VHF Data Exchange System (VDES) implementation for disasters early detection system in Indonesia

Qonita, Aulia Haque, Muhtadin, Nurul

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VHF Data Exchange System (VDES) Implementation for Disasters Early Detection System in Indonesia

Aulia Haque Qonita*[a], Nurul Muhtadin[a]
[a] Satellite Technology Center, National Institute of Aeronautics and Space (LAPAN), Bogor, Indonesia

ABSTRACT

Indonesia is an archipelago with a geographical location prone to natural disasters such as volcanic eruptions and tsunamis. One way to cope with this disaster is by optimizing disaster sensor communications on earth through satellite technology. One of satellite technologies that can be used for disaster sensor communication is by utilizing the VHF Data Exchange System (VDES). VDES is a maritime communication system using Very High Frequency (VHF). In this study the authors conducted a study of VDES implementation for sensor communication in Indonesia. This study will analyze and provide conclusions about the capacity and capability of VDES as transciever data of all disaster sensor platforms in Indonesia. From this study, it was concluded that VDES can be used as an alternative technology to support disaster sensor communication in Indonesia.

Keywords: disaster sensor communication, satellite technology, VDES, VHF

1. INTRODUCTION

Indonesia geographically is an archipelago region, which affected by four major tectonic plates, namely the Asian Continent, Australian Continent, Indian Ocean, and Pacific Ocean plates. Indonesia is in the cluster of volcanoes as known as the Pacific Ring of Fire and the meeting point of several plates of the earth made it very vulnerable to be exposed to the natural disaster. Trends of the natural disaster in Indonesia increased over the last decade, which dominated by floods, landslides, and tornados. Nevertheless, the deadliest disaster caused by the earthquake and tsunami.

Disaster risk faced by Indonesia is very high. UNISDR (United Nations International Strategy for Disaster Reduction) said that concerning the potential for tsunamis, Indonesia ranked first out of 265 countries in the world. In the past year, Indonesia experienced many major disasters. BNPB noted that as of October 2018 there are 605 tornadoes, 506 floods, 353 forests and land fires, 319 landslides, 55 volcanic eruptions, 33 tidal waves and abrasion, 17 destructive earthquakes, and 1 tsunami occurrence. As of 30 December 2018, BNPB recorded that disaster events in Indonesia reached 2,564 incidents resulting in 3,349 people died, 1,432 people were missing, 21,064 people were injured, 10.2 million people were displaced and affected, and 319,527 housing units were damaged. [1]

The increasing of risk disaster in Indonesia is due to the lack of adequate disaster technology support. For example, with so many tsunami risk potential areas, Indonesia should install a buoy device on each of these areas. But Indonesia has no active buoys since 2012 [2].

From the description above, Indonesia still has many tasks to prepare a system that supports disaster risk reduction, one of which is by preparing disaster early detection technology. In developing a disaster early detection system requires a system with reliable capacity and capability because the system will accommodate many sensors.

A Technology that can be utilized to accommodate the system requirement is using satellite. Satellite technology will become a data collection platform to receive information from sensors on the earth. The existing satellite used as a data collecting platform is Argos DCS satellites which uses UHF frequencies. [3]

One of the satellite payloads that can be used to support collecting data platforms is VHF Data Exchange Systems (VDES). VDES is a maritime communication system using Very High Frequency (VHF). Recently, VDES is widely used for maritime communication. In this study, the authors conducted a study of the use of VDES for disaster sensor communication in Indonesia [4]. The advantage of sensor communication using VDES is that the frequency used in communication is VHF so it requires low power to transmit data from the earth station, with the VHF frequency the VDES

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is able to transmit data with a small capacity that is usually used for sensor communication, VHF frequencies require smaller user terminal dimensions and are more portable when compared to user terminals with higher frequency, with such small user terminal dimensions that will support the ease of installation of user terminals in remote locations or mobile locations such as ships station.

2. VDES OVERVIEW

The architecture of the VDES consist of three application. These are AIS,ASM and VDE (VDE-Terrestrial and VDE-Satellite). Figure 1 and Table 1 shows channel management of the AIS, ASM and VDE application.

The original idea of AIS development in 1990s is to avoid collisions between vessels without help of shore authorities. The mechanism of AIS is exchange the current position, velocity information and tracking information of their vessels. The power levels of transmitting AIS data is range from 1W up to 12.5W depending on which amplifiers are used. The AIS signals in space are received and collected. The AIS via satellite collecting and detecting data in an area larger than terrestrial coverage that is approximately 40 times. AIS data is repeatedly broadcasted so the satellite receive the data. And then downlink data is done. Post-processing could be done off-line and cope with the different transmitters and interference level units.

