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Simultaneous Operations During LNG Bunkering at LNG-powered Vessels

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ABSTRACT: The usage of liquefied natural gas (LNG) as fuel for maritime vessels is widely viewed as a transitional option to meet the stringent EU and IMO regulations in the context of long-term decarbonization. Usage of LNG as a transitional fuel is associated with the goal of reducing or completely eliminating CO2 production (related to the emissions from fossil fuel use such as oil, hard coal, and lignite) in the shipping industry. Bunkering operations can be done by trucks, bunker barges and specialize ports. In case of bunkering by trucks or barges, vessel can provide at the same time other operations, such as cargo operations or ballasting. This article considers some key issues associated with Simultaneous Operations (SIMOPS) Procedure Guide. A typical case study of bunkering LNG-powered vessel "Containerships Nord" by barge in Rotterdam is used to demonstrate and verify the proposed SIMOPS Procedure. The results indicate that any SIMOPS activity undertaken by LNG Bunker vessel, LNG receiving vessel and Container Terminal shall be reviewed and scheduled to minimize any potential interference or safety impact.

1 INTRODUCTION

Due to the emission of detrimental by-products, including, nitrogen oxides sulphur oxides, etc., which therefore gives rise to severe environmental impacts, the shipping regulatory authority has imposed several rounds of increasingly stringent environmental regulations controlling sulphur oxide emissions between 2006 and 2015. These regulations have thus prompted ship owners and operators to reconsider their fuel choices. In place of heavy fuel oil, liquefied natural gas (LNG) is one of the best alternatives as a shipping fuel, which brings more advantages from environmental viewpoints, practical and financial [1].

LNG bunkering demands careful attention to safe operations as it entails potential risks pertaining directly to the cryogenic liquid transfer and vapour returns, much more than the conventional liquid fuel bunkering.

It is apparent that further advancement of LNG as a marine fuel relates to three factors: the building of new vessels (or modification of existing ones), the development of adequate bunkering infrastructure, and the establishment of an adequate and comprehensive regulatory framework. at this article we will stop at regulatory framework to combine bunker process and other operations, which vessel should be carry on.

The purpose of this Simultaneous Operations (SIMOPS) Procedure is to provide all personnel from LNG Bunkering/Receiving vessels, Bunkering Truck and Container Terminal who are involved with simultaneous operations during LNG Bunkering with a sound knowledge of the relevant safe work practices and procedures applicable to simultaneous operations.

This Procedure shall also be used to determine the compatibility, interference and limitations raised during the planning and operational stages of LNG Bunkering operations (Fig. 1).

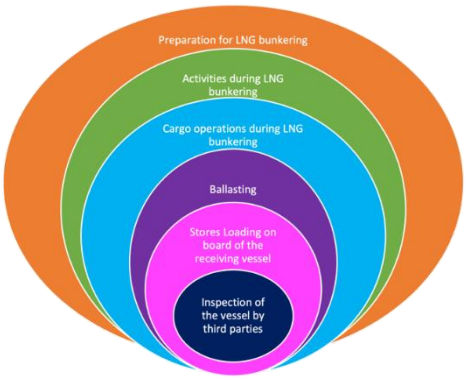

Figure 1. The activities covered by SIMOPS Procedure.

The requirements of this SIMOPS Procedure shall be applied to cargo operations during LNG bunkering activities to highlight and mitigate any potential restrictions and/or safety impact when planning SIMOPS work activities due to take place at the same time and in the same/vicinity location.

As a minimum, this Procedure shall be distributed by Company to the personnel referenced in the list below:
- Recognized Organization
- Port Authorities
- Container Terminal Administration
- LNG Supplier
- Bunkering vessel
- Bunkered vessel
- Simultaneous Operations Leader
- Simultaneous Operations Controller
- Person in Charge (PIC) of Bunkering operations

To summarize, Simultaneous operations are allowed by Company on board of LNG fuelled vessel when this recommended procedure are followed and conditions outlines in the procedures are met.

2 LITERATURE REVIEW AND PROBLEM STATEMENT

The maritime industry is under pressure to improve its sustainability – especially its emissions to air. In terms of greenhouse gas emissions (GHG), the industry needs to take advantage of improvements today – to minimize the long-term impact on the planet [2]. According to article [3], various incentives and motivations, including laws and regulations, to reduce shipping's exhaust emissions are being adopted. One of the emission reduction attempts is the use of LNG as a marine fuel. LNG, as a marine fuel, produces virtually 0% sulphur dioxide emissions. Moreover, compared with conventional marine bunker fuels, LNG has the potential to reduce carbon dioxide emissions by 10% to 20%, nitrogen oxide emissions by up to 80% or 90%, and particulate matter emission by 98% to 100%. At this paper examines the regulatory legal regime in relation to the use of LNG as marine fuel and highlights the areas where further development is necessary. But this analysis was done only by presenting regulations and requirements for use of LNG as fuel. For further development of it need to collect all practical data such as costs, reduction of CO2 emission, quantity of vessel, etc.

Paper [4] states the general regulation for actions to cut the GHG emission from shipping. The main strategy of GHG envisages the reduction of international shipping in carbon intensity (reducing CO2 emissions from transport activities on average for international shipping from 40% to 70% by 2050). According to this, growing the problem concerning new opportunities for seafarers. However, article is not covered new requirements for seafarer who will work at LNG-powered vessels (which certificates and training they should have).

