A. Appendix A: Scientific Research Paper

IMPROVING THE TRAJECTPLANNER

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Abstract

This research focused on improving a current traveltime estimation system called the Trajectplanner. This system simulates the movements of inland ships on a network model of the Dutch inland waterways in order to calculate and to estimate the Estimated Time of Arrival (ETA) for every ship that sails the inland waterways (excluding pleasure crafts). There are errors in the estimation of this ETA and this research focused on the cause of these errors and find ways to improve the system. These improvements were than tested via a self-made simulation tool.

1. Introduction

Inland shipping is an important part of the Dutch economy, 34% of all transport is done by inland shipping (1).Just like trucks have uncertain travel times due to possible traffic jams and road works, inland ships have uncertain travel times due to locks, water levels and other ships. For both modalities, Rijkswaterstaat is the organization which controls and maintains the Dutch infrastructure. Rijkswaterstaat is part of the Dutch Ministry of Infrastructure and Environment and responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. Which include among others the inland waterways and the management of inland shipping. The management of inland shipping is now done from many locations where objects and sectors are being operated individually. Rijkswaterstaat wants to centralize the management of inland shipping and has started the project CBB (Corridor gericht Bedienen en Begeleiden) which, when translated, stands for Corridor oriented Operating and Guiding. The goal of this project is to centralize the management of inland shipping.
The inland waterway system is divided into corridors. These corridors represent important shipping routes and are shown below

Figure 1 Corridor map (5)

The idea of CBB is that a ship can sail over a corridor faster and more efficient than it would do today due to better planning of objects and a better knowledge of the situation on the waterway.
In order to achieve this, the CBB project will centralize the management of the inland waterways. The goal is to have 1 location for each corridor (figure 1) from where all the objects and sectors are being operated. For Rijkswaterstaat, this means more efficiency with operating objects and better and easier communication between objects and sectors. When objects and sectors are being operated from the same location, it is easier for operators to communicate with each other and because multiple objects are operated from one location, one operator can operate multiple objects. For the skipper this means a better service with better information about his journey and the situation on the water and near objects.
Next to centralizing the operation, the CBB project is also creating and updating systems in order to implement corridormanagement. These systems help the operators with their jobs and facilitate the skipper in giving him better service and better information. For example, a new system is being developed to track ships. Other systems, like data systems about water levels and waterway characteristics are being updated. Another new system is the Trajectplanner. This system is a tool which helps both the skipper and Rijkswaterstaat with managing inland shipping. It does this by using data from many other systems and using that data to simulate the entire journey the ship will be making.With this simulated data it makes schedules for locks and bridges which the ship will be passing and will make prognoses of the occupancy rate of the inland waterways. With these prognoses and schedules, the skipper can adapt his speed and/or route in order to sail more efficient. For example, when a ship starts its journey, the skipper has to give information about his cargo, destination and draft to Rijkswaterstaat. This information is then used by the Trajectplanner to predict the route the ship is going to take. When this is done, the Trajectplanner knows which objects the ship is going to come across. It can than schedule the ship in with the objects. in the case of bridges, if the ship is low enough and the bridge doesn't have to open, the ship can than sail through without stopping or slowing

down. But when the ship encounters a lock, it has to go through the lock procedures. Which means it has to wait for the lock chamber to be ready and maybe ships that have to go in first. If it is busy at the lock, it can be that the ship has to wait for an hour to let other ships go through the lock. The Trajectplanner can schedule all ships into the lock procedures, so when it is busy at the lock, the Trajectplanner can tell the ship to slow down, so it doesn't have to wait when it arrives at the lock. Because the Trajectplanner has all this data it can tell the skipper when to arrive at a lock, but it also knows when it is through the lock and can therefore tell the skipper when he will arrive at his final destination. The data which is estimated by the Trajectplanner is also used by Rijkswaterstaat to efficiently control their objects and corridors. When the lock operators know when ships will arrive, they can reduce the amount empty lock operations. And when corridor managers know when certain parts of the waterway will be busy with ships, they can take actions accordingly. For the Trajectplanner, the Dutch waterway system was modelled with dots and lines which are similar to a network of nodes and arcs. This will be further discussed later in this report. These arcs represent part of the waterway and the nodes represent points on the waterway. When a ship is starting his journey, the Trajectplanner predicts the route the ship will take. This route is predicted along the nodes and arcs. Each node the ship passes has an ETA (Estimated Time of Arrival) for that ship. These ETA's are estimated by the Trajectplanner. To estimate the ETA for the next node, the Trajectplanner uses the ETA it estimated for the previous node and ads the cost of the arc between the nodes. For arcs without objects the cost consists of is the sailing time for that arc which depends on the type of ship, the type of waterway and if the ship is loaded or not.

For arcs with an object on them, the cost consists of the sailing time for that arc plus the time it takes to pass the object. This paper is structured as follows. The next section describes the research and analysis that was done into the problem and its cause. Section 3 describes the improvements that were thought of after the analysis of the problem and section 4 describes the Simulation tool which was made in order to test the improvements. Last, section 5 will describe the conclusion and recommendations.

2. Research and analysis

As mentioned before, the ETAs which are estimated by the Trajectplanner are important. Because the Trajectplanner uses the ETA of one point to estimate the ETA for the next point, it is important that these estimations and simulations are accurate. At the moment, this is not always the case. Inaccurate ETA's is a problem for single ships, but also for the other ships.

Single ships: If an ETA of a ship for one of the nodes is incorrect/inaccurate, all the points following will be incorrect/inaccurate. And when there is a lock on the route and the ETA for that lock is inaccurate, the schedule for that ship will be inaccurate. The inaccuracy which occurred at the first point will become bigger at the last point.

Multiple ships: If the schedule for a single ship is incorrect because of an incorrect ETA, the schedule for all the other ships that were in the same schedule will be incorrect. And so, if an ETA for one ship is inaccurate, ETA's for other ship will also become inaccurate.

A literature review was first performed in order to analyse any previous research and systems. Reports about inland shipping often didn't use a true node and arc representation of the waterway, although Li (2017) (2) comes close. Zhou et al.(2016) (3)described an interesting model which could easily be converted for use to describe an inland waterway system. The model used by Zhou et al.(2016) (3) combined with the model used by Li (2017) (2) could be used to make a full model of the inland waterway system. The paper by Li (2017) (2) also shows that locks are a big source of uncertainty. However, the model used by Li assumes that ships will follow the route given by the model which would only be true in a perfect situation. Parolas (2016) (4) showed the importance of an accurate ETA when multiple stakeholders come together in the transportation of goods. Problems with the received data about position and speed or problems with traffic on the way will not be used in this paper because the error in location and speed compared to the size and travel times of the ships are assumed neglectable. A search for other system like the Trajectplanner gave programs like SIVAK and BIVAS. These are used in order to analyse influences like blockages, new lock design and policy changes on inland shipping. The output of these programs is for example, average waiting times, occupancy of the waterways, etc. They are used to look at the bigger picture, not at individual ships.

Rijkswaterstaat uses KPI's for all their services, but because the Trajectplanner is not operational yet (it is running and working, but it is not yet used in the operation (guiding ships, lock operations, etc.)), there are no KPI's formulated yet. This means that a new KPI needs to be thought of. Considering the problem this paper describes it is logical to include the estimated arrival time (ETA) in the KPI.

Just like a car navigation system, a system which simulates the movements of ships will simulate every couple of seconds or minutes. This means that the ETA to the destination will change if new events occur in the simulation. This also means that the estimated ETA can be tracked over time and with the knowledge of the actual arrival time (ATA), the accuracy of the ETA can be monitored (afterwards).

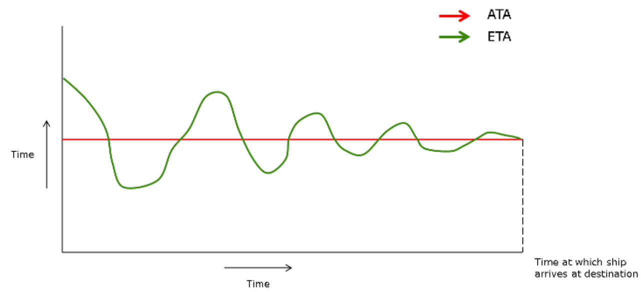

Figure 2 ETA fluctuations through time

The skipper needs an accurate ETA when he plans his journey, or when he is at the beginning of his journey. The ETA needs to stay accurate, also during the journey. If the skipper wants to use Trajectplanner the way it is intended (More efficient planning and sailing, slowing down or speeding up), the accuracy of the ETA needs to stay constant during the trip. It is therefore important that the ETA doesn't fluctuate to much. This can be represented by a max difference between ETA and ATA which is small.
The proposed KPI is therefore:

$$KPI_x = MAX|ETA_x - ATA_x|$$

This means that the KPI is based on the max difference between the ETA and ATA. This is done because a spike in the ETA estimations would cause errors throughout the journey but also for other ships. It is therefore important that this value is as low as possible. This KPI can be determined for every point in the system and different point are important for different users, for example, for the skipper, the point before a lock and the final destination point are important. But for this research the points before and after a lock are important because of the influence of a lock on the estimation.
As explained before, the Trajectplanner is a system which estimates, simulates and predicts the movements of all the inland ships which sail on the Dutch waterways system and have an AIS transponder (A radio device which sends out the position, speed and ID of the ship). To simulate this, the Trajectplanner receives information from other systems and uses this do run the simulation. For example, the system receives GPS data for all the ships as well as their departure and destination points. To be clear, the Trajectplanner has no influence on the ship, the way a ship sails or the workings of objects. The RTA it gives out for ships and the schedules it gives out for objects, are suggestions for the skipper and the operator. The Trajectplanner does not make decisions.

Figure 3 Trajectplanner part map of waterways

In figure 3, part of the Dutch waterways system is displayed as used by the Trajectplanner. Figure 3 shows the area around Utrecht/Nieuwegein in which the Beatrix, Irene and Marijke locks are positioned. The locks are not shown or indicated in this figure. In figure 3 blue lines and dots can be seen. These lines represent the waterways on which ships sail and the points represent points on the waterway to where ships can sail to and from. It could be said that the lines are arcs which connect the nodes, in this case the blue dots.
The dots are used to represent junctions, begin/end positions like ports and docks. These dots don't represent objects like locks and bridges.
These dots are used to estimate ETA's. For every ship in the system, the Trajectplanner estimates the ETA's for each dot that ship will encounter. In order to do this the Trajectplanner uses data like: Type of ship, max speed of ship, max speed allowed on waterway, depth of waterway, If the ship is loaded or empty, draft of ship, dimensions of waterway, dimensions of ship. Every 6 minutes, the Trajectplanner simulates all the ships and their movements in the inland waters of the Netherlands which have AIS transponders on board. The skipper itself has to put in the destination. The Trajectplanner combines all the information it has and uses it to calculate the best route for the ship and uses this route to determine which objects the ship will encounter. And if needed, the Trajectplanner schedules the ship in a lock. It does this every 6 minutes and does not keep track of previous simulations. In other words, it starts over every 6 minutes. The Trajectplanner uses an event based simulation which means, certain simulations will only be done if an event is triggered.
The analysis of the output of the system was performed with the UI which is also available for the operators. This means that the data which is shown by the Trajectplanner is the same data that is used by the operators and systems like IVS Next.
For each dot the Trajectplanner estimates the ETA's for all the ships that pass that dot. These dots don't have any characteristics other than being a point for which an ETA is estimated.

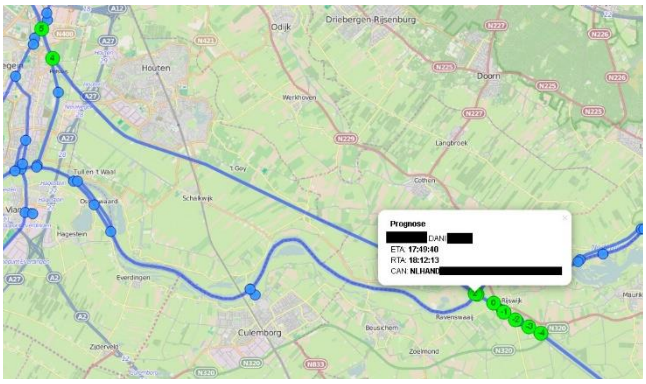

Figure 4 Trajectplanner UI data

The data which the Trajectplanner shows is shown in figure 4. For normal dots the only data the Trajectplanner gives is the ETA for that point, for dots with a lock or bridge behind it, the Trajectplanner also gives an RTA (Requested Time of Arrival) for when the ship is requested. This RTA indicates at which the the ship has to be there in order to go through the lock or past the bridge. This RTA value can be used by skippers to decide if they can slow down or have to speed up. The data which is shown in figure 4 is used to analyse the Trajectplanner. The Trajectplanner simulates every 6 minutes which means that every 6 minutes, new data is available.

In order to perform an analysis, a ship is chosen to follow for a couple of hours. The routes these ships take can be different, but often there is a lock within the route to see how this effects the ETA's. During the analysis, comments are written down about speed, other ships on the waterway, location in front of a lock etc. In order to start an analysis a ship is chosen and 2 or more points are chosen along the route to track. Every 6 min (or when new data is available) the ETA's and RTA's for every chosen point are recorded. These data points are put into a graph in order to see how the ETA fluctuates over time. An example with explanation is given below.

On both the X and Y axis time is displayed. On the Y-axis the different ETA's are plotted and on the X axis, the simulation time is displayed. So in figure 5, the ETA for KP2 at 12:00:00 was 14:13:41

The ATA's (Actual time of arrival) are displayed as a horizontal straight line in order to clearly see the difference between the ETA and the ATA. The ATA itself is of course a single value only known after the ships has arrived at the node. But to make the difference visibly clear, the straight line is shown.

The figure 6-3 above shows the ETA, RTA and ATA of 1 ship passing 1 set of locks. This means that before the ship arrives at the first point it doesn't encounter other locks or bridges which can influence its sailing. In other analysis, a route is chosen where a ship encounters multiple locks and/or busy intersections in order to see how other locks can influence the ETA of different points. The bars in the graph show when the ships is before, in and out of the lock. This is to help analyse the graphs and to show what the ETA data does when a ship is near a lock.

The analysis shown in figure 6-3 is of a ship passing the Beatrix locks on 19-9-2017. In this analysis KP1 is the node south of the Beatrix locks and KP2 is the node north of the Beatrix locks. See figure 6-4 The lock itself is not shown in the figure but sits in between KP1 and KP2. When the analysis was started the ship was sailing on the Lek from Rotterdam. The ship would not encounter any objects until the Beatrix locks.

What can be seen in figure 6-3 is that the ETA and RTA for KP1 are equal for most of the time. What also can be seen is that the RTA for KP1 and the ETA for KP2 have an almost fixed distance between them. ETA KP1, RTA KP1 and ETA KP2 all make a jump around 12:00:00. There was no explanation found for the 'jump ' itself, but after the jump the ETA for KP1 becomes accurate within +/- 2 minutes.

The ETA KP2 keeps at a set distance from RTA KP1

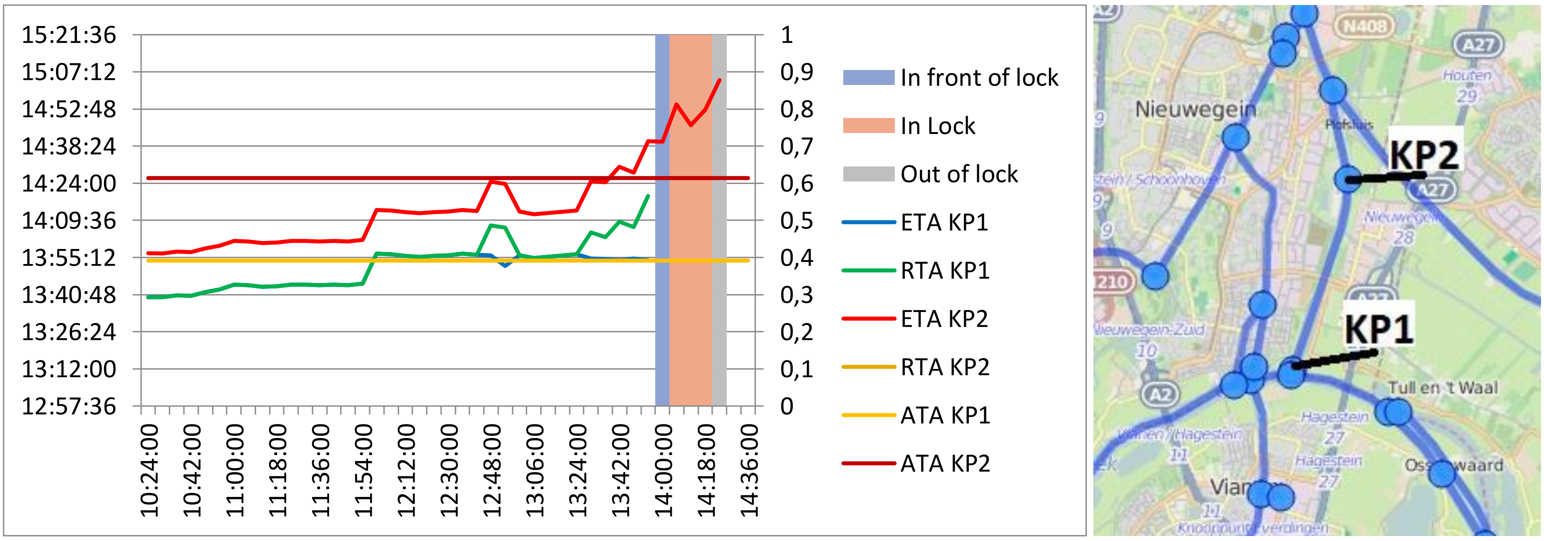

Figure 5 Left:Example of ETA fluctuations in Trajectplanner data/Right: Map with KP1 and KP2 marked

and once the ship is near the lock, both the RTA KP1 and the ETA KP2 keep rising. Even when the ships is

'in' and 'after' the lock, the ETA KP2 keeps rising.
After analysis of multiple ships with different journeys, several conclusions can be drawn. The different analysis that were done show that when a ship is near a lock, the ETA for the point after the lock keeps rising, as if the Trajectplanner keeps scheduling the ships into the lock without knowing the ship is already near, or even in the lock. When there are no objects between the ship and the KP that is analysed, the ETA for that KP is accurate within a few minutes and doesn't change very much. The RTA for a point keeps changing which indicates the schedule or planning changes every time. This makes sense as the Trajectplanner keeps no record of previous simulations.
Because of the first point made above, if a ship encounters multiple locks, the ETA for the end point will fluctuate a lot. This was seen when a ship was analysed with multiple locks on the route.
Factors like other ships, wind and current are not taken into account by the Trajectplanner but will be reflected in the current speed of the ship. This was confirmed by reviewing the programming code of the Trajectplanner. To determine the accuracy of the current system, the KPI was used on the analysis of the output of the system.

And for a data set or analysis of a ship's journey, this would give a table like this (Table 1):

Table 1

	KPI KP1	KPI KP2	KPI KP3	KPI KP4
Max KPI	00:12:34	00:32:05	00:28:19	00:31:28
Max KPI(seconds)	754	1925	1699	1888

From the KPIs of all the ships that were followed, the following conclusion could be drawn. If the route of a ship has no locks, the Trajectplanner is accurate within a few minutes (+/- 5min, with exceptions)
If the route of a ship does have lock(s) on it, the accuracy of the Trajectplanner fluctuates with a maximum of about an hour. So far, the analysis of the system suggests that the locks within the system are the biggest source of inaccuracy for the prediction of the ETA. To confirm this, an analysis was performed on one lock for the duration of 6 hours and the ETA for all the ships that came through the lock were monitored. The analysis was performed by monitoring the north and south node at the Bernhard locks. See figure 6. Ships in both directions were followed and analysed. From the previous part of the analysis it is expected that the ships that sail toward the lock have almost straight lines in the graph, meaning that their ETA is estimated correctly from the start of the analysis.It is also expected that ships sailing away from the lock have a rising ETA when they come near the lock and the node. The ETAs and ATAs from this analysis were also compared to determine the KPI for each journey and each ship. These were than used to get the KPI averaged over several ships making the same journey. After this analysis it is clear that locks are a big factor in the accuracy of the estimated ETAs. There are several factors that play a role in this problem

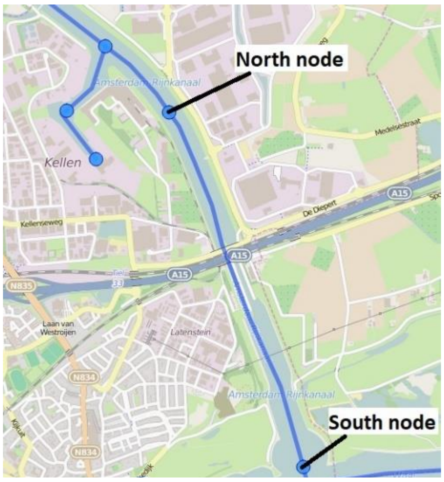

Figure 6 Map with N- and S- node mapped

- The Trajectplanner doesn't know when a ship is in front, in or out of a lock and keeps planning the ship into the lock. What happens is that the ETA for the next node keeps going up with the passing time of the lock.
- Because the Trajectplanner doesn't know what it has previously done it makes a new schedule every time it simulates, even if the previous schedule was good, the system doesn't know
- Missing or incorrect/old data is a problem for the Trajectplanner because the simulation cannot be done then. This is not directly the fault of the Trajectplanner, but it is a problem.

3. Improvements

In an ideal situation, all the ETAs that are estimated at the start of the journey are accurate and don't change much during the journey. This would mean that the schedules that are made with these ETA's will stay the same and skippers can start to use the schedules and improve their efficiency.
The current model of the Dutch waterway network could be altered. In this network model, the objects are represented by an arc between two nodes, one on each side of the object. For locks, these nodes can lay on the position of the doors. This way, the RTA for such a point would make much more sense as it is the requested time at the door. Not the requested time for a node which can be kilometre away. For bridges these nodes can lay on the spot where ships would normally have to wait for the bridge to open. For bridges that can't open, a single node would suffice as it would only indicate the position of the bridge and would occur no extra travel time as with other nodes. With the model of the network improved, the lock model needs some improving as well. The Trajectplanner already uses the in- and outsail times of the ships, schedules ships into the procedures and uses this to estimate when certain ships can go through the lock. But it still doesn't know when ships are in the lock or waiting to sail in or out. An improvement would be that the simulation knows when ships are waiting to sail in or are in the lock and if the lock is in procedures or not. This way it could

use this information in the estimation for the ETAs for the following nodes and make these estimations more accurate. As mentioned, the Trajectplanner doesn't remember data from previous simulations and starts over every 6 minutes. This means that the schedules made for all the ships are made every time the simulation runs. This is shown in chapter 6 were the RTA for the node before the lock changes a lot. An improvement should be that the Trajectplanner has a memory where it can store the schedule that it made. With this memory it could check if all ships can still make their scheduled times. And if so, no other schedule should be made. If this was the case, the schedule could be passed on to the skippers and they could make sure that they would make that scheduled time.The memory could also be used for more improvements, like if the ETA for a specific node changes a lot from one simulation to the next, it could signal that something is wrong or has changed. This could be used by the Trajectplanner to check estimations, data or send a warning to someone who can check it out.

4. Simulation

The simulation tool has to simulate the movement of inland ships sailing over a piece of waterway with a lock on it. To do this, discrete event simulation is used to create a simulation environment. The waterway is modelled as a straight line with the only property being its length. The lock is situated on this line. The lock and ships are modelled as components of the simulation. Components can have different properties like size, location etc. An important component within the simulation environment is the Estimator. This component tries to estimate where the ships will be and at what time they will be at either A or B. It calculates and estimates the ETA for these points. These points can be defined in the simulation and will be modelled after a real-life scenario.Other components that are used are: ship generator (generates ship on each side of the waterway), the ships, the lock and small components that are used as monitor systems.The simulation simulates certain things accurately, other things are simplified and some things are not modelled. These are listed below.
Modelled accurately:

- speed of ships
- length of ships
- in- and outsail times of ships at the lock
- lock size
- service time of the lock

Simplified:

- area/capacity of the lock chamber
    - The capacity of the lock chamber is modelled only with length
- The exact procedures at a lock
    - The procedures are simulated as a constant length of time
- Placement and room between ships in locks
    - The rules for ships carrying dangerous materials are not modelled
    - The room between ships in a lock is neglected. For example, in a 300 m lock, 3 ships of 100 m will fit.

Not modelled:

- Influences on the sailing of ships
    - Ships will have their own speed which will not be affected by other ships, wind, current or other influences.
- Small pleasure vessels
    - Small ships and pleasure vessels that would have AIS in the real world are not modelled
- Curves and corners in the waterway
- Rules for watermanagement
- Draft and cargo of ships

When the simulation starts, ships are created at the two ends of the network. The ships start to sail until they encounter the lock. They will then want to go through the lock. After the ship went through the lock it will then sail on to the end. When it reaches the end, the ships will stop. As long as the simulation runs, the lock is active. The lock checks whether there are ships waiting to go through the lock on both sides of the lock. When a ship wants to go through the lock, the lock will check whether the water is on the 'right' side. If not, it will go through the procedure empty. It will then open the doors and let the ship(s) in. When the lock is full or no more ships want to go through on that side. The lock will close the doors and start the procedures. When the procedures are done. The lock will open the doors on the other side and let the ships out. Then the process starts over again by the lock checking whether any ships want to go through.
During the simulation, an estimator is running as well. Simply said, this estimator will estimate the ETAs for all the ships in the system. The above is a simple description of the simulation of the different components. What can be seen is that the ships, the lock and the estimator don't influence each other. The ships have full control over their own speed. The lock only gives permission to sail in or out, but does not actually tell the ships to sail in. The estimator only looks at the data from the ships and makes estimations based on that.
The simulation tool was first verified with a simulation run with 1 ship from each side. It was then validated by comparing the results of a long run to data gathered from the real world and from the Trajectplanner itself. The new network model(Design 1) and new lock model (Design 2) were than tested with the simulation tool.
The output of this simulation looked like the graphs shown in figure 7(next page). The average of all max KPIs over all ships is shown in table 2. Based on table 2, The improvements do actually improve the KPI of the simulation tool. Especially when one takes the median value into account
The big difference between the estimators used in this simulation and the Trajectplanner is the planning module. The simulation did not schedule ships for locks, it looked how many ships were at the lock

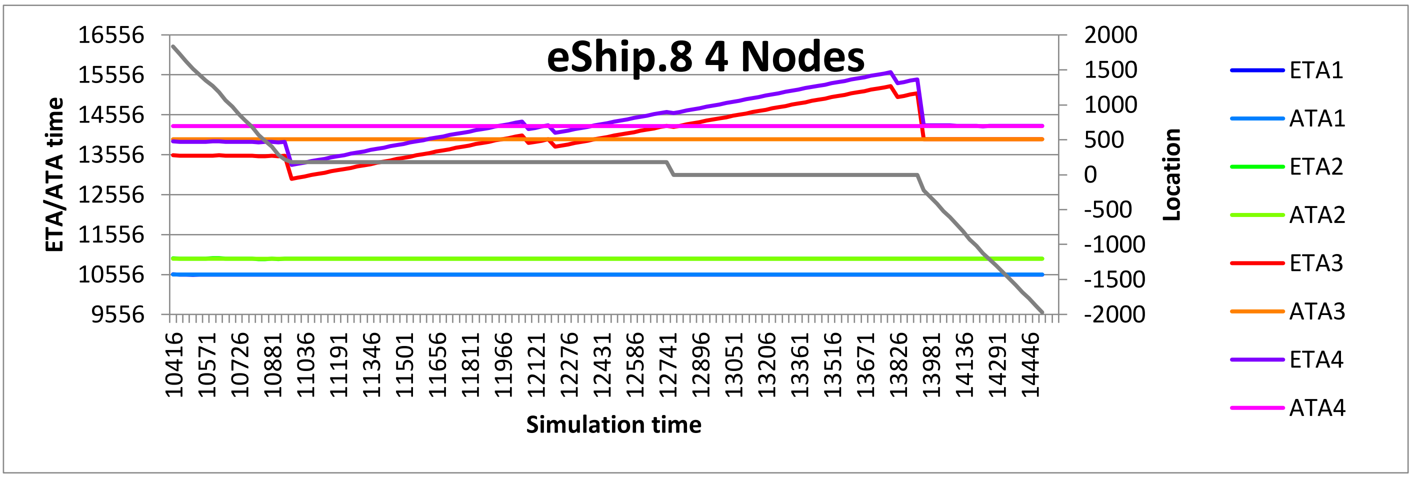

Figure 7 Example of data output from simulation environment

before another ship and estimated the extra waiting time. This estimation was based on the ETAs of those other ships. This is also why the ETA for some ships was 'jumpy'. The conclusion of these test is therefore that the extra nodes, the awareness of being in a lock and knowing when the lock was entered would improve the ETA estimation a lot.

The next step would be to improve the scheduling module in the way mentioned before.

5. Conclusion and recommendations

As mentioned, this report analysed the Trajectplanner in order to find the cause of inaccurate ETAs. After an analysis of the current Trajectplanner backed by a literature review. It was concluded that the way the inland waterway network is not modelled correctly within the Trajectplanner. Therefore, an improved model was thought out and tested with a simulation. After the simulation it can be concluded that the improved network model worked. But the simulation did not schedule ships the way the current Trajectplanner does. It can be seen that in the simulation, the waiting of ships before entering a lock takes up the most time. Because of this, the scheduling becomes the next big problem after the network model and lock awareness issues have been solved.

The overall conclusion after the analysis and simulation tests is that there is quite some room for improvement of the Trajectplanner. Especially when the goal is to advise skippers to adjust their speed and to make inland shipping more attractive by giving accurate travel times. One of the goals of the Trajectplanner is to inform skippers that they can sail faster or slower. And with that achieve more efficiency with accurate travel times and less laying still with engines running. In the bigger picture, this could improve the whole supply chain where inland ships are involved and make them more attractive to use.

To achieve this, the Trajectplanner needs to be improved, apart from the suggestions done in this report further study should take place.

The first step should be to implement the new model which models the inland waterway network. With this improvement it should be possible for the system to make a better schedule but also to be aware whether ships are inside the lock or not.

Other improvements could be found in:

- Improvement of the scheduling. The scheduling keeps changing every 6 min, this would not work for a skipper. For example, if a schedule is made it should stay that way as long as all the ships in that schedule are still able to make the RTA.
- A memory of passed simulations. With a memory, the Trajectplanner could check itself when the ATA for every node is known. It could also be used to flag big fluctuations in ETA estimations. This could indicate something is wrong with the system or with the ship.
- A test to see how much impact it would have when ships are scheduled into locks based on the Trajectplanner instead of the arrival time at the object. Now, ships enter the lock on the same order as they arrive at the lock. For the Trajectplanner to reach its full potential, it is needed that ships need to rely on a schedule they are given and not worry about being overtaken.

	KPI for Trajectplanner	**Validation of simulation**	**Design 1**	**Design 2**
Mean	2986	2870	1494	1685
Median	2495	2719	1463	1448
Standard deviation	2550	689	269	688
Data type	**Real world**	**Validation**	**New model**	**New model**

6. References

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2. Li, K. ***Dynamic traffic assignment model for inland waterway freight transport.*** **2017.**
3. W. Zhou, H. Teng. ***Simultaneous passenger train routing and timetabling using an efficient train-based Lagrangian relaxation decomposition.*** **2016.**
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5. Rijskwaterstaat.

Appendix B – Chapter 6

This Appendix contains the graphs and analysis which are discussed in chapter 6
The next figures show the graphs from other ships sailing through the Beatrix locks

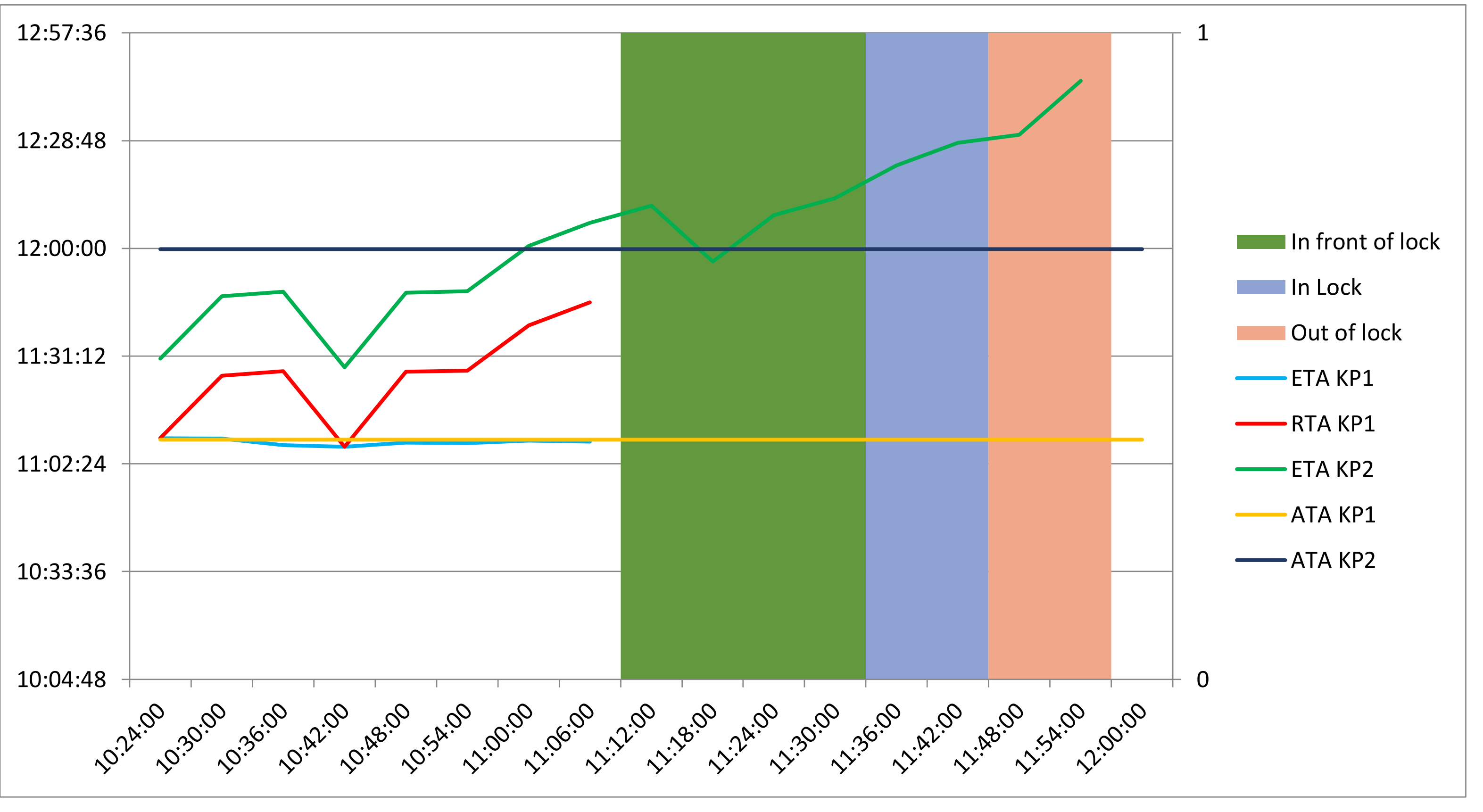


Figure 0-1 Graph showing ETA and ATA data from an anlysis

Figure B-1 displays the analysis of a ship which sailed through the Beatrix locks on 19-9-2017. It went the same way, so KP1 and KP2 are the same as in figure 6-4 (See main report).
It can be seen that the RTA and the ETA are a fixed width from each other. And again, the ETA KP1 is accurate within a few minutes from the start of the simulation. The same phenomenon can be seen as in the previous analysis and that is that the ETA KP2 keeps rising while the ships is in the lock and even when it is out of the lock.

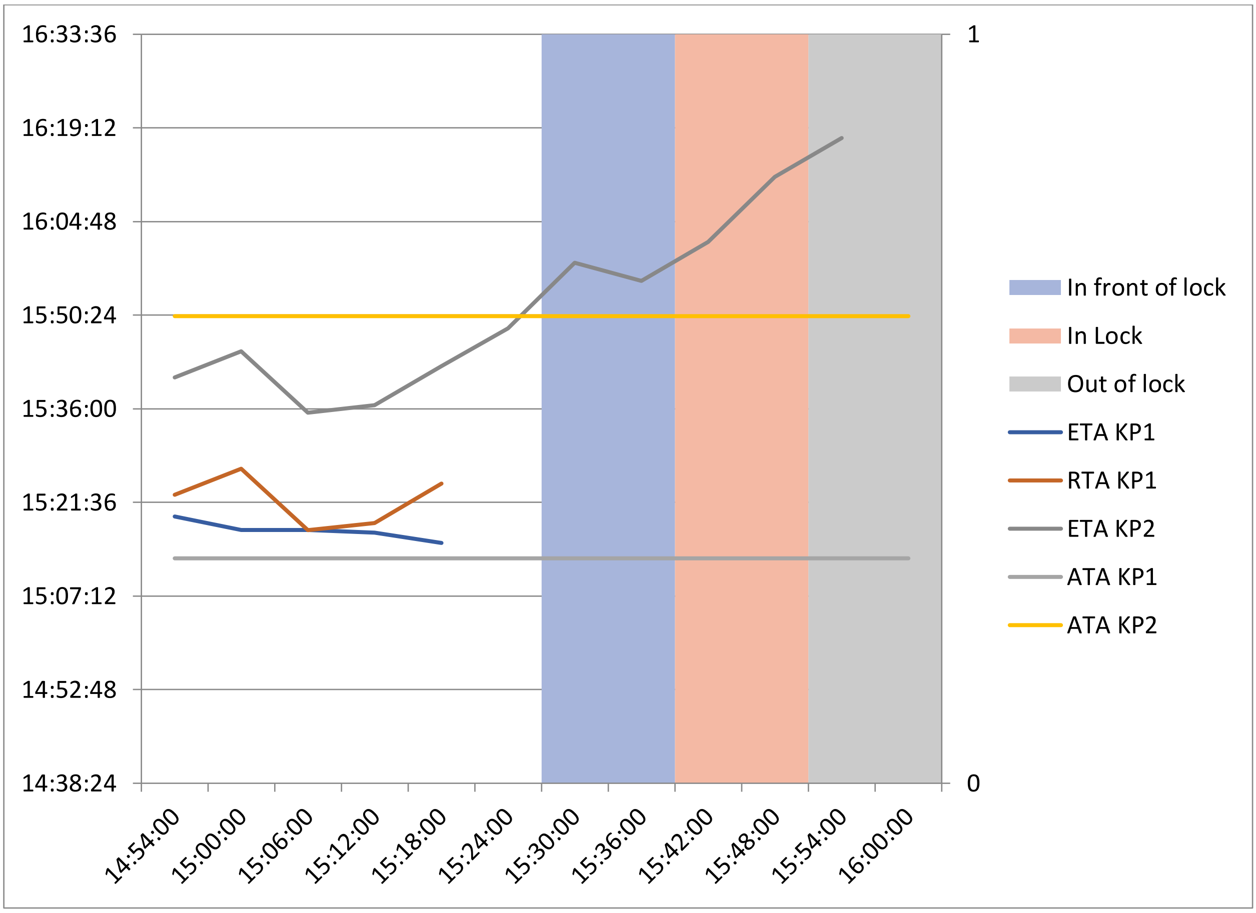


Figure 0-2 Graph showing ETA and ATA data from an anlysis

Figure B-2 Shows another ship passing the Beatrix locks. This ship went the other way, so the KP's are as in figure 6-4 (See main report) but reversed. The analysis shows the exact same behaviour as the previous graph's.

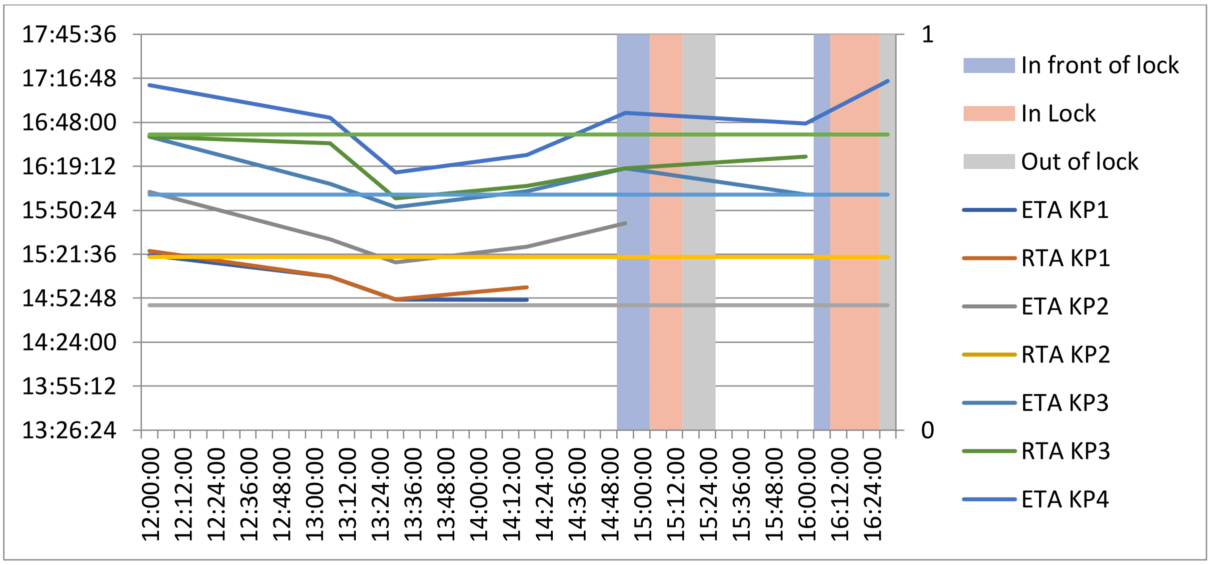


Figure 0-3 Graph showing ETA and ATA data from an anlysis

Figure B-3 Shows the analysis of a ship sailing from Nijmegen, past the Bernhard locks and the Irene locks. In this case, 4 KP's were chosen in order to follow the ETA data of the 2 locks. The KP's are shown below in figure B-4

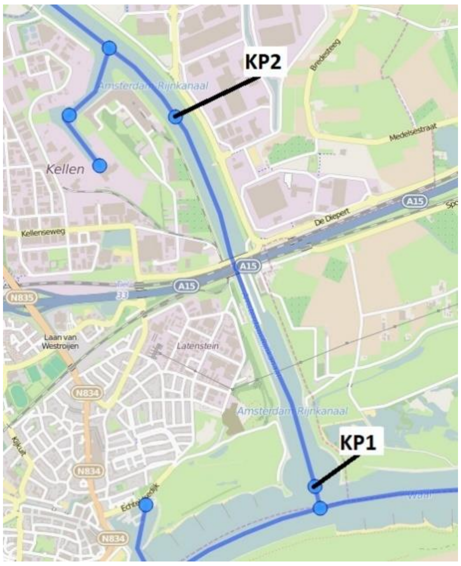


Figure 0-4 Location of KP1, KP2, KP3 and KP4

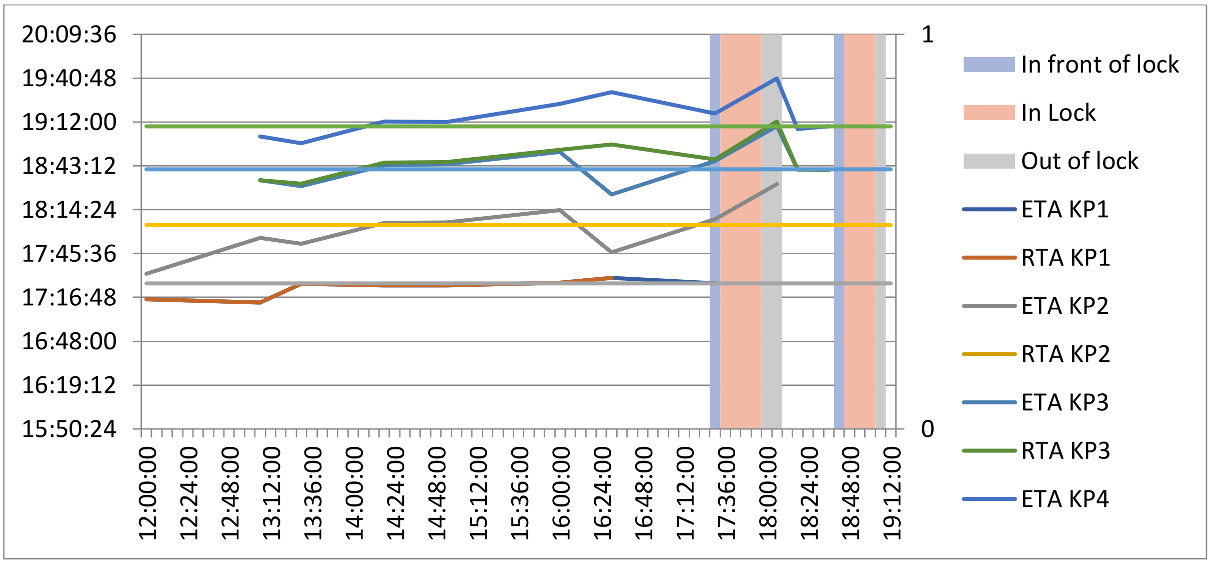


Figure 0-5

Figure B-5 shows a different ship sailing the same route the other way. The KP's are the same points but 1=4, 2=3, etc.

