Utilization of LAPAN Satellite (TUBSAT, A2, and A3) in supporting Indonesia's potential as maritime center of the world

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Abstract. Indonesia has archipelago area of 2.8 million km², territorial sea area of 0.4 km². Indonesia have number of 13,466 islands. Coastline length of Indonesia reached 99,093 km². Large areas can be monitored using remote sensing technology. Currently, Indonesia have research remote sensing satellites, namely LAPAN TUBSAT, LAPAN A2, LISAT (A3). All of these satellites could be used to monitor Indonesia. These satellites can be used to make the DSM using videogrammetry and depth cue perceptive methods. They also can be used for identification of geobiophysic parameter. Indonesian maritime territory which has sea highway planning can also be monitored using this satellites combination. AIS sensor on LAPAN A2 can be used to identify ships that pass in the territorial waters of Indonesia. It diagonally across the Indonesian region of west to east as much as 14 times a day. At this point it will have detection radius of over 100 km and has the ability to receive signals from maximum of 2000 vessels in the coverage area. Utilization of this satellites is expected to be helpful in supporting the ships cruise monitoring and their support sea highway also in making Indonesia as maritime center of the world.

I. Introduction
Indonesia is a maritime country has an area of 2.8 million km² archipelago, territorial sea area of 0.4 km², as well as claims on the Continental Shelf beyond the 200 mile area of 3500 km² in west Aceh (according to the documents LKRI submissions to the Committee for the limits of the Continental Shelf (CLCS, United Nation). Indonesia has 13,466 islands pieces named and coordinated. Coastline length of Indonesia reached 99,093 km², placing it in second place as the country with the longest coastline in the world after Canada. Maritime conditions can be monitored using remote sensing technology and hydrographic.

Remote sensing is the science, engineering and the arts to obtain information about object, area or phenomenon by analyzing data obtained from a device without directly related to the object, area or phenomenon being studied by a device remotely (eg from airplane, spacecraft, satellites, ships or other equipment). Remote sensing support in precision, data acquisition, efficiency cost, and effective time.

According to the philosophy of knowledge, Hydrography also call Marine Geodesy. Etymologically, Hydrography is picture of earth surrounded by water. Definition of old Hydrography in 1960, is limited to the definition bathymetry surveying and mapping, positioning bathymetry [1]. Hydrography activities include coastal, offshore, oceanic. Hydrography simply intended to describe the seabed relief, includes all the elements of the natural and man-made, in principle, similar to the map of the land, in this case the topography [2]. Hydrography is not only associated with marine mapping and positioning, but also with the law of the sea and the physical aspects of integrated...
coastal area management[3,4]. This shift is due to the advancement of computing technology and measurement instruments. These technologies include photogrammetry, remote sensing, global navigation systems, geoinformatics. In addition, this shift caused by the demands of society and industrial users of hydrography products as a result of increased activity in the waters.

Hydrography definition agreed by the International Hydrography Organization (IHO) in Special Publication Number 32 (SP-32) in 1970 and the Group of Experts on Hydrography Surveying and Nautical Charting in the Second United Nations Regional Cartographic Conference for the Americas in Mexico City in 1979. IHO argued that Hydrography is the branch of applied science which deals with the measurement and description of physical features of the navigable position of the earth's surface and joining coastal areas, with special reference to their use for the purpose of navigation [5,6].

Users of hydrography products can come from variety of sectors, such as transportation and marine navigation, coastal management, exploration and exploitation of marine resources[7], management of the marine environment, engineering offshore, as well as the determination of the law of the sea and the Exclusive Economic Zone (EEZ). Two major information generated by hydrography is depth data for making seabed map and coastline. Both of these data can be obtained by sounding, tides observations, ocean current measurements, and the determination of obstruction under the water as constituent component of the seabed [8].

Hydrography survey aims to obtain depth data and seabed topography configuration (bathymetry), including the location and size of objects as well as the information described in geospatial [9]. Hydrography surveys conducted along the corridor include surveys with varying width [10]. The main lanes should be run at intervals of 100 meters and cross line at intervals of 1000 m. The main strip is run at intervals of 50 m and cross line at intervals of 500 m [11]. Bathymetry survey work should not be conducted in the state of wave with height of more than 1.5 m if no heave compensator or up to 2.5 m when using heave compensator [12]. Remote sensing is used to cope with such conditions. Remote sensing is also useful in efficient and effective of survey mapping.