Study [5] consider about issues with LNG terminals. It shows the main aspect of problems that can arise during bunkering at such terminals. Further research could be in comparing specialized terminals and bunkering through the barges. At the other study [6] employs a second-stage empirical analysis approach that selects criteria for shipping companies' selection of a LNG bunkering port through a literature review and interviews, and then adopts a fuzzy-AHP methodology to reveal the priority of the LNG bunkering port selection criteria in LNG bunkering decision making. The results indicate that most shipping companies decide on LNG bunkering port with a stronger emphasis on safety/security or port services rather than port reputation. According to this research, port Rotterdam provides safe operation to bunker vessels through barges. In our paper will provide an example on using SIMOPS directly in port of Rotterdam.

The usage of LNG as fuel for maritime vessels (Fig. 2) is widely viewed as a transitional option to meet the stringent EU and IMO regulations in the context of long-term decarbonization [7].

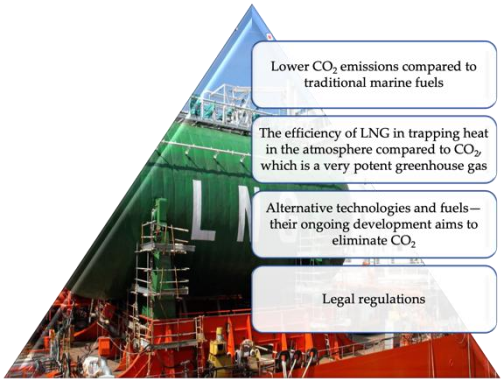

Figure 2. Associations with usage use of LNG as a transitional fuel

LNG as a shipping fuel has been gaining supporters worldwide and is considered the most advanced new technology in the shipbuilding industry. Compared to conventional fuels, the use of LNG as marine fuel makes it possible to reduce the following [8, 9]:
1. Sulfur oxide emissions by ca. 90–95%;
2. Carbon dioxide emissions by ca. 20–25%.

The most important of the criteria mentioned above is the possibility of bunkering LNG on key shipping routes. The existing LNG-bunkering infrastructure is poorly developed and situated along the coast. The ultimate LNG-bunkering infrastructure should

comprise facilities, LNG-powered ships, and LNG bunkering vessels capable of meeting the demand in SECA while adhering to the principles of rational management [10].

Paper [11] proposes the size of the distribution of LNG as a marine fuel using the example of the southern Baltic Sea. This paper [11] presents the distribution network for LNG as a marine fuel in the southern Baltic Sea. An analysis of ship traffic intensity was presented and the demand for LNG as a bunker fuel was determined. Research was carried out for polish ports. For further development it can be done in same manner for Asian ports.

Analysis of prices for LNG as fuel was done in Netherlands (Fig. 3). As shown, prices are dropping down. That makes more benefits for owners to transfer to LNG fuel.

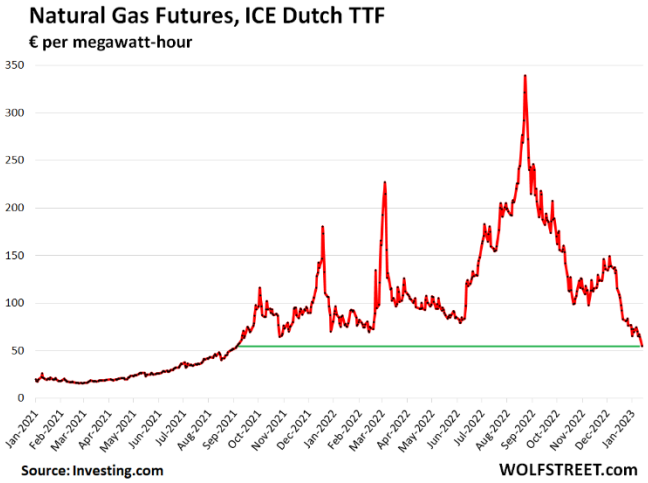

Figure 3. Prices for LNG fuel in Netherlands

Research [12] compares nine different scenarios with the use of different fuel for vessels such as ammonia, LNG, scrubber, low Sulphur fuel use and selective catalytic reduction, and each scenario is analyzed both environmentally and economically and compared to each other. However, this study does not indicate all available technologies to reduce emission.

Paper [13] presents an experimental methodology for LNG ship handling in ports using the full mission simulator and describes the implementation of the proposed procedure in simulation development. For the methodology of conducting a fruitful simulation, this paper provides the detailed experimental procedure systematically. Simulation was in the Meizhou Bay terminal in China. However, the high cost of the full mission simulation is controversial, and it may be a disadvantage to this method.

Article [14] provides an overview of performing shore-to-ship and ship-to-ship (Fig. 4) compatibility studies. The key aspects of ship-to-ship compatibility study are:

- Manifold configurations between bunkering and receiving vessels;
- Receiving vessel flat surface and bunkering vessel fender surface contact;
- Vessel mooring analysis;
- Personnel transfer approach;
- Crane outreach;
- Hose length.

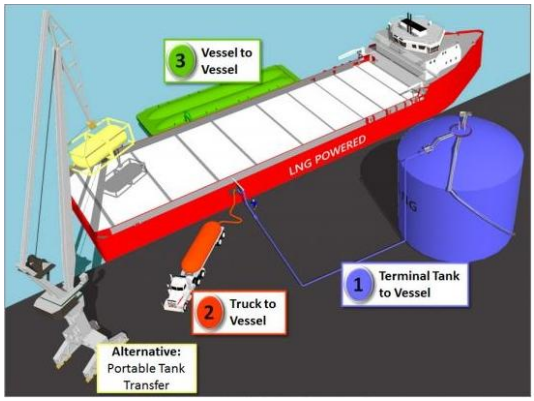

Figure 4. Types of LNG bunkering

Also, need to mentioned about importance of placement of LNG tanks. Most ships have two basic options for bunker tank placement: in the middle of the vessel, instead of the hold, and at the rear of the vessel's superstructure. Both of these options provide safety during SIMOPS [15]. This type of design can be seen in the example of the company Nordic Hamburg: mv "Containerships Nord" and mv "CMA CGM Mermaid".

