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Safety of ships evacuation from Tsunami
- Survey Unit about the Great East Japan Earthquake -

Saori Iwanaga[1] and Yoshinori Matsuura[1]

[1]Japan Coast Guard Academy, Kure, Hiroshima 737-0832, Japan
(Tel: 81-823-21-4961 (ext.373), Fax: 81-823-21-8105)

[1]s-iwanaga@jcga.ac.jp

Abstract: The Great East Japan Earthquake occurred at 14:46 on Friday, 11 March 2011. It was the most powerful known earthquake to have hit Japan, and one of the five most powerful earthquakes in the world overall since modern record-keeping began in 1900. The earthquake triggered extremely destructive tsunami waves of up to 40.5 meters in Miyako, Iwate. Over 20,000 people dead and the missed.

International Research Center for Marine Policy is think tank of Japan Coast Guard and is belong to Japan Coast Guard Academy. Research unit was organized to survey and research of The Great East Japan Earthquake in particular about ocean. This unit collects the information about it and analyzes and synthesizes collected information from a professional viewpoint respectively. Then, the unit study about damage by TSUNAMI, damage of ships, urgent refuge and search rescue to pick new actual explication and various lessons out.

Keywords: the Great East Japan Earthquake, TSUNAMI, evacuation, multi-agent simulation.

1 INTRODUCTION

The earthquake off the Pacific coast of Tohoku, also known as the 2011 Tohoku earthquake, or the Great East Japan Earthquake, was a magnitude 9.0 undersea megathrust earthquake off the coast of Japan that occurred at 14:46 on Friday, 11 March 2011. It was the most powerful known earthquake to have hit Japan, and one of the five most powerful earthquakes in the world overall since modern record-keeping began in 1900. The earthquake triggered extremely destructive tsunami waves of up to 40.5 meters in Miyako, Iwate. In some cases it traveled up to 10 km inland. In addition to loss of life and destruction of infrastructure, the tsunami caused a number of nuclear accidents in the Fukushima I Nuclear Power Plant complex.

Over 20,000 people dead and the missed and over 125,000 buildings damaged or destroyed by the earthquake. The earthquake and tsunami caused extensive and severe structural damage in Japan, including heavy damage to roads and railways as well as fires in many areas, and a dam collapse. Around 4.4 million households in northeastern Japan were left without electricity and 1.5 million without water. Many electrical generators were taken down, and at least three nuclear reactors suffered explosions due to hydrogen gas that had built up within their outer containment buildings after cooling system failure.

International Research Center for Marine Policy is think tank of Japan Coast Guard and is belong to Japan Coast Guard Academy. Research unit was organized to survey and research of Tohoku - Pacific Ocean Earthquake in particular about ocean. This unit collects the information about it and analyzes and synthesizes collected information from a professional viewpoint respectively. Then, the unit study about damage by TSUNAMI, damage of ships, urgent refuge and search rescue to pick new actual explication and various lessons out.

In our viewpoint, we focus on the evacuation from TSUNAMI. Then, we analyze about ships evacuation from TSUNAMI using multi-agent simulation and we want to prepare for a coming earthquake. When considering evacuation, we often stick to only refuge to a hill and a shelter to get it. But, as seen on TV news, some ships run aground on land by TSUNAMI. And staffs of local public bodies lead refuge or staffs of peace or rescue organization go to the office urgently. Then, there occur very traffic jam and it is difficult to reach the destination. We investigate the evacuation to shelter from TSUNAMI of refugees and perform the own mission of staffs.

2 RESERCH UNIT

Research unit was organized to survey and research of the Great East Japan Earthquake in particular about ocean this summer. And they collect and the public or non-public information about the earthquake and analyzes and synthesizes collected information from a professional viewpoint respectively. Then, the unit study about damage by TSUNAMI, shipping damage, urgent refuge and search

rescue to pick new actual explication and various lessons out.

