https://humicpress.org/journals/index.php/ijohce
Intl. Journal of Human Centric Engineering
Vol. 1, No. 1, Mar 2024. pp.1-11

Development of a Mini Weather Station Based on Rainboard and Android Applications in Cipageran Cimahi

Valianda Farradillah Hakim[1], Kemas Muslim Lhaksmana[2], Hilal H. Nuha[3]

[1,2,3]*Faculty of Informatics,* [1,2,3]*Telkom University*
Bandung

[1]valiandafh@students.telkomuniversity.ac.id , [2]kemasmuslim@telkomuniversity.ac.id ,
[3]hilalnuha@telkomuniversity.ac.id

Abstract

Every airport necessitates a weather station to furnish crucial weather information for aircraft operations. However, not all airports possess adequate weather stations due to their high costs and susceptibility to damage. Consequently, both new and established small airports require weather stations. Thus, this study endeavors to develop affordable mini weather station equipment composed of cost-effective domestic components. Development and testing of this equipment took place in Cipageran Cimahi, representative of Indonesia's natural weather conditions. After conducting various tests, sufficient weather data was obtained, closely resembling actual weather station conditions. The hardware utilized comprises budget-friendly options such as Rainboard or Arduino Uno, paired with domestic component sensors. Data is displayed through Android-based applications and compared against calibration tools like "heles" and BMKG Info. While the sensor and calibration tool data exhibited symmetrical results, BMKG Info differed due to its broader coverage area, unlike the local weather measurements obtained by the sensors and calibration tools. Further refinement of this equipment can be achieved by employing superior sensor components and ensuring calibration.

Keywords: Weather, Rainboard, Arduino, Android, Sensors

Abstrak

Setiap bandara membutuhkan stasiun cuaca untuk memberikan informasi cuaca yang penting untuk operasi pesawat. Namun, tidak semua bandara memiliki stasiun cuaca yang memadai karena biayanya yang tinggi dan kerentanan terhadap kerusakan. Oleh karena itu, baik bandara baru maupun bandara kecil yang sudah mapan membutuhkan stasiun cuaca. Oleh karena itu, penelitian ini berusaha untuk mengembangkan peralatan stasiun cuaca mini yang terjangkau yang terdiri dari komponen-komponen dalam negeri yang hemat biaya. Pengembangan dan pengujian peralatan ini dilakukan di Cipageran Cimahi, yang mewakili kondisi cuaca alami di Indonesia. Setelah melakukan berbagai pengujian, diperoleh data cuaca yang cukup memadai, sangat mirip dengan kondisi stasiun cuaca yang sebenarnya. Perangkat keras yang digunakan terdiri dari pilihan yang terjangkau seperti Rainboard atau Arduino Uno, yang dipasangkan dengan sensor komponen dalam negeri. Data ditampilkan melalui aplikasi berbasis Android dan dibandingkan dengan alat kalibrasi seperti "heles" dan Info BMKG. Data sensor dan alat kalibrasi menunjukkan hasil yang simetris, namun Info BMKG berbeda karena cakupan wilayahnya yang lebih luas, tidak seperti pengukuran cuaca lokal yang diperoleh oleh sensor dan alat kalibrasi. Penyempurnaan lebih lanjut

Published on 30 March 2024.

dari peralatan ini dapat dicapai dengan menggunakan komponen sensor yang lebih unggul dan memastikan kalibrasi.

Keywords: Weather, Rainboard, Arduino, Android, Sensors

I. INTRODUCTION

A. Background

Station Weather observations are available at all airports which function to measure weather conditions at that time in real-time which contain information regarding temperature, pressure, humidity, altitude, wind speed, wind direction, rainfall and visibility. This information is packaged in format
METAR is sent via radio communication with a certain frequency which is received by aircraft that will carry out flights and landings periodically every minute. The data obtained will be used as a consideration for the pilot to fly safely under permitted weather conditions.

The equipment used is mostly made abroad, the level of accuracy is quite high and the price is quite expensive. If it is made domestically, it requires reliable hardware and software that meets aviation specifications, but it can also be made at an affordable price using components with functions. the same one. Creation of a mini weather observation station to study some of the processes of a real weather observation station, the data observed only partially includes temperature, pressure, humidity, wind speed, wind direction, rainfall and visibility. It is hoped that the weather data obtained will be close to actual weather conditions.