Paper [16] proposes the concrete actions in case of different emergency situations during LNG bunkering. The proposed prevention actions and activeness in case of emergency further safety regulations, such as using Personal protective equipment, at ports and port areas for LNG bunkering should be developed. Further study of the problem of ensuring the safe operation of the LNG-powered vessels is relevant.

To sum-up, LNG bunkering is challenging process. It requires appropriate knowledge and skills. But during bunkering should not be postpone cargo operations or any other. For this reason, the importance of proper SIMOPS is leading to safe time for shipping and keep safety all operations.

3 FORMULATION OF THE GOALS OF THE ARTICLE (STATEMENT OF THE TASK)

The main aim of the article is to study the process of the possibility of conducting simultaneous operations during LNG bunkering, as well as the impact of this on the safety of the receiving vessel, bunkering vessel, and port terminal. The main secondary operation will be considered cargo operations on the vessel since they are of particular importance. The article demonstrates the possibility of reducing the minimum impact on the delay of cargo operations during LNG bunkering in the port of Rotterdam using the example of a m/v "Containerships Nord". Any SIMOPS activity undertaken by LNG Bunker vessel, LNG receiving vessel and Container Terminal shall be reviewed and scheduled to minimize any potential interference or safety impact.

To achieve this goal there are several tasks which should be determine:

1. Responsibilities of all relevant parties.
2. Area Classification on LNG-powered vessel.
3. Cargo operations SIMOPS
4. SIMOPS organization

The methodology of this research presents at Fig. 5. To attain the first task is necessary to designate responsibilities between SIMOPS Leaders and Controllers. To accomplish second goal, need to determine the location and quantity of hazardous and safety zones. The next step is distribution of tasks for cargo operation between terminal and vessel. Only after that will be possible to formulate the time management for organization of SIMOPS and create check lists. Also, it is important to organize assistance in case of emergency and support team. As the result of this article, Risk analysis flow chart will be presented.

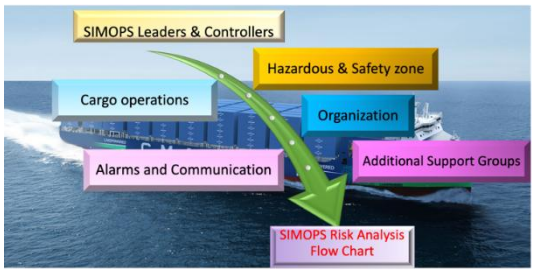

Figure 5. Methodology of the research article

4 PRESENTATION OF THE RESEARCH MATERIAL WITH A FULL JUSTIFICATION OF THE OBTAINED SCIENTIFIC RESULTS

4.1 *Responsibility of the SIMOPS Leader and Controller form vessel and terminal parts*

Information relevant to any SIMOPS activity, which has potential impact to the other personnel working in the same area, shall be informed to all concerned personnel prior to the commencement of the planned SIMOPS activity.

Urgent decisions regarding any SIMOPS shall fall under the responsibility of the SIMOPS Leader and Terminal Leader, who, through joint agreement, shall reach conclusion as to which activity takes precedent. For this reason is necessary to obtain the role of each participant at SIMPOS.

The company appointed Master (Chief Officer as deputy) on board the vessel to perform duties of SIMOPS Leader. The Simultaneous Operations Leader is responsible for proper coordination and safe simultaneous interfaces between parties as well as identification and resolution of any potential impact on other operations. The SIMOPS Leader liaises with all involved parties and supervisors such as Terminal leader, SIMOPS Controller, Bunkering vessel/truck Leader and Port Authorities. The SIMOPS Leader ensures that all members of the operational teams duly enforce the requirements of this SIMOPS procedure.

However, Bunkering vessel, Bunkering truck and Terminal's team shall remain fully responsible for the safe management of their own operations. The SIMOPS Leader acts under guidance and control of the Company, additionally he reports and liaises with Company as required.

It is the responsibility of the SIMOPS Leader to follow up to completion of all planned SIMOPS activities and to report to the Company any trend or omission, which could potentially jeopardize the planning schedule, work areas or terminal. In the event of a disagreement regarding the safety or schedule of a proposed simultaneous operation or the continuation of activity, the matter should be decided by the SIMOPS Leader. The SIMOPS Leader must oversee work coordination meeting.

The responsibilities of SIMOPS Leader present at Fig. 6, but this list is not limited.

Figure 6. SIMOPS Leader responsibilities

The Company appointed Chief Officer (2nd.Off as deputy) on board Managed vessels to perform duties of SIMOPS Controller. His duties provide at Table 1.

Table 1. Duties of Terminal and Vessel Controllers

No.	Duties of Vessel Controller	Duties of Terminal Controller
1	Control and monitoring of all simultaneous works	Control of SIMOPS activities from terminal side
2	Authorization for activities on board of involved personnel during SIMOPS	Ensuring proper authorization, issue and cancellation of Permits for SIMOPS in terminal areas
3	Risk Assessment preparation	Reporting deviations in the conditions of the Permit during cargo operations and, if necessary, the suspend or cancel SIMOPS
4	Preparing Permit to Work and Controlling during SIMOPS activities	Arranging means of emergency stop of cargo operations during SIMOPS activities
5	Evaluating the intended work to highlight any potential risks	Coordinating with the terminal's planner to ensure most optimum schedule is achieved for cargo operations during SIMOPS activities
6	Identifying the requirements for any electrical and/or process mechanical isolation	
7	Ensuring all preparations for SIMOPS completed as required	
8	Ensured requirement of SIMOPS in Safety zone fulfilled	

4.2 *Differences between Terminal and Operation areas with example*

Two types of areas are defined on LNG Bunkering: Terminal areas and Operation area on board of receiving vessel (Hazard and Safety Zone).

