is no knowledge or researches about the subject, the aim is to create deep understanding about the subject or the goal is to find new theories and hypothesis about the subject. The quantitative method enables very thorough research, but the conclusions are valid only in the cases under the particular research. The qualitative research does not give possibility to generalization. (Kananen 2014, p. 17)

Interviewing the target group is the main method of collecting material in qualitative research. The questions used in qualitative research are often wide in order to cover all angles of the topic. The advantage of qualitative research is the flexibility of it, e.g. questions can be added during the research to ensure deep understanding about the subject. On the other hand, the problem with qualitative method is the selection of the data used in the research; the research can be subjective, because the researcher cannot use statistical conclusions. (Oliver 2008, p. 20)

Researches made by interviewing the target group can be divided to three categories: interviews based on forms, semi-structured interviews and structured interviews. This research is based on semi-structured interviews. For the semi-structured interview, it is characteristic that some topics of the interview are pre-selected, but all are not. This means that the questions of interview are created beforehand, but the order and phrasing of the questions can be changed during the interview. Also the interviewees are answering to the questions with their own words. This is the way this research was carried out. (Hirsjärvi & Hurme 2004, pp. 47-48)

2.2 The background of research

The research was started by searching other bachelor thesis and publications from Theseus using terms *saattohinaus*, *saattohinaaja*, *escort towing* and *escort tug*. Theseus is an open repository online and there can be found theses and publications of the Universities of Applied Sciences in Finland. No theses directly concerning escort towing were found by using search terms mentioned above.

First publications published in Theseus are from 1998, but first Thesis for Bachelor of Marine Technology published there are from year 2007. This means that Theseus does not give wide knowledge of researches made about the subject.

From web based search program Google Scholar, researches made about escort towing can be found by using terms *escort towing* and *escort tug*. The researches and articles found from Google Scholar are mainly technical studies about the design of escort tug. From the found researches and articles the ones used in the thesis were chosen by reading the abstracts of the papers. Three researches were chosen as material; as examples are the research of Allan, R.G., Molyneux, D. and Birmingham, R. (2005) *Escort tug design alternatives and a comparison of their hydrodynamic performance* and the research of Molyneux, D. and Bose, N. (2008) *Escort tug at large yaw angle: comparison of CFD predictions with experimental data*.

Only one research found was studying the effects of escort towing. *Numerical Simulation of Ship Maneuverability in Wind and Current, With Escort Tugs* (2005) is executed by Ye Li and Sander M. Calisal. They made simulations about escort towing operations in the entrance of Vancouver Harbour.

The questions asked during the interviews were based on the information found from the literature. Before the interviews the interviewees knew only that the subject is escort towing and the aim of the research is make a bachelor thesis for Maritime Management. The interview questions are listed in Appendix I.

2.3 Literature

Literature was searched from Vaski libraries using terms *saattohinaus*, *saattohinaaja*, *escort towing* and *escort tug*. With those terms no literature concerning escort towing was found. Vaski libraries comprise more than 40 libraries on western Finland. Also material from the library of Tampere University of Technology and web based search program Google Scholar was searched with same search terms. Some scientific

researches and articles were found about tests made for escort tug models. These researches and articles are used as base for this thesis.

It can be deduced that researches used as material in this thesis are reliable, because also other scientific articles are referring to these researches, e.g. Allan, R.G., Molyneux, D. and Birmingham, R. (2005) *Escort tug design alternatives and a comparison of their hydrodynamic performance.* The researches used are also one of the few researches available about the subject.

I went through the library of m/t Purha. One booklet explaining briefly the principle of escort towing was found; *Recommendations for ships' fittings for use with tugs – With Particular Reference to Escorting and Other High Load Operations* (produced by Oil Companies International Marine Forum 2002). The booklet was a good starting point for collecting information. Another book that contains lots of information about tugs and tug operations is *Tug Use in Port – a practical guide*, 2nd edition (2003), written by Henk Hensen. Hensen's book was used through the whole research. Those books can be assumed to be reliable, because they are used by professional seafarers on board vessels.

3 History of escort towing

In this section the history of escorting oil tankers is shortly covered. The history is divided to two parts: the history worldwide and the history in Finland.

Systematic escorting of oil tankers started in the 1990's, but it does not mean that the principle of escort towing is a new thing. Escorting and assisting the different types of vessels has been done basically since tall ship –times. The basic idea of escorting vessels is to help a vessel, which is big comparing to the fairway, to navigate safely. For example, dry docks often escort their new buildings out at open sea. (Toivola, interview 2015)

3.1 Worldwide

In the 1980s and 1990s there happened some big oil tanker accidents (e.g. Exxon Valdes at 1989 and Sea Empress at 1996) and those events raised the question, how can we eliminate similar accidents in the future. Researching and developing of escort towing started worldwide in the beginning of 1990s; before that some of the states of USA had had regulations considering escorting oil tankers. (Hensen 2003, p. 134)

The Norwegians were interested in developing safety in oil transportation on their coast. They became pioneers at escorting oil tankers, because they had money and oil terminals. The first tug built specially for escort towing is Norwegian Thorax. (Toivola, interview 2015)

Thorax is a tractor tug built in Norway in 1993. It is designed for escort services and ship handling duties and it is equipped with firefighting and pollution prevention equipment. Thorax has two Wärtsilä Wichmann, the propulsion is placed under its forebody and the towing gear is located on the aft deck. The overall length of the tug is 45,50 meters. (The TRIS and ITRD database)

"*First propulsion manufacturers that started design propulsion for escort tugs were Voith Schneider and Aquamaster*", tells Jarkko Toivola in an interview (2015). Most of tractor tugs have Voith Schneider propulsion and it is the most research escort tug design according to Molyneux & Bose (2008, p. 6).

3.2 In Finland

Neste started escort towing in the early 1990s with tugboat Esko after they bought tankers Natura and Futura. They escort tankers to Naantali oil harbour, but only part of the voyage in archipelago. Esko was designed for harbour assistance and ice breaking in harbour and she is an ASD-tug. (Toivola, interview 2015)

Neste started their escort tug project after m/t Natura run aground in Porvoo in 1998 (Toivola, interview 2015). M/t Natura was 242 meters long vessel fully loaded with crude oil. The accident occurred at 13th October 1998 when she was on her way to Porvoo oil harbour. M/t Natura lost her second main engine while on pilot voyage in Porvoo archipelago. When the engine emergency stopped itself, it also activated the controller of the controllable pitch propeller and steered the pitch to zero. The vessel lost its manoeuvrability due the loss of water flow to rudder. (Onnettomuustutkintakeskus C 8/1998 M, p.1)

In the report of Safety Investigation Authority, it is stated that 5,5 minutes after loss of the manoeuvrability m/t Natura was grounded. So for the crew it left 2,5 minutes time to react and prevent grounding (Onnettomuustutkintakeskus C 8/1998 M, p. 29, 35). 2 and half minutes are not much time to find and fix or override a problem. With the help of escort tug the accident could have avoided - it would have prevented m/t Natura to turn to shallow waters and given more time to crew of m/t Natura. (Toivola, interview 2015)

Neste started reviewing the options of buying second hand escort tugs, but at the market there were none which can operate in ice conditions. This lack of stock was the starting point for the escort tug designing project of Neste. Neste established an

escort tug project group and the group visited in Norway to see Thorax-tug and to familiarize themselves to the way Norwegians executed escort towing. Jarkko Toivola was part of this group and he tells that the tension winch was one of the most important idea given by Norwegians. Tugs Ahti and Ukko are the result of this escort tug project. They are the first escort tugs with ice classification in the World. (Toivola, interview 2015) After getting the tugs Neste started to train their employees on new course. More about that in the chapter 6.3.

