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Maritime Autonomous Surface Ship Operation near Small Traditional Wooden and Fishing Boat

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Abstract: ***The advancement of IoTand thedream of having transportation mode where there is no human presence on board comes true. We have proceedin to the stage where artificial intelligence (AI) technology brings efficiencies in almost all sectors. Maritime Autonomous Surface Ship (MASS) is available now and soon it is expected to be a marine mode of transportation that can sail all over the world. It may visit a place where there is so much difference in culture and custom with the place where it built. While there are several ships with difference of technology used,meet on the same layer of sea surface at the same time.The difficulties in interacting for those type of ships with different technology may exist. The worst condition is that collision accident may occur if one could not detect the presence of other. Present technology of radar detection is still having weakness of detecting small wooden boat. Especially during bad weather and rough seas. The nature of fishing boat fleet where mostly stay still in the middle of ocean during fishing period, might bring the risk of collision if they are not detected properly by the passing MASS. This paper is highlighting the risk of collision between these type of vessels, the options to prevent the risk of collision accidentthat can be implemented both for MASS and Small Traditional Wooden and Fishing Boatare proposed. There are several models that can be used to solve that problem with pros and cons of each option. At the end of the paper, it will be proposed the most effective and efficient method that can be used to prevent such accident.***

Keywords: autonomous ship, small wooden boat, detection, risk of collision.

I.INTRODUCTION

A. Research Background

Small wooden boats that are built traditionally by local people in the islandshave existed since long time ago. They still exist and become important public transportation between islands in this archipelagic country. They take important roles as a public transportation and also widely being used as a fishing boat. These boats known, as sampan or lete-lete is a low freeboard wooden boat that normally sailed by a single person to catch fish. Some of these small boats have also been used as public transportation that connecting island to island in Indonesia. They have been used widely and available across archipelagic nations in Indonesia. The fishing boats works in a group. The fleets are operated in the night at sea.

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They sail in a group and willstay whole night at least until the time to return to the homeport in the morning. They stay still for several hours in a darkness of the night at sea. That is after they letting go their nets. They will stay for several hours before they heave it in the morning. During that waiting time they will stay calm and most of them will unlit the light. Even though they are in huge group of wooden boats, their presences are hardly identified by most of ship's radar especially during bad weather. The development of unmanned ship that known as autonomous ship has recently become a new era of sea transportation mode. This will definitely eliminate the presence of ship's crew and further any navigating officer as well. That means that the operation of ship is being done without any human directly control the operation. This remark the new era of ship's model operation. The benefit is cutting operation cost. These types of ships have been equipped with lots of advanced navigational equipment and sensors available presently in the market. One of them is Radar ARPA, one of important navigation equipment used for collision avoidance. The problem is how sensitive the radar can pick up target of typical small wooden boats and fishing boats in this region, where the boats are different from common fishing boat in European countries. These difficulties of identification of wooden boats by ship's radar may also happened for the autonomous ships which are equipped with the same kind of radar and its getting worst that there is no human as natural eyes identifying object for the lookout. Several advantages of autonomous ships are eliminating human error, reducing crewing costs, more space can be used for cargo. There are several disadvantages too. There are among others such as capital expenditure in early stages of development of initial investment in technology will be high. Setting up on shore ship's monitoring system will be another investment to install. However since this model of ship has been developed and some of them have been well run in developed region, made these problem solved. Difficulties in identification of these boats are expected to be one of problems for autonomous ship sailing in the same region. The same difficulties was encountered by Officer On Watch (OOW) and the look out while they combined the use of electronic navigation and detection system such a Radar and ARPA together with visual lookout, the autonomous ships will only rely on its electronic navigation system. Therefore both of small wooden boat and autonomous ship have to take several precautions to avoid collision.

B. Purpose of This Research

This research is made with regards to identifyproblem that may arise for autonomous ship operating in region where there are the presence small wooden boat that difficult to identify are exist.

The preparedness of small wooden boat less than gross tonnage 7 to be able to be identified easily and information to be taken into account for autonomous ship's operator is explained in this paper.

There are two purposes of this research paper. First, the resultof the research will be submitted to the government for them as reference to take policy regarding the small wooden boat safety. This paper will be used as a reference in order to make sure the safety of small wooden boat to operate in the vicinity of presence of autonomous vessel. Second, the result of the research will be used as a reference to the boat builder, operator and the owner of the autonomous ships in order to make them understand of the collision risk with small wooden boat.

