D2.9 Results of simulation and on-board testing

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Contents

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Scope of the document

The following document is a deliverable D2.9 of the EfficienSea2 project. It presents the on-board test scenarios and results, as well as the details of the simulation tests of the Seamless Roaming concept.

After a brief introduction, the Seamless Roaming testbed architecture and configuration used during the on-board tests will be described. In the next section, the technical details about the Roaming Device simulator will be provided. After that, the results will be presented for both of the testing campaigns: for the simulation experiments, and for the on-board tests, respectively.

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Abbreviations

AP	*Access Point*
API	*Application Programming Interface*
FTP	*File Transfer Protocol*
GNSS	*Global Navigation Satellite System*
GPS	*Global Positioning System*
HTTP	*Hypertext Transfer Protocol*
HTTPS	*Hypertext Transfer Protocol Secure*
MMP	*NIT's Mobile Measurement Platform*
NIT	*National Institute of Telecommunications*
OS	*Operating System*
QoS	*Quality of Service*
SOAP	*Simple Object Access Protocol*
SSH	*Secure Shell* (cryptographic network protocol)
TCP/IP	*Transmission Control Protocol/Internet Protocol*
USB	*Universal Serial Bus*
WWW	*World Wide Web*

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1. Introduction

With radio communication systems integrated into a network, it is possible to route information and data through the most feasible or lowest cost external communication channel. Based on a study of existing and new solutions and requirements, strategies were developed for hybrid solutions for channel selection based on availability, cost, restrictions in bandwidth and other technical parameters, but also content priority.

The document presents the on-board test scenarios and results, as well as the details of the simulation tests of the Seamless Roaming concept. The concept of the seamless roaming mechanism is already developed and described in the deliverable D2.7 [1], and the interface for the cooperation between Maritime Cloud and hybrid communication system was defined in the deliverable D2.8 [2].

It has to be mentioned that the activities described in this Deliverable are connected with the works in the Task 2.4. concerning establishing a prototype demonstration set-up with focus on ship to shore communication roaming, delivery D2.12, and can be seen as an input to the further work on the Roaming Device prototype.

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2. Seamless Roaming software

In the following section, the software designed and implemented by NIT, used in the tests of the Seamless Roaming (both on-board and simulation), is described.

2.1. Seamless Roaming application programming interface (API)

The only Seamless Roaming API procedure call used during the tests was the "*Configure*" call – which is described in the Table 1.

Table 1 API of the Seamless Roaming software used in the testbed and the simulator

Procedure name	Parameters	Return value
Configure	service, serviceReq, userReq, connectionId	ID of the radio link selected for the connection

The Internet connection sharing with the users of the system is transparent – the user is not obliged to call any of the Seamless Roaming API procedures to gain a possibility to connect to the Internet. Using the "Configure" procedure, however, maximizes the user's chance to utilize the radio link that is the most optimal for their work with services (e-navigation ones as well as well-known Internet services).

The Service Requirements are used in the Seamless Roaming algorithm to filter the available radio link list (some of the radio link types can be excluded from the switching procedure based on a service QoS requirements). The User Requirements (or preferences) are used in the algorithm to determine the values of coefficients to be used in the quality calculation formula (described in the next subsection).

2.2. Network monitoring algorithm

Network Monitoring thread is constantly testing the available radio links, in 2 steps:

1. Testing of **signal power level**,
2. Estimating **throughput**.

Power level and throughput are rated from 0.0 to 1.0, and the final radio link quality parameter is calculated as a weighted geometric mean:

$$quality = (throughput\_rate^{w_t} * powerLvl\_rate^{w_p})^2 * 100$$

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where w_t, w_p are weight coefficients (from 0.0 to 1.0, they sum up to 1.0). For more complex cases, there can be more parameters [1].

Once in every $interval$ seconds the algorithm tests if some radio link has better quality than the one currently being used. In the final solution, the $interval$ parameter needs to be configurable.

The $powerLvl\_rate$ and $throughput\_rate$ are calculated for each of the available radio links based on the measured parameter (received signal power level and estimated data rate, respectively), and on the pre-defined limits. If the measured parameter is lower than the low limit, then the rate parameter is equal to 0. If its value is above the high limit, then the rate parameter is set to 1. In other cases, the linear interpolation is used to determine the value of the rate parameter.

During the on-board tests, the Linux's *ping* software was used for the throughput estimation.

In case of cellular networks, the received signal power level rate calculations are based on the *Arbitrary Strength Unit* (ASU), commonly used in the modern cellular terminals (phones and modems).

The throughput low limit is set to 0 (which means that it is not possible to transmit anything at the moment), and the high limit is 500 kb/s. The received signal power level limits are set differently for each of the radio link types. The power level limits – which were obtained experimentally – are presented in Table 2.

Table 2 The received signal power level limits used in network monitoring algorithm

Received signal power level limits		
Radio link type	**Low limit**	**High limit**
Wi-Fi	-90 dBm	-70 dBm
Satellite	-90 dBm	-60 dBm
LTE	-140 dBm	-44 dBm
3G	-120 dBm	-25 dBm

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For some types of the radio links, such as satellite links, data rate estimation will generate some costs. To avoid this kind of situation, such links are not actually subjected to tests, but instead the network monitoring algorithm makes some assumptions about their data rate. For example, it is possible to define satellite link data rate as a stable 100 kb/s (this value was used during the Seamless Roaming simulation tests, and is based on the real world data rate offered by the satellite communication systems, e.g. Iridium [3]).

2.3. Radio link switching

At the beginning of its operation, the Roaming Device prepares a routing table for each of the available radio links. After the radio link switch decision (made by Network Monitoring algorithm), the Roaming Device changes the current network configuration to the one assigned to the chosen radio link. Roaming Device also re-establishes the ship-to-shore VPN tunnel, if it is necessary.

The switching procedure is initiated if the quality of a radio link (measured by the network monitoring algorithm, described earlier) proves superior to the quality of the in-use radio link during $Ntests$ consecutive tests.

In the final solution, the $Ntests$ parameter needs to be configurable. The $Ntests$ parameter was applied in the algorithm to test radio link stability, which is very important in some types of connection.

An example of the quality testing and radio link switching algorithms performance is presented in Figure 1. In this case, the $Ntests$ parameter value was set to 5, and the $interval$ parameter value was set to 10.

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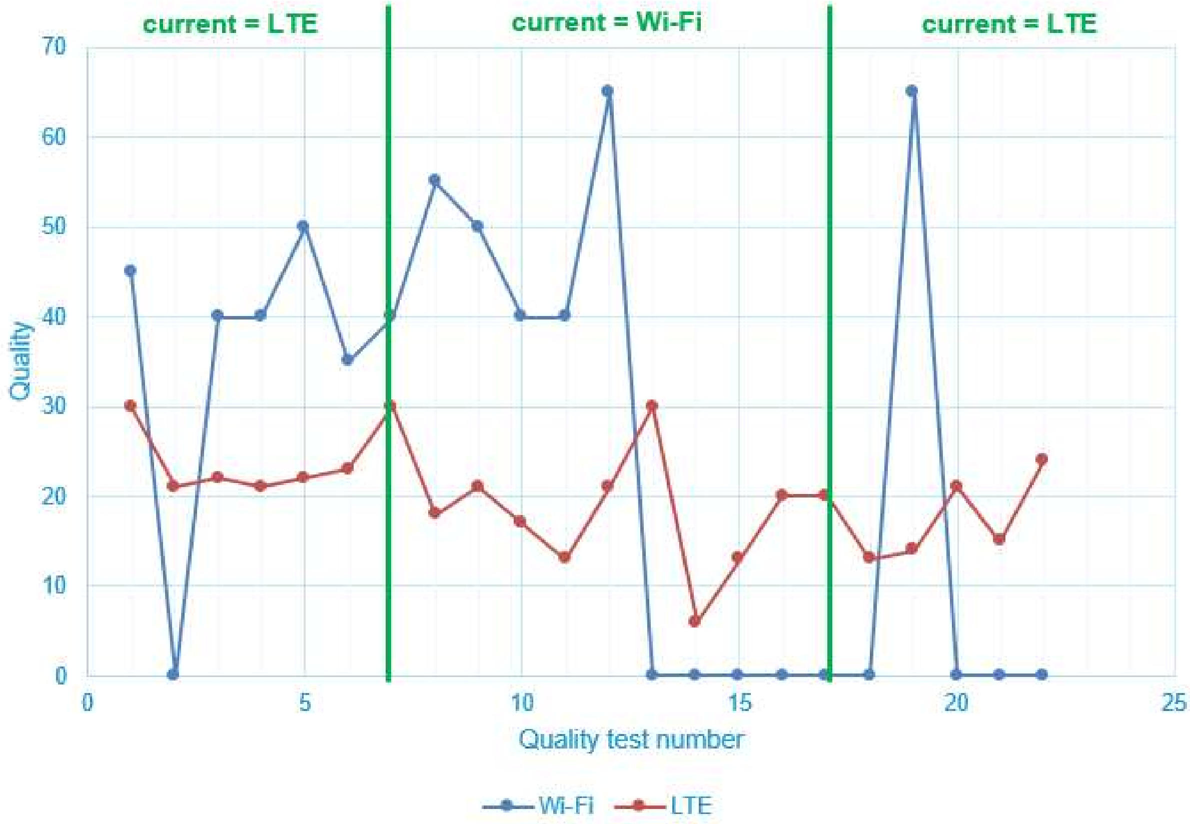

Figure 1 Example of the switching algorithm results during the on-board tests

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3. Testbed configuration

In this section, the architecture, technical realization and the configuration of the testbed used in the tests is described. The authors present diagrams that illustrate which devices were used during experiments, and how they were connected to each other. Additionally, the network architecture used during the tests is discussed.

3.1. Devices used in the testbed

Below, the connection scheme of the devices used in the Seamless Roaming testbed during the on-board tests is presented. It is worth to mention that on the ship side of this testbed, the access to the ship's power supply was very limited – and this problem was addressed by the authors of the presented testbed architecture, by adding an USB hub, which was able to supply power to radio devices.

Devices that were used in the testbed are listed below:

- GNSS receiver: Holux M-215+, chipset MTK MT3333 (GPS + GLONASS) [4],
- Roaming Device (control unit): Raspberry Pi 2 [5],
- Ethernet switch: Linksys SE2500 [6],
- USB Hub: D-Link DUB-H7 [7],
- LTE modem: LTE USB Access Head UAH-MC7710-1800-STD, chipset AirPrime MC7710 LTE/HSPA+ [8],
- Wi-Fi card: TP-Link WN722N [9],
- Wi-Fi access point: TP-Link Archer C5 AC1200 802.11ac Dual Band 2xUSB GBLAN [10].

The connection scheme of all devices used during the on-board tests is shown in Figure 2.

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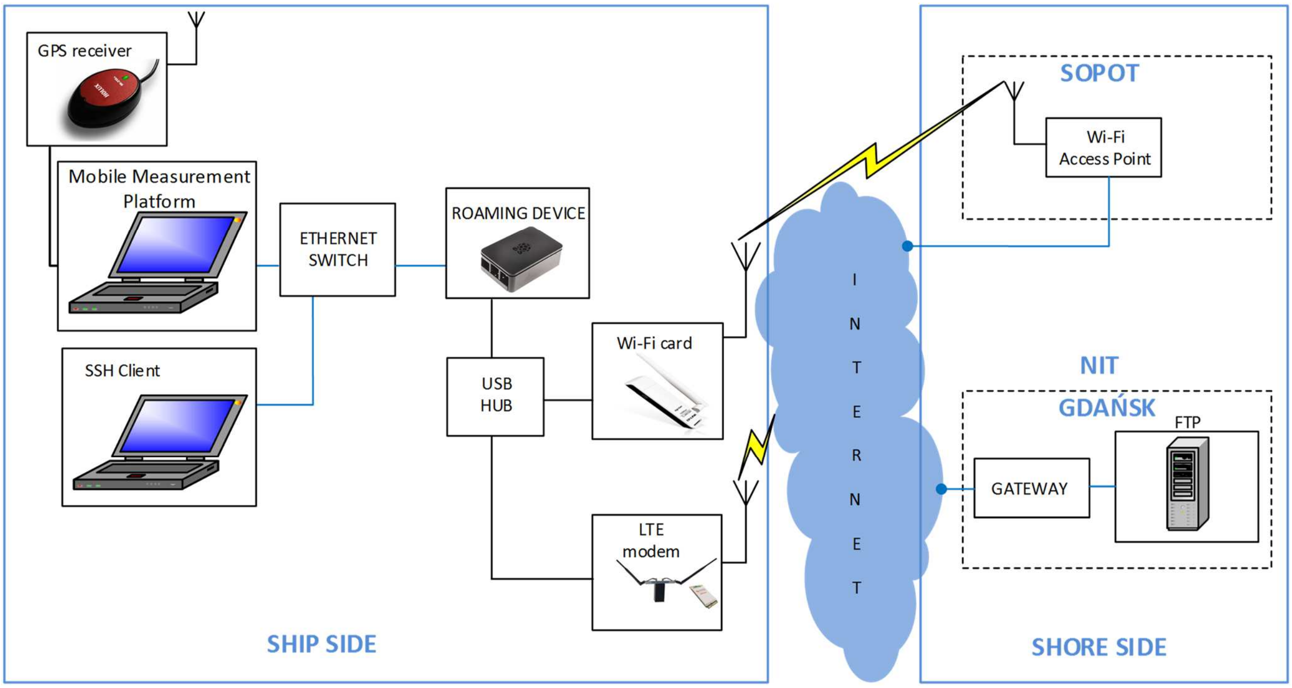

Figure 2 The connection scheme of the devices used in the Seamless Roaming testbed

3.2. Network architecture

During the on-board tests, the simplified network architecture was set-up to test only the main functionality of the Roaming Device. This architecture is presented in Figure 3.

