E-Fleet – A strategic decision support tool for energy-efficient fleet design

Given a specific set of transportation needs (e.g. crossing time and cargo amount) and constraints (e.g. physical laws, available resources and max harbor dimensions) the transportation system can be designed more or less effectively. Effectively here referring to how well the solution meets the chosen benchmarking properties (e.g. emissions, costs, or speed) compared with other solutions. By analyzing and thereby understanding the relationship between these basic needs, constraints and their resulting properties, more effective transportation systems can be designed. E-fleet is a tool that can be used to perform such analysis. It is based on a methodology developed for evaluating complex transportation system concepts for the ferry traffic between the Swedish mainland and the island of Gotland.

Initial vessel design

The initial design of a vessel is often referred to as the design process between the basic specified requirements (ship owner) and the contract design (yard). A design spiral is used to illustrate the design of the vessel.

Several prominent naval architects have combined naval architecture with systems engineering and thereby developed good design procedures. These procedures can be seen as road maps for how to complete one lap in the design spiral.

Depending on the size and complexity of the problem these procedures can become time consuming, since things quickly become detailed – general arrangement, ship structure, weight estimations, required propulsion power, cost, updating the general arrangement and so on.

E-fleet

E-fleet is a tool for rapidly and resource-efficiently evaluating transportation systems, either consisting of a single vessel or a complex fleet consisting of different ships with different operational profiles.

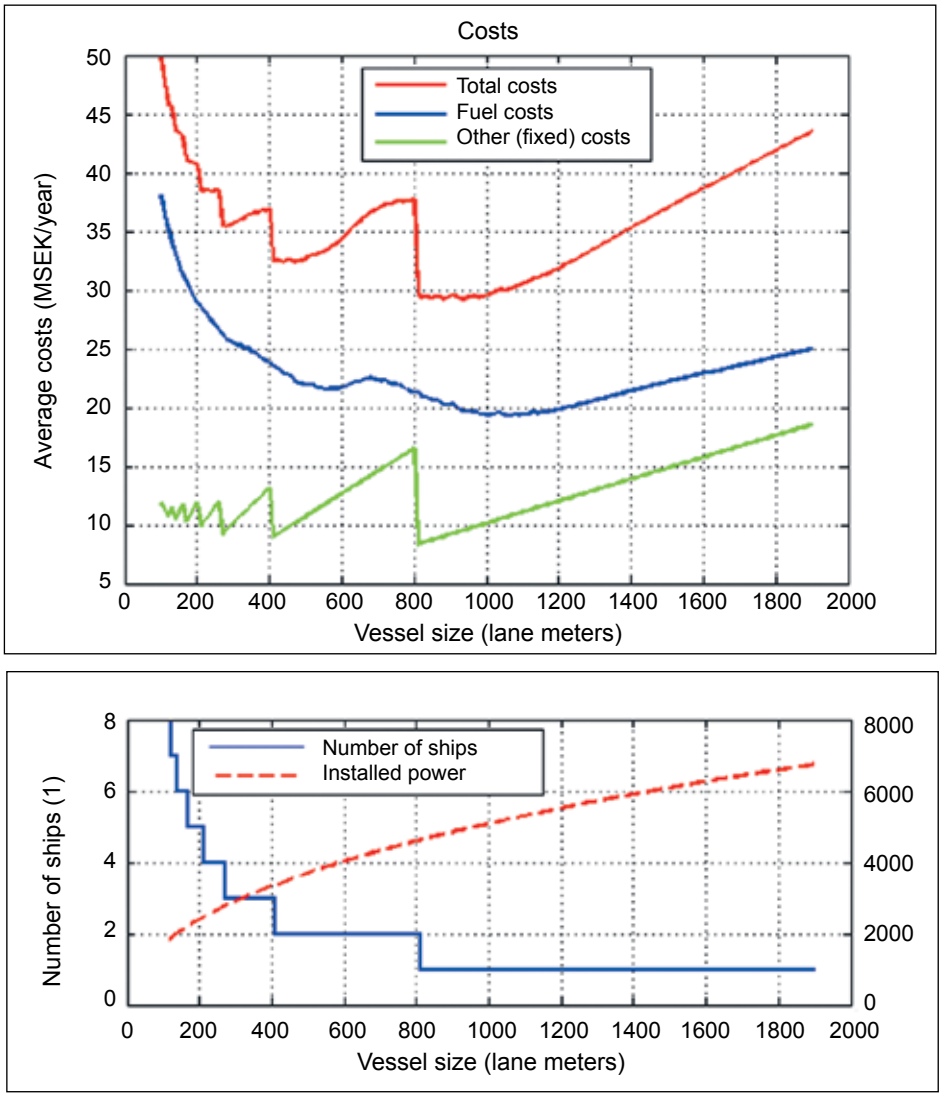
Compared with the design spiral, it completes the first lap and is therefore a helpful tool at the planning stage when determining the holistic design of the transportation system. The result of an analysis using E-fleet could for instance be input variables for an initial design.