II.DESCRIPTION OF PROBLEM

Indonesia has unique culture where regarding public traditional transportation; people use very small and slim wooden boat that has been existed since long time ago. It may happen due to the condition around the tropical region where most of the time the weather is fine, there is not so often strong wind and the sea is smooth. However, time-to-time the condition may get worse, especially during rainy season where wind force is a bit higher.

These conditions are not like in any other region. Indonesia has a lot of islands. It is about 17.000 islands in the region. Make people are sailing on that small wooden boat without any worry at all. People near the sea mostly are a fisherman or at least they have small wooden boat in a family that they made by themselves using an ancient technique of building a water craft with different technique compared with modern system. They built the ship on their own time and it is their rights to have their own built boat. However, they are been proved to be seaworthy by being used by people for hundreds years.

The government has decided not to strictly regulate these types of boats. Under the Government Ministerial of Transportation Decree no. 39/2017. These small boats of less than gross tonnage 7 are not required to be registered. However government encourage them to built more ship for them to have job and improve their life. The Government are taking care of their safety aspect by time to time conducting safety campaign on small boat safety, given them lifejackets for free and educated them for safe navigation. However due to massive numbers of boats, it is understood that there may be some of them are not exactly operating the way the Government has suggested.

Recently technology has proved that a ship can sail without its crew. Not like usual believe that ship without a crew is not a ship; the technology could proved it otherwise. While the system is growing and technology applied is rapidly change and getting advanced. The ship with modern technology and the old fashioned small, wooden and traditional boats are sailing in the same layer of sea surface. They may interface each other in the region.

It is understood that technology applied on Maritime Autonomous Surface Ships (MASS) may have the most advanced system. However there could be a limitation of capability of each equipment's. The boat itself can be equipped with present tools such as radar reflector, but it is not always useful to identify small wooden boat where the high of the boat mostly the same as the high of the waves. The possibility collision accident may occurred even when all advanced system implemented.

III.METHODOLOGY

There are two methods being discussed in this paper. The first is how to improved the system on maritime autonomous surface ships to be more vigilant in detecting small wooden boats in the region and the second is to give an idea on how the small wooden boat can be detected easily by maritime autonomous surface ship operating in the region. Data and model will be taken from actual models on the field and from the ministry in charged for the safety of the small wooden boat and from information available in the information from international organization in-charged for the development, the market and scholar literature for the latest models and technology applied for maritime autonomous surface ship.

IV.SELECTION ANALYSIS

A. Ship

One method of transferring cargoes or passenger from one place to another place or from port to another port is by using a sea mode, by ship or vessel. Under the Convention of Collision Regulation 1972, Vessel is defined as every description of water craft, including non-displacement craft and seaplanes, used or capable of being used as a means of transportation on water. [1].

The autonomous ship is a ship, that equipped with some automated equipment so as to configure several; level of automation and self-governance. Automation means a process with computerisation and works without control of human. [2].

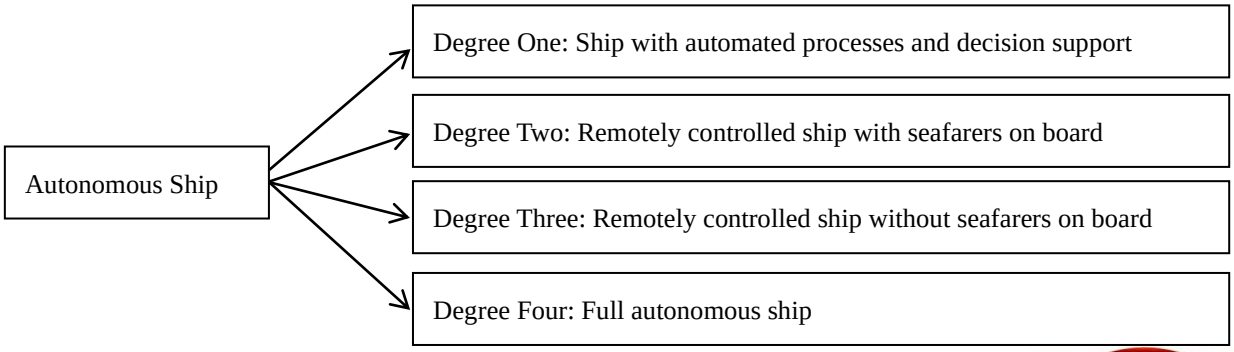

Fig. 1. Type of Autonomous Ship (*Courtesy of IMO.org*)

B. Maritime Autonomous Surface Ship

Digitalisation is continuouslyreshaping shipping industry. Autonomous and unmanned ships available and challenge the old fashioned, conventional methods. There are several degrees of automated or autonomous level of ship. It depends on the extent of uncontrolled or automation implemented to the ship. It also reflects to the design testing and approving of a ship and their system. Maritime Autonomous Surface Ship has been used as a general term for autonomous ships.