B. Problem formulation

The problem formulation of this research is

a) How does the Rainboard or Arduino Uno hardware read several sensor modules into weather data and process it?
b) How does the Rainboard or Arduino Uno hardware connect and send data to the internet network?
c) How does the Android hardware connect to the internet network and connect with weather data sent by the Rainboard or Arduino Uno hardware, and display the data in a form that is easy to observe?

C. Scope of problem

The problem limitations of the research carried out are:

a) Developments in Mini Weather Stations.
b) How to get real weather data through multiple sensors.
c) Hardware processes capture, process, collect, send, and display data.

D. Objective

The development of this mini weather station examines how the Rainboard or Arduino Uno hardware measures data from several sensors and processes it in the form of weather data, obtains the results of weather observations and sends them to the Internet network. Then an Android-based application was implemented to make it easier to collect data and observe in visual form.

E. Writing Organization

The next section is explained in Chapter two Related Studies regarding studies that support the TA Topic such as explanations of the hardware used and research methods used, after that Chapter three concerns System Design such as modeling of tools, then the Evaluation Chapter regarding test results and analysis and finally Chapter Conclusion regarding the conclusions from the test results.

II. RELATED STUDIES

This research begins by selecting the equipment that will be needed, including a control board for processing data, appropriate sensors and network communications so that the application can be displayed properly. Control Board selection is selected using Rainboard or Arduino Uno hardware. Meanwhile, the sensors chosen consist of Anemometer, Rainfall, BMP180, DHT11, which are available on the commercial market at affordable prices. Network communication uses the ESP2866 component with a wireless method (Wifi). IoT data communication on the Internet uses the api.thingspeaks.com server which can be accessed by the control board and also by applications on Android. The Android application was chosen to display data so that it is informative and can produce sound. The METAR format was chosen as the official reference for weather data communication.

A. Rainboard, ESP8266 Arduino Module, and Android

Rainboard is a tool for carrying out data control activities, receiving data, and processing data. This tool is equipped with a hardware interface and IDE software which allows the use of a multifunctional tool for various control purposes. This device is equipped with main components consisting of a serial converter, microcontroler, power regulator, I/O interface, and controllable hardware interface[1].

The ESP8266 Arduino module is a Wi-Fi chip with full TCP/IP capabilities, this small board has an integrated Micro Controller Unit (MCU) to control the digital I/O pins via simple pins and almost pseudo-code like a programming language. The device is manufactured by Shanghai-based Chinese manufacturer Espressif Systems [2].

Android is a Linux-based and open-source operating system founded by Android Inc by Andy Rubin, Rich Miner, Nick Sears and Chris White in 2003. This operating system is available on 2.5 billion active devices, ranging from 5G-based smartphones to to tablets [3]. Features include: Wifi Assistant, TextView Autosizing, Notification Snoozing, Pointer Capture, Etc.

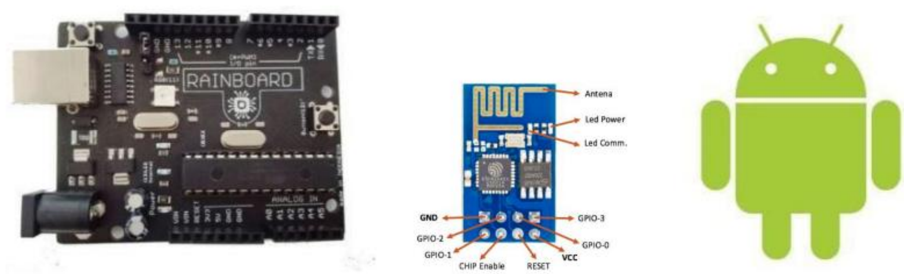

Fig. 1.Rainboard, ESP8266 Arduino and Official Android Logo

B. Anemometer, Rain Detector, DHT11, and BMP180

The anemometer serves as a device utilized to gauge both wind speed and pressure, holding significance for meteorologists engaged in the examination of weather phenomena and are also important for the work of physicists, who study how air moves [4].

