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Feasibility Study of Win-In-Ground (WIG) for Rescue Operation in Kepulauan Riau

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ABSTRACT

This study aims to investigate performance of current rescue facilities and position based on statistic data of sea accident between 2010 and 2011 in Kepulauan Riau. Current rescue facilities are located at the latitude 0.93105 and longitude 104.4. Using the statistic data, an optimal recue location and facilities in Kepulauan Riau are determine based on International Maritime Organization (IMO) standard. International Maritime Organization requirement, an emergency, passengers should be able to leave the ship with time 60 minutes. The optimal position and rescue facilities are determined using Great Circle Distance-Spherical Trigonometry and Statistical of Standard Error methods. In this study, simulation code is developed using visual basic 2010 language. Results of simulation show current rescue facility requires a lot of time to reach the accident location which is up to 12.5 hours. In order to meet IMO requirement, this study proposes wing in ground for rescue operation. Using current rescue location, wing in ground also does not meet the IMO standard which is up to 3.04 hours. Additional, this study divides the Kepulauan Riau into two regions of rescue operation. The optimal for rescue facilities of region 1, at the latitude 0.74568 and longitude 104.36256, and based on the distribution of the accidents in Kepulauan Riau 2010-2011, current rescue facility required up to 5.6 hours to reach the accident area, while the wing in ground facilities required up to 1.3 hours. The optimal for rescue facilities of region 2, at the latitude 3.00338 and longitude 107.79373, current rescue facility required up to 5 hours to reach the accident area, while the wing in ground facilities required shorter time that is up to 1.2 hour.

KEY WORDS: *Kepulauan Riau, accident at sea, rescue operation, initial position, optimal position, great circle distance, standard error, latitude, longitude, wing in ground.*

NOMENCLATURE

WIG	Wing-In-Ground
IMO	International Maritime Organization
DOC	Direct Operating Cost
RCC	Rescue Coordinate Centre
SMC	Search and rescue Mission Coordinator
T_a	Time annual utilization

1.0 INTRODUCTION

Kepulauan Riau is a province one of the nation of Indonesia. Total area of Kepulauan Riau Province is 253,420 km^2 consist of 242,825 km^2 (96%) by sea, and the land area is 10,595.41 km^2 (4%). Marine transportation plays a very important to support the smooth flow of people, goods, and services.

Currently, search and rescue facilities in Kepulauan Riau Province there are only in Bintan. They have 1 unit rescue boat measuring 28.5 meters and has 10 units rubber boat.In the last two years (2010-2011) occurred 53 ship accidents in Kepulauan Riau province, with the number of victim 444 people, 381 people is survived, 37 people is died and 26 people is lost. Many people are dead and missing, caused due to lack facilities of rescue operations, the length of the evacuation process is done, and addition to the location of current rescue facilities were less strategic, considering the Riau archipelago 96% is the sea.

Therefore, it is necessary alternative equipment for rescue operations, to complement the limitations of the existing facilities. This paper propose wing in ground for alternative equipment in rescue operation**.** In addition, the position the central office of search and rescue is also a consideration. The position of the rescue facilities should have been more strategic to reach all areas of Kepulauan Riau Provinces with a faster time. So that, in case of any accident, the rescue transports can reach the target point and moves more flexibly to minimize casualties.

The paper discusses initial and optimal location for rescue facilities and time for rescue operation in Kepulauan Riau based on International Maritime Organization requirement. International Maritime Organization requirement, an emergency, passengers should be able to leave the ship with time 60 minutes. To find an initial and optimal position of rescue facilities in the Kepulauan Riau, researcher using the Great Circle Distance-Spherical Trigonometry Formula and statistical of Standard Error, in order that rescue facilities can be work an optimal. For calculating and mapping, researchers using visual basic programming, to make it more simple and automatic.

2.0 LITERATURE REVIEW

2.1. Rescue Operation

Search and Rescue Operation is activities and efforts search, help, and save lives and feared lost or in danger of calamities such as shipping, aviation, and disaster. The term Search and Rescue has been used internationally, do not be surprised if it is so global that it becomes familiar to people anywhere in the world (Wikipedia, 12 December 2012).

