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Pekan Lightning Detection System (PLDS) and Data Validation with Lightning TNBR

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Abstract— **Lightning Location System (LLS) based on MDF and TOA technique has been installed and setup in Universiti Malaysia Pahang, Pekan for lightning warning and monitoring system. The two important aspects of the performance of LLS are the location accuracy and detection efficiency (DE). In this paper, the real-time data include the time of lightning strokes, their location and an estimate of the peak current has been compared with Lightning Location Network (LDN) owned by TNBR Malaysia to validate the DE of the system.**

Keywords-component;Lightning Location System; detection efficiency;data validation;Pekan

I. INTRODUCTION

Pekan are located at east of peninsular Malaysia which that like other tropical countries which experience very high cloud to ground (CG) density. Observations performed by the Malaysian Meteorological Services indicate that thunders occur 200 days a year in Malaysia [1]. The Lightning Location System (LLS) can be used to minimize the harmful effects of lightning by providing early warning of such lightning hazards to the people.

The LLS systems have collected a large number of data on the time, location, lightning coordinates, amplitude, polarity of the CG flashes and number of stroke per flash [2]. LLS are being operated in many countries, including the U.S. [2], U.K. [3], Japan [4], Canada [5], Austria [6], Sweden [7], China [8], Indonesia [9], Malaysia [1] and other countries. There are more than 60 LLS networks worldwide [10] that employ commercial instrumentation operating in the VLF/LF range.

Lightning can be located from low and high frequency sferics with time of arrival (TOA) and interferometer technologies. Nowadays, the combination of TOA and DF technology cause the greatest benefit in location accuracy and detection efficiency (DE) of lightning flashes [11]. Two important aspects of the performance of LLS are location accuracy and detection efficiency which is basically the function of the source strength and distance of lightning flashes [12].

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The U.S. Precision Lightning Network (USPLN) is employs the VLF/LF TOA technique of detection. The system was reported that greater than 90% stroke detection efficiency (DE) with 250m typical location error [10]. The LDN comprises of 8 remote DFs, a central processor APA 280-T and a lightning location display. The location accuracy and detection efficiency are 3km (or better) and 85 percent (or better) respectively [1].

The ALDIS system is estimated to be higher than 90% of DE which is one of the best detection in the world [6]. The long range detection network, Zeus [13] is reported to typically locate 20% of the CG flashes at a distance of about 5000 km, with higher DE closer to the sensor array.

In this paper, the data validation of PLDS and detection efficiency (DE) has been described. The real-time data include the time of lightning strokes, thunderstorm, their location and an estimate of the peak current has been compared with Lightning Detection Network (LDN) owned by TNBR Malaysia.

II. OVERVIEW OF DETECTION SYSTEM

A. Lightning Detection Network

The need for an accurate lightning data and the desire to reduce the impact of lightning on the supply reliability and quality has motivated TNB Research Sdn. Bhd. (TNBR) to install the Lightning Detection Network (LDN) in Malaysia. [1]

In an effort to reduce the impact of lightning in TNB, TNB Research Sdn. Bhd. (TNBR), a research arm of TNB, has installed a Lightning Detection Network (LDN) in Peninsular Malaysia in 1994.TNBR using IMPACT ESP sensor which is located at eight difference location in Malaysia. TNBR also tracking the real time lightning data and estimating fault location. [1]

Continuous monitoring of sensors performance for upgraded network is being carried out by Lightning Detection System Laboratory operated by TNBR. Lightning events and its locations are recorded by a system called Lightning Processor 2000 (LP 2000), which is developed by VAISALA. [1].

The function of LDN is tracking the lightning activities in real-time. LDN also estimation faults locations based on location of lightning strokes and speedy supply restoration. LDN also do an analysis of faults on power lines and justification for lightning mitigation efforts and assessment for its effectiveness. LDN is using IMPACT sensor to detect lightning which:

a) Isolates electromagnetic waveforms of lightning
b) Combines MDF and TOA technology
c) Detects C-G and C-C lightning
d) Detects radio frequency energy in range of 0.4 to 400kHz
e) Has detection range up of about 1500 km, up to 625km is use.