In both figures the lines run straight, this is because a lot of the time the simulation could not run and no new data would be available. So the few points of data that are available, have been connected by straight lines. Both figures do show that again, the locks have a big influence on the ETA calculation of the points after the lock.

Table 0-1 KPIs for all analysis done up to this point

						Corresponding figure
	KPI KP1	KPI KP2				none
Max KPI	00:14:46	01:16:01				
Max KPI (seconds)	886	4561				
	KPI KP1	KPI KP2				none
Max KPI	00:09:27	00:22:31				
Max KPI (seconds)	567	1351				
	KPI KP1	KPI KP2				none
Max KPI	01:51:56	01:25:08				
Max KPI (seconds)	6716	5108				
	KPI KP1	KPI KP2				6-3
Max KPI	00:14:11	00:38:00				
Max KPI (seconds)	851	2280				
	KPI KP1	KPI KP2				6-5
Max KPI	00:33:05	00:32:18				
Max KPI (seconds)	1985	1938				
	KPI KP1	KPI KP2				B-1
Max KPI	00:01:54	00:44:58				
Max KPI (seconds)	114	2698				
	KPI KP1	KPI KP2	KPI KP3	KPI KP4		None
Max KPI	00:03:53	00:12:12	00:09:54	00:53:42		
Max KPI (seconds)	233	732	594	3222		
	KPI KP1	KPI KP2	KPI KP3	KPI KP4		6-7
Max KPI	00:06:21	00:10:58	00:11:32	00:11:48		
Max KPI (seconds)	381	658	692	708		
	KPI KP1	KPI KP2	KPI KP3	KPI KP4		B-3
Max KPI	00:32:47	00:42:37	00:37:55	00:35:01		
Max KPI (seconds)	1967	2557	2275	2101		
	KPI KP1	KPI KP2	KPI KP3	KPI KP4		B-5
Max KPI	00:12:34	00:32:05	00:28:19	00:31:28		
Max KPI (seconds)	754	1925	1699	1888		

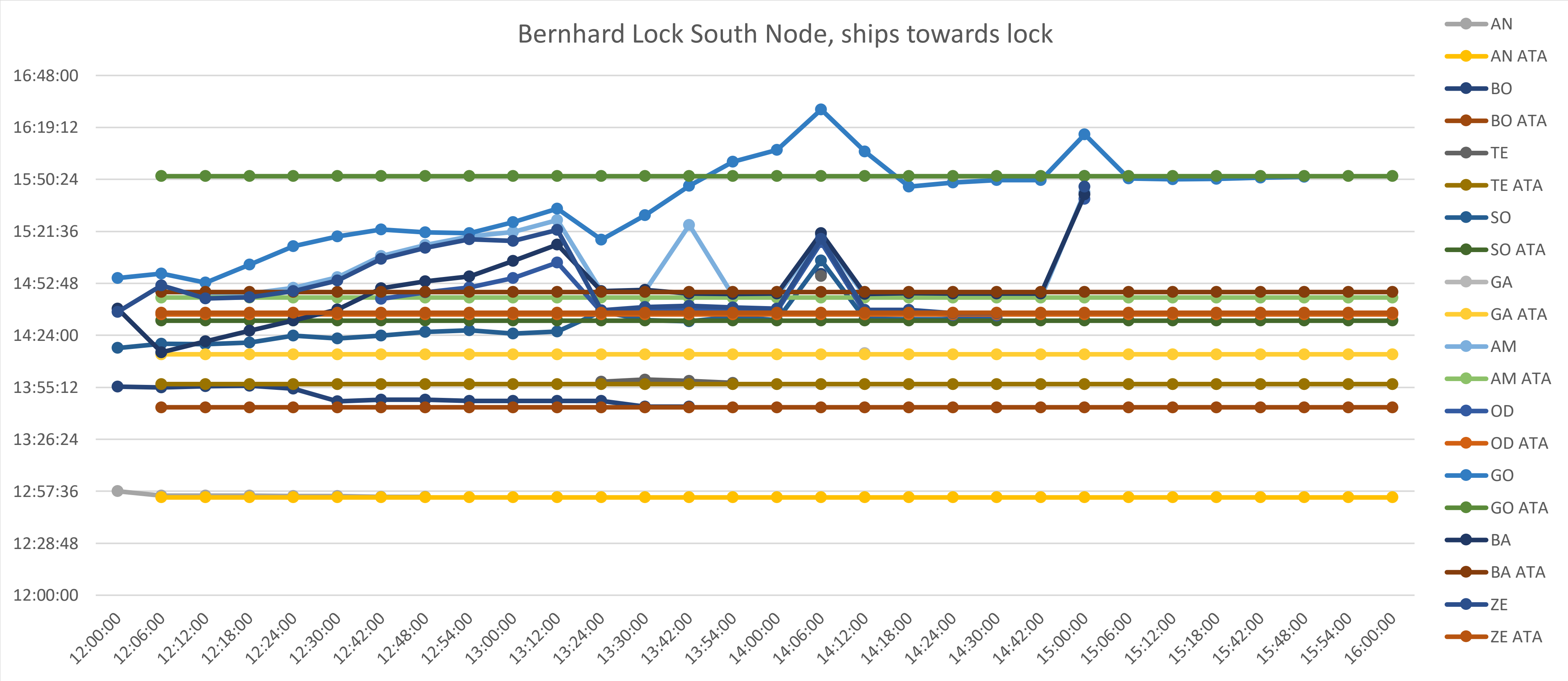


Figure 0-6 Data from 1 lock analysis

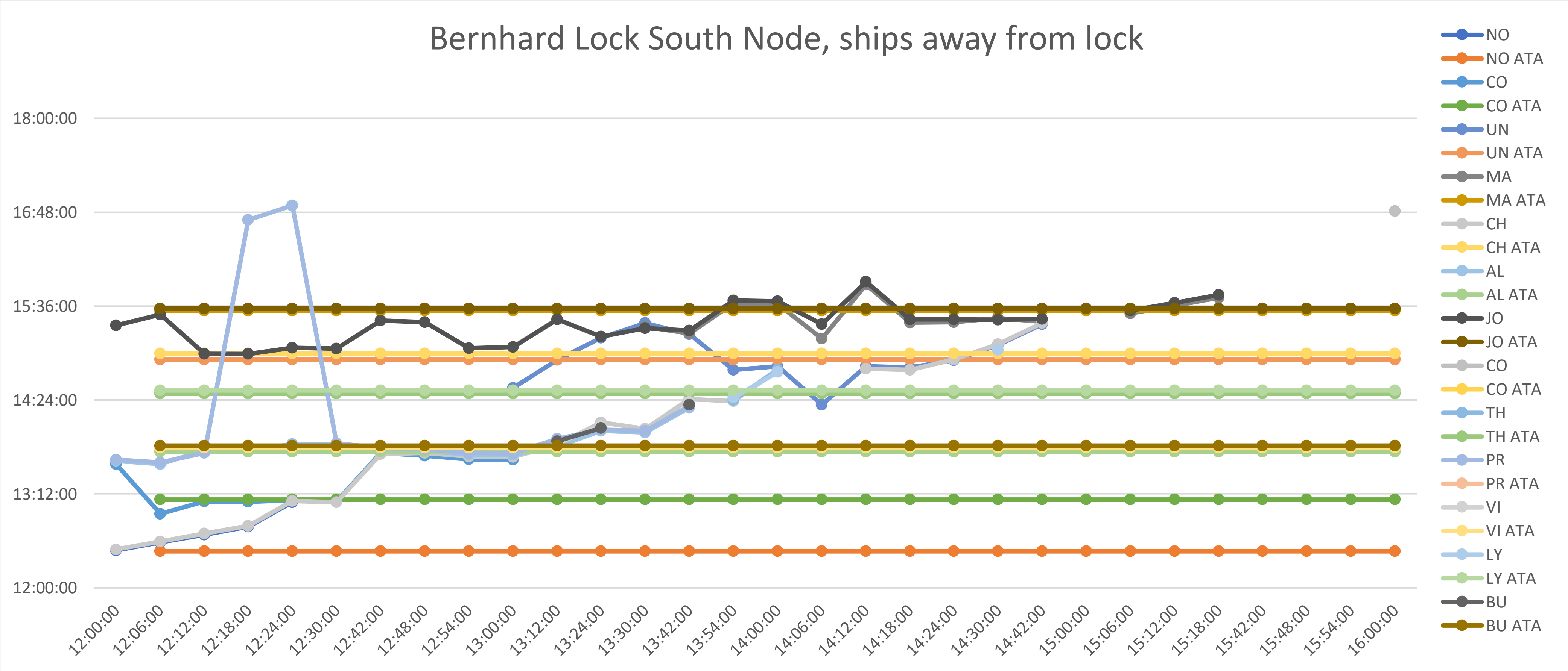


Figure 0-7 Data from 1 lock analysis

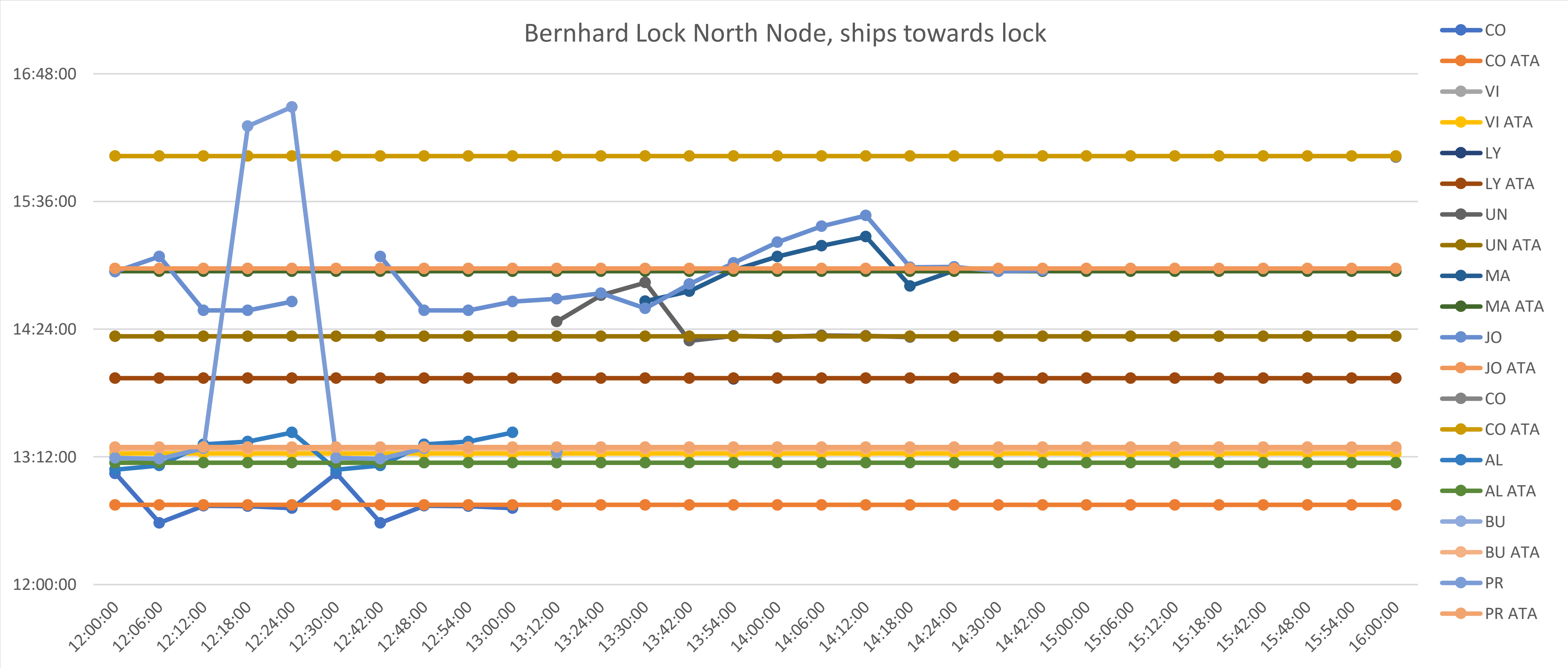


Figure 0-8 Data from 1 lock analysis

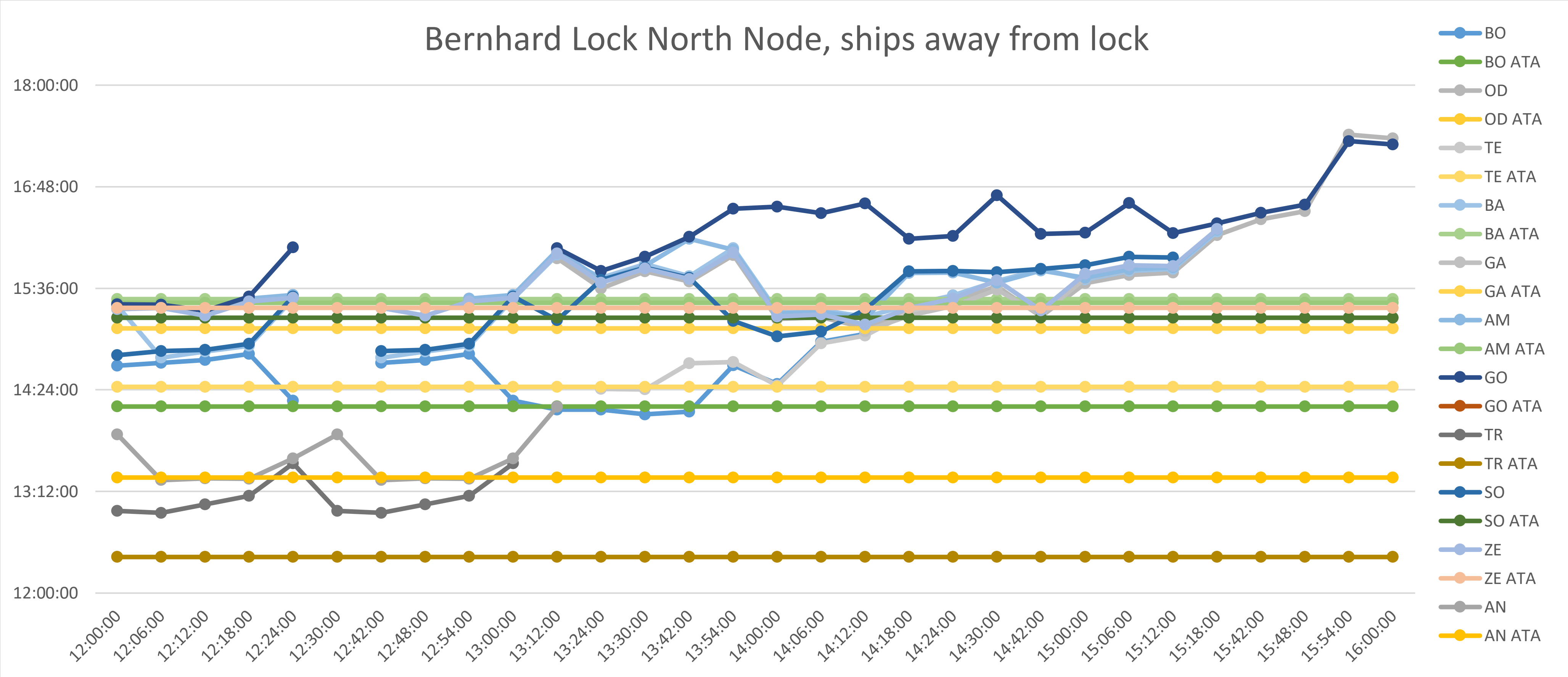


Figure 0-9 Data from 1 lock analysis

B. Appendix C – Chapter 9

This Appendix contains all the data from the experiments and some discussion about some of these experiments

C.1 Sailing time validation experiment

The results from this experiment need to show a one thing in order for the simulation to be validated. For the simulation of the ships it is necessary that the ATA's from the simulation are similar to the ATA's from the validation data.
The simulation that was run to test the simulation of the ship movements had a lock with 720 m space (2*360). 720m because most of the time, 2 ships fit next to each other in the lock. With the assumption that 2 ships will fit next to each other the simulation used twice the length of the lock in the simulation. The service time that was used is 12 min.

Table C-1 shows the actual ATAs from ships and the difference between them

Table B-1 Data from sailing time analysis.

Schip	ATA1	ATA2	Difference (hh:mm:ss)	Difference (seconds)
A Ship1	13:08:41	13:44:30	00:35:49	2149
A Ship2	15:25:41	14:44:58	00:40:43	2443
A Ship3	13:21:53	12:54:11	00:27:42	1662
B Ship4	15:28:21	14:48:00	00:40:21	2421
B Ship5	14:12:12	13:44:08	00:28:04	1684
B Ship6	13:16:33	13:49:00	00:32:27	1947
C Ship7	12:44:57	13:07:39	00:22:42	1362
G Ship8	15:07:35	14:13:30	00:54:05	3245
J Ship9	14:58:13	15:34:04	00:35:51	2151
L Ship10	13:56:22	14:31:20	00:34:58	2098
M Ship11	14:56:41	15:32:30	00:35:49	2149
P Ship12	13:17:31	13:47:50	00:30:19	1819
S Ship13	15:15:08	14:32:07	00:43:01	2581
U Ship14	14:19:58	14:55:01	00:35:03	2103
V Ship15	13:13:54	13:47:30	00:33:36	2016
Z Ship16	15:22:09	14:36:31	00:45:38	2738

The ships in table 9-4 came from both directions, so it could happen that ATA1 is later than ATA2 and vice versa.

In the tables below (table 9-5), the simulation results are shown. Each simulation step is a second, so the difference in ATAs is in seconds as well.

In the simulation, seeds are used to create random numbers and sequences. This is also done to recreate results if the seeds are known. The test above was repeated with different seeds and the resulting tables are shown below

Table B-2 Results from validation test

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
eShip.0	VIIb	784	4730	988	4479	3491
eShip.2	III	2353	4751	2501	4564	2063
eShip.1	I	1568	4808	1756	4562	2806
wShip.1	VIb	2303	6180	2532	5981	3449
eShip.4	II	3921	7861	4086	7676	3590
eShip.3	VIb	3137	7900	3326	7651	4325
eShip.5	VIIb	4705	8180	4918	7930	3012
wShip.3	Va	4606	9513	4792	9366	4574
wShip.4	III	5758	9608	5939	9457	3518
wShip.5	VIa	6909	9882	7168	9681	2513
eShip.6	VIc	5490	11790	5699	11541	5842
eShip.8	Vb	7058	11922	7218	11738	4520
eShip.7	VIIb	6274	11945	6485	11697	5212
eShip.10	I	8627	12162	8835	11914	3079
wShip.6	II	8061	13540	8251	13392	5141
wShip.7	III	9212	13631	9402	13480	4078
wShip.8	VIIb	10364	13952	10606	13751	3145
eShip.9	Vb	7842	15820	8008	15631	7623
eShip.12	IV	10195	16095	10341	15909	5568
eShip.11	VIIb	9411	16132	9629	15882	6253
eShip.13	III	10979	16183	11134	15996	4862
eShip.14	VIa	11764	16460	11951	16209	4258
wShip.9	VIb	11515	18227	11755	18028	6273
wShip.11	Vb	13819	18339	14000	18188	4188
wShip.10	VIb	12667	18363	12910	18164	5254
wShip.12	III	14970	18428	15152	18279	3127
eShip.16	Vb	13332	20471	13498	20285	6787
eShip.15	VIIb	12548	20491	12741	20242	7501
eShip.18	Vb	14901	20714	15048	20529	5481
eShip.17	VIa	14116	20740	14338	20491	6153

Table B-3 Results from validation test

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
wShip.0	VIc	1247	3630	1494	3435	1941
eShip.1	II	2303	5009	2455	4820	2365
eShip.0	VIIb	1152	5040	1359	4790	3431
wShip.2	Vb	3741	6287	3927	6138	2211
wShip.1	MO	2494	6310	2739	6110	3371
eShip.2	IV	3455	7507	3593	7322	3729
eShip.3	I	4606	7746	4810	7497	2687
wShip.3	VIb	4989	9153	5235	8955	3720
wShip.4	VIc	6236	9316	6490	9120	2630
eShip.5	III	6909	10837	7050	10652	3602
eShip.4	VIb	5758	10903	5946	10655	4709
eShip.6	VIIb	8061	11153	8256	10904	2648
wShip.6	VIb	8730	12765	8977	12565	3588
wShip.7	I	9977	12854	10239	12653	2414
eShip.7	Vb	9212	14189	9366	14005	4639
eShip.9	III	11515	14407	11670	14218	2548
eShip.8	VIa	10364	14466	10558	14219	3661
wShip.8	Vb	11224	16022	11420	15877	4457
wShip.9	VIIb	12471	16342	12735	16144	3409
eShip.10	III	12667	17577	12832	17389	4557
eShip.11	I	13819	17813	14019	17565	3546
eShip.12	MO	14970	17874	15168	17625	2457
wShip.11	VIIb	14966	19182	15223	18986	3763
wShip.12	MO	16213	19249	16461	19049	2588
eShip.14	III	17273	20489	17438	20302	2864
eShip.13	MO	16122	20545	16326	20295	3969
eShip.15	II	18425	20599	18570	20413	1843

Table B-4 Results from validation test

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
wShip.0	VIIb	1078	3488	1322	3287	1965
eShip.0	Vb	1379	4482	1531	4297	2766
wShip.1	VIc	2155	6126	2420	5928	3508
wShip.2	VIIb	3233	6292	3513	6091	2578
eShip.1	VIb	2759	7698	2975	7449	4474
eShip.2	VIIb	4138	7863	4332	7614	3282
wShip.3	I	4311	9370	4566	9170	4604
wShip.4	VIc	5389	9531	5632	9333	3701
wShip.5	VIa	6466	9657	6714	9457	2743
eShip.4	III	6897	11193	7037	11009	3972
eShip.3	VIIb	5518	11259	5736	11010	5274
wShip.6	II	7544	12671	7735	12522	4787
wShip.7	III	8622	12759	8815	12611	3796
wShip.8	MO	9700	12975	9948	12776	2828
eShip.6	IV	9656	14103	9797	13916	4119
eShip.7	IV	11036	14219	11174	14033	2859
wShip.10	IV	11855	16048	12048	15899	3851
wShip.9	VIIb	10777	16086	11038	15887	4849
wShip.11	VIIb	12933	16365	13182	16167	2985
eShip.10	Va	15174	18122	15323	17936	2613
eShip.9	VIIb	13795	18154	13986	17904	3918
wShip.12	VIb	14011	20077	14262	19876	5614
wShip.14	II	16166	20125	16342	19974	3632
wShip.13	I	15088	20159	15340	19961	4621
wShip.15	VIIb	17244	20439	17478	20239	2761

Table B-5 Results from validation test

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
wShip.0	Vb	1379	3394	1565	3245	1680
eShip.1	IV	2155	4921	2297	4734	2437
eShip.0	VIIb	1078	4961	1281	4711	3430
wShip.1	I	2759	6391	2988	6192	3204
wShip.2	VIa	4138	6513	4372	6314	1942
eShip.2	VIc	3233	8127	3438	7881	4443
eShip.3	VIc	4311	8293	4515	8043	3528
eShip.4	MO	5389	8351	5588	8105	2517
wShip.4	VIIb	6897	9543	7147	9343	2196
eShip.5	II	6466	11000	6628	10814	4186
eShip.6	VIIb	7544	11316	7734	11070	3336
eShip.7	VIb	8622	11453	8816	11203	2387
wShip.6	III	9656	12744	9842	12595	2753
wShip.5	VIc	8277	12805	8529	12609	4080
eShip.8	II	9700	14250	9853	14063	4210
eShip.10	VIa	11855	14639	12056	14392	2336
wShip.8	IV	12415	16115	12613	15965	3352
wShip.7	VIa	11036	16150	11289	15954	4665
wShip.9	II	13795	16234	13984	16086	2102
eShip.11	III	12933	17662	13087	17475	4388
eShip.13	II	15088	17897	15238	17709	2471
eShip.12	VIa	14011	17933	14217	17683	3466
wShip.10	IV	15174	19200	15347	19052	3705
wShip.11	Vb	16554	19328	16740	19180	2440
eShip.14	MO	16166	20807	16353	20560	4207
eShip.16	III	18322	20883	18471	20694	2223
eShip.15	VIb	17244	20941	17440	20692	3252

Table B-6 Results from validation test

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
wShip.0	VIIb	824	3214	1072	3018	1946
eShip.0	II	1048	4374	1199	4185	2986
eShip.1	VIb	2096	4657	2307	4411	2104
wShip.1	VIIb	1648	6457	1923	6259	4336
wShip.2	VIIb	2473	6618	2739	6419	3680
wShip.3	VIIb	3297	6777	3536	6580	3044
eShip.2	I	3144	8138	3333	7888	4555
eShip.4	II	5240	8188	5387	8001	2614
eShip.3	I	4192	8223	4401	7976	3575
wShip.4	II	4121	10247	4300	10099	5799
wShip.5	VIc	4945	10560	5199	10363	5164
wShip.6	VIb	5769	10691	6007	10495	4488
wShip.8	II	7418	10777	7615	10631	3016
wShip.7	VIa	6594	10814	6863	10618	3755
eShip.5	VIb	6288	12685	6506	12440	5934
eShip.7	VIIb	8384	12966	8592	12719	4127
eShip.8	MO	9432	13032	9627	12782	3155
wShip.10	III	9066	14805	9253	14657	5404
wShip.9	VIc	8242	14871	8503	14673	6170
wShip.11	VIb	9890	15097	10130	14898	4768
wShip.13	VIa	11539	15217	11799	15018	3219
eShip.9	III	10480	16750	10623	16561	5938
eShip.11	IV	12576	16997	12730	16813	4083
eShip.10	VIb	11528	17035	11738	16787	5049
eShip.12	VIa	13624	17269	13799	17021	3222
wShip.12	VIIb	10714	19360	10970	19163	8193
wShip.14	VIb	12363	19491	12608	19293	6685
wShip.16	II	14011	19612	14199	19467	5268
wShip.15	VIIb	13187	19655	13443	19457	6014
wShip.17	MO	14835	19836	15071	19636	4565

C.2 Sailing validation - Results

By comparing the table with the real ATA and the table with the simulated ATA it is clear that the ships in the simulation take longer to complete the same distance than the ships in real life. But the difference can be explained. With the simplifications that were made in the simulation, some key aspects of the lock procedure got lost. A big aspect is the second chamber that the lock has in real life. This makes it that the operators can use the chambers in such a way that ships can sail in on both side for most of the time. This means that ships don't have to wait for the water to go to their level. The simulation only has 1 lock chamber so if the water is on the 'wrong' side, the ship has to wait for the lock to go through the procedure and get the water on the 'right' side. In this case, 720 sec. This can clearly be seen when the simulation is run with 2 ships, 1 on each side.

Table B-7 Results Validation with 1 ship from each side

Name	Type	Start	End	ATA1	ATA2	Difference (seconds)
wShip.0	VIc	1247	3630	1494	3433	1939
eShip.0	VIIb	1152	4823	1359	4574	3215

What can be seen in table 9-4 Is that both ships start around the same time (368 s = 6 min) but finnish with quite a difference (1276 s= 21,5 min). The lock starts at the west side, so the East ship(eShip.0) has to wait the 12 + insailtime(2 min) + outsailtime(1,5 min) = 14,5 min already. The lock component waits 5 minutes for other ships to arrive at the side of the lock on which the doors are open. This put together (19,5 min) explains the longer traveltime. The west ship (wship.o) can sail right through and has a realistic traveltime (1939 s or 32 min)So if one uses the above explanation on the tables shown above, the longer travel times make sense.

The text above points out another big aspect of lock operation. In real life, the lock is operated by people, which check other system such as a radar if more ships arrive, or make sure ship can sail in from both sides. This can of course also be done with a simulation, but this simulation is purely to show improvements of the Trajectplanner and not an exact representation of the real world.

C.3 Estimator validation

The second validation test was to validate the workings of the estimator that tries to copy the behaviour of the current Trajectplanner. As mentioned before, this estimator is a simplification, it does not schedule the ships, it does not place the ships and it does not give out an RTA. For these reasons, the estimator will not give out the same estimation as the Trajectplanner. It does however predict when the ships arrive at their nodes. With this prediction, this version of the predictor tries to copy the Trajectplanner. This means that when the ships is between 2 nodes, the Trajectplanner does not know where the ships is exactly. This was seen in chapter 6, in figures 6-5 to figures 6-11. The lines in these graphs are the ones that this simulation tries to copy and show the same behaviour. The same simulation as in the previous section is used for this test, so the parameters are the same.

The simulation code makes a graph out of the collected data per ship. This looks somewhat like the figures in chapter 6 and can be read in the same way. The simulates is run for 6 hours (simulation time). All the graphs can be found in Appendix C.4

C.3.1 Estimator - Results

As mentioned in chapter 8, the simulation put in a small variation in the speed of the ship which the estimator does not know about. In the figures above, this is not clearly visible. But if one looks at a graph (figure C-2) which only displays the ETA towards node 1, this can be seen

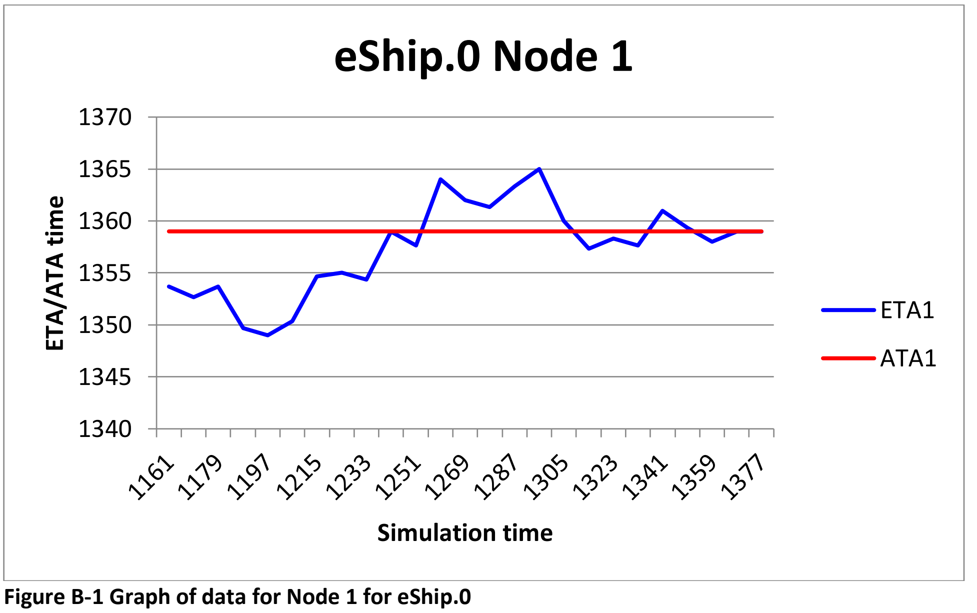


Figure B-1 Graph of data for Node 1 for eShip.0

It can be seen that the variation does not cause a lot of fluctuation in the ETA calculation, only 10 seconds at max. This is somewhat true to the actual Trajectplanner although those variations are within a couple of minutes.
The location of the ship is also plotted in the graph to indicate when a ship is at what location. The location line has the left vertical axes as indicator. As mentioned, all ship either sail from 2000 to -2000 or from -2000 to 2000.
As can be seen in the description shown in chapter 8, the ship's location becomes the location of the door (180 or -180) when the ship waits to enter the lock.
In figure 9-5 it can be seen that when the ship passes the first node and comes between 2 nodes with the lock between them, the ETA keeps climbing. Although it is not an exact representation of what was shown in chapter 6. It is very similar behaviour. The max KPI from the shown figures was 2123 s =35 min which is very similar to the max KPI found in chapter 6 for ships with 1 lock on the route to KP2.

The variation seen in chapter 5 is probably caused by the scheduling the Trajectplanner does. The estimator used in these tests didn't do any planning.

To replicate these fluctuations assumed caused by the scheduling done by the Trajectplanner, the test was done with an estimator which tries to replicate the scheduling of the Trajectplanner in a simple way. This estimator has an extra function (extrawaitingtime), which checks on both sides, which ships arrived at the nodes first. It checks how many switches it takes to let these ships through and adds that time to the ETA. It uses to ETA for Node 1 of other ships to estimate how many ships will arrive at the lock before the current ship

C.3.2 Estimator validation - Planning

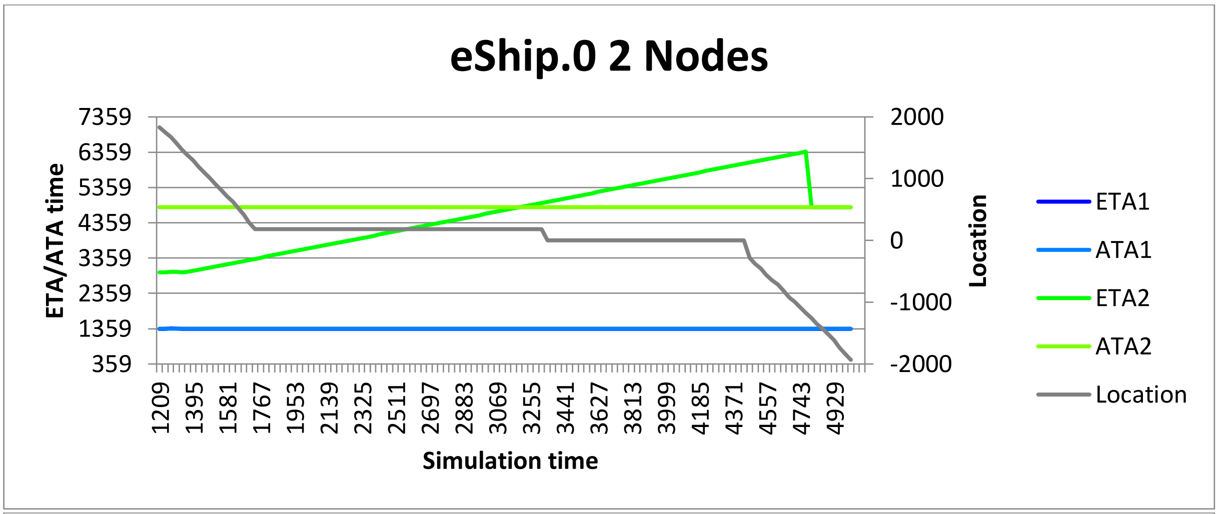
All the graphs from this experiment can be found in Appendix C.5

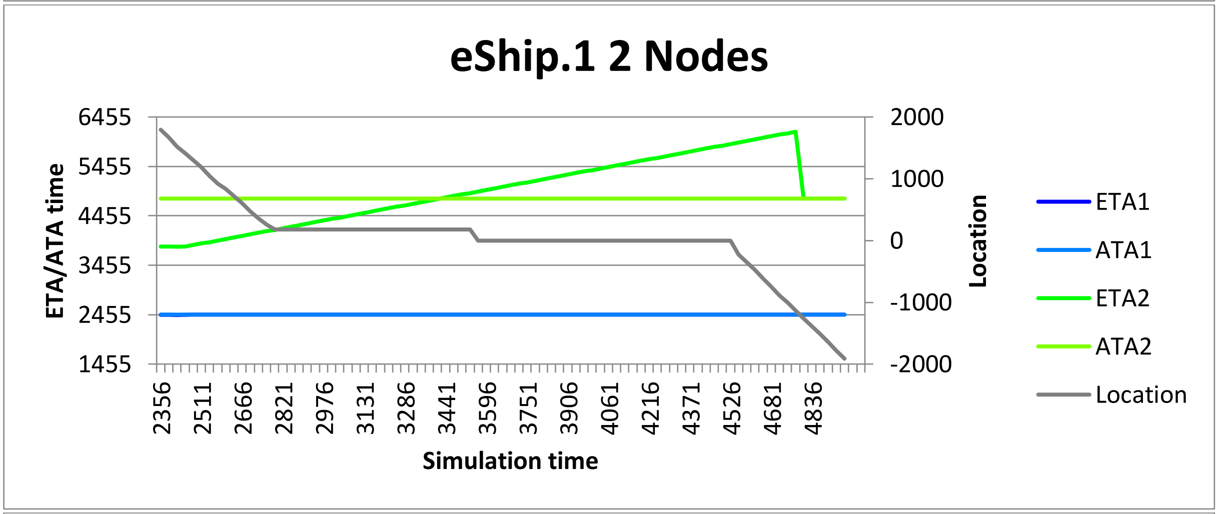
C.3.2.1 Estimator planning validation - Results

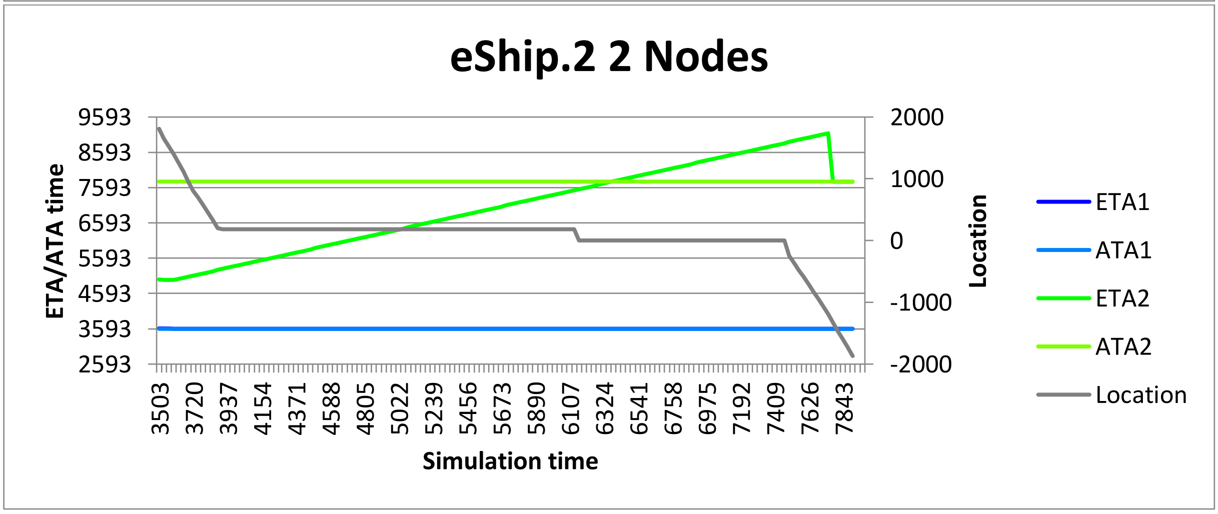
As can be seen in the table at the end of section C.5, the 'planning' did not improve the KPI but it did bring more fluctuations into the graph which is more accurate to the Trajectplanner. The average, median and standard deviation from all the KPIs is shown as well in the table. This shows that the estimator gets very similar results as the Trajectplanner. The goal of this estimator was to give similar results as and have similar behaviour as the Trajectplanner and that it did. There will be differences because the Trajectplanner makes schedules and in this case has two chambers to work with. This means that ships have less waiting time in the real-world than in the simulation, which means that in the simulation, there is more time for the ETA estimation to rise.