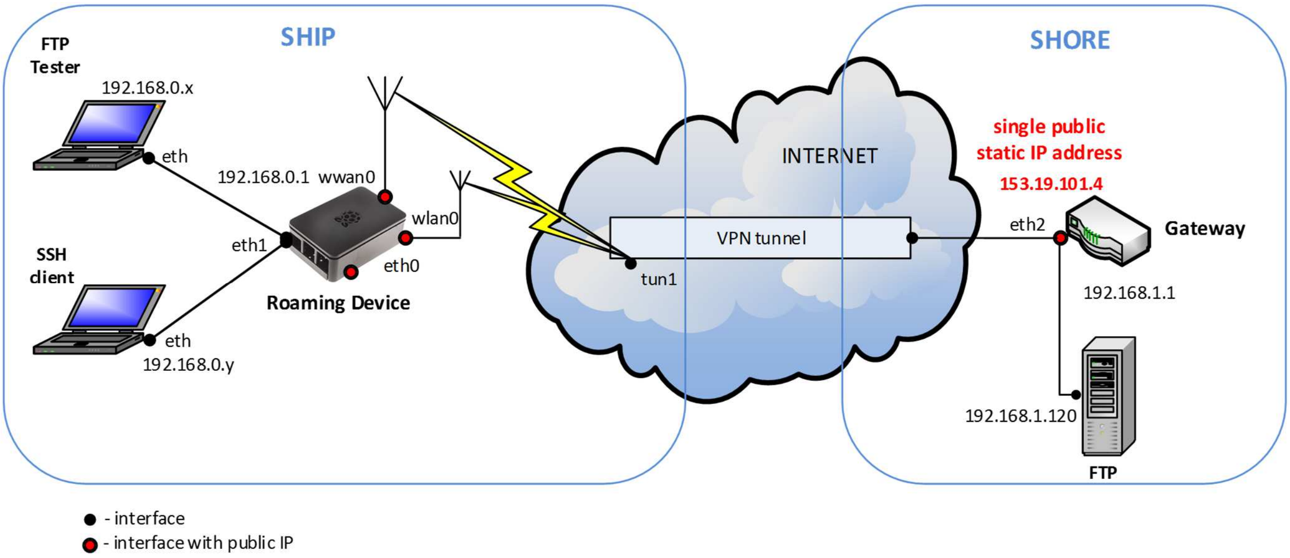

Figure 3 The network architecture used during the on-board tests of the Seamless Roaming concept

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4. On-board tests

In this section the test scenarios used for on-board tests, testbed configuration and locations, as well as the technical details about utilized radio antennas and devices are presented.

4.1. On-board tests scenario and configuration

The configuration of the testbed, other measurement instruments, etc., was as follows:

- Ship: Sonda II,
- Speed: up to $20\ km/h$,
- Distance from the shore: from $200\ m$ to $5.6\ km$,
- Wi-Fi AP distance from the coastline: $\sim 250\ m$,
- FTP service was set-up in the NIT office, connected to the NIT gateway (with known IP address).

Technical details of the antennas used in the on-board tests are listed in the Table 3 and Table 4.

Table 3 Ship Wi-Fi antenna technical specification

Ship Wi-Fi antenna (Taoglas Hercules WS.01.B.305151) [11]	
Height of the antenna above sea level	4 m
Radiation pattern	omnidirectional
Frequencies	2.4 GHz, 5 GHz
Antenna gain	~4 dBi in 2.4 GHz, ~4.5 dBi in 5 GHz
Polarization	Linear - Horizontal
VSWR	< 1.8
Impedance	50 ohm

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Table 4 Shore Wi-Fi Access Point antenna technical specification

Wi-Fi Access Point antenna (SEC-XL24/50DP) [12]	
Height of the antenna above ground	20 m
Height of the ground in the transmitter's location	4 m.a.s.l.
Frequencies	2.4 GHz, 5 GHz
Antenna gain	2 x 15 dBi in 2.4 GHz, 2 x 18 dBi in 5 GHz
Polarization	2 x dual H&V
Antenna beamwidth (Horizontal)	90° (-3 dB), 120° (-6 dB)
Antenna beamwidth (Vertical)	12° in 2.4 GHz, 6° in 5 GHz
VSWR	< 1.8
Impedance	50 ohm
Front-to-Back ratio	> 35 dB

The NIT's *Mobile Measurement Platform* (MMP) [13] was continuously connecting to the server (using the Internet connection provided by the Roaming Device), and it was measuring the service quality. The executed scenario can be presented as follows:

1. The ship moved from Gdansk to the north, to the fixed destination within the Wi-Fi Access Point antenna coverage, at approx. $500\ m$ distance from the Access Point,
2. The ship was moving in a straight line from the shore, up to the point where Wi-Fi Access Point signals could not be received anymore,
3. The ship returned to the same fixed destination mentioned in point **1**.

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4. Points **2** and **3** were repeated,
5. The ship moved from the fixed destination mentioned in **1** to the north (to Gdynia), and it left the Wi-Fi Access Point antenna coverage.

Figures 5, 6 and 7 present the Seamless Roaming testbed's installation on-board.

Figure 4 Sonda II - the vessel that was used during the Seamless Roaming on-board tests

Figure 5 Installation of the antennas on the ship during the Seamless Roaming on-board tests

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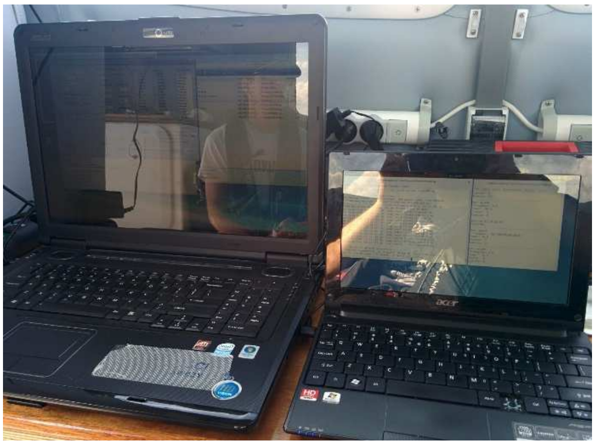

Figure 6 The Seamless Roaming testbed (ship side) during the tests

The map in Figure 8 presents the actual geographic location of the Wi-Fi access point that was used during the campaign. Additionally, in Figures 9 and 10, the installation of the Wi-Fi access point antenna is depicted.

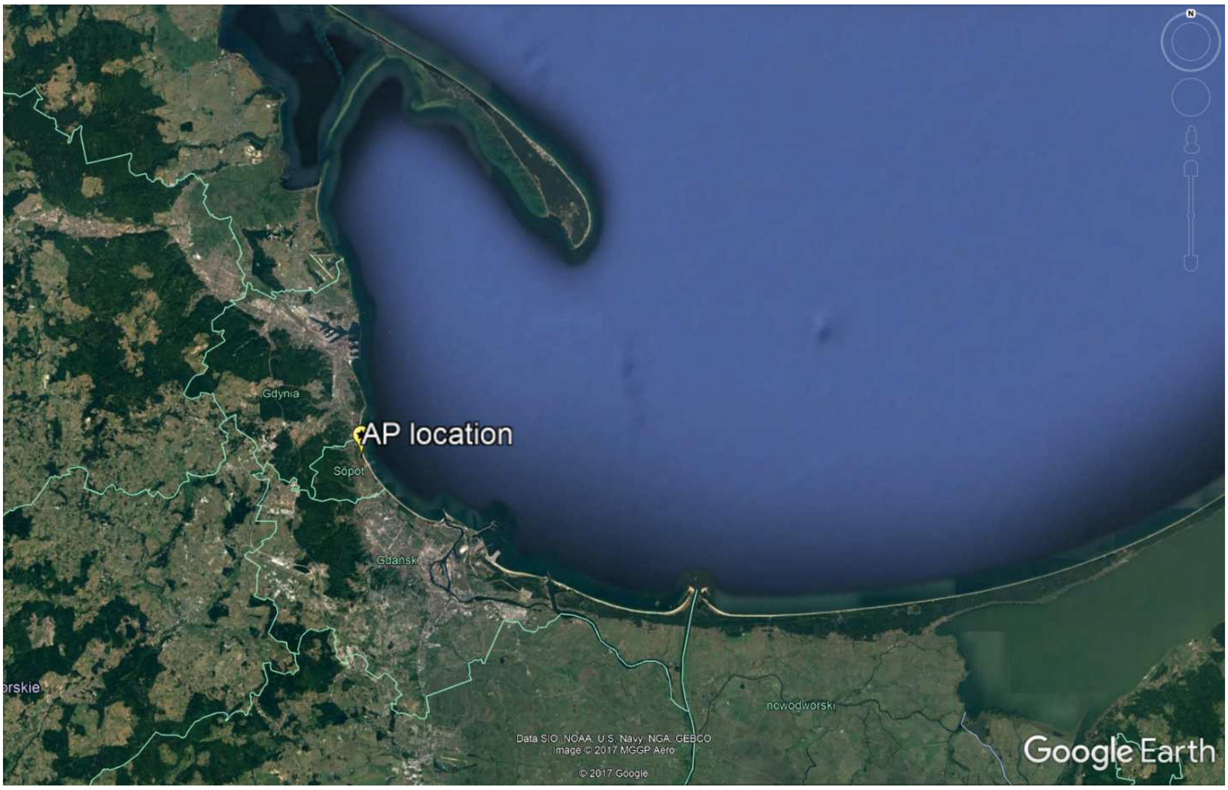

Figure 7 The location of the Wi-Fi Access Point used during the on-board tests

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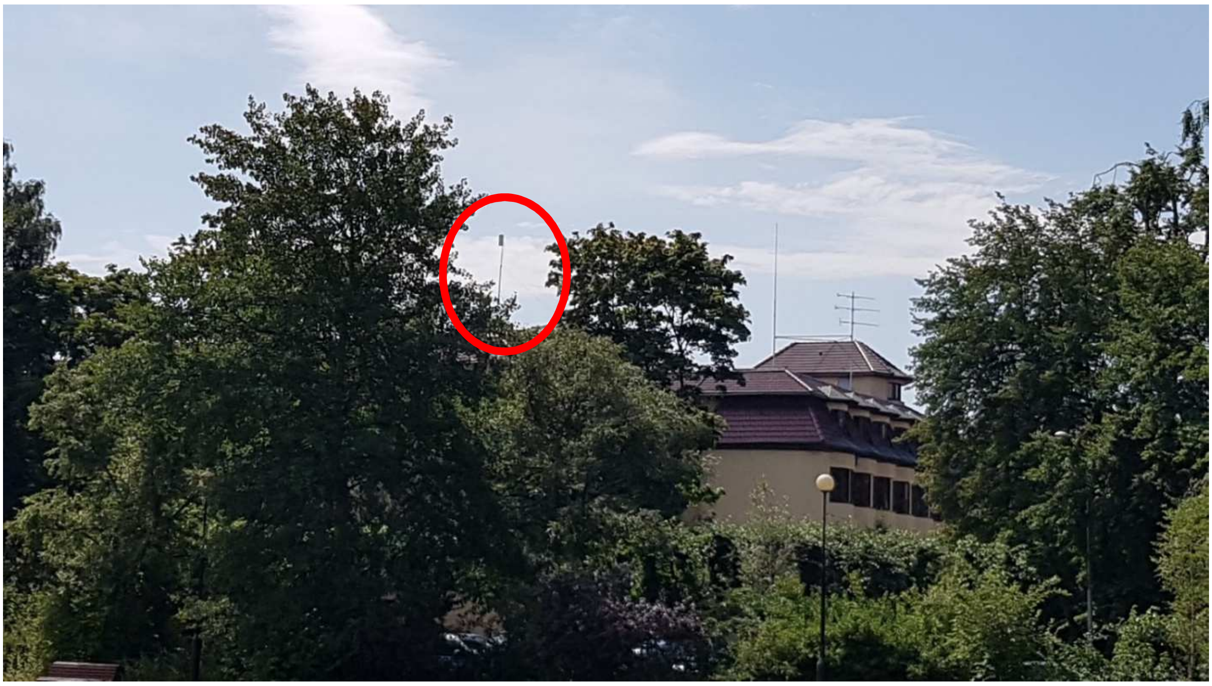