B. PLDS

At the early of 2012, a lightning detection system based on Magnetic Direction Finder and Time of Arrival was first installed in Pekan. Then the system was renowned as Pekan Lightning Detection System (PLDS). Fig.1 has shown the GUI of PLDS that has been installed at UMP, Pekan.

The system consists of three major parts, including the combination of magnetic direction and time –of- arrival finder antenna, receiver and lightning location information analysis and GUI system. The sensor was located on coordinate 3° 32' 0" North, 103° 28' 0" East which is Block 1, FKEE, Universiti Malaysia Pahang, Pekan campus.

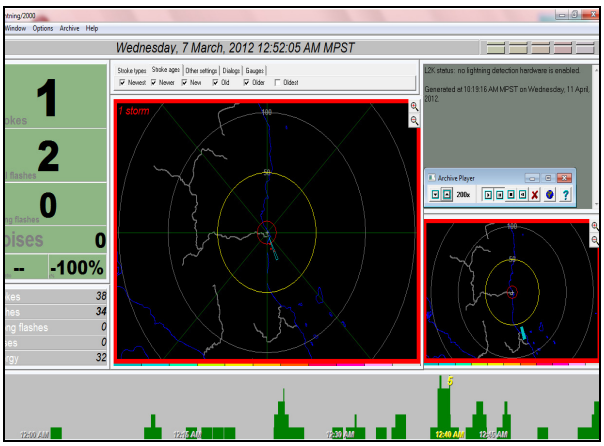

Figure1. Pekan Lightning Detection System (PLDS)

The PLDS system is used a sensor which consist a small active antenna to receive the EMF and E-field from lightning strikes. The sensor detection is based on the magnetic direction finder (MDF) and time-of-arrival technique to detect the lightning. It consists of two orthogonal magnetic loops from which the source azimuth can be deduced. The source location is then estimated by the triangulation technique [14].

The purpose of developing PLDS is to publish real time lightning data in 50km radius from the sensor location. The populations in this area consist of fishermen who make a livelihood from the sea and industrials park which exposed to damage that cause by lightning. The information about lightning occurrences at this region might help these people to buckle up during lightning. It is important to understand the phenomena and characteristic of the lightning because lightning cannot be prevented.

III. PLDS DATA VALIDATION

Data validation is very important to make sure all the collected data is accurate. The LDN has made possible detection of lightning in the Peninsular Malaysia in real-time. Quantitative data on stroke locations, time and parameters have enabled accurate estimation of lightning severity in Malaysia.

This information which never has been available before has provided TNB the opportunities to be more scientific and quantitative in their approach when dealing with lightning [14]. The LDN has become an invaluable resource for TNB to facilitate lightning mitigation actions. Historical data obtained from Tenaga Nasional Berhad (TNB) Research, Peak discharge current, location and time.

After several weeks of collecting data, all the collected data must be validate with lightning TNBR before proceeding to the next step. Once the data had been validate, analyze on comparison between data and find the error percentage.

A. Lightning TNBR Data

Tenaga Nasional Berhad Research provided the data for March 2012 in latitude 3.5555° longitude 103.4667° within 50km radius from the point, which is where Pekan region is located. Historical data obtained from TNBR is in Peak discharge current, location and time. Lightning data for one month are given by TNBR. The data started from 1st March 2012 until 31th March 2012 is used to compare. The data contain the lightning location and amplitude which in kA (kilo ampere). These data are compared with PLDS data which will be discussed in Part IV

B. PLDS Lightning data

By using PLDS, the daily summary will be provided. The total strokes, flashes, noises and energy are calculated by the software every 24 hours. The software will display in yellow or red alert when there is stroke nearby where the sensor are locate. The yellow alert will trigger when the stroke within 50km radius while the red alert trigger in 10km radius from the located sensor. The triggering level was set during the software initial setup.

C. *Validation Data*

The process to validate the data is by taking the PLDS real time data and compare with lightning TNBR data. Data from the achieve file need to be playback to compare with every lightning data with TNBR to fine the similarities of the time for lightning occurrence.

IV. RESULT AND DISCUSSION

Tenaga Nasional Berhad Research had provided the data for March 2012 in latitude 3.5555° longitude 103.4667° within 50km radius from the point, which is where Pekan region is located. Historical data obtained from TNBR is in Peak discharge current, location and time. The data contain the lightning location and amplitude which in kA (kilo Ampere). These data are compared with PLDS data which will be discussed in validation data and data analysis. Table1 showed the peak current comparison between PLDS and TNBR system.