ASM was developed to reduce the load on the AIS channels for dedicated information. Increased use of ASMs makes high loading of the VDE and new channel of ASM. The capacity of VDL is increase but the message structure is same.

And then, VDE offers its frequency band to transmit non dedicated data. VDE has two application that are VDE via terrestrial and VDE via satellite.

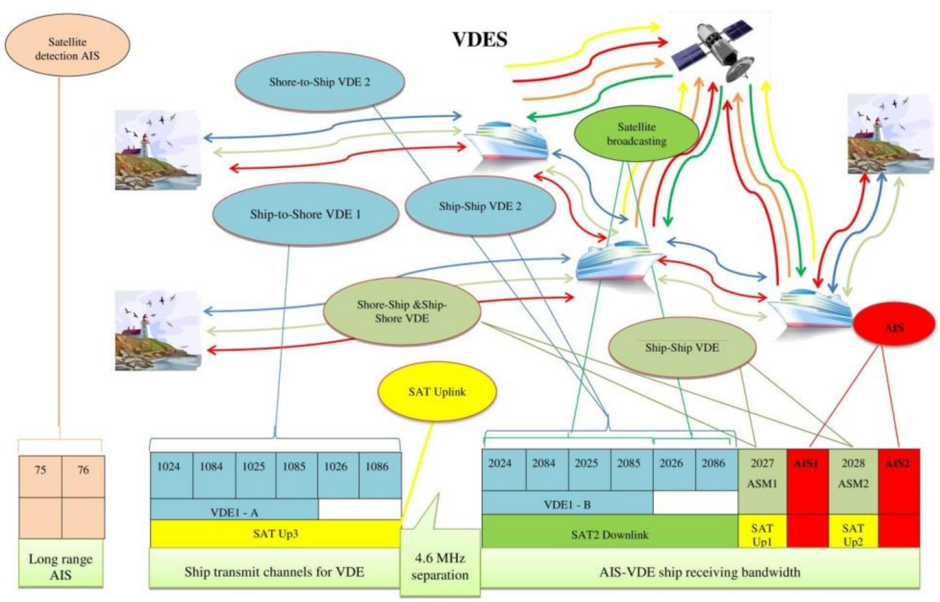

Figure 1. VHF data exchange system functions and frequency usage [7]

Table 1. Margins and print area specifications. [5]

RR Appendix 18 channel number		Transmitting frequencies (MHz)	
		Ship stations (ship-to-shore) (long range AIS) Ship stations (ship-to-satellite)	Coast stations Ship stations (ship-to-ship) Satellite-to-ship
AIS 1		161.975	161.975
AIS 2		162.025	162.025
75 (long range AIS)		156.775 (ships are Tx only)	N/A
76 (long range AIS)		156.825 (ships are Tx only)	N/A
2027 (ASM 1)		161.950 (2027)	161.950 (2027)
2028 (ASM 2)		162.000 (2028)	162.000 (2028)
24/84/25/85 (VDE 1)	**24/84/25/85/26/86** **(Ship-to-satellite,** **satellite-to-ship)**	**100/150 kHz channel** (24/84/25/85, lower legs (VDE1-A) merged) Ship-to shore **(24/84/25/85/26/86) Ship-to satellite**	100/150 kHz channel (24/84/25/85, upper legs (VDE1-B) merged) Ship-to-ship, Shore-to-ship (24/84/25/85/26/86) Satellite-to ship
24	**24**	**157.200 (1024)**	161.800 (2024)
84	**84**	**157.225 (1084)**	161.825 (2084)
25	**25**	**157.250 (1025)**	161.850 (2025)
85	**85**	**157.275 (1085)**	161.875 (2085)
	26	**157.300 (1026)**	161.900 (2026)
	86	**157.325 (1086)**	161.925 (2086)

A common design goal of the terrestrial and the satellite VDE system is to keep the development costs low and to target a simple replacement of an AIS transceiver with a single VDES. The goal of VDE is to support higher modulation schemes, reuse hardware parts, use of common system blocks, for both VDE systems.