All berths fall under the responsibility of the Container terminal and Port Authorities (Terminal area) shall be deemed as Monitoring and Security zone. The Monitoring and Security Zone is the area around the bunkering vessel and receiving vessel where ship traffic and other activities are monitored (and controlled) to prevent entry and provide a 'stand-off' distance during the bunkering operation (Fig. 7).

All areas which fall under the responsibility of the SIMOPS Leader (Operation area) shall be deemed as Restricted Areas. Restricted areas shall be surrounded by security fencing and shall have warning signs erected. All work in restricted areas must be performed with a valid permit to work and entry is also restricted to authorized/permitted personnel (Fig. 7).

The Restricted areas fall into two zones as follows:
– Hazardous zone;
– Safety zone.

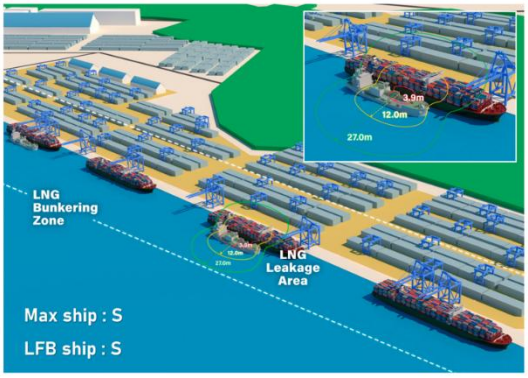

Figure 7. Restricted areas during LNG bunkering

Bunkering-related hazardous areas (Fig. 8) means any hazardous area zone 1 and zone 2 defined for:
– The receiving ship in accordance with IGF Code, regulation 12.5.
– The bunkering ship in accordance with IGC Code, regulation 1.2.24.

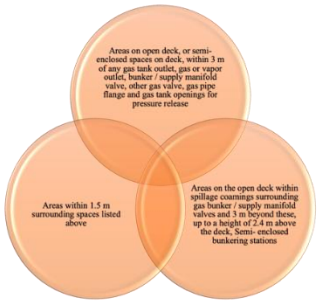

Figure 8. Determination of Hazardous areas on board

The bunkering-related hazardous zone (Fig. 9) also includes areas around LNG bunker vessel or shore-based bunkering facility. Depending on the outcomes of the risk assessment and the specific details of the bunkering process (equipment and transfer flow rates and pressures) the size of these areas may be increased.

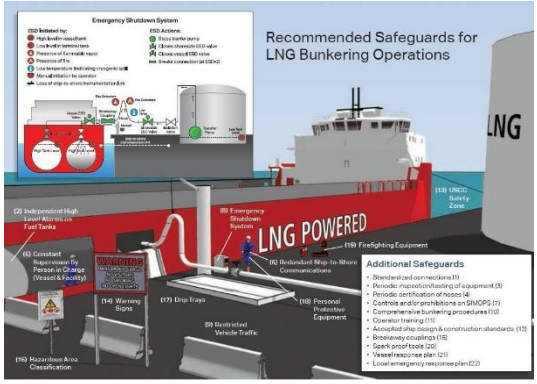

Figure 9. Hazardous zone during LNG bunkering

In the hazardous zones, only electrical equipment certified in accordance with IEC 60079 is permitted.

Attention is drawn to the following equipment, which is not intrinsically safe and should therefore be disabled, except if otherwise justified:
– The radar equipment on bunkering and receiving vessels, which may emit high power densities.
– Other electrical equipment of the ship, such as radio equipment and satellite communication equipment.

The "Safety Zone" (Fig. 10) is defined as an area around the bunkering station where only dedicated and essential personnel and activities are allowed. The Safety Zone shall be established around LNG Bunkering Operation. This is to control ignition sources and ensure that only essential personnel and activities are allowed in the area that could be exposed to flammable gas in the event of an accidental release during the LNG Bunkering Operation.

The dimensions of the safety zone are determined by a horizontal safety zone distance for each dispersion surface (depending on the actual wind direction) and a vertical safety zone distance above each dispersion surface. All horizontal distances should be seen from the location of the bunker station at the container vessel.

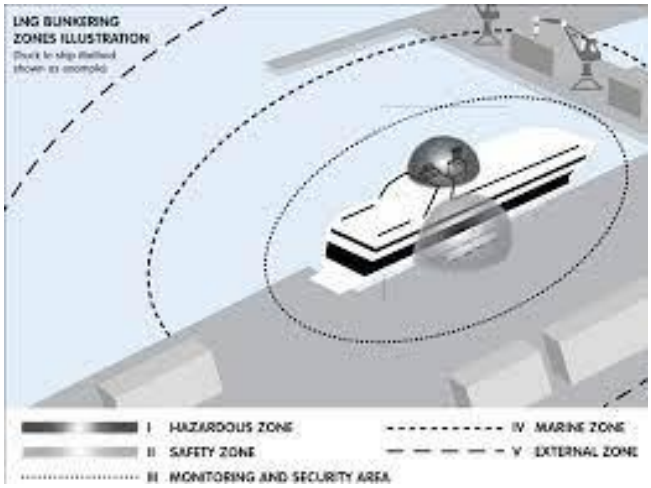

Figure 10. Safety zone during LNG bunkering

As an example we take m/v "Containerships Nord" and determine the Safety Zone on it during bunkering with "LNG London" in port Rotterdam.