During its 98th session on 7 to 16 June 2017, Maritime Safety Committee (MSC) [3] of the International Maritime Organization (IMO) has agreed to include the Maritime Autonomous Surface Ship in the agenda to form of a scoping exercise to determine how the safe, the security and environment sound operation of Maritime Autonomous Surface Ship (MASS) may be introduced in IMO instruments. It is decided to accommodate the growing of technology where the ship can sail with more advance technology, more automatic tools implemented to the ship up to full autonomous ship, the ship that is sailing without any control of human.

There are several shipping companies that mostly from Europe and also East Asia working on full size autonomous ship. They built not only for short distance cargo ship or passenger ship, but also a long distance autonomous ship. Some of them have used renewable energy or green energy for ship's fuel such as gas fuel or solar energy. This ship will become the future of maritime ships in the world.

There are several elements of regulation being reviewed due to its nature of ship has been gradually deviated from old fashion type of ship such as human element, safety, security, interactions with ports, pilotage, response to incidents and protection of the marine environment.

MASS or autonomous ship as in Figure 1 is divided into 4 degrees [4] that are:

- Degree one, the ship that has been equipped with several automatic tools to process and assist seafarers on board to make a decision for the operation of the ship. It is considered like common modern ships presently which are equipped with auto steering control, radar detection, ship auto fixing position (GPS) and other tools where assisting seafarers on board to make decision. Information is given by the equipment's however the decision is manually taken by the seafarers.
- Degree two, the ship has been equipped with navigation equipment's that not only assisting seafarers to make decision, the equipment itself has made decision base on human setting, and it is remotely controlled and the seafarers on board task is to supervise to smoothness of the operation. This system is still allowing seafarers on board to overriding control when it is deeming necessary or when the result with the situation is predicted not as expected.
- Degree three, the ship has been equipped with navigation equipment's controlled by human ashore and there is none on board. This ship has not a seafarer on board. All control and action in case of emergency is decided from shore.
- Degree four, the ship has been equipped with navigation equipment's and fully controlled the operation of the ship.

Based on those four types of autonomous ship, the definition of autonomous ship can be differentiated with unmanned ship that is used in public information. Unmanned ship means there is no any human on that ship. It is considered to the type of degree three and degree four of autonomous ship. There are four types of degrees of autonomous ship. Basically it is understood that main consideration when the level of autonomous can be counted is based on how the ship navigate. How the ship communicate, interaction and observed the situation surround the ship. Cargo operation is mostly conducted in port where presence of human is likely to be there. It is not considered as a primary aspect to be considered. The autonomous vessel with regards to navigation aspect can be differentiated with two different terms. There are Bridge Control Team (BCT) and called Shore Control Team (SCT).

European Maritime Safety Authority with DNV/GL [5] describe the type of autonomy and control level of the ship:

- A0 Manual. Manual operation and control of ship system and function, including basic individual system level automation for simple task and functions.
- A1 Delegated. Permission is required for the execution of functions, decisions and actions; the operator can override the system at any stage.
- A2 Supervised. The qualified operator is always informed of all decisions taken by the system. Permission of the qualified operator is not required for the ship system to execute functions, decisions and actions; the qualified operator can override the system at any stage.
- A3 Autonomous. The qualified operator is informed by the system in case of emergency or when ship systems are outside of defined parameters. Permission of the qualified operator is not required for the ship system to execute functions, decisions and actions; the qualified operator can override the ship system when outside of defined parameters. Provided the boundaries of the ship system are not exceeded, "human control" becomes "human supervision".

If we take a look at the system used on board on how autonomous the ship can be considered as autonomous ship. There is consideration with several aspects of operation such as navigation control, cargo operation, interaction with emergency situation, port/shore/other ship communication. These four aspects of operation can be used as how autonomous the ship is.