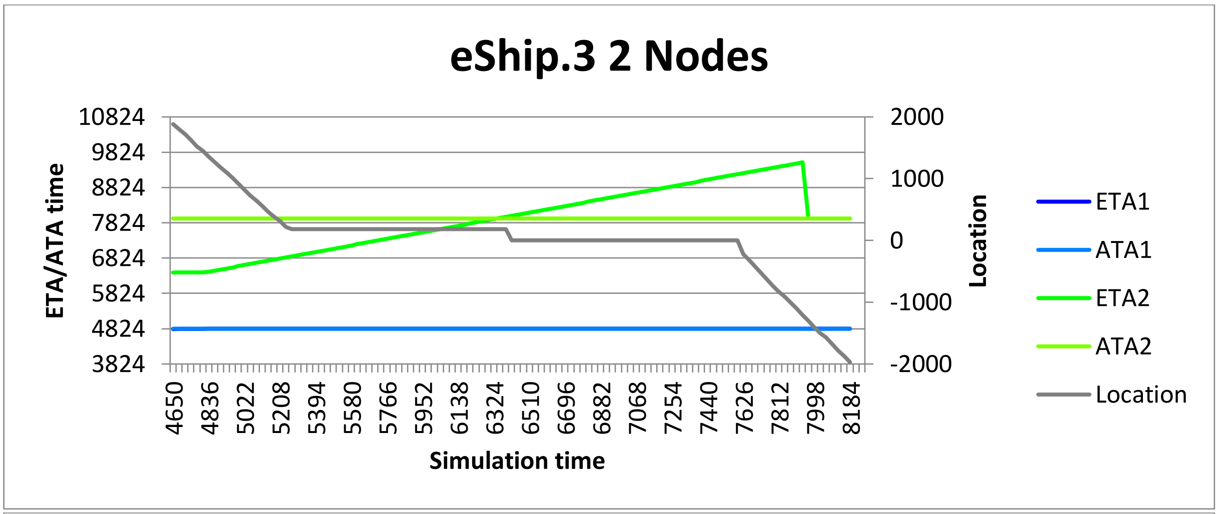
C.4 Estimator validation – Graphs

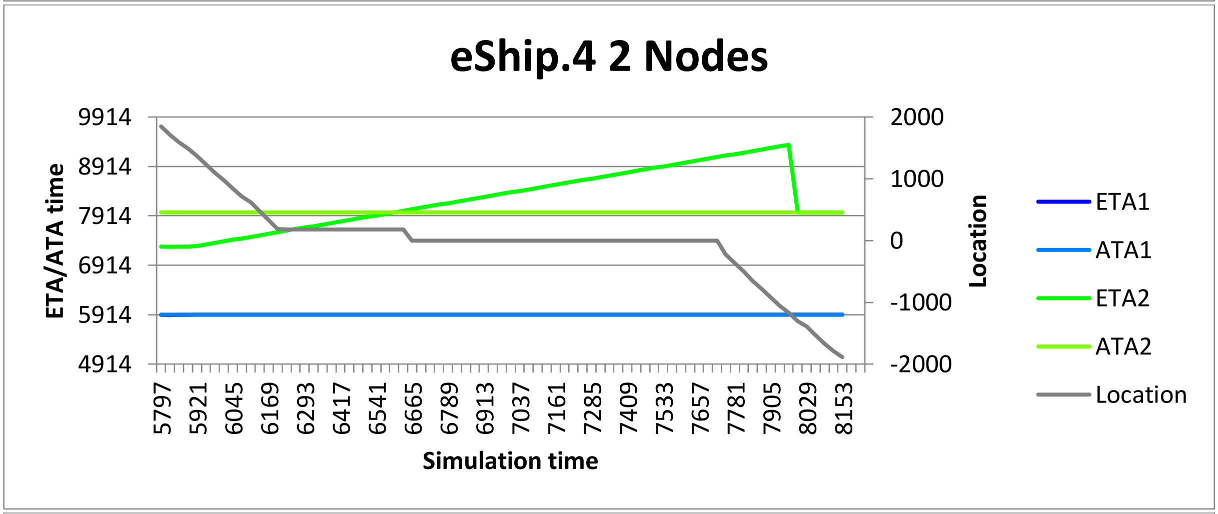
The graphs made by the simulation in the estimator validation experiment are shown in this section At the end of this section, the table with the max KPIs for each ships and each node is displayed

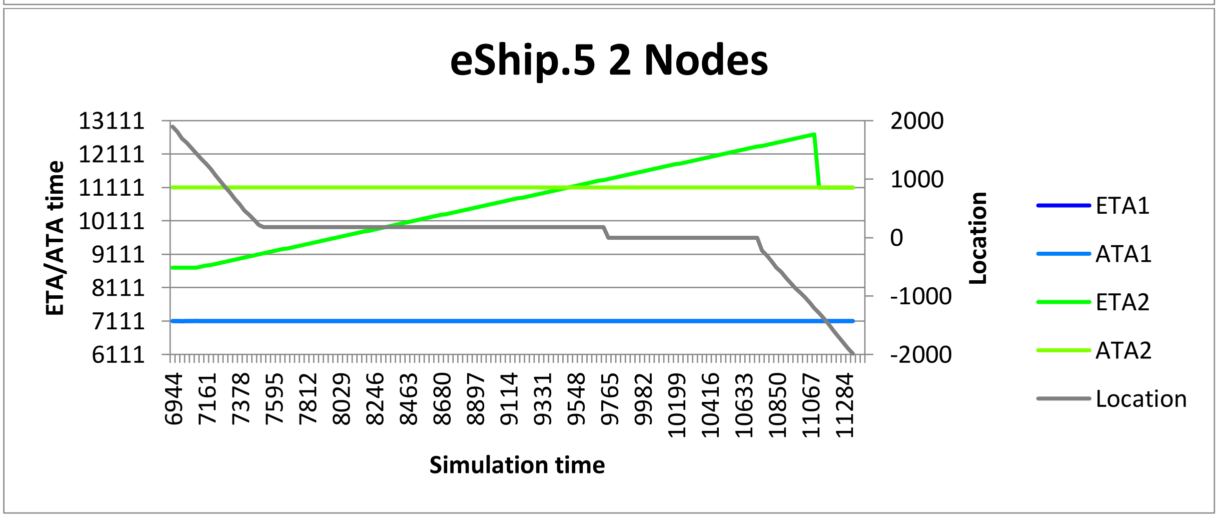

eShip.0 2 Nodes
ETA/ATA time
7359
6359
5359
4359
3359
2359
1359
359
2000
1000
0
-1000
-2000
Location
1209
1395
1581
1767
1953
2139
2325
2511
2697
2883
3069
3255
3441
3627
3813
3999
4185
4371
4557
4743
4929
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

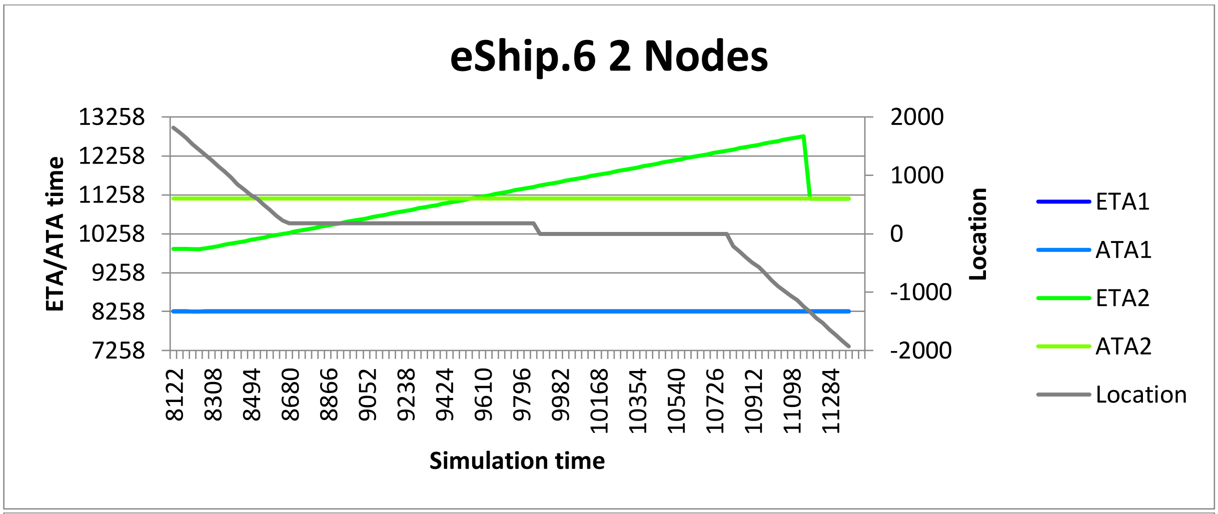

eShip.1 2 Nodes
ETA/ATA time
6455
5455
4455
3455
2455
1455
2000
1000
0
-1000
-2000
Location
2356
2511
2666
2821
2976
3131
3286
3441
3596
3751
3906
4061
4216
4371
4526
4681
4836
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

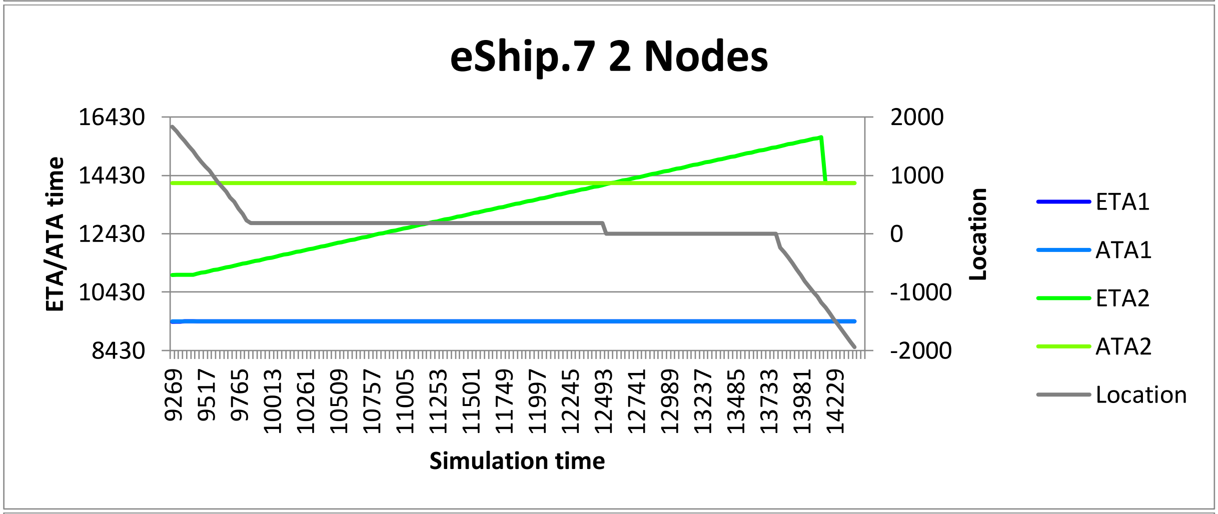

eShip.2 2 Nodes
ETA/ATA time
9593
8593
7593
6593
5593
4593
3593
2593
2000
1000
0
-1000
-2000
Location
3503
3720
3937
4154
4371
4588
4805
5022
5239
5456
5673
5890
6107
6324
6541
6758
6975
7192
7409
7626
7843
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

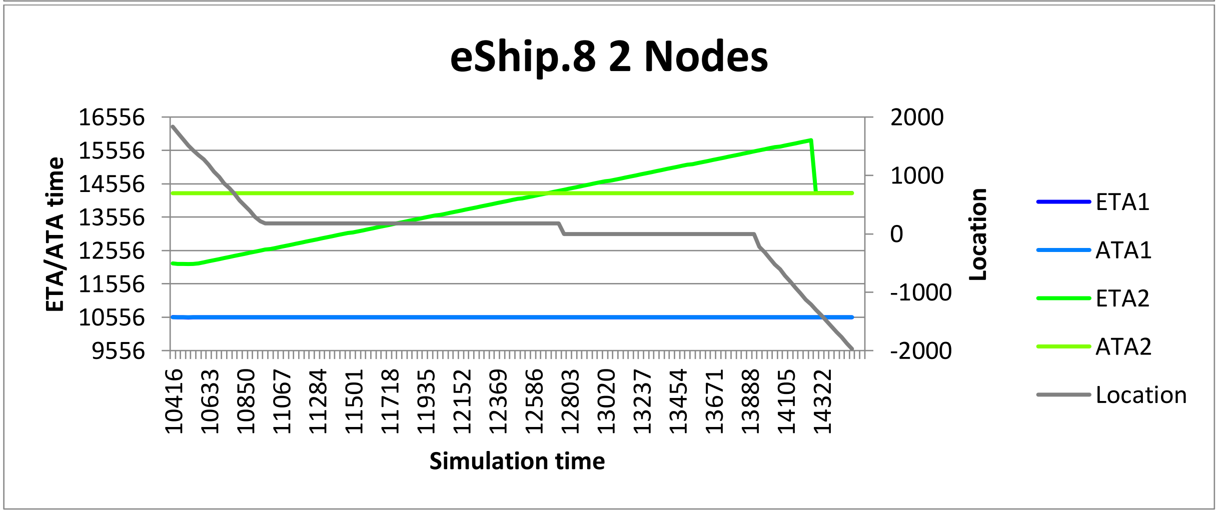

eShip.3 2 Nodes
ETA/ATA time
10824
9824
8824
7824
6824
5824
4824
3824
2000
1000
0
-1000
-2000
Location
4650
4836
5022
5208
5394
5580
5766
5952
6138
6324
6510
6696
6882
7068
7254
7440
7626
7812
7998
8184
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

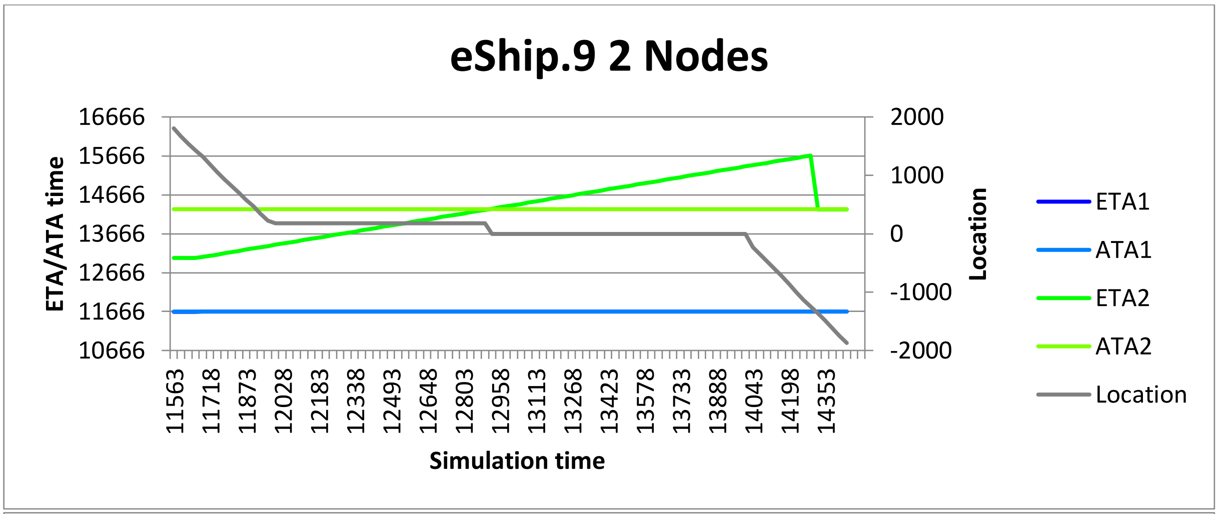

eShip.4 2 Nodes
ETA/ATA time
9914
8914
7914
6914
5914
4914
2000
1000
0
-1000
-2000
Location
5797
5921
6045
6169
6293
6417
6541
6665
6789
6913
7037
7161
7285
7409
7533
7657
7781
7905
8029
8153
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


eShip.5 2 Nodes
ETA/ATA time
13111
12111
11111
10111
9111
8111
7111
6111
2000
1000
0
-1000
-2000
Location
6944
7161
7378
7595
7812
8029
8246
8463
8680
8897
9114
9331
9548
9765
9982
10199
10416
10633
10850
11067
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

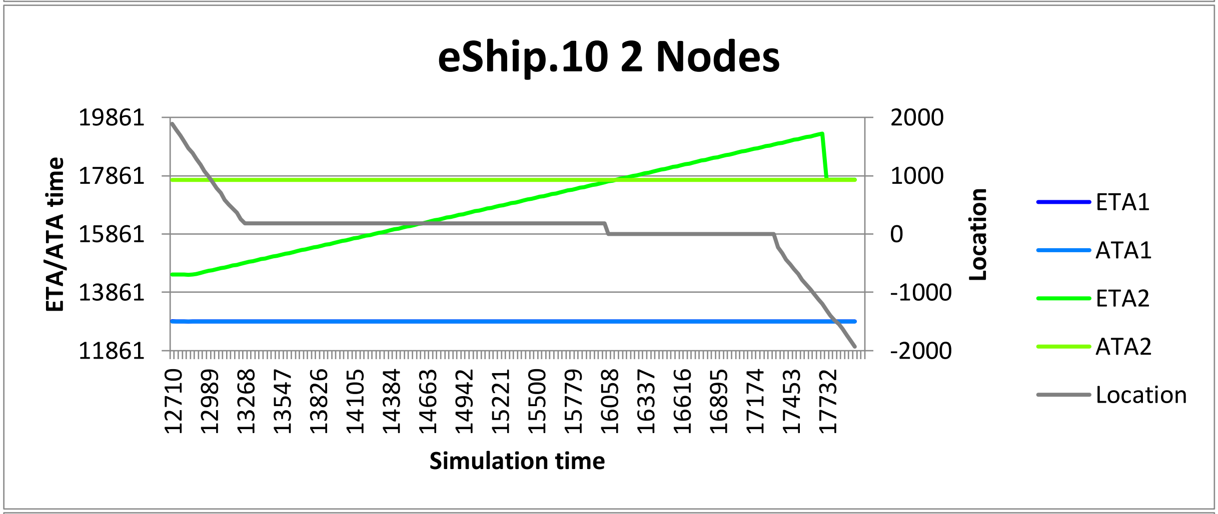

eShip.6 2 Nodes
ETA/ATA time
13258
12258
11258
10258
9258
8258
7258
2000
1000
0
-1000
-2000
Location
8122
8308
8494
8680
8866
9052
9238
9424
9610
9796
9982
10168
10354
10540
10726
10912
11098
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


eShip.7 2 Nodes
ETA/ATA time
16430
14430
12430
10430
8430
2000
1000
0
-1000
-2000
Location
9269
9517
9765
10013
10261
10509
10757
11005
11253
11501
11749
11997
12245
12493
12741
12989
13237
13485
13733
13981
14229
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

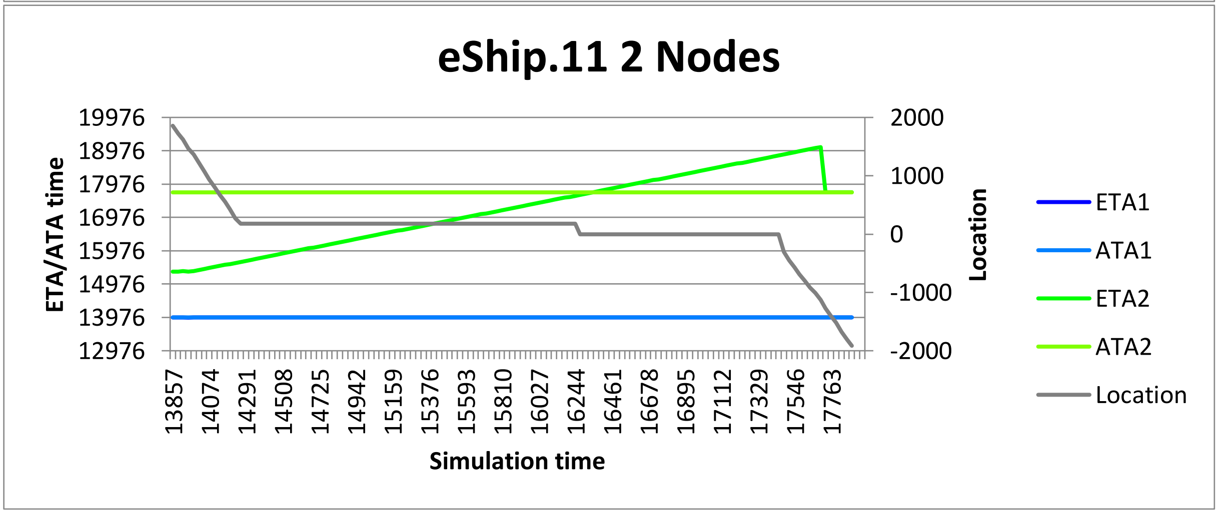

eShip.8 2 Nodes
ETA/ATA time
16556
15556
14556
13556
12556
11556
10556
9556
2000
1000
0
-1000
-2000
Location
10416
10633
10850
11067
11284
11501
11718
11935
12152
12369
12586
12803
13020
13237
13454
13671
13888
14105
14322
Simulation time
ETA1
ATA1
ETA2
ATA2
Location



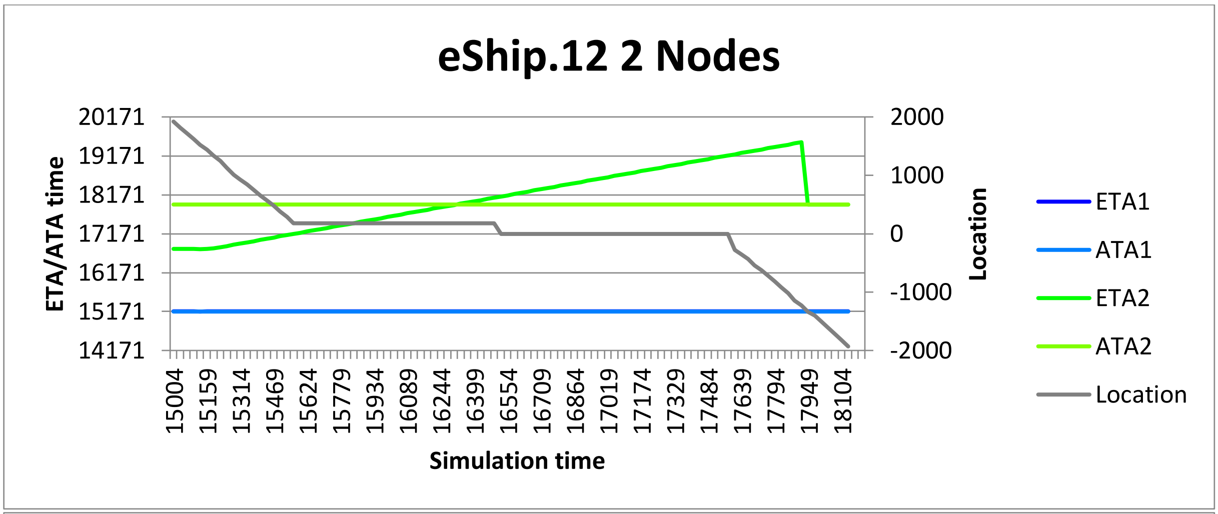
eShip.9 2 Nodes
ETA/ATA time
16666
15666
14666
13666
12666
11666
10666
2000
1000
0
-1000
-2000
Location
11563
11718
11873
12028
12183
12338
12493
12648
12803
12958
13113
13268
13423
13578
13733
13888
14043
14198
14353
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

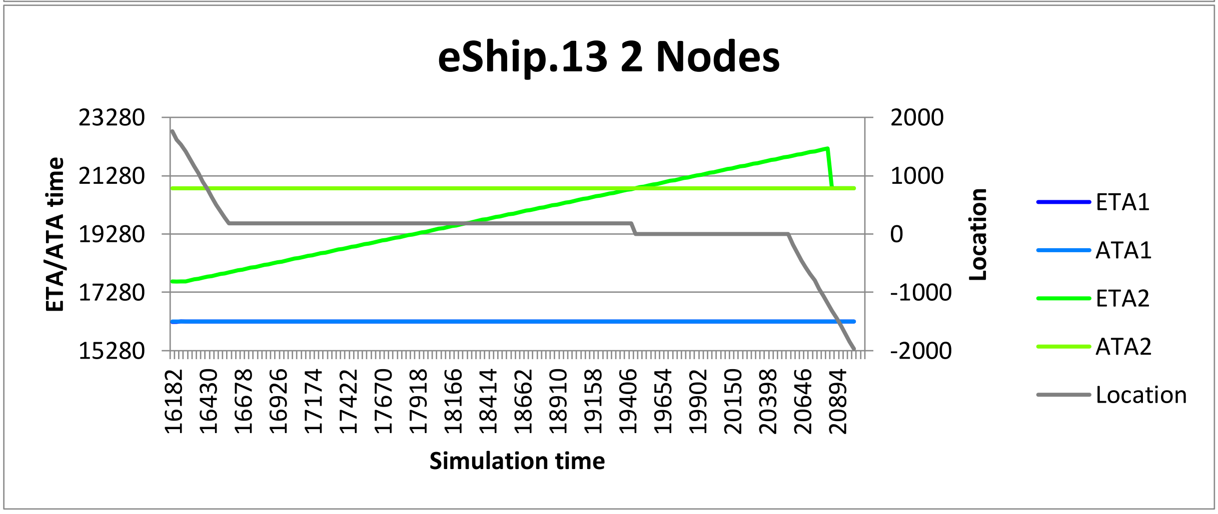


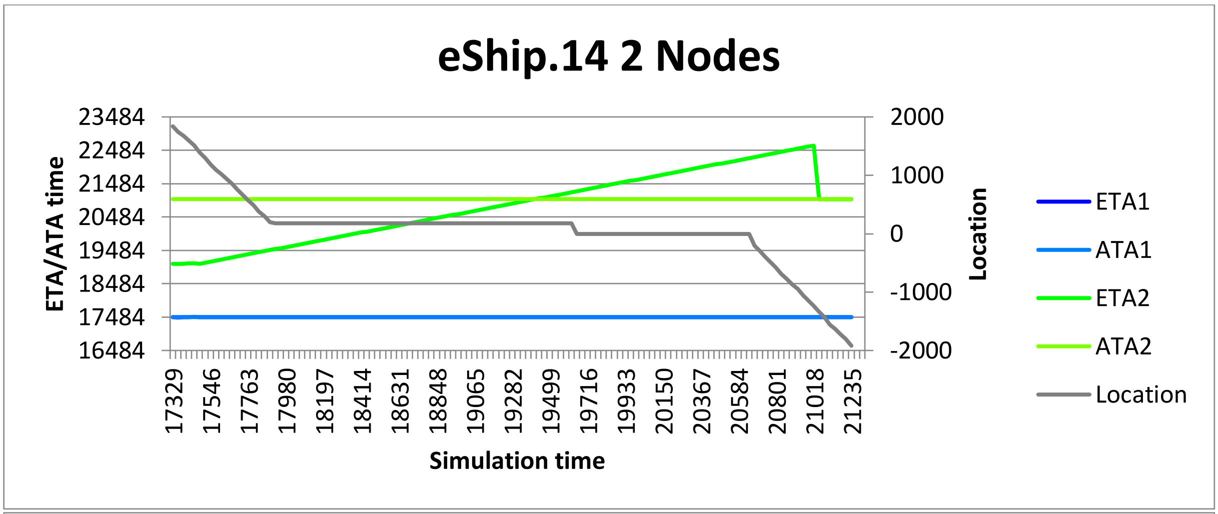
eShip.10 2 Nodes
ETA/ATA time
19861
17861
15861
13861
11861
2000
1000
0
-1000
-2000
Location
12710
12989
13268
13547
13826
14105
14384
14663
14942
15221
15500
15779
16058
16337
16616
16895
17174
17453
17732
Simulation time
ETA1
ATA1
ETA2
ATA2
Location



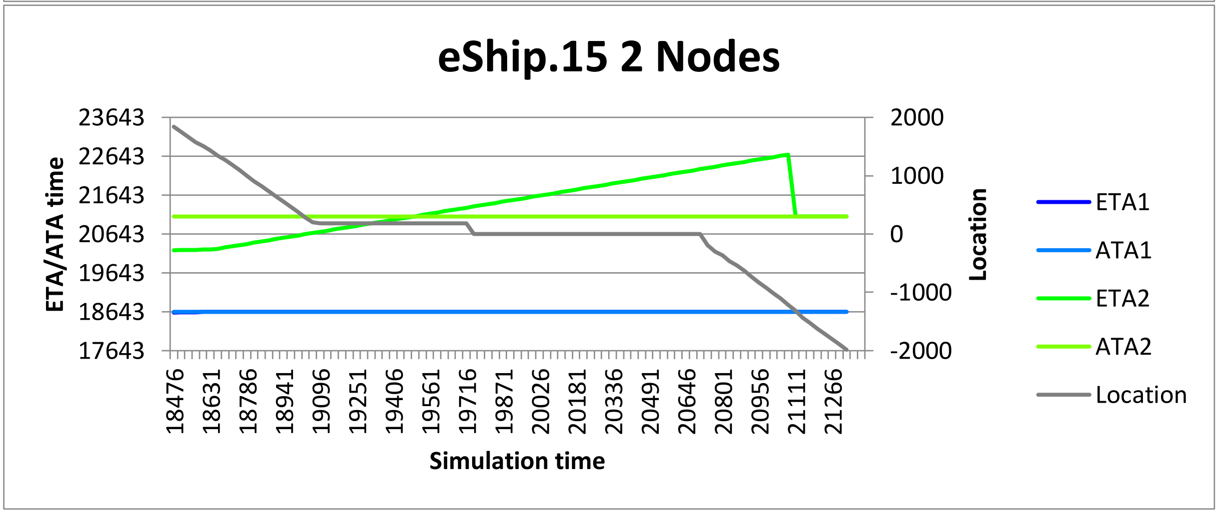
eShip.11 2 Nodes
ETA/ATA time
19976
18976
17976
16976
15976
14976
13976
12976
2000
1000
0
-1000
-2000
Location
13857
14074
14291
14508
14725
14942
15159
15376
15593
15810
16027
16244
16461
16678
16895
17112
17329
17546
17763
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


eShip.12 2 Nodes
ETA/ATA time
20171
19171
18171
17171
16171
15171
14171
2000
1000
0
-1000
-2000
Location
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
16554
16709
16864
17019
17174
17329
17484
17639
17794
17949
18104
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

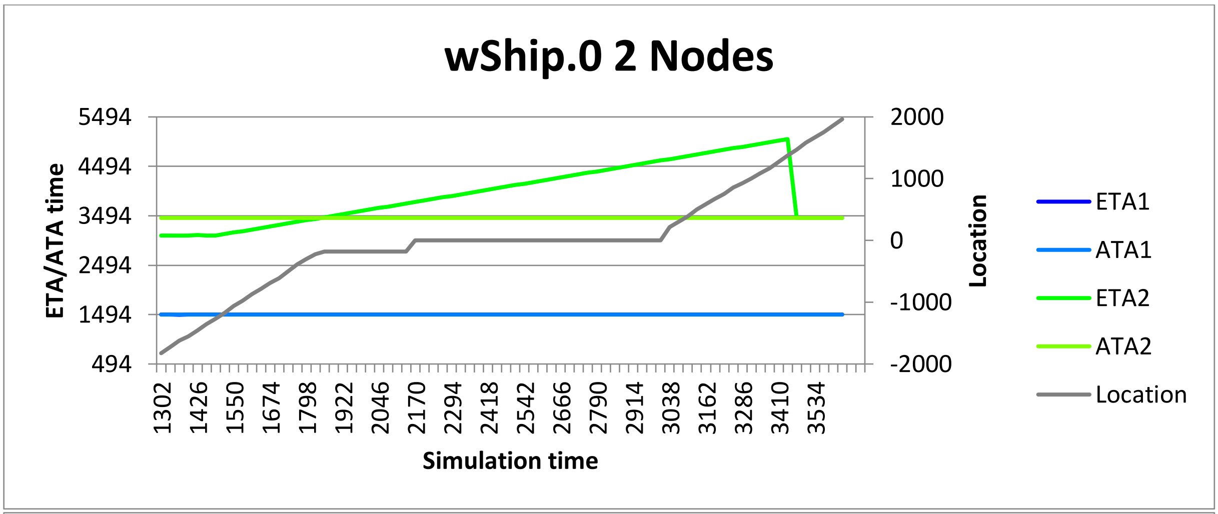

eShip.13 2 Nodes
ETA/ATA time
23280
21280
19280
17280
15280
2000
1000
0
-1000
-2000
Location
16182
16430
16678
16926
17174
17422
17670
17918
18166
18414
18662
18910
19158
19406
19654
19902
20150
20398
20646
20894
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

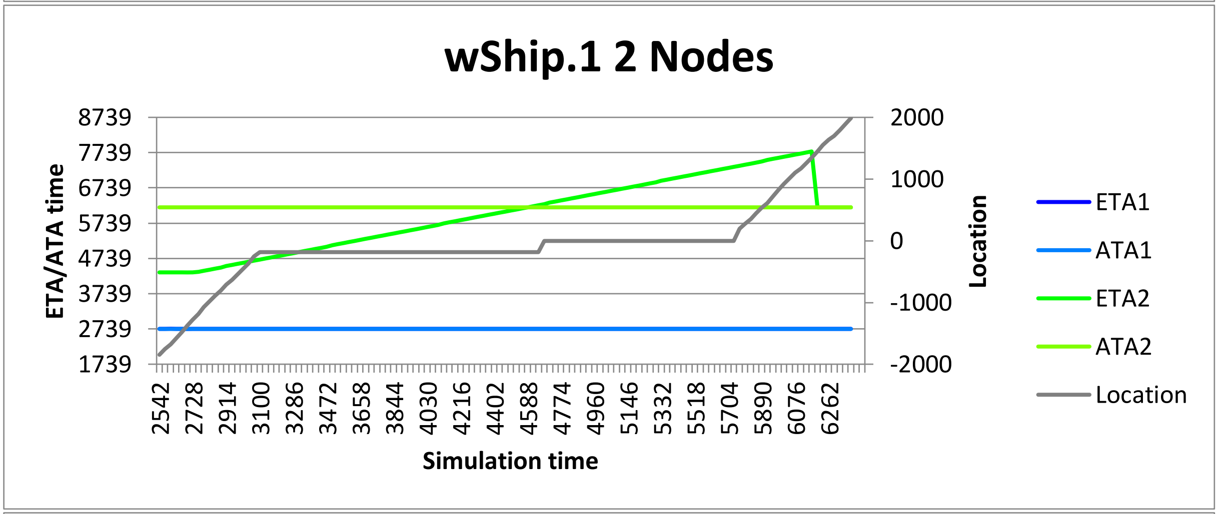


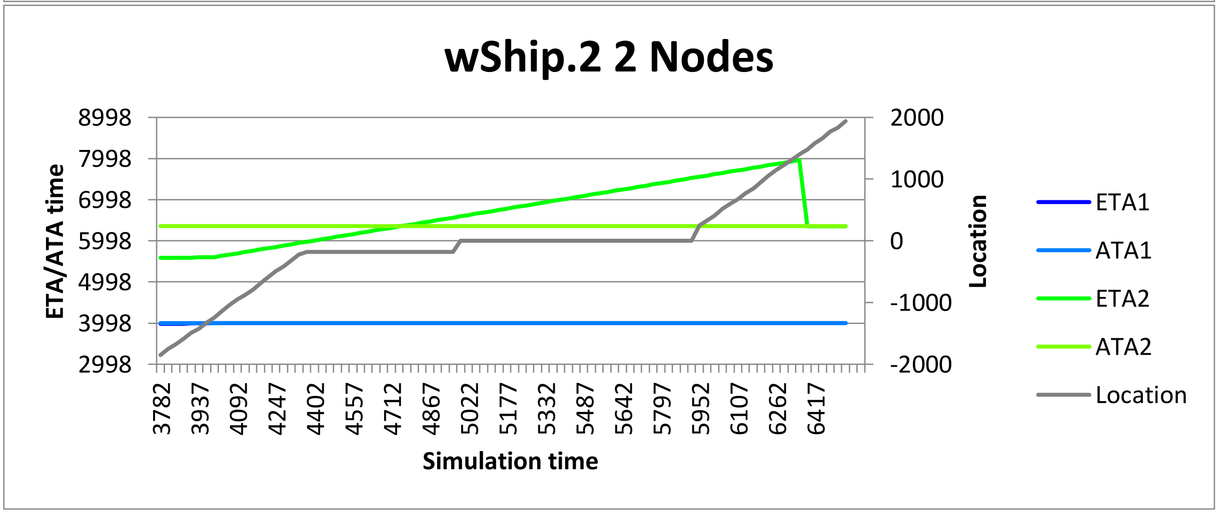
eShip.14 2 Nodes
ETA/ATA time
23484
22484
21484
20484
19484
18484
17484
16484
2000
1000
0
-1000
-2000
Location
17329
17546
17763
17980
18197
18414
18631
18848
19065
19282
19499
19716
19933
20150
20367
20584
20801
21018
21235
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

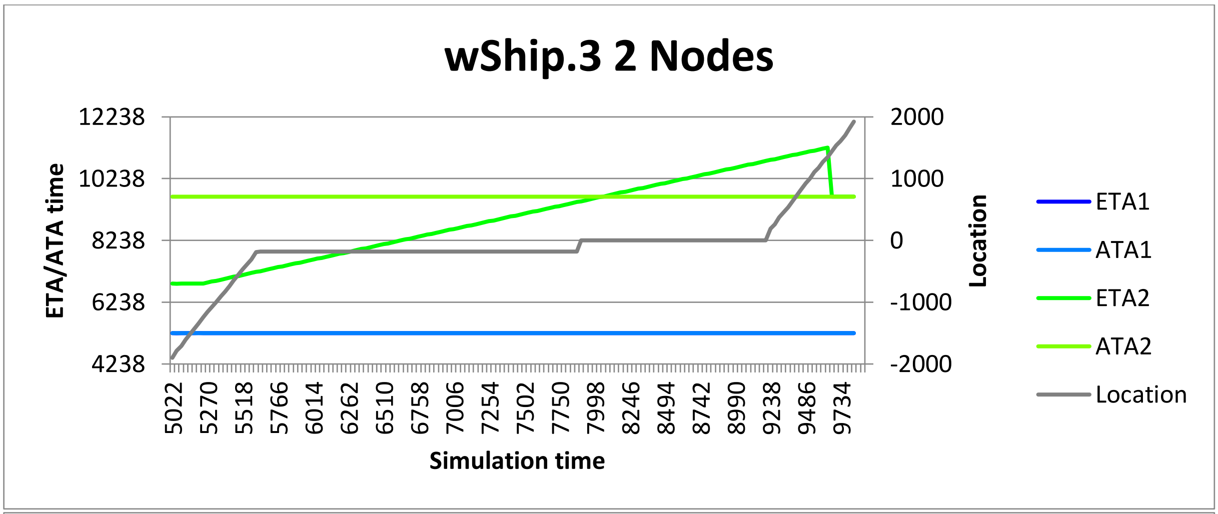


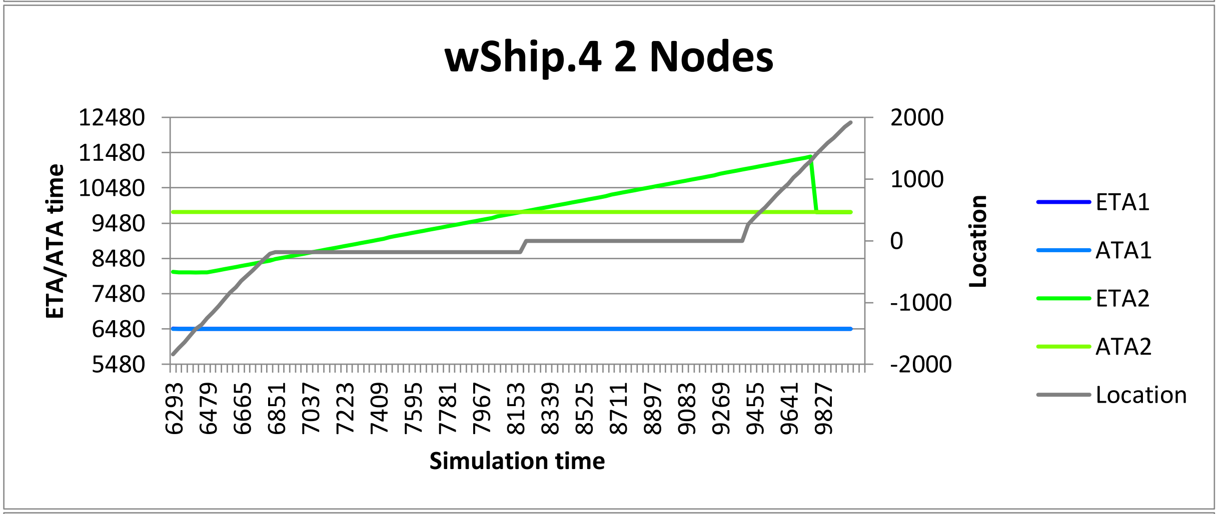
eShip.15 2 Nodes
ETA/ATA time
23643
22643
21643
20643
19643
18643
17643
2000
1000
0
-1000
-2000
Location
18476
18631
18786
18941
19096
19251
19406
19561
19716
19871
20026
20181
20336
20491
20646
20801
20956
21111
21266
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

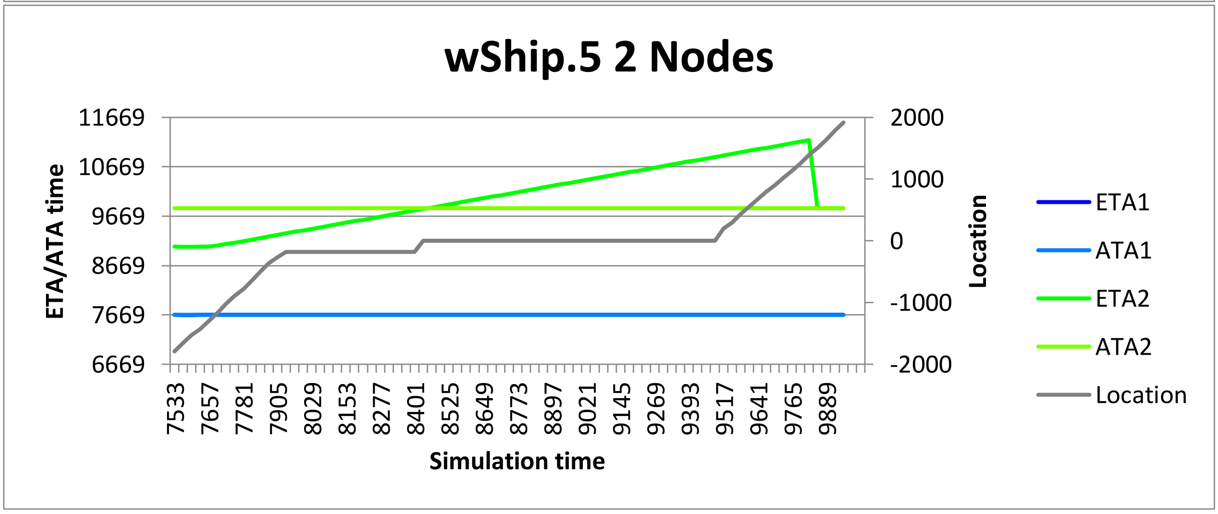

wShip.0 2 Nodes
5494
4494
3494
2494
1494
494
ETA/ATA time
2000
1000
0
-1000
-2000
Location
1302
1426
1550
1674
1798
1922
2046
2170
2294
2418
2542
2666
2790
2914
3038
3162
3286
3410
3534
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

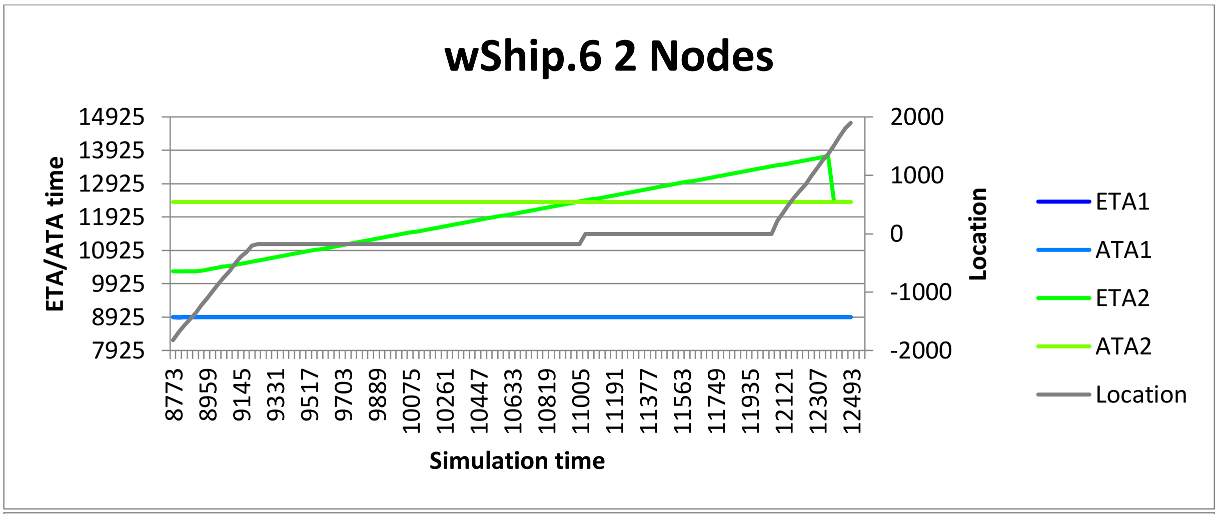

wShip.1 2 Nodes
8739
7739
6739
5739
4739
3739
2739
1739
ETA/ATA time
2000
1000
0
-1000
-2000
Location
2542
2728
2914
3100
3286
3472
3658
3844
4030
4216
4402
4588
4774
4960
5146
5332
5518
5704
5890
6076
6262
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

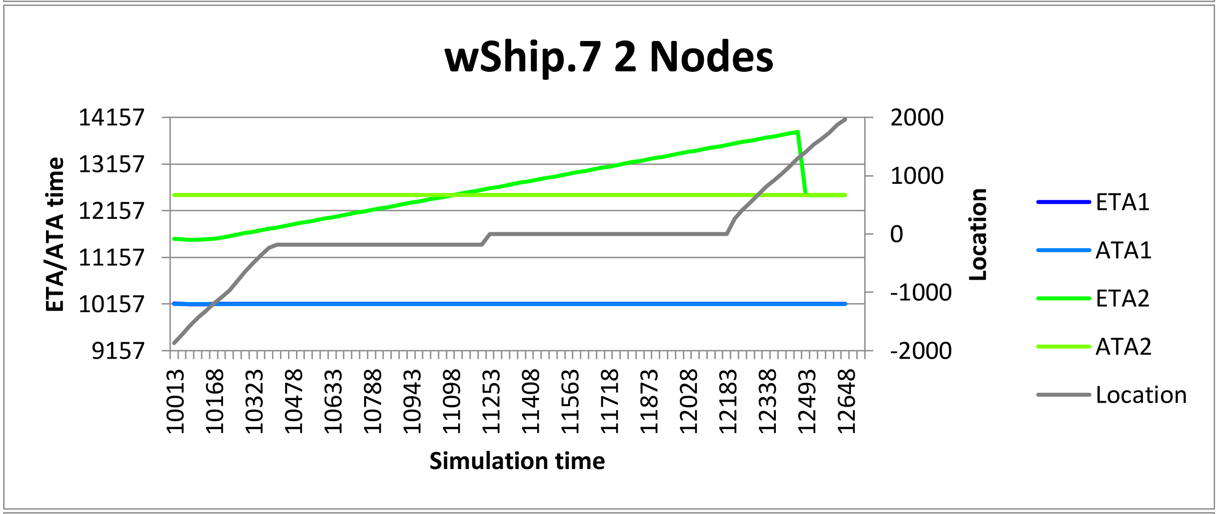

wShip.2 2 Nodes
8998
7998
6998
5998
4998
3998
2998
ETA/ATA time
2000
1000
0
-1000
-2000
Location
3782
3937
4092
4247
4402
4557
4712
4867
5022
5177
5332
5487
5642
5797
5952
6107
6262
6417
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

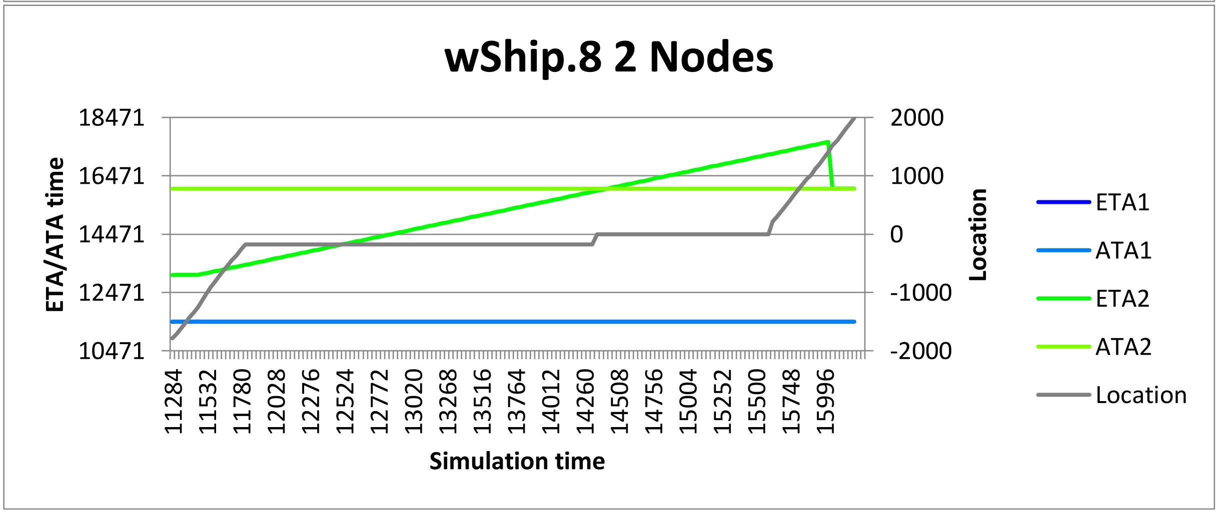

wShip.3 2 Nodes
ETA/ATA time
12238
10238
8238
6238
4238
2000
1000
0
-1000
-2000
Location
5022
5270
5518
5766
6014
6262
6510
6758
7006
7254
7502
7750
7998
8246
8494
8742
8990
9238
9486
9734
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