The rainfall sensor (Rain detector) consists of a rain detection plate with a comparator that manages intelligence. This sensor detects water coming short of the printed circuit recording circuit. The sensor functions as a variable resistance, altering its state accordingly: resistance rises when the sensor is wet, and decreases when it's dry. [5].

DHT11 sensor for measuring temperature and humidity. The sensor is furnished with a specialized NTC for temperature measurement, along with an 8-bit microcontroller to display temperature and humidity values as serial data. This sensor can measure temperature from 0 °C to 50 °C and humidity from 20% to 90% with an accuracy of ±1 °C and ± 1% [6].

The BMP180 module is a sensor for measuring air pressure and is designed to measure Barometric Pressure or Atmospheric Pressure. This sensor also has high precision and is designed for consumer applications [7].

Fig. 2. Anemometer, Rain Detector, DHT11, and BMP180

C. METAR format

Aviation Routine Weather Report or Meteorological Terminal Format (METAR) is the international code name for routine weather reporting on flights. METAR observations are usually conducted and disseminated every hour. SPECI is the code name for selected flight-specific weather reporting that will be reported when weather changes significant to the flight are observed. This code consists of several groups that are always in the same position relative to each other. If a weather element or phenomenon is absent, the associated group or extension is excluded. [8].

Fig. 3. METAR format (meteocentre.com)

D. C and Java Programming Languages

C is a procedural programming language. Originally developed by Dennis Ritchie in 1972, it was mainly developed as a systems programming language for writing operating systems. The main features of the C language are low-level access to memory, a simple set of keywords, and a clean style [9].

Java is a programming language that was first released by Sun Microsystems in 1995. There are many applications and websites that will not function unless you have Java installed, this programming language has the ability to be fast, safe and reliable [10].

E. Automated Airport Weather Station (AWOS)

Automated Airport Weather Station (AWOS) is an air navigation facility that distributes weather information. Comprising a computerized system, this setup automatically assesses one or more weather parameters and conducts data analysis, prepares weather observations consisting of the measured parameters, provides dissemination of observations and broadcasts observations to pilots in the vicinity of the AWOS, usually using integral or navigational very high frequency radio (VHF). aid (NAVAID), or Automatic Terminal Information Service (ATIS) [11].

F. Standards for Placement of Weather Observation Equipment

The standard for equipment placement refers to WMO 1064, and specifically the placement of class 1 temperature and humidity sensors can be seen in Figure 4. If the condition of the equipment is not suitable then the classification class will drop from 1 to 2 and so on according to the environmental conditions around the weather equipment. and the climate [12].

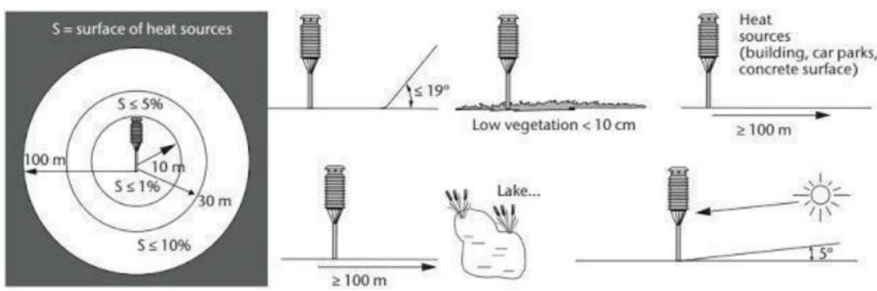

Fig. 4. Temperature and Humidity Installation Standard (WMO 1064)

III. SYSTEM DESIGN

System design begins by creating a system schematic consisting of a control board and several sensors whose pins are adjusted based on the datasheet for each sensor. Next, model communication between hardware and test the control board and create an Android application

A. System Schematic

The system schematic is assembled as in Figure 13, consisting of Rainboard or Arduino Uno hardware as a data controller and processor, and sensors (BMP180, DHT11, anemometer and rain detector), as well as the ESP8266 module as an introduction to the connection to the Internet network.