Degrees three and degrees four where Shore Control Team must have very good control of the ship. SCT has to be able to see the real picture of what is going on board the ship. There could be anything that can be clearly seen by Shore Control Team, however it should be a several back up system to cover is the main, the first or the second system is fail to operate.

The Norwegian Forum for Autonomous Ships (NFAS) has defined different types of ship autonomy [6] as explained in this table:

Table - I: Type of Autonomous Ship (*Courtesy of NFAS*)

	Manned bridge	Unmanned bridge - crew on board	Unmanned bridge - no crew on board
Decision support	Direct control - No autonomy	Remote control	Remote control
Automatic	Automatic bridge	Automatic ship	Automatic ship
Constrained autonomous	-	Constrained autonomous	Constrained autonomous
Fully autonomous	-	-	Fully autonomous

The NFAS defined the concept of Operating Design Domain (ODD). It defines problems and tasks the system should be able to control. ODD is very important with regards the autonomous ship. The control and monitoring of ODD includes the expected complexity of the operation, the manoeuvrability of the ship including the contribution of any humans that are interact in the system.

Another term it is used is Dynamic Navigation Task (DNT) where all the task are summarised for the autonomous ship system to executed all foreseeable operational requirements in the ODD. The automatic DNT will be set to the autonomous system on shore or on board. This defines the requirements for sensor systems, object detection and classification, anti-collision system. However, it is understood that in general, it is not possible to make sure that all conditions the ship may encounter will be in the limit where the ODD is set.

C. Ship's Radio Detection and Ranging (RADAR)

The radar used for marine radar divided into 2 (two) class under X-band (10 GHz) and S-band (3 GHz) frequencies. The X-band is the higher frequencies used. With high frequencies, it gave sharper image and better resolution. The S-band is better to be used during rain or fog. The S-band is used for identification and tracking.

SOLAS Chapter V regarding Navigation, Regulation 19 states that All ships of 300 gross tonnage and upwards shall in addition to meeting the requirements of paragraph 2.5, have a 3 GHz radar or where considered appropriate by the Administration a second 9 GHz radar, or other means to determine and display the range and bearing of other surface craft, obstructions, buoys, shorelines and navigational marks to assist in navigation and in collision avoidance, which are functionally independent of those referred to in paragraph.

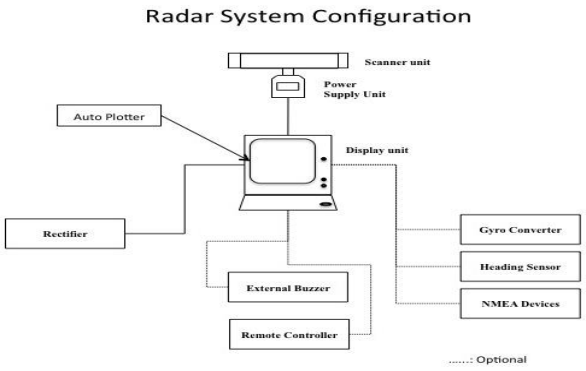

Fig. 2. Radar System Configuration

The features of marine radar as follows:

- The parabolic radar antenna transmit and receives electromagnetic waves as far as target being displayed is concerned, the wave that was transmitted bounced back off a certain object that showing on the radar screen the echo of the object. It appears on a display of Plan Position Indicator (PPI).
- The echo reflected on the PPI can be seen as to measure the actual distance and bearing of the object.
- If the object made of material that could not bounce the electromagnetic waves, the echo would never be seen on the radar PPI just like if there is no objects in the direction of the wave. The Radar screen will show blank.