Based on the assessment of the rescue requirements and the available assets identified, the Search and rescue Mission Coordinator (SMC) must determine the most appropriate rescue unit; considerations for maritime and inland waters rescue are: urgency of the rescue situation, Ability to provide life supporting assets until the rescue is completed, Time of day and its implications for an air rescue, Medical advice concerning rescue methods, Land and air assets available and their suitability for the task, Weather conditions, Potential risk to rescue assets, Distance from land and its implication for available rescue assets, Surface assets available and their suitability for the task at hand.

2.2 Implementing the Rescue

Task the most suitable rescue units based on the rescue requirements and provide such rescue units with a briefing including the following information as a minimum location of survivors, communication available en route and on scene, weather on scene, nature of the task, return location for survivors, condition of survivors (if known), specialised medical treatment required (if known).

Coordinate with appropriate authorities for survivor transfer and any post-incident / accident requirements. Arrange logistics to support rescue units. The following are common support requirements for rescue units: equipment, communications, top-cover aircraft, medical assistance, fuel, accommodation, food, consideration of relief crew.

Consider stand-by resources, display rescue units in the Rescue Coordinate Centre (RCC). Display the unit information on boards including: call sign, type of aircraft, equipment carried on board, estimated time of arrival on scene.

2.3 Current Rescue Operation

In this opportunity only discussed or explained about some of the facilities used for the rescue operation at sea. The first airborne lifeboat was British, a 32-foot (10 m) reinforced wooden canoe-shaped boat designed in 1943 by Uffa Fox to be dropped by Avro Lancaster heavy bombers for the rescue of aircrew downed in the English Channel (Strahan, 1998), Then it is followed by a lifeboat or rescue boat. Fast, rugged, and powerful motorised lifeboats or rescue boat have been used to perform sea rescues since the late 19th century. The principles of coordinating small surface boat rescue efforts with direction and assistance from air units were developed in the 1930s by Germany, followed by other nations in the 1940. But, both airborne lifeboat and rescue boat has the disadvantage that has limited speed. So it will be required much time to close in location of accident. Then is helicopters have taken a primary role in air-sea rescue since their introduction in the 1940 (Evans, Clayton, 2003). Helicopters also tend to have limited range and endurance and cannot land at sea (Poulton, Thomas J. 1986).

2.4. Wing In Ground

To this day there is relatively little government funding into research and development of wing in ground craft. The speed advantage of Wing in ground craft over conventional marine vessels and no special landing is required as helicopter and airplane, may well provide the reason for considering Wing in ground craft for particular applications.

There are some theories clarify about Wing In ground can be used for search and rescue operation. Here is some of the theory which stated. According to Sungbu Suh, et al (2011), Du mian-yin and chen pei (2010),Han-Koo Jeong et.al (2010), Belavin, Volkov et al. and Hooker, in Kirill V. Rozhdestvensky (2006), Lee Qihui (2006), Graham K Taylor (2006), Quah Yong Seng, Jonathan (2005), Alexander Nebylov (2006), Graham Taylor (2003), Nikolai Kornev and Konstantin Matveev (2003), Seung-Hyun gwag (1997), E.A.Aframeev (1998), all of the they say wing in ground can be used for rescue operation.

According to Quah Yong Seng, Jonathan (2005), potential benefits of Wing In Ground is :Wing In Ground craft can fulfill the need for increased speed of marine transport and may thus fill the gap between shipping and aviation, WIG boats achieve high speeds while still maintaining high efficiency, especially when compared to other high speed marine craft, Due to the marine nature of Wing In Ground boats their operating cost are low as compared to aircraft, The infrastructural requirements for Wing In Ground boats are very low, any existing port is sufficient., Especially in a wavy sea the comfort level in cruise is very high as compared to other high speed marine craft.

According to Graham K Taylor (2003) & (2005), its main attributes wing in ground is :Turning the business machine faster, bringing destinations closer together, opening new routes within acceptable journey times, No sea motion, or sea sickness Low fatigue for occupants or equipment, No wash, no environmental damage to waterways, no effect on other waterway users, Immune to sea or river currents, will not hit floating objects such as driftwood, whales, etc, Shallow water operation, unaffected by tidal variation/water level, In the rescue environment Wing In Ground attributes are: Ability to cover a wide area within a short time, Rapid response capability – rapid closure.

