TurboRouter

Vessel schedule optimizing software

Table of contents:

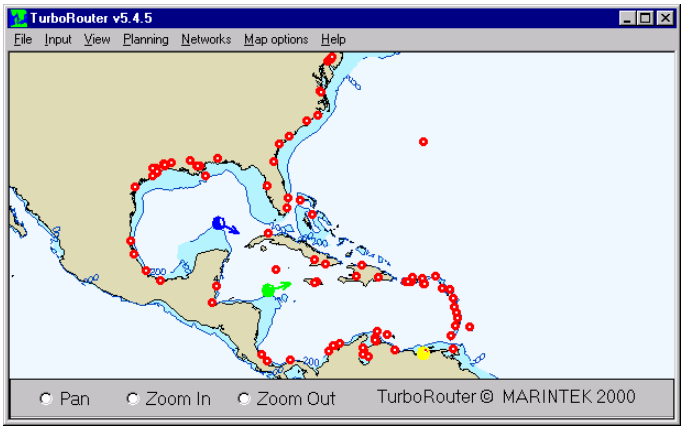
TurboRouter - Optimization of vessel fleet scheduling

Traditionally, vessel fleet scheduling has been considered as somewhat of an art. You are either gifted with an extraordinary talent or you are more of an amateur. It has most often been done manually using paper and pen based on the planners' knowledge and experience. There has been little or no use of advanced optimisation software in planning of fleet schedules in maritime transportation. However, planners have human constraints - a chartering manager can in practice consider only a few vessels and cargoes simultaneously; thus, only a few schedule alternatives are evaluated. Optimisation software implemented on a computer can calculate millions of alternatives in only a few seconds but tend to have restricted ability to handle all practical constraints that occur in real life.

MARINTEK Logistics has developed TurboRouter, a tool for optimizing vessel fleet scheduling. The design philosophy behind TurboRouter has been to combine the knowledge and experience of the planners with the calculating capabilities of the computer. Therefore, much emphasis has been put in the development of the graphical user interface, and it is always possible for the planner to overrule or edit schedule suggestions from TurboRouter.

The TurboRouter Software – Features

TurboRouter is based on electronic sea charts (C-MAP) where scheduling information can be displayed. This figure shows the main window in TurboRouter. The red circles represent the ports, while the other symbols in the map correspond to vessel positions (provided by Pole Star).



Other key elements of TurboRouter include:

- Database for vessels, ports, cargoes, etc.
- Automatic calculation of port-to-port distances
- Vessel position reports and automatic update of Estimated Time of Arrival
- Sophisticated optimization routines for fleet scheduling
- Schedule visualization
- Schedule calculator for manual planning

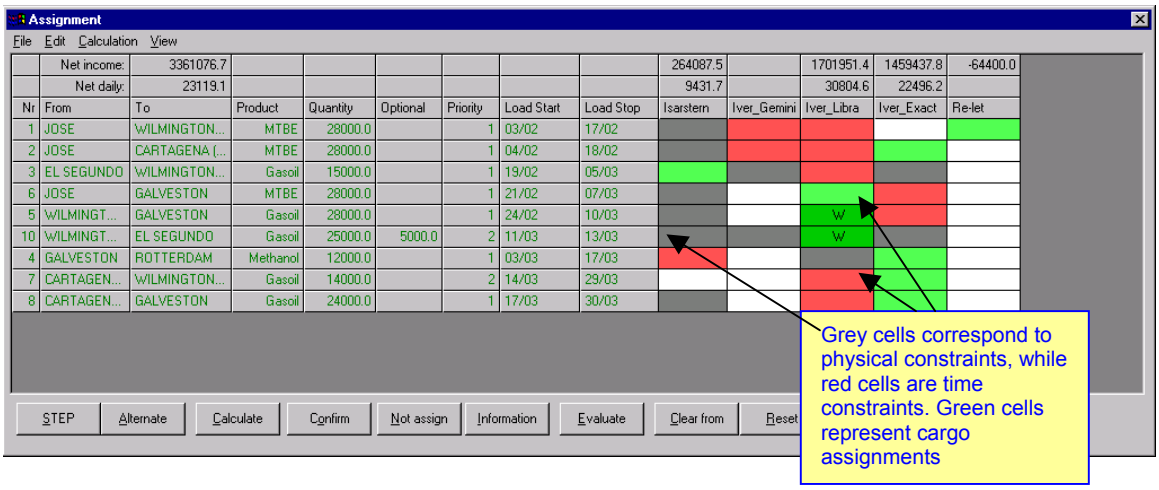
By using TurboRouter, the following effects can be achieved:

- Improved utilisation of assets
- Improved TC-results
  - reduced costs
  - increased income
- Improved work processes
  - less time consuming planning processes
  - improved information flow
- Better basis for budgeting