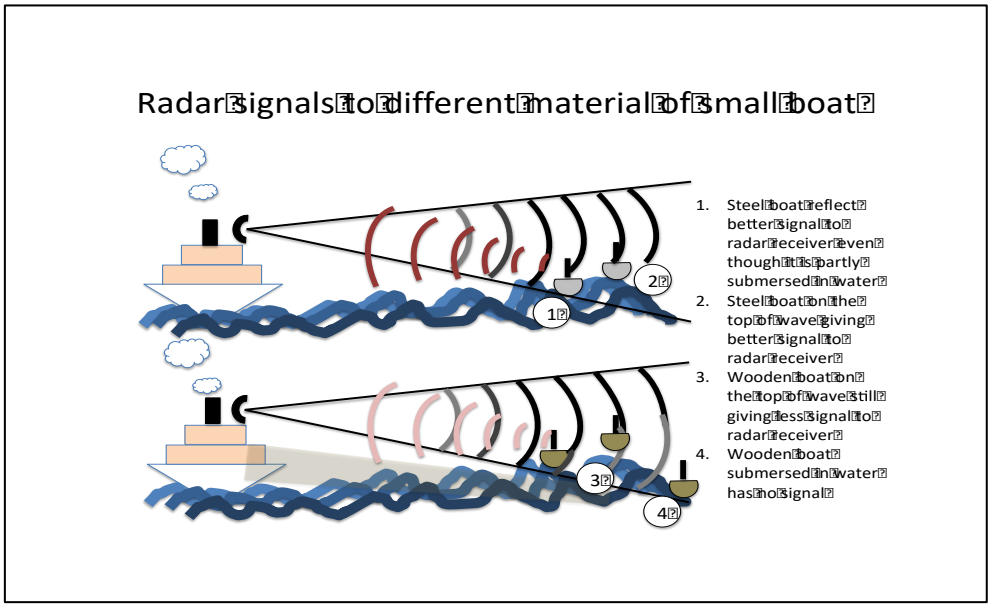

Fig3. Echo from wooden and steel boat

The wave of electromagnetic energy travels through air at a high constant speed, equivalent to the speed of light (300,000 kilometres per second). It travels several miles in the direction of radar facing. If there is an object, the wave will bounce back and then will be received by the scanner and to be displayed in the screen as target echo.

The advantages of the radar is that it can sea through conditions such as darkness, haze, fog, rain and snow which is not possible for human eye. Further more it can measure the range of target, location of target, velocity of target and angular position of target. Radar signal can penetrate insulators and can give information the difference between moving and stationary target. However there is several disadvantages of radar system such as it cannot recognize the colour of object, it cannot tell the internal aspects of target and it cannot resolve targets, which are placed in deep sea. It cannot resolve in the details like human eye, mainly at short distances.And it has difficulties to detect non-reflective material of target such as small wooden boat.

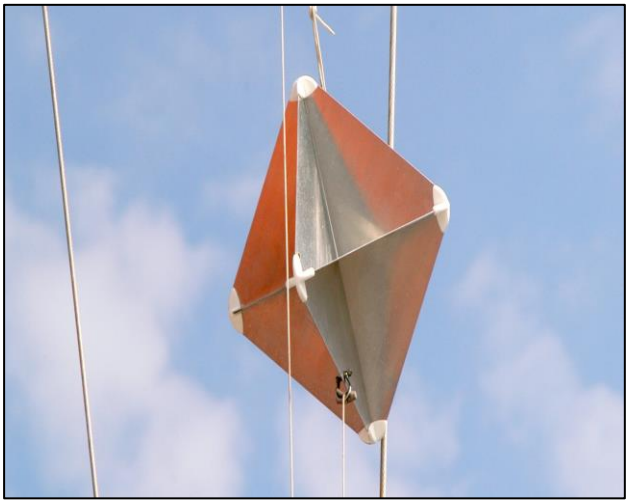

Fig 4. **Radar Reflector (Courtesy of https://pmrpressrelease.com)**

Small wooden and fiberglass is very hard to be detected by marine radar. Further more the size of boat, which are too small, made the changes of radar to detect even more difficult. Plain material should have reflected the electromagnetic waves, however the material made it disappears. Round mast, even if this part is from metal material, it will scatter the radar electromagnetic waves. In figure 7 it can be seen target echo spot on the display. The target echo can be detected easily when the wave of sea states increasing and if the radar operator tried to adjust sea clutter made the target echo will be slightly loose.

There are several factors affecting radar performance, it depends on:

- The range scale of radar being used to detect specified target
- The accuracy of its measurement of target location range and angle
- Its ability to distinguish one target from another
- Its ability to detect the desired target echo when masked by large clutter echoes.

Wood and fiberglass material are not reflecting electromagnetic waves completely, in some cases even the electromagnetic waves is disappeared. That is one of the reason why the small wooden boat where hugely available in the region could be a challenge for modern autonomous ship that crossing the region.

Using Radar Transmission Enhancer (RTE) on a small boat can eliminate the difficulties. The boat should use radar reflector as RTE that made from simple metallic foil with blades placed at right angles to maximise the reflection of radar electromagnetic waves. However when the boat is to small, there is no high point to place the reflector, and the weather is not in clam sea, it will still very difficult for the radar to detect.