Based on paper made by E. A. Aframeev, 1998, he said : Global sea rescue system is a worldwide concern to develop effective rescue measures on the high seas, the creation of global international sea rescue system based on the heavy WIG is the challenge for the international community. Experience shows that it is very difficult if not impossible to provide timely aid at wreckages and ecological disasters at sea. Use of seaplanes is often limited because of unfavorable meteorological conditions, whereas use of helicopters is restricted to coastal areas. Until now, the main means of rescue (salvage) on water has been ships finding themselves accidentally near the disaster area and hardly suitable for this purpose.

It should be emphasized that the effective rescue may be carried out if two components are available: quick notification about the catastrophe and quick arriving to the rescue means to the point of distress (E. A. Aframeev, 1998).

2.5. Mathematical Formulation

Initial and optimal location, distance and time are firstly are determined before cost estimation. In the present study, the initial location, distance and time are determined using real data of ship by accident in the form of latitude and longitude using the Great Circle Distance- Spherical Trigonometry Formula as follows:

$$D = R\,arccos[sin(lat_1)sinsin(lat_2) + cos(lat_1)cos(lat_2)cos(lon_2 - lon_1)] \quad (1)$$

where R is the radius of the earth in whatever units desire. The value is R=3437.74677 (in nautical miles), $R = 6378.7$ (in kilometers), $R = 3963.0$ (in miles).

At the calculate time used the Great Circle Distance Formula divided by speed of ship (V). The Algorithm of Spherical Trigonometry in determining the initial location (Jovin. J. Mwemezi. 2011).

i. Express latitudes and longitudes given in degree as radians :

$$R = \frac{deg}{180}\pi \quad (2)$$

ii. And then determine the initial coordinate of the new position (x^*, y^*), is defined by centre of gravity formula:

$$x^* = \frac{\sum w_i x_i}{\sum w_i} \quad (3)$$

$$y^* = \frac{\sum w_i y_i}{\sum w_i} \quad (4)$$

In order to get a range of optimal position, error of initial position is firstly calculated. In this case use a statistical of standard error. The standard error of a statistic is the standard deviation of the sampling distribution of that statistic (David Lane's, 2011). It is the standard deviation of the sampling distribution of the initial position. The formula for the standard error of the initial position is:

$$\sigma_M = \frac{\sigma}{\sqrt{n}} \quad (5)$$

Where σ is the standard deviation of the original distribution and n is the sample size (the number of scores each initial position is based upon).

To Estimate of Total Direct Operating Cost, Albeit various methods of cost analysis have been used to calculate operating costs, Chin Su Peak. (2006) (as cited in Akagi's, 1993) formula is suited to estimate direct operating costs ($per\ seat \cdot km$).

$$DOC = \left[\left\{\frac{1-r_v}{A} + r_{ins} + r_{int}\right\} + r_m\right]\left(\frac{K_s}{N_p V_s}\right)\frac{1}{T_a} + \left(\frac{C_{fu} M_f}{R N_p}\right) + \left(\frac{S_c N_c}{N_p V_s}\right) + \frac{1}{T_a} \quad (6)$$

where r_v is rate of residual value, A is amortization, r_{ins} is annual rate of insurance, r_{int} is annual, rate of interest, r_m is annual rate of maintenance, K_s is price of the vehicle, N_p is number of passenger, V_s is vehicle speed (km/h), T_a is time annual utilization (in hours), C_{fu} is price of fuel per kg, including lubricant, M_f is mass of the fuel, R is range (km), S_c is average yearly crew cost per person, N_c is number of crew.

The annual utilization time (T_a) has used the following formula taken by Akagi (1993).

$$T_a = n_a\left(\frac{t_d}{t_r + {L_R}/{V_s}}\right) \cdot \left(\frac{L_R}{V_s}\right) \quad (7)$$

where n_a is annual number of operating days, t_d is number of operating hours per day, t_r is terminal hours per service, L_R is length of the route.