Figure 8 The placement of the Wi-Fi Access Point antenna on the roof of the building

Figure 9 The Wi-Fi Access Point antenna used during the tests

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4.2. On-board tests results

Before the on-board tests, the NIT team conducted pre-tests of the Seamless Roaming algorithms in 2 different locations: in the laboratory and in a rural environment (where propagation conditions are quite similar to the maritime environment, because of the small number of high obstacles in the propagation path, as well as the considerably long distance to the nearest base station of the cellular network and relatively small number of the network users). The pre-tests lasted almost 50 days, starting from 12th June 2017.

The pre-tests results were used to determine proper values of the $interval$ and N_{tests} parameters to the network monitoring algorithm (see: section 2.2.), as well as the weight coefficients in the quality calculation formula. Having completed this stage, the final values of the parameters were as follows:

- $interval = 10\ s,$
- $N_{tests} = 5,$
- $w_t = 0.5,$
- $w_p = 0.5.$

In the result, the final quality calculation formula can be expressed as:

$$quality\ = throughput\_rate\ * powerLvl\_rate * 100.$$

The on-board tests took place from 1st to 3rd August 2017 in the area of the Gdansk Bay (Poland). The route of the vessel recorded during the tests is depicted on Figure 11.

During the actual on-board tests, the switching procedure was successful in 100% of cases, with exactly half of the switches being the LTE-to-Wi-Fi switches, and the other half being the Wi-Fi-to-LTE switches.

The chart in Figure 12 shows the distance from the ship to shore as a function of time (recorded during the tests). The Wi-Fi network was preferred by the Seamless Roaming algorithm near the coast (Wi-Fi was used in the area up to 1.6 km distance from the Wi-Fi Access Point antenna). At greater distances, though, the Wi-Fi connection became very unstable (with packet loss ratio greater than 50%), so the algorithm selected the LTE radio link instead.

Instability of the Wi-Fi network can be seen at charts generated on the basis of data collected by the MMP. In case of the radio link chosen by the Seamless Roaming algorithm, the client's downlink data rate was in the range from 1500 to 2500 kb/s when using the LTE link, whereas in case of the Wi-Fi link the downlink data rate varied from 500 to 4000 kb/s and the transmission was interrupted several times due to lack of signal.

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The LTE network had a significant decrease in quality and the received signal power during a period from 10:00 to 11:30 UTC, when a lot of people were seen on the beach. It was probably caused by the increasing number of network users at this time in the coastal area.

Charts on Figures 13, 14 and 15 present an estimated throughput, a measured received signal power level and a computed quality rating, respectively, that were recorded during the tests. Figures 16 and 17 show the real data rate (in downlink and uplink, respectively) achieved by the Seamless Roaming client during the tests, measured by the MMP.

The real data rate recorded by the MMP was quite stable, with only a few "peak" values visible on the chart. It is because the Seamless Roaming algorithm preferred the LTE most of the time, and it was working on Wi-Fi network only for a small periods of time (e.g. for 100 s, see: Figure 1, where the tests were executed with the default value of the parameter $interval = 10$).

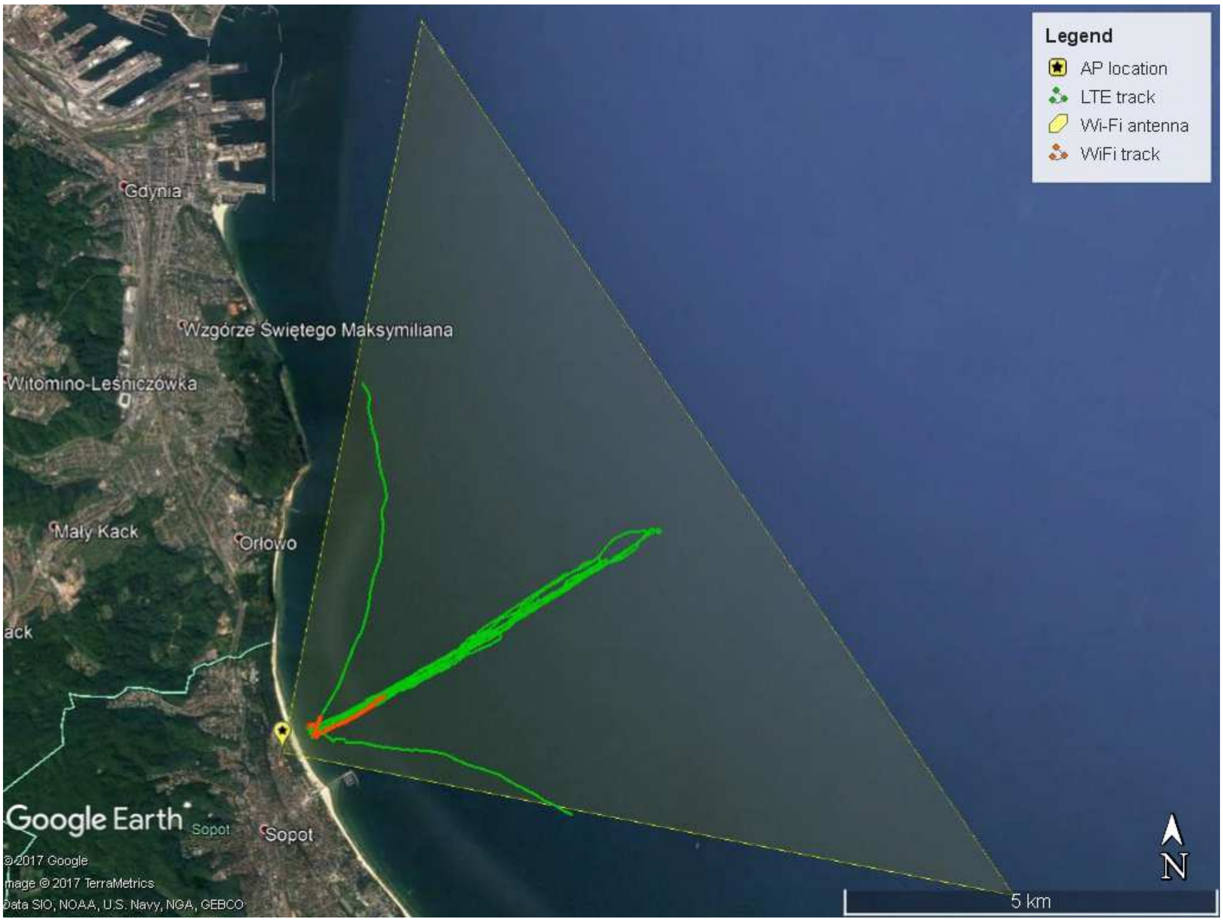

Figure 10 The route of the vessel during the tests, and the visualization of the Wi-Fi Access Point antenna sector

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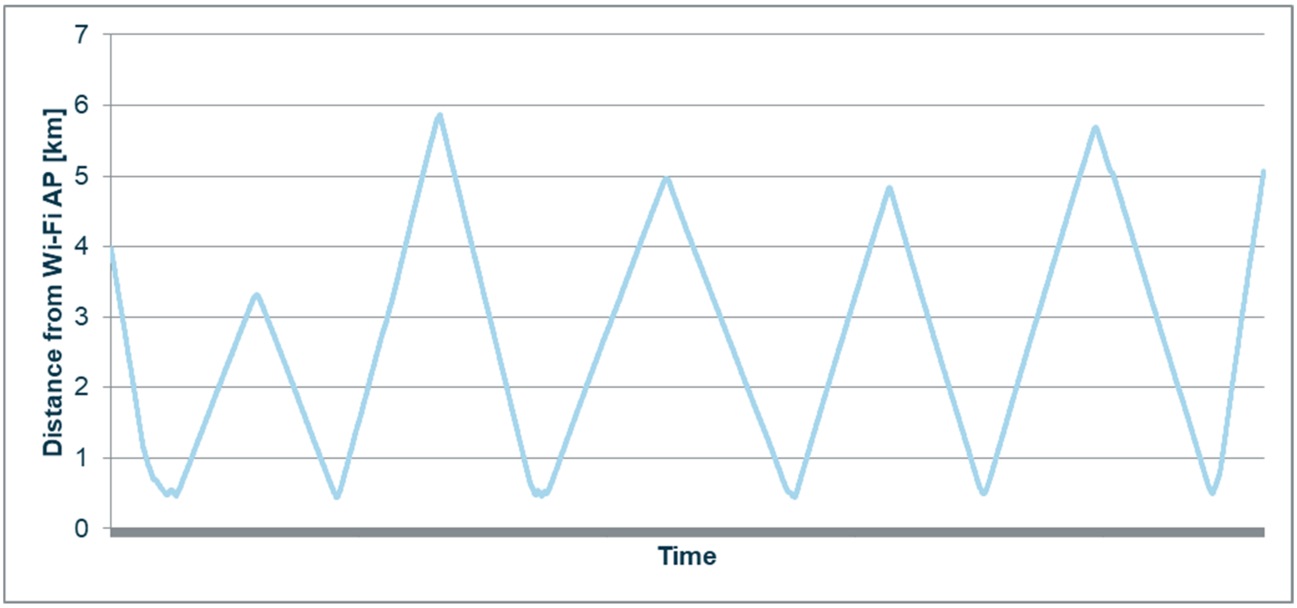

Figure 11 The distance from the ship to the Wi-Fi access point during the on-board tests

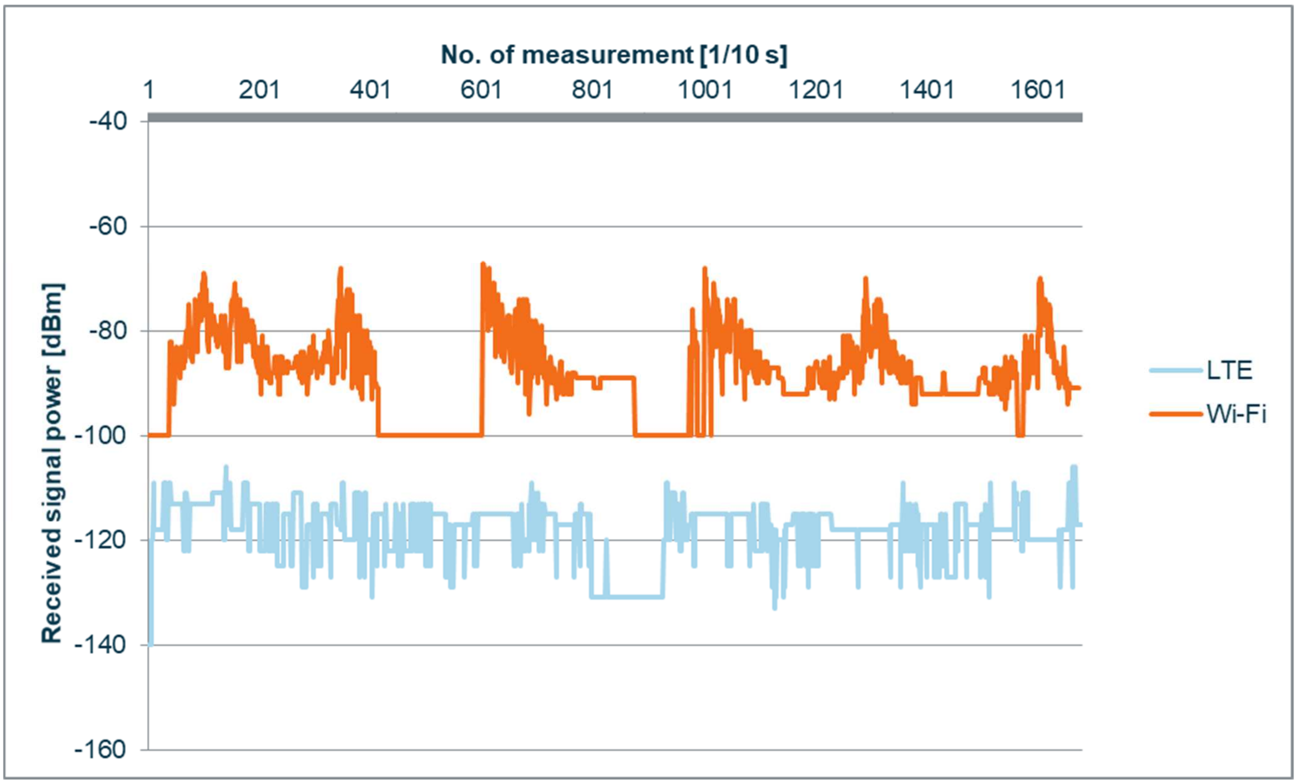

Figure 12 Received signal power level for all of the available radio links, measured during the on-board tests