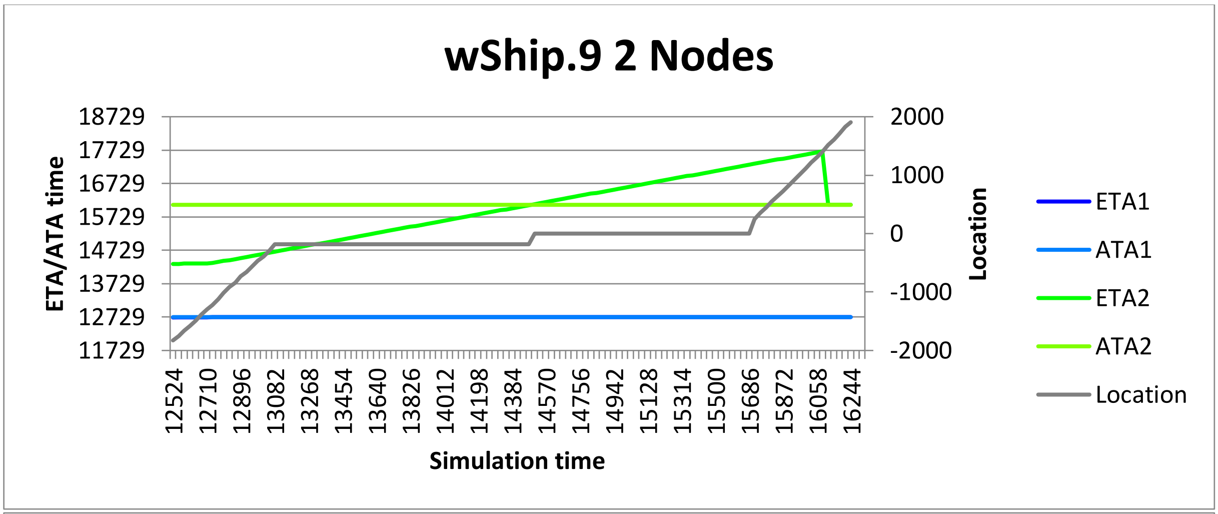

wShip.4 2 Nodes
ETA/ATA time
12480
11480
10480
9480
8480
7480
6480
5480
2000
1000
0
-1000
-2000
Location
6293
6479
6665
6851
7037
7223
7409
7595
7781
7967
8153
8339
8525
8711
8897
9083
9269
9455
9641
9827
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

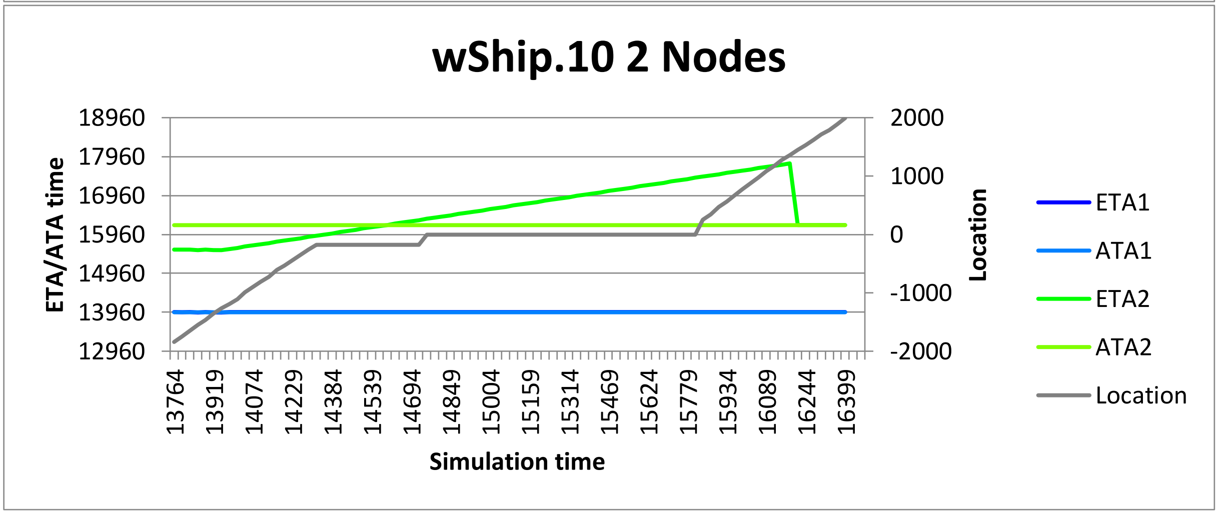

wShip.5 2 Nodes
ETA/ATA time
11669
10669
9669
8669
7669
6669
2000
1000
0
-1000
-2000
Location
7533
7657
7781
7905
8029
8153
8277
8401
8525
8649
8773
8897
9021
9145
9269
9393
9517
9641
9765
9889
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

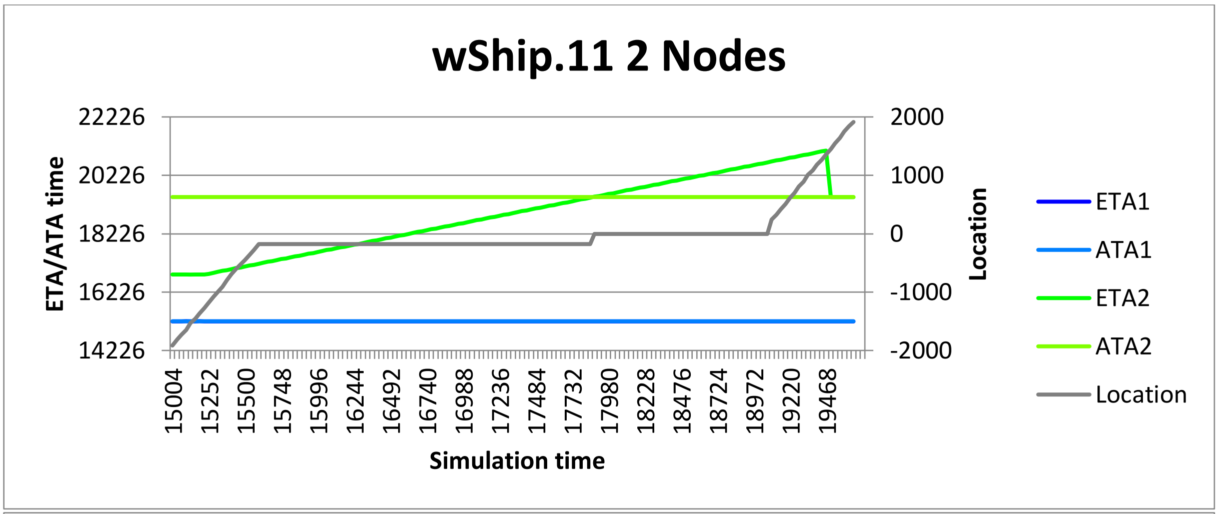

wShip.6 2 Nodes
ETA/ATA time
14925
13925
12925
11925
10925
9925
8925
7925
2000
1000
0
-1000
-2000
Location
8773
8959
9145
9331
9517
9703
9889
10075
10261
10447
10633
10819
11005
11191
11377
11563
11749
11935
12121
12307
12493
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

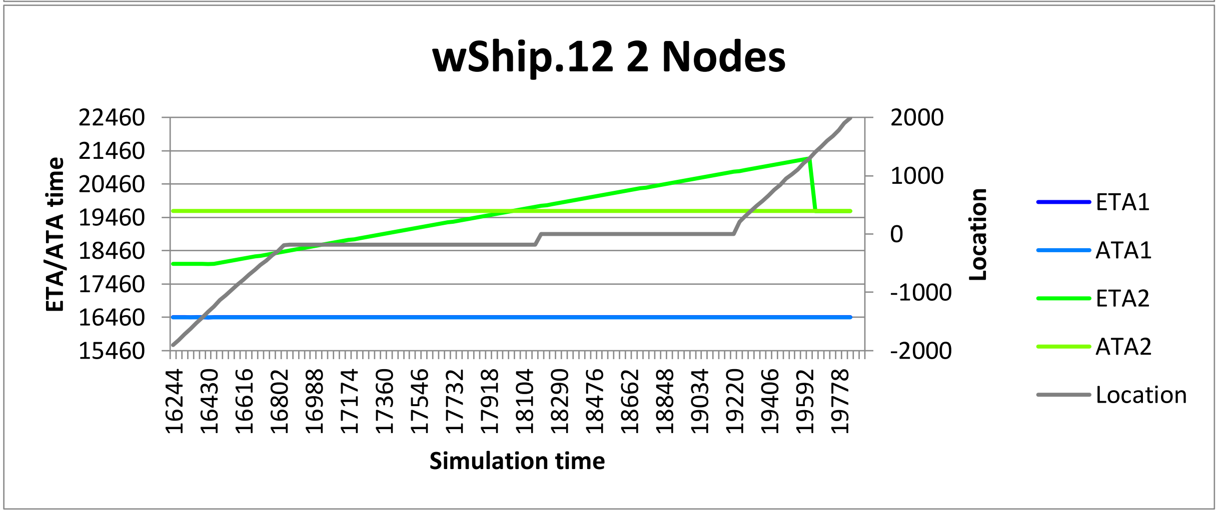

wShip.7 2 Nodes
ETA/ATA time
14157
13157
12157
11157
10157
9157
2000
1000
0
-1000
-2000
Location
10013
10168
10323
10478
10633
10788
10943
11098
11253
11408
11563
11718
11873
12028
12183
12338
12493
12648
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.8 2 Nodes
ETA/ATA time
18471
16471
14471
12471
10471
2000
1000
0
-1000
-2000
Location
11284
11532
11780
12028
12276
12524
12772
13020
13268
13516
13764
14012
14260
14508
14756
15004
15252
15500
15748
15996
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.9 2 Nodes
ETA/ATA time
18729
17729
16729
15729
14729
13729
12729
11729
Location
2000
1000
0
-1000
-2000
12524
12710
12896
13082
13268
13454
13640
13826
14012
14198
14384
14570
14756
14942
15128
15314
15500
15686
15872
16058
16244
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.10 2 Nodes
ETA/ATA time
18960
17960
16960
15960
14960
13960
12960
Location
2000
1000
0
-1000
-2000
13764
13919
14074
14229
14384
14539
14694
14849
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

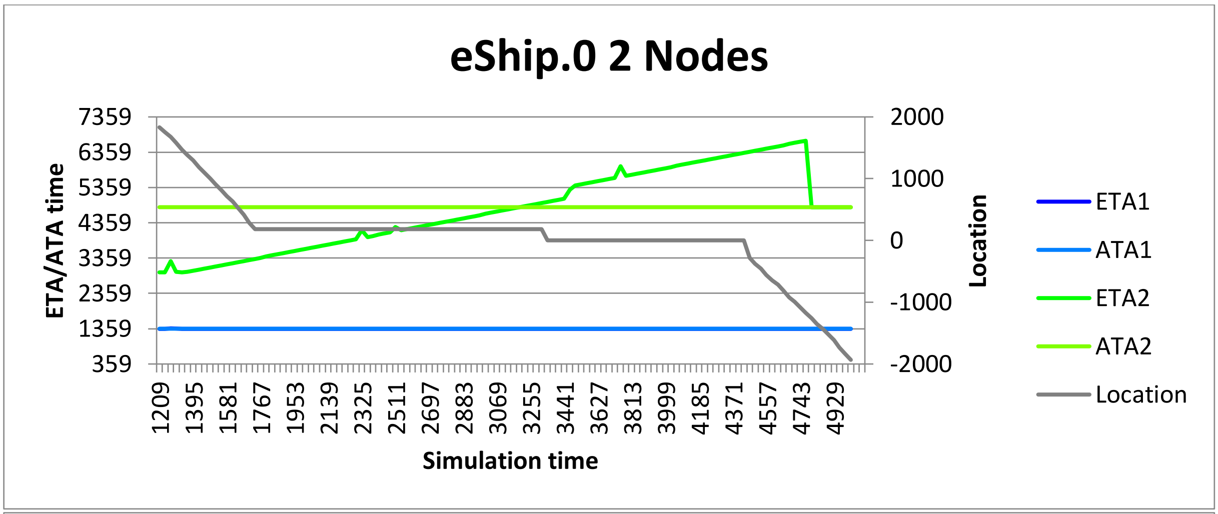

wShip.11 2 Nodes
ETA/ATA time
22226
20226
18226
16226
14226
2000
1000
0
-1000
-2000
Location
15004
15252
15500
15748
15996
16244
16492
16740
16988
17236
17484
17732
17980
18228
18476
18724
18972
19220
19468
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

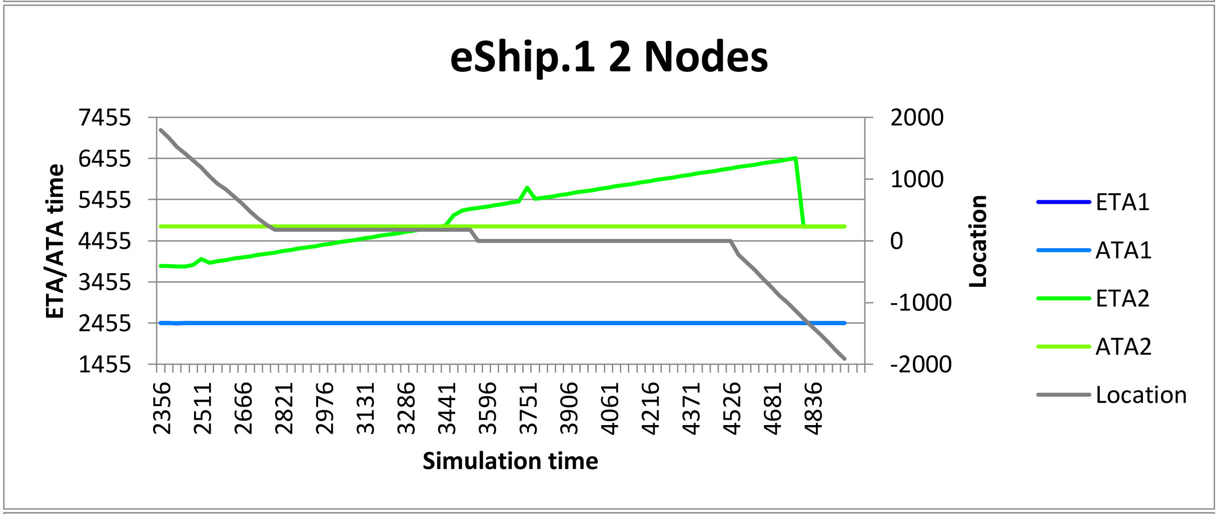

wShip.12 2 Nodes
ETA/ATA time
22460
21460
20460
19460
18460
17460
16460
15460
2000
1000
0
-1000
-2000
Location
16244
16430
16616
16802
16988
17174
17360
17546
17732
17918
18104
18290
18476
18662
18848
19034
19220
19406
19592
19778
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

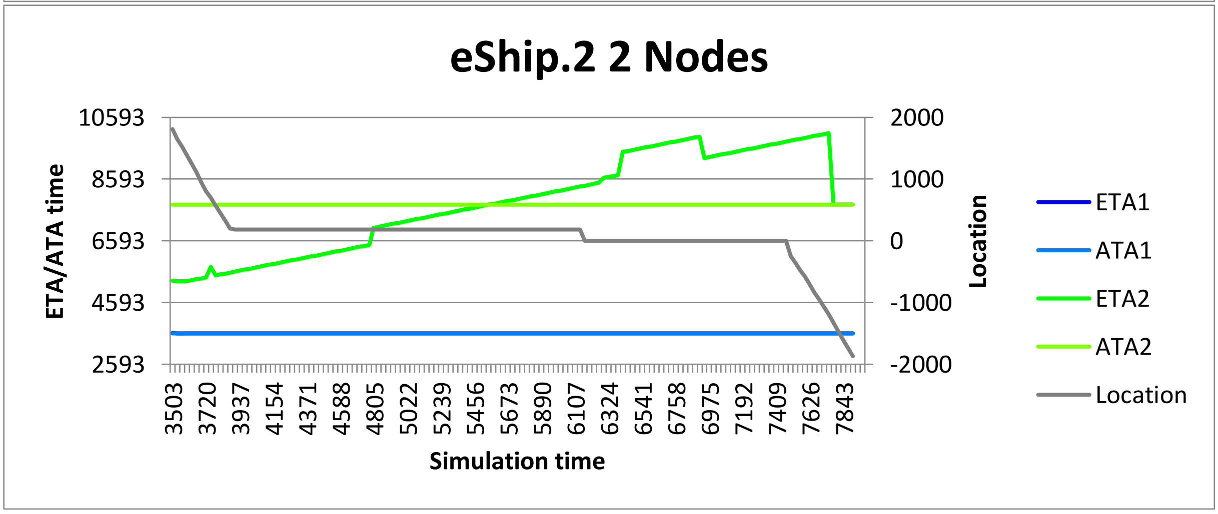
	MaxKPI1	MaxKPI2
wShip.0	5	1594,333
eShip.1	8,25	1352,5
eShip.0	6	1845,667
wShip.1	6,333333	1846
wShip.2	18,33333	1602,333
eShip.2	12,5	2785,5
eShip.4	10,25	1364,5
eShip.3	15,33333	1592,333
wShip.3	5,333333	2819
wShip.5	3,75	1378,5
wShip.4	10,33333	1715,667
eShip.5	6	2402,667
eShip.6	6,666667	1601,333
wShip.6	11,75	2078,25
wShip.7	10,75	1351,5
eShip.7	17	3149,667
eShip.9	7	1377,5
eShip.8	9,333333	2123
wShip.8	7,666667	2961,333
wShip.9	12,33333	1770
wShip.10	7	1587,333
eShip.11	8,75	2377,25
eShip.10	12	3253,667
eShip.12	6,666667	1600,333
wShip.11	8,333333	2661
wShip.12	3,666667	1592,333
eShip.13	13	3198,5
eShip.14	9,333333	1943
eShip.15	20,66667	1590,333

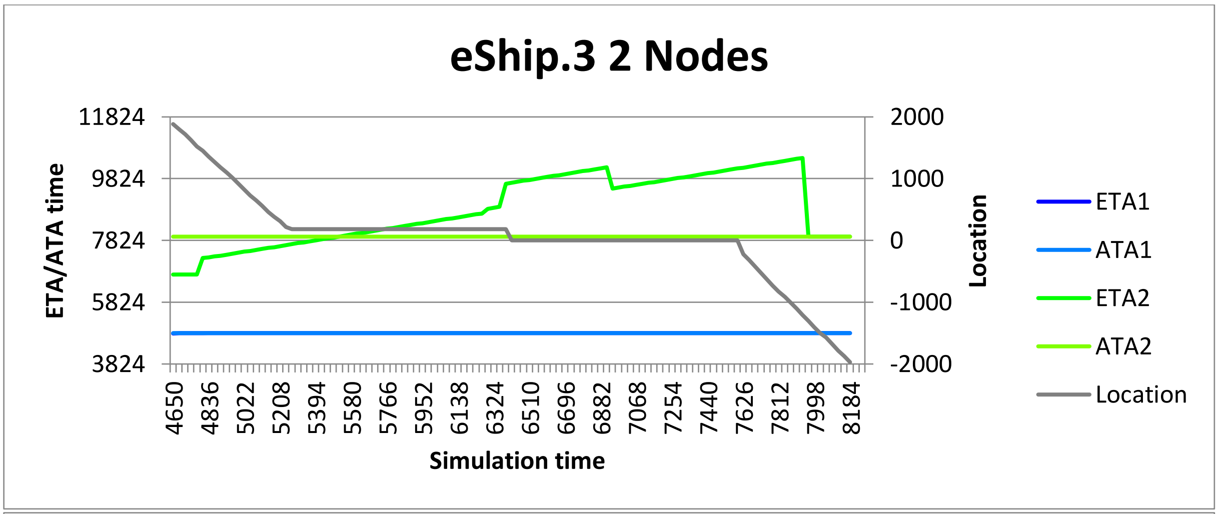
C.5 Estimator planning validation – Graphs

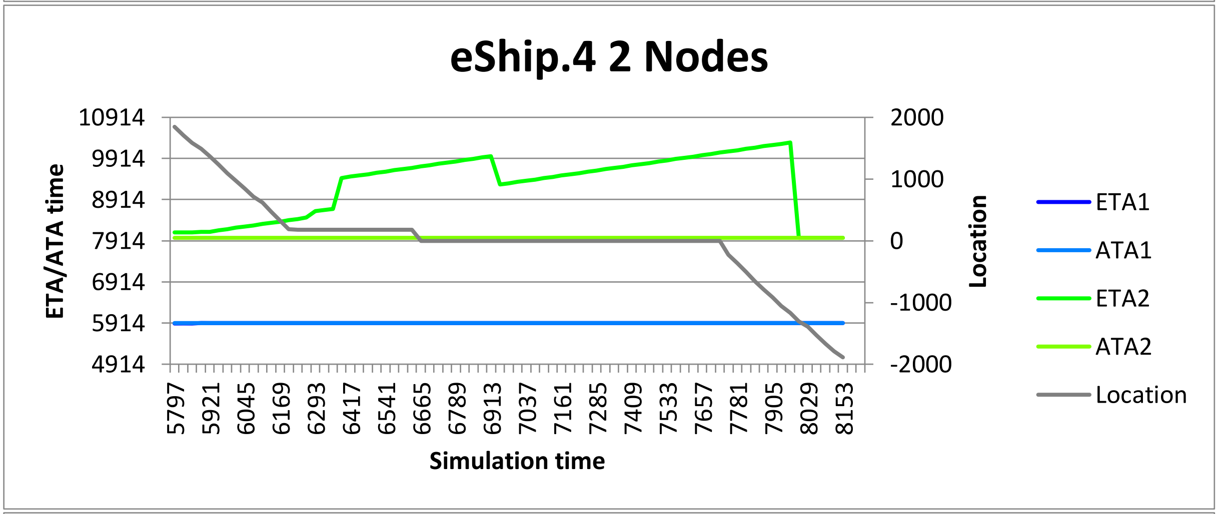
The graphs made by the simulation in estimator planning validation are shown in this section.
At the end of this section, the table with the max KPIs for each ships and each node is displayed

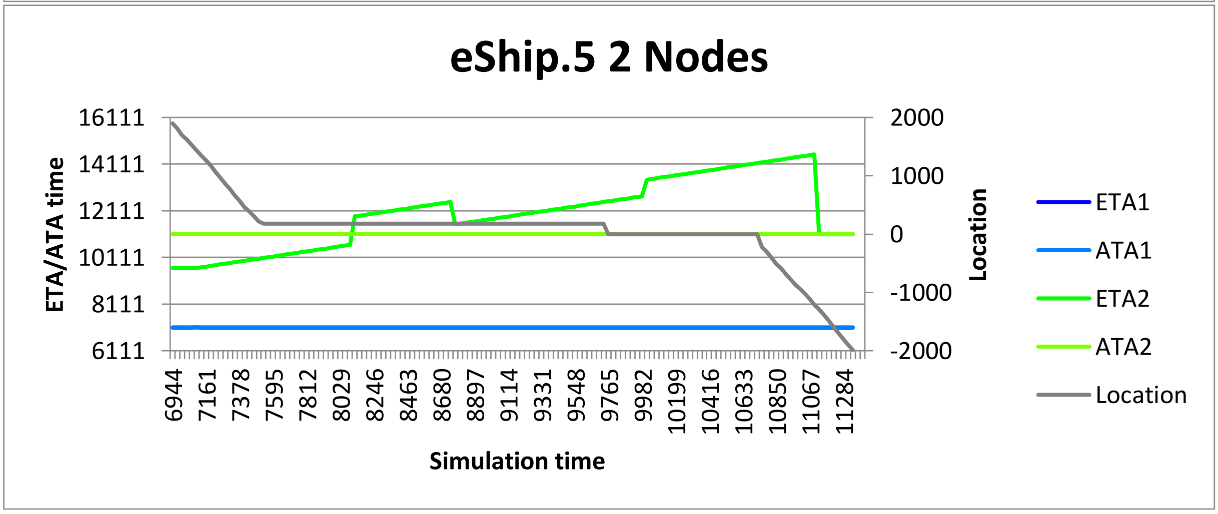

eShip.0 2 Nodes
ETA/ATA time
7359
6359
5359
4359
3359
2359
1359
359
2000
1000
0
-1000
-2000
Location
1209 1395 1581 1767 1953 2139 2325 2511 2697 2883 3069 3255 3441 3627 3813 3999 4185 4371 4557 4743 4929
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

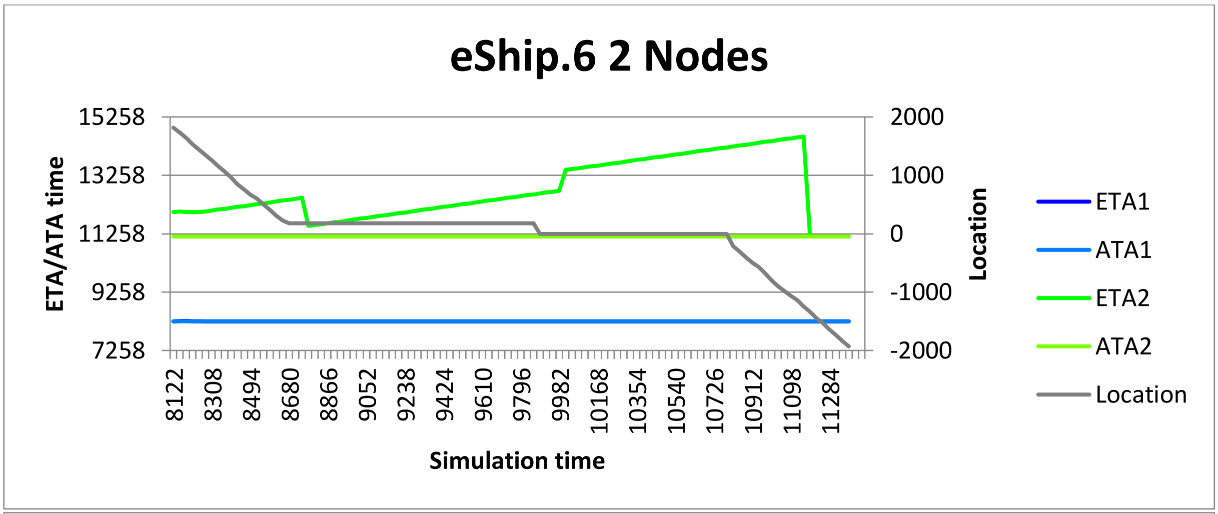

eShip.1 2 Nodes
ETA/ATA time
7455
6455
5455
4455
3455
2455
1455
2000
1000
0
-1000
-2000
Location
2356 2511 2666 2821 2976 3131 3286 3441 3596 3751 3906 4061 4216 4371 4526 4681 4836
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

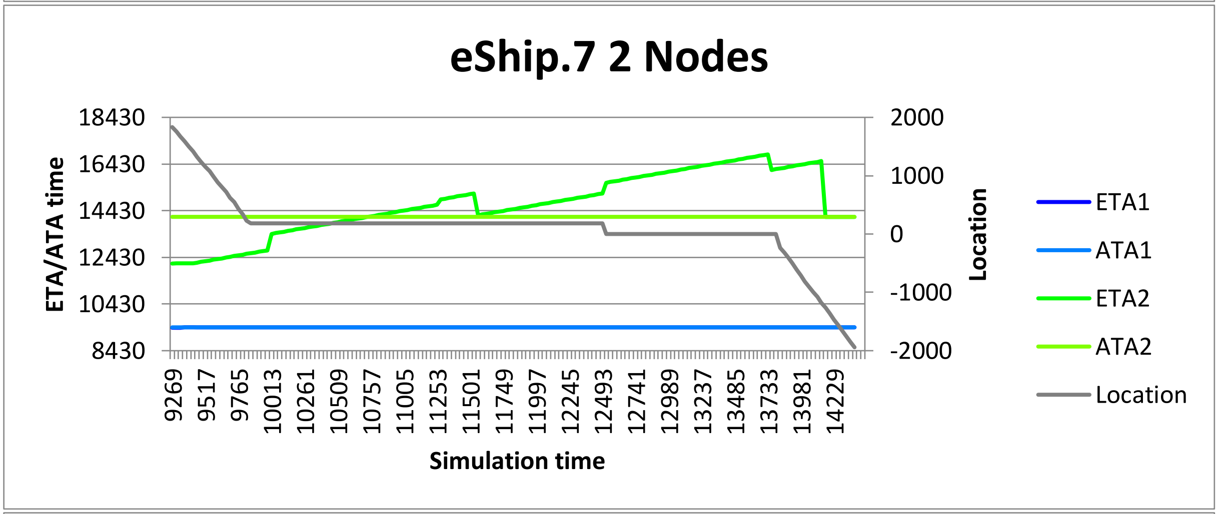

eShip.2 2 Nodes
ETA/ATA time
10593
8593
6593
4593
2593
2000
1000
0
-1000
-2000
Location
3503 3720 3937 4154 4371 4588 4805 5022 5239 5456 5673 5890 6107 6324 6541 6758 6975 7192 7409 7626 7843
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

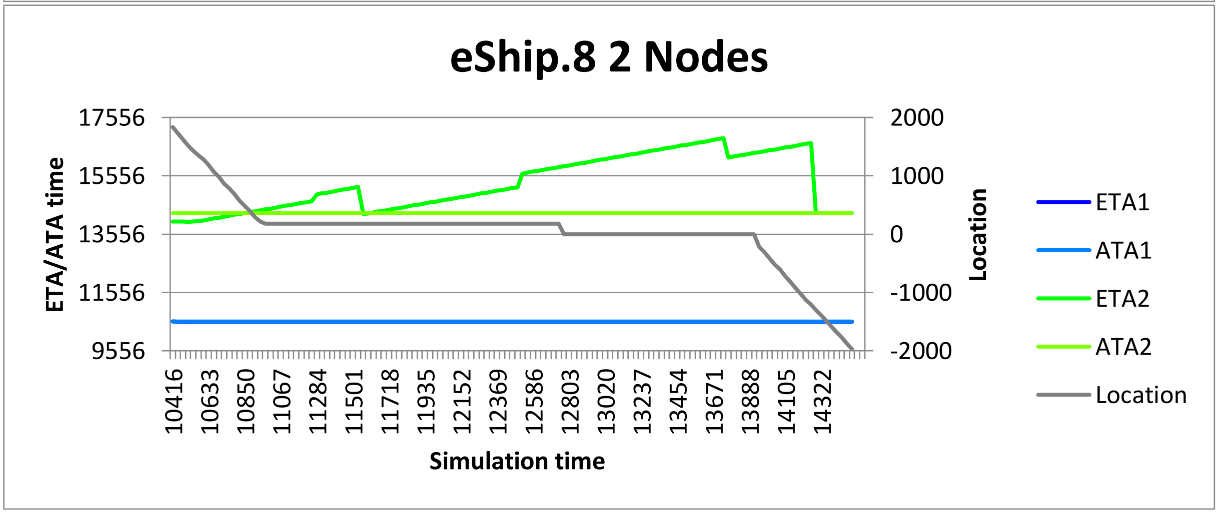

eShip.3 2 Nodes
ETA/ATA time
11824
9824
7824
5824
3824
2000
1000
0
-1000
-2000
Location
4650
4836
5022
5208
5394
5580
5766
5952
6138
6324
6510
6696
6882
7068
7254
7440
7626
7812
7998
8184
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

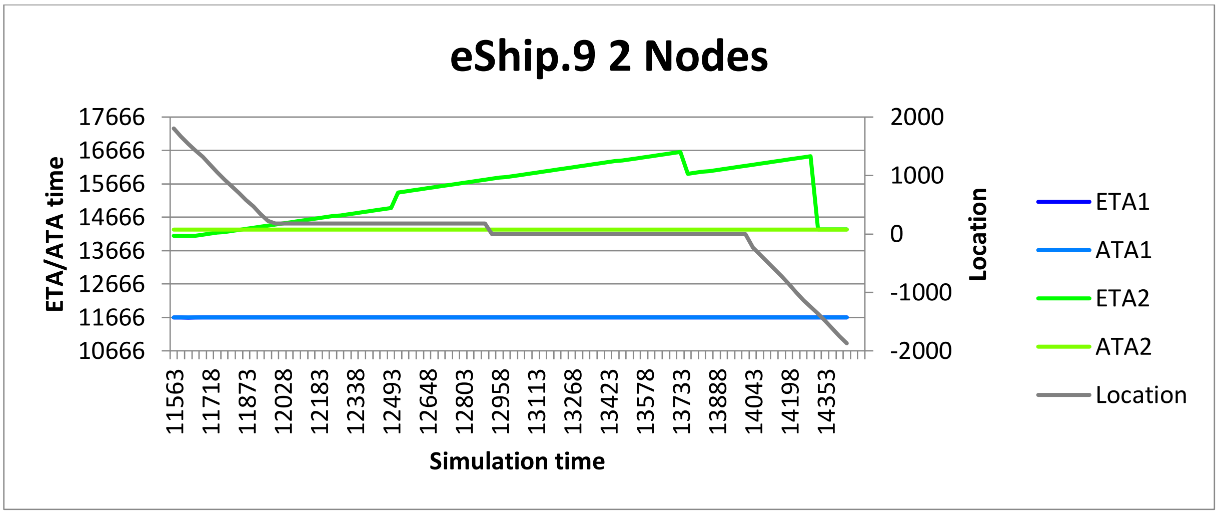

eShip.4 2 Nodes
ETA/ATA time
10914
9914
8914
7914
6914
5914
4914
2000
1000
0
-1000
-2000
Location
5797
5921
6045
6169
6293
6417
6541
6665
6789
6913
7037
7161
7285
7409
7533
7657
7781
7905
8029
8153
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

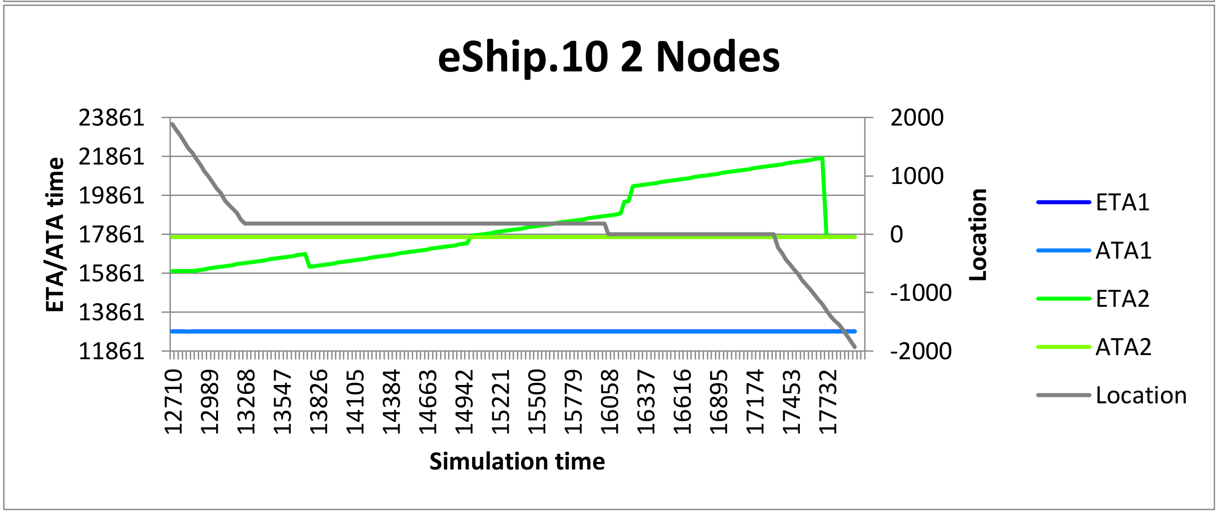

eShip.5 2 Nodes
ETA/ATA time
16111
14111
12111
10111
8111
6111
2000
1000
0
-1000
-2000
Location
6944
7161
7378
7595
7812
8029
8246
8463
8680
8897
9114
9331
9548
9765
9982
10199
10416
10633
10850
11067
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

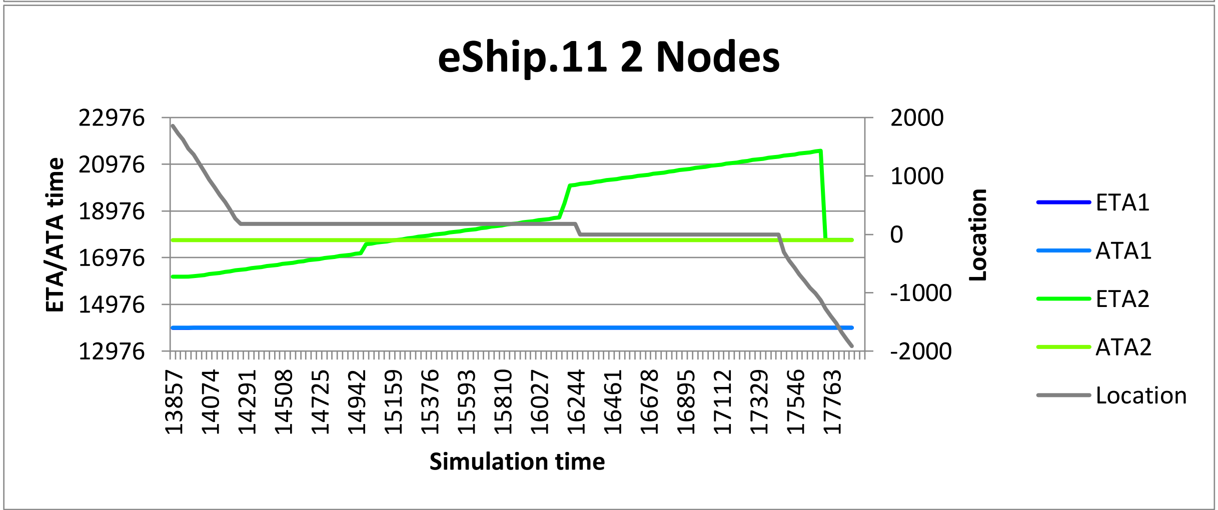

eShip.6 2 Nodes
15258
13258
11258
9258
7258
ETA/ATA time
2000
1000
0
-1000
-2000
Location
8122
8308
8494
8680
8866
9052
9238
9424
9610
9796
9982
10168
10354
10540
10726
10912
11098
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

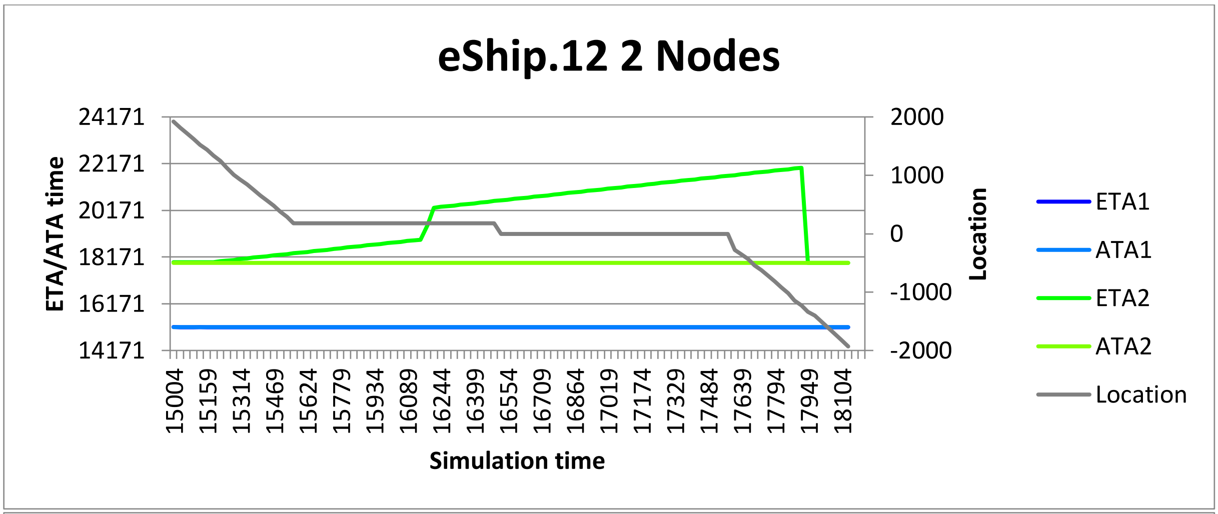

eShip.7 2 Nodes
18430
16430
14430
12430
10430
8430
ETA/ATA time
2000
1000
0
-1000
-2000
Location
9269
9517
9765
10013
10261
10509
10757
11005
11253
11501
11749
11997
12245
12493
12741
12989
13237
13485
13733
13981
14229
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

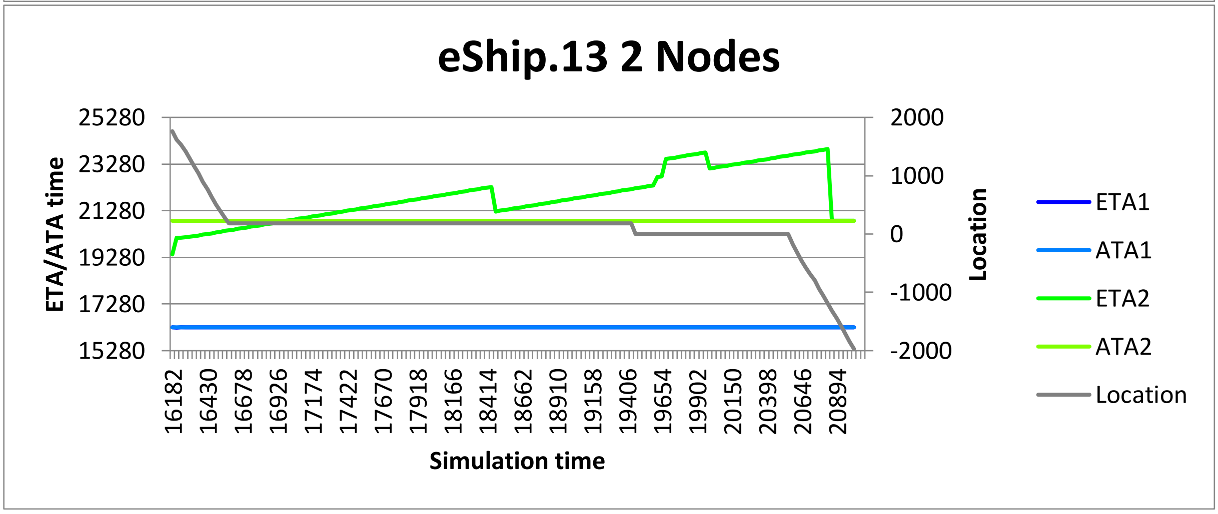

eShip.8 2 Nodes
17556
15556
13556
11556
9556
ETA/ATA time
2000
1000
0
-1000
-2000
Location
10416
10633
10850
11067
11284
11501
11718
11935
12152
12369
12586
12803
13020
13237
13454
13671
13888
14105
14322
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