3.0 METHODOLOGY

To conduct a systematically and thoroughly research, the research methodologies are based on the research process. The research process is a sequence of steps, which allow the researcher to create the structure and plan to investigate to problem selected for study. The general framework of proposed study is as shown in Figure 1. The following section will discuss the processes in detail.

In the literature review, researchers have searched many papers or journal which states that free wing in ground can be used for facilities of rescue operations. After learning that the wing in ground can be used as a facility of rescue operations, researchers must know the element - element that influence or are a barometer of the wing in ground more economical than the current of rescue operations. Based on survey data, current rescue cannot reach the whole sea area in the Kepulauan Riau province with a fast time. So, it requests to make feasibility study to find the strategic positioning as station of rescue facilities that means the rescue operation could be operating optimally.

In theoretical description is a little knowledge about the wing in ground, search and rescue operation, great circle distance-spherical trigonometry, statistical of standard error formula is needed to understand what they are actually.

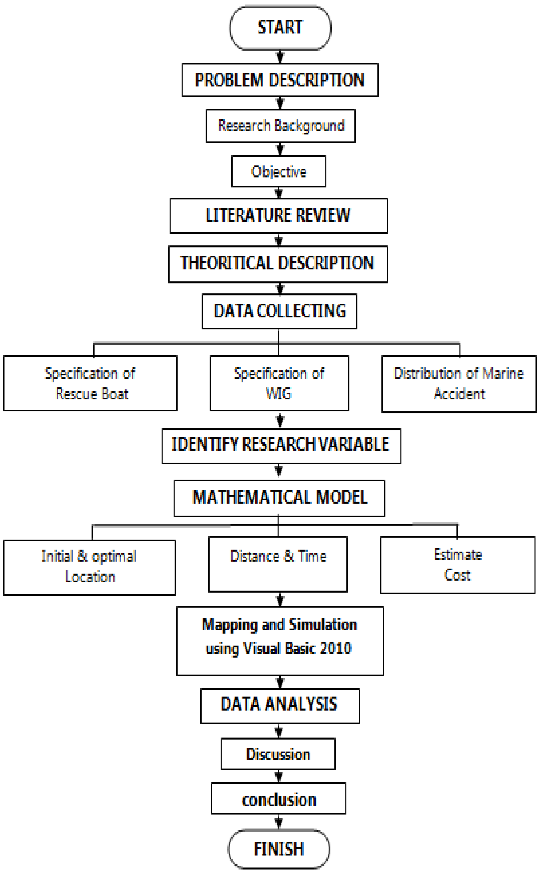

Figure.1 Flow Chart of Research Activity

The purpose is to review some references, to know the basic theory more specific. In data collecting, the data researcher collects is about current rescue boat specifications, the wing in ground specification, data by accident, and guidelines for evacuation analysis for new and existing passenger ships. For specifications of current rescue boat accident and data by accident, researcher get from the Search and Rescue Agency in Kepulauan Riau Province, while the data on the Wing in Ground (WIG) and Guidelines For evacuation analysis for new and existing passenger ships, researcher got from some journal / paper, and the internet. From the data collecting, researcher to identify research variables, in this thesis research variables are time, distance, speed, and coordinate.

Mathematical model, in this thesis about initial and optimal location, distance and time, and then estimates the cost. After mathematical modeling, mapping and simulation are created. The mapping and simulation were using visual basic 2010 software. Mapping done to visualize the distribution of accident, so it can determine its position with certainty, not just imagined. And then simulation is carried out simulation calculation of time, distance, and cost, to make it more automatic and simple.

4.0 SIMULATION AND DISCUSSION

After napping in visual basic, it can be seen from the position of current facilities and distribution of accidents at sea that occurred in the Kepulauan Riau Province in 2010-2011 as shown in figure 2.

Using the current position rescue and distribution facilities accidents, the distance and time required to reach the crash site of each type of vehicle are determined. In this case, the current rescue facilities and wing in ground that has been selected.