D. SART Interface

A search and Rescue Radar Transponder (SART) may be used as a model what the small boat should have a device to prevent being collided by bigger ship. It may be triggered by X-band (3cm) radar which be read for the first time by about 8Nm range. Each radar pulse received by transponder causes it to transmit a response. X-band radar will sweep repetitively. It first sweeps rapidly (0.4μs) thru its band before become slow sweep (7.5μs) thru the same band back to starting frequency. This process is repeated for 12 times complete cycles.

At some point at the direction of target, the SART frequency will match and when the SART is in range, the frequency that match during each 12 slow sweeps, will produce response on radar screen, a 12 dots equally will be appear.

SART is a device that can be modified to be a radar beacon that with specific characteristic can be the tools for small wooden Radar detection. The only problem that may be encountered is about the power source of the modified SART. The SART that used battery can only continuously on for several hours. It has to be modified to use solar and battery power.

E. Traditional wooden boat

There is several different type of traditional wooden vessel, which has been used in Indonesia. The history of Indonesian maritime sector could not be separated by the history of its national traditional vessel. They are mostly being used as transporting human or cargo from island to island and they are also being used as a fishing boat. Type of wooden traditional [8] as follow:

1. KunLunpo (Jung Ship)

KunLunpo was a sailing vessel used during the time of kingdom of Majapahit near East Java province in about 13 to 15 centuries. The vessel length is more than 50 meters and with its height of about 4 to 5 meters. KunLunpo has about 4 sail mast.KunLunpo was the big boat from the southern place. It could carry as much as 700 people and cargo up to 1000 tons. Kunlun means southern country and po means boat/ship. It was the biggest ship during that time.

This ship has been destroyed in 1655 as the effort to prevent rebellion people from Mataram Sultanate in Java. However even if the ship still available, due to the size of the ship, it can be detected easily by modern common radar equipment.

2. Phinisi

There is another type of wooden vessel than since beginning were used as for transporting goods. These vessel are known as Phinisi Sailing Vessel. These Phinisi are now still being used as for transporting goods in traditional way, servicing niche goods and traditional market in Indonesia. It is a traditional wooden vessel originally came from South Sulawesi.Phinisi is a traditional sailing vessel from Bugis, Makassar in South of Sulawesi. The main characteristic of this ark contained on the screen, which has 7 screens with varying sizes. Two large screen that serves as the main screen while other screen is smaller. The smaller screen acts as a supporter.LamboPhinisiis generally has a length of 10 to 15 meters, with a carrying capacity of about 20 to 30 tons. All part of the vessel is made of special kind of wood called iron wood.

According to the script I Babad La LagaligoLontarak, the 14th century, the first Phinisi was made by PhinisiSawerigading, crown prince kingdom of Luwu. He sail fro South Sulawesi to China to see the Chinese princess named Cudai.Sawerigading managed to reach China by his sailing vessel and married with Princess Cudai. After a long stay in the country of China, he returned back to Luwu. However, just before the vessel reaches its homeport, accident had happened and the vessel was severely damaged. The people there, reassembled the wreck and they gave it name “Phinisi”.

3. Padewakkang

Padewakkang is another type of Indonesian wooden boat from South Sulawesi. This type of boat is still being used today for transporting people and goods in small portion. Some of people use it as fishing boat. Horst Liebner in his paper of Traditional Boats said that Padewakkang is the biggest art of marine transportation and fighting fleet from kingdom of South Sulawesi. The boat that normally people of Mandar, Makassar and Bugis merchants used it for hundreds years.

4. Sandeq

Sandeq wooden boat have slim hull and due to its very slim hull, this boat is equipped with attachment stabilizer on each side. Some of Sandeq boat has only one stabilizer on one side. This is very small wooden boat that most of modern ship’s radar are unable detect these boat, especially during windy and sea force of above 4. This is the smallest type of Mandar tribes boat. The slimmest boat with stabilizer wood “cadik” attached on its each side. Make it became the most manouvrable boat at time. This boat initially was not intended to carry goods. Instead this boat was being used as another fighting boat. With its slim hull and with attachment stabilizer on each side, these boat became the most maneuverable boat from kingdom of South Sulawesi.