Shipping lanes and signs that the current monitoring and maintenance needs to be done regularly to maintain the safety and smoothness of the cruise ships do. Maintenance of navigation channel can be done by implementing Hydrography surveys periodically by using Global Navigation Satellite System (GNSS) method of differential real time kinematic (dRTK). This condition can help accurately surveying, precision, and faster when compared to conventional equipment such as arc sextan, theodolites, and other tools [13]. Navigation channel has function to give way to the vessel to enter the port area and the pool safely and easily [14]. Another function of the navigation channel is to eliminate the difficulties that occur due to movement of the ship towards the top (minimum ships maneuver activity) and natural disturbances. The world economy will lead to increased use of sea transport is increasingly congested, especially straits and canals, port and intersection crossings or traffic navigation. This research aims to study the use of LAPAN satellite in supporting Indonesia as maritime center of the world.

1.2. 3D modeling Satellite Imagery

Satellite imagery is a product of imaging were performed using a satellite vehicle with passive, active, radio, microwave, and/or sonar sensors. Satellite images with passive sensors have the disadvantage of not free cloud effect but have the look naturally. Satellite imagery with active sensors have advantages of free cloud effect but require special ability to analyze the data. Satellite image sensors commonly referred to as passive optical image sensor is active while the satellite image with an image called Synthetic Aperture Radar (SAR). Image sensor with radio, microwave, and multifunction sonar has advantages but requires special algorithms to analyze the data.

Satellite imagery is available in 2D where the condition is similar to the condition of a single aerial photograph. Satellite imagery can be modeled stereo if at least two satellite images with different viewpoints angle, ie on nadir, backward, and forward. The stereo model must have at least 70% overlay on the front and rear satellites fly and 30% on the fly sideways direction of the satellite.
and the condition of base height to ratio near to one value. There was also a model of reverse stereo using a single satellite image with few specific methods, one of which depth cue perceptive.

Height model or also known as the 3D model is view of a model with the 3D coordinate system (polar, geodetic, raster and Cartesian) to the reference plane defined on the projection and datum. Height model can be created from optical and radar data. Besides height model can also be defined as a digital model that gives information form of the earth's surface (topography) in the form of raster, vector or other forms of data.

![Figure 1. Differences DSM, DEM, DTM, and Geoid (left) and the videogrammetry concept (right)](image)

Height model consists of two pieces of information, namely: height data and height position coordinates on the earth's surface. In some references, the term height model often associated with some other term, namely: Digital Elevation Model (DEM), Digital Terrain Model (DTM) and Digital Surface Model (DSM), see Figure 1. DEM is height surface information displayed without any object earth surface, in a state of bare earth. DTM is the height surface information of the earth without the earth object surface, but is equipped with natural features such as rivers. DSM is a land cover information from the earth surface and above the earth's surface objects (for example, 3D urban areas). Height data storage using GeoTIFF format with the file type 32 bit floating point samples.

Videogrammetry is the development of photogrammetry. Photogrammetry is the art and science of measurement procedures in the object based on the location and shape. This measurement is carried out without direct contact with the object but directly on the image or the image of an object. Photogrammetry has proximity understanding with remote sensing. Videogrammetry is a coordinate measuring technology in three-dimensional form of points on an object is determined by measuring the source of two or more video images in which they were taken from a different angle. Images can be obtained from two angles simultaneously display the objects or derived from sequential images were captured the same video with the look of an object. Videogrammetry expand close-range photogrammetry method and apply it into a sequence of images to present or produce series of three-dimensional models are manufactured using the concept of photogrammetry. Depth Cue Perceptive method is one of the formation of 3D models from photographs/single image with the concept see the depth of an object with a particular viewpoint. The depth of an object this will produce two photographs/images come from photographs/single image with the condition of the base height to a certain ratio. This method is the opposite of the concept of stereo model.

There are several methods of Depth Cue Perceptive that used to make reverse stereo model, namely Averaging, Geometric, Red Search, Green Search, Blue Search, Search Cyan, Yellow Search, Search Yellow, Magenta Search, Neighbor Search, Search Luminance, and Saturation Search. Figure 2 displays the defining of depth technical object from the image or the original video, the concept model of 2D and 3D models, as well as the concept of depth scale use of pictures/video. Both models are only differentiated by the use of the parallax barrier. 3D models enable parallax barrier system that can generate images/video to 3D shape, while the 2D models do not enable parallax barrier system that can not produce images/video to 3D conditions. The greater the number value, the level of depth of stereo 3D model will be more obvious.
Reverse stereo model is a view in 3D with formation of two photos/images from single image/photo, and is one of the methods for the formation of 3D models. On the reverse stereo models need to be checked at some point/object. It is useful to ascertain the degree of correlation and the condition of base height to ratio of the right images and left images resulting from the Depth Cue Perceptive method.