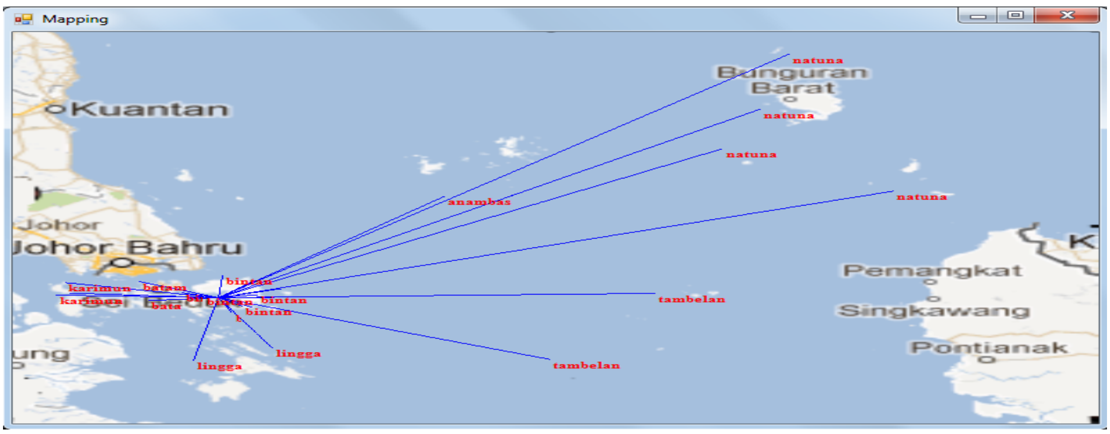

Figure.2 Current position of Rescue Facilities and Distribution of Accidents

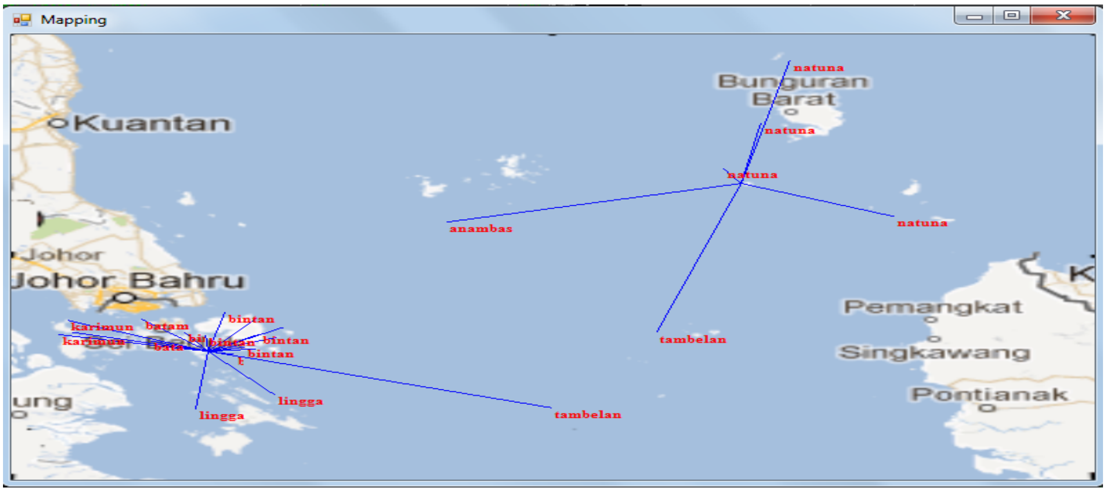

Figure.3 Optimal Position of rescue facilities Region 1 and Region 2.

The longest distance from the accident is 580.2 km and the shortest distance is 11.18 km. While the time required of current rescue to reach the accident site very long, there are up to 12.5 hours for the longest distance and up to 0.24 hours for the closest distance.

International Maritime Organization requirement, an emergency, passengers should be able to leave the ship with time 60 minutes. To fulfill International Maritime Organization requirement, this study propose wing in ground for rescue operation.

With the current position of rescue facilities, used wing in ground to rescue operation. When using the wing in ground facilities, is also too much time to cover the entire distribution of a ship accident of achieving 3.04 hours for the longest distance and 0.058 hours for the shortest distance.