The research unit is classified into six groups. The groups is for stering and perform a ship, traffic on the sea, estimation of floatage, rescue and disaster prevention, technique of search in the sea, and the engine of ship.

Our study belongs to group about traffic on the sea. We can deal with Automatic Identification System data what is called AIS [1] data, Marine Traffic Information service[2], what is called MARTIS radar data, record of communication by VHF, directions such as taking shelter of ships, ebb and flow data, tide data, and so on. The research group has three sub groups. First sub group is to analyze the actual taking shelter of ships when a seismic sea-wave warning alarmed and TSUNAMI came. Second sub group is to survey the control in the port and sea route control when a seismic sea-wave warning alarmed and TSUNAMI came. And last sub group is to study of simulation when ships take shelter, which is we belong to.

3 BEHAVIOR OF SHIPS AFTER EARTHQUAKE

Fig. 1 is plotting figure of the real AIS data of ships after the earthquake around port of Sendai-Shiogama.

With the AIS installed, vessels are able to monitor the movement of a multiple number of vessels simultaneously regardless of visibility, thereby dramatically reducing the danger of ship collision. Furthermore, ground facilities can obtain the ship-specific information necessary for automatic, real-time maritime traffic control. AIS will play an important role in ensuring navigational and operational efficiency in congested waterways [1].

In Japan, passenger ships of less than 300 tons of gross tonnage and all ships of more than 300 tons of gross tonnage for international sailing, and all ships of more than 500 tons of gross tonnage for non-international sailing have to be equipped AIS equipment[3].

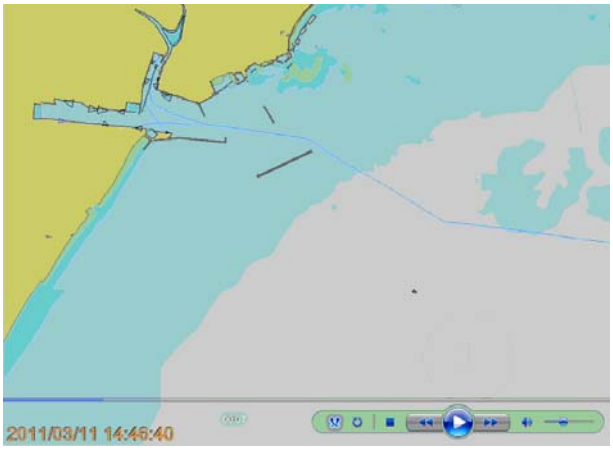
Because AIS data was recorded, we can review the behavior big ships by AIS data in Japan.

In Fig.1, there are several banks at offshore of port. And in Fig. 1(a), there were some ships with AIS in the bay at the time of earthquake. Ship is described by an isosceles triangle and the heading is shown by the top. Speed and the heading of the ship are described by a bar, that is, length of the bar means the speed and the direction of bar means the heading of ship. And light lines mean the traits of ships.

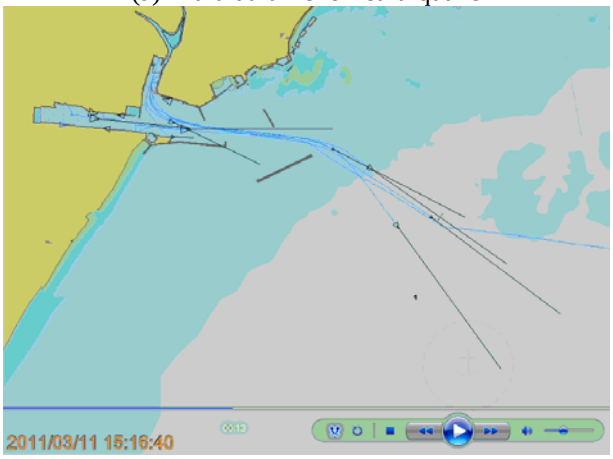
Then, from Fig. 1(b), we found that many ships started to go offshore to evacuate at 30 minutes after the earthquake. Fig.1 (c) shows the behavior of ships at one and half hour after earthquake, it looks like that many ships were push by TSUNAMI. It is reported that TSUMAMI reach to this area around 4 pm, which is about between 1 hour and 1.5 hours after earthquake. Then, many ships could escape TSUNAMI, but several ships, which started go offshore lately, could not evacuate and were repelled from TSUMANI to bay.