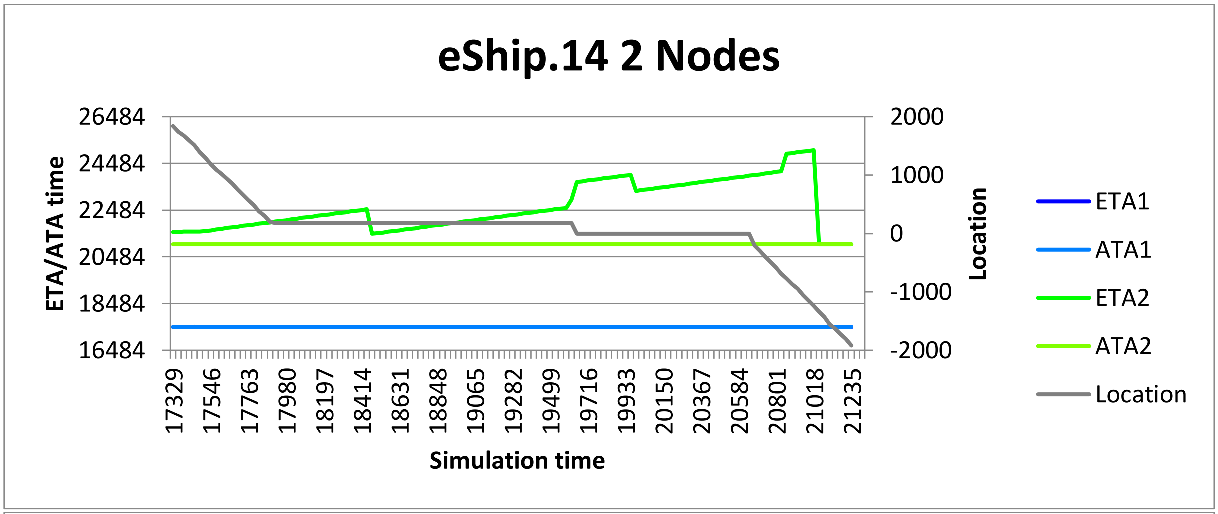

eShip.9 2 Nodes
ETA/ATA time
17666
16666
15666
14666
13666
12666
11666
10666
2000
1000
0
-1000
-2000
Location
11563
11718
11873
12028
12183
12338
12493
12648
12803
12958
13113
13268
13423
13578
13733
13888
14043
14198
14353
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

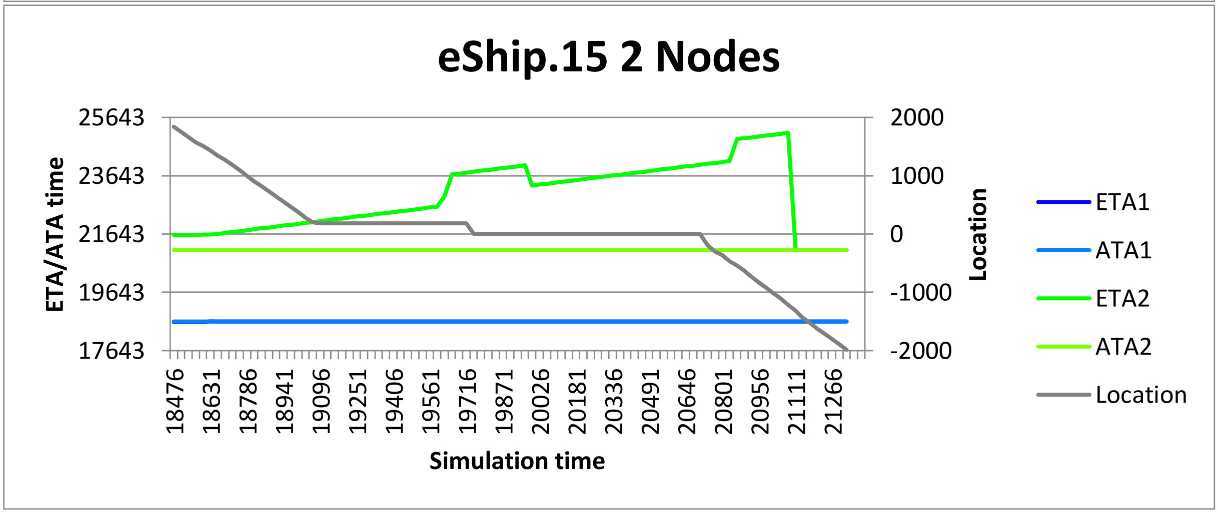

eShip.10 2 Nodes
ETA/ATA time
23861
21861
19861
17861
15861
13861
11861
2000
1000
0
-1000
-2000
Location
12710
12989
13268
13547
13826
14105
14384
14663
14942
15221
15500
15779
16058
16337
16616
16895
17174
17453
17732
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

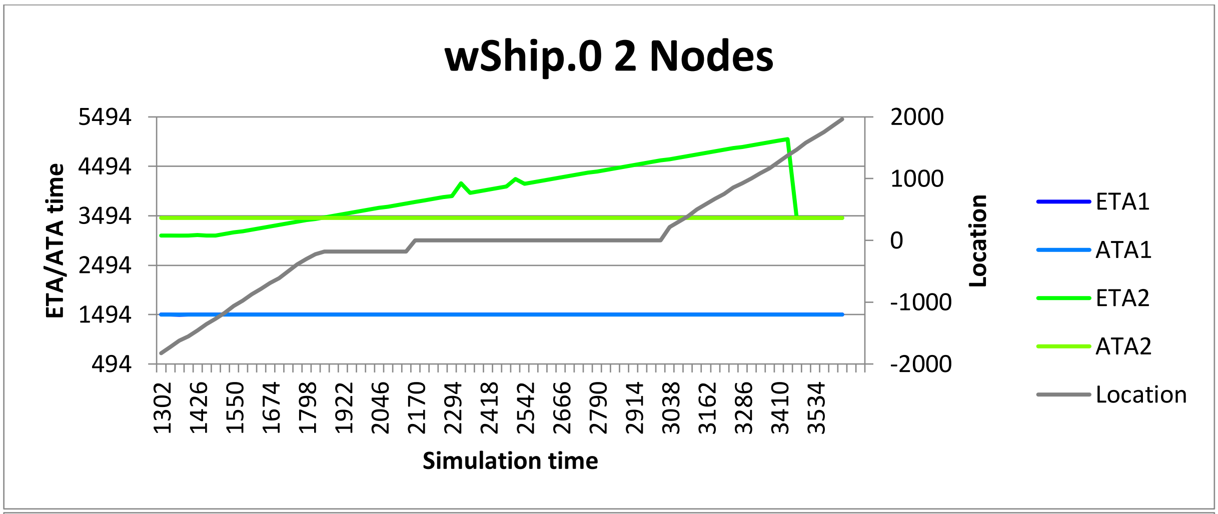

eShip.11 2 Nodes
ETA/ATA time
22976
20976
18976
16976
14976
12976
2000
1000
0
-1000
-2000
Location
13857
14074
14291
14508
14725
14942
15159
15376
15593
15810
16027
16244
16461
16678
16895
17112
17329
17546
17763
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

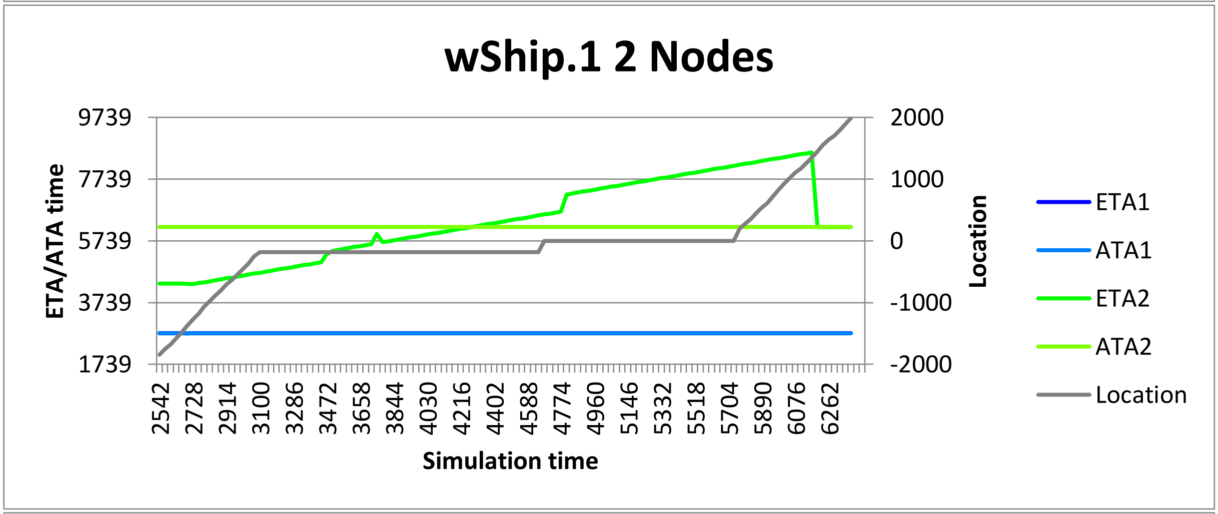

eShip.12 2 Nodes
ETA/ATA time
24171
22171
20171
18171
16171
14171
2000
1000
0
-1000
-2000
Location
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
16554
16709
16864
17019
17174
17329
17484
17639
17794
17949
18104
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

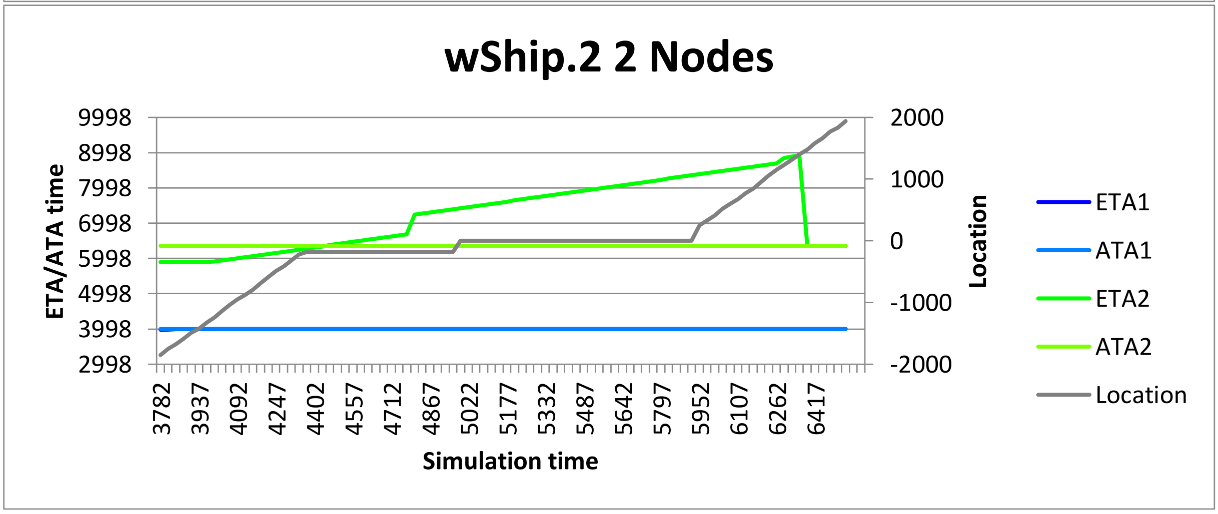

eShip.13 2 Nodes
ETA/ATA time
25280
23280
21280
19280
17280
15280
2000
1000
0
-1000
-2000
Location
16182
16430
16678
16926
17174
17422
17670
17918
18166
18414
18662
18910
19158
19406
19654
19902
20150
20398
20646
20894
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

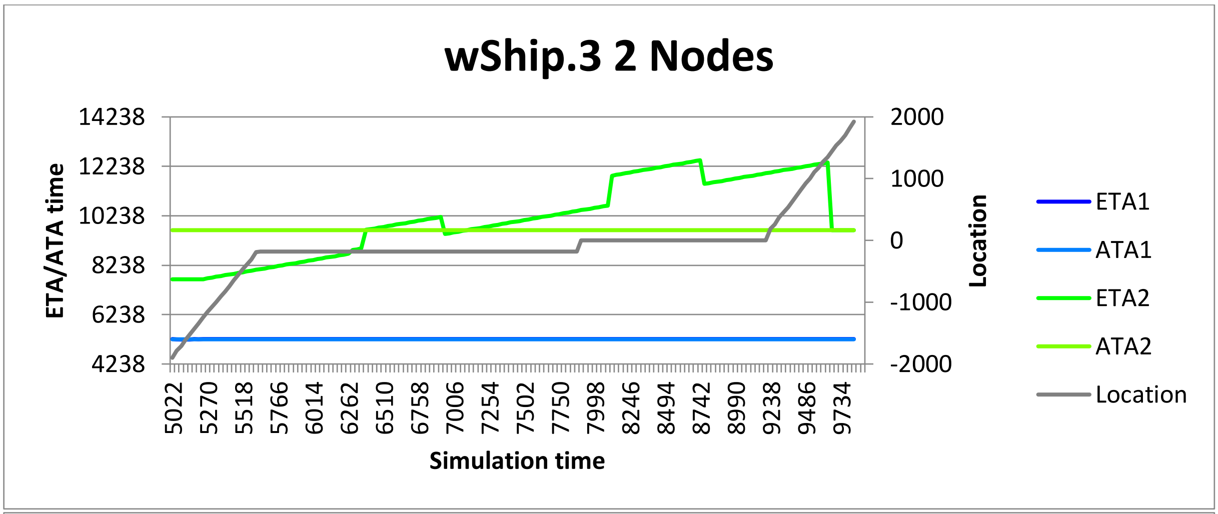

eShip.14 2 Nodes
ETA/ATA time
26484
24484
22484
20484
18484
16484
2000
1000
0
-1000
-2000
Location
17329
17546
17763
17980
18197
18414
18631
18848
19065
19282
19499
19716
19933
20150
20367
20584
20801
21018
21235
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

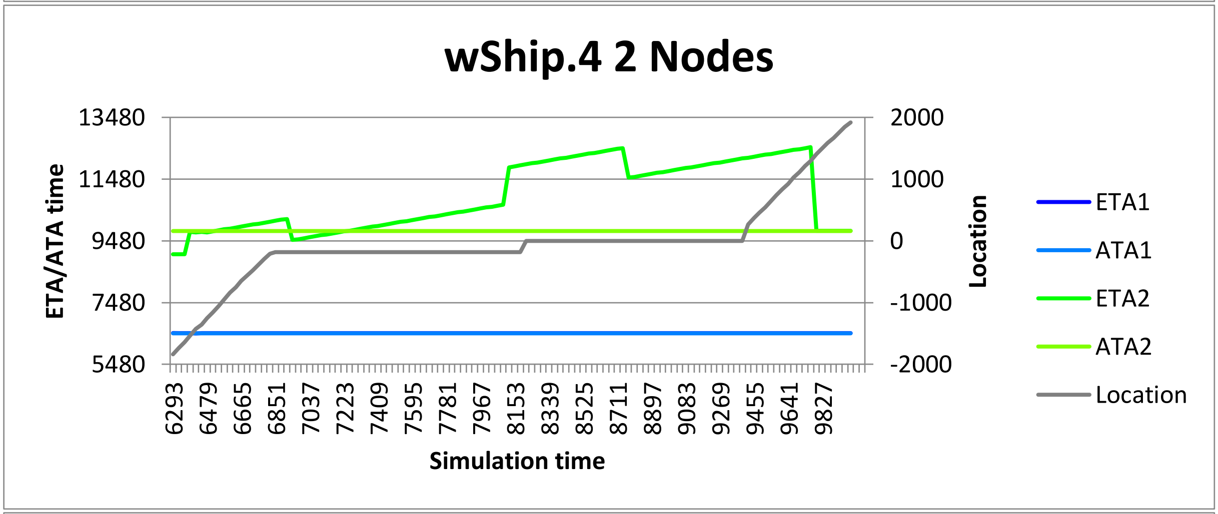

eShip.15 2 Nodes
ETA/ATA time
25643
23643
21643
19643
17643
2000
1000
0
-1000
-2000
Location
18476
18631
18786
18941
19096
19251
19406
19561
19716
19871
20026
20181
20336
20491
20646
20801
20956
21111
21266
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

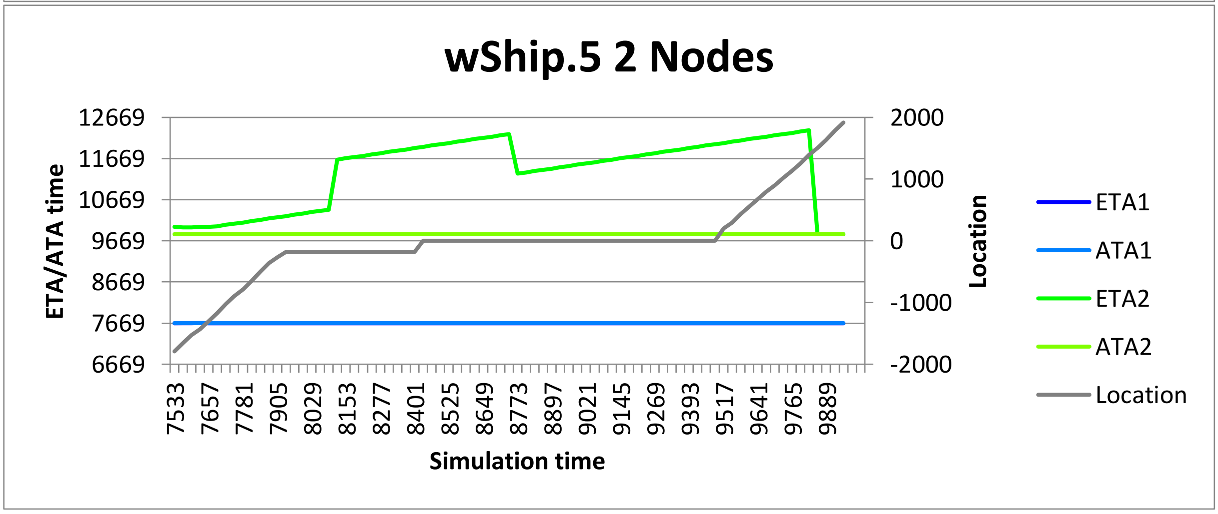

wShip.0 2 Nodes
ETA/ATA time
5494
4494
3494
2494
1494
494
2000
1000
0
-1000
-2000
Location
1302
1426
1550
1674
1798
1922
2046
2170
2294
2418
2542
2666
2790
2914
3038
3162
3286
3410
3534
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

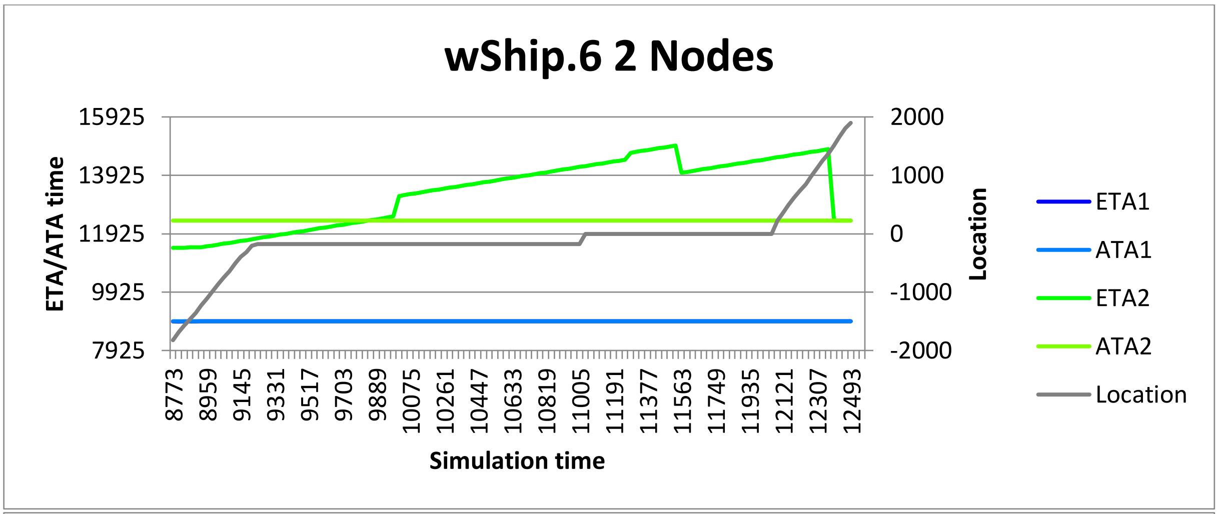

wShip.1 2 Nodes
ETA/ATA time
9739
7739
5739
3739
1739
2000
1000
0
-1000
-2000
Location
2542
2728
2914
3100
3286
3472
3658
3844
4030
4216
4402
4588
4774
4960
5146
5332
5518
5704
5890
6076
6262
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

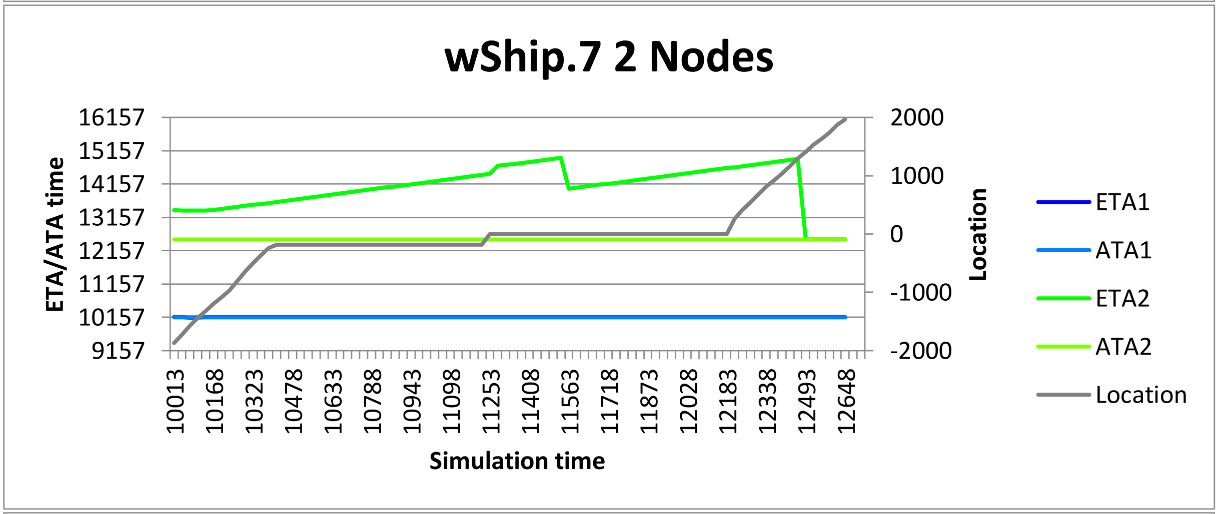

wShip.2 2 Nodes
ETA/ATA time
9998
8998
7998
6998
5998
4998
3998
2998
2000
1000
0
-1000
-2000
Location
3782
3937
4092
4247
4402
4557
4712
4867
5022
5177
5332
5487
5642
5797
5952
6107
6262
6417
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

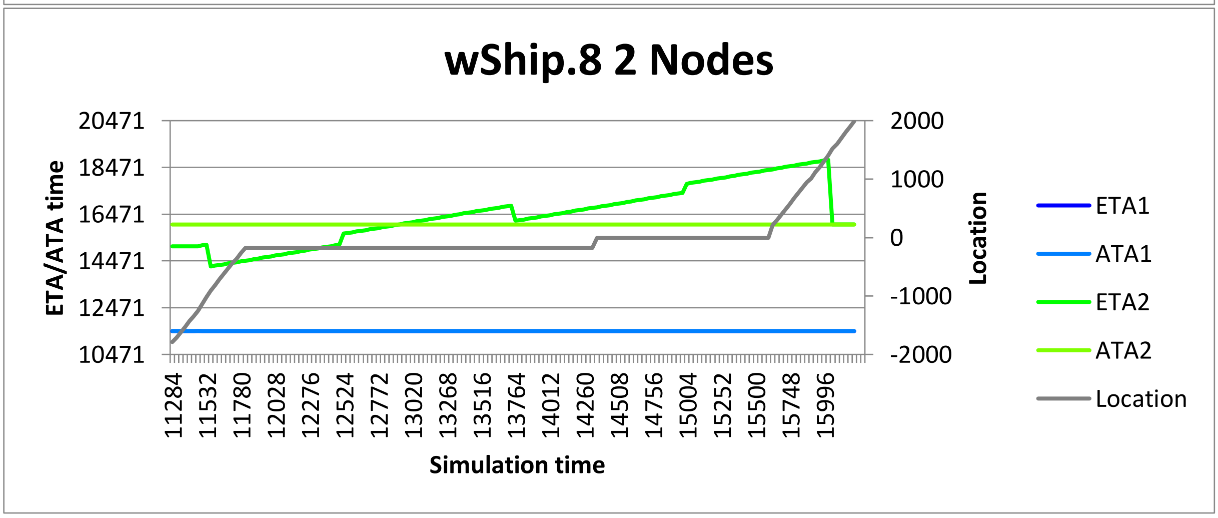

wShip.3 2 Nodes
14238
12238
10238
8238
6238
4238
2000
1000
0
-1000
-2000
ETA/ATA time
Location
5022
5270
5518
5766
6014
6262
6510
6758
7006
7254
7502
7750
7998
8246
8494
8742
8990
9238
9486
9734
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

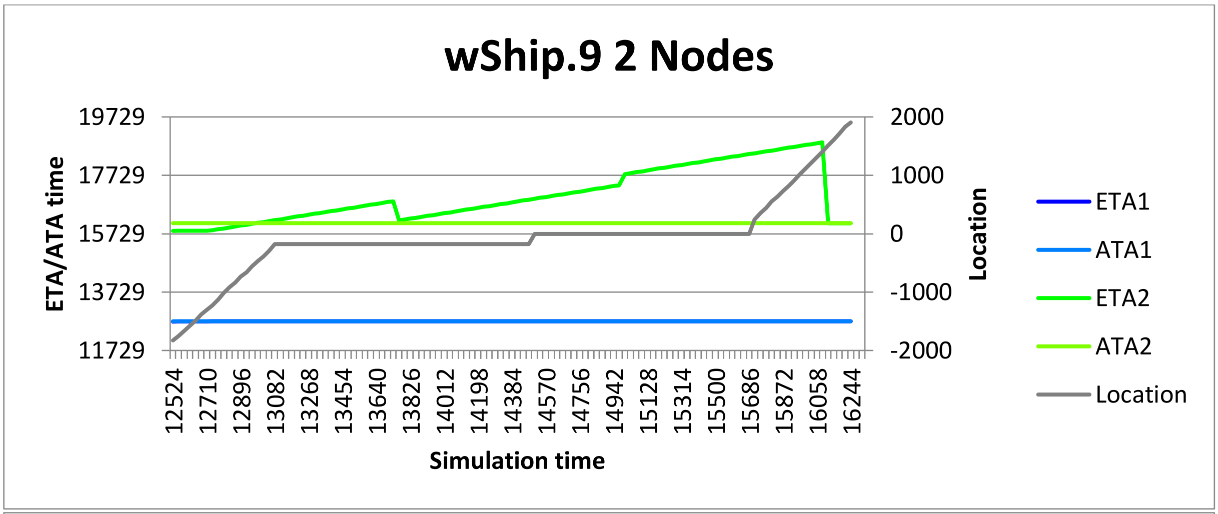

wShip.4 2 Nodes
13480
11480
9480
7480
5480
2000
1000
0
-1000
-2000
ETA/ATA time
Location
6293
6479
6665
6851
7037
7223
7409
7595
7781
7967
8153
8339
8525
8711
8897
9083
9269
9455
9641
9827
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

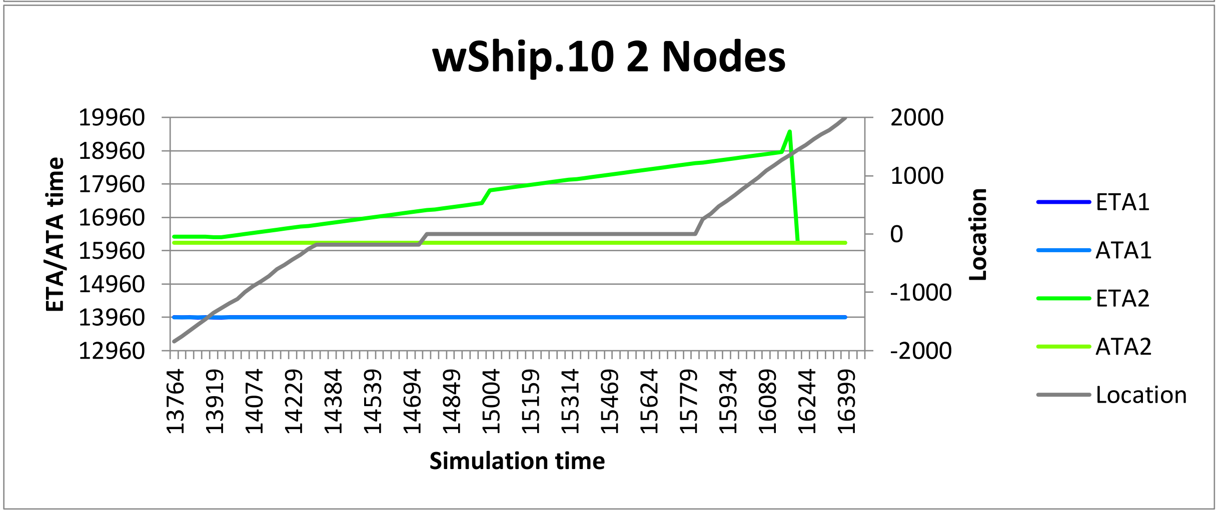

wShip.5 2 Nodes
12669
11669
10669
9669
8669
7669
6669
2000
1000
0
-1000
-2000
ETA/ATA time
Location
7533
7657
7781
7905
8029
8153
8277
8401
8525
8649
8773
8897
9021
9145
9269
9393
9517
9641
9765
9889
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

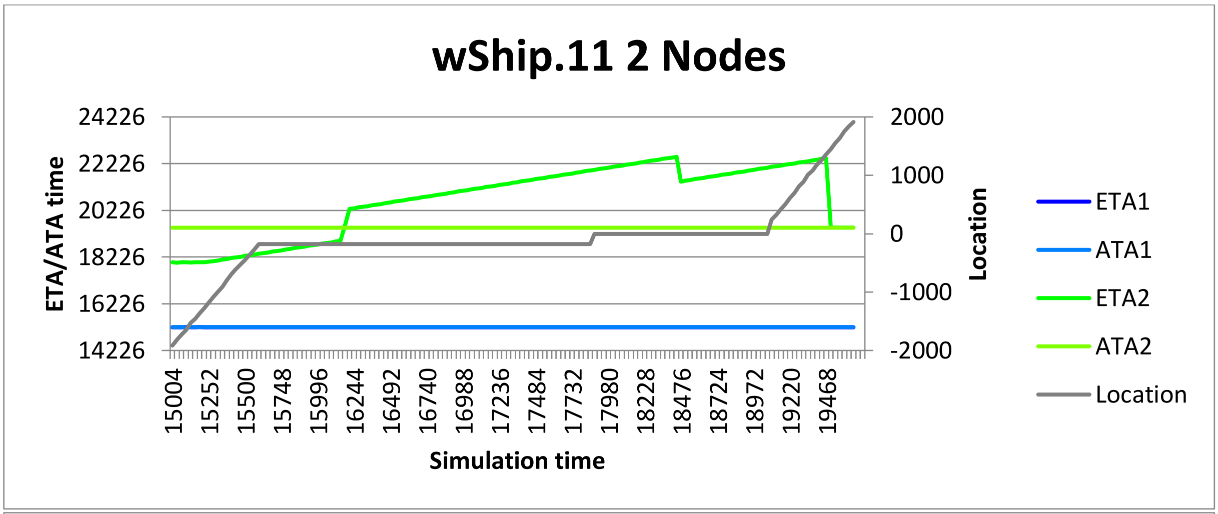

wShip.6 2 Nodes
ETA/ATA time
15925
13925
11925
9925
7925
2000
1000
0
-1000
-2000
Location
8773
8959
9145
9331
9517
9703
9889
10075
10261
10447
10633
10819
11005
11191
11377
11563
11749
11935
12121
12307
12493
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

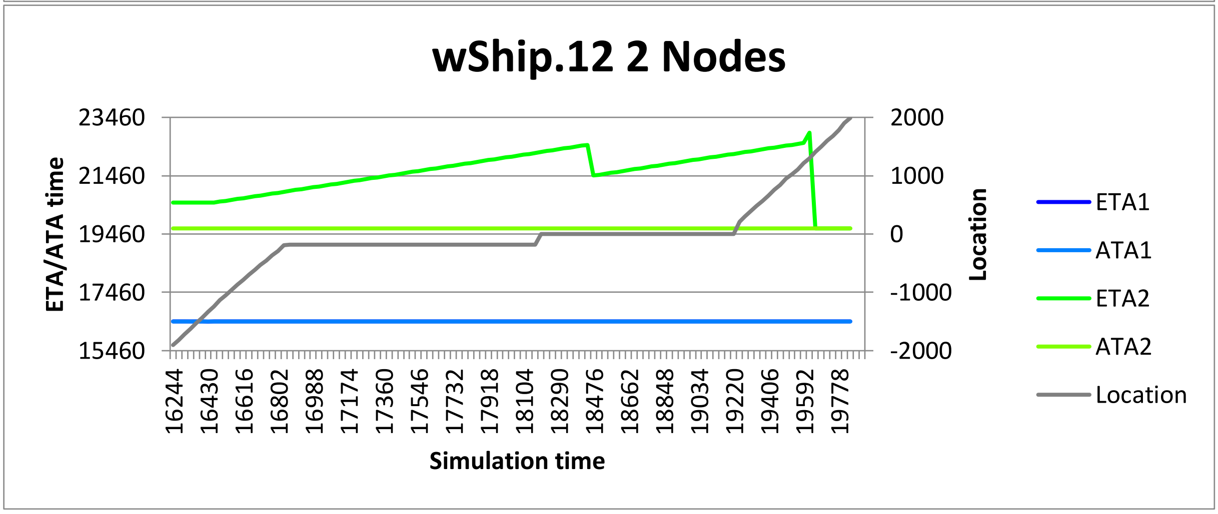

wShip.7 2 Nodes
ETA/ATA time
16157
15157
14157
13157
12157
11157
10157
9157
2000
1000
0
-1000
-2000
Location
10013
10168
10323
10478
10633
10788
10943
11098
11253
11408
11563
11718
11873
12028
12183
12338
12493
12648
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.8 2 Nodes
ETA/ATA time
20471
18471
16471
14471
12471
10471
2000
1000
0
-1000
-2000
Location
11284
11532
11780
12028
12276
12524
12772
13020
13268
13516
13764
14012
14260
14508
14756
15004
15252
15500
15748
15996
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.9 2 Nodes
ETA/ATA time
19729
17729
15729
13729
11729
2000
1000
0
-1000
-2000
Location
12524
12710
12896
13082
13268
13454
13640
13826
14012
14198
14384
14570
14756
14942
15128
15314
15500
15686
15872
16058
16244
Simulation time
ETA1
ATA1
ETA2
ATA2
Location


wShip.10 2 Nodes
ETA/ATA time
19960
18960
17960
16960
15960
14960
13960
12960
2000
1000
0
-1000
-2000
Location
13764
13919
14074
14229
14384
14539
14694
14849
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

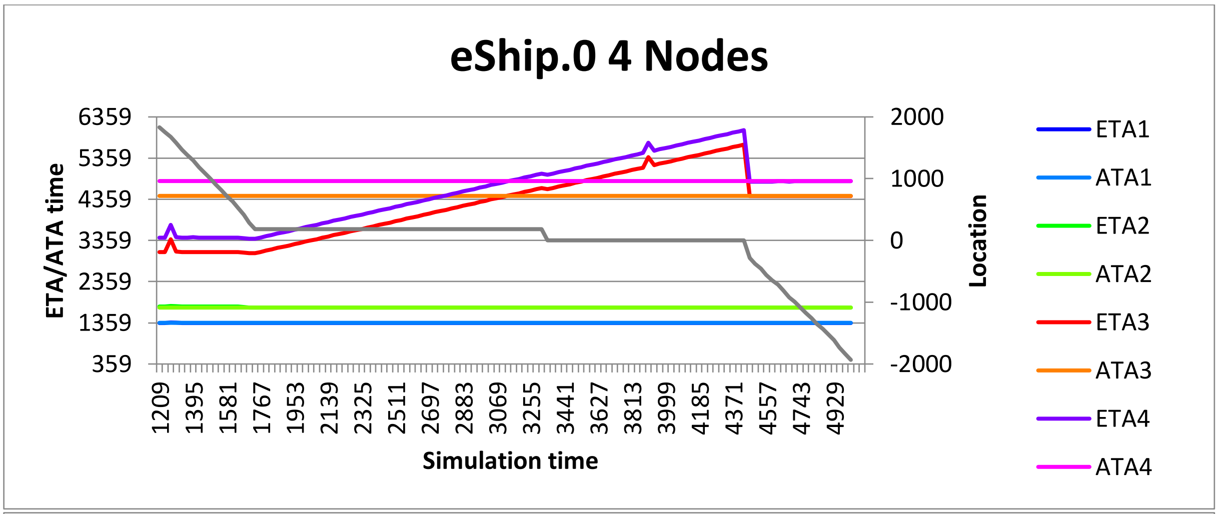

wShip.11 2 Nodes
ETA/ATA time
24226
22226
20226
18226
16226
14226
2000
1000
0
-1000
-2000
Location
15004
15252
15500
15748
15996
16244
16492
16740
16988
17236
17484
17732
17980
18228
18476
18724
18972
19220
19468
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

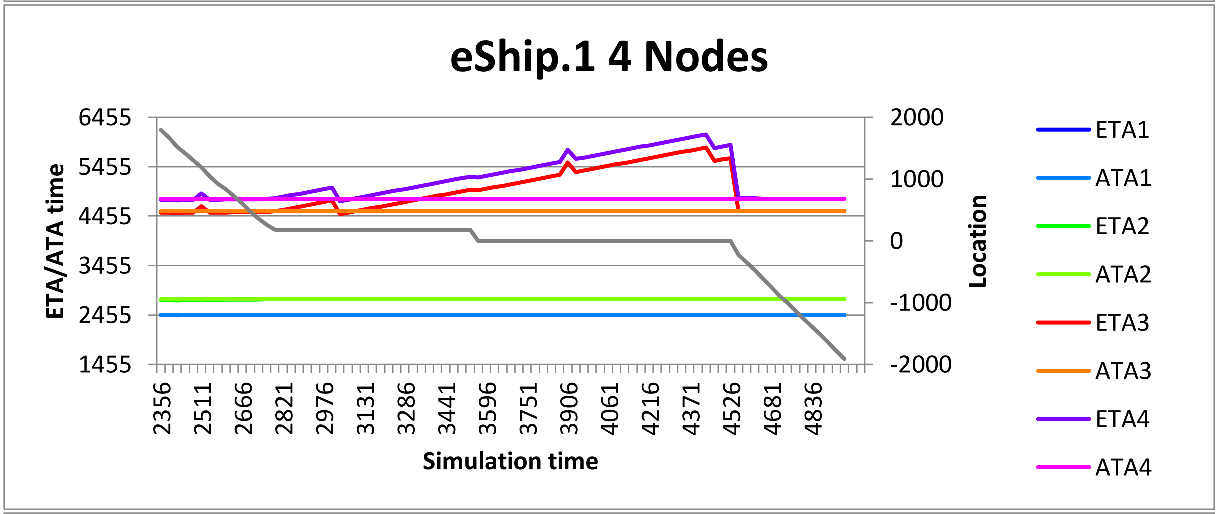

wShip.12 2 Nodes
ETA/ATA time
23460
21460
19460
17460
15460
2000
1000
0
-1000
-2000
Location
16244
16430
16616
16802
16988
17174
17360
17546
17732
17918
18104
18290
18476
18662
18848
19034
19220
19406
19592
19778
Simulation time
ETA1
ATA1
ETA2
ATA2
Location

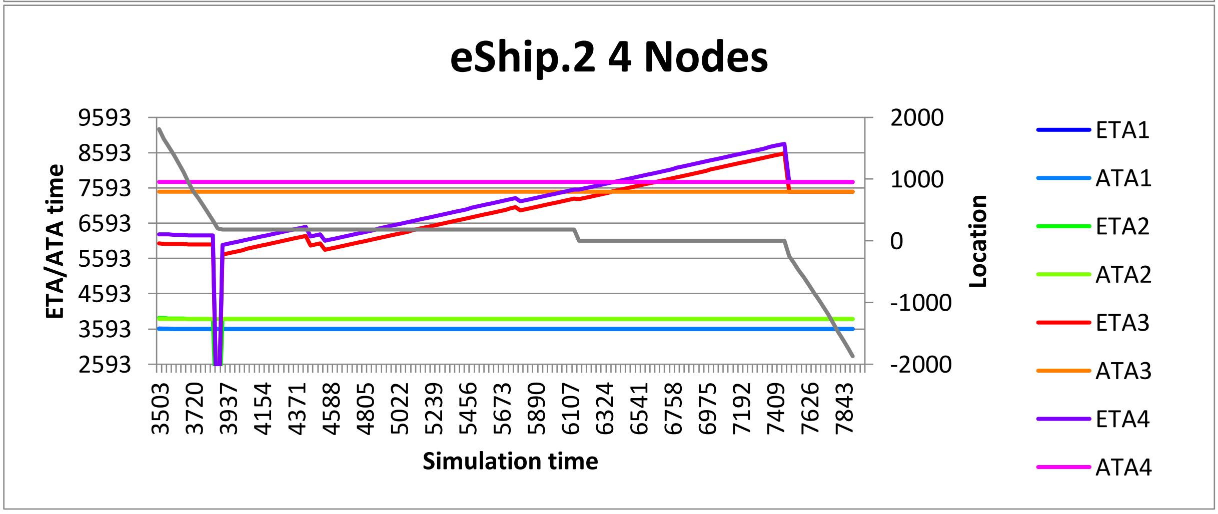
	MaxKPI1	MaxKPI2
wShip.0	5	1594,333
eShip.1	8,25	1658,5
eShip.0	6	1881,333
wShip.1	6,333333	2416,333
wShip.2	18,33333	2556,333
eShip.2	12,5	2479,5
eShip.4	10,25	2318,5
eShip.3	15,33333	2546,333
wShip.3	5,333333	2830,333
wShip.5	3,75	2525,5
wShip.4	10,33333	2719,333
eShip.5	6	3414,333
eShip.6	6,666667	3425,333
wShip.6	11,75	2571,5
wShip.7	10,75	2452,5
eShip.7	17	2675,333
eShip.9	7	2324,5
eShip.8	9,333333	2568,333
wShip.8	7,666667	2768,333
wShip.9	12,33333	2768,333
wShip.10	7	3338,333
eShip.11	8,75	3827,5
eShip.10	12	4059,333
eShip.12	6,666667	4071,333
wShip.11	8,333333	3037,333
wShip.12	3,666667	3282,333
eShip.13	13	3074,5
eShip.14	9,333333	4028,333
eShip.15	20,66667	4018,333
Average	9,632184	2870,075
Median	8,75	2719,333
Standard deviation	4,27029	688,9542

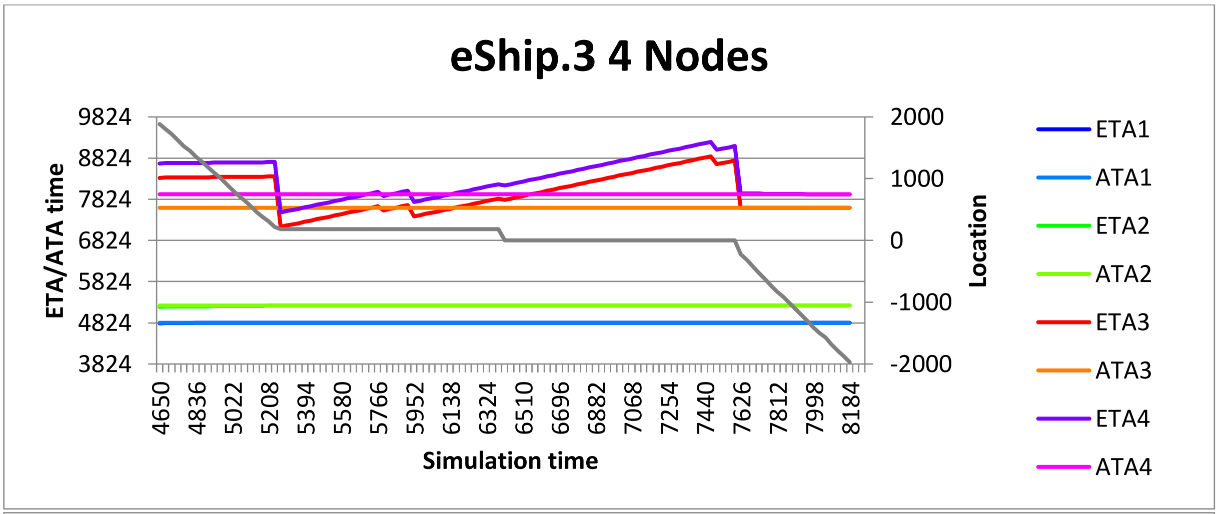
C.6 Design 1 - New network model – Graphs