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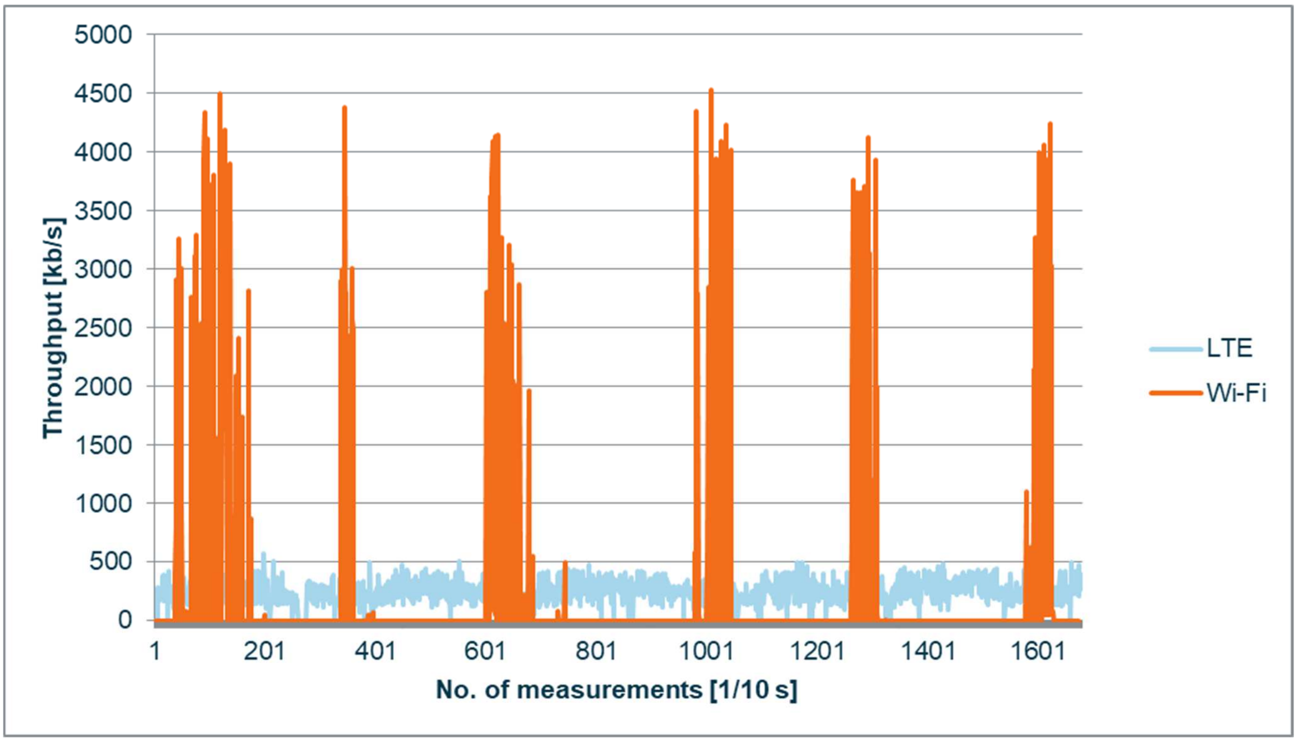

Figure 13 Estimated throughput of the available radio links during the on-board tests

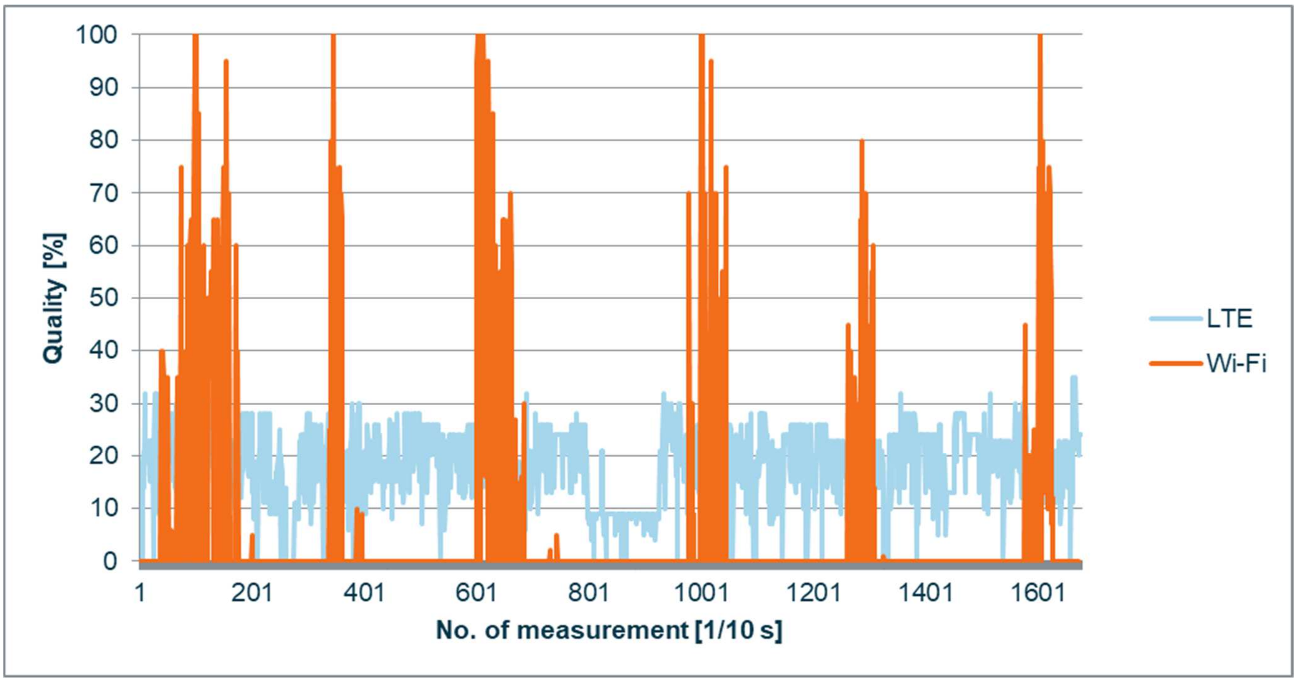

Figure 14 Quality of the available radio links computed by the Seamless Roaming algorithm during the tests

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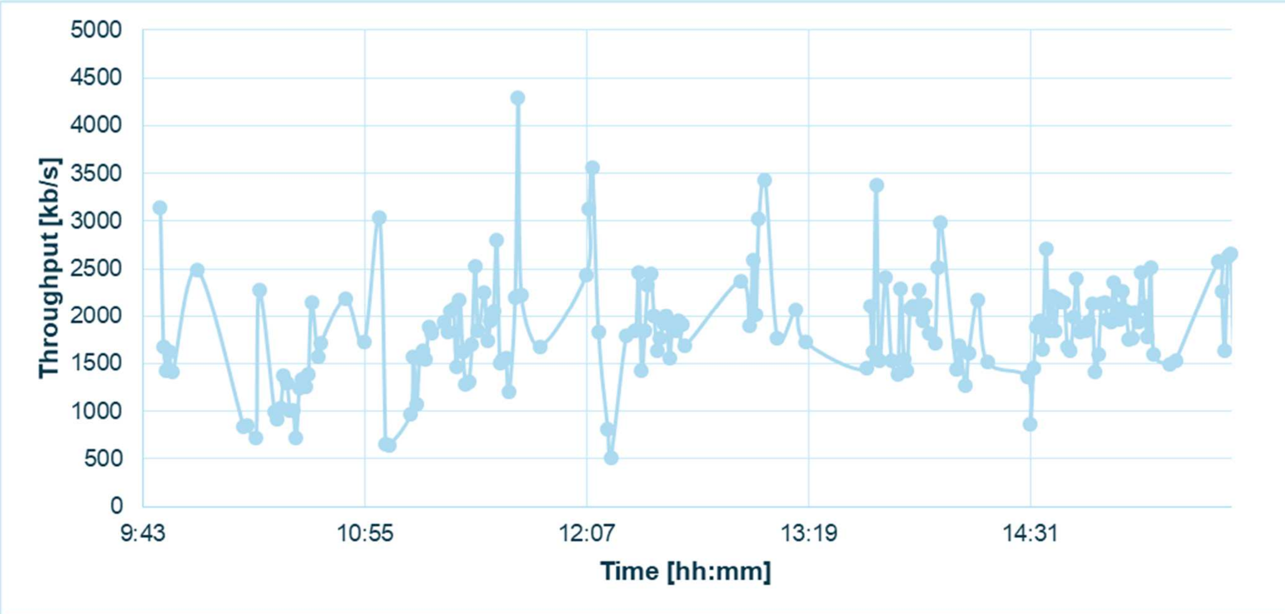

Figure 15 Downlink data rate achieved by the user of the Seamless Roaming system, measured by MMP during the on-board tests

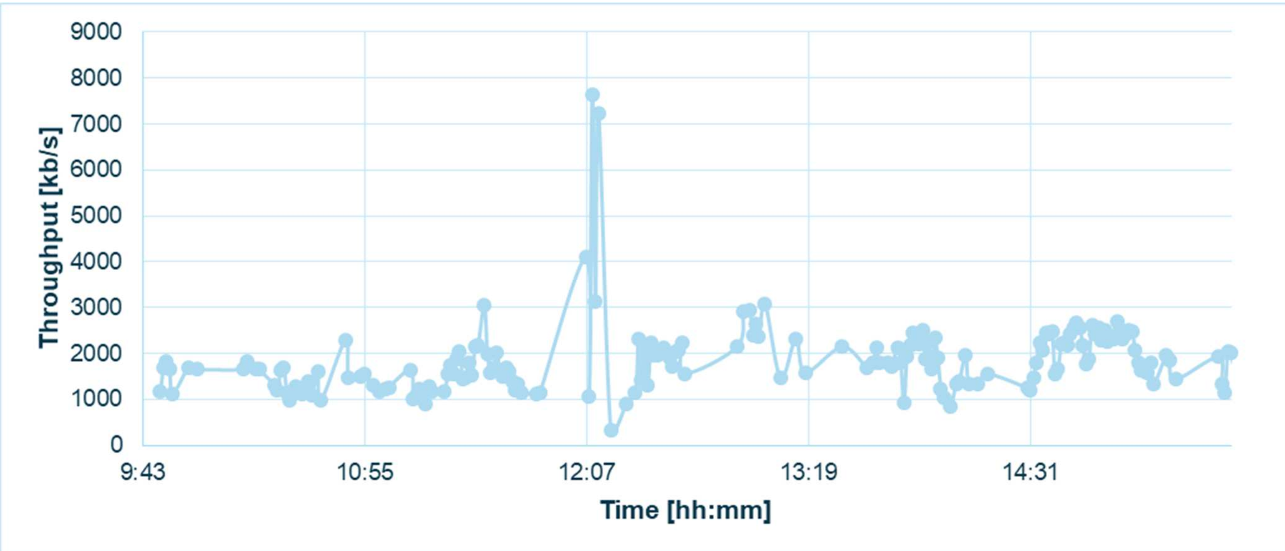

Figure 16 Uplink data rate achieved by the user of the Seamless Roaming system, measured by MMP during the on-board tests

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5. Technical details of the simulator

The Seamless Roaming simulator uses the same algorithms as the Seamless Roaming testbed (in fact, it uses the very same implementation of the algorithms), with modified functions that are communicating with the operating system of the device, and different Network Monitoring entity.