Fig.1 (d) shows the behavior of ships at three hours after earthquake. We found that several ship remain the bay because they fail to escape.

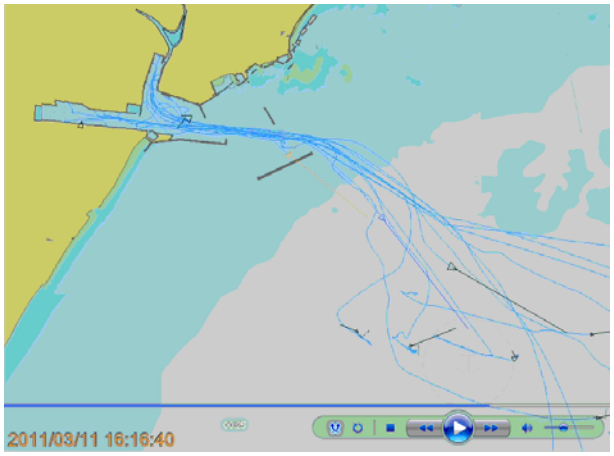
Then, we found that ship started go offshore early could escape the TSUNAMI. Japan Coast Guard also recommends going away off the port for safety of ships in case of TSUNAMI. And this is the cope with the TSUNAMI. But, sailors are not always on ship and many sailors are on the ground when the ship is anchoring. So, to go offshore the ship, the sailors must rerun the ship quickly. But, the roads to the port on the ground are crowded because many people evacuate from TSUNAMI for the hill. Then, it will be done to confront the crowded for the port.



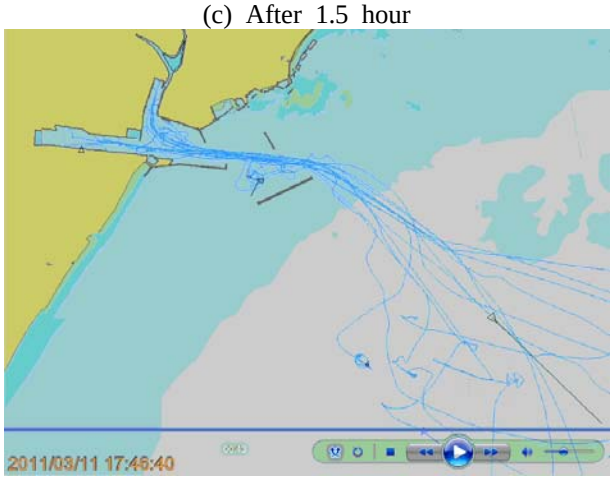
(a) At that time of earthquake



(b) after 30 minutes



(c) After 1.5 hour



(d) After 3 hours

Fig. 1. Traits of large big ships

After the earthquake, many people will move to get away. And staffs of local public bodies lead refuge or staffs of peace or rescue organization, such as policemen, firemen or coast guard staffs, go to the office urgently. Then, there occur very traffic jam and it is difficult to arrive at the destination. We investigate the evacuation to shelter from TSUNAMI of refugees and perform the own mission of staffs.

Indeed, staffs of local public bodies or city worker have to lead refuge or broadcast for going away to hills. Staffs of Japan Coast Guard have to go to work, that is, he has to go port after the big earthquake immediately. And some fire brigades have to go to shut the floodgate in case of TSUNAMI.