2. Indonesia as the maritime center of the world

Currently, the need Means Navigation Aid Sailing (SBNP) met only about 3,541 units (66.96%), necessitating the addition of approximately 1750 units SBNP (Tower Suar, signs Beacon, Beacon buoys, signs Signs Lunch, Kids Floats), but the development of additional SBNP number of year 2010-2013 tend to be small, ie, 93 units SBNP for 3 years (1.44% per year). The number of navigation vessels 64 units (already meet the requirements up to the year 2020) but most his age is quite old and inadequate operational reliability.

Great value can be achieved by a program that is World Maritime Axis/Center, which could be achieved if there are policies and programs supporting the Right, Effective and Competitive. Toll sea is the sea of effective connectivity in the form of their ships and sail regularly scheduled from west to east Indonesia [15]. Sea Toll function in Indonesia as a pivot support maritime world in the year 2045. The main line toll ocean uses six major ports in Indonesia, namely the port of Belawan, Tanjung Priok, Tanjung Perak, Makassar, Bitung, and Bintuni Bay. Lane expressway proposed use of this sea route using four sea plan. The path is proposed in the form of Belawan-Tanjung Priok-Makassar-Bitung, Belawan and Tanjung Priok-Makassar-Bintuni Bay, Belawan and Tanjung Perak-Makassar-Bitung, and Belawan-Tanjung Perak-Makassar-Bintuni Bay. The main line should also be supported by a companion track. The line was supported by many seaports around Indonesia [15].

According to the 2013-2014 world economic forum, the condition of the national sea transport is still not functioning significantly. Indonesia connectivity index ranking in the marine transport sector in 2014 increased to 77 compared to the year 2013, which was ranked 104. The rating is lower than Thailand and Malaysia [16]. According [15] there are several indices in the determination of sea transport, namely the provinces connectivity index and the index of sea transport connectivity. Connectivity index is measured by a factor province registered vessel, carrying container capacity, the maximum size of the ship, the number of ship visits, and shipping companies registered. Based on the index of sea transport connectivity, Jakarta has a strong connectivity in Indonesia. Value indices so far compared to the eastern region of Indonesia. Equitable development is needed to address this.

3. Result and Discussion

Based on the statistics of national territorial assets, an area of Indonesian waters reached 5.9 million km² including the Exclusive Economic Zone (EEZ). This large area can be monitored using remote sensing technology. Remote sensing can be used for preliminary hydrography surveys. Currently, Indonesia has remote sensing satellite, namely LAPAN TUBSAT (A1), LAPAN A2, LAPAN A3 [17]. The third satellite could be used to monitor Indonesia.
Utilization of remote sensing technology in supporting the development of hydrography sea toll is on the use of satellite imagery. The satellite imagery can be optical, Synthetic Aperture Radar (SAR), microwave, sonar and lidar. One recommendation sensing data used in the development of toll marine hydrography is satellite imagery LAPAN A2, A3, Sentinel 1, Sentinel 2, Aster and Landsat 8. Satellite of A1, A2, A3 can be used to make height model such as the Digital Surface Model (DSM) using videogrammetry and depth cue perceptive. It also can be used for identification of land cover, geology and mining potential, land changes, coastal, and ocean dynamics, identification of the cruise ship, the Earth's magnetic field, and others. Indonesian maritime territory which has sea toll planning can also be monitored with the use of combination of satellite stretcher. Sea toll is planned to make Indonesia as a maritime center of the world in 2045.

![Figure 3](image1.png)

**Figure 3.** Sample detection of ships and other objects at sea (left), bathymetry mapping, ocean currents (right), oceanographic parameters, the dynamics of the coastal and marine remote sensing data (Sentinel 1). LAPAN imagery could potentially be used for the detection of ships and other objects in the sea

Satellite imagery can be used to make bathymetric map, see Figure 3. This map can be used to a preliminary survey in bathymetric mapping in hydrography. It also can be as the integration and fusion of various bathymetric data. LAPAN A2 image using optical and microwave imagery. LAPAN A2 image can be used to ship identification that will cross the region range [18]. AIS sensor in orbit has a detection radius of over 100 km and has the ability to receive signals from a maximum of 2000 vessels in the area of coverage. As for high performance surveillance mission system, LAPAN A2 digital camera adopts earth observation with 4 band multispectral camera scanning [19]. The camera resolution of 18 m with a coverage of 120 km and 6 m resolution camera with 12 x 12 km coverage. The main camera is equipped with 1000 mm lens is a charge coupled device (CCD) 2000 x 2000 pixels. The main camera has a ground resolution of up to 3.5 meters. Then a second camera with a lens color CCD 1000 mm with a resolution of 752 x 582 pixels. The second camera has a ground resolution of up to 5 m [20].