4 Escort towing at the moment

This chapter is concentrating on escorting vessels with Azimuth Stern Drive Tugs (ASD). The chapter is divided in to three parts: Principle of escort towing, Design of escort tug and Azimuth stern drive tugs.

An escort tug is a backup plan for a vessel in a failure situation; they are designed to provide emergency steering and stopping of assisted vessel while underway. In normal conditions an escort tug is fasten to the aft of the vessel, but it does not take actions (picture 1). So the tug is just running after the vessel with a slack towline. If the vessel loses its ability to manoeuvre, for example it has a black out situation, the escort tug steers the vessel. In narrow channels and in an archipelago, it is critical to have a working back up plan, because distances to the shallow waters are often short. (Toivola, interview 2015)

Picture 1 *Tug escorting tanker to Naantali.* (Saari 2012)

4.1 Principle of escort towing

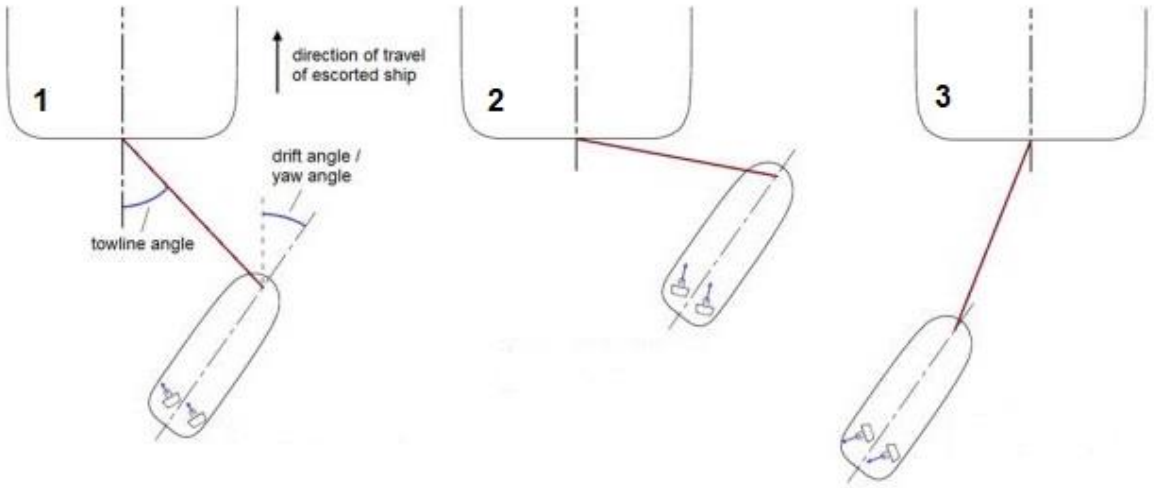
Det Norske Veritas defines escort towing as following action: "*The term Escort service includes steering, braking and otherwise controlling the assisted vessel*". (Det Norske Veritas AS 2012, p.78) During escort operation the tug is prepared for three scenarios: if the propulsion of assisted vessel works but rudder does not, the escort tug shall steer the vessel; if propulsion does not work, the escort tug shall break and stop the speed of assisted vessel or the escort tug shall push the assisted vessel to more safe position. (Westilä, interview 2015)

The most important factors influencing to the successful recovery from a failure situation are initial speed and effective controlling of the rate of turn of the assisted vessel (Saari & Huumonen 2011 p. 6). In order to be able to control the assisted vessel, the tug has to have enough power. The power is not created only with the bollard pull delivered by the propulsion system, but also with the hydrodynamic force created by the hull shape and appendages of tug. When escorting a vessel at high speed the tug can create large yaw angels to control the vessel as it can be seen in picture 2. (Allan et al. 2005, pp.191-205)

The speed is important matter to think during escort operation - at high speed the mass of the assisted vessel can create more force than the tug is able to overcome. Normally the maximum speed at escort operation is about 12 knots; when speed races much over that the tug cannot change effectively the speed or course of the assisted vessel anymore. "*For example the tugs in Neste harbours have safety limit of 10 knots*", tells Jani Huumonen in an interview (2015). (Oil Companies International Marine Forum 2002)

Depending of the speed, the tug has different ways to execute escorting. Indirect steering is used at high speed. As it can be heard from the name, the steering forces are created by indirectly steering the tug. When the tug steers sideways, the water flow against the hull of tug creates hydrodynamic forces and those combined with the propulsion forces create the steering forces (picture 2). At speed under six knots the

tug change to static bollard bull, which is called a combination mode (picture 2). (Oil Companies International Marine Forum 2002)



Picture 2 *Indirect and direct steering* (Bureau Veritas 2014)
1. and 2. Indirect steering mode
3. Combination mode

There are mainly two reasons why escort tugs change from indirect steering to combination mode. The water pressure towards the hull of tug at indirect towing decreases when speed decreases under six knots. Also the ability of the tug to rise up to direct pull gets better when speed is under six knots. The limit of six knots between indirect steering and combination mode is more guideline than rule, reminds Jani Huumonen. The speed limit has been found in practise, not in theoretical research. (Huumonen, interview 2015)

Because there are no international regulations for escort towing, every operator has their own way to execute it. For example, in Finland an escort tug is always fasten to the aft of tanker, but in Russia the policy is not to tether the tug, until it is needed. (Toivola, interview 2015) Those methods are called active and passive escorting; escorting is active when the tug is tethered. (Hensen 2003, p. 152)

"*The ability of a passive escort tug to work and help a vessel is only a small part what an active escort tug can do*" mentions Janne Artila in an interview (2015). If an escort tug is tethered, the reaction time is much shorter than with untethered tug. Finnpilot (producer of pilotage services in Finland) and Neste had made simulations in the simulators of Maritime Research Institute Netherlands (MARIN) about escort towing cases in 2009, these simulations were part of *Reliability of Feedstock Supplies to the Refineries project* and the idea was to develop the safety of oil transportation. In the conclusions of the project it was stated that the reaction time affects a lot to results: "*any delays in action reduce possibilities for successful recovery*". (Saari & Huumonen 2011, p.8)