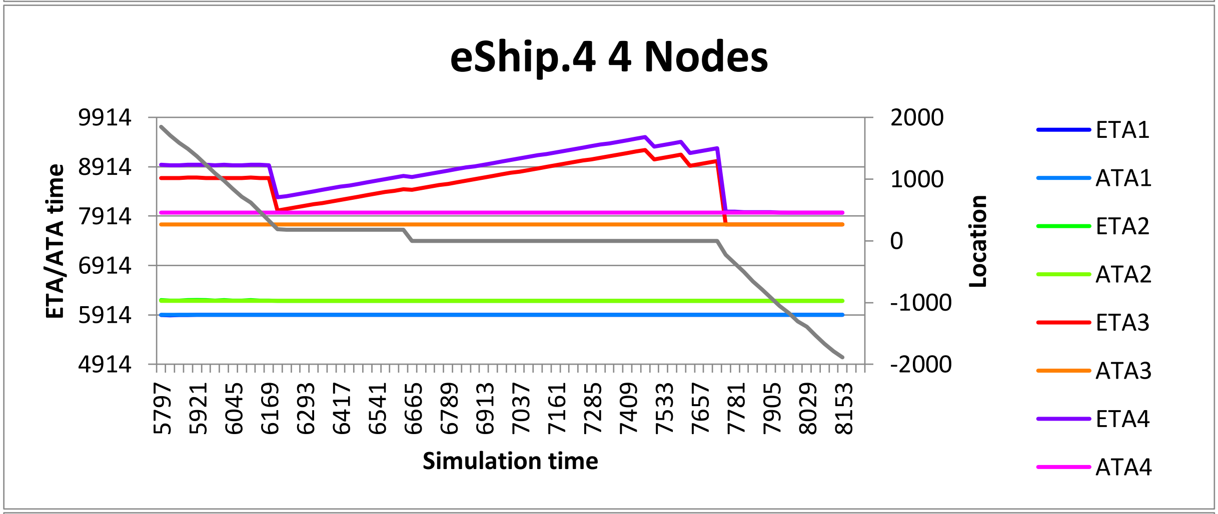
The graphs made by the simulation in the evaluation of design 1 are shown in this section.
At the end of this section, the table with the max KPIs for each ships and each node is displayed

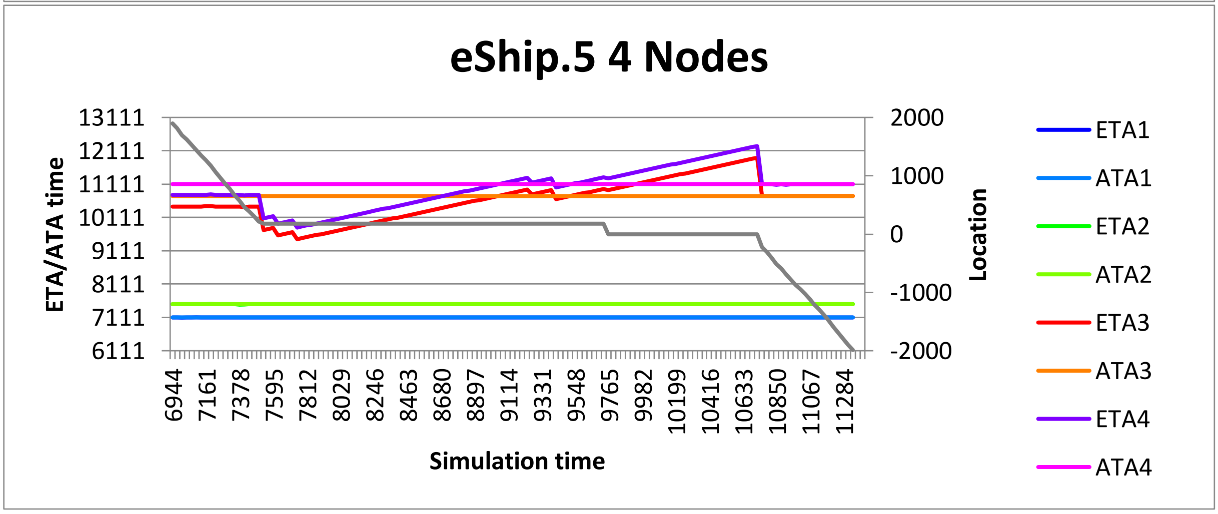

eShip.0 4 Nodes
ETA/ATA time
6359
5359
4359
3359
2359
1359
359
Location
2000
1000
0
-1000
-2000
1209 1395 1581 1767 1953 2139 2325 2511 2697 2883 3069 3255 3441 3627 3813 3999 4185 4371 4557 4743 4929
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

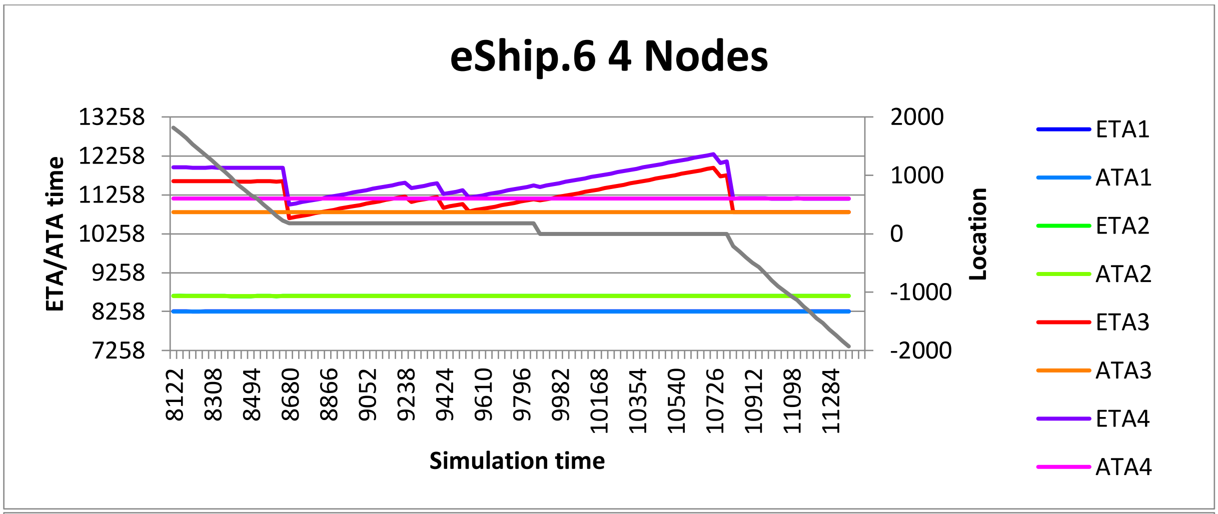

eShip.1 4 Nodes
ETA/ATA time
6455
5455
4455
3455
2455
1455
Location
2000
1000
0
-1000
-2000
2356 2511 2666 2821 2976 3131 3286 3441 3596 3751 3906 4061 4216 4371 4526 4681 4836
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

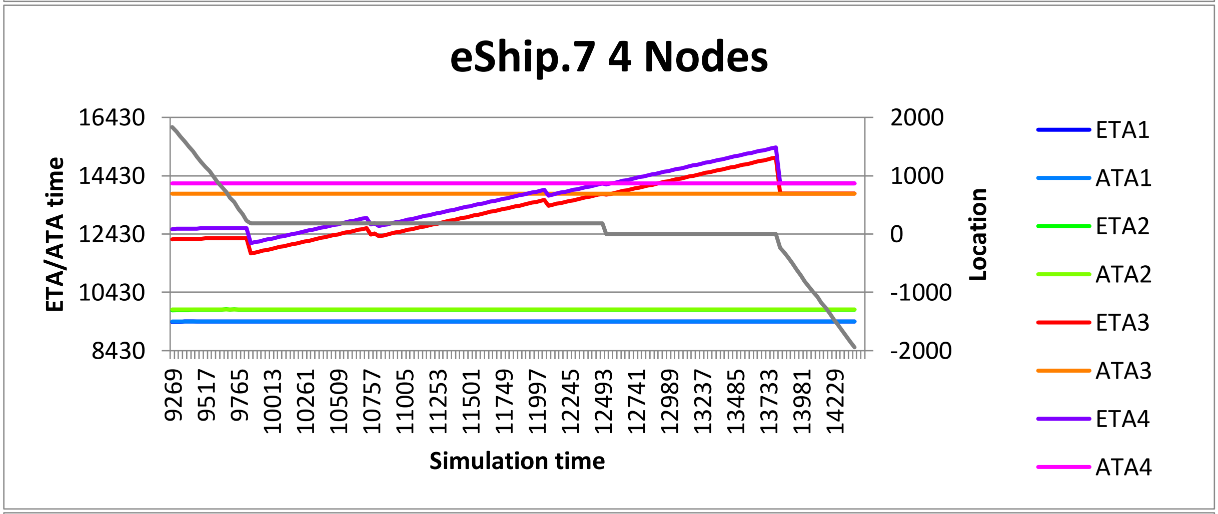

eShip.2 4 Nodes
ETA/ATA time
9593
8593
7593
6593
5593
4593
3593
2593
Location
2000
1000
0
-1000
-2000
3503 3720 3937 4154 4371 4588 4805 5022 5239 5456 5673 5890 6107 6324 6541 6758 6975 7192 7409 7626 7843
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

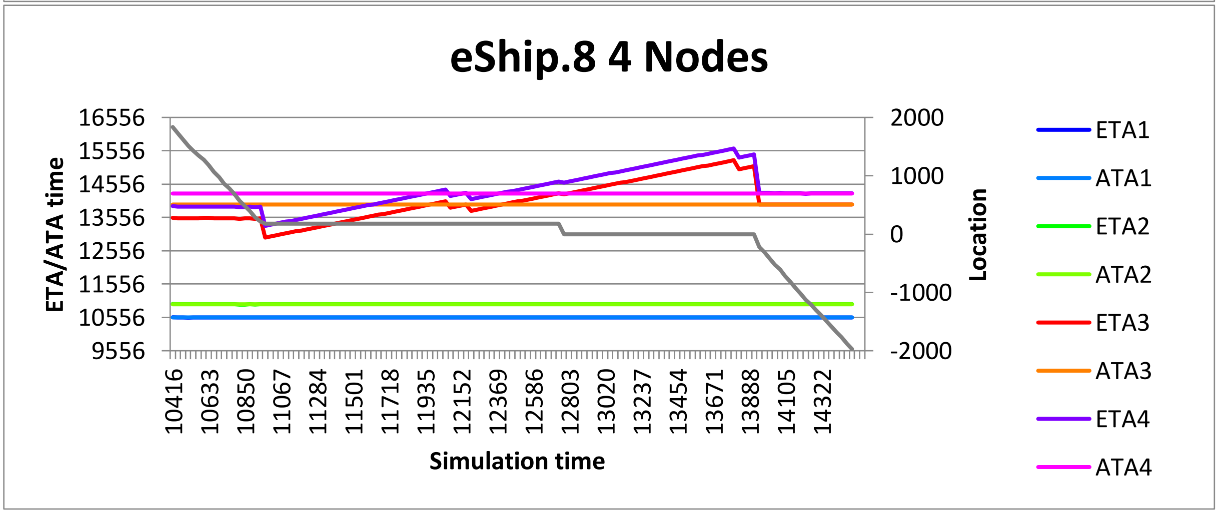

eShip.3 4 Nodes
ETA/ATA time
9824
8824
7824
6824
5824
4824
3824
2000
1000
0
-1000
-2000
Location
4650
4836
5022
5208
5394
5580
5766
5952
6138
6324
6510
6696
6882
7068
7254
7440
7626
7812
7998
8184
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

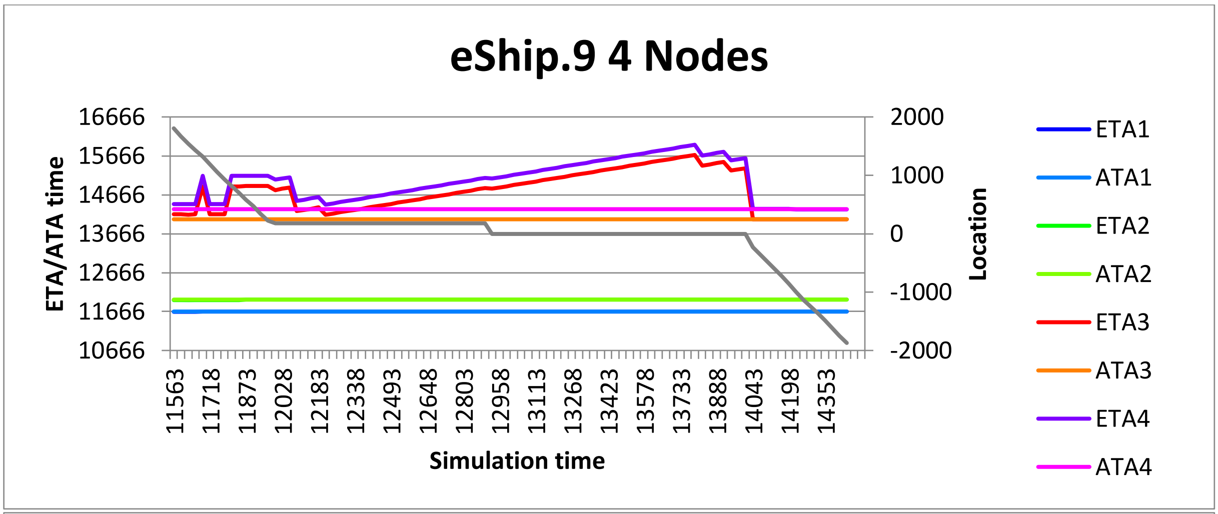

eShip.4 4 Nodes
ETA/ATA time
9914
8914
7914
6914
5914
4914
2000
1000
0
-1000
-2000
Location
5797
5921
6045
6169
6293
6417
6541
6665
6789
6913
7037
7161
7285
7409
7533
7657
7781
7905
8029
8153
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

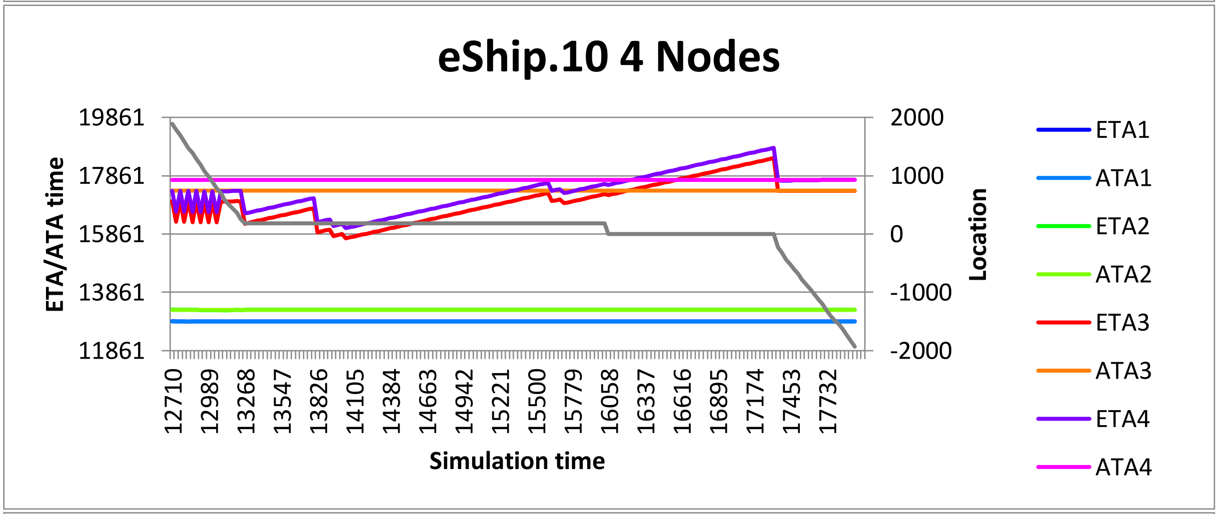

eShip.5 4 Nodes
ETA/ATA time
13111
12111
11111
10111
9111
8111
7111
6111
2000
1000
0
-1000
-2000
Location
6944
7161
7378
7595
7812
8029
8246
8463
8680
8897
9114
9331
9548
9765
9982
10199
10416
10633
10850
11067
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

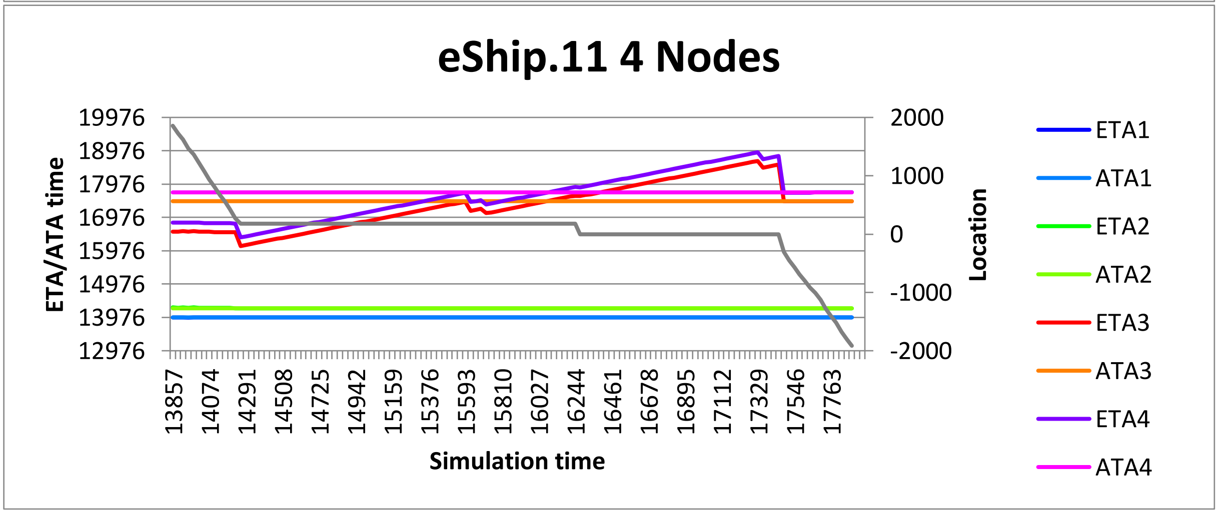

eShip.6 4 Nodes
ETA/ATA time
13258
12258
11258
10258
9258
8258
7258
2000
1000
0
-1000
-2000
Location
8122
8308
8494
8680
8866
9052
9238
9424
9610
9796
9982
10168
10354
10540
10726
10912
11098
11284
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

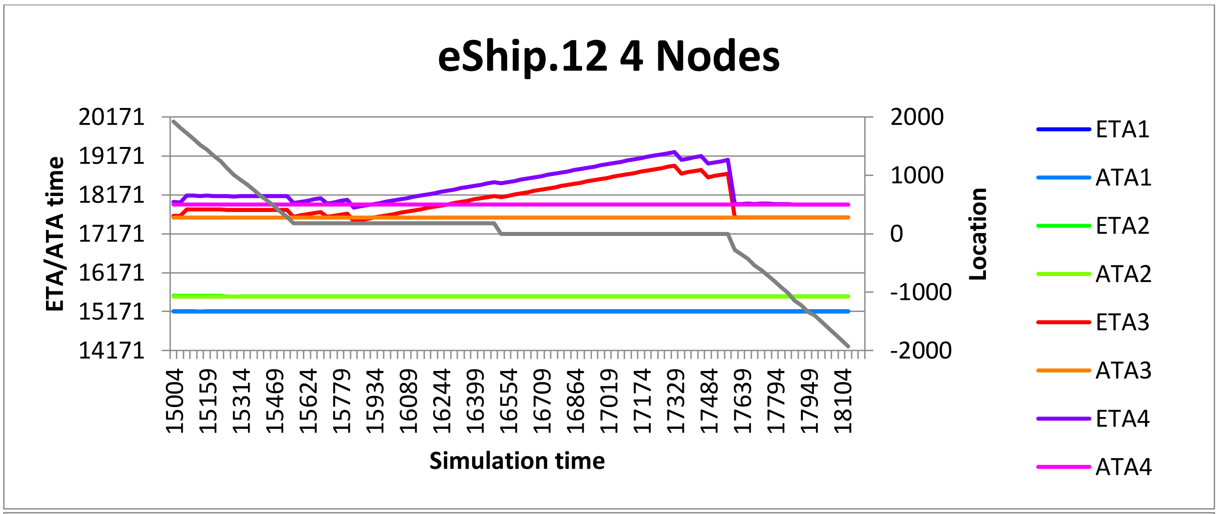

eShip.7 4 Nodes
ETA/ATA time
16430
14430
12430
10430
8430
2000
1000
0
-1000
-2000
Location
9269
9517
9765
10013
10261
10509
10757
11005
11253
11501
11749
11997
12245
12493
12741
12989
13237
13485
13733
13981
14229
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

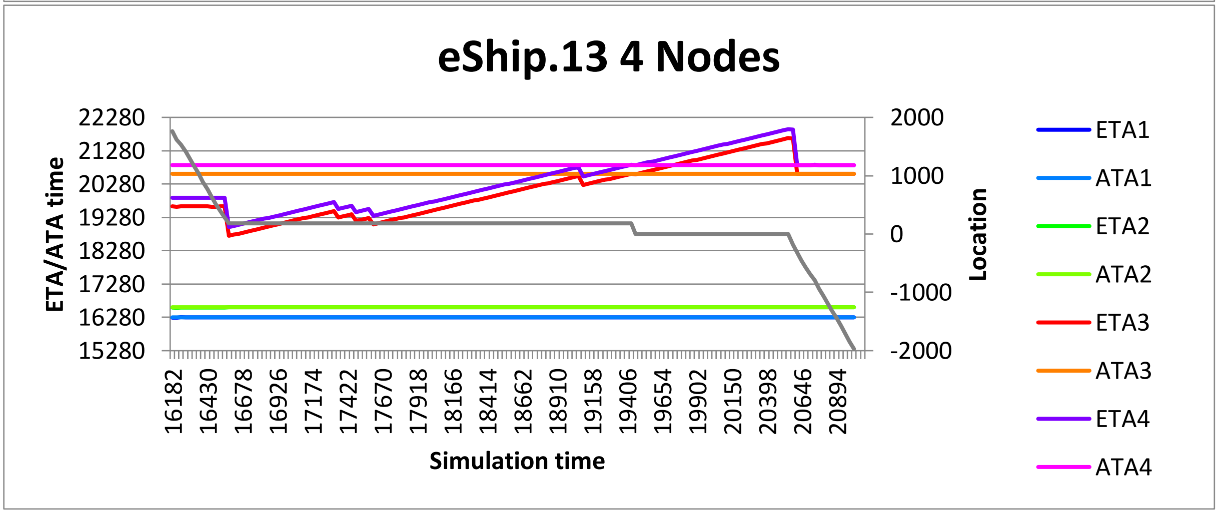

eShip.8 4 Nodes
ETA/ATA time
16556
15556
14556
13556
12556
11556
10556
9556
2000
1000
0
-1000
-2000
Location
10416
10633
10850
11067
11284
11501
11718
11935
12152
12369
12586
12803
13020
13237
13454
13671
13888
14105
14322
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

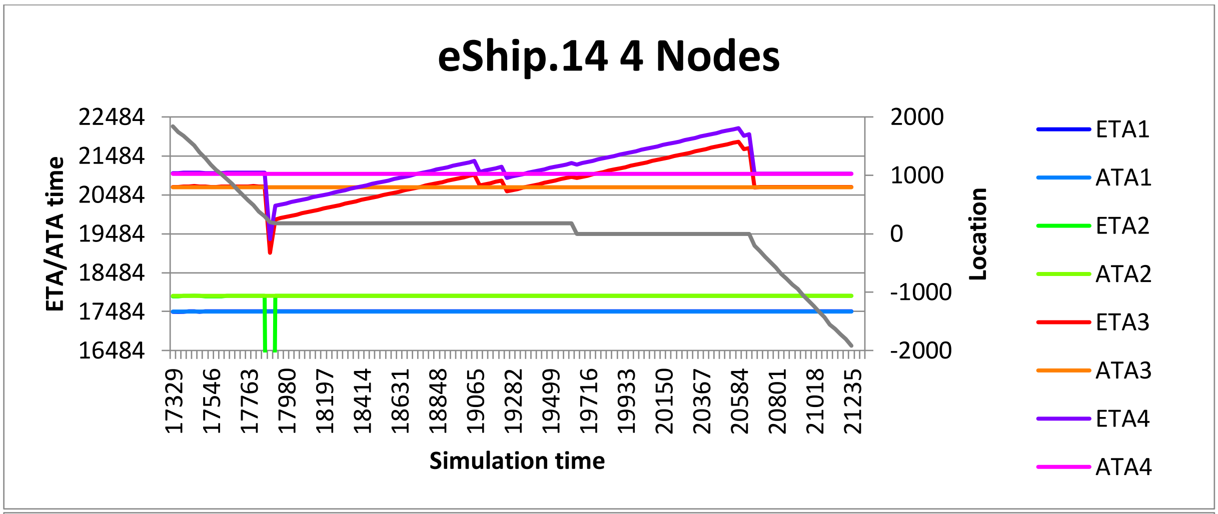

eShip.9 4 Nodes
ETA/ATA time
16666
15666
14666
13666
12666
11666
10666
2000
1000
0
-1000
-2000
Location
11563
11718
11873
12028
12183
12338
12493
12648
12803
12958
13113
13268
13423
13578
13733
13888
14043
14198
14353
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

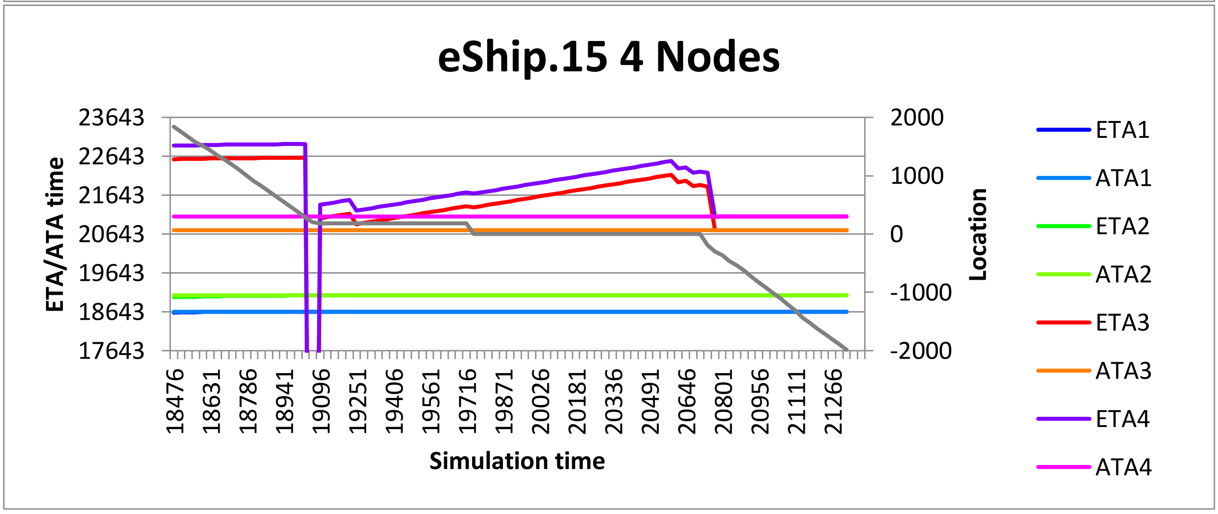

eShip.10 4 Nodes
ETA/ATA time
19861
17861
15861
13861
11861
2000
1000
0
-1000
-2000
Location
12710
12989
13268
13547
13826
14105
14384
14663
14942
15221
15500
15779
16058
16337
16616
16895
17174
17453
17732
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

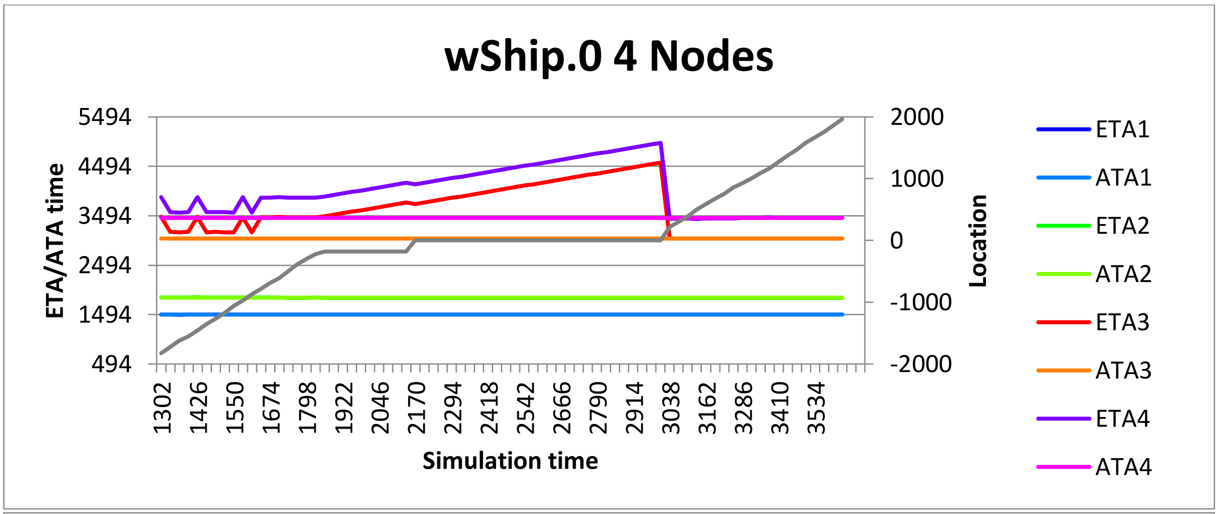

eShip.11 4 Nodes
ETA/ATA time
19976
18976
17976
16976
15976
14976
13976
12976
2000
1000
0
-1000
-2000
Location
13857
14074
14291
14508
14725
14942
15159
15376
15593
15810
16027
16244
16461
16678
16895
17112
17329
17546
17763
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

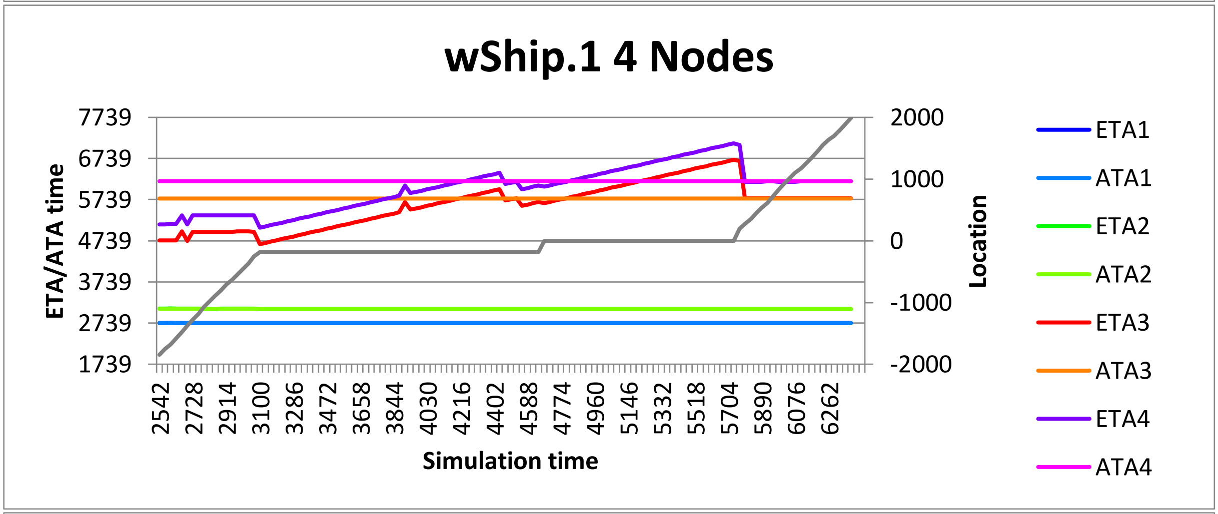

eShip.12 4 Nodes
ETA/ATA time
20171
19171
18171
17171
16171
15171
14171
2000
1000
0
-1000
-2000
Location
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
16554
16709
16864
17019
17174
17329
17484
17639
17794
17949
18104
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

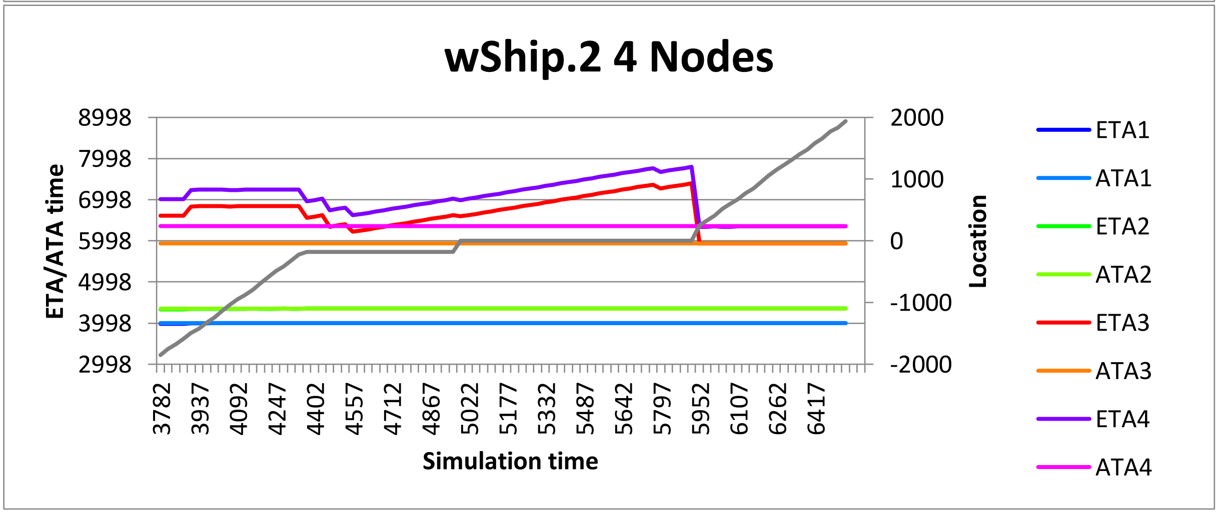

eShip.13 4 Nodes
ETA/ATA time
22280
21280
20280
19280
18280
17280
16280
15280
2000
1000
0
-1000
-2000
Location
16182
16430
16678
16926
17174
17422
17670
17918
18166
18414
18662
18910
19158
19406
19654
19902
20150
20398
20646
20894
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

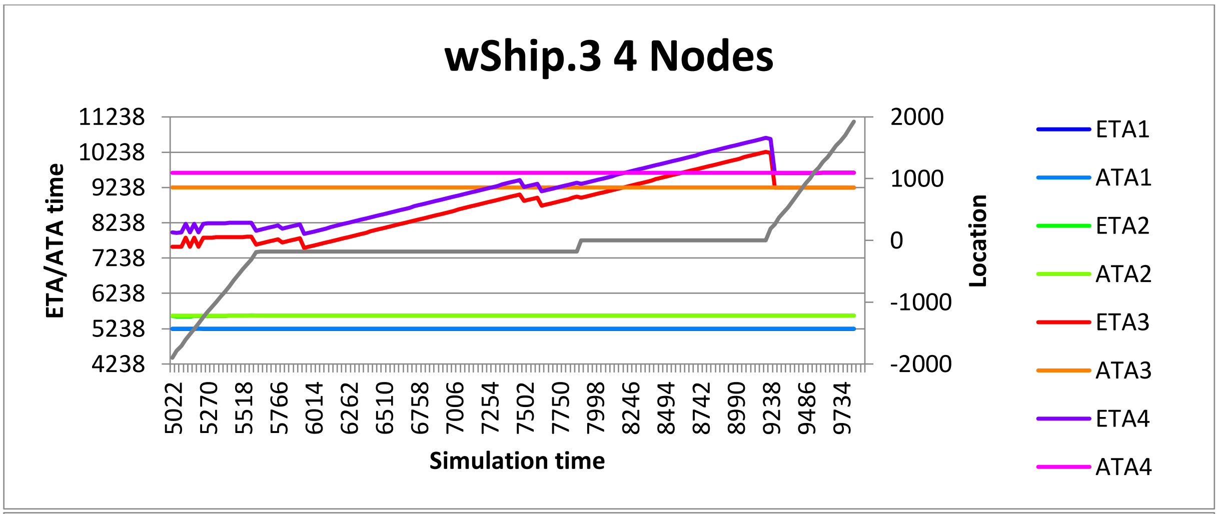

eShip.14 4 Nodes
ETA/ATA time
22484
21484
20484
19484
18484
17484
16484
2000
1000
0
-1000
-2000
Location
17329
17546
17763
17980
18197
18414
18631
18848
19065
19282
19499
19716
19933
20150
20367
20584
20801
21018
21235
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

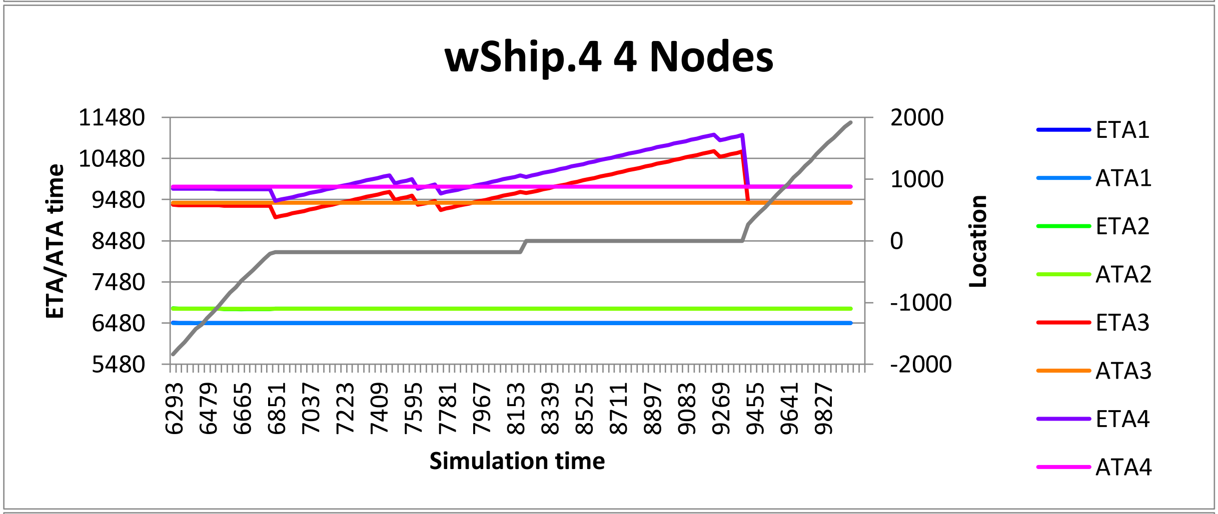

eShip.15 4 Nodes
ETA/ATA time
23643
22643
21643
20643
19643
18643
17643
2000
1000
0
-1000
-2000
Location
18476
18631
18786
18941
19096
19251
19406
19561
19716
19871
20026
20181
20336
20491
20646
20801
20956
21111
21266
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

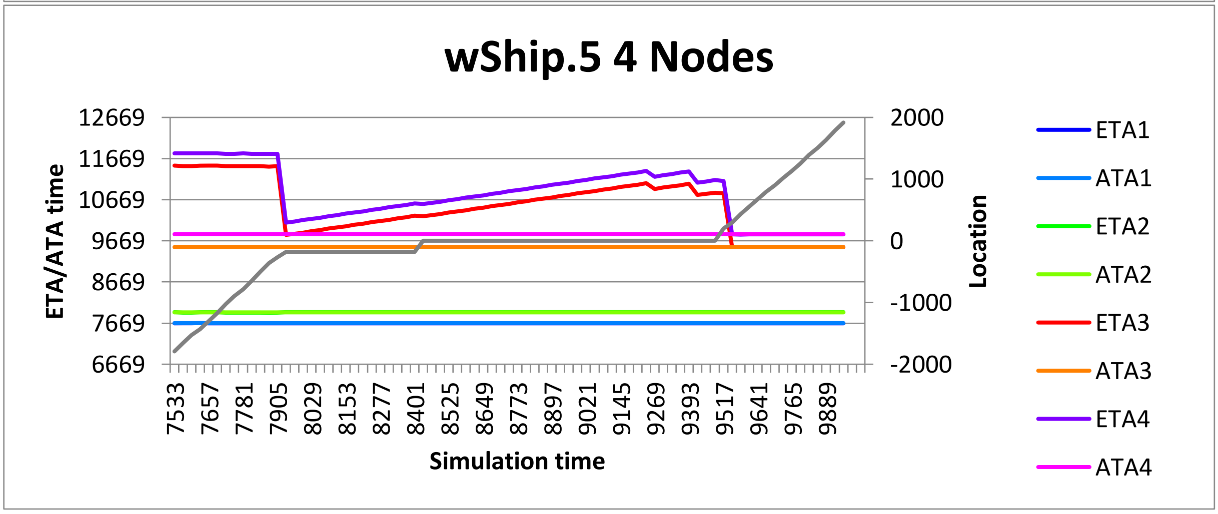

wShip.0 4 Nodes
ETA/ATA time
5494
4494
3494
2494
1494
494
2000
1000
0
-1000
-2000
Location
1302
1426
1550
1674
1798
1922
2046
2170
2294
2418
2542
2666
2790
2914
3038
3162
3286
3410
3534
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

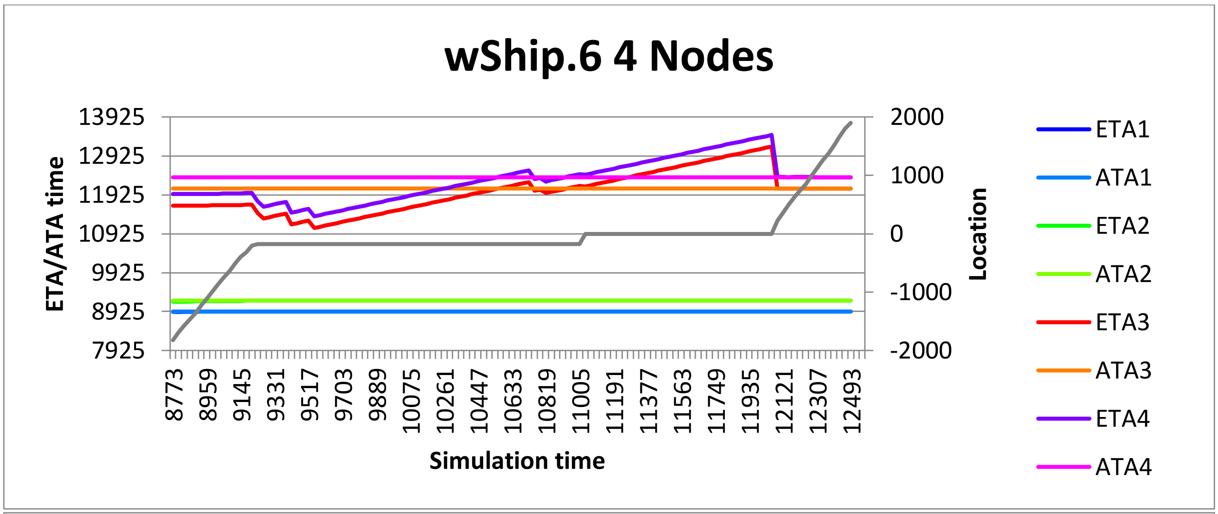

wShip.1 4 Nodes
ETA/ATA time
7739
6739
5739
4739
3739
2739
1739
2000
1000
0
-1000
-2000
Location
2542
2728
2914
3100
3286
3472
3658
3844
4030
4216
4402
4588
4774
4960
5146
5332
5518
5704
5890
6076
6262
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