At the beginning, we thought about on the sea to escape the ships. But, the ships could not launch because the sailor could not gather the ship in time in many cases. So, we expand the research area not only on the sea but also on the land. Moreover, when we think about disaster prevention, we tend to focus on the refuge of people. On the other hands, there are many people to support the refugee. And they want to complete the mission, safety. But, there occur very traffic jam and it is difficult to arrive at the destination.

Then, we investigate the evacuation to shelter from TSUNAMI of refugees and action to perform the own mission using multi-agent simulation.

4 MODEL

We have an idea of simulation of earthquake and TSUNAMI. We denote briefly as follows.

4.1 Space

We deal with land and ocean. The sample is shown Fig.2 using Google Map (http://www.google.co.jp). In land, there are many roads and almost people move on the roads to get away. And people want to get away in time to survive. So, behaviors of people are restricted by space and time. But, there might be traffic jam or the road might cut by earthquake. Then, there need to control traffic. On the other hand, sailors gather to port to launch the ship to offshore. If sailor is in town, he will be done to confront the crowded for the port to go back to port.

Then, when the sailors gather to the ship, the ship will launch to offshore. On the sea, ship can move freely because there are not specified road. But, if ship move freely, ships can corrupt each other or ship can go aground. Then, it becomes difficult for ships to go away. Especially after earthquake, almost all are in hurry. Then, we design the sea route for simplify the simulation.

In fact, the performers on the sea is very few, comparing with on land because only few people have ship, such as fisher, ferry company, Japan Coast Guard. That is why multi-agent simulation on the sea is few and agent in the sea such as fish often moved freely on the sea. And agents move shortsightedly, such as fish go to the nearest plankton and eat it. So, if there is obstacles in front of the fish, it cannot eat the over the obstacle. But, ship is clever because sailors ride on. And they have a map and they know the land and the obstacles. To realize the ships as agent, it is simple to design the ocean route similar on land.

Fig. 2. Image of simulation

4.2 Agent

We define the agents as Table 1. Refugee agent evacuate from TSUNAMI shelter or hill immediately. City worker agent of local public bodies broadcasts the information about TSUNAMI and leads refuge or patrol the town immediately. And policeman agent goes to point of traffic jam or traffic accident immediately. Fireman agent leads refuge. Sailor agent in town goes to the port. If sailors of ship are gathered, the ship agent leaves the port t to offshore.

Table 1. Agents in simulation

	Behavior	Destination	Start time
Refugee	Move	Hills	Immediately
City worker	Stay building		Immediately
	patrol		Immediately
policeman	Move	Traffic jam point	Immediately
fireman	patrol		Immediately
Sailor	Move	Port	Immediately
ship	move	offshore	when sailors gather

4.3 Behavior of agent

4.3 Simulation

We are now programming using multi-agent simulator Artisoc [4]. Artisoc allows us to easily and quickly reproduced on a computer interactions between humans, is a multi-agent simulator to analyze social phenomena alive dynamically changing.

Artisoc, the five-year plan implemented in fiscal 2003 Scientific Creation Project "social order change research by the multi-agent simulator," which was developed as part of copyright, Ltd. Kozo Keikaku belong to both the Graduate School of Arts and Sciences, Professor, University of Tokyo Susumu Yamakage.

Using this simulator, some disaster or accident are dealt with such as TSUNAMI in Okushiri in 1993, accident on Akashi footbridge in 2001.

4 CONCLUSION

Now, we are discussing and programming the simulation. We analyze about ships evacuation from TSUNAMI using multi-agent simulation and we want to prepare for a coming earthquake. When considering evacuation, we often stick to only refuge to a hill and a shelter to get it. And staffs of local public bodies lead refuge or staffs of peace or rescue organization go to the office urgently. Then, there occur very traffic jam and it is difficult to reach the destination. We investigate the evacuation to shelter from TSUNAMI of refugees and perform the own mission of staffs.

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www.kaiho.mlit.go.jp/info/tsunami/tsunami-shiryo.pdf

[4] Aritisoc http://mas.kke.co.jp/index.php