Reaction time should be in seconds not in minutes to ensure affective escorting, so it is not ideal to lose time to tethering the tug after problems have occurred. For example, to get the crew ready for tethering the tug takes time and it is possible that the assisted vessel has black out situation, so deck machineries do not work. Also the passive tug can be farther away losing time to drive to right place to get tethered. (Huumonen, interview 2015)

4.2 Design of escort tug

Hensen (2003 p.vi) defines *escort tug* as "*Tug specifically build for escorting at high speeds".* Also other types of tugs are used in escort operations, but Hensen uses word *escorting tug* from any other type of tug used escorting a vessel underway. Also some Classification Societies separates escort tugs from other tugs with additional escort-vessel class (more about those requirements in chapter 5). (Hensen 2003, p. vi, 154)

The design of the escort tug is very important, otherwise escorting can actually reduce safety, not raise it. According to Allan al et. (2005) "*The most critical elements in an escort tug are size, stability, and power*". A conventional tug has propulsion and towing device at the same end: aft. This makes the tug fall easily over at high speed, because steering forces press the tug sideways and the tug has no power to straighten itself. Usually conventional tugs can escort safely and effectively only when speed is

under 4 knots. The speed limitation raises some other problems, for example it is not effective for the company use a lot of time only on arrivals and departures and often large tankers lose their manoeuvrability at low speed. (Toivola, interview 2015)

"*There have happened some accidents with conventional tugs during higher speed operations*", tells Jarkko Toivola in an interview (2015). For example, tug Pegasos sank off in Helsinki on 13th November 2003 and the Chief Engineer of tug drowned in the accident. Pegasos was a conventional tug assisting container vessel MSC Hina to the West Harbour of Helsinki. During the operation the stern of Pegasos hit the propulsion current of MSC Hina and this force turned Pegasos quickly in sideways causing the tug capsize immediately. (Onnettomuustutkintakeskus B2/2003M, p. V, 91)

The shape of the hull, tension winch and propulsion are important qualities that make an escort tug safe to operate - those also make biggest difference compared to normal harbour tug. Another critical matter is a towline; if it breaks during escorting, consequences can be fatal. (Toivola, interview 2015)

"*Good towline floats and it does not stretch*", tells Jarkko Toivola in an interview (2015). Towlines made from high-modulus polyethylene fibres (HMPE) are used a lot on board escort tugs (examples from manufacturers are Spectra and Dyneema). Both fibres are light and they float. Those abilities do not only reduce the risk of the towline fouling propellers, but also makes the line easier to handle even in an emergency situation, where no power is available on board an assisted vessel. (Hensen 2003, p. 149)

The risk of overloading and breaking the towline is always present during towing operations, especially during escort towing, because it is a high speed operation. The dynamic motions of tug and vessel create high loads: they move closer to each other during operation due e.g. waves and the towline slacks. This is followed by opposite motion and a rapid high load focus to the towline; of course the higher the snap load increase, the risk of breaking the towline rises in relation to that. It is critical to limit

the snap loads, and it can be done by preventing the towline to slack. (van der Laan & Kraaijeveld p. 2)

Tug operations in exposed conditions have been under research. For example, the SafeTug I and II projects of Maritime Research Institute Netherlands (MARIN) were researching tug operations under variable wind, wave and current conditions by doing model tests and limited model definitions. Also Neste took part to those projects (Saari & Huumonen 2011 p. 8). (de Jong 2007 p. 7)

According to Jani Huumonen a winch is one of most important features of an escort tug. The winch has to be able to react quickly to the rapid high loads of towline to prevent the towline from breaking. Also when the tug is changing from indirect steering position at one side of the assisted vessel to the position at other side of the vessel, this movement creates forces to the towline and challenges the winch. Tension winch has a load reducing system that allows the towline to be paid out and recovered also under high loads. Classification societies pay close attention to the winches of escort tugs. For example, to get classification certificate from DNV GL, it is mandatory to have a load reducing system of winch (DNV GL AS October 2015, p. 115). (Huumonen, interview 2015)

A load reducing system means that the winch has a self rendering device or tension device (Hensen 2003, p. 99). Both systems allow a towline to be paid out or heaved in in case of tension variation in the towline. Because of the working principle of Constant Tensioning Winch, the working speed of the winch is limited to the maximum speed of the winch motor: speed and force of towline are related to the applied motor power and gear ration. Render-recovery winches have higher pay out and pull speed. (van der Laan & Kraaijeveld p.1)

A winch with a load reducing system automatically adjusts the towline according to given values. The values of winch can be pre-set to and changed from a winch control panel. The winches of modern tugs can be controlled from bridge; in that case it is

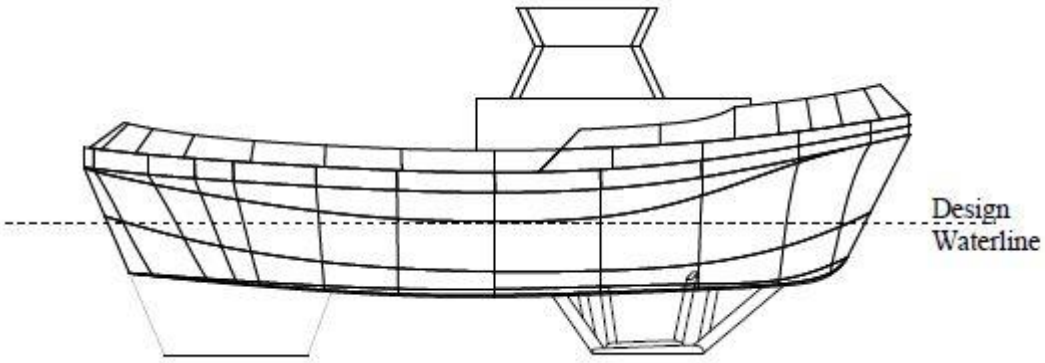
critical to have a good view to the towing winch from the winch control panels to avoid accidents. (Hensen 2003, p. 97, 99)

The hydrodynamic force is created when a harbour tug is moving forward in a straight line or it is turning slowly under the action e.g. rudder. However, the hydrodynamic force created during indirect steering is much higher than the forces created in the classical tug performance, so it is essential to consider the force when designing an escort tug. The hydrodynamic performance of escort tug is the combination of hull shape, appendages and propulsion. (Allan et al. 2005, p.191)

According to Molyneux and Bose (2008) the designs of escort tugs have been developed from practical and model experiments. The scientific research of escort tug design has started after 2000, e.g. Allan and Molyneux (2004) and Molyneux and Bose (2007). In those research they have measured hull forces and yaw angels of escort tug models. (Molyneux & Bose 2008, p. 3)

Normal harbour tugs have such hull forms that they are unable to develop high forces needed in escort towing operations. Escort tugs are designed for large yaw angels (picture 2), but normal harbour tug lack the stability required in that kind of operations. Allan et al. (2005) states that "*The steering and braking forces developed are directly related to the projected underwater lateral area of the hull and appendages*". (Allan et al. 2005, p. 192, 200)