Based on the distance between the position of the rescue facilities with distribution of ship accident happened in the Kepulauan Riau 2010-2011, some cost in rescue operation is calculated according to the data obtained from references and the data obtained from the calculation program, for current rescue facilities, Operation Costs During the Rescue Operation is Fixed Cost per Capacity-Speed = 0.2224, Annual Utilization = 70.1 and Fuel Cost = 25822, and while for wing in ground, Operation Costs During the Rescue Operation is Fixed Cost per Capacity-Speed = 0.0229, Annual Utilization = 14.2 and Fuel Cost = 6352.2.

It can be concluded that using a single rescue facilities are not optimal, given the area of Kepulauan Riau 96% is sea. Moreover, it cannot perform a rescue operation with quickly based on international maritime organization requirement. In view of this fact, researchers proposed must have a minimum two position of rescue facilities in Kepulauan Riau. In this case, the researchers divided the Kepulauan Riau into two region.

In the calculation obtained the optimal position from the initial position for region 1 is the longitude 104.261901554392 up to longitude 104.597809556719 and latitude 0.7403857999495 up to latitude 0.92670086671708. While the optimal position of the initial position for region 2 is the longitude 107.2050954149 up to longitude 108.0024245850 and latitude 2.438283497774 up to latitude 3.464019835558.

From an optimal range of position is obtained, we can determine the optimal position of rescue facilities in the nearby island of optimal range position.

Researchers determined the optimal position of region 1 is the longitude 104.36256 and latitude 0.74568, while in region 2 is on the longitude 107.79373 and latitude 3.00338, as shown in figure 3.

The time it takes current rescue facility in region 1 to reach the accident site in the region is still also need much time, up to 5.59 hours for the longest distance and 0.41 hours for the closest distance. While in region 2, the current rescue takes 4.99 hours for the longest distance and 0.562 hours for the shortest distance.

Region 1 it takes wing in ground, only 1.35 hours for the longest distance and 0.1 hours for the shortest distance. While in region 2, which is only 1.2 hours for the longest distance and 0.13 hours for the shortest distance.

Based on the distance between the position of the rescue facilities with distribution of ship accident happened in the Kepulauan Riau 2010-2011, some cost in rescue operation is calculated according to the data obtained from references and the data obtained from the calculation program, for current rescue facilities region 1, Operation Costs During the Rescue Operation is Fixed Cost per Capacity-Speed = 0.2224, Annual Utilization = 19.3 and Fuel Cost = 8686.1, and while for wing in ground, Operation Costs During the Rescue Operation is Fixed Cost per Capacity-Speed = 0.0229, Annual Utilization = 3.2 and Fuel Cost = 2136.8. Then for current rescue facilities region 2, Operation Costs During the Rescue Operation is Fixed Cost per Capacity-Speed = 0.2224, Annual Utilization = 15.6 and Fuel Cost = 5998.7, and while for wing in ground, Operation Costs During the Rescue Operation, Fixed Cost per Capacity-Speed = 0.0229, Annual Utilization = 2.9 and Fuel Cost = 1475.7.

5.0 CONCLUSION

Based on current position of rescue facility, it is required a lot of time to reach the accident location in order to perform rescue operation, reaching up to 12.5 hours. When using the wing in ground facilities, it also needs time to cover the entire distribution of a ship accident of achieving 3.04 hours. The optimal for rescue facilities of region 1, at the latitude 0.74568 and longitude 104.36256, current rescue facility required up to 5.6 hours to reach the accident area, while the wing in ground facilities required up to 1.3 hours. The optimal for rescue facilities of region 2, at the latitude 3.00338 and longitude 107.79373, current rescue facility required up to 5 hours to reach the accident area, while the wing in ground facilities required shorter time that is up to 1.2 hour. So, wing in ground can be improved rescue operations in the Kepulauan Riau, given the current rescue cannot cover all the whole area quickly based on international maritime organization requirement, although two rescue boats used in the two regions. In addition, the cost incurred rescue boat more expensive than the wing in ground, during the rescue operation.

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