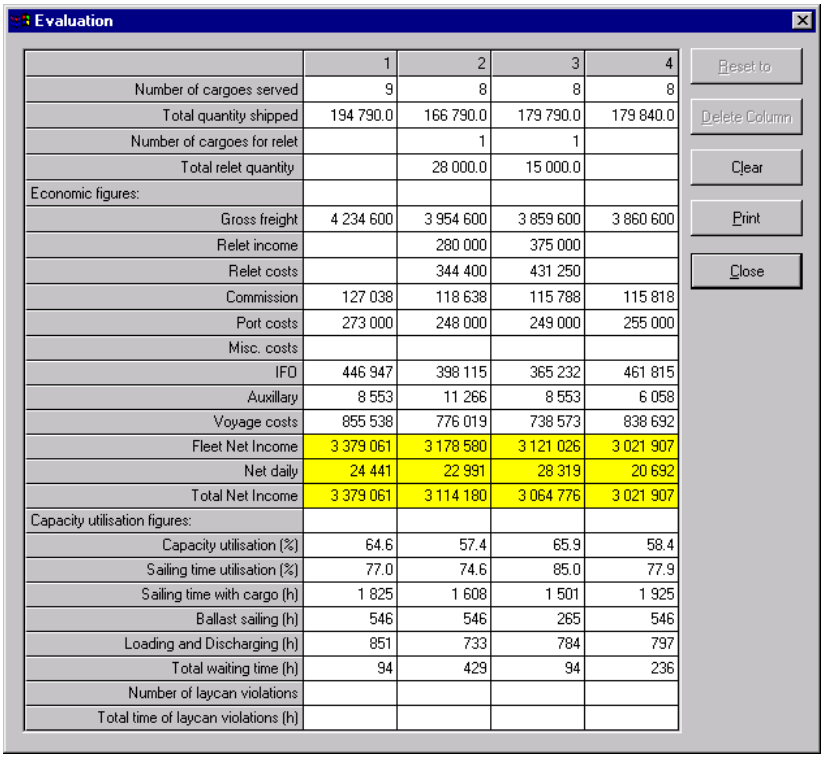
Fleet schedule optimization

The cargo assignment function in TurboRouter is developed for designing optimal fleet schedules, i.e. to decide which vessels to assign the different cargoes to. The planner can do this by manually assigning the cargoes to the vessels or he can activate the optimization algorithm for fleet scheduling, or a combination of these two ways of planning.

TurboRouter will always show the planner an updated view of the assignment possibilities, represented by white cells in the cargo assignment function. By assigning a cargo to a given vessel, TurboRouter will immediately calculate the economic impact for the fleet and for the given vessel. In addition, if the given cargo assignment restricts the possibilities for assigning other cargoes to the particular vessel (for instance due to cargo laycan), it will be shown in the planning window.



The planner can also operate with a number of possible schedule scenarios in order to select the optimal one, see the figure below.



	1	2	3	4
Number of cargoes served	9	8	8	8
Total quantity shipped	194 790.0	166 790.0	179 790.0	179 840.0
Number of cargoes for relet		1	1	
Total relet quantity		28 000.0	15 000.0	
Economic figures:				
Gross freight	4 234 600	3 954 600	3 859 600	3 860 600
Relet income		280 000	375 000	
Relet costs		344 400	431 250	
Commission	127 038	118 638	115 788	115 818
Port costs	273 000	248 000	249 000	255 000
Misc. costs				
IFO	446 947	398 115	365 232	461 815
Auxillary	8 553	11 266	8 553	6 058
Voyage costs	855 538	776 019	738 573	838 692
Fleet Net Income	3 379 061	3 178 580	3 121 026	3 021 907
Net daily	24 441	22 991	28 319	20 692
Total Net Income	3 379 061	3 114 180	3 064 776	3 021 907
Capacity utilisation figures:				
Capacity utilisation (%)	64.6	57.4	65.9	58.4
Sailing time utilisation (%)	77.0	74.6	85.0	77.9
Sailing time with cargo (h)	1 825	1 608	1 501	1 925
Ballast sailing (h)	546	546	265	546
Loading and Discharging (h)	851	733	784	797
Total waiting time (h)	94	429	94	236
Number of laycan violations				
Total time of laycan violations (h)				

Experience shows us that by using the fleet schedule optimization function in TurboRouter, the planner is be able to improve fleet utilization. This may for instance result in more spot cargo liftings, which can have a huge impact on bottom line.

The optimization routine in TurboRouter can accommodate the following:

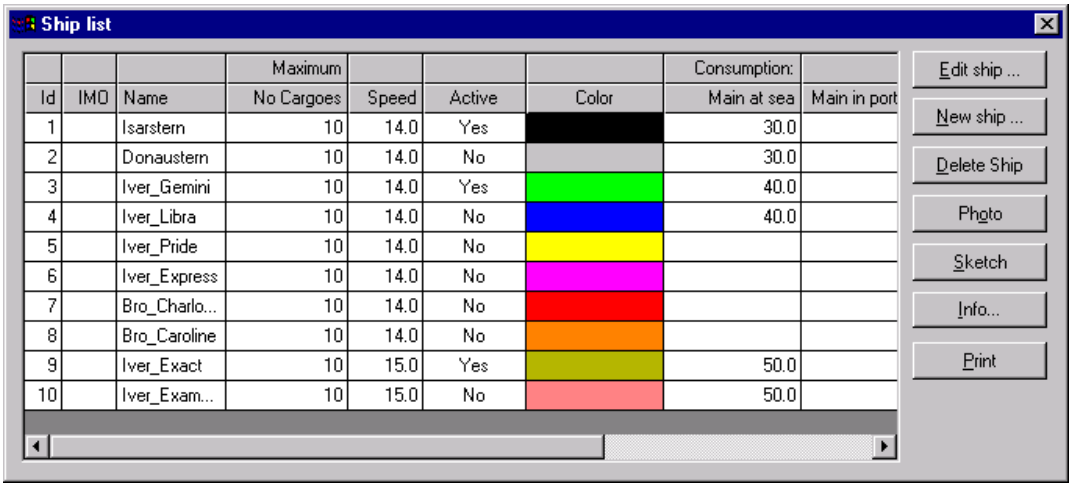
- Optimize with respect to financial result (net daily) or with respect to fleet capacity utilization
- Cargo time windows (laycan) both for loading and/or discharging
- Vessel capacities
- Compatibility between vessels and loading/discharging ports
- Compatibility between vessel equipment/certificates and products to be shipped
- Parcel cargoes or full shiploads
- Split cargoes (the cargoes can be divided in several cargoes to be shipped by several vessels)
- User-specified planning period
- Multiple products
- Combination of spot and contract cargoes
- Priorities on the cargoes
- Relet of cargoes
- Inclusion/exclusion of time charter vessels
- Sequencing constraints due to incompatible products in vessel tanks on consecutive voyages

The fleet schedule optimization function can also be used for more long-term planning such as for instance:

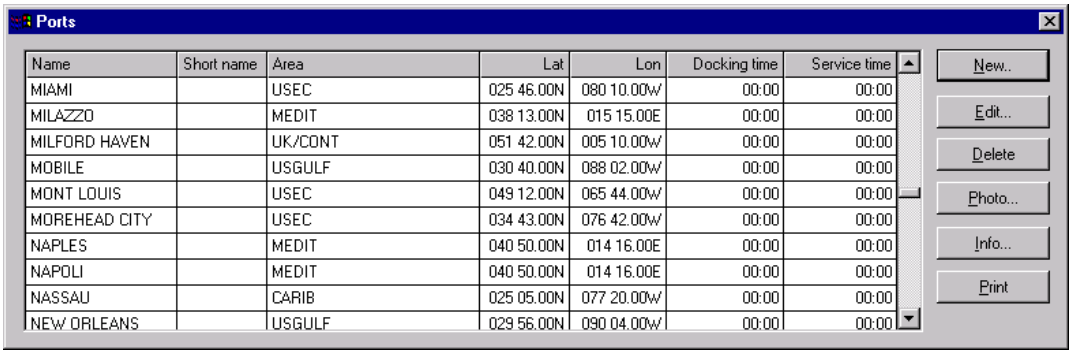
- Cargo contract evaluations
- Tonnage planning
- Fleet merger evaluations
- Budget planning

Database for vessels, ports, cargoes, etc…

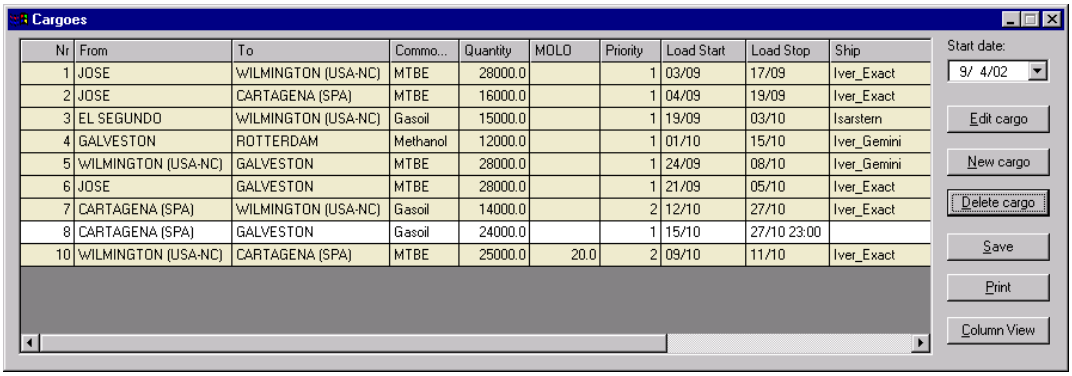
TurboRouter includes a database for all types of information necessary for planning of fleet schedules, such as vessels, ports, cargoes, etc… The following shows the TurboRouter dialogs for the vessel fleet, ports and the cargoes:



Id	IMO	Name	Maximum No Cargoes	Speed	Active	Color	Consumption: Main at sea	Main in port
1		Isarstern	10	14.0	Yes		30.0	
2		Donaustern	10	14.0	No		30.0	
3		Iver_Gemini	10	14.0	Yes		40.0	
4		Iver_Libra	10	14.0	No		40.0	
5		Iver_Pride	10	14.0	No			
6		Iver_Express	10	14.0	No			
7		Bro_Charlo...	10	14.0	No			
8		Bro_Caroline	10	14.0	No			
9		Iver_Exact	10	15.0	Yes		50.0	
10		Iver_Exam...	10	15.0	No		50.0	