The simulator is not using the specific Linux (or any other OS) procedures – the decisions made by the radio link switching algorithms and measurements made by the Network Monitoring entity are executed “virtually”, and they only change the state of the simulator (not the OS).

The Figure 4 presents the concept of the simulator modularity (which is similar to the concept of the Seamless Roaming testbed, described in the Deliverable D2.7 [1]). The Control Unit collects data from other modules: geographical data from a GNSS receiver, measurement results from the Network Monitoring software (which is continuously scanning network interfaces), and is interoperating with the Simulation Control software, from which it receives configuration commands and to which it sends logs. Then, based on the collected data, the Seamless Roaming algorithm decides if the switching procedure needs to be executed.

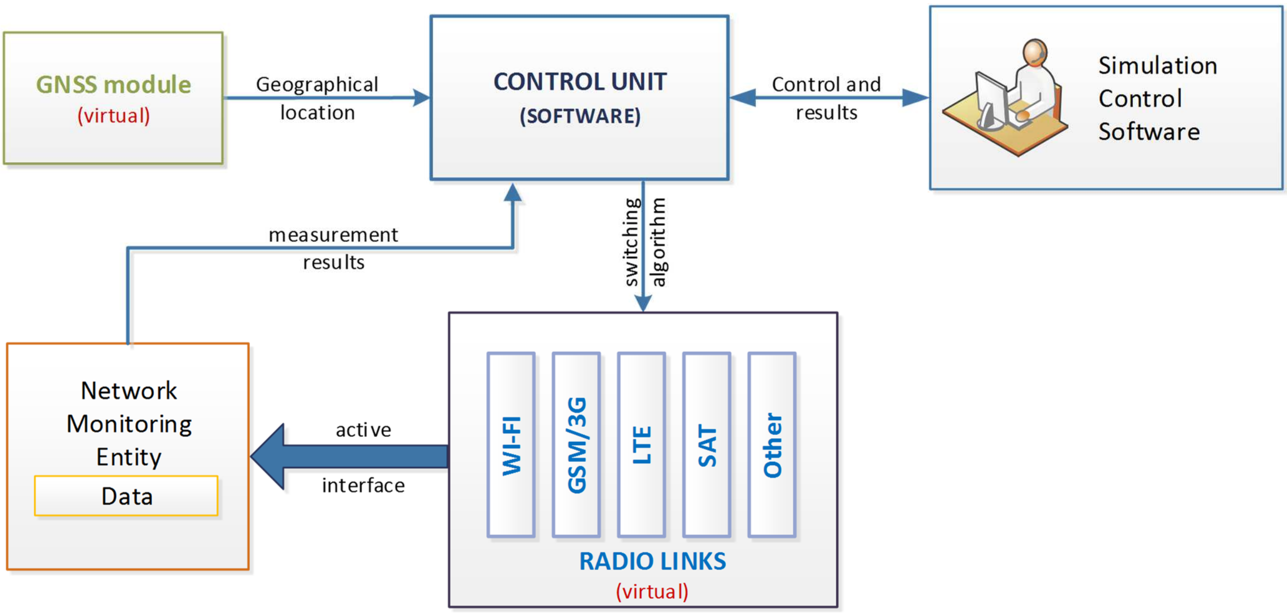

Figure 17 The Seamless Roaming simulator design diagram

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6. Simulation tests

In the simulation tests, the NIT team used the "offline" measurement database collected during several on-board testing campaigns in the past[1], as well as the theoretical analysis of the satellite radio links. The measurement results from the database were used instead of the real-time radio link measurements that were used in the on-board tests.

6.1. Simulation test scenarios

To show different situations that could occur during the ship's course, two different test scenarios were defined for the purpose of simulations.

6.1.1. Scenario 1

The first simulation scenario is based on the real-world situation, when the vessel with the Roaming Device installed on-board approaches the shore (e.g. the harbor), and then changes its direction and moves away from the shore (a similar situation was tested during the Seamless Roaming on-board tests).

The chart on the Figure 18 depicts a function of the distance from the ship to shore over time, assumed for the first scenario of the Seamless Roaming simulation tests.

Charts on Figures 19 and 20 present the received signal power levels and throughputs, respectively, assumed for the first scenario of the Seamless Roaming simulation tests.

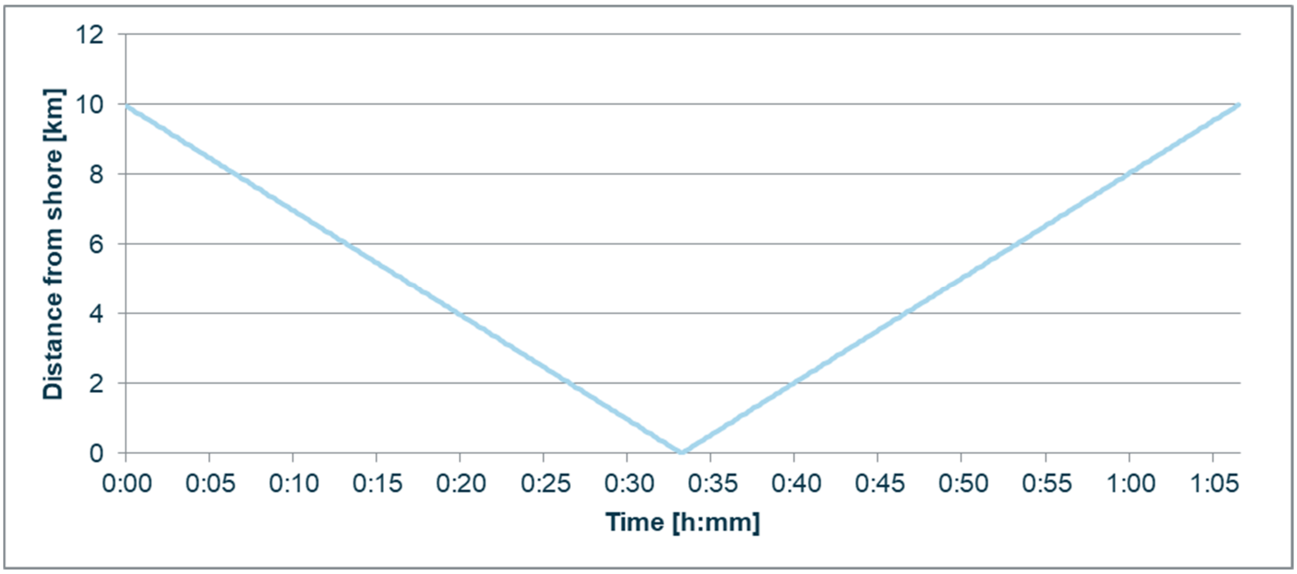

Figure 18 The distance from the shore over time, that was assumed for the first simulation scenario

[1] During previous NIT's activities and projects, including the EfficienSea 1 project.

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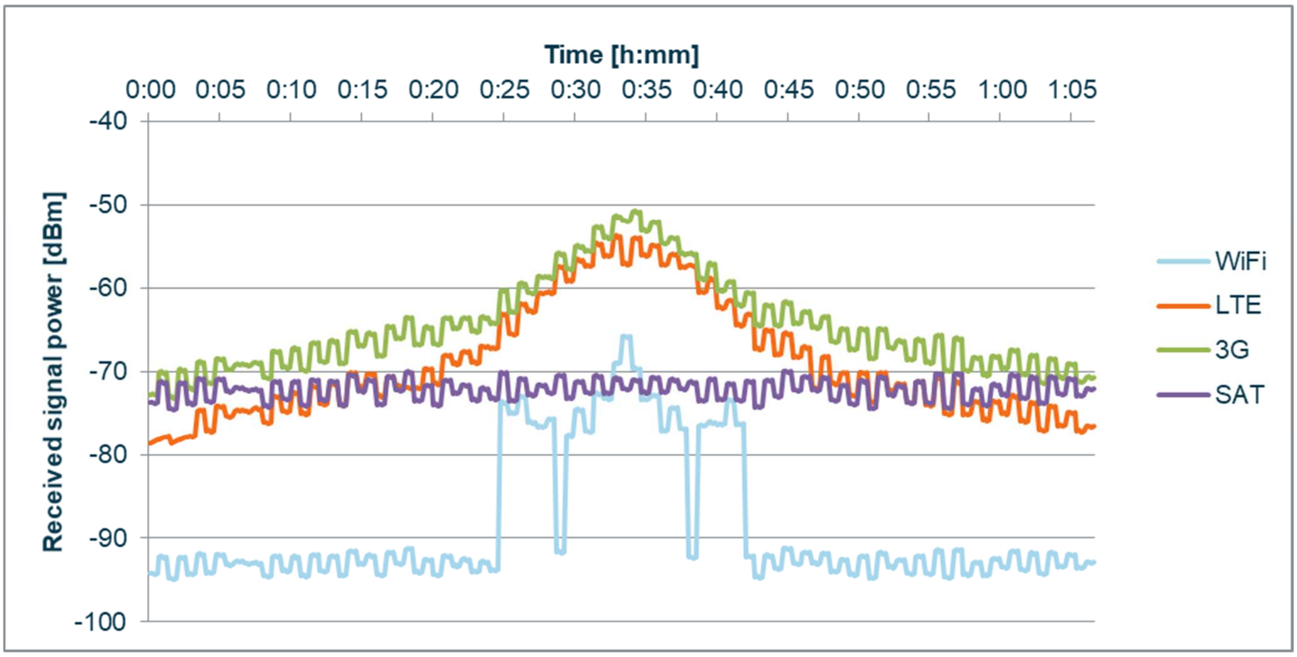

Figure 19 The received signal power over time assumed for the first simulation scenario for each of the available radio links

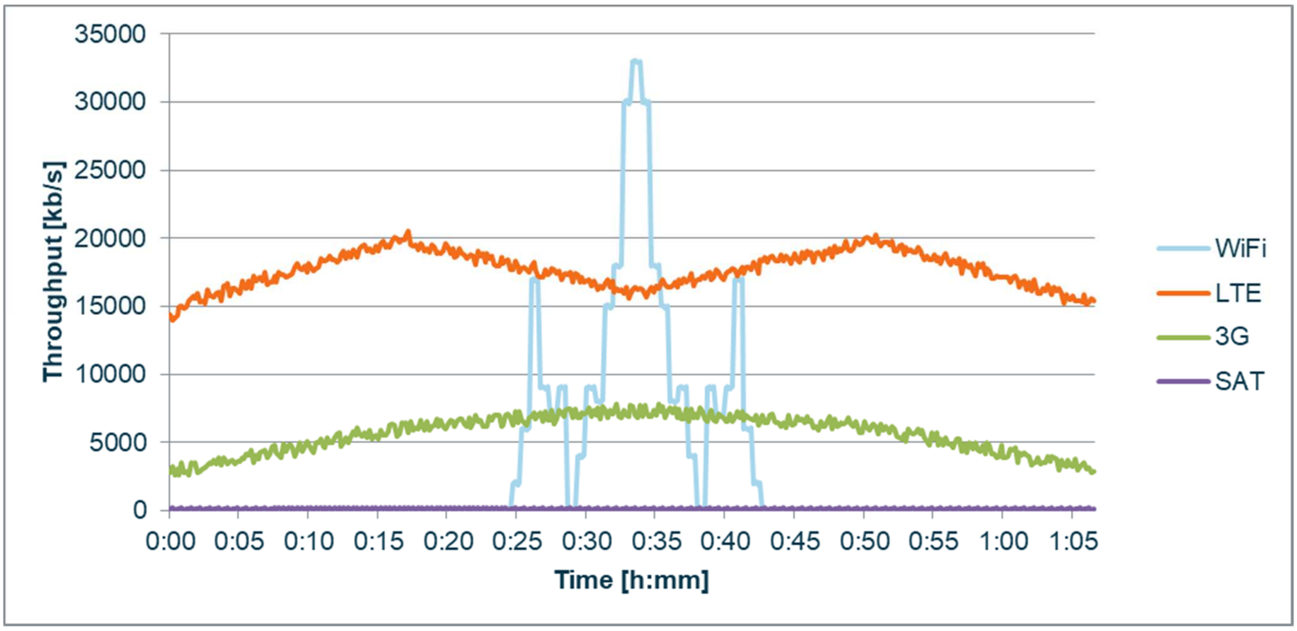

Figure 20 The throughput over time assumed for the first simulation scenario for each of the available radio links

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6.1.2. Scenario 2

The second simulation scenario is based on the real-world situation, when the vessel with the Roaming Device installed on-board moves around some point, changing its distance from the shore (in this scenario, the distance is changing from 40 km to 30 km). The Wi-Fi and 3G signals are not detected at these distances from the base stations, so the algorithm takes into account only the LTE and satellite radio links. Additionally, at some point of its route, the vessel approaches the area beyond satellite coverage.