The horizontal safety zone distances are as follows:
– In the direction of the container vessel / quay: 24 meters from bunker manifold
– In the direction of the LNG bunker vessel / water: 43 meters from bunker manifold
– In the direction parallel to the length of both vessels (above the water in between the vessels):48 meters from bunker manifold

It is important to note that the deck width of the container vessel is 26.5 m. The horizontal safety zone remains on the container vessel (extends 24 m from bunker manifold).

The extent of the horizontal safety zone in the three different directions is illustrated in the Fig. 11. There is a discontinuity of the safety zone at the bow of the LNG bunker vessel (intersection of dispersion surface water and LNG bunker vessel). This the area where the cloud still be flammable as determined by a detailed

evaluation of the dispersion on water in this area. The extent of the zone is conservatively assumed based on the maximum cloud width as function distance downwind, taking into account the possible wind directions and the physical obstruction of the bow of the bunker vessel.

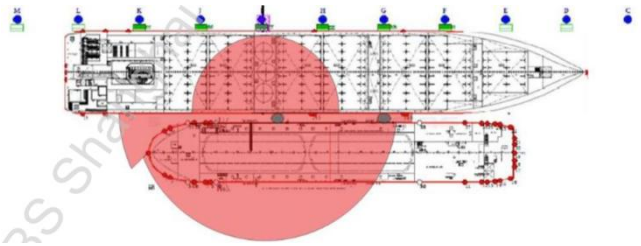

Figure 11. Horizontal Safety zone

The maximum extent of the vertical safety zone is based on the same cases that are used to determine the horizontal safety zone (the maximum height is taken). The vertical zone should be seen relative to the dispersion surfaces and extends over the entire horizontal safety zone in the same direction.

The vertical safety zone distances are as follows:
- Above the container vessel: 10 m;
- Above the LNG bunker vessel (and further on the water): 11 m;
- Above the water in between the two vessels: 17 m.

The extent of the vertical safety zone in the three different directions is illustrated in the Fig. 12.

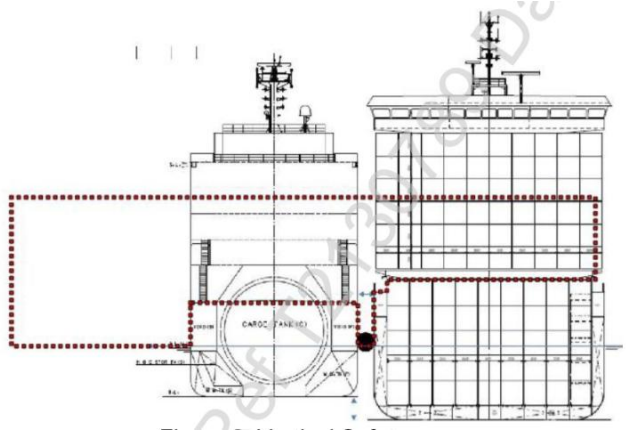

Figure 12. Vertical Safety zone

Each company should establish restrictions during SIMOPS in Hazardous and Safety Zones. As example, here provides requirements by Nordic Hamburg:

1. In order to protect the bunkering station from dropped objects, all container operations (for outer row on top of Fuel Gas Handling Room Bay 21) next to bunkering station while bunkering activities are under progress must be suspended.
2. Smoking outside of accommodation is strictly prohibited any time. Smoking allowed in dedicated smoking room only.
3. Presence of naked lights, mobile phones, cameras, and other non-certified portable electrical equipment in Safety Zone are strictly prohibited during LNG bunkering. Safety posters to be placed at the gangway. Every visitor to be instructed before boarding the vessel. All unauthorized devices to be collected and stored in dedicated area.
4. Access to the safety zone is granted to authorized staff if they are fitted with personal protective equipment (PPE) with anti-static properties.
5. Prior SIMOPS activities the Generic Risk assessment for LNG bunkering to be reviewed, Operation part to be completed by SIMOPS controller and signed by SIMOPS Leader.
6. Receiving any kinds of stores and supplies prohibited in Safety zone
7. Any maintenance jobs within Safety zone strictly prohibited
8. Cargo Holds ventilation within Safety zone shall be stopped. In case of specific cargo required ventilation of cargo holds covered by safety zone, only exhaust mechanical ventilators to be used as far as practically possible from Hazardous zone.
9. Reefer containers plugging/unplugging to vessel's power supply sockets within Safety zone not allowed during LNG Bunkering. In case of any abnormal parameters of LNG transfer, the reefer's power supply to be cut off from main switchboard
10. In case of any abnormal parameters or alarms appear during LNG transfer, the bunkering/cargo operations to be stopped immediately and Container terminal's staff to be informed accordingly
11. Due to permanent location of Hazardous zone on Bay 1, Bay 19 and Bay 21, twist lock's installation and lashing of containers to be performed under supervision of qualified crew only. In case of any alarms or notification of abnormal parameters any activities in Hazardous and Safety zones to be suspended and crew/stevedores evacuated immediately.