An escort tug has a skeg (example in picture 3) underneath the hull. The skeg is placed to the hull of tug at bow aft direction to create the necessary hydrodynamic forces for escort operations. The skeg of ASD-tugs differs from the skeg of tractor tug, because the high-aspect ratio skeg (picture 3) does not fit to the hull geometry of ASD-tug. The skeg of ASD-tug can be seen in picture 5. If a tug has a skeg, the stability of the tug has to be considered, because the skeg increases towline force and that way also the heeling force increases (Hensen 2003 p. 144). (Allan et al. 2005, p. 194)



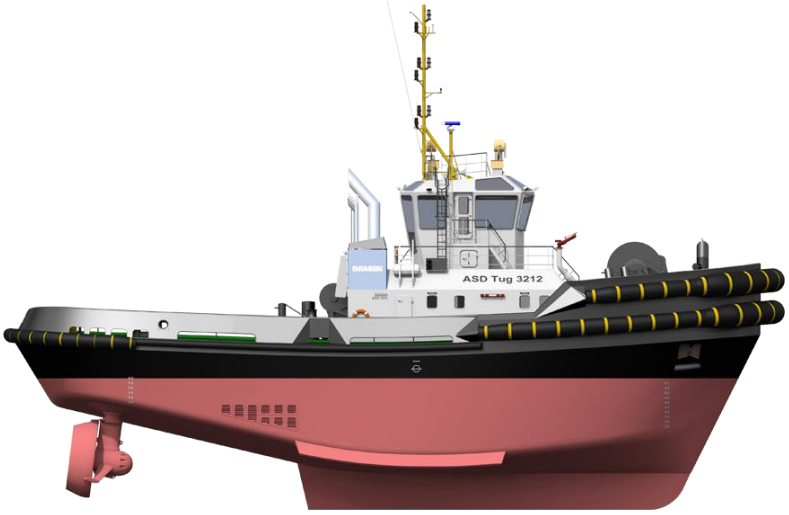
Picture 3 *Profile view of tractor tug, a skeg and Voith Schneider propulsion system as appendages of tug.* (Molyneux & Bose 2008)

Voith Schneider and azimuth propellers are examples from propulsion used in escort tugs. In Voith Schneider system (picture 4) the propulsion is produced with vertical propeller blades. Azimuth propeller is placed in pod making the propeller 360° steerable (picture 5). Both systems can deliver thrust in any direction, because they combine propulsion and steering to one unit. (Hensen 2003, p. vii, 8)

Picture 4 *Voith Schneider propeller* (The Art Of Dredging 2015)

4.3 Azimuth Stern Drive Tugs

Azimuth Stern Drive (ASD) tugs differs from e.g. tractor tugs at propulsion. ASD-tugs have two azimuth propellers fitted under the stern, as it can be seen in picture 5. Propellers can be fixed or controllable pitch propellers. Thanks to azimuth propellers, the ASD-tugs are able to deliver thrust in any direction and they are highly manoeuvrable; an ASD-tug can e.g. turn on a spot and move sideways. The winch used in escort operations is located in the bow (picture 5), it means that ASD-tugs are assisting vessels over the bow. (Hensen 2003, p. 28)



Picture 5 *The design of ASD-tug.* (Damen)

The design of ASD-tug is flexible. They can work as a conventional tug and tow forward on a line, but they are also effective in push-pull operations. The ASD-tugs can easily change from towing on line to push-pull – there is no need to release the towline or change the towline position. (Hensen 2003, p. 28)

Some ASD-tugs are equipped with a bow thruster; it can be a tunnel bow thruster or an azimuth propeller. Bow thrusters can be seen especially with tugs working in offshore operations; there good position keeping ability is critical. (Hensen 2003, p. 28)

ASD-tugs fit well to operational needs in Finland. Azimuth propulsion works in ice conditions and the depth of ASD-tugs is smaller than the depth of a same size tractor tug. The depth of the tug has to be considered, because the tug has to be able to work effectively in the shallow waters of Finnish archipelago. (Artila, interview 2015)

In Finland we have three tugs designed for escort operations and all of them are ASD-tugs. Two of them, Ukko and Ahti, are owned by Huoltovarmuuskeskus and Eläkevakuutusyhtiö Ilmarinen and operated by OSM Shipping Management Finland Oy. The newest escort tug Ahto is owned and operated by Arctia Karhu Oy (Arctia Karhu).

4.3.1 Ukko and Ahti – Neste

Ukko and Ahti are identical escort and harbour tugs build in Spain in 2002. The length overall of the tugs is 33,5 meters. Ahti and Ukko (picture 6) are designed for year around operations at the Baltic Sea. At the moment they are operating at the oil terminals of Neste. The tugs are escorting and assisting berthing and unberthing of tankers. According to Jani Huumonen (interview 2015) other duties and responsibilities of Ukko and Ahti are oil spill response, firefighting and the transportation of humans and goods. (Neste Oil)

Picture 6 *Ukko during escort towing operation.* (Saari 2011)

Ukko and Ahti are ASD-tugs, and they have two Aquamaster US 3001 as propulsion. The tugs have two winches: one in the bow and one in the stern. Both winches are tension winches and the bow winch is used for escort operations. The bridge of tugs is designed for one-man operations, meaning that there is good overall visibility from the bridge. Also the winch control panels are placed at bridge. (Neste Oil)

The tugs were owned by Neste until 2014, Neste has also designed the tugs in cooperation with Beacon Finland Ltd. The tugs were sold to Huoltovarmuuskeskus and Eläkevakuutusyhtiö Ilmarinen, and they are operated by OSM Shipping Management Finland Oy.

4.3.2 Ahto - Arctia Shipping

Ahto (picture 7) is 40 meters long icebreaker that has been designed also for escort towing operations. The vessel is currently operating at Bay of Bothnia, but Ahto has classification to work on international waters. Ahto was launch in 2014 in Uusikaupunki and the vessel got classification as an escort tug at summer 2015. After that Ahto has been escorting ships in Tornio. (Kärkkäinen, interview 2015)

Picture 7 *Drawing of Ahto.* (Arctia Shipping)

Ahto is an azimuth stern drive tug and she has two Rolls Royce Aquamaster propellers as propulsion. The escort winch of Ahto is placed to the bow, it is singled

drum winch made by Rolls Royce. Escort force and brake holding force of the winch are adjustable. The crew of Ahto is three persons. (Arctia Karhu)

Arctia Shipping has contract for ice breaking in Tornio harbour and it is the main task of Ahto, but the vessel is also assisting ships to and from harbours at winter time. During open water season Ahto assists ships with traditional ways or by escorting. At the moment the vessel is escorting propane ships in Tornio harbour. Ahto has also been escorting big timber and container ships in Kemi and Tornio by request of pilots. In future it is planned that Ahto will escort LNG-tankers to Tornio, after LNG-terminal has been build there. (Kärkkäinen, interview 2015)

"*Even icebreaking is the main task of Ahto, the escorting performance of the vessel is also good. It was taken in to consideration while designing the vessel, so escorting and icebreaking features complete one and others in Ahto*", tells Joakim Kärkkäinen in an interview (2015).