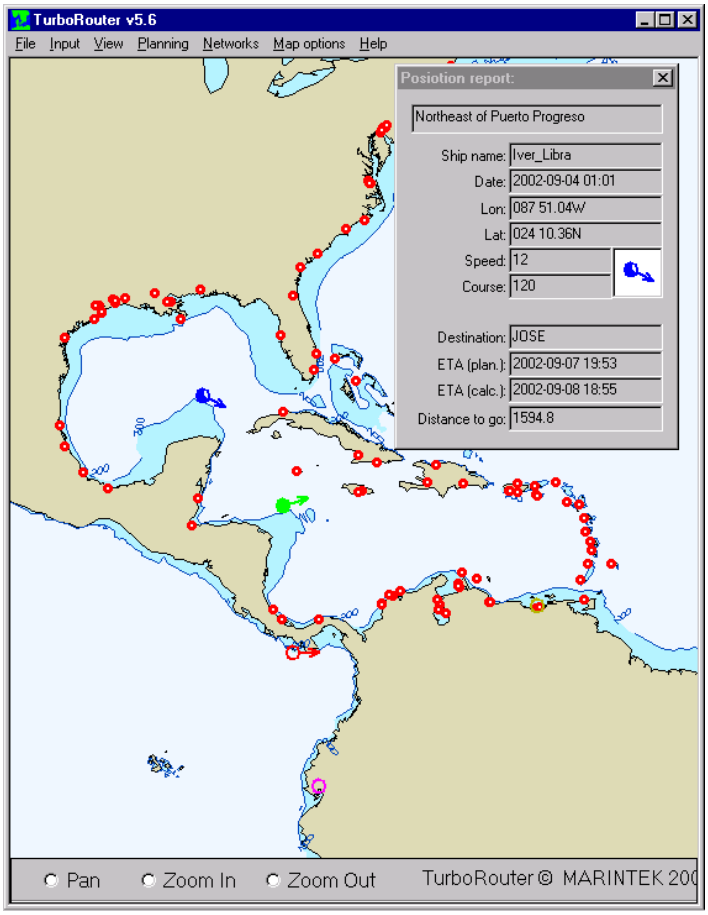


Name	Short name	Area	Lat	Lon	Docking time	Service time
MIAMI		USEC	025 46.00N	080 10.00W	00:00	00:00
MILAZZO		MEDIT	038 13.00N	015 15.00E	00:00	00:00
MILFORD HAVEN		UK/CONT	051 42.00N	005 10.00W	00:00	00:00
MOBILE		USGULF	030 40.00N	088 02.00W	00:00	00:00
MONT LOUIS		USEC	049 12.00N	065 44.00W	00:00	00:00
MOREHEAD CITY		USEC	034 43.00N	076 42.00W	00:00	00:00
NAPLES		MEDIT	040 50.00N	014 16.00E	00:00	00:00
NAPOLI		MEDIT	040 50.00N	014 16.00E	00:00	00:00
NASSAU		CARIB	025 05.00N	077 20.00W	00:00	00:00
NEW ORLEANS		USGULF	029 56.00N	090 04.00W	00:00	00:00



Nr	From	To	Commo...	Quantity	MOLO	Priority	Load Start	Load Stop	Ship
1	JOSE	WILMINGTON (USA-NC)	MTBE	28000.0		1	03/09	17/09	Iver_Exact
2	JOSE	CARTAGENA (SPA)	MTBE	16000.0		1	04/09	19/09	Iver_Exact
3	EL SEGUNDO	WILMINGTON (USA-NC)	Gasoil	15000.0		1	19/09	03/10	Isarstern
4	GALVESTON	ROTTERDAM	Methanol	12000.0		1	01/10	15/10	Iver_Gemini
5	WILMINGTON (USA-NC)	GALVESTON	MTBE	28000.0		1	24/09	08/10	Iver_Gemini
6	JOSE	GALVESTON	MTBE	28000.0		1	21/09	05/10	Iver_Exact
7	CARTAGENA (SPA)	WILMINGTON (USA-NC)	Gasoil	14000.0		2	12/10	27/10	Iver_Exact
8	CARTAGENA (SPA)	GALVESTON	Gasoil	24000.0		1	15/10	27/10 23:00	
10	WILMINGTON (USA-NC)	CARTAGENA (SPA)	MTBE	25000.0	20.0	2	09/10	11/10	Iver_Exact