4.3 *Objectives and planning of cargo operations during LNG bunkering as part of SIMOPS*

The SIMOPS Leader has responsibility (Fig. 13) for the planning of cargo operations SIMOPS and for establishing, together with the Container

Figure 13. Responsibilities of SIMOPS Leader

The SIMOPS Leader has to notify and agree the Simultaneous Operations with terminal Leader . When SIMOPS are identified, the SIMOPS Leader will advise all involved parties (LNG bunkering/receiving vessels) the planning of SIMOPS. The cargo operations shall incorporate all relevant information relating to SIMOPS including limitations, areas of conflict and include or refer to applicable emergency procedures. They should did this agreement in paper manner. For this reason much better to have some checklist to easier understanding. As example, provide Nordic Hamburg Checklist (Fig. 14) between Terminal and Vessel.

For Simultanious cargo operations during LNG bunkering

Vessel:		Port:	
Date/Time		Terminal / Quay:	
Estimated quantity of containers to be handled		Handling rate Cont/hour	
BAY's will be affected		Expected duration of bunkering	
Name of Bunkering vessel			

The SIMOPS Controller and the Terminal Leader, should complete this checklist jointly. Advice on points to be considered is given in Company SIMOPS procedure. The safety of operations requires that all questions should be answered affirmatively and the boxes ticked. If this is not possible, the reason should be given, and agreement reached upon precautions to be taken between ship and terminal. If a question is considered to be not applicable, tick the box mark "N/A" and explain why appropriate.

		Ship	Terminal	N / A
1	Has SIMOPS allowed by port Authorities at the container terminal?			
2	Is terminal informed about toolbox meeting schedule prior SIMOPS?			
3	Has SIMOPS been advised and agreed?			
4	Is there safe access between the ship and the wharf?			
5	Are mooring arrangements adequate for all local effects of tide, current, weather, traffic, and craft alongside?			
6	In emergency, is the ship able to leave the berth at any time?			
7	Are adequate number of crew on board and staff at terminal on emergency?			
8	Is the agreed ship / terminal communication system operative?			
	Communication method			
	Language			
	Radio channels / phone numbers			
9	Has terminal been instructed in:			
	SIMOPS procedures			
	Emergency procedures and coordinated alarms			
	Fire-fighting equipment and locations			
	Emergency shutdown equipment and locations			
10	Are the liason contact persons during the operations positively identified?			
	Ship contact person			
	Shore contact person(s)			
	Port Emergency team			
11	Has the ship been provided with copies of port and terminal regulations, including safety and pollution requirements and details of emergency services?			
12	Is procedure for recording of personnel involved in SIMOPS on board being discussed and agreed?			
13	Are dimentions/location of Hazardous/Safety zones discussed and agreed?			
14	Are below restrictions during SIMOPS in Safety zone discussed and agreed?			
	No cargo operations for outer row top of Fuel Gas handling Room			
	Smoking outside of accommodation is strictly prohibited			
	Presence of naked lights, mobile phones, cameras and other non-certified portable electrical equipment in Safety Zone are strictly prohibited during LNG bunkering. Safety posters placed at the gangway. Every visitor instructed before boarding the vessel. All unauthorized devices collected and stored in dedicated area.			
	Access to the safety zone is granted to authorized staff, if they are fitted with personal protective equipment (PPE) with anti-static properties and certified portable gas detector.			
	Prior SIMOPS activities the Operation Risk Assessment completye and signed by SIMOPS Leader			
	Receiving any kinds of stores and supplies prohibited			
	Any maintenance jobs within Safety zone strictly prohibited			
	Cargo Hold's ventilation within Safety zone stopped			
	Reefer's containers plugging/unplugging to vessel's power supply sockets within Safety zone not allowed during LNG Bunkering			
15	Is using of ex-proof communication equipment within Safety zone on board discussed and agreed?			

The above has been agreed:

Date: _____ Time: _____

For ship:		For terminal:	
Rank:		Position / Title	
Name:		Name:	

Signature: _____ Signature: _____

SIMOPS Controller Terminal Leader

Figure 14. Ship-Terminal SIMOPS checklist

Prior to commencing Simultaneous operations the SIMOPS Leader and SIMOPS Controller will meet with all involved parties to verify the aspects of the operation, confirm emergency procedures and identify any constraints and/or limitations and conflicting activities. Once the plan of the operation is confirmed and the detailed program and/or procedures approved, every effort shall be extended to mobilize equipment and personnel to meet and achieve the schedule. Methods of communication shall be clearly established between all work parties during the planning of any SIMOPS activity.

4.4 *SIMOPS organization including Work Permits and Check Lists*

Prior SIMOPS activities the pre-bunkering conference shall be carried out by the SIMOPS Leader, Terminal Leader and SIMOPS Controller to ensure that all precautions have been implemented and equipment is available to fulfil the planned schedule. Special attention will be given to the methods of raising the alarm and acting on emergency. Pre-bunkering conference shall include discussion of necessary escape routes, location of safety equipment and muster points.

SIMOPS meetings shall be held and are required to:

1. Ensure the highest standards of safety awareness for all personnel.
2. Ensure proper communication, cooperation and coordination is maintained between the parties.
3. Ensure proper understanding of planning and progress of SIMOPS activities to minimize time losses.

Also, need to carry out The Work Permit Procedures and Risk Assessment for each LNG bunkering and SIMOPS. Near miss and incident reporting for any SIMOPS activity shall be in accordance with the Company requirements.

The preparation of the SIMOPS activities as far as organization, equipment, material and procedures are concerned, shall be shared with Terminal and sign the Checklists (Fig. 14 – 15).

SIMOPS Internal Check List Doc. No. DF F 07.02-A Rev/ Date 0/ 01.05.18 Page 1 of 2

This Check List to be completed prior each LNG Bunkering operations if any SIMOPS planned.