"E-fleet is a tool for rapidly and resource-efficiently evaluating transportation systems, either consisting of a single vessel or a complex fleet consisting of different ships"

Energy efficient ferry traffic to Gotland – A tricky challenge

The tool was initially developed for analyzing the energy needs of different transportation system concepts for the ferry traffic between the Swedish mainland and the island of Gotland.

The traffic to Gotland carries passengers, passenger vehicles and trailer transport on two different routes. It is



E-fleet simulation showing yearly costs, needed amount of vessels and required installed power for different size of vessels.

characterized by large variations in transportation needs during the year, icy winters and the desire for a top-quality service, referring here to short crossing times and at a high rate. Together with the requirement for an overall cost minimization, designing the most energy-efficient solution, i.e. transportation system, became a tricky challenge.

Different plausible transportation systems with different setups of vessels were specified and evaluated using E-fleet. Total emissions and costs were compared and from that the most suitable concept was found.

Method

E-fleet's strategy was to replace conventional analytical and physical models, e.g. required propulsion power, with statistical models. Large databases with information of similar vessels together with knowledge of the trends the data described, laid the foundation for the statistical models.

Here, one statistical model with few input parameters could replace several physical equations that could depend on many more parameters. By doing so, many time-consuming operations could be skipped, while at the same time realistic results could be obtained.

One large Ro-Pax or two smaller fast Ro-Pax ferries plus one slow Ro-Ro?

An additional area of application, that is possible due to the rapid and automated format of E-fleet, is studying the consequence of single parameters. By varying parameters and repeating the evaluation in E-fleet, the parameters' influence on the result can be studied. This can be of interest for parameters that are either left out or not important for the design – or in other words, where there is room for improvement.

Such parameters could range from different mooring alternatives to choosing between one large or several small vessels.

The result of such an analysis is presented in the figure to the left. The figure illustrates the annual costs for different vessel sizes (given here in cargo capacity) and amount of vessels for a given operational profile: specific cargo and transportation needs, specific routes, service speed, etc,. The analysis shows that the most economical fleet configuration is obtained for one vessel with a capacity of 800 lane meters.

The conclusion from the example is that the solution is not easy and even quite complex in a rather simple scenario.

Current development

Last year E-fleet was awarded funding for further development through the Hugo Hammars fond för sjöfartsteknisk forskning research fund. The goal of the project is to produce a more general model for calculating energy needs given a specific operational profile (route, service speed, installed power, etc.). The purpose has been to cover more types of marine traffic, especially maneuver-intensive traffic, such as smaller archipelago vessels. The project is planned to end in mid-2013 and will be ready for commercial use later in the year.

Philippe Ghawi

Project Manager.
He graduated with an M.Sc. in Naval Architecture from the Royal Institute of Technology in 2012. At SSPA, he works with the development of E-fleet while participating in various ship design and traditional naval architecture-related projects.

Contact information:
Direct: +46 31 772 91 91
E-mail: philippe.ghawi@sspa.se