Vessel position reports and updated Estimated Time of Arrival



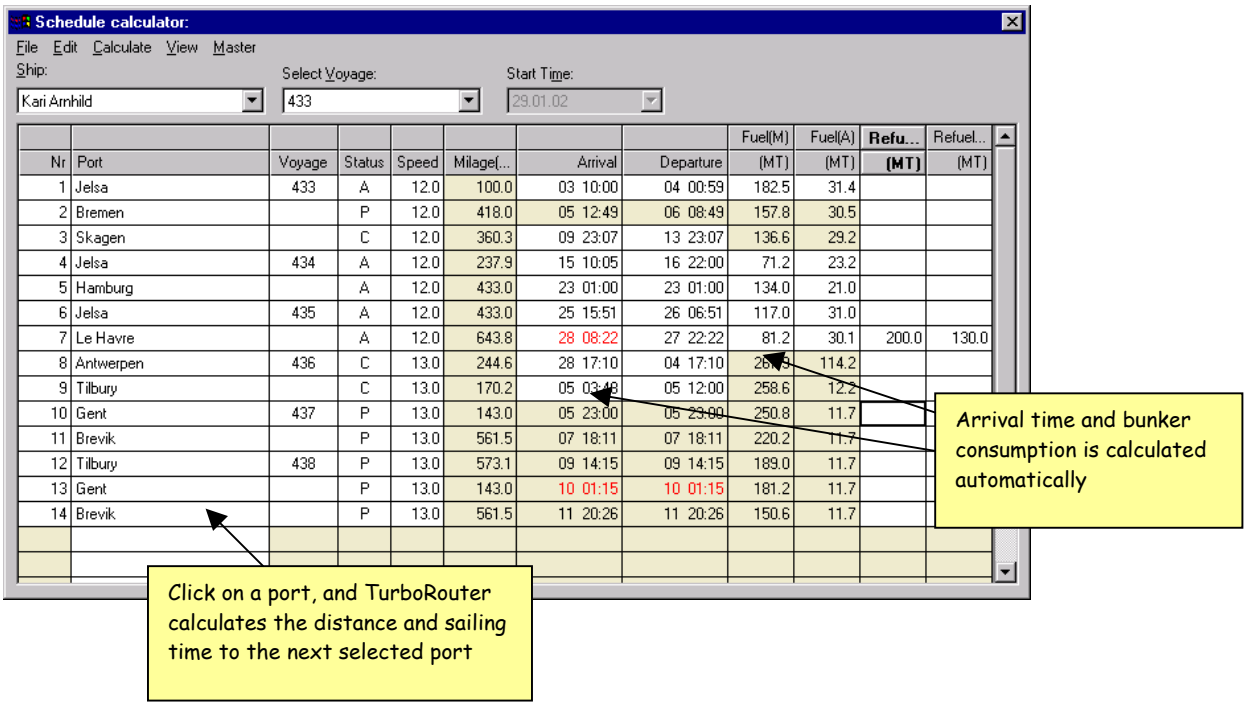
Satellite vessel position reports (provided by Pole Star) gives the planner an intuitive picture of fleet status. TurboRouter can calculate the distance and the sailing time from the ship position to the next port in the schedule. This function is also used for calculating updated ETAs. In this way, the planner can reveal deviations from the planned schedule at an early stage and make corrective decisions.

The ship-to-port distance calculation function can also be used to evaluate whether a vessel can arrive the port in time for a particular cargo.

Schedule calculator - manual planning

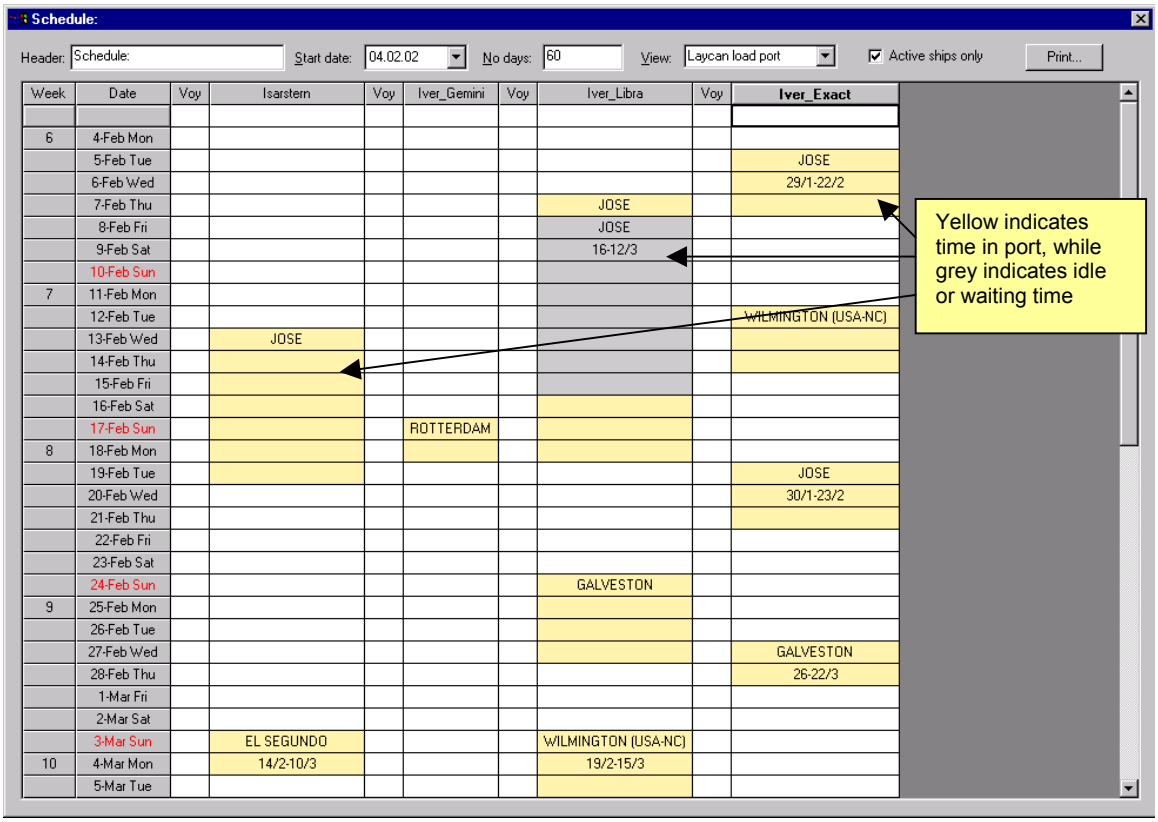
The schedule calculator is an excellent function for manual planning and following-up of schedules generated by the function for fleet schedule optimization. The user can enter a sequence of port calls for a given vessel and TurboRouter calculates the distance and sailing times between the ports, and hence the arrival and departure times.