3. MATERIAL AND METHOD

In this study, an assessment was carried out on the implementation of an early disaster detection system using VDES. The first research method is to study the VDES specifications, from the frequency used, the number of channels, the number of slots that can be sent at one time, the data packet format, modulation, access scheme, its utilization and others. The second is to study the characteristics of sensor communication needs in Indonesia, starting from the type and minimum number of disaster sensors needed by Indonesia, the format of the data packet sent, the length of messages in one data packet, the need for data transmission time intervals, and so on. Third is calculating the capability and capacity of VDES to communicate with disaster sensors in accordance with the VDES specifications set out in ITU Rec. M.2092-0.

Of the three applications provided by VDES, the authors chose to use frequencies for VDE applications, where VDE applications are regulated in ITU Rec. M.2092-0 has wider bandwidth than 2 other applications, VDE also has a more varied modulation technique, this makes the VDE bitrate greater than the other 2 applications. VDE is planned to have a data package format that can be adopted to user needs unlike the 2 predecessor applications. In this study the authors used a specific VDE application for communication with satellites (VDE-SAT) where VDE-SAT has 6 channels that can be used namely channels 24, 84, 25, 85, 26, and 86, each channel has a 25 kHz bandwidth.

In this study, it is assumed to use QPSK modulation with a roll-off factor of 0.3, so that the maximum bitrate is 19.2 kbit/s. The time interval for 1 burst of data transmission (1 slot) VDE-SAT is 26,667 ms (60 000/2250 = 80/3 ≈ 26,667). Calculation of the time required by a frame to be sent in Figure 2. The frame hierarchy definition is independent of the assigned bandwidth to the VDE channel. The length of the VDE information message per slot is 512 bits according to the specifications regulated in ITU Rec. M.2092-0.

Study of sensor station requirement in Indonesia is carried out through several methods, by seeking information from resource in related institutions, through national news and literature study. The disaster sensors used in this study are limited to seismographs, tidal sensors, GPS and tsunami buoys. The results of this study obtained the number of stations that exist and are planned to be installed this year in Indonesia, as shown in Table 2

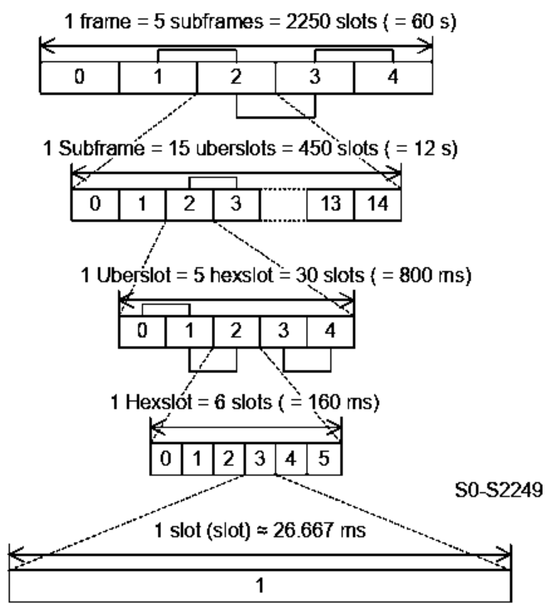

Figure 2. Frame Hierarchy for Shared Frequency of VDES [5]

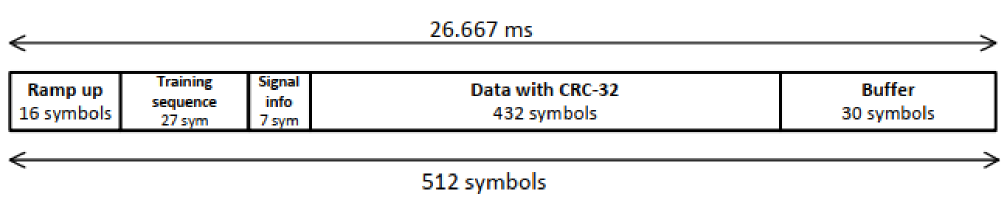

Figure 3. One Slot Structure of 25 kHz Bandwidth [5]

Table 2. Sensor Station Requirement in Indonesia

Station Type	Station Number	Information Length (include header)
Seismographs	369	168
Tide Gauge Sensor	138	152
GPS	207	152
Tsunami buoys	22	312

VDE-SAT has 6 channels, in this study the authors designed 1 channel used for communication of 1 type of sensor, except for seismograph. Seismograph required up to 396 stations, this is the highest number of stations compared to other sensors, where seismograph communication requires a real-time transmit interval which can reach 0.1 s It caused a seismograph communication require wider channels compared to other sensors. So that the seismograph communication in this study was designed using 3 channels.