5 Escort towing regulations

There are no international regulations considering escort towing. It is also typical that even countries, like Finland, do not have regulations in this matter; some exceptions can still be found, for example Norwegian and some states of USA. Every county or port can decide their limitations by themselves. (Toivola, interview 2015)

When asking about the need of national regulations or laws in Finland, interviewees gave variable answers. Some interviewees stated that regulations could clarify the situation significantly, because now all the responsibility is set to the operator. On other hand also comment "*new rules are not simple to define and even harder to justify"* was given. An interviewee also highlighted the point that every harbour and fairway need special attention due to different environments (e.g. archipelago or no archipelago). Even there are no requirements, when escort towing should be used, there are classification requirements ruling the structure of escort tugs. Regards of classification requirements, it has to be noticed that operational issues are not in the interest of Classification Societies. Class rules of DNV GL are presented in this chapter as an example, also the escort towing rules of Neste are studied in the chapter. The rules of Neste are an example of requirements set by an operator.

5.1 Classification requirements

Only few Classification Societies have made own class or sub-rules for escort tugs. Such Societies are for example DNV GL and American Bureau of Shipping (ABS). Det Norske Veritas was the first one to make own standardisation for escort tugs in 1996. (Hensen 2003, p. 154)

According to Hoffman, it was an industry need to set standard for escort operations and the need rose from the lack of international regulations. "*Classification is used as an independent third party, which is setting the minimum requirement in its Rules both for the yard (designer) and purchaser (shipowner)",* states Jonas Hoffman in an interview (2015). It is important to remember that class rules are minimum

standards for the vessel and e.g. escort class is additional and voluntary. (Hoffman, interview 2015)

DNV GL has specific chapter that contains additional rules for escort tugs in *Rules for Classification of Ships, Part 5 Ship types, Chapter 10 Vessels for special operations*. The requirements for escort tugs are present in Section 11 *Tugs and Escort vessels*; the section contains information for tugs and additional requirements for tugs used in escort operations. The special notations and requirements for escort tugs contain information about hull arrangements, towing winch, stability and full scale testing. The new rules of DNV GL for escort vessels were published in October 2015 and they are coming in force from 1st of January 2016 (Hoffman, interview 2015). (DNV GL AS October 2015, pp. 100-117)

The stability of escort tug is very important factor in ensuring the safety for the crew of tug. DNV GL has requirements for the stability and hull shape to ensure enough hydrodynamic lift in indirect towing mode. The hull has to be designed so that in case of the loss of propulsion, the tug will turn to a safe position without aggressive heeling. (DNV GL AS October 2015, p. 115)

According to the requirements of DNV GL an escort tug has to have a hydraulic load reducing system in the towing winch. The system shall prevent overloads caused by snap loads in the towline. The hydraulic system shall pay out towline before the load in towline reaches the maximum capacity of towline. Also it is stated that "*Normal escort operation shall not be based on use of brakes on the towing winch, but the hold function shall be provided by the gearbox and the hydraulic system instead*". (DNV GL AS October 2015, p. 115)

To get the DNV GL class certificate, Full Scale Testing shall be done to the tug. The test is presented in a separate note: Classification Note 57.2, which will be replaced with new Classification guidance note CG-0155 *Full Scale testing of escort vessels* during December 2015. The new Classification guidance note is based to the present one; the modification of the Classification note is a part of developing jointly regulations for

DNV and GL after the fusion. The Full Scale Testing includes manoeuvre test and the measurements of steering force taken during an escort operation (DNV GL AS October 2015, p. 104). (Hoffman, interview 2015)

The purpose of the Full Scale Testing is to "*determine the escort rating parameters (F_s,t,v)*" of the tested tug and make sure they meet the standards introduced in *Rules for Classification of Ships, part 5, chapter 10, section 11.* Persons involved in the test are Master and crew on board the tug, Master, Pilot and officers on board the assisted vessel and the attending DNV surveyor/surveyors. According to Hoffman (interview, 2015), the surveyor is usually technical expert who is familiar with classification note *Full Scale testing of escort vessels.* (Det Norske Veritas AS no 57.2 2012, p. 8)

Both parts of Full Scale Testing are done while the tug is tethered to the assisted vessel. When the measurement of steering force is taken the tug shall position itself to steering positon with agreed angle. In this position the tug is creating a hydrodynamic force, which can be divided to lift and drag forces. With those numbers and with known steering angle it is possible to establish steering force. (Det Norske Veritas AS no 57.2 2012, p. 8)

The purpose of manoeuvre test is to find the time spend on shifting the tug from indirect steering position at one side of the assisted vessel to the same position at other side of the vessel. The steering position has to be at least 30° to the side of the assisted vessel, meaning that the total angel to shift is at least 60°. (Det Norske Veritas AS no 57.2 2012, p. 8)

To get the certificate from Full Scale Testing from DNV GL, the Full Scale Testing shall be driven once, meaning that only one officer of the tug shall drive the test. The Full Scale Testing includes manoeuvring test, and the driving performance of the officers may vary, but the difference in the performance of the officers is an operational issue and it is not controlled by Classification Society. (Hoffman, interview 2015)

From identical sister vessels the test is driven only with one vessel. In this context word *identical* means that the vessels are built from the same drawings and have same escort related documents. Documents have to be approved by DNV GL. Additional escort class notation has no re-test requirements, meaning that the class certificate will be in force unless the tug is modified or converted. (Hoffman, interview 2015)

In addition to class regulations for tugs there are also regulations concentrating to escorted vessels. For example, the towline connection points are under observation and they have to fulfill standards for towing equipment; these standards are controlled by Classification Societies. Then again industry standards define the selection and building of the shipboard fittings. (DNV GL July 2015, p. 18 – 11)

5.2 Regulations of Neste

Typically escort towing is regulated by the owner of the harbour. In Finland there are only two oil harbours that have regulations regarding escort operations; those are Porvoo oil harbour and Naantali oil harbour. The harbours are owned and operated by Neste. (Toivola, interview 2015)

Escort towing demand is mentioned in *Harbour and Safety Regulations* of Neste harbours, but those cover only operations done inside the harbour area. Finnish law does not know escort towing (as e.g. piloting is regulated by law), so Neste has made *Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes*. Those requirements cover also fairways through archipelago, even the fairway areas are not owned by Neste. (Konkola, interview 2015)

In the harbours of Neste the need of escort towing is limited by the size of the vessel. The rule from *Harbour and Safety Regulations* is "*All tankers over 40 000 DWT, when carrying cargo, are escorted from pilot embarking place to terminal or from terminal to pilot disembarking place with tug A*". Size limitation for assisted tankers is same than

in *Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes.* (Neste Oil Corporation 2014, p.16)

Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes are written and up-dated by Marine Risk Management department of Neste. The requirements contain information about which vessels need escort towing and what are the weather limitations for escorting operations. Also speed and size limitations are presented in the requirements. All the limitations have been found during *Reliability of Feedstock Supplies to the Refineries -project*. The project started in 2006 and Jarkko Toivola was the project manager. The project was running for four years and also Finnpilot took part to it. (Konkola, interview 2015)