Fig5. Sandeq boat (*Courtesy of Nature Explorer*)

Sandeq is the smallest type of Mandar wooden boat. It is made by long wood that the length reach 7 to 11 meter, and with narrow beam of only about 60 to 80 cm. Therefore if it use its sail, it could not work without additional stabilizer wood attached as out-rigged. It is the slimmest boat with stabilizer wood “cadik” attached on its each side. Make it became the most manoeuvrable boat at time. This boat is the most boat that people has. They built it traditionally by their own, using all available resource near their own home. They used mostly from a kind of strong woodsuch as iron wood or teak wood. they built it without any drawing approval.Nowadays sandeq boat is being used as smallest fishing boat, only one or two person sail in it for hunting fish.It is largely used most for private own fishing boat. They sail and work together in a fishing boat fleet at sea.

F. Small wooden boat of less than 7 GT

According to the Minister of Transportation Decree number PM. 39 year 2017 regarding Ship Registration system in Indonesia, it is explained that ships which can be registered, as Indonesian-flagged vessels are only ships with a size of GT.7 and above. This means ships with size <GT.7 do not need to be registered. Vessels with size <GT.7 or commonly called tonnage size <GT.7 have not been registered as Indonesian-flagged vessels. Vessels of this size are measured and a nationality certificate is called Pas Kecil but not registered in the Indonesian ship list. Pas Kecil is a Nationality Certificate of Ship intended for ships with Tonnage Less than GT 7, most of which are traditional ships and fishing vessels in large numbers.

Prior to the enactment of Law No.23 of 2014 on Local Government, the issuance of a Pas Kecil nationality certificate was implemented by the Office of the District Government Liaison at the location of the ship. The Pas Kecil nationality certificate is valid for a period of 1 (one) year. For later when the Pas Kecil nationality certificate reaches its end, it can be extended again.

Provision of Pas Kecil carried out by each of these agencies lasted for years and no problems were found until the government through the Ministry of Maritime Affairs and Fisheries tried to record fishing vessels in Indonesia. Problems found include: the size of the ship which is physically visibly incompatible, the number of vessels that cannot be known with certainty, and the possibility of foreign vessels sneaking into fishing vessels operating in Indonesian territory.

G. Automatic Identification System

The use of Automatic Identification System (AIS) on board of ship has been regulated to be implemented on a vessel of gross tonnage 35 and more while international regulation required a vessel of gross tonnage 300 and more. However one fundamental basic for the implementation of AIS is that the boat should have enough power supply to run the AIS all the time. The IMO Convention of Safety of Life At Sea has made international regulation that all ship of gross tonnage 300 and more engaged in international voyage and cargo ship of gross tonnage 500 and more not engaged in international voyages including all size of passenger ship to install and activate the AIS.[20]

This is the equipment that can be used to provide information of a ship to other ship in order to communicate between each other without necessary to start communication through radio VHF. The communication between ships is important to gain more information regarding intended ship including direction, speed and type of ship. The guidelines of AIS in 2003 [21][22], AIS data contain:

- static information, including Maritime Mobile Service Identity (MMSI), IMO number, ship's name, radio call sign, ship type and overall length, breadth.
- dynamic information, including UTC time, Ship's Position, Speed, Course (Heading), Navigational Status.
- Voyage-related information, including Cargo, Draft, Destination, Origin Port.

The use of AIS to let other ship detecting own ship is become another option on how to make sure that the small traditional and fishing boat can be detected by other ship including MASS. MASS has to have AIS system on board and it can determine automatically the status of other ship nearby. However the equipment price is still very expensive for small wooden traditional and fishing boat. Further more it is also difficult to implement AIS on a small wooden traditional and fishing boat due to lack of power supply and there is not much space to place it.

H. Identification Light

There are specific marine navigational lights requirement under the IMO Convention on Collision Regulation 1972. They have minimum intensity of lights applied for different type of navigational lights including the size of the ship. Even though the small wooden traditional and fishing boat of less than gross tonnage 7 is not belong to convention requirements, the possibility to use correct specific characteristic to be placed on the small boat could be the other means to prevent from being alluded by autonomous ship. The light being used as for marine navigation light shall meet minimum luminous intensity requirement. It can be calculated by using the following formula:

Table- II: Range of visibility and luminous intensity (*Courtesy of IMO Collision Regulation 1972*)

Range of visibility (luminous range) of light in nautical miles	Luminous intensity of light in candela for K=0.8
D (range in Nm)	I (luminous intensity in candelas)
1	0.9
2	4.3
3	12
4	27
5	52
6	94