4. RESULT AND ANALYSIS

In this study, the calculation of the capacity of the VDE to communicate with the disaster sensor is in accordance with the VDES specifications regulated in ITU Rec. M.2092-0. Table 1 shows the results of the VDES-based System Calculation for Disaster Sensor Communication. The data presented in the format of satellite receiver specifications including burst time (ms), burst payload (bits / burst), burst data rate (bps), bandwidth (Hz), and spectral efficiency (bps / Hz).

Furthermore, the specifications of each sensor station are calculated, for the payload data information of the seismograph station requirement of 21 bytes / message (168 bits / message), a tide gauges sensor station by 19 bytes / message (152 bits / message), a GPS station by 19 bytes / message (152 bits / message), and tsunami station buoys by 39 bytes / message (312 bits / message). With the burst payload specification used on satellites, the number of bursts for a single payload data information transmission at one sensor station is calculated. Because the size of the burst payload is greater than the information payload, the number of bursts for sending information payload is just once.

The VDE receiver's ability to receive the number of sensor stations per second is calculated. The results show that 1s per VDE channel capable of receiving messages from 37 sensor stations for each sensor type. The calculation is excluded for seismograph stations because seismograph stations use 3 channels, then within 1s per 3 VDE channels can receive messages from 111 seismograph stations. Receiving information data within the 1s did not meet the need to receive messages from all existing sensor stations, a TDMA access scheme was used so that messages from all sensors could be received. However, to receive messages from all sensors with TDMA access schemes, real-time data reception cannot be generated every 1s, so there will be a delay in sending each sensor.

The delay generated for each type of sensor is as follows, the delay of one sensor station from the first transmission to the second transmission is 4s for seismograph sensors, 4s for tide gauges sensor stations, 6s for GPS stations, and real-time per 1s for tsunami buoys.

From the calculations result, it can be analyzed that the VDES implementation for early detection system disasters in Indonesia can be done and produce near-realtime data reception with a maximum delay of 6s. The results of calculations can still be developed considering the calculation is still limited to TDMA access schemes. If in one channel want to produce realtime communication <= 1s with several sensors that exceed the channel capacity, can implement the development access scheme of TDMA.

Table 3. VDES-based System Calculation for Disaster Sensor Communication

VDES-based System	**Unit**	**Value**			
		Channel 1,2,3 (Seismograph)	**Channel 4 (Tide Gauges Sensor)**	**Channel 5 (GPS)**	**Channel 6 (Tsunami Buoys)**
Receiver Satellite Specification					
Burst Time	ms	26.667	26.667	26.667	26.667
Burst Payload	bits/burst (slot)	512	512	512	512
Burst Data Rate	bps	19,200	19,200	19,200	19,200
Bandwidth	Hz	25,000	25,000	25,000	25,000
Spectral Efficiency	bps/Hz	0.768	0.768	0.768	0.768
Station Specification					
Information Payload (+Header 30%)	bytes/message	21	19	19	39
Information Payload	bits/message	168	152	152	312
Number of bursts	bursts (slot) /message	1	1	1	1
Length of message	ms/message	26.667	26.667	26.667	26.667
Messages per second	messages (slot)/s	37	37	37	37
Update Interval per station	s/station	1	1	1	1
Update per second per station	updates/s/station	1	1	1	1
Number of stations	stations	37	37	37	37
Number of sensor stations	stations	369	138	207	22
Number of channels		3	1	1	1
Total number of stations	stations	**111**	**37**	**37**	**37**
Delay Time	s	4	4	6	1
Daily Info	bits/s	6,216.0000	5,624.0000	5,624.0000	11,544.0000

5. CONCLUSION

This paper has conducted a study on the implementation of VDES for disaster early detection systems in Indonesia. The implementation of VDES for disaster early detection systems is very possible in Indonesia using the VDE-SAT application. But the VDE-SAT has a limitation in bandwidth and the number of channels provided, if the data sent is long and very large. So, to accommodate all the disaster sensors, and the bigger size, we need wider bandwidth and an additional number of channels. The solution is to use other VHF maritime frequencies that are not regulated by VDES regulations or frequencies above VHF. Further studies that can be carried out are studies of the number of communication channels required for all type of disaster sensors in Indonesia, the total amount data capacity, and the types of access schemes required.

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