The purpose of *Reliability of Feedstock Supplies to the Refineries project* was to find limits for safe oil transportation in Finnish archipelago. The investigation was made by running simulator tests in the simulator of Maritime Research Institute Netherlands (MARIN). The exact models of two vessels (m/t Tempera/Mastera and a conventional Aframax tanker) and fairways to Naantali and Porvoo oil harbours were made to the simulator. During the project about 700 simulations were driven through with the different model combinations and different weather conditions to find limits for safe working. Both full time and fast time simulations were included to the project; full time simulations are driven by humans, but fast time simulations are totally driven by computers, so human factor does not affect to the results, tells Jarkko Toivonen in an interview (2015). (Konkola, interview 2015)

Reliability of Feedstock Supplies to the Refineries project was hold at same time with SafeTug I and II projects. *Reliability of Feedstock Supplies to the Refineries project* exploited the information and methods found during SafeTug I and II simulations to find safety limits for oil transportation. During the project also the base for the escort towing course of Neste was created. (Toivola, interview 2015)

It is not possible and maybe not even ideal to escort all tankers visiting Neste harbours. Escort towing is a safety related services and the benefits of it has to be

evaluated closely and from every angle. With small vessels the risk of accident caused by failure situation is smaller, e.g. they do not drift that far away than big vessels with big mass. The company operating harbour just have to find the level of risk that they can manage; in Neste it is the responsibility of Marine Risk Management department. The company has to consider the consequences of possible accident, but also costs of escort towing. Poor regulations affect directly to the profitability of company, e.g. the price level of freight rises, if there are extra costs during harbour visits (Artela, interview 2015). (Konkola, interview 2015)

After simulations made during *Reliability of Feedstock Supplies to the Refineries project* the size limit of escorted tankers was set to 40 000 DWT. The limit has to be set to somewhere and the tankers with 40 000 DWT are already so large that possible accident causes lots of damage. (Neste 2015, p. 3)

Number of tugs is one thing limiting the possibilities to escort, because in Porvoo one escort operation takes about 3,5 hours, but the tugs running hours from berth to berth are 5 hours and in Naantali the escorting takes about 7 to 8 hours, but whole operation from berth to berth takes about 13 hours. Jani Huumonen points out that "*escorting all the tankers is beautiful idea, but there are more than 2500 vessel operations only Porvoo oil harbor every year, so with this tug capacity it is not an option*". (Huumonen, interview 2015)

According to the pilotage statistics of Finnpilot (2015) the number of pilotage operations in Porvoo oil harbour have been between 2200 and 2500 operations per year for last four years. When reading those numbers, it has to be noticed that every vessel visiting the harbour needs an operation in and out, but all vessels does not need a pilotage to both directions, meaning that the total number of harbour operations is higher. Also it is stated at Neste web-pages (2015) that the Porvoo oil harbour is the biggest harbour in Finland when compared in the volume of cargo in metric tons; the volume of shipped crude oil and oil products is totally over 20 million metric tons per year.

Weather limitations for escorting operations on Porvoo and Naantali are stated in *Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes.* The requirements of Neste (2015, p. 5) are:

- the maximum wind force in average is 18m/s,
- the maximum wind force in the strongest gusts is 23m/s,
- the maximum significant wave height is 3 meters, and
- the visibility shall be at least 1 nautical mile.

The size of tanker is not limited in Porvoo, but in Naantali the maximum size of tanker is 130 000 summer deadweight tons (SDWT). (Neste 2015, p. 5)

Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes are not sent to the vessels but instead *Harbour and Safety Regulations* and *Minimum Safety Criteria* are given out to the vessels visiting harbours of Neste. Those instructions cover all needed information also about escort towing manners. (Konkola, interview 2015)

Neste has oil transportation by seas also to other harbours in Finland. Escort towing is not used in those harbours (e.g. Kokkola and Oulu), because the tankers visiting there are under 40 000 DWT and Neste is using the same safety limits to all operations, including harbours not mentioned in *Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes*. (Konkola, interview 2015)

6 Crew and training

In this chapter the competences of crews are covered. The chapter is divided to the crew of an escort tug and to the crew of an escorted vessel. Also training regarding escort operations organized by Neste is introduced.

6.1 Crew of escort tug

The crew of escort tug is often 3 persons. The size of the crew depends on the size of the tug and the traffic area, but the trend is to cut down the crew on board. Personnel are replaced by high level of automation, for example by placing a winch control to the bridge of the tug. (Hensen 2003, p. 172)

Ahti, Ukko and Ahto have crew of 3-4 persons. The crew on board those vessels includes master, chief engineer and watchman. The master of Ahti/Ukko has to have pilot exemption certificate and after new personnel is hired they will have a familiarization time for escorting operations. Escort towing can be trained also in cooperation with tankers. Outside of the Porvoo archipelago there is wide fairway to try escorting in practise. (Artila, interview 2015)

When new personnel are hired to OSM Finland Ship Management as a tug master, they are working on board Esko for the first year, because the master of Ahti and Ukko needs to have pilotage exemption certificate (Huumonen, interview 2015). The certificate can be request after 12 months' experience at the particular sea area. The requirements for the certificate are practice drives, and theoretical and practical examination. (Trafi)

6.2 Crew of escorted vessel

On board the tankers of Neste, officers have been in an escort towing course, but this is usually not the case with international crews. Normal officer training and study program contains only little or none training concerning escort operations. The

training organized by Neste is introduced in chapter 6.3. For the crew of escorted vessel, connecting the escort tug is same than connecting some other tug. (Toivola, interview 2015)

The responsibility about actions taken during escort operation is always on the master of assisted vessel. The master with assistance of pilot gives all manoeuvring commands to the vessel and also to the tug. The tug master chooses the most efficient way to assist the vessel, but to be able to do that he is dependent on the information given from the vessel. From this it can be observed that efficient and clear communication is vital in ensuring successful recovery from a failure situation. (Saari & Huumonen 2012, p. 53)

A pilot is an important part of bridge team during escort operations, because pilotage is compulsory to all loaded tankers (2003/940 §5 Law on pilotage). Especially with non-trained and foreign crews, the importance of a well-educated pilot is highlighted. The main task of the pilot is always to be specialist for the local conditions and practice; in a failure situation the need of specialist is emphasized. It is critical that someone from bridge team knows right solutions, terminology and can act without delay during escort operation. (Saari & Huumonen 2012 p. 5)

At the moment officers worldwide working on board escorted vessels are not trained to operate with an escort tug, and this practice is not likely to change unless e.g. IMO or OCIMF creates new regulations demanding training. (Huumonen, interview 2015)

6.3 Training by Neste

Neste started to train their employees in an escort towing course after they bought escort tugs Ahti and Ukko. The escort course includes a theory part and simulator exercises. The main focus of the course is to practise actions taken during accidents, for example if the assisted vessel loses its propulsion or rudder. During the simulator exercises communication and cooperation between a vessel and a tug is practised. (Artila, interview 2015)