	SIMOPS Checklist	Yes	No	N/A	If No, Explain
	General preparations				
1	Has person-in-charge been assigned for the SIMOPS?				
2	Are the locations and of potential LNG releases (Safety zones) identified?				
3	Are there more than one SIMOPS that could occur at the same time?				
4	Has SIMOPS work plan been discussed?				
5	Permit to work activities and Risk Assessment completed?				
6	Have all persons on board involved in the SIMOPS been instructed:				
7	- SIMOPS procedures				
8	- Emergency procedures and alarms				
9	- Muster Point Locations.				
10	- Fire-Fighting Equipment and locations				
11	Is good housekeeping in Safety zone maintained?				
12	Is smoking restriction followed in Safety zone?				
13	Has electrical equipment to be used in Safety zone ex-proof as required?				
14	Have all personnel working in the restricted area registered at the gangway?				
15	Are all non-essential personnel removed from the Safety zone?				
16	Are authorized gas detectors calibrated and tested (including LEL alarm)?				
17	Are mooring ropes tight and regularly checked?				
	Safety preparations				
18	Is adequate PPE being worn by involved personnel?				
19	Are fire hoses and fire extinguishers ready at bunker station?				
20	Safety guards and warning signs posted?				
21	Are gas level continuously monitoring by portable gas detectors?				
22	Has emergency response team been informed and ready?				
23	Are fixed gas detectors and/or Emergency Shut Down systems ready?				
	Crane Operations				
24	Has Ship-Terminal Checklist completed?				
25	Has communication with gantry crane involved in SIMOPS been established?				
26	Has been emergency stop means were discussed?				
	Ballast operations				

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27	Has ballasting operations been adjusted to LNG Bunkering to avoid excessive movement of the vessel ?				
28	Has antiheeling system been activated and settled to 0.5 deg to prevent excessive list during cargo operations?				
29	Has LNG bunkering vessel been informed about ballasting operations and location of ballast line outlet?				
30	Are measures to prevent ballast water overflow been taken?				

Port	Date	Time
SIMOPS Leader (Master)	SIMOPS Controller (Chief officer)	
Signature	Signature	

Figure 15. SIMOPS Internal Check List

All equipment shall be in conformance with classification for hazardous area. Other equipment will be subject to and controlled by the Permit to Work System.

Such equipment may include, but not limited to:
- Power tools
- Communication system
- Lifting equipment
- Hand tools

All plant and equipment for use within the SIMOPS areas will be subject to pre-inspection.

5 DISCUSSION OF RESULTS

All areas under simultaneous operations shall be restricted to unauthorized access by personnel not involved in the operation. Measures presented on Fig. 16 shall be put in place to control entry into these areas.

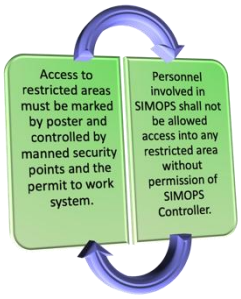


Figure 16. Precautions measures during SIMOPS

All the time SIMOPS Controller shall monitor restricted areas and maintain communication between vessels and Terminal Leader. Firm communication to be established and tested with regular interval during SIMOPS. Means of Emergency stop and alarm to be discussed during SIMOPS toolbox meeting.

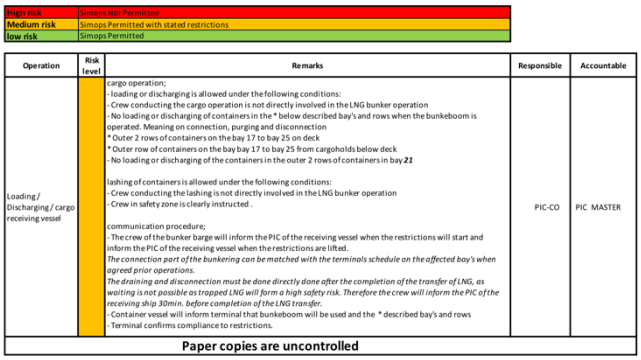
Additional supporting groups (Table 2) shall be available and shall fully support any SIMOPS activity as required.

Table 2. Additional Support Groups regulations

Fire and Emergency Team	Safety Guard
1. The onboard the fire and rescue team as prescribed by Muster List shall be ready for immediate use during SIMOPS works and shall fully support the Bunkering/receiving vessel and Terminal personnel on board during SIMOPS activity.	1. All personnel are in possession of an authorized work permit prior to entry into a Restricted zone.
2. Fire team shall be mustered in designated area in case of emergency.	2. Check all personnel upon entry and exit from the Restricted zone for unauthorized equipment tools, materials and equipment.
3. In the event of an emergency, the fire and rescue team shall take immediate action to secure the area and commence preparations for control of the situation.	3. All personnel must be recorded in Visitor's log book before entry to Restricted area.
4. As necessary, the firefighting Port Emergency team may be called to assist with control of the situation (refer to Emergency Contact list for Ports).	4. No hand phones are carried into the Safety zone.
	5. No cameras are carried into the Safety zone.
	6. All walkie-talkies used within the Safety zone are ex-proof.
	7. "No smoking" rule is enforced within the safety zone.