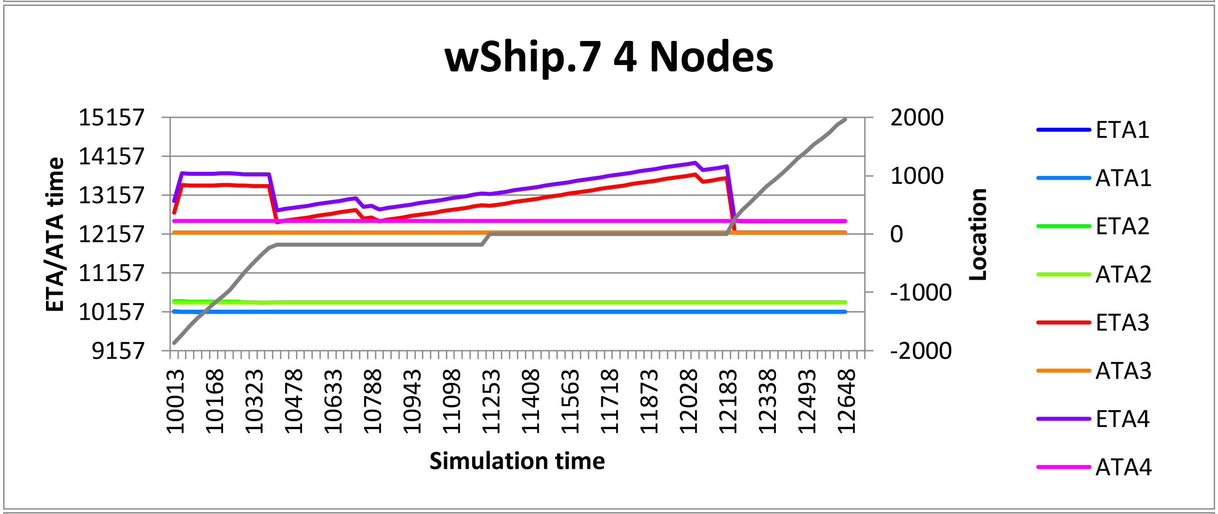

wShip.2 4 Nodes
ETA/ATA time
8998
7998
6998
5998
4998
3998
2998
2000
1000
0
-1000
-2000
Location
3782
3937
4092
4247
4402
4557
4712
4867
5022
5177
5332
5487
5642
5797
5952
6107
6262
6417
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

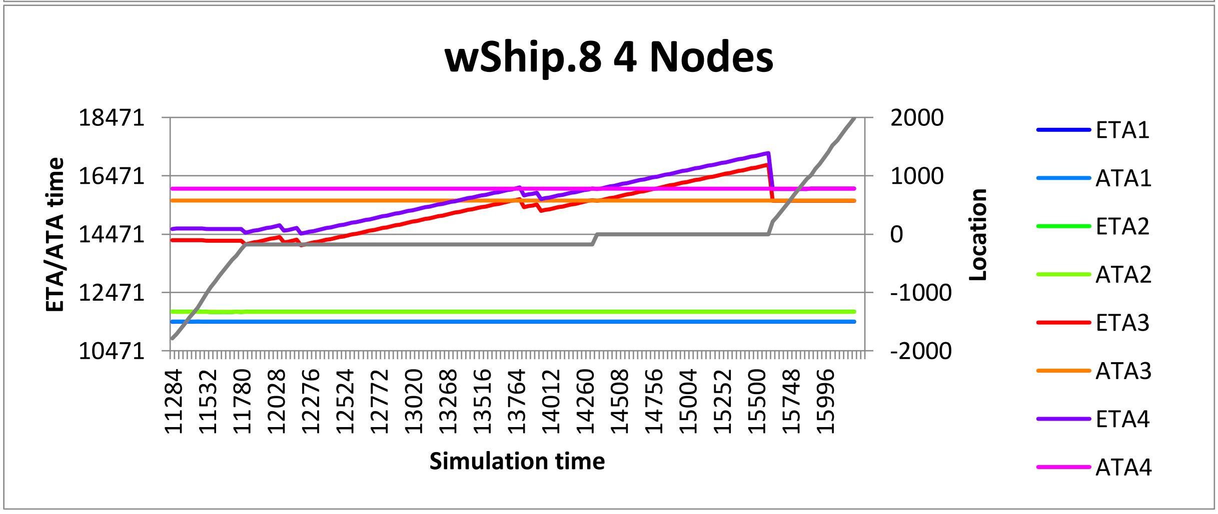

wShip.3 4 Nodes
ETA/ATA time
11238
10238
9238
8238
7238
6238
5238
4238
2000
1000
0
-1000
-2000
Location
5022
5270
5518
5766
6014
6262
6510
6758
7006
7254
7502
7750
7998
8246
8494
8742
8990
9238
9486
9734
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

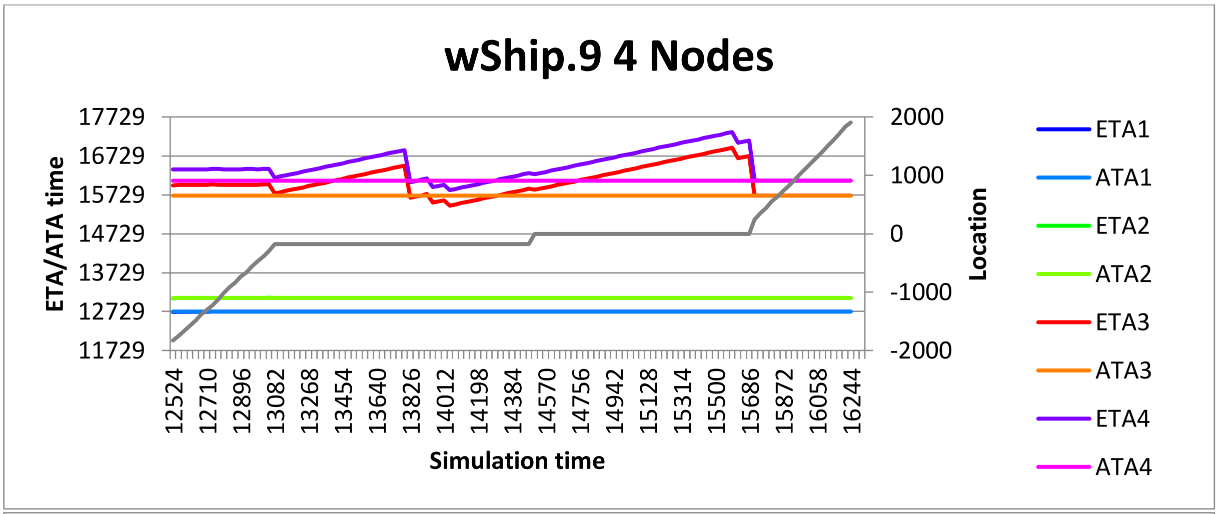

wShip.4 4 Nodes
ETA/ATA time
11480
10480
9480
8480
7480
6480
5480
2000
1000
0
-1000
-2000
Location
6293
6479
6665
6851
7037
7223
7409
7595
7781
7967
8153
8339
8525
8711
8897
9083
9269
9455
9641
9827
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

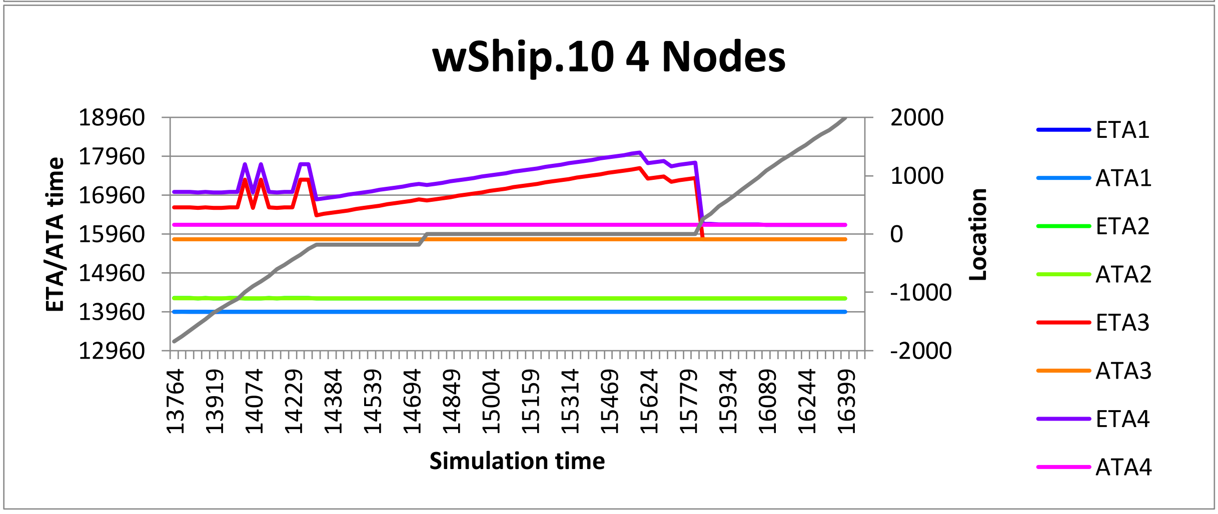

wShip.5 4 Nodes
ETA/ATA time
12669
11669
10669
9669
8669
7669
6669
2000
1000
0
-1000
-2000
Location
7533
7657
7781
7905
8029
8153
8277
8401
8525
8649
8773
8897
9021
9145
9269
9393
9517
9641
9765
9889
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

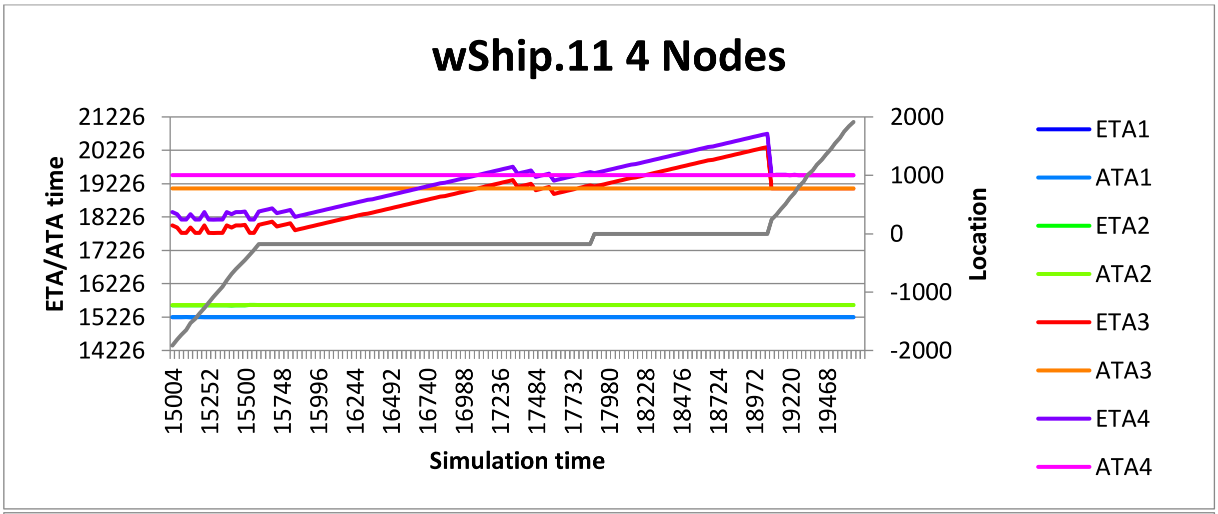

wShip.6 4 Nodes
ETA/ATA time
Location
Simulation time
13925
12925
11925
10925
9925
8925
7925
2000
1000
0
-1000
-2000
8773
8959
9145
9331
9517
9703
9889
10075
10261
10447
10633
10819
11005
11191
11377
11563
11749
11935
12121
12307
12493
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.7 4 Nodes
ETA/ATA time
Location
Simulation time
15157
14157
13157
12157
11157
10157
9157
2000
1000
0
-1000
-2000
10013
10168
10323
10478
10633
10788
10943
11098
11253
11408
11563
11718
11873
12028
12183
12338
12493
12648
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

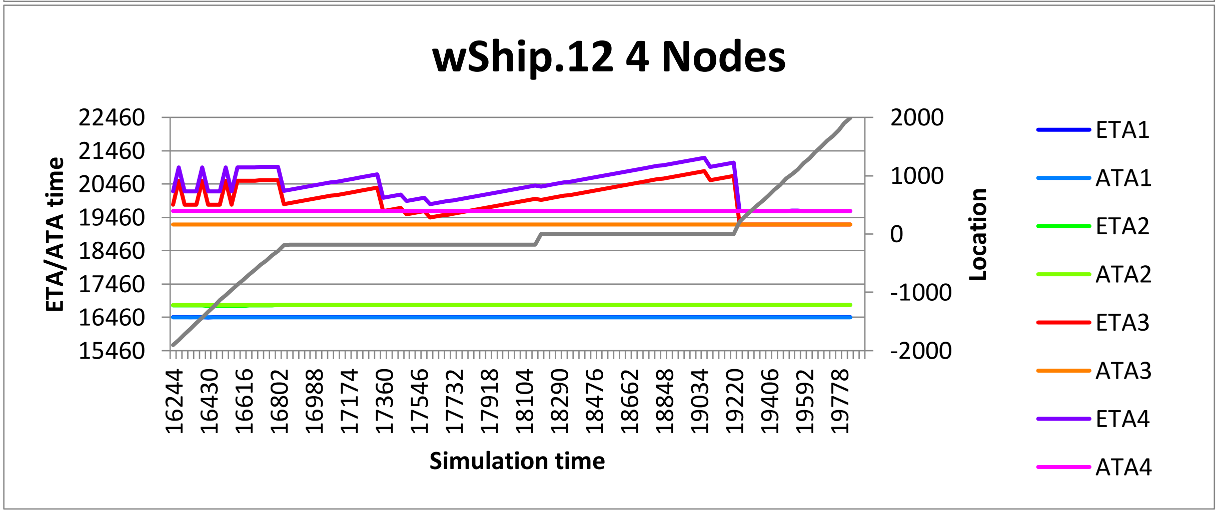

wShip.8 4 Nodes
ETA/ATA time
Location
Simulation time
18471
16471
14471
12471
10471
2000
1000
0
-1000
-2000
11284
11532
11780
12028
12276
12524
12772
13020
13268
13516
13764
14012
14260
14508
14756
15004
15252
15500
15748
15996
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.9 4 Nodes
ETA/ATA time
17729
16729
15729
14729
13729
12729
11729
2000
1000
0
-1000
-2000
Location
12524
12710
12896
13082
13268
13454
13640
13826
14012
14198
14384
14570
14756
14942
15128
15314
15500
15686
15872
16058
16244
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.10 4 Nodes
ETA/ATA time
18960
17960
16960
15960
14960
13960
12960
2000
1000
0
-1000
-2000
Location
13764
13919
14074
14229
14384
14539
14694
14849
15004
15159
15314
15469
15624
15779
15934
16089
16244
16399
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4



wShip.11 4 Nodes
ETA/ATA time
21226
20226
19226
18226
17226
16226
15226
14226
2000
1000
0
-1000
-2000
Location
15004
15252
15500
15748
15996
16244
16492
16740
16988
17236
17484
17732
17980
18228
18476
18724
18972
19220
19468
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

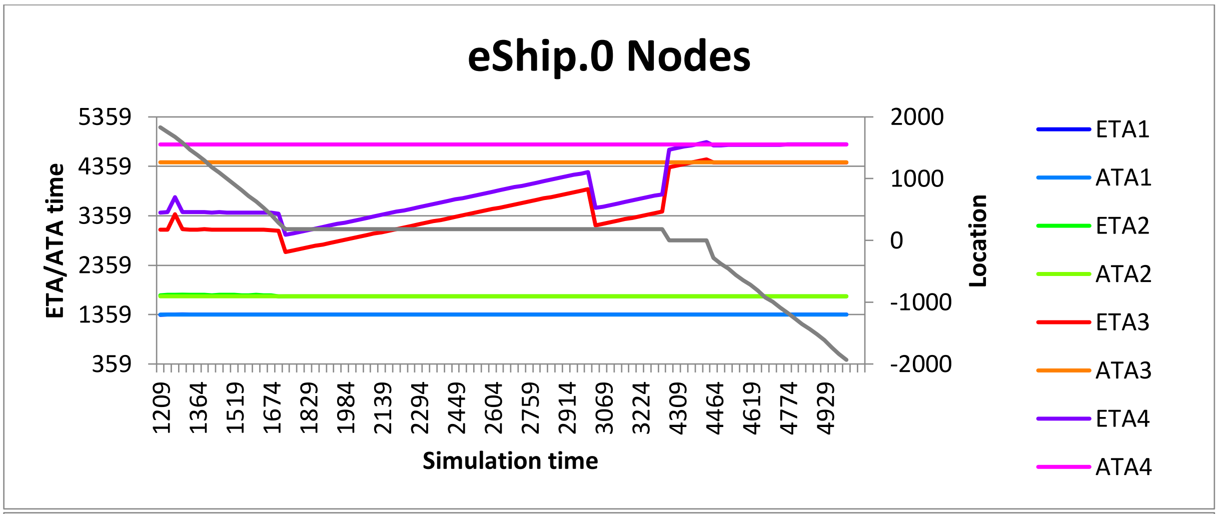


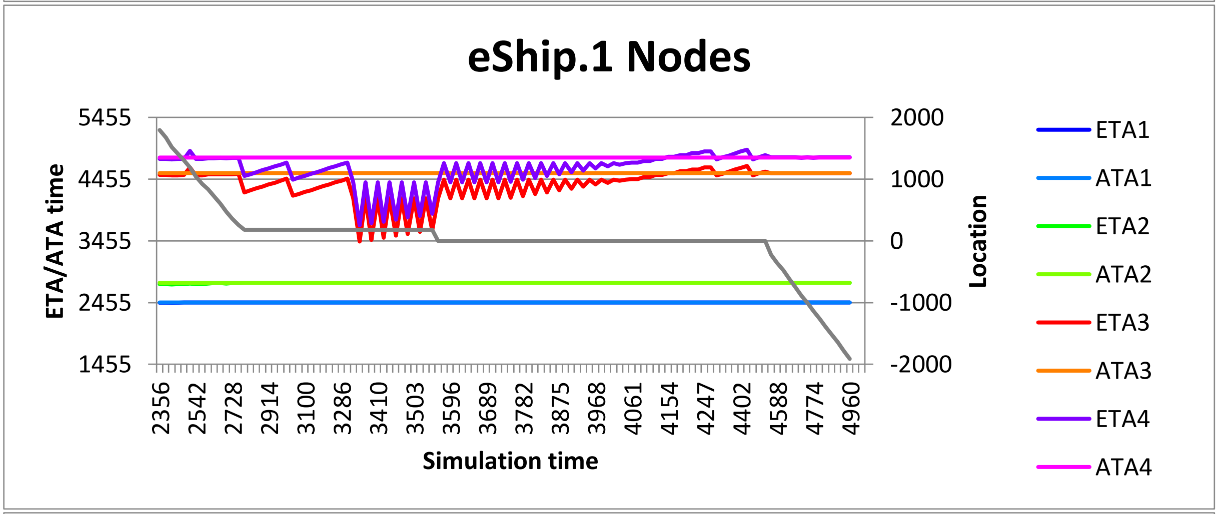
wShip.12 4 Nodes
ETA/ATA time
22460
21460
20460
19460
18460
17460
16460
15460
2000
1000
0
-1000
-2000
Location
16244
16430
16616
16802
16988
17174
17360
17546
17732
17918
18104
18290
18476
18662
18848
19034
19220
19406
19592
19778
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

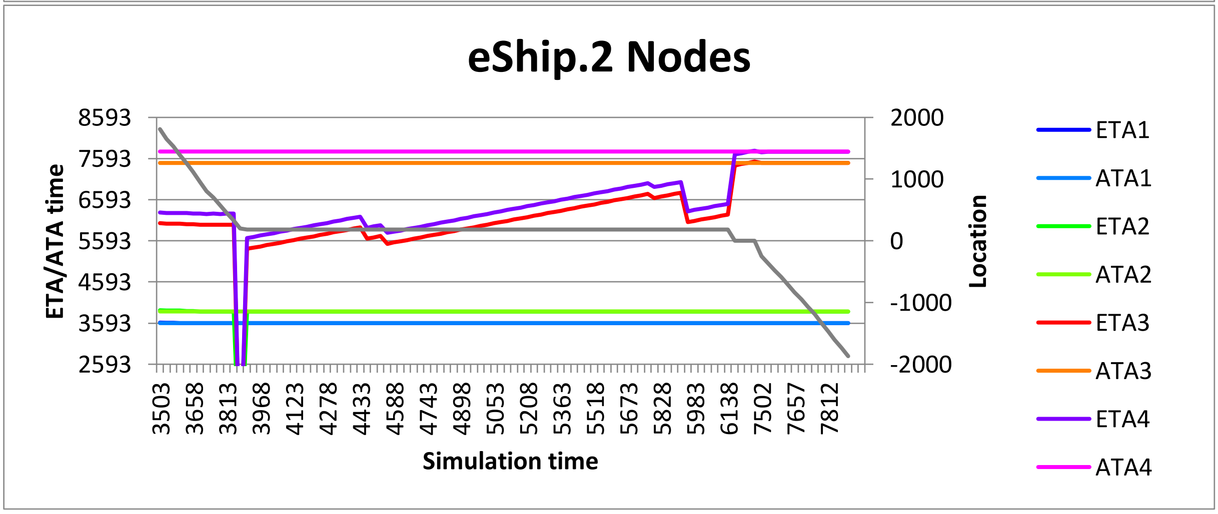
	MaxKPI1	MaxKPI2	MaxKPI3	MaxKPI4
wShip.0	5	13,66667	1534,667	1517,667
eShip.1	8,25	28,25	1291	1301,5
eShip.0	6	34	1390,333	1401,333
wShip.1	6,333333	12,33333	1108,333	1129,333
wShip.2	18,33333	20,33333	1462,667	1441,667
eShip.2	12,5	3876	7486	7764
eShip.4	10,25	17,5	1508	1530,5
eShip.3	15,33333	35,33333	1248,667	1268,667
wShip.3	5,333333	25,33333	1715,333	1729,333
wShip.5	3,75	15,25	1979	1965
wShip.4	10,33333	13,33333	1254,667	1263,667
eShip.5	6	11,33333	1295,333	1305,333
eShip.6	6,666667	8,666667	1138,667	
wShip.6	11,75	31,25	1078	1089
wShip.7	10,75	33,25	1489	1495
eShip.7	17	30	2047,333	2049,333
eShip.9	7	14	1653	1655,5
eShip.8	9,333333	12	1330,667	1350,667
wShip.8	7,666667	16,33333	1534,333	1541,333
wShip.9	12,33333	11,33333	1231,667	1248,667
wShip.10	7	10	1830,667	1857,667
eShip.11	8,75	26,5	1347	1348,5
eShip.10	12	16,66667	1636,333	1652,333
eShip.12	6,666667	22,66667	1333,667	1347,667
wShip.11	8,333333	20,33333	1337	1336
wShip.12	3,666667	26,33333	1601,667	1595,667
eShip.13	13	16	1859,5	1858
eShip.14	9,333333	17888	1684	1678
eShip.15	20,66667	43,66667	20741	21093

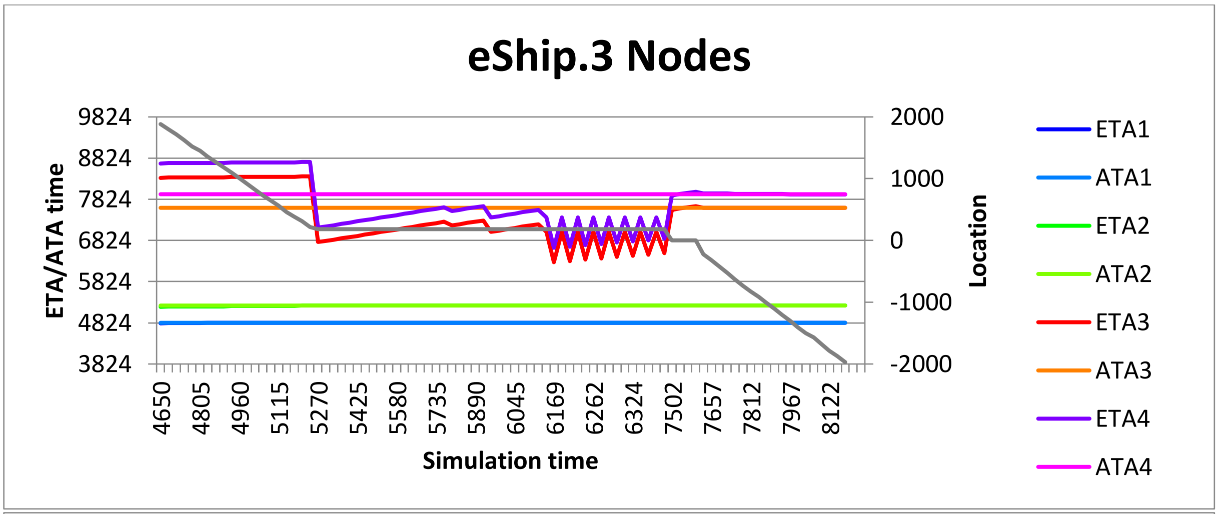
C.7 Design 2 - New Network model + Awareness of lock – Graphs

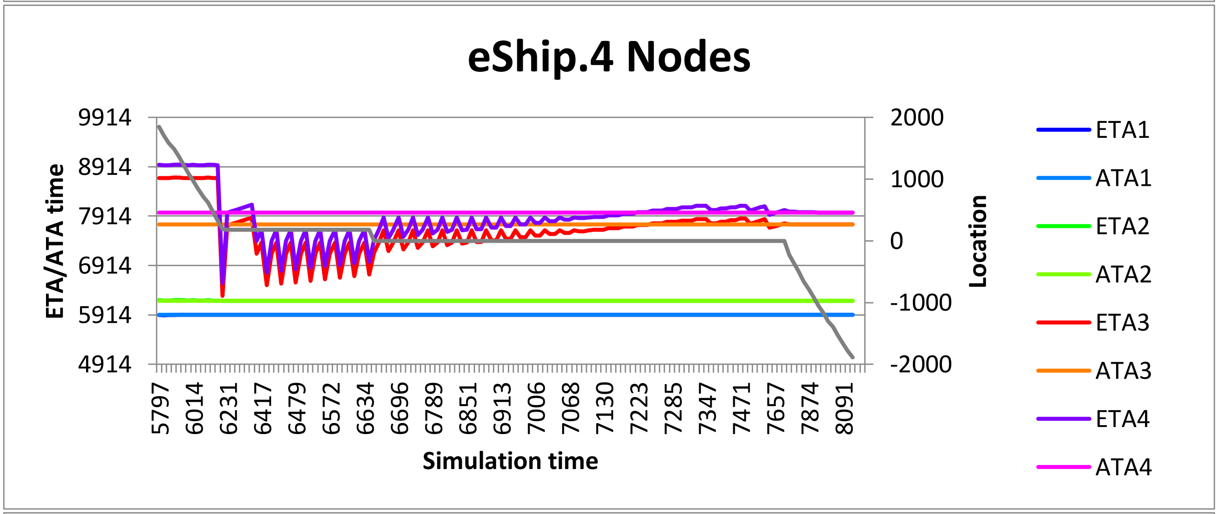
The graphs made by the simulation in the evaluation of Design 2 are shown in this section.
At the end of this section, the table with the max KPIs for each ships and each node is displayed

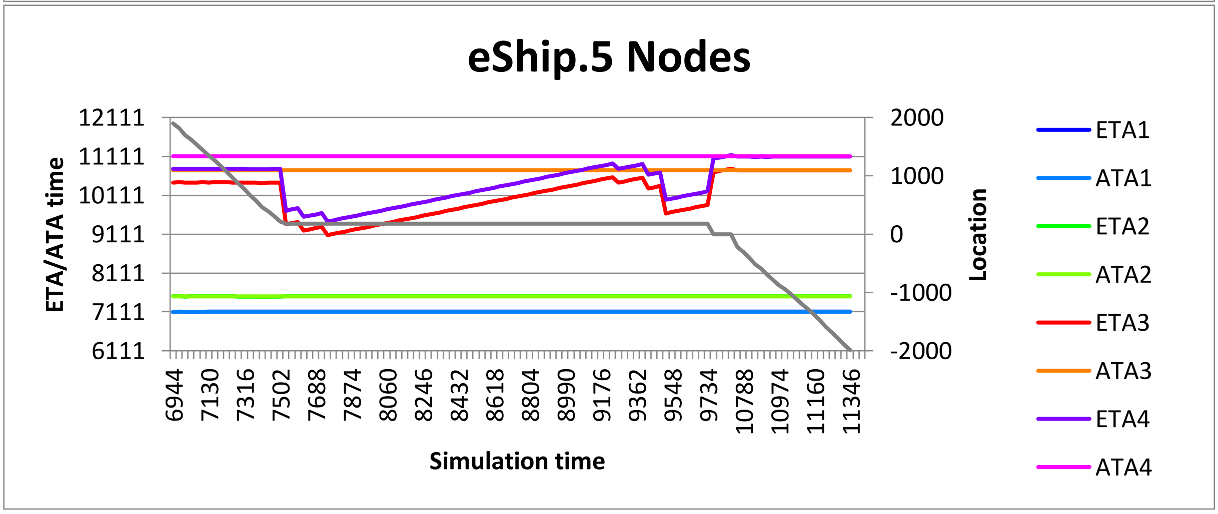

eShip.0 Nodes
ETA/ATA time
Location
Simulation time
5359
4359
3359
2359
1359
359
2000
1000
0
-1000
-2000
1209
1364
1519
1674
1829
1984
2139
2294
2449
2604
2759
2914
3069
3224
4309
4464
4619
4774
4929
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

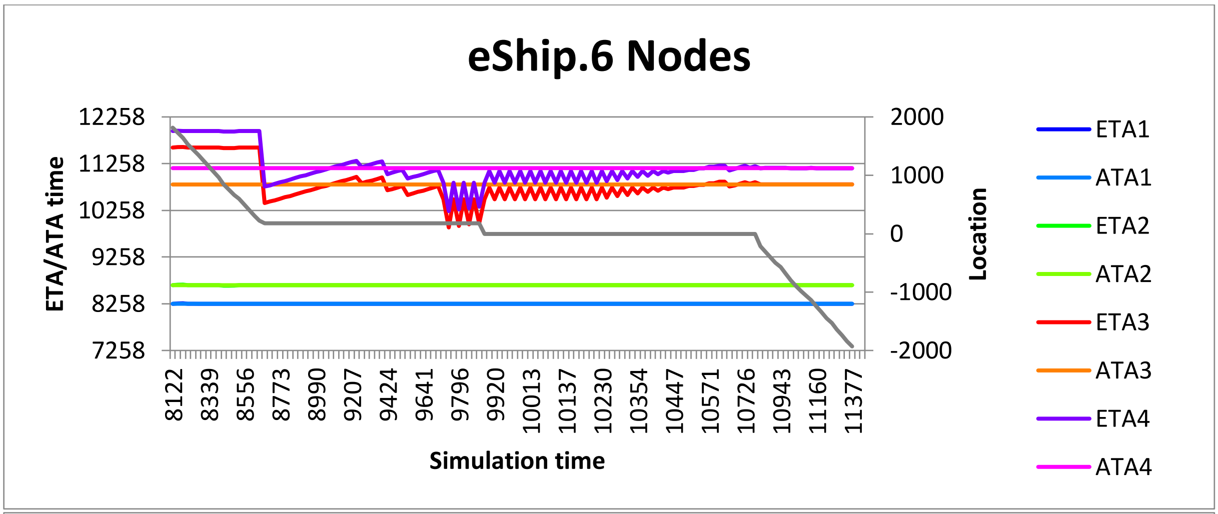

eShip.1 Nodes
ETA/ATA time
Location
Simulation time
5455
4455
3455
2455
1455
2000
1000
0
-1000
-2000
2356
2542
2728
2914
3100
3286
3410
3503
3596
3689
3782
3875
3968
4061
4154
4247
4402
4588
4774
4960
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

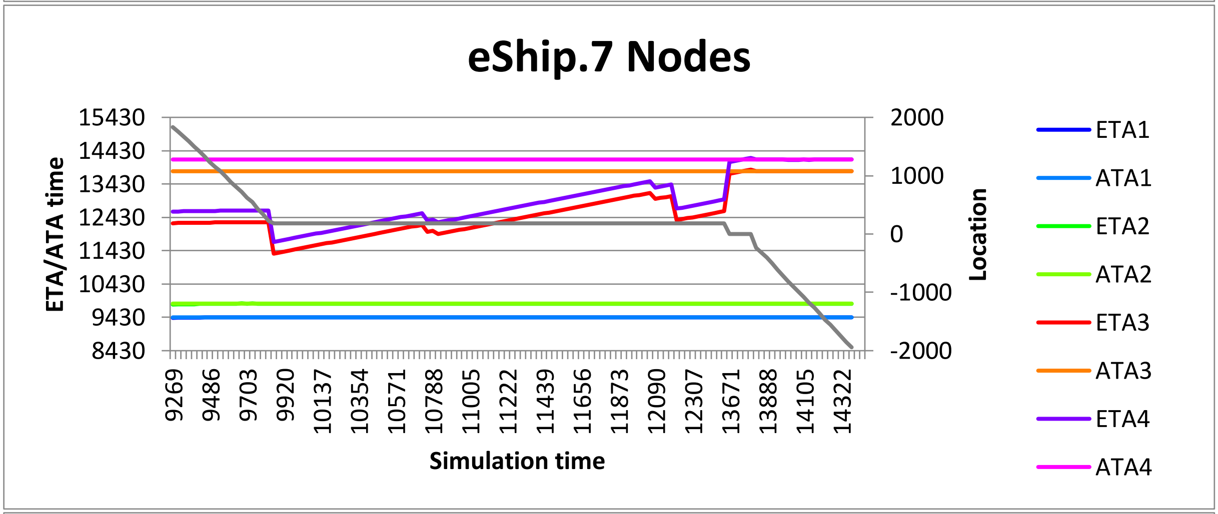

eShip.2 Nodes
ETA/ATA time
Location
Simulation time
8593
7593
6593
5593
4593
3593
2593
2000
1000
0
-1000
-2000
3503
3658
3813
3968
4123
4278
4433
4588
4743
4898
5053
5208
5363
5518
5673
5828
5983
6138
7502
7657
7812
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

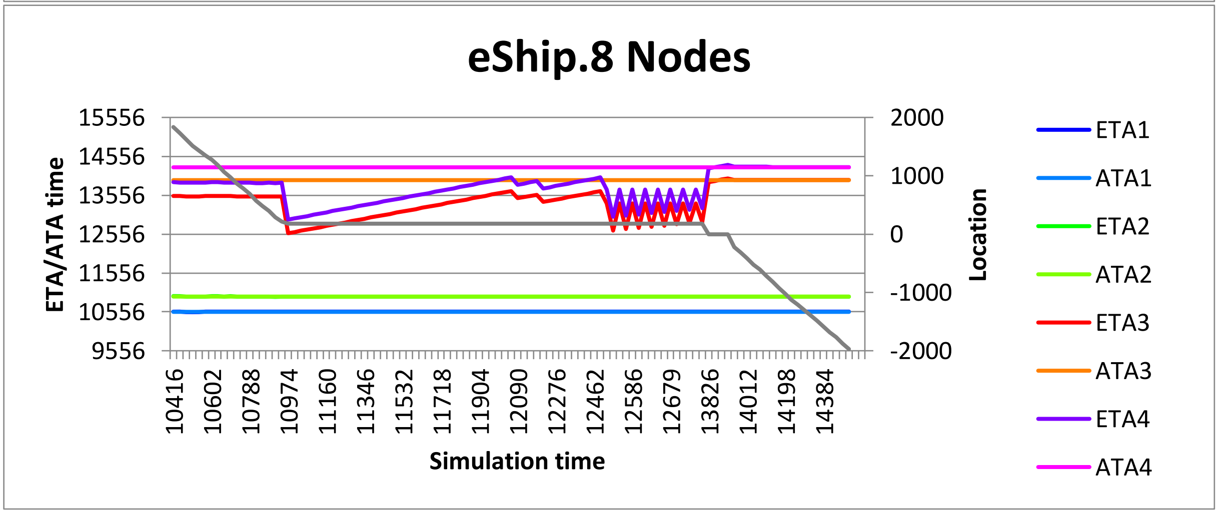

eShip.3 Nodes
ETA/ATA time
9824
8824
7824
6824
5824
4824
3824
2000
1000
0
-1000
-2000
Location
4650
4805
4960
5115
5270
5425
5580
5735
5890
6045
6169
6262
6324
7502
7657
7812
7967
8122
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

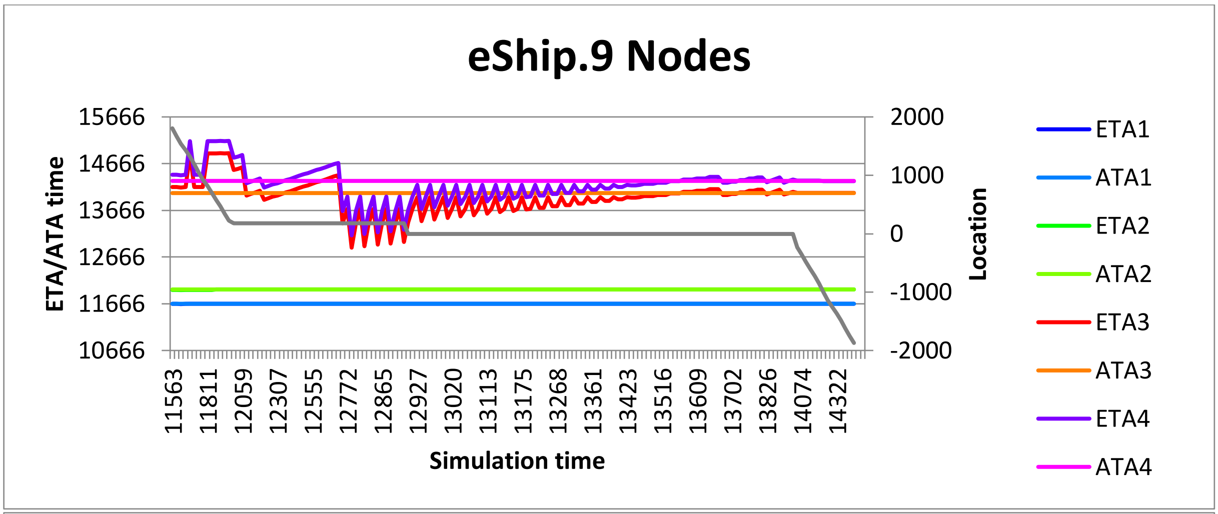

eShip.4 Nodes
ETA/ATA time
9914
8914
7914
6914
5914
4914
2000
1000
0
-1000
-2000
Location
5797
6014
6231
6417
6479
6572
6634
6696
6789
6851
6913
7006
7068
7130
7223
7285
7347
7471
7657
7874
8091
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

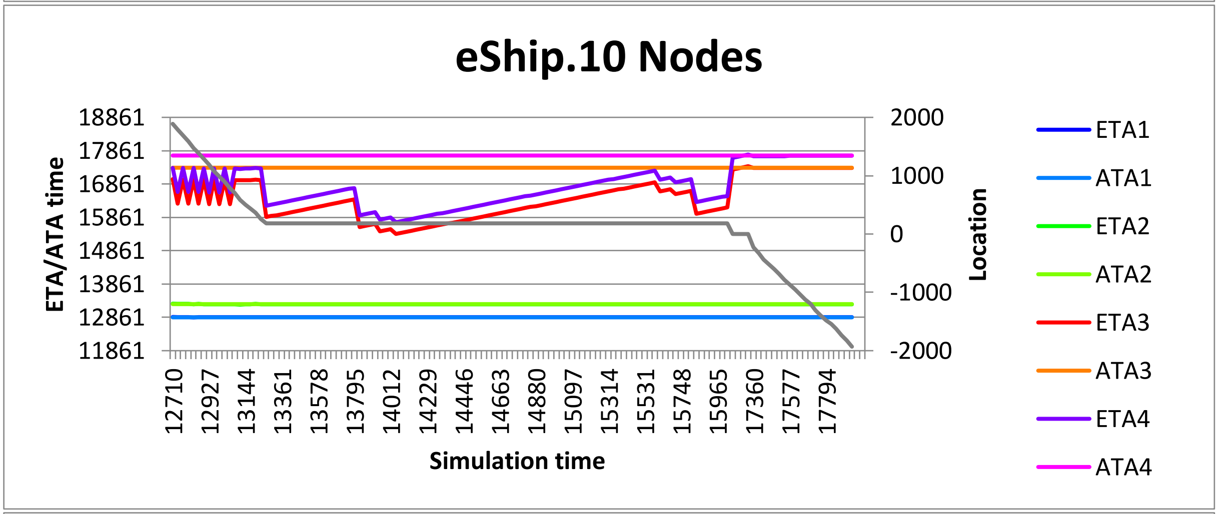

eShip.5 Nodes
ETA/ATA time
12111
11111
10111
9111
8111
7111
6111
2000
1000
0
-1000
-2000
Location
6944
7130
7316
7502
7688
7874
8060
8246
8432
8618
8804
8990
9176
9362
9548
9734
10788
10974
11160
11346
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

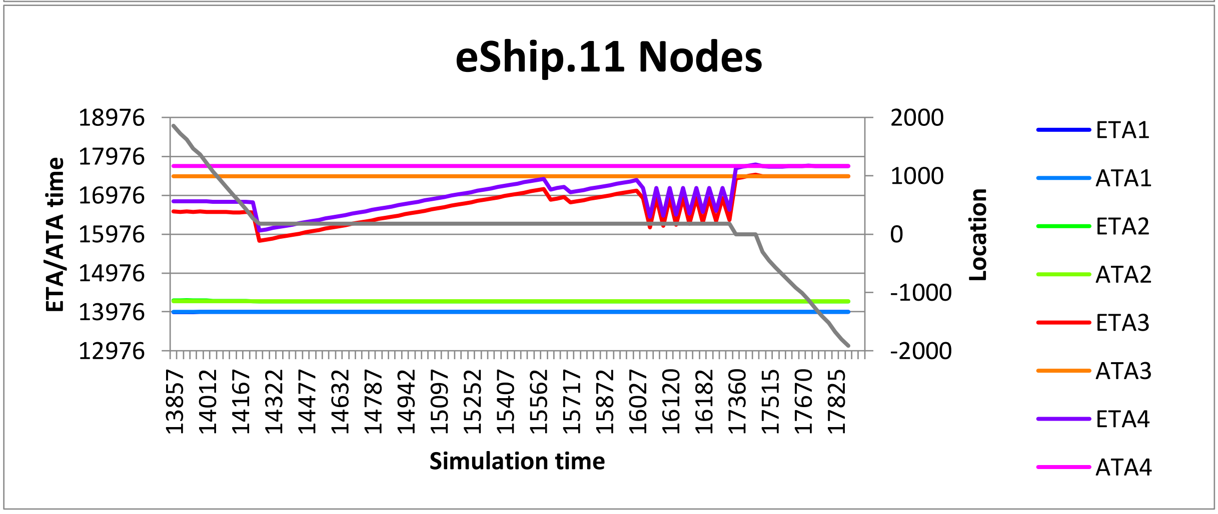

eShip.6 Nodes
ETA/ATA time
12258
11258
10258
9258
8258
7258
2000
1000
0
-1000
-2000
Location
8122 8339 8556 8773 8990 9207 9424 9641 9796 9920 10013 10137 10230 10354 10447 10571 10726 10943 11160 11377
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

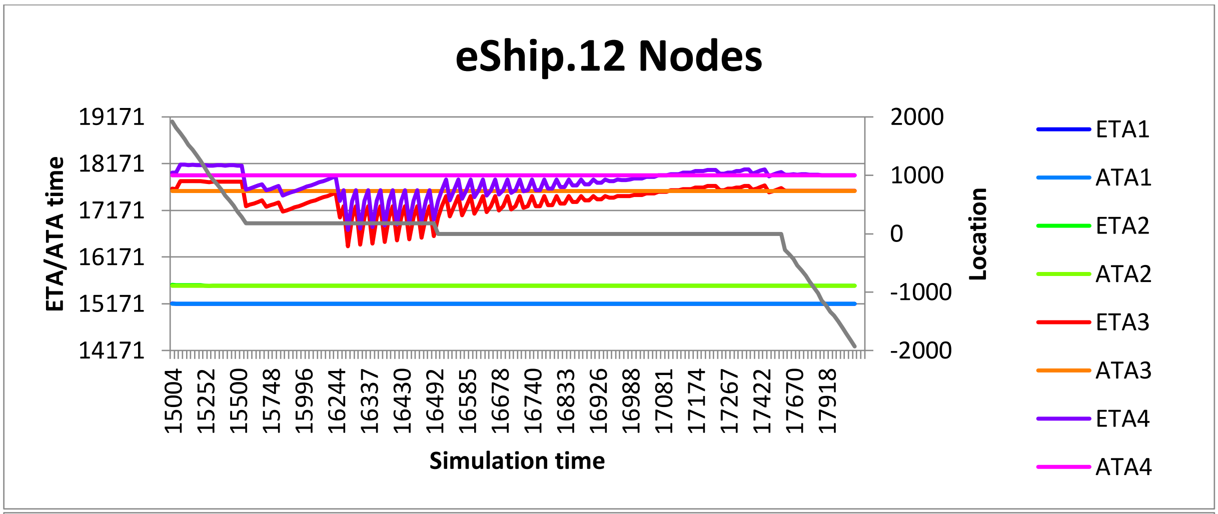

eShip.7 Nodes
ETA/ATA time
15430
14430
13430
12430
11430
10430
9430
8430
2000
1000
0
-1000
-2000
Location
9269 9486 9703 9920 10137 10354 10571 10788 11005 11222 11439 11656 11873 12090 12307 13671 13888 14105 14322
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