TABLE I. PEAK CURRENT OF PLDS & TNBR

Date	PLDS		TNBR	
	Time	Peak current	Time	Peak Current
2/3/2012	17:36:26	-26.8	17:37:13	-19
6/3/2012	17:35:34	-24.1	17:35:34	-22
6/3/2012	17:53:55	-29	17:52:10	-46
6/3/2012	18:02:04	-28.4	18:02:58	-23
6/3/2012	18:34:31	-40.2	18:34:29	-42
7/3/2012	17:53:21	-32.4	17:52:46	-33
8/3/2012	4:01:45	-42.1	4:01:57	-42
8/3/2012	4:18:54	-14.4	4:17:39	-14
8/3/2012	5:06:40	63.9	5:17:44	64
8/3/2012	5:29:28	-76.9	5:28:39	-79
21/3/2012	14:09:09	-38.9	14:09:09	-31
21/3/2012	14:16:51	-15.1	14:15:35	-14
21/3/2012	17:07:35	-25.5	17:08:01	-36
27/3/2012	17:25:27	-20.6	17:25:56	-28
27/3/2012	17:33:42	--22.5	17:33:46	-21
27/3/2012	17:45:41	-21.4	17:45:08	-22
29/3/2012	17:01:19	-36.7	17:01:29	-33
29/3/2012	18:42:58	-23.6	18:40:46	-28

Most of the data recorded is the –ve discharge lightning which the most dangerous lightning discharge. The highest peak current is -79 kA which is recorded by TNBR while -76.9 kA recorded by PLDS. The averaged peak current recorded by the both system during March 2012 is 38.4kA. Based on data has been captured, less than ±5% different between both systems. Table II shown the time of lightning occurred recorded by the both system.

TABLE II. TIME OF LIGHTNING STROKES

Date	Time	
	PLDS	TNBR
2/3/2012	17:36:26	17:37:13
6/3/2012	17:35:34	17:35:34
6/3/2012	17:53:55	17:52:10
6/3/2012	18:02:04	18:02:58
6/3/2012	18:34:31	18:34:29
7/3/2012	17:53:21	17:52:46
8/3/2012	4:01:45	4:01:57
8/3/2012	4:18:54	4:17:39
8/3/2012	5:06:40	5:07:44
8/3/2012	5:29:28	5:28:39
21/3/2012	14:09:09	14:09:09
21/3/2012	14:16:51	14:15:35
21/3/2012	17:07:35	17:08:01
27/3/2012	17:25:27	17:25:56
27/3/2012	17:33:42	17:33:46
27/3/2012	17:45:41	17:45:08
29/3/2012	17:01:19	17:01:29
29/3/2012	18:42:58	18:40:46

The data showed that almost ±2 minutes different between the PLDS and TNBR in term of time occurrences. The time difference is due to several aspects. Current time setting at where both of the detectors were setup might cause difference of lightning activities occurrence time. Time setting is based on the desktop time setting

When the lightning occurred, the software will took 30 seconds for each stroke to be plotted in the real time display when using PLDS. This is because the sufficient number of strokes must be accumulated to perform a reliable analysis. Also every 5minutes, the real time lightning window will resize the shape of lightning displayed on the desktop thus the lightning distribution will display around 5-20 minutes on the window.

The polarization error might be one of the causes of difference time occurrence of both lightning data. The accuracy of the detector is poor at less than 200km because the sensor records the ionospheric reflection.

Lightning daily distribution were took base on the observation of collected data using PLDS at Kuala Pahang and lightning TNBR data. The observation had been done on 17th March 2012 and data were calculated based on the area of detection by the both difference sensor.