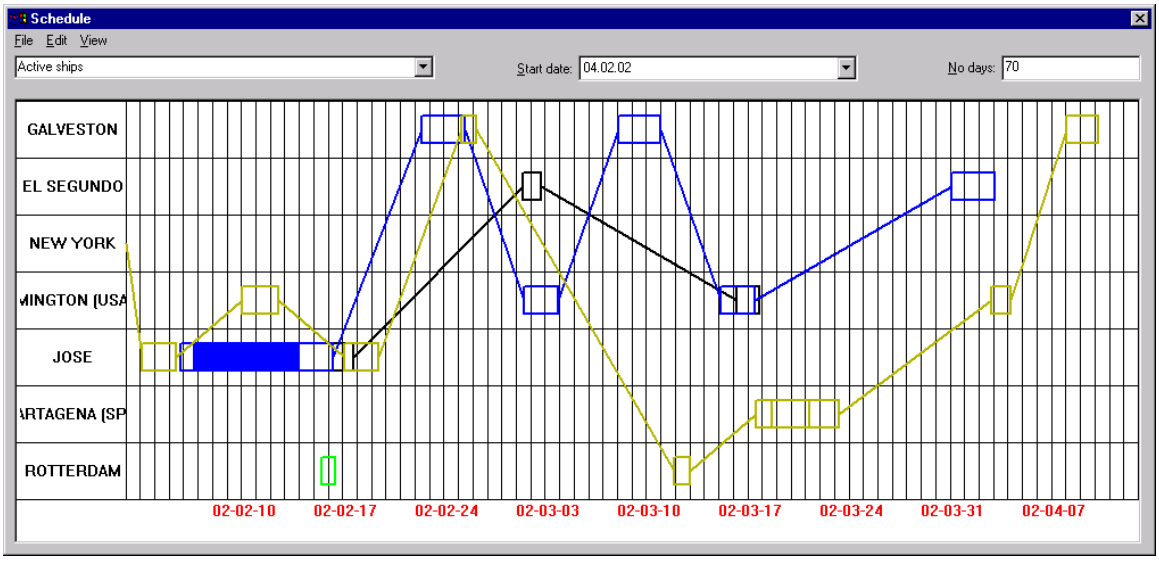
The schedule calculator has also been used by some shipping companies as decision support for evaluating where and how much to bunker.