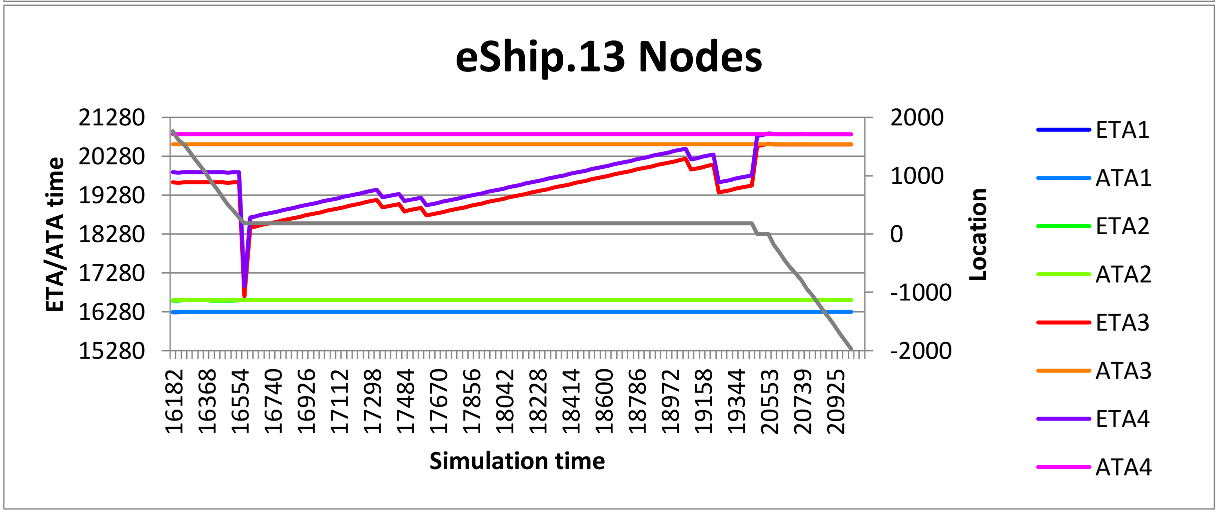

eShip.8 Nodes
ETA/ATA time
15556
14556
13556
12556
11556
10556
9556
2000
1000
0
-1000
-2000
Location
10416 10602 10788 10974 11160 11346 11532 11718 11904 12090 12276 12462 12586 12679 13826 14012 14198 14384
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

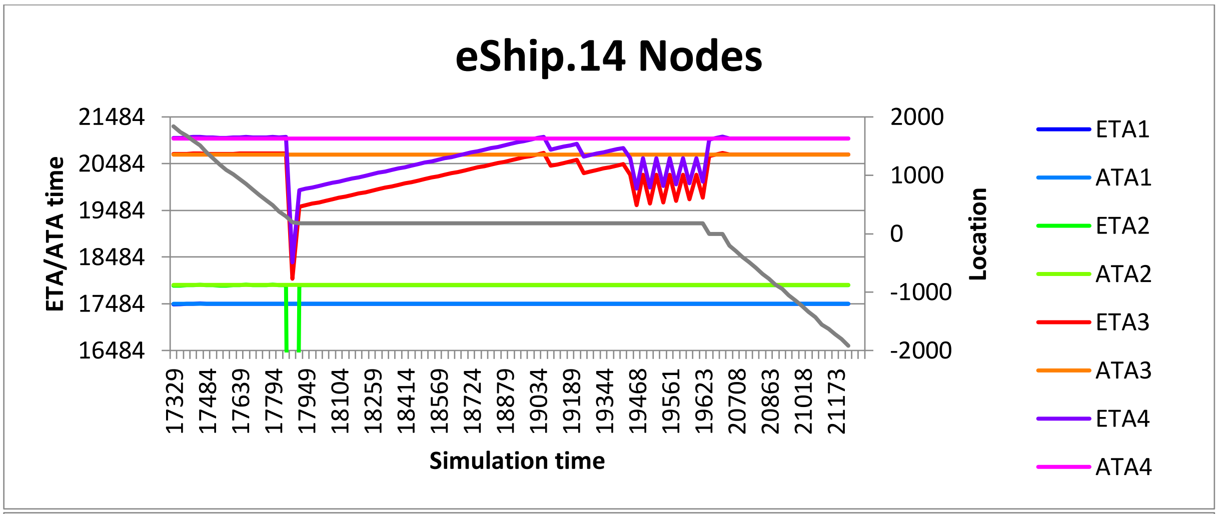

eShip.9 Nodes
ETA/ATA time
Location
Simulation time
15666
14666
13666
12666
11666
10666
2000
1000
0
-1000
-2000
11563
11811
12059
12307
12555
12772
12865
12927
13020
13113
13175
13268
13361
13423
13516
13609
13702
13826
14074
14322
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

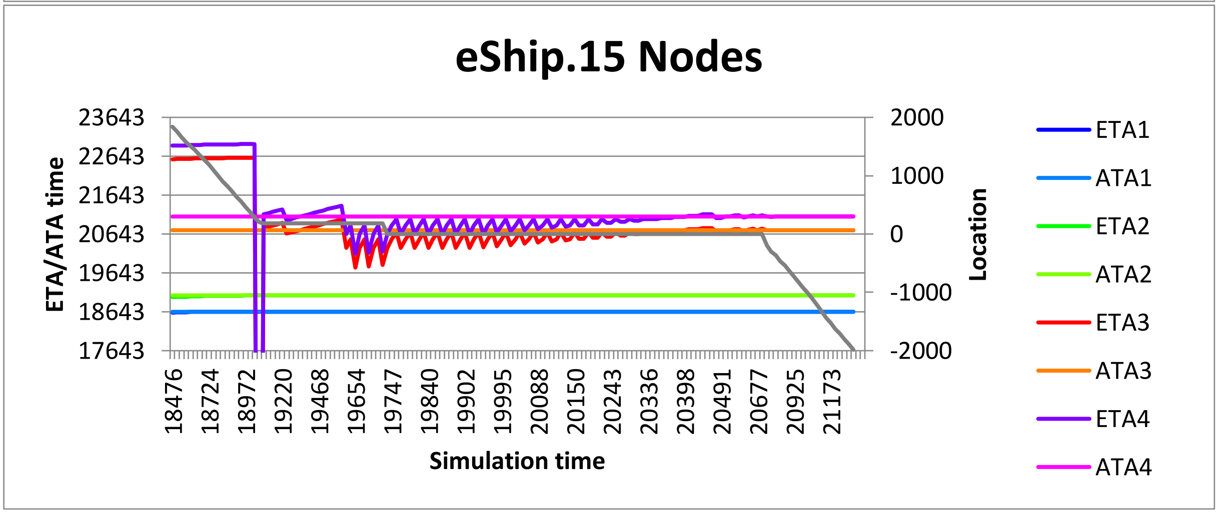

eShip.10 Nodes
ETA/ATA time
Location
Simulation time
18861
17861
16861
15861
14861
13861
12861
11861
2000
1000
0
-1000
-2000
12710
12927
13144
13361
13578
13795
14012
14229
14446
14663
14880
15097
15314
15531
15748
15965
17360
17577
17794
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

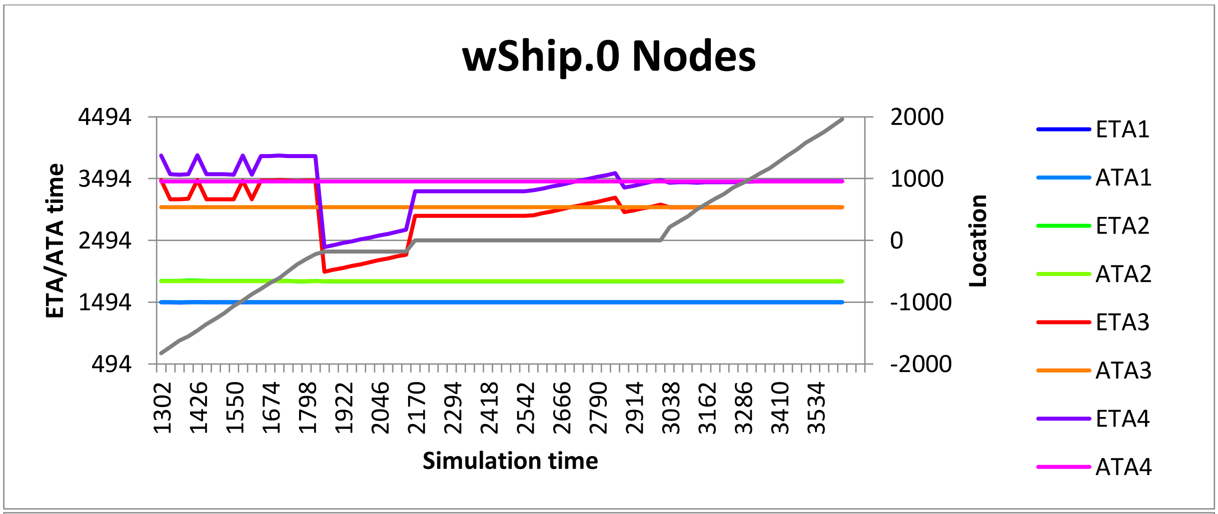

eShip.11 Nodes
ETA/ATA time
Location
Simulation time
18976
17976
16976
15976
14976
13976
12976
2000
1000
0
-1000
-2000
13857
14012
14167
14322
14477
14632
14787
14942
15097
15252
15407
15562
15717
15872
16027
16120
16182
17360
17515
17670
17825
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

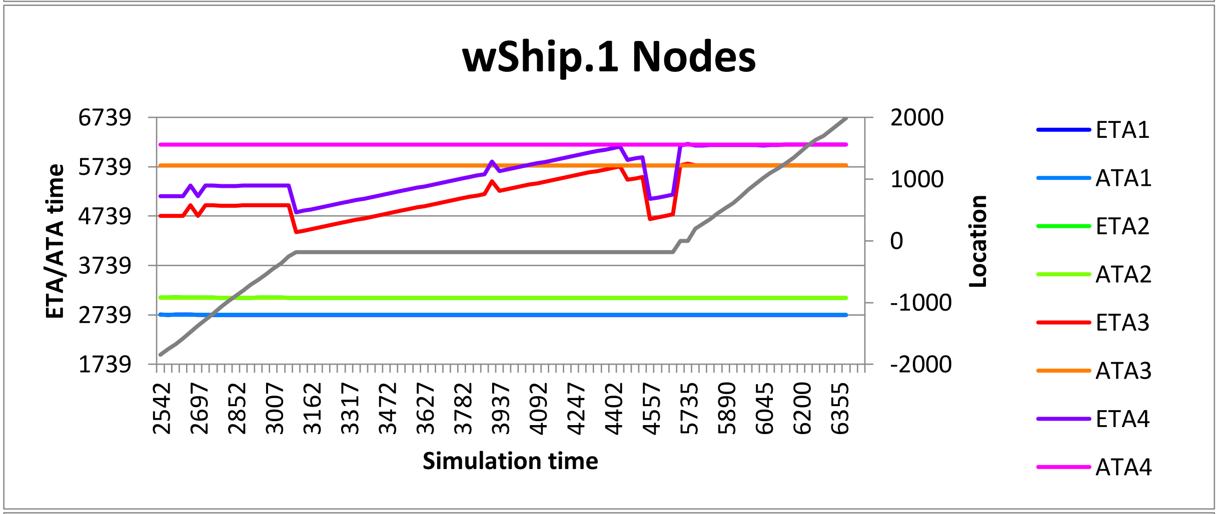

eShip.12 Nodes
ETA/ATA time
19171
18171
17171
16171
15171
14171
2000
1000
0
-1000
-2000
Location
15004
15252
15500
15748
15996
16244
16337
16430
16492
16585
16678
16740
16833
16926
16988
17081
17174
17267
17422
17670
17918
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

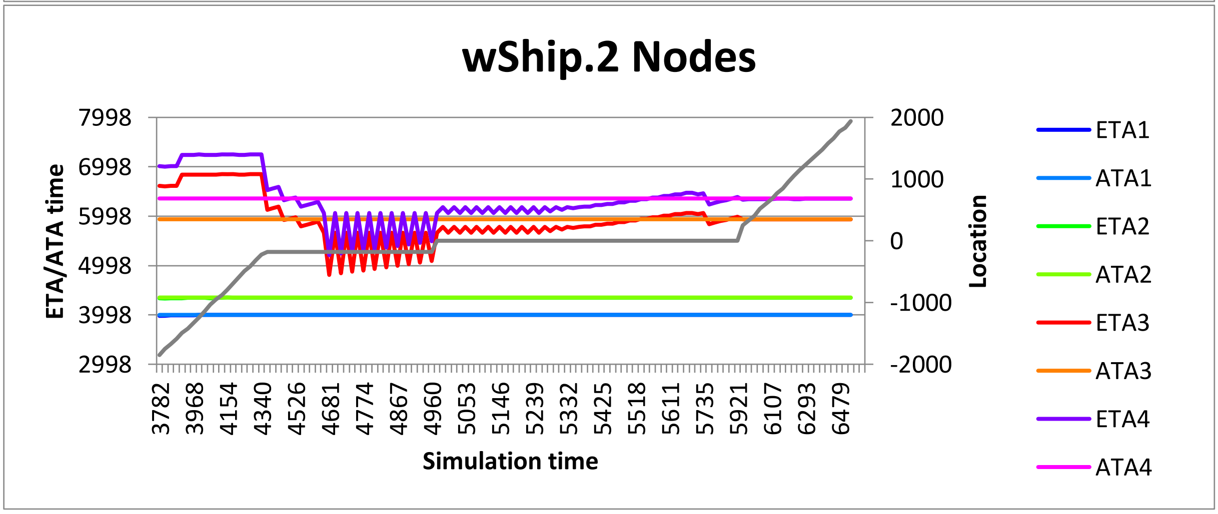

eShip.13 Nodes
ETA/ATA time
21280
20280
19280
18280
17280
16280
15280
2000
1000
0
-1000
-2000
Location
16182
16368
16554
16740
16926
17112
17298
17484
17670
17856
18042
18228
18414
18600
18786
18972
19158
19344
20553
20739
20925
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

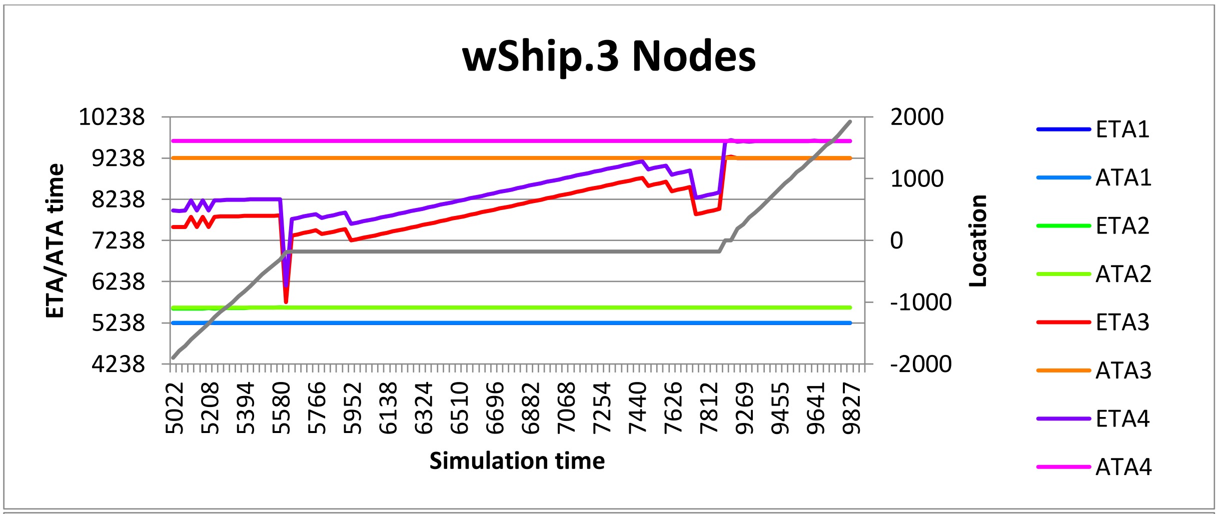

eShip.14 Nodes
ETA/ATA time
21484
20484
19484
18484
17484
16484
2000
1000
0
-1000
-2000
Location
17329
17484
17639
17794
17949
18104
18259
18414
18569
18724
18879
19034
19189
19344
19468
19561
19623
20708
20863
21018
21173
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

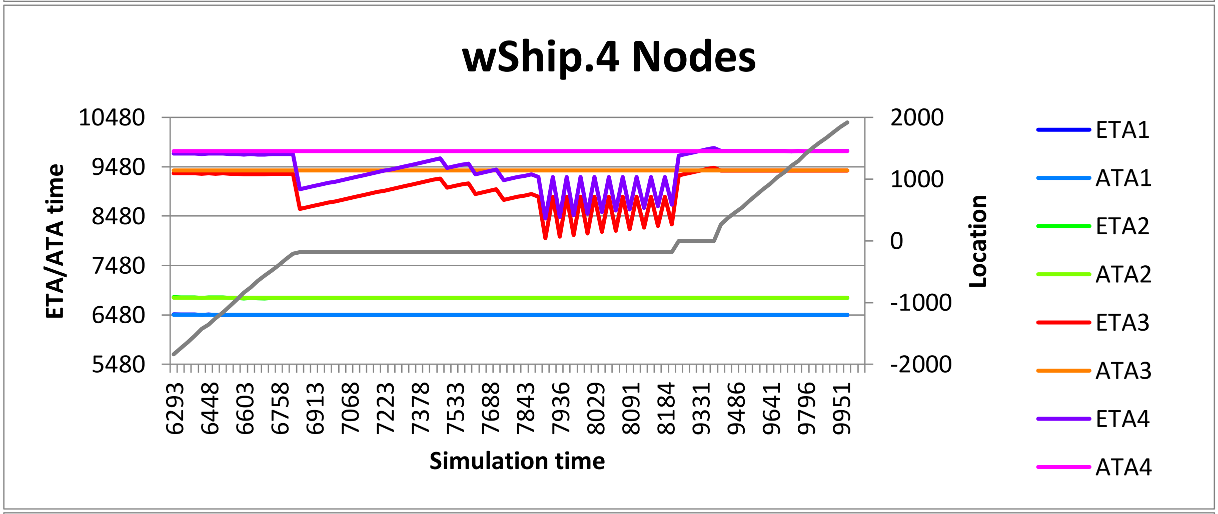

eShip.15 Nodes
ETA/ATA time
23643
22643
21643
20643
19643
18643
17643
2000
1000
0
-1000
-2000
Location
18476
18724
18972
19220
19468
19654
19747
19840
19902
19995
20088
20150
20243
20336
20398
20491
20677
20925
21173
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

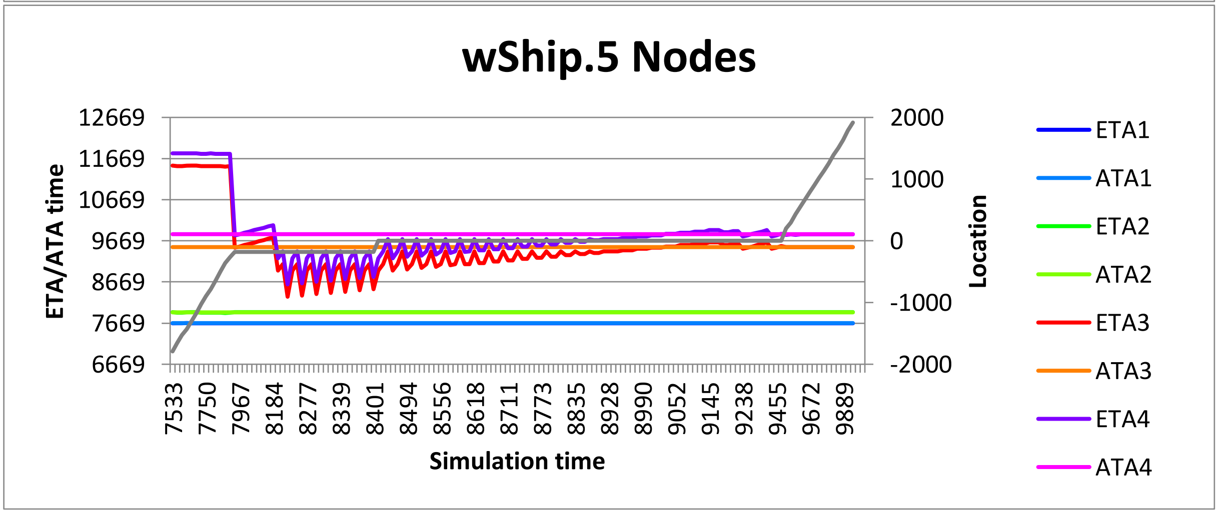

wShip.0 Nodes
ETA/ATA time
4494
3494
2494
1494
494
2000
1000
0
-1000
-2000
Location
1302
1426
1550
1674
1798
1922
2046
2170
2294
2418
2542
2666
2790
2914
3038
3162
3286
3410
3534
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

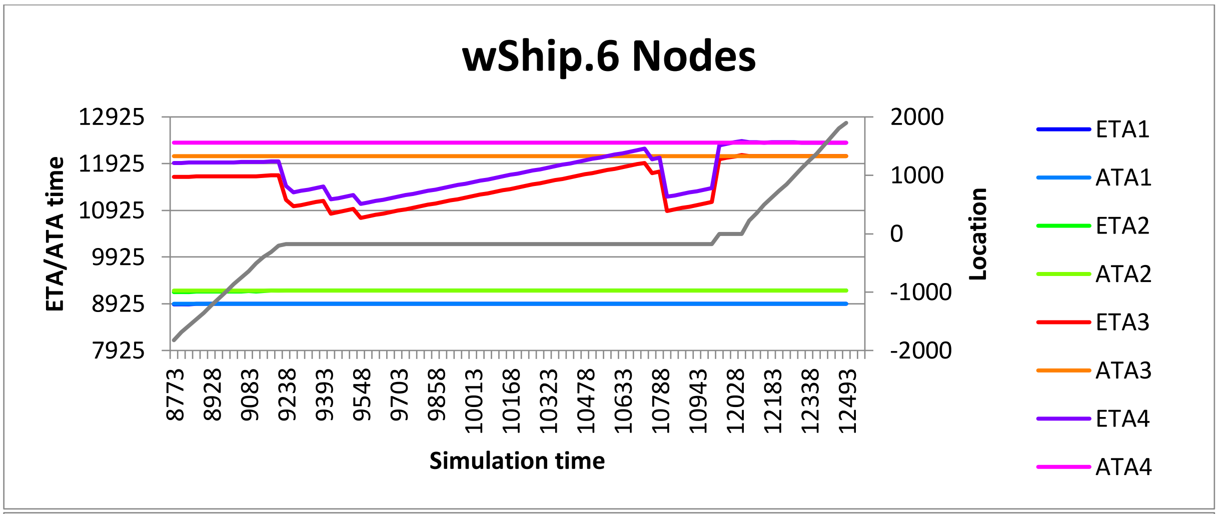

wShip.1 Nodes
ETA/ATA time
6739
5739
4739
3739
2739
1739
2000
1000
0
-1000
-2000
Location
2542
2697
2852
3007
3162
3317
3472
3627
3782
3937
4092
4247
4402
4557
5735
5890
6045
6200
6355
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

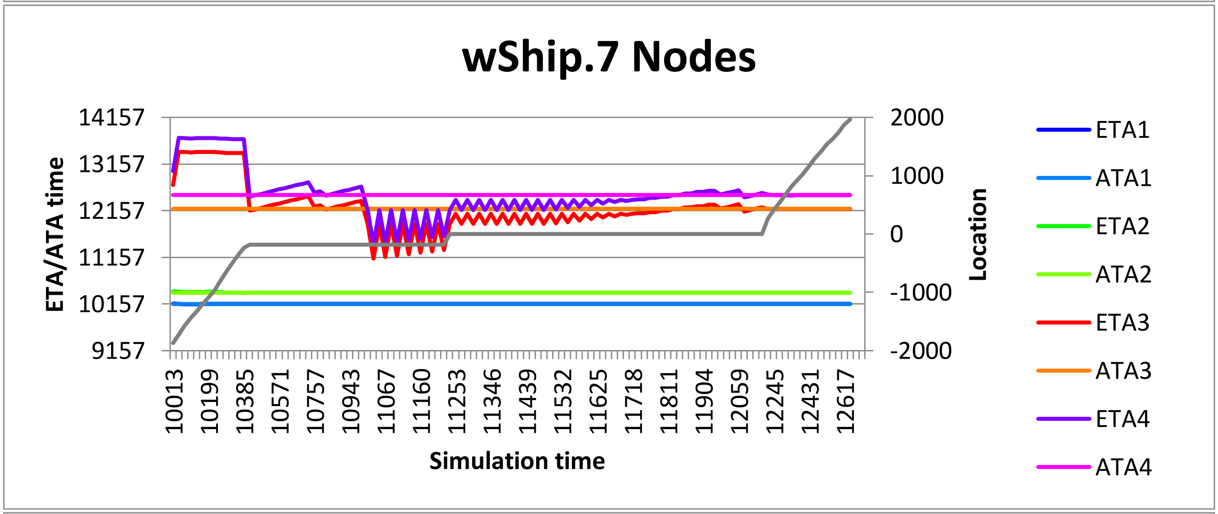

wShip.2 Nodes
ETA/ATA time
7998
6998
5998
4998
3998
2998
2000
1000
0
-1000
-2000
Location
3782
3968
4154
4340
4526
4681
4774
4867
4960
5053
5146
5239
5332
5425
5518
5611
5735
5921
6107
6293
6479
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

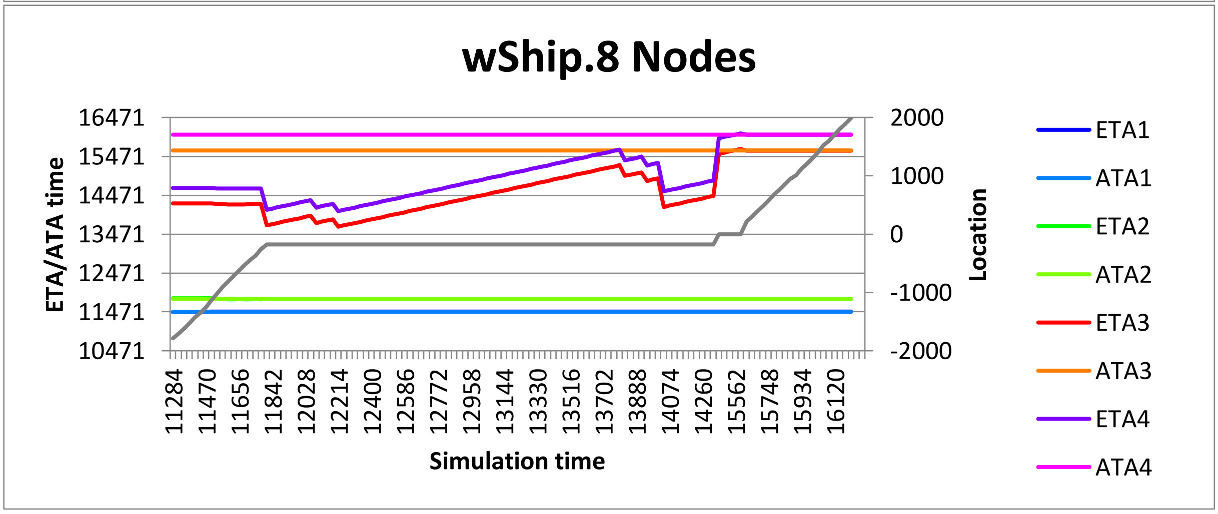

wShip.3 Nodes
ETA/ATA time
10238
9238
8238
7238
6238
5238
4238
2000
1000
0
-1000
-2000
Location
5022
5208
5394
5580
5766
5952
6138
6324
6510
6696
6882
7068
7254
7440
7626
7812
9269
9455
9641
9827
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

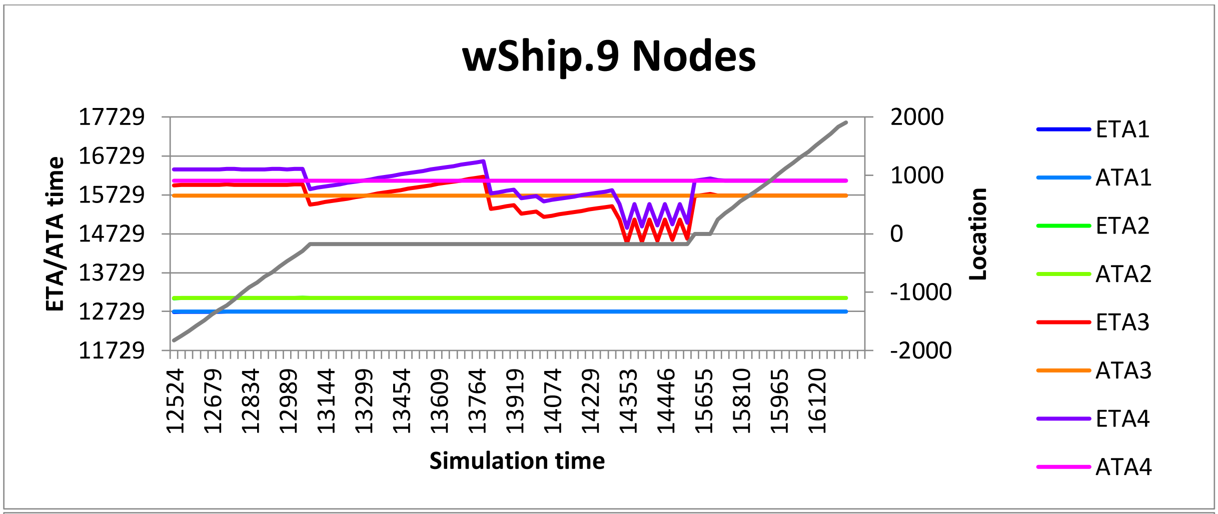

wShip.4 Nodes
ETA/ATA time
10480
9480
8480
7480
6480
5480
2000
1000
0
-1000
-2000
Location
6293
6448
6603
6758
6913
7068
7223
7378
7533
7688
7843
7936
8029
8091
8184
9331
9486
9641
9796
9951
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

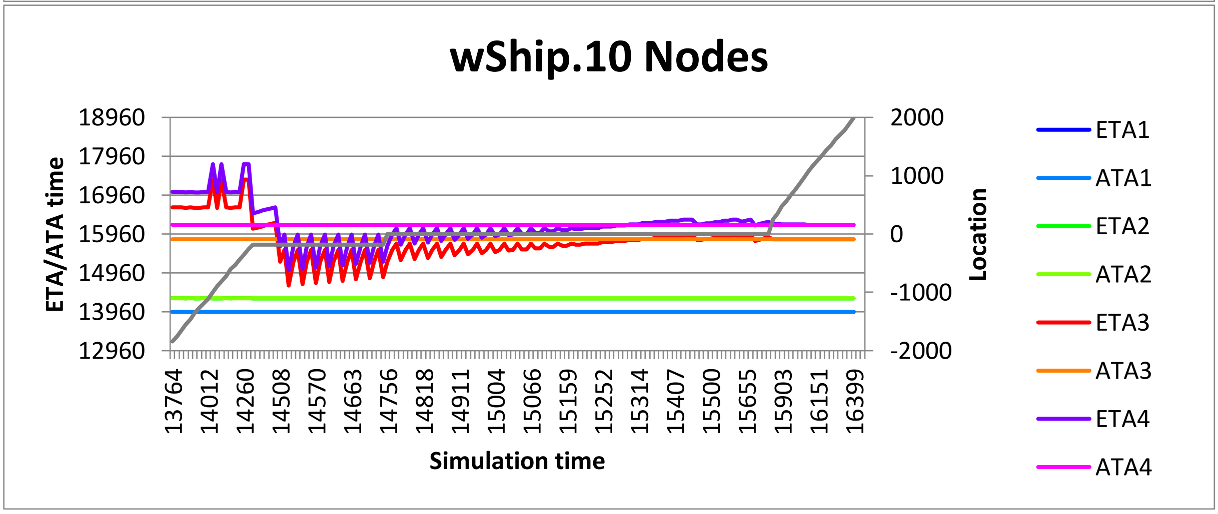

wShip.5 Nodes
ETA/ATA time
12669
11669
10669
9669
8669
7669
6669
2000
1000
0
-1000
-2000
Location
7533
7750
7967
8184
8277
8339
8401
8494
8556
8618
8711
8773
8835
8928
8990
9052
9145
9238
9455
9672
9889
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

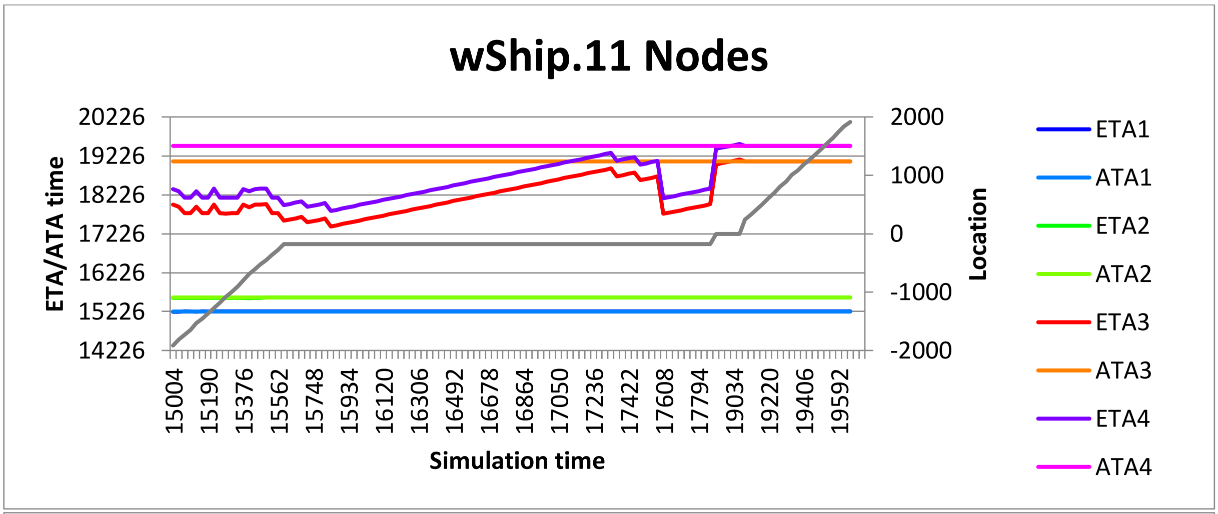

wShip.6 Nodes
ETA/ATA time
12925
11925
10925
9925
8925
7925
2000
1000
0
-1000
-2000
Location
8773
8928
9083
9238
9393
9548
9703
9858
10013
10168
10323
10478
10633
10788
10943
12028
12183
12338
12493
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

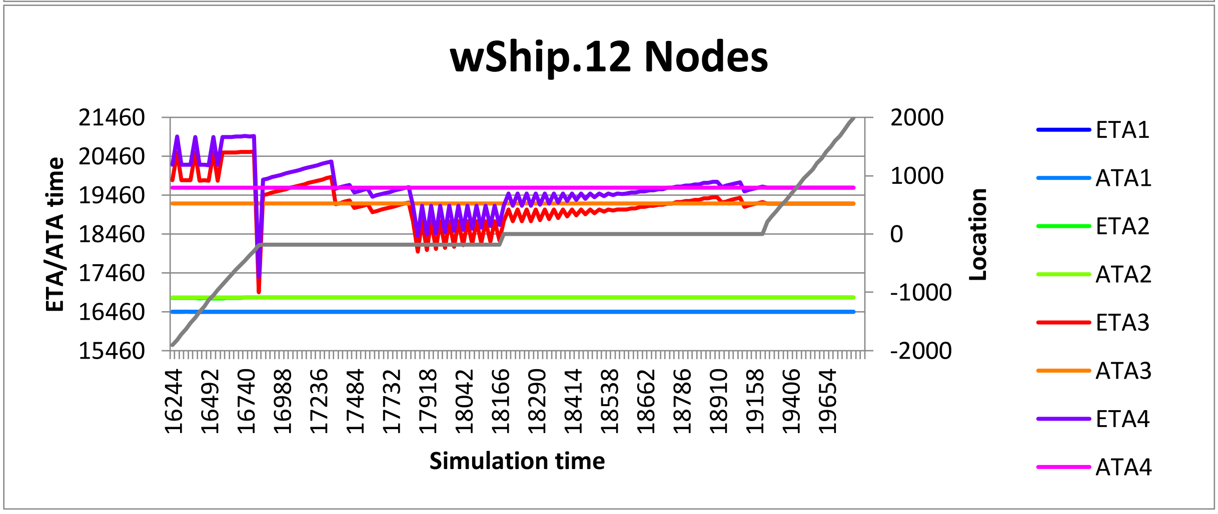

wShip.7 Nodes
ETA/ATA time
14157
13157
12157
11157
10157
9157
2000
1000
0
-1000
-2000
Location
10013
10199
10385
10571
10757
10943
11067
11160
11253
11346
11439
11532
11625
11718
11811
11904
12059
12245
12431
12617
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.8 Nodes
ETA/ATA time
16471
15471
14471
13471
12471
11471
10471
2000
1000
0
-1000
-2000
Location
11284
11470
11656
11842
12028
12214
12400
12586
12772
12958
13144
13330
13516
13702
13888
14074
14260
15562
15748
15934
16120
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.9 Nodes
ETA/ATA time
17729
16729
15729
14729
13729
12729
11729
2000
1000
0
-1000
-2000
Location
12524
12679
12834
12989
13144
13299
13454
13609
13764
13919
14074
14229
14353
14446
15655
15810
15965
16120
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.10 Nodes
ETA/ATA time
18960
17960
16960
15960
14960
13960
12960
2000
1000
0
-1000
-2000
Location
13764
14012
14260
14508
14570
14663
14756
14818
14911
15004
15066
15159
15252
15314
15407
15500
15655
15903
16151
16399
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.11 Nodes
ETA/ATA time
20226
19226
18226
17226
16226
15226
14226
2000
1000
0
-1000
-2000
Location
15004
15190
15376
15562
15748
15934
16120
16306
16492
16678
16864
17050
17236
17422
17608
17794
19034
19220
19406
19592
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4


wShip.12 Nodes
ETA/ATA time
21460
20460
19460
18460
17460
16460
15460
2000
1000
0
-1000
-2000
Location
16244
16492
16740
16988
17236
17484
17732
17918
18042
18166
18290
18414
18538
18662
18786
18910
19158
19406
19654
Simulation time
ETA1
ATA1
ETA2
ATA2
ETA3
ATA3
ETA4
ATA4

	MaxKPI1	MaxKPI2	MaxKPI3	MaxKPI4
wShip.0	5	13,66667	1046,333	1063,333
eShip.1	8,25	28,25	1109	1098,5
eShip.0	6	34	1816,333	1827,333
wShip.1	6,333333	12,33333	1351,333	1372,333
wShip.2	18,33333	20,33333	1127,333	1148,333
eShip.2	12,5	3876	7486	7764
eShip.4	10,25	17,5	1447,75	1425,25
eShip.3	15,33333	35,33333	1321,333	1301,333
wShip.3	5,333333	25,33333	3500,333	3514,333
wShip.5	3,75	15,25	1979	1965
wShip.4	10,33333	13,33333	1373,333	1364,333
eShip.5	6	11,33333	1667,333	1677,333
eShip.6	6,666667	8,666667	920,3333	
wShip.6	11,75	31,25	1322	1311
wShip.7	10,75	33,25	1218,5	1224,5
eShip.7	17	30	2473,333	2475,333
eShip.9	7	14	1169	1166,5
eShip.8	9,333333	12	1364,333	1344,333
wShip.8	7,666667	16,33333	1960,333	1967,333
wShip.9	12,33333	11,33333	1227,333	1210,333
wShip.10	7	10	1535,333	1562,333
eShip.11	8,75	26,5	1659	1660,5
eShip.10	12	16,66667	1986,333	2002,333
eShip.12	6,666667	22,66667	1183,333	1169,333
wShip.11	8,333333	20,33333	1671,333	1670,333
wShip.12	3,666667	26,33333	2283,333	2289,333
eShip.13	13	16	3905,5	3904
eShip.14	9,333333	17888	2657	2651
eShip.15	20,66667	43,66667	20741	21093

C.8 All max KPIs

Below is the table which displays the max KPIs from each experiment for each ship. It should be noticed that some values are in red. This is done because they are incorrect. This is due to a mistake during the simulation which cause one of the ETA to become 0.

Ships	**Estimator validation**	**Estimator planning validation**	**New network model**	**Ne network model + Lock Awareness**
wShip.0	1594,333	1594,333	1534,667	1063,333
eShip.0	1845,667	1881,333	1401,333	1827,333
wShip.1	1846	2416,333	1129,333	1372,333
eShip.1	1352,5	1658,5	1301,5	1109
wShip.2	1602,333	2556,333	1462,667	1148,333
eShip.2	2785,5	2479,5	7764	7764
wShip.3	2819	2830,333	1729,333	3514,333
eShip.3	1592,333	2546,333	1268,667	1321,333
wShip.4	1715,667	2719,333	1263,667	1373,333
eShip.4	1364,5	2318,5	1530,5	1447,75
wShip.5	1378,5	2525,5	1979	1979
eShip.5	2402,667	3414,333	1305,333	1677,333
wShip.6	2078,25	2571,5	1089	1322
eShip.6	1601,333	3425,333	1138,667	920,3333
wShip.7	1351,5	2452,5	1495	1224,5
eShip.7	3149,667	2675,333	2049,333	2475,333
wShip.8	2961,333	2768,333	1541,333	1967,333
eShip.8	2123	2568,333	1350,667	1364,333
wShip.9	1770	2768,333	1248,667	1227,333
eShip.9	1377,5	2324,5	1655,5	1169
wShip.10	1587,333	3338,333	1857,667	1562,333
eShip.10	3253,667	4059,333	1652,333	2002,333
wShip.11	2661	3037,333	1337	1671,333
eShip.11	2377,25	3827,5	1348,5	1660,5
wShip.12	1592,333	3282,333	1601,667	2289,333
eShip.12	1600,333	4071,333	1347,667	1183,333
eShip.13	3198,5	3074,5	1859,5	3905,5
eShip.14	1943	4028,333	17888	17888
eShip.15	1590,333	4018,333	21093	21093

The table below has the 'wrong' values manually checked and corrected.

Ships	**Estimator validation**	**Estimator planning validation**	**New network model**	**Ne network model + Lock Awareness**
wShip.0	1594,333	1594,333	1534,667	1063,333
eShip.0	1845,667	1881,333	1401,333	1827,333
wShip.1	1846	2416,333	1129,333	1372,333
eShip.1	1352,5	1658,5	1301,5	1109
wShip.2	1602,333	2556,333	1462,667	1148,333
eShip.2	2785,5	2479,5	1794,5	2106,5
wShip.3	2819	2830,333	1729,333	3514,333
eShip.3	1592,333	2546,333	1268,667	1321,333
wShip.4	1715,667	2719,333	1263,667	1373,333
eShip.4	1364,5	2318,5	1530,5	1447,75
wShip.5	1378,5	2525,5	1979	1979
eShip.5	2402,667	3414,333	1305,333	1677,333
wShip.6	2078,25	2571,5	1089	1322
eShip.6	1601,333	3425,333	1138,667	920,3333
wShip.7	1351,5	2452,5	1495	1224,5
eShip.7	3149,667	2675,333	2049,333	2475,333
wShip.8	2961,333	2768,333	1541,333	1967,333
eShip.8	2123	2568,333	1350,667	1364,333
wShip.9	1770	2768,333	1248,667	1227,333
eShip.9	1377,5	2324,5	1655,5	1169
wShip.10	1587,333	3338,333	1857,667	1562,333
eShip.10	3253,667	4059,333	1652,333	2002,333
wShip.11	2661	3037,333	1337	1671,333
eShip.11	2377,25	3827,5	1348,5	1660,5
wShip.12	1592,333	3282,333	1601,667	2289,333
eShip.12	1600,333	4071,333	1347,667	1183,333
eShip.13	3198,5	3074,5	1859,5	3905,5
eShip.14	1943	4028,333	1174,667	1112,333
eShip.15	1590,333	4018,333	1864,333	1864,333
Average	2017,77	2870,075	1493,517	1684,876