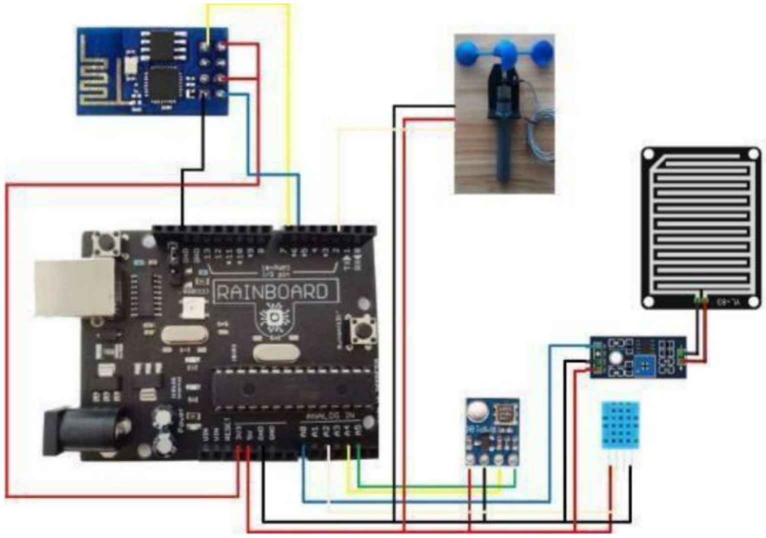

Fig. 5. Hardware System Schematic

The test begins by applying a voltage of 5 Vdc. The program will carry out initialization to get to know the installed modules, then the program will read data from all sensors, including DHT11 (Temperature, Humidity), BMP180 (Temperature, Pressure and Altitude), Anemometer (Wind Speed) and Rain detector (Rainfall). The Wind Direction and Visibility parameters are assumed to be constant values. The program will collect and process all data in real-time, and send it to the network every 5 seconds locally and 30 seconds for IoT data.

B. Hardware Modeling

Rainbord or Arduino Uno hardware modeling consists of DHT11 to measure temperature and humidity, BMP180 to measure temperature, pressure and altitude, Anemometer to measure wind speed, and Rain detector to measure rainfall, while wind direction and visibility are assumed to be constant values, then there are also ESP8266 module to transmit data over the Internet network, Android application created to observe weather measurement data results.

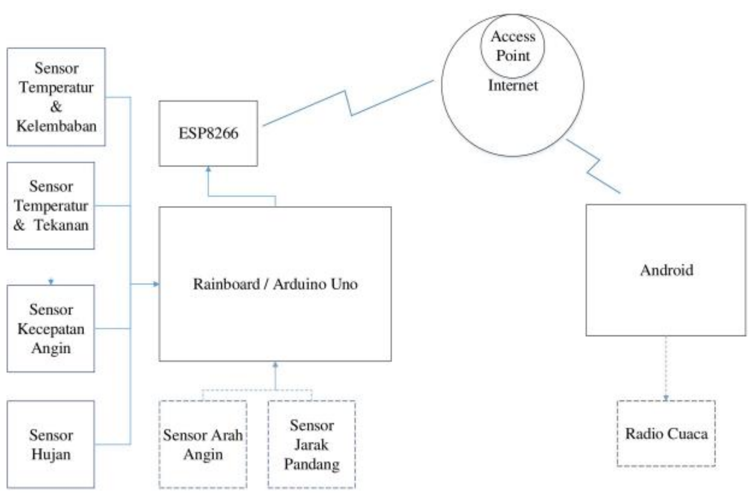

Fig. 6. Hardware Modeling

C. *Hardware and Android Testing and Appearance*

Hardware testing begins with initialization and getting to know the installed modules. Then the program reads the data of all sensors. The program collects and processes all data in real-time, and sends it to the internet network.