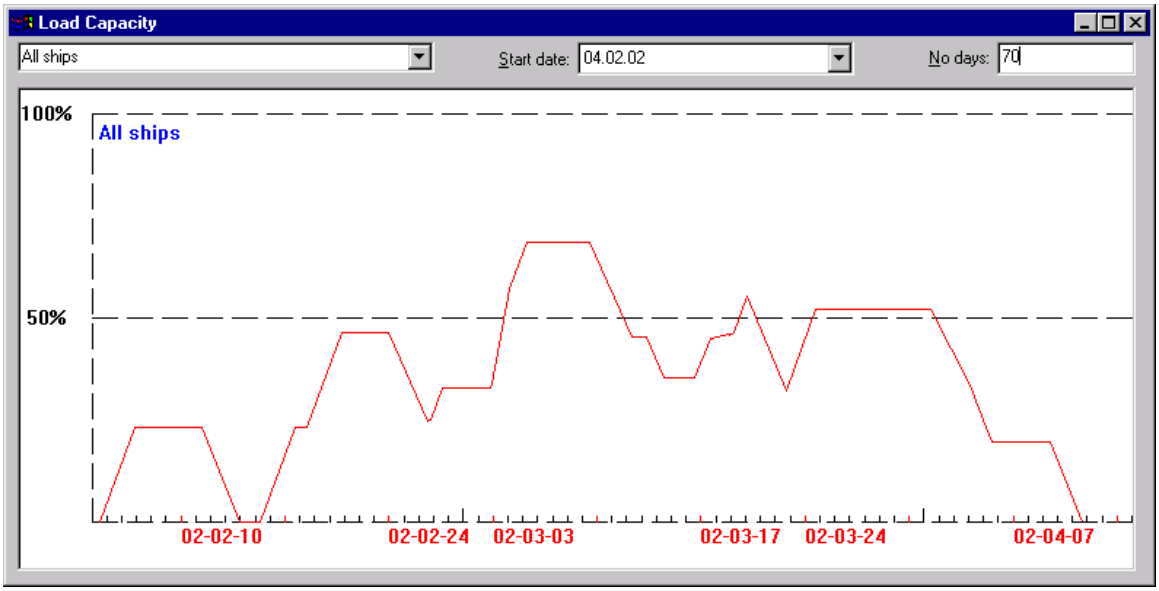


Schedule visualization

The following figures show examples on different views for visualizing the planned fleet schedule.





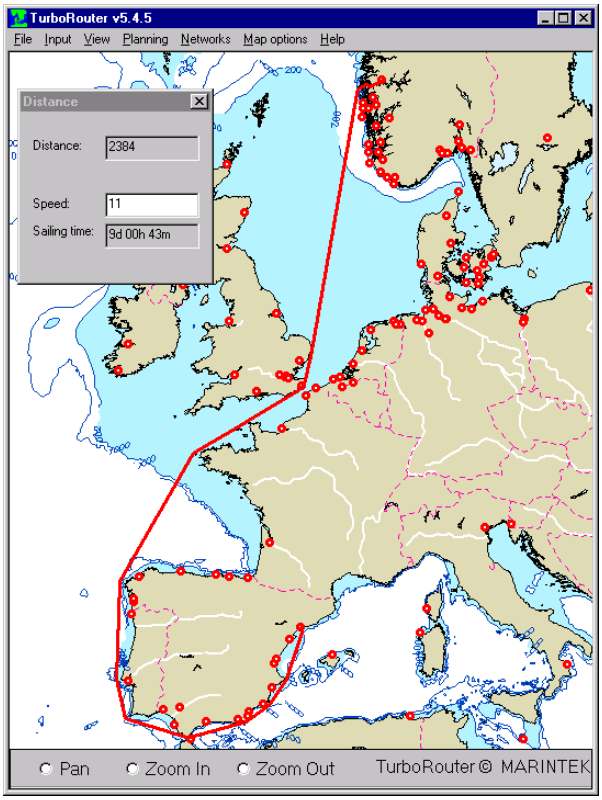


Fleet Program

File View loading View discharging

Isarstern	Iver_Gemini	Iver_Exact
JOSE	ROTTERDAM	JOSE
13/09 19	17/09 13	05/09 04
EL SEGUNDO L3	WILMINGTON (USA-NC) L5	JOSE L1
01/10 12 - 02/10 18	29/09 15 - 01/10 23	05/09 04 - 07/09 12
19/09 - 03/10	24/09 - 08/10	03/09 - 17/09
15000 Gasoil	28000 MTBE	28000 MTBE
WILMINGTON (USA-NC) D3	GALVESTON D5	JOSE L2
16/10 07 - 17/10 20	06/10 03 - 09/10 11	07/09 12 - 08/09 20
		04/09 - 19/09
	GALVESTON L4	16000 MTBE
	09/10 11 - 10/10 11	
	01/10 - 15/10	WILMINGTON (USA-NC) D1
	12000 Methanol	13/09 09 - 15/09 23
	CARTAGENA (SPA) L8.1	JOSE L6
	25/10 03 - 26/10 12	20/09 12 - 23/09 08
	15/10 - 27/10	21/09 - 05/10
	16840 Gasoil	28000 MTBE
	ROTTERDAM D4	GALVESTON D6

Port-to-port distance calculations in TurboRouter



TurboRouter includes unique routines for calculating port-to-port distances. Instead of using static distance tables that are hard to keep updated, TurboRouter calculates the distance between any pair of ports. This is done by calculating the shortest (great circle) distance between the ports that does not intersect any land contours. Experience shows that the calculated distances are far within the requirements for this type of planning tool.

The red line in the screenshot illustrates the shortest distance calculated by TurboRouter between two ports.

Partners

Partners in the TurboRouter development

The shipping companies Beltship Management AS and Iver Ships AS are contributing with expertise from the ocean shipping industry in the TurboRouter development. They have especially played an important role in determining the requirements to be handled by TurboRouter.

MARINTEK (www.marintek.sintef.no) has recently signed an exclusive distribution agreement with ShipNet (www.shipnet.no), a major software provider for the shipping industry. We have also started the work of linking TurboRouter with ShipNet software systems.

Pole Star (www.polestar.com) is our provider of vessel position reports, while C-map (www.c-map.no) provides the electronic sea charts that is a part of the user interface in TurboRouter.

The Norwegian Research Council has partly funded the TurboRouter development.