The first course was during 2004-2005. The escort courses have been kept in cooperation with Aboa Mare, Finnpilot and Neste. The training aggregates together all operators related to escort towing in Finland. Masters, chief officers, pilots and masters of tugs have been at the same course. Janne Artela mentions in an interview (2015) that the courses have been kept also with different target groups, for example there have been courses for only officers of Neste and courses mainly for pilots. (Toivola, interview 2015)

Training concentrating to the cooperation between tanker and tug is needed, because effective communication is vital when technical or human failure appears suddenly. Also position and movement awareness of all parties is crucial for the result. Pilots working on Porvoo and Naantail fairways have been on this course, because they have to be able to handle failure situations of tankers with escort tug also with non-trained crew. (Saari & Huumonen 2011, p.9)

The courses have been kept in simulators of Aboa Mare and MARIN (Saari & Huumonen 2011, p. 7). In Aboa Mare the course is using two simulators and those are designed together with Neste. The simulator bridges have same equipment than the ships of Neste. During the course the simulators are running in same exercise and with them escort towing can be practised. Cooperation between Aboa Mare and Neste started in the early 2000s. (Westilä, interview 2015)

The simulator models of Aboa Mare are based on Sindel-system. There is one model build with the characteristics of Ukko/Ahti and one model of m/t Natura. The operation devices of the tug simulator can be seen in picture 8. When a simulator model of vessel is designed there has to be the 3D-pictures of vessel and also hydrodynamic information, how does it behave in the water; that is why the developing of the simulators took several years. (Westilä, interview 2015)

Picture 8 *The operation devices of tug simulator of Aboa Mare, the control device of tension winch can be seen at the left.* (2015)

The simulators of MARIN have different navigational equipment than the vessels of Neste, but simulator models are very realistic and precise. Vessel models used in MARIN simulators are a double acting tanker (DAT Tempera/Mastera), a conventional AFRAMAX and an escort tug (Ukko/Ahti). According to Saari the simulators of MARIN are more designed for research work and the data out-put of simulators after exercises is excellent. The design of the MARIN simulator can be seen it the picture 9. (Saari & Huumonen 2011, p. 7)

Picture 9 *The simulator of MARIN.* (Saari, 2011)

After Neste sold all their vessels, including tugs, there have been discussions how the training shall continue. Organizing the course is not in the interest of Neste anymore, so a new sponsor has to be found. During the simulations it has been noticed that training improves the controlling of a failure situation significantly, so there is a need for the course also in the future (Saari & Huumonen 2011, p.15). (Artila, interview 2015)

7 Future of escort towing

For Neste the reason of starting escort towing tankers was to manage risks on oil transportation, to protect nature and to secure the functioning of the oil terminals (Toivola, interview 2015). The safety impacts of escort towing are proved in different researches (e.g. Li and Calisal 2005) and the need of escort towing vessels has not reduced in the last ten years.

Safety impacts of escort towing have been studied worldwide in different areas. Often the researches are made by simulating the harbour area or fairway under different weather conditions with different simulator models. For example, in the study *Numerical Simulation of Ship Maneuverability in Wind and Current, With Escort Tugs* (2005) by Ye Li and Sander M. Calisal simulation area were the entrance of Vancouver Harbour. In the conclusion Li and Calisal state that the simulated escort towing improved the safety at harbour entrance by about 40%. (Li & Calisal 2005, p.175)

The demand of escorting operations in the harbours of Neste is likely to increase. "*The purchase of crude oil will change in the future",* tells John Konkola. The oil is bought more and more as a chartered, so the visits of conventional tankers will increase in the future. Also smaller conventional tankers than 40 000 DWT could use escorting, because they lose their directional stability quickly, if problems with propulsion or rudder occur. (Konkola, interview 2015)

Interest in escort towing is increasing nationwide. As Kärkkäinen mentioned in an interview (2015), LNG tankers in Tornio are planned to be escorted with a tug. The use of LNG is expected to increase in the future, so the transportation of LNG also to other Finnish harbours can be predicted. According to Konkola, Neste is discussing about shipping LNG, but those vessels carrying LNG would likely to be relatively small (under 40 000 DWT). Based to the limits of *Requirements for Escort Towing for Naantali and Porvoo Deepwater Routes* those vessels would not use escort towing services. (Konkola, interview 2015)

Also in Uusikaupunki the size of ammonia carriers (LPG-ships) might increase after the dredging work on the fairway. The use of escort tug service on Isokari – Yara 12.5 m fairway could increase the safety of navigation of the large ammonia carriers. (Saari, interview 2015)

The impacts of escort towing to the safety of cruise ships can be discussed. They are using very narrow fairways and they always have thousands of passengers on board, but other hand they have several engines and maneuvering devices. "*Usually losing e.g. one engine does not lead to the total loss of ability to maneuver on board cruise ships*", mentions Artila in an interview (2015).

The development of marine engineering could affect to the need of escort towing. If it will be effective and profitable to build vessels with high level redundancy (e.g. with several engines and maneuvering devices) the need of escort towing could reduce. The redundancy concept means that the system is able to maintain the functions even after any single failure in the system (Det Norske Veritas AS 2011, p. 9). Already the double acting tankers are released from escort towing requirement when the tankers are not carrying cargo, because it can be assumed that those tankers will recover from failure better than conventional vessels (Neste 2015, p. 4). At the moment it is still very expensive to build vessels with the high level of redundancy, because those systems are more sophisticated and the systems also use more energy; it can be expected that the developments of technical systems will not affect to the number of escort towing operations at least in the short-term future.

8 Conclusions

The aim of the thesis was to create a compact and easily accessed paper about escort towing. In order to do the thesis, information from different operators were collect, the persons interviewed are working with issues related to escort towing in Finland. The starting point in the thesis was to find out, what escort towing means and how does it differ from other tug operations. When this question was researched, it was found that escort towing is a high speed operation, that needs special attention to succeed. Not only the design of escort tug makes the operation safe, but also the training of crew influences a lot to the results.

The information got from the interviews and literature support the hypothesis that escort towing has significant impact to the safety of sea transportation. When this conclusion is compared to other researches (e.g. Li & Calisal 2005), same result can be seen. The number of escort towing operations can be expected to be growing in the future and escorting also other than oil vessels is likely to increase.

As a conclusion from the interviews it can be stated that the ideal limitations for vessels escorted are hard to find; answers of the interviewees about good regulations vary. Because there are no national regulations ruling this business, the operator of harbour has to find a risk limit that they can manage by themselves. The limits can be found e.g. with simulations done in different conditions.

For example, at the moment it is not possible to escort all the vessels visiting Porvoo harbour; there are not enough tugs to cover all over 2500 harbour operations per year in Porvoo. The idea of *Reliability of Feedstock Supplies to the Refineries project* of Neste was to find acceptable level for risks in oil transportation. The limit was set to 40 000 DWT, it has been decided that accidents with smaller vessels can be handled and they are less likely, because small vessels also have smaller mass and they will not drift that far in failure situation.