$I = 3.43 \times 10^6 \times T \times D^2 \times K^{-D}$

I = luminous intensity in candelas under service conditions

T= threshold factor 2 x 10-7 lux

D= range of visibility (luminous range) of the light in nautical miles

K= atmospheric transmissivity

The use of lights on small wooden boat with specific colour and luminous intensity required to be detected in proper distance, while the MASS is equipped with specific colour of light sensor of small wooden boat can be used as the effective and efficient method of detection.In this case, small wooden boat detection is not relying radar electromagnetic waves, instead it use specific light detection between small wooden boat and MASS.

I. Comparison table

From different type of methods that can be proposed with specific requirement for each of them, it is identified 4 different methods that possible to be implemented as in Table III.

Table- III: Proposed methods

No	Option 1 for the MASS	Option 1 for the small wooden boat	Percentage of Effectiveness	Cost and benefit consideration	Maintenance Feasibility
1	Use recent type of X-band Radar	Radar Reflector	60%	Cheap and useful for bigger boat	Radar maintenance for MASS and free maintenance for wooden boat
2	Use recent type of X-band Radar	Radar Beacon (Modification of Search and Rescue Radar Transponder	95%	More expensive and very useful for small boat	Maintenance for boat devices
3	Use AIS	Use AIS	90%	Even More expensive and there will be a problem with the antenna height	Maintenance for boat devices
4	Use specific colour of light sensor/detection system	The boat is provided with specific colour of light	95%	Cost efficiency for small wooden boat preparation. The boat require to have power source that can be achieved by SOLAR power generator	Maintenance for the sensor on MASS, and maintenance for Solar power generator for small wooden boat.

The use of radar reflector on small traditional wooden boat and fishing vessel and radar x band on MASS should be maintained as it is the present methods used. One thing has to be kept in mind that the best picking up of radar detection is if the reflector is placed or rigged on the boat highest point. Considering not all boat has mast to rig it. It will be the weakness oh this method. However this is the easiest and the inexpensive way to proceedconsidering that the MASS has all been equipped with radar.

Automatic Identification System (AIS), if it is used by both vessels, it will be perfect, however due to the traditional wooden boat does not have electric power generator where AIS required it for long period of usage, it is not a good option to implement both of vessel with AIS.

One thing that has never been used for small traditional wooden bat to have at least a light that with proper luminous intensity, preferably with a specific colour that can distinguished both by manned vessel or full autonomous MASS to identify the presence of the boat. With specific light picking up sensor, which attached to MASS, it can easier detect the light instead of radar waves to pick up echo from small wood boat. Implementing light is also feasible for small wooden boat that the installation is not expensive as compared with AIS.

Officer On Watch for manned ship will identify easily in his/her lookout and the light sensor of MASS can receive information that can be used for the MASS to take action to avoid collision. In this case the use of specific light can be identified by both different technology used on board the vessel.

V.CONCLUSION

There are several methods encounter difficulties in detecting small wooden boat or canoe type of boat. Themethodsuse high RCS corner reflectors mounted on target with space-based SAR. That means even in the recent type of Radar available now, the difficulties in detecting of small object still exist. The use of radar reflector is the best it can be done with regards to the smallest cost to be used.

The other method is to use Automatic Identification System (AIS), the electronic equipment that can introduce the identification of the vessel using it. It will send information regarding it identity, position and the movement of the vessel including all other information required. The only problem with the use of AIS is that the AIS require power supply that the small wooden boat such as canoe or sandeq would not be able to have. This option only can be achieved if the system on boat has electric power generator.

There is another option that the boat is equipped with a kind of Search And Rescue Radar Transponder (SART) but the equipment is not to be used in Search and Rescue mission. Instead, it will be used for position identification for bigger ship approaching in the vicinity. This is a modification of SART that should be able to be used as tools to assist in navigation. It should be given the name as Radar Transponder (RT).

In order to save the battery, the tools is only in standby mode and will be activate only when there is a radar electromagnetic waves reaching the transponder. It is then the time when the transponder should responding by resending a beacon to the radar.

The used of specific light on small traditional wooden boat is the best feasible and applicable considering that the device is inexpensive. The implementation of specific light on small wooden boat can be used for better detection both bay manned ship or MASS. The combination of those device will given even better result to avoid collision.

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