TurboRouter clients

Beltship Management AS
Beltship Management was established in 1997 as a 50/50 partnership between Jebsens and Heidelberger Zement Group of Germany. The company is located in Bergen, Norway. Beltships has 9 vessels at their disposal, mainly with independently operated belt self-unloaders. Most of the vessels operate in the North Sea basin and in the Mediterranean.
Beltships has been involved in the development of TurboRouter since 1999, and have used the tool for optimizing fleet scheduling in the North Sea basin since then. According to Tom Konow, Chartering Manager in Beltships, "Time consuming fleet scheduling processes have been significantly improved by using TurboRouter".

Knutsen OAS Shipping
Knutsen OAS, with their head office in Haugesund, Norway, operates a significant number of purpose-built shuttle tankers, chemical carriers and product tankers world wide. They have used TurboRouter since July 2001 mainly for optimizing fleet scheduling of their shuttle tankers in the North Sea Basin. They have experienced that by using TurboRouter, they have been improving fleet utilisation in a way enabling them to carry more spot cargoes in addition to their contract commitments. According to Ingolf Haughovd, Charterer in Knutsen OAS, "TurboRouter has significantly improved the utilisation of our fleet" and "it has proved to be an excellent tool for evaluating new contracts and tonnage".

Iver Ships AS
Iver Ships, with their head office in Sandefjord, Norway, operates between 25 and 30 chemical tankers world wide. They have been involved in the development of TurboRouter since 2000, and have used the tool for optimizing fleet scheduling for their Atlantic operation since 2001.

Publications within maritime logistics and the TurboRouter development

The TurboRouter project has in addition to the development of a fleet scheduling software also resulted in a number of academic contributions. The following list shows a number of articles that have been published in refereed journals or in conference proceedings:

M. Christiansen and K. Fagerholt (2002) Robust ship scheduling with multiple time windows. Naval Research Logistics 49, 611-625.

K. Fagerholt and B. Rygh (2002) Design of a sea-borne system for fresh water transport - A simulation analysis. Belgian Journal of Operations Research, Statistics and Computer Science 40(3-4), 137-146.

K. Fagerholt (2001) Ship scheduling with soft time windows - An optimisation based approach. European Journal of Operational Research 131(3), 559-571.

K. Fagerholt and M. Christiansen (2000) A travelling salesman problem with allocation, time window and precedence constraints - An application to ship scheduling. International Transactions in Operational Research 7(3), 231-244.

K. Fagerholt, A. Loktu and S. I. Heimdal (2000) Shortest path in the presence of obstacles - An application to ocean shipping. Journal of the Operational Research Society 51(6), 683-688.

K. Fagerholt (2000) Evaluating the trade-off between the level of customer service and transportation costs in a ship scheduling problem. Maritime Policy and Management 27(2), 145-153.

K. Fagerholt and H. Lindstad (2000) Optimal policies for maintaining a supply service in the Norwegian Sea. OMEGA - The International Journal of Management Science 28(3), 269-275.

K. Fagerholt and M. Christiansen (2000) A combined ship scheduling and allocation problem. Journal of the Operational Research Society 51(7), 834-842.

K. Fagerholt (1999) Optimal fleet design in a ship routing problem. International Transactions in Operational Research 6(5), 453-464.

K. Fagerholt (1999) A simulation study on the design of flexible cargo holds in small sized bulk ships. Maritime Policy and Management 26(2), 105-109.

K. Fagerholt and S. I. Heimdal (1998) Algorithms for effective transfer of ballast for an oil installation. Journal of the Operational Research Society 49(1), 16-22.

K. Fagerholt (1999) Optimisation based methods for solving ship routing and scheduling problems. Ph.D. thesis.

K. Fagerholt and H. Lindstad (1999) Reducing costs for supply services. Scandinavian Oil & Gas Magazine.

M. Christiansen and K. Fagerholt (2001) Ship scheduling with restricted port opening hours. In proceedings from the Triannial Symposium on Transportation Analysis (TRISTAN IV), Ponta Delgada, Acores - Portugal, 2001.

K. Fagerholt and A. Kroneberg (2000) Designing future transport systems by scenario and optimisation techniques. In proceedings from the 7th International Marine Design Conference, Kyongju, Korea, 2000.

K. Fagerholt and M. Christiansen (1998) Multi-product ship scheduling problem with flexible cargo holds - An optimisation based heuristic approach. In proceedings from the Triannial Symposium on Transportation Analysis (TRISTAN III), San Juan, Puerto Rico, 1998.

K. Fagerholt and S. I. Heimdal (1996) Improving short sea bulk operations. In proceedings from the Third European Research Roundtable Conference on Short Sea Shipping, Bergen, Norway, 1996.

K. Fagerholt (2002) A computer-based decision support system for vessel fleet scheduling – Experience and future research. Submitted revised.

K. Fagerholt (2002) Designing optimal routes in a liner shipping problem. Submitted.

M. Christiansen and K. Fagerholt (2002) Ship routing and scheduling – Status and trends. Submitted.

Contact

For more information about TurboRouter, please contact:

Kjetil Fagerholt, Dr.ing., Senior Research Engineer
MARINTEK Logistics
E-mail: kjetil.fagerholt@marintek.sintef.no

Address:
P.O. Box 4125 Valentinlyst
N-7450 Trondheim, NORWAY

Phone: +47 73 59 56 80
Fax: +47 73 59 57 78