TABLE III. TNBR LIGHTNING STROKES LOCATION ON 7TH MARCH 2012

Time	Latitude	Longitude
17:31:07.315	3.927826166	103.374473572
17:51:41.857	3.814896345	103.199104309
17:52:46.776	3.819240093	103.352523804
17:57:50.058	3.814645767	103.314262390
17:59:38.138	3.829422951	103.355972290
17:59:38.351	3.865771294	103.265899658
18:03:37.471	3.817229509	103.208770752
18:21:56.725	3.804736853	103.225082397
19:17:16.795	3.297623634	103.100593567
19:47:03.089	3.320519447	103.111595154
23:05:22.028	3.121590137	103.411422729
23:10:44.353	3.128731012	103.590423584
23:23:44.240	3.197701454	103.454574585
23:26:16.739	3.145009279	103.397682190
23:32:11.175	3.128959417	103.395767212
23:40:05.941	3.202405691	103.606208801
23:53:18.942	3.162781477	103.411071777

Based on Table III, there were 17 lightning activities captured by lightning TNBR within 50km radius. The lightning activities are recorded around 5.31pm until 11.53pm on that day. Table IV showing the lightning activities captured by PLDS between 5.36pm until 11.38pm which have total 20 lightning within that area. Fig.2 shown the red alert lightning activity captured by PLDS on 7th March 2012 at 5.37 PM. There have active thunderstorm activity in the 50km radius from Kuala Pahang.

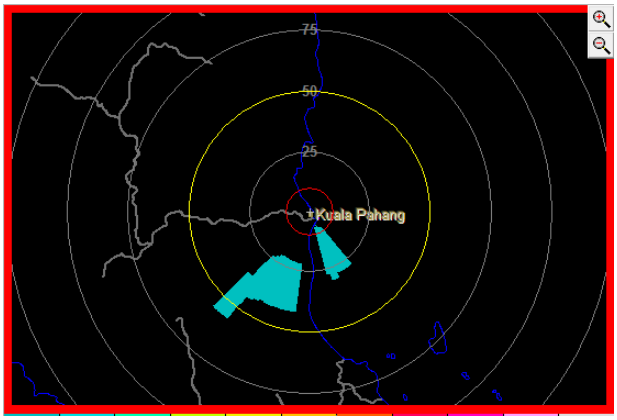

Figure2. Lightning activity on 7th March at 5.37 PM

TABLE IV. PLDS LIGHTNING STROKES ON 7TH MARCH 2012

Time	Stroke activities	Energy ratio (%)
17:36 – 17:41	3	73
17:52 – 17:57	4	98
18:20 – 18:25	5	39
19:15 – 19:20	1	107
19:25 – 19:30	2	108
23:11 – 23:16	2	130
23:33 – 23:38	3	49

Most of the lightning activity has been captured by TNBR system on 7th March 2012 lie between 3.19 latitudes, 103. 39 longitudes to 3.92 latitudes, 103.374 longitudes. The latitude and longitudes given by the TNBR data is referring to Pekan region. While, PLDS just show the location of the lightning activity on map (Fig.2). Others information can be accessed by clicking on maps and the data such as peak current, time occurrence, range and etc can be clarified.

Fig.3 shown the lightning location accuracy comparison in term of quantity lightning detected by the system. The data is analyses based on data captured during March 2012.

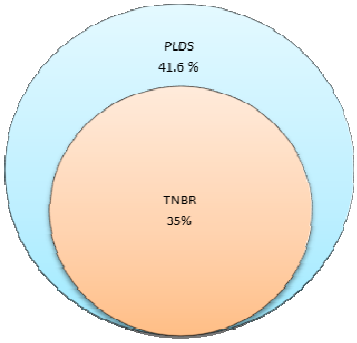

Figure3. Quantity of lightning detected by the system

The PLDS has successfully detected 41.6% lightning activity instead of 35% by lightning TNBR. The rate of detection for PLDS is higher than TNBR because PLDS is installed to cover the 50 km radius of Pekan region while the LDN TNBR is covered on peninsular Malaysia. The detection efficiency (DE) of PLDN is almost 85% based on March 2012 data. However, the percent of detection can be changed if one year data has been analyzed.

V. CONCLUSION

PLDS has been installed on early of January 2012 at Universiti Malaysia Pahang, Pekan. The data captured using the system has successfully compared and validate by the Lightning Detection Network (LDN) owned by TNBR Malaysia. The lightning data on March 2012 has been processed and analyze. The peak current, time occurrences and location of the lightning activity has been compared as a result the DE of PLDS is almost 85 percent.

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