As an example of SIMOPS requirements take LNG bunkering of m/v "Containerships Nord" and bunker vessel "LNG London" in port Rotterdam, Netherlands terminal RST. There is an Agreement (Fig. 17) between 3 parties (Terminal, bunkering vessel and receiving vessel) that cargo operations shall carry out in accordance with following rules:

1. Loading or discharging is allowed under the following conditions:
   - Crew conducting the cargo operation is not directly involved in the LNG bunker operation;
   - No loading or discharging of containers in the below described bay's and rows when the bunker boom is operated. Meaning on connection, purging and disconnection:
     - outer 2 rows of containers on the bay 17 to bay 25 on deck;
     - outer row of containers on the bay bay 17 to bay 25 from cargo holds below deck.
   - No loading or discharging of the containers in the outer 2 rows of containers in bay 21.
2. Lashing of containers is allowed under the following conditions:
   - Crew conducting the lashing is not directly involved in the LNG bunker operation - Crew in safety zone is clearly instructed communication procedure;
   - The crew of the bunker barge will inform the PIC of the receiving vessel when the restrictions will start and inform the PIC of the receiving vessel when the restrictions are lifted.
3. The connection part of the bunkering can be matched with the terminals schedule on the affected bay's when agreed prior operations.
4. The draining and disconnection must be done directly done after the completion of the transfer of LNG, as waiting is not possible as trapped LNG will form a high safety risk. Therefore the crew will inform the PIC of the receiving ship 30min. before completion of the LNG transfer.
5. Container vessel will inform terminal that bunker boom will be used and the described bay's and rows.
6. Terminal confirms compliance to restrictions.



High risk	Simops Not Permitted
Medium risk	Simops Permitted with stated restrictions
low risk	Simops Permitted

Operation	Risk level	Remarks	Responsible	Accountable
Loading / Discharging / cargo receiving vessel		cargo operation; - loading or discharging is allowed under the following conditions: - Crew conducting the cargo operation is not directly involved in the LNG bunker operation - No loading or discharging of containers in the * below described bay's and rows when the bunkeboom is operated. Meaning on connection, purging and disconnection * Outer 2 rows of containers on the bay 17 to bay 25 on deck * Outer row of containers on the bay bay 17 to bay 25 from cargoholds below deck - No loading or discharging of the containers in the outer 2 rows of containers in bay 21 lashing of containers is allowed under the following conditions: - Crew conducting the lashing is not directly involved in the LNG bunker operation - Crew in safety zone is clearly instructed . communication procedure; - The crew of the bunker barge will inform the PIC of the receiving vessel when the restrictions will start and inform the PIC of the receiving vessel when the restrictions are lifted. *The connection part of the bunkering can be matched with the terminals schedule on the affected bay's when agreed prior operations.* *The draining and disconnection must be done directly done after the completion of the transfer of LNG, as waiting is not possible as trapped LNG will form a high safety risk. Therefore the crew will inform the PIC of the receiving ship 30min. before completion of the LNG transfer.* - Container vessel will inform terminal that bunkeboom will be used and the * described bay's and rows - Terminal confirms compliance to restrictions.	PIC-CO	PIC MASTER
Paper copies are uncontrolled				

Figure 17. Agreement between parties for SIMOPS

As result of this research we propose SIMOPS Risk Analysis Flow Chart (Fig. 18).

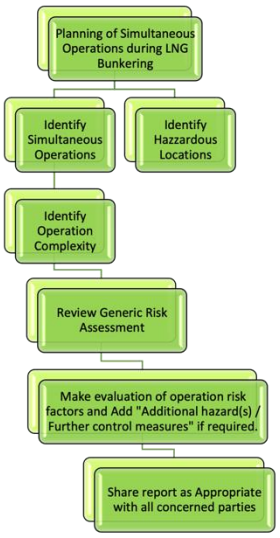


Figure 18. SIMOPS Risk Analysis Flow Chart

According the Flow chart before commence any SIMOPS it is necessary to:

1. Identify operation, which will be carry out; Hazardous locations and complexity of operation.
2. Analyze all risk factors which could be raised.
3. Informed all involved parties.

6 CONCLUSIONS

To summarize, the process of the possibility of conducting simultaneous operations during LNG bunkering was found acceptable. The impact of cargo operations on the safety of the receiving vessel, bunkering vessel, and port terminal is minimize in case all parties will follow SIMOPS Risk Analysis Flow Chart. As result of this study:

1. All SIMOPS shall have the SIMOPS Leader and Terminal Leader, who, through joint agreement, shall reach conclusion as to which activity takes precedent. Leaders can delegate some of their duties to Controllers.
2. Near both vessels establish Safety zone and hazardous zone. Hazardous zone includes 2 zone. And Safety zone divides for Horizontal safety zone and Vertical Safety zone.
3. Before commence of anu operations Ship-Terminal SIMOPS checklist shall be discuss and sign.
4. All Risk Assessment shall be taken in account.

As statement of the requirements of SIMOPS Procedure we can mention following:

1. Establish a mechanism for the review of proposed activities to identify roles and responsibilities
2. Establish an organization chart of responsible personnel who shall authorize simultaneous activities.
3. Ensure simultaneous activities are controlled and performed in a safe manner by:
   - Defining the responsibilities of all personnel involved in the tasks.
   - Appointing a Simultaneous Operations Leader to coordinate the activities between the vessel and terminal.
   - Identifying any preventive safety measures, which shall be implemented prior to commencement of the simultaneous activities
   - Establishing communication channels.
   - Providing training of all personnel involved in the tasks.
4. To minimize the potential for personnel injury and equipment damage by:
   - Controlling and restricting personnel access to areas where simultaneous activities may be taking place.
   - Providing specific instruction for securing operations and mustering personnel in case of emergency.

This study is a continuation of previous work such as [4] about requirements for transferring for green opportunities to reduce greenhouses gases and [16] – training crew to perform LNG bunkering. Further research is needed in description of safety concept of LNG bunker facility.

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