The chart in the Figure 21 depicts a function of the distance from the ship to shore over time, assumed for the second scenario of the Seamless Roaming simulation tests.

Charts on Figures 22 and 23 present the received signal power levels and throughputs, respectively, assumed for the second scenario of the Seamless Roaming simulation tests.

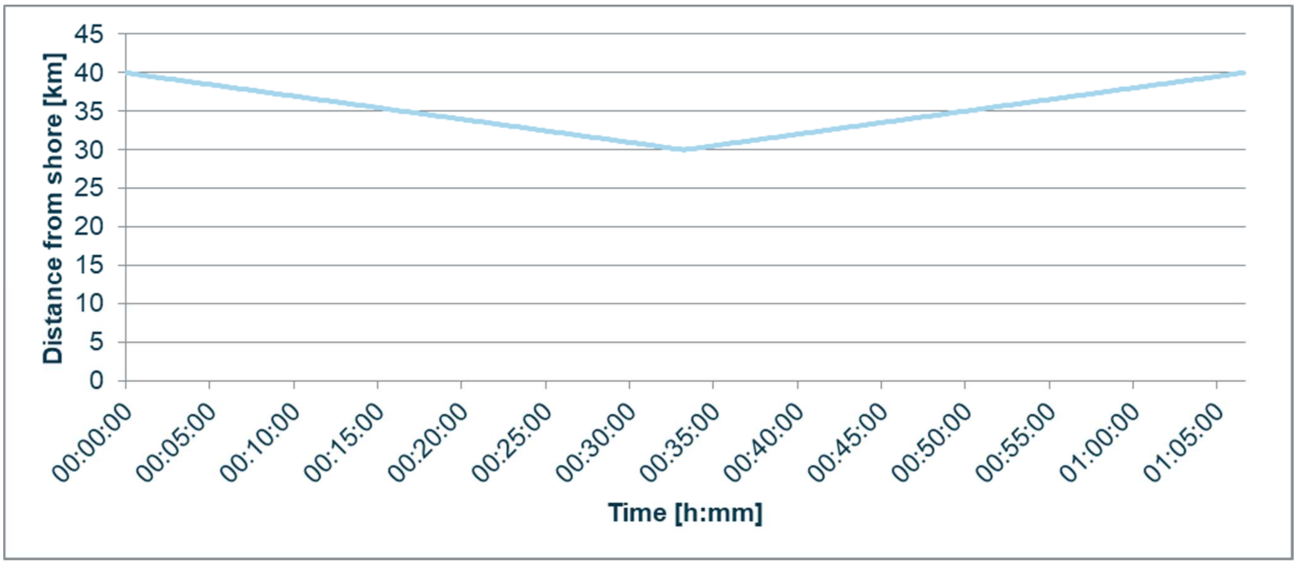

Figure 21 The distance from the shore over time, that was assumed for the second simulation scenario

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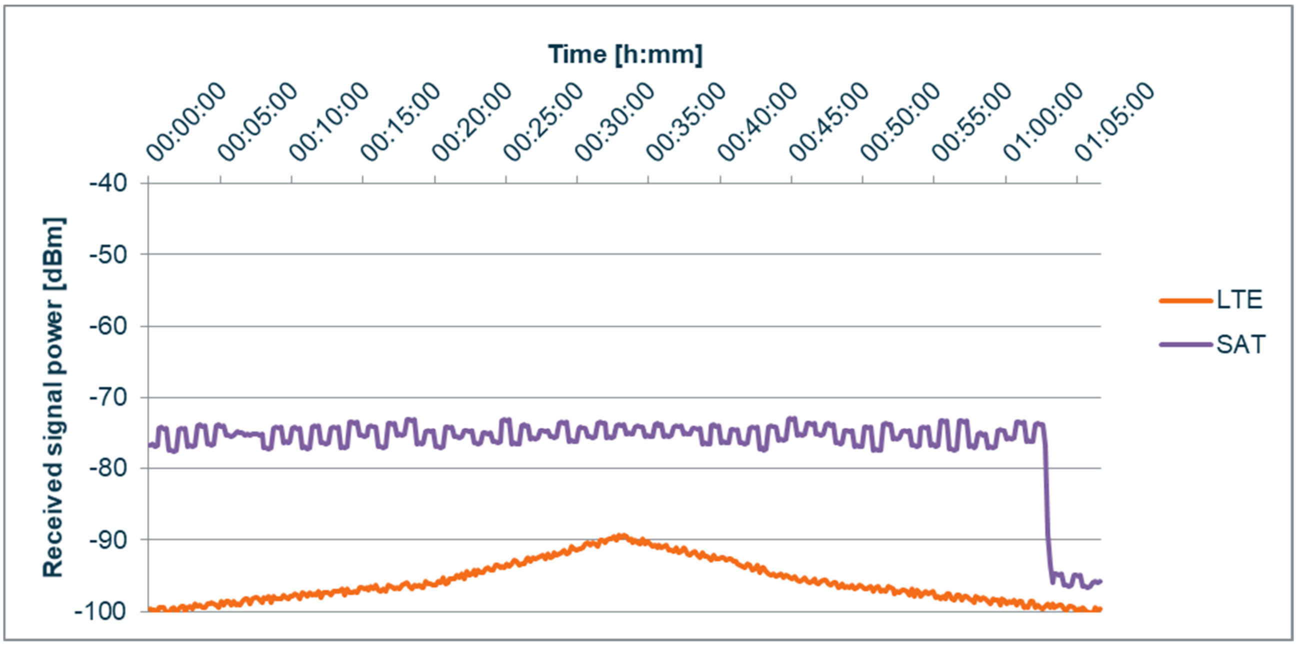

Figure 22 The received signal power over time assumed for the second simulation scenario for each of the available radio links

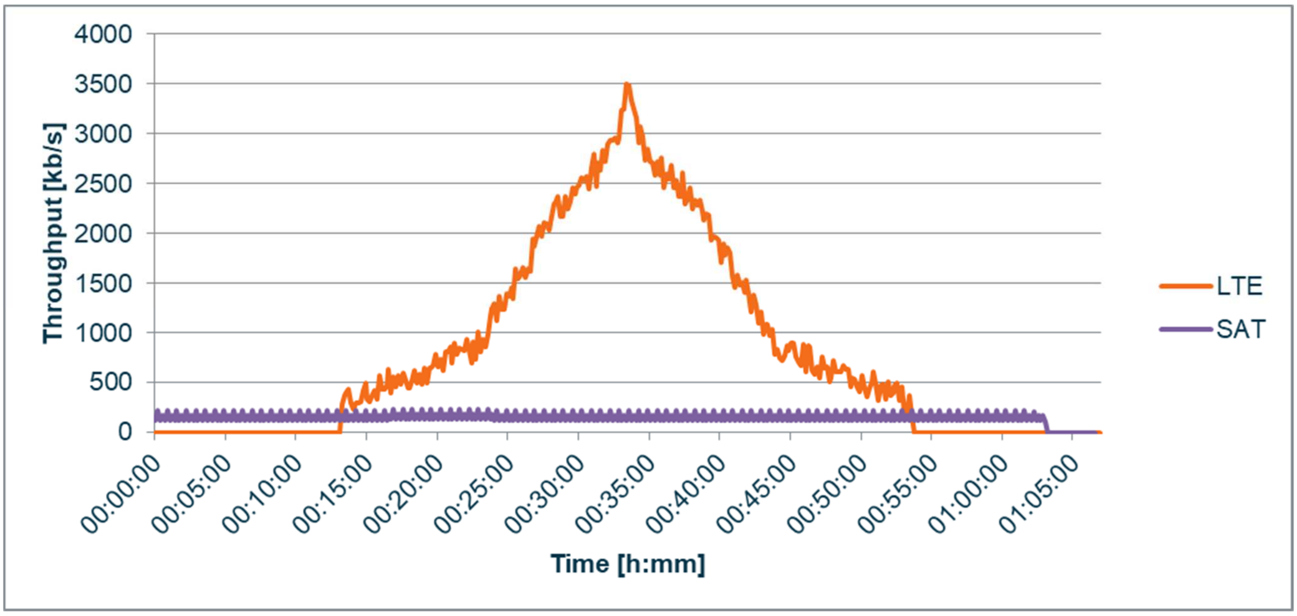

Figure 23 The throughput over time assumed for the second simulation scenario for each of the available radio links

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6.2. Simulation tests results

The resulting quality parameters presented in this section were computed by the Seamless Roaming algorithm during the simulation tests, with the input parameters based on the assumptions described in the previous section (slightly modified, with addition of small pseudo-random values).

During the simulation tests, the Seamless Roaming algorithms parameters were the same as for the on-board tests.

6.2.1. Scenario 1

The first simulation, configured with the assumptions of the Scenario 1, was running for approximately 2 hours. The charts presented below illustrate the actual input values for the algorithm for all of the network monitoring algorithm measurements. The last figure in this section presents the quality parameter computed for each of the radio links during the simulation, and the moments where the system triggers the switching algorithm.

It is clearly visible that, despite having four different radio links, the algorithm almost always preferred the LTE radio link, and occasionally switched to the Wi-Fi link (in cases where small distances to the shore were simulated).

Charts in Figures 24, 25 and 26 present a measured received signal power level, an estimated throughput, and a computed quality rating, respectively, that were recorded during the execution of the first scenario of the simulation tests.

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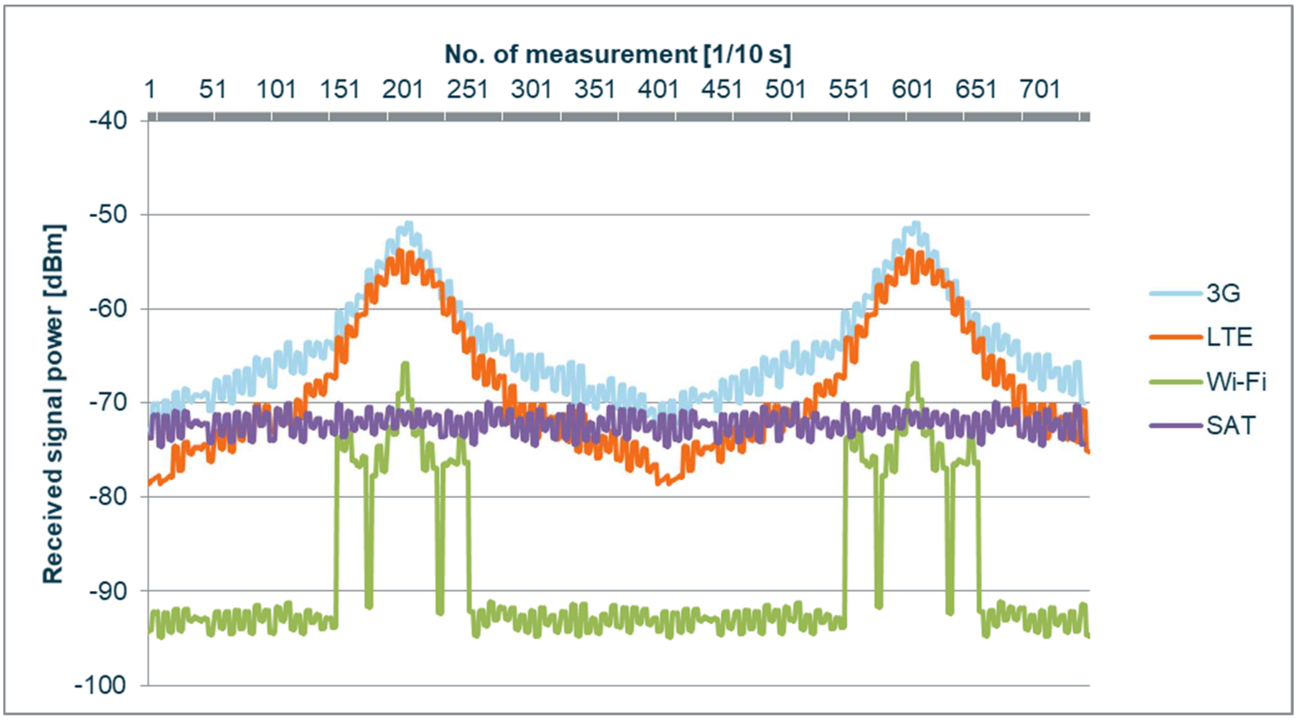