![Figure 4](image2.png)

**Figure 4.** Acquisition system (left) and image coverage LAPAN A2 (right)
LAPAN A2 equatorial orbits at an altitude of 650 km. Judging from the height of the orbit, the satellite entered to Low Earth Orbit (LEO). Because it orbits at the equator, the satellite will continue to move around the earth's rotation. LAPAN A2 diagonally across the territory of Indonesia as many as 14 times a day, with an orbital period of 100 minutes. LAPAN A2 equatorial satellites circling the Earth through the equator, reaching across the face of the Earth from 6 degrees north latitude and 6 degrees South latitude, AIS device shall be installed in all large and medium ships, see Figure 4. AIS signals emitted from ships and satellites captured determined the ship's position every time, so the route is known. By observing the movement of the ship, can be identified whether the ship merchant ships, fishing or illegal fishing boats.

Sensor Automatic Identification System (AIS) on LAPAN A2 satellite can be used to identify ships that pass in the territorial waters of Indonesia. LAPAN A2 diagonally across the Indonesian region of west to east as much as 14 times a day (noon and night seven times) with a long pass about 20 minutes. At this point the AIS sensor of LAPAN A2 detection will have a radius of over 100 km and has the ability to receive signals from a maximum of 2000 vessels in the coverage area. LAPAN satellite utilization is expected to be useful in supporting the monitoring of vessels at sea and shipping lane expressway support and in making Indonesia as maritime center of the world.

In this paper used depth cue Perceptive value of 10. Using the value 10, the resulting model is already significant in describing the 3D condition. The model results show the level of depth vision is in the inside condition. Image (left) and image (right) has an overlay of more than 70%. This will cause the formation of stereo model so that it can be made 3D models. Examples of 3D images at this paper is in the region of Mount Bromo, see Figure 5.

| Image (left) | Image (right) | 3D image |
|--------------|--------------|----------|
| ![Image (left)](image-left.jpg) is in left side from the image center and have overlay > 70% | ![Image (right)](image-right.jpg) is in right side from the image center and have overlay > 70% | ![3D image](image-3d.jpg) is made from overlay > 70% of image (left) and image (right) |

**Figure 5.** 3D LAPAN imagery in Bromo volcano

Visually, the formation of 3D images at the crater of Mount Bromo is already under optimal conditions with minimal error rate on reverse stereo models. After checking visually, it can be checked by geostatistics. Checking this form of correlation checking the same object in both photo/image with two different viewpoints. The correlation is above 0.9 between the photo/image with a confidence level of 95%. This is one alternative in the formation of a 3D image from a photo/single image. In addition to effective use of the number of photos/images, also produces 3D images with better accuracy as well.

Potential of height model from LAPAN A2 satellite imagery can refer to the height model on LAPAN TUBSAT satellite imagery. Examples of this paper uses height model from LAPAN TUBSAT image of Mount Merapi, see Figure 6. This process includes the creation of stereo image, creating DEM, and the transverse profile [21]. Figure 6 are height model of LAPAN TUBSAT satellite imagery. The left image and right image has an overlay of more than 70%. These conditions will allow the formation of stereo images that can be made 3D models.

This height model can be used for various applications such as geology, mining, spatial, deformation, bathymetry, coastal mapping, currents and waves, as well as a variety of engineering and non-engineering applications. DEM LAPAN image created has done terrain correction, height
error correction (bull eyes) and geoid undulation correction. Terrain correction is to transform DSM into DEM. Height error correction is eliminating anomalies occur in pixels height value or height point relative to its surrounding neighbors. Geoid undulation correction for DEM LAPAN image using EGM 2008. In addition to the transverse profile test, the DEM LAPAN also geostatistical tests have been conducted with the least squares method which includes global test, data snooping (outlier), and significance test. It also conducted a height different test, the results obtained are a total height difference of the minimum (zero). This means that the model has height altitude point relative to the plane of the same datum. It is also useful in removing the systematic error that still exists on the height model.

| Image (left) | Image (right) | Stereo image | DEM | DEM+Contour |
|--------------|---------------|--------------|-----|-------------|

Figure 6. Height Model from LAPAN satellite Imagery

Acknowledgement
Thank you very much to LAPAN for the data of LAPAN imagery and has been included in the LISAT seminar 2016.

Conclusion
Remote sensing and hydrography can play an important role in the development of marine tolls to support the realization of Indonesia as the maritime center of the world. Remote sensing technology can be used to support the development of hydrography in the sea toll. Indonesia has many potential and great resources in creating a world maritime in 2045.

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