When setting the limits, the benefits and costs of escort towing have to be balanced, because poor regulations can affect to the profitability of the company. Not only the costs caused by escort towing or possible accident are taken into account, but also the damage to the reputation caused by an accident. The reliability of the company affects straight to the profitability, and that way accidents can affect to the business for long time.

The training of escort towing operations has major effect for the results of controlling failure situations. Usually the failure situations occur suddenly, so fast reaction is critical in reaching the successful recovery. To be able to react quickly the humans operating both the tug and the vessel have to have the experience of right approach to the situation. This can be reach only with active training. Especially the training of pilots is vital; at the moment there are not international regulations about escort towing training, so the most seafarers worldwide have not had any training regarding this subject. In those cases, the pilot is important link between the vessel and the tug.

This bachelor thesis can be defined as reliable source of information; this claim is based to the fact that several independent sources are used in theoretical parts to support one and other. The references are select so they are answering to the research questions. It can be assumed that the conclusion of this work would not change significantly by changing the used reference researches; most of the available research have the similar conclusions. When searching statistics about the effects of escort towing in Finland, none was found. This can be seen as shortage in this research, that kind of information could have increased the value of the thesis.

The coverage of the thesis can be discussed. The interviews are concentrating only to persons working on the field, so their answers are guided by practice and experience. Of course the answers are based on knowledge, but this can also lead to thinking positively and biased about escort towing. The authorities could have been interviewed to get their notions about the importance and future of escort towing.

For the future researches it would be interesting to study the need for international or national regulations or laws for escort operations. Objective could be something like, why escort towing is not mandatory by law. Now the whole responsibility is moved to the operator, but regulations could clarify the situation. From the other hand "*new rules are not simple to define and even harder to justify",* remarks Toivola. Now we already have regulations in harbours and every harbour anyway needs own standards, because they are built differently and located in different places (e.g. archipelago versus no archipelago).

Other idea for the future researches is to study the size limit of escorted tankers. What would be a good limit? According to Konkola the size limit in Brofjorden in Sweden is 20 000 DWT. Especially with conventional vessels the need of escort towing does not reduce even when the size of vessel is under 40 000 DWT; conventional vessels lose their directional stability quickly after failure, as it was noticed e.g. in m/t Natura accident in 1998.

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Captain Westilä, Ossi *Manager of simulator training at Aboa Mare*, interview on 17th November 2015

Pictures

Picture 1 Taken by Ari Saari, 2012

Picture 2 Bureau Veritas (July 2014), *Safety Guidelines for Design, Construction and Operation of Tugs*, Guidance Note NI 617 DT R00 E, page 9 http://www.veristar.com/portal/rest/jcr/repository/collaboration/sites%20content/live/veristarinfo/web%20contents/bv-content/generalinfo/giRulesRegulations/bvRules/rulenotes/documents/Ni%20617%20July%202014.pdf (retrieved: 10.11.2015)

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Picture 4 The Art Of Dredging 2015 http://www.theartofdredging.com/voithschneider.htm (retrieved: 1.12.2015)

Picture 5 Damen http://products.damen.com/en/ranges/asd-tug/asd-tug-3212 (retrieved: 28.11.2015)

Picture 6 Taken by Ari Saari, 2011

Picture 7 Arctia Shipping http://arctia.fi/uudentyyppinen_jaanmurtaja_peramerelle

Picture 8 Taken by Eveliina Saari, 2015

Picture 9 Taken by Ari Saari, 2011

Appendix I – Questions for interviews

- Mitä saattohinaus on?
- Miten saattohinaus erotetaan muusta hinaustoiminnasta?
- Mikä vaikuttaa siihen, milloin saattohinaajaa käytetään?
- Luoko saattohinaus jotain erityisvaatimuksia alukselle tai miehistölle?
- Miksi saattohinaustoiminta aloitettiin maailmalla?
- Milloin saattohinaustoiminta on aloitettu Suomessa?
- Miksi se aloitettiin?
- Mitkä tahot olivat ensimmäisiä toimijoita?
- Onko Suomessa saattohinausta määrittelevää lainsäädäntöä?

- Mikä on riskienhallinta-osaston tehtävä?
- Kuka päättää sataman säännöistä?
- Miksi öljy-yhtiö haluaa saattohinauksen terminaaleihin, vaikka viranomaiset eivät vaadi sitä?
- Miten saattohinattavien alusten kokoluokka on päätetty?
- Mitä ovat olosuhdemittarit ja miten ne on määritelty?
- Verrataanko sääntöjä muiden alan (ulkomaisten) toimijoiden toimintatapoihin?
- Onko tarvetta sääntöjen muuttamiselle? esim. kiristäminen
- Onko saattohinauksen vaikutuksia tutkittu/ kirjattu ylös?
- Neste kuljettaa laivoilla öljyä muihinkin satamiin kuin Porvooseen ja Naantaliin. Onko saattohinaustoimintaa ajateltu laajentaa niihin?
- Neste ei enää omista hinaajia. Miten yhtiö varmistaa, että toiminta jatkuu? Entä esimerkiksi tarvittavan koulutuksen takaaminen miehistöille?
- Miltä näyttää saattohinaajien tulevaisuus Nesteen satamissa?

- Arctia.fi-sivuilla mainittiin, että saattohinaus ja jäänmurto ovat hyvin erilaisia toimintoja. Miten ne on pystytty yhdistämään Ahto-hinaajan ominaisuuksissa?
- Onko jäänmurto hinaajan ensisijainen työtehtävä?
- Millä alueella Ahto toimii?

- Mitä aluksia hinaajalla on tarkoitus saattaa ja missä?
- Onko Ahto jo toiminut saattohinaustehtävissä?
- Käyttääkö Arctia Shipping muita aluksia saattohinaustehtävissä?

- I found Classification rules for escort tugs from July 2012 (*Rules for classification of Ships, Part 5 Chapter 7)*. Is there any updated publication?
- If the answer to above mentioned question is yes, where can I found those documents?
- Why do we need an additional escort class for tugs? What is the function of classifications?
- I read from escort class rules that Full Scale Testing is done while driving the tug. How it is done in practice? Is the tug escorting a vessel and measurements are taken during the operation or is there some other way to do it?
- When Full Scale Testing is driven shall every officer drive it or is it enough that only one officer drives it?
- If there is a group of identical tugs, shall Full Scale Testing be driven with every tug separately?
- How long the escort tug classification certificate for a tug is in force?
- What kind of background the DNV surveyor mentioned in Full Scale Testing – chapter usually have?
- Do different Classification Societies have similar requirements for escort tugs? For example, when DNV and GL integrated did they have different rules for escort tugs?
- Has there been pressure for extort regulations regarding escort tugs?
- Should there be different escort classes for different size of tugs? E.g. with the same way than in ice class there are different levels (1A,1B,1C). Could that help vessel owners to know which tug can effectively escort different size of ships?