Figure 24 The received signal power over time for each of the available radio links, serving as the input for the Seamless Roaming algorithm in the first simulation scenario

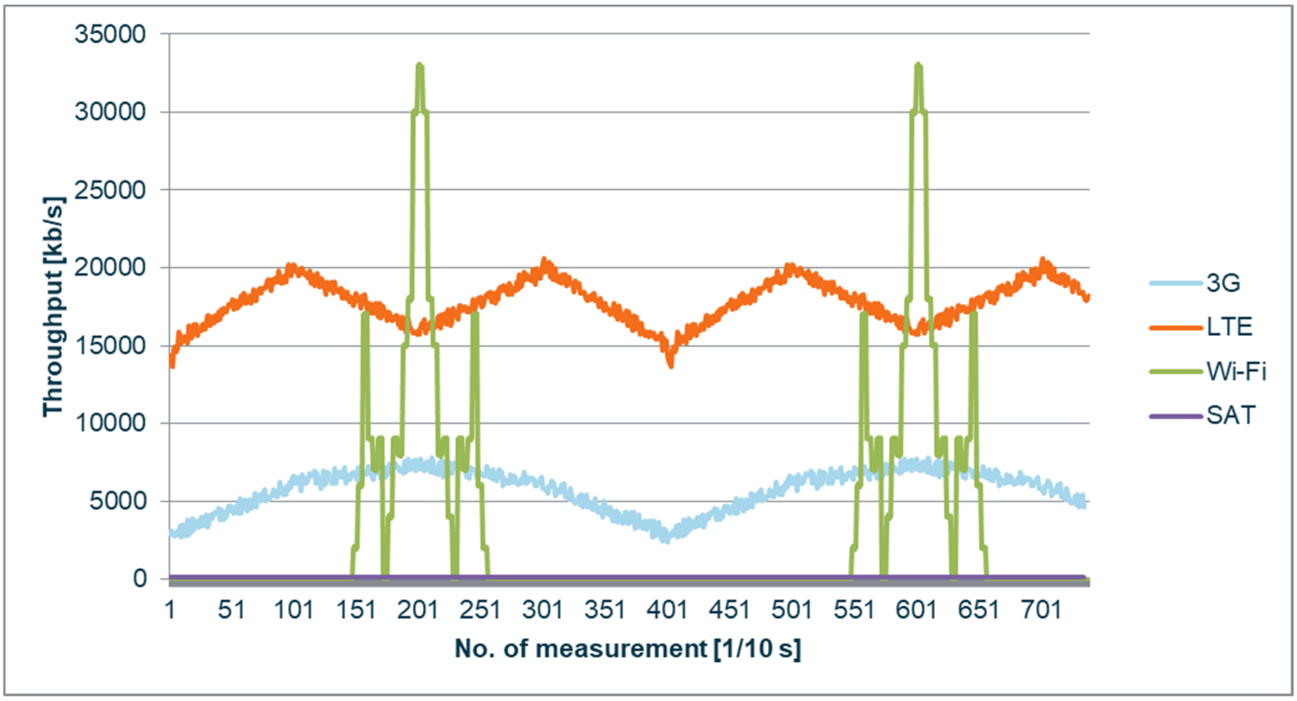

Figure 25 The throughput over time for each of the available radio links, serving as the input for the Seamless Roaming algorithm in the first simulation scenario

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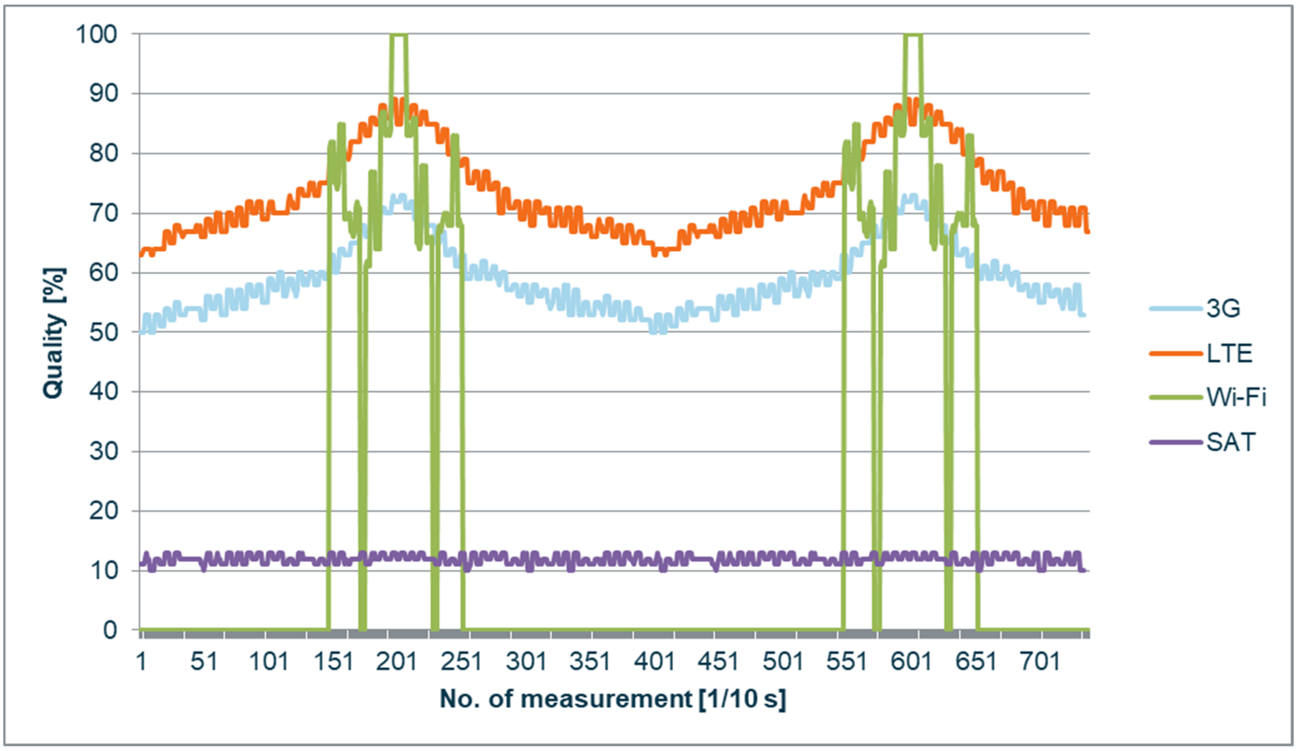

Figure 26 The quality computed by the Seamless Roaming algorithm for each of the available radio links during the first simulation scenario

6.2.2. Scenario 2

The second simulation, configured with the assumptions of the Scenario 2, was running for approximately 2 hours. The charts presented below illustrate the actual input values for the algorithm for all of the network monitoring algorithm measurements. The last figure in this section presents the quality parameter computed for each of the radio links during the simulation, and the moments where the system triggers the switching algorithm.

Because of the special treatment defined in the algorithms for the satellite links, the estimated throughput for the SAT link given as an input to the algorithm is constant, and is equal to 100 kb/s. The received satellite signal power level is not constant, however, it is quite stable (with the exclusion of the area beyond satellite coverage, where the signal power level is low). With this in mind, it is clear that the quality parameter for the satellite link should be stable, but very low. For the LTE radio link, the situation is different – at the moments when the simulated distance to the shore is relatively low, the received signal power and the throughput of LTE link are high, but at greater distance from the shore, the received signal power will be below the receiver sensitivity, and in that case the transmission using the LTE network will be impossible.

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Charts on Figures 27, 28 and 29 present a measured received signal power level, an estimated throughput, and a computed quality rating, respectively, that were recorded during the executing of the first scenario of the simulation tests.

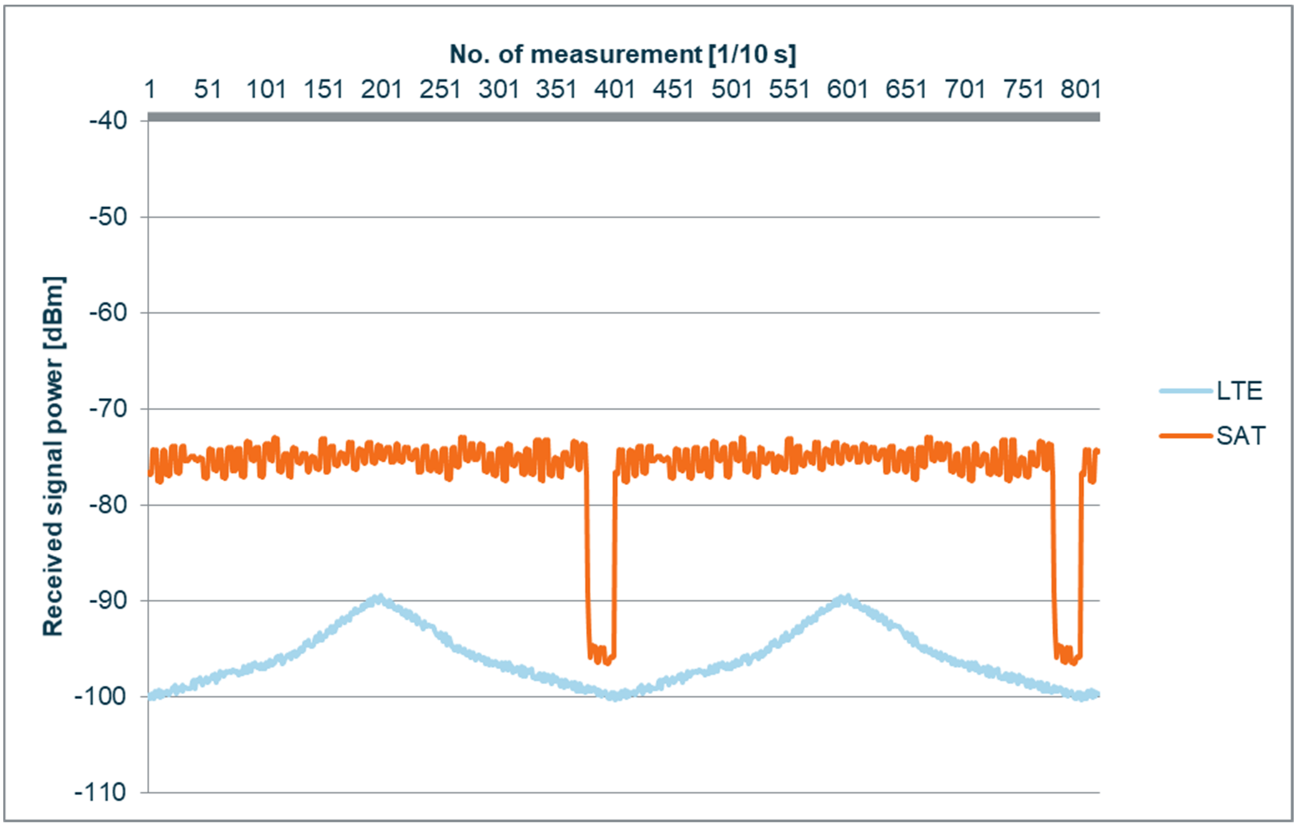

Figure 27 The received signal power over time for each of the available radio links, serving as the input for the Seamless Roaming algorithm in the second simulation scenario