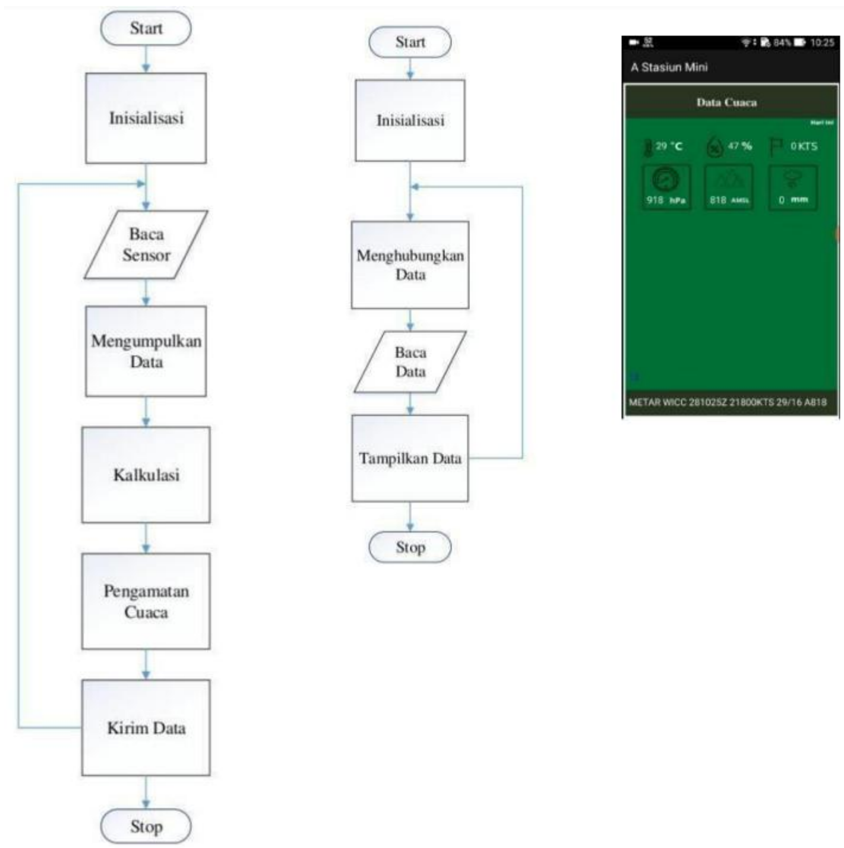

Fig. 7. Hardware and Android Testing and Application Display

The Android application is used to retrieve data from the network and display data continuously. This application contains an Internet communication module (TCP) to retrieve and process data. The final result is METAR data in text form which is displayed and voiced using the text-to-speech module.

The application display contains weather data from Rainboard Hardware which contains temperature data in C (Celsius) units and Humidity in % (percent) units, Pressure in hPa (Hectopascal Pressure Unit) units, Altitude in AMSL (Above Mean Sea Level) units. , Wind speed in units of KTS (Knots), and Rainfall in units of mm (millimeters), Wind direction and Visibility are assumed to be constant values, there is also a METAR format as the weather code, here are the details of the code:

a. WICC = Airport Code (Husein Sastranegara Airport)

b. 262121Z = Date Hour Minutes (in Zulu/UTC time)

c. 21800 KTS = Wind Speed and Direction

d. 29/16 = Temperature / Dew-Point (Dew Point) The Dew-Point formula is as follows:

$$Tp = \left(\frac{f}{100}\right)^{\frac{1}{8}} (112 + 0{,}9T) + 0.1T - 112 \quad (1)$$

e. A818 = Altitude

IV. EVALUATION

Evaluation is carried out to observe the test results according to the required parameters and then analyzed according to the test sequence so that the expected results are obtained.

A. Needs Analysis

In designing this mini weather station, the equipment needed and the parameters to be measured are:

a. Control Board includes Rainboard, Wifi ESP8266, and PCB (Printed Circuit Board)
b. Sensors include DHT11, BMP180, Anemometer, and Rain detector
c. Parameters measured include Temperature, Humidity, Pressure, Altitude, Rainfall, Wind Speed, Wind Direction and Visibility

These eight parameters are needed to fulfill METAR data. Wind direction and visibility are assumed to be constant values (Wind Direction = , Visibility = 7000 m) and the Heles tool and the BMKG Info Application on Android are also needed for data comparison.0^0

B. Test result

From the results of tests carried out for 48 hours for Cipageran Village, North Cimahi District on Monday, 17 August 2020 at 19.10 pm to 23:11 pm, Tuesday 18 August 2020 at 06:39 am to 21:11 pm, Wednesday, 19 August 2020 at 7:21 am to 23:11 pm, and finally on Thursday, 20 August 2020 at 7:11 am to 16:11 pm, that there is real-time weather data updated every 1 minute from Rainboard or Arduino Uno hardware. Data measurement results (Temperature and Humidity) are compared and displayed with other data (Heles tool and BMKG info) in the form of tables and graphs of time functions.