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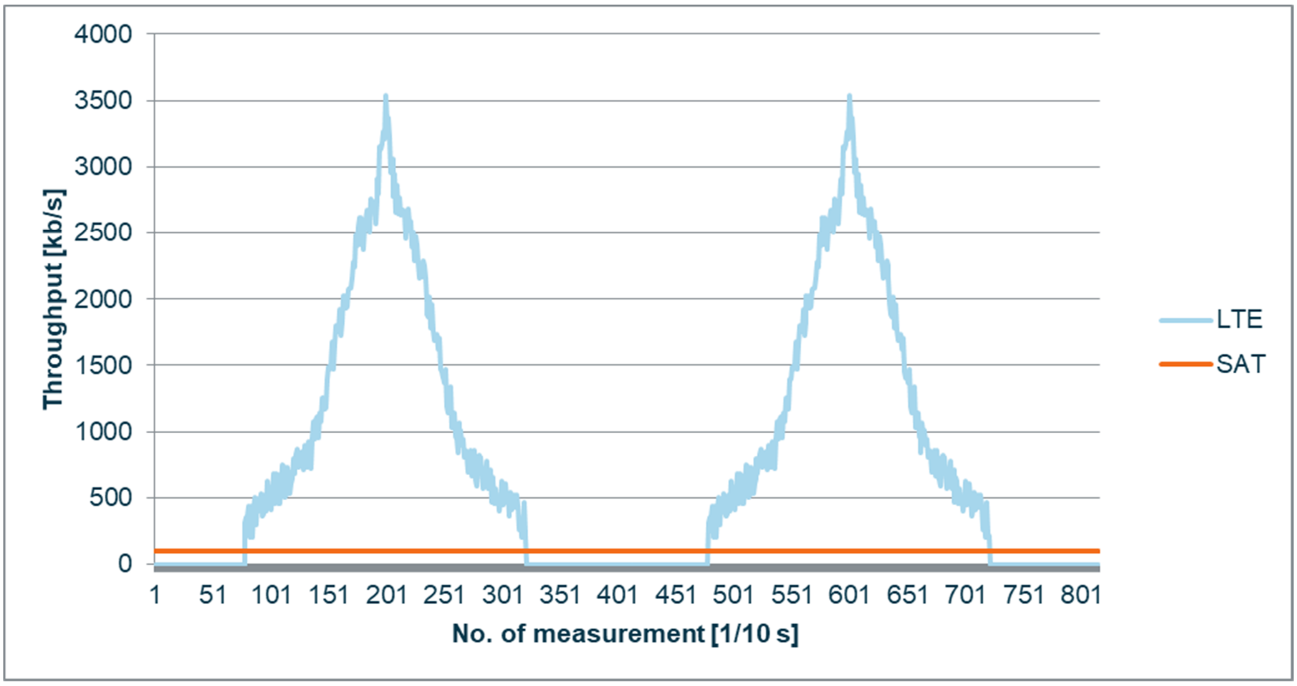

Figure 28 The throughput over time for each of the available radio links, serving as the input for the Seamless Roaming algorithm in the second simulation scenario

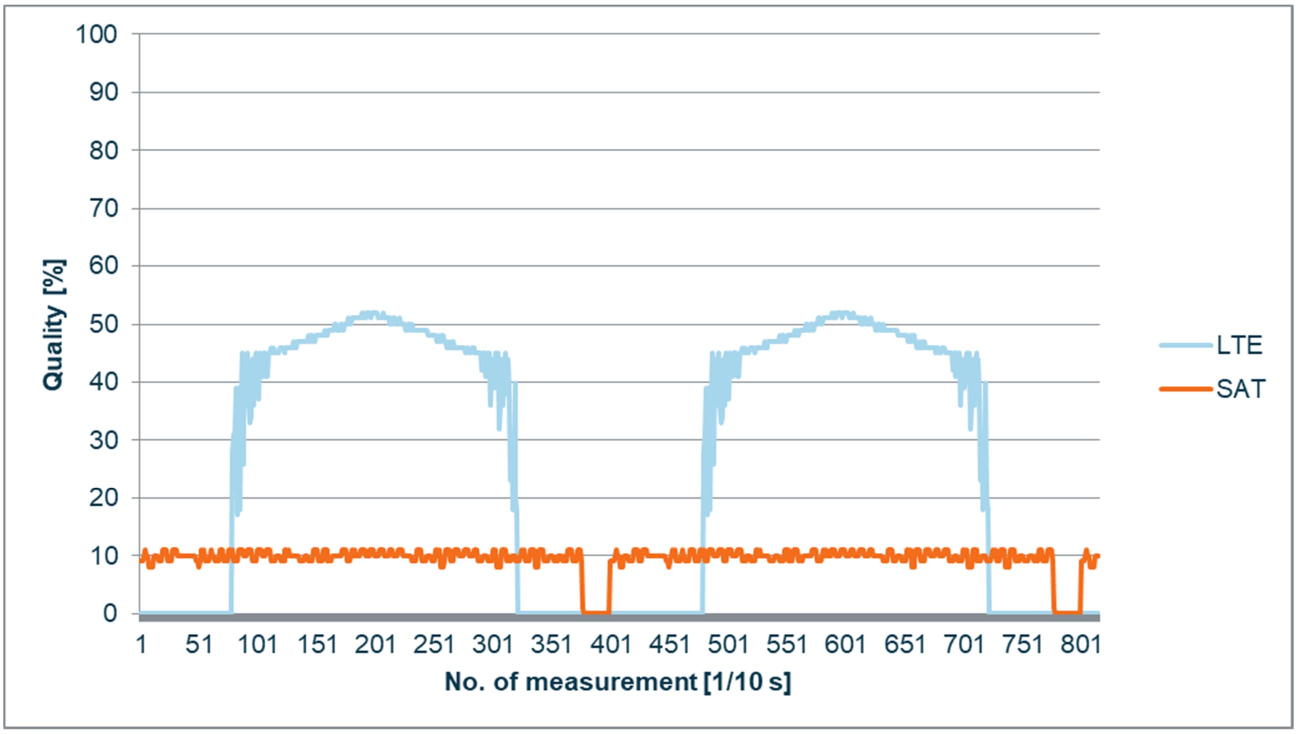

Figure 29 The quality computed by the Seamless Roaming algorithm for each of the available radio links during the second simulation scenario

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7. Conclusions

Tests of the Seamless Roaming algorithms were conducted to validate the technology in a laboratory environment, as well as in the relevant environment (i.e. maritime). The tests also confirmed the correct operation of the algorithms in different conditions.

LTE data rates were low during the on-board test – it was caused by the vessel's physical attributes (small ship, with LTE antenna at a relatively low altitude).

During the test, the ping method (ICMP protocol) was used to estimate the throughput of a given network. Generally, the method proved rather reliable in case of Wi-Fi networks, but in case of cellular networks the obtained results were often underestimated. The reasons for that are as follows:

- Ping utilizes a very small packet of data, which might not be a very good representation of actual sizes of packets transmitted in the network;
- Ping usually utilizes the basic (i.e. the simplest) modulation scheme (e.g. QPSK rather than 64QAM). In a normal network's operation, much more advanced modulation schemes might be selected, depending on the radio channel state. Obviously, higher-order modulation schemes are capable of providing much higher data rates than the simplest modulation;
- The scheduler will probably assign much less resources to the ping service than to the "typical" data transmission services.

These three observations, taken together, clearly demonstrate that in many cases the ping-based throughput estimation results might be underestimated (i.e. the real data rates might actually be higher than the values indicated by method's output).

The parameters used in Seamless Roaming algorithms should be modifiable by the network administrators in some way, for example with use of a graphical user interface (GUI). However, basing on the results from the tests, it was possible to determine the default values for the parameters, which will work for the majority of vessels and situations on-board. These default values are presented in the Table 5.

It is possible to define several different methods of the throughput estimation. We recommend to give the network administrators a possibility to implement throughput estimation methods of their own, or at least to choose an estimation method from a list that consists of two or more throughput estimation methods.

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Table 5 Default values for the Seamless Roaming algorithms parameters

Parameter name	Default value	Notes
N_{tests}	5	Can be modified by User Requirements
w_t	0.5	Can be modified by User Requirements
w_p	0.5	Can be modified by User Requirements
$interval$	$10\ [s]$	Can be modified by the network administrator
$throughput\_limit$	$500\ [\frac{kb}{s}]$	Can be modified by the network administrator
$powerLvl\_limit$	See: Table 2	Can be modified by the network administrator (should be based on the technical parameters of the antennas)

The API interface that could be used to modify the algorithm parameters is currently being developed and will be delivered with the whole Seamless Roaming software.

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References

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[6] Vendor website: https://www.linksys.com/us/p/P-SE2500/

[7] Vendor website: http://us.dlink.com/products/connect/7-port-usb-2-hub/

[8] Vendor website: http://creotech.pl/wp-content/uploads/2016/11/LTE-USB-Access-Head.pdf

[9] Vendor website: http://www.tp-link.com.my/products/details/cat-11_TL-WN722N.html

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Appendix 1 - Review procedure

No°	Reviewer Initials	Reference in document (General or Paragraph, Figure …)	Type (editorial, structural, formulation, error)	Reviewer's Comments, Question and Proposals	Editor's action on review comment.
1.	RN	4.1. (5.1)	general	It would be worthwhile to add a map showing an exact WiFi access point's location during the tests	The map has been added – see fig. 8
2.	RN	Chapter 5 (6)	general	What assumptions have been made with respect to the satellite links throughput? The tests of the satellite links should not require an actual transmission due to high costs of such transmission.	It has been explained and discussed in section 2.2
3.	BW	On-board test results and Chapter 5 (6)	general	How does the algorithm assess the received signal power? I think this assessment should be carried out differently depending of the radio link's type.	Appropriate explanation has been added in section 2.2.
4.	BW	Chapter 5 (6)	general	Some introduction in the chapter describing simulation tests scenarios would be appreciated. The scenarios should reflect realistic situations that might really happen on a ship with a hybrid system on-board.	The scenarios have been described. It's been also explained how they relate to realistic situations that might occur at sea.
5.	BW	General	general	Could you explain the difference between the simulator and the solution that was utilised during the on-board tests?	A new chapter (chapter 4) has been added
6	PAN	Introduction	formulation	Please consider the alternative wording suggested	OK
7	PAN	Chapter 2.2 page 8	editorial	Please consider the alternative wording suggested	OK

	PAN	Chapter 2.3	structural	Please consider adding information about an optional user interface,	Information about GUI is added now (in Conclusions)
9	PAN	Bullet list chapter 3.1	Editorial	Alignment of terminology between the bullet list and Fig.2	OK
10	PAN	Chapter 3.2	Editorial	It looks like parts are missing in the ship side of Fig.3	Figure 3 depicts the network architecture (the networking aspect of these devices), whereas Figure 2 shows all devices used in the testbed, including the ones which are not connected to the network (and have not been assigned any IP address)
11	PAN	Chapter 5	Editorial	Consider changing the word planned with used	OK
12	PAN	Chapter 5.2	structural	The chapter "During the actual on-board…… please consider the conclusion, With only two states in the switch i think it will always be 50/50	There are other situations possible. For example, the number of switches could be equal to zero, or the number of switches from the first picked interface to the second could be greater by one than the number of switches in the opposite way (if measurements ended at the moment in which the second interface was being used).
13	PAN	Chapter 4	Structural	Consider moving chapter 4 to after chapter 5 to make a logic bridge between the onboard test and simulation	OK
14	PAN	Conclussion	Structural	What is written in the last sentence is already touched in the introduction. Consider a short conclusion on the report and the opportunities it give.	Last sentence is removed

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15	HBH	Chapter 1	General	"It has to be mentioned that the activities described in this Deliverable are connected with the works in the Task 2.4. concerning the Roaming Device, and could be seen as an input to the Task 2.4." As you know, we disagree on what is expected as input from T2.3 to T2.4. We expected a working prototype to use in a prototype setup. Our understanding is also that it is NOT the job of T2.4 to develop a roaming device, but to use it as a component in the architecture. Therefore I disagree with the formulation in section 1.	The sentence is changed now
16	HBH	Conclusion	General	"The results achieved during the tests of the Seamless Roaming algorithms and presented in this Deliverable should be used as an input to the Task 2.4 works which are dedicated to the development of the Roaming Device prototype." This statement is NOT correct. It is our understanding that T2.3 are supposed to deliver a prototype roaming device to T2.4.	Last sentence is removed

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