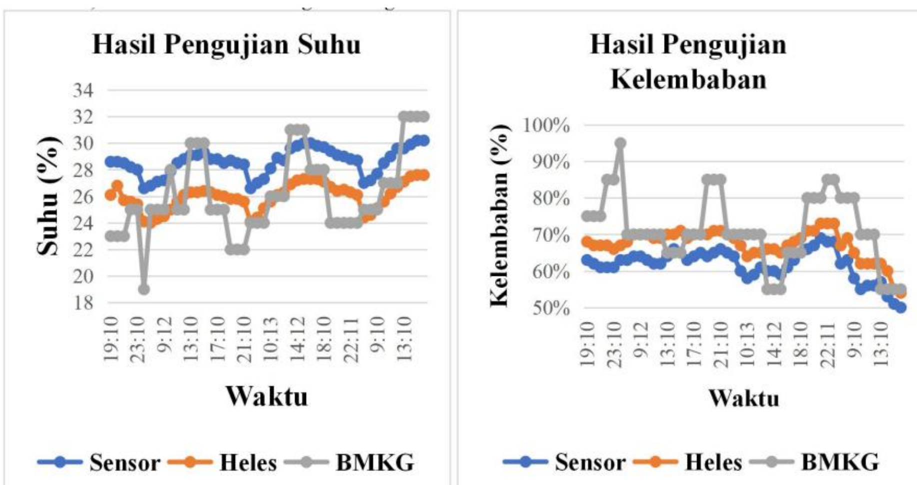

Chart. 1. Temperature and Humidity Data Test Results

Figure 8 shows the test results for Tuesday, August 18 2020 at 18:11. Aims to compare weather data in Thingspeak, Heles tool and BMKG Info. The results show that the temperature at Thingspeak is $28{,}5^0C$, in Heles , BMKG info .26^0C25^0CHumidity data at Thingspeak is 65%, at Heles 70% while BMKG information is 70%.

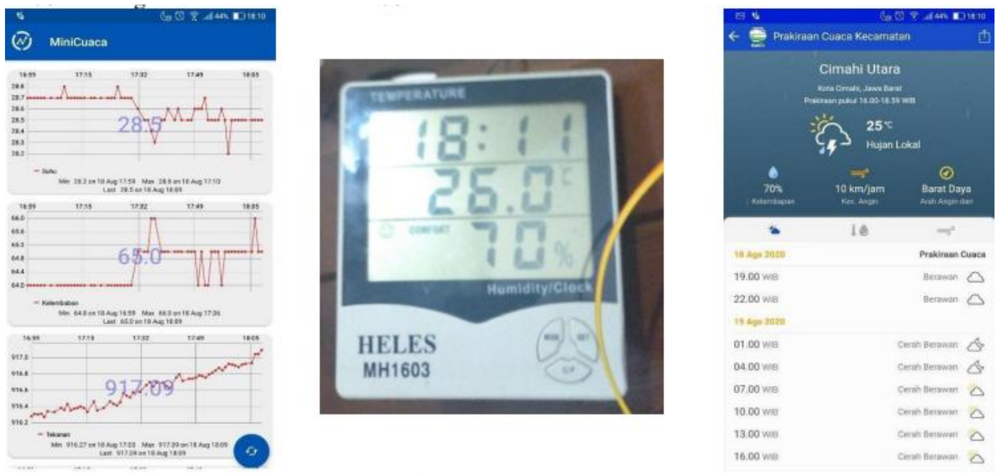

Fig. 8. Tool, Heles, and BMKG Test Results

C. Test Analysis

Test analysis is carried out by observing two parameters of temperature and humidity, the data of which changes over time, and can also be compared with other data as a comparison, namely using BMKG data and the Heles additional calibrator module. The results are shown in the following table.

TABLE I
TEMPERATURE AND HUMIDITY TEST RESULTS

No	Time	Temperature			Humidity		
		Censorship	Helles	BMKG	Censorship	Helles	BMKG
0	19:10	28.6	26.1	23	63%	68%	75%
1	20:10	28.6	26.8	23	62%	67%	75%
2	21:10	28.5	26.7	23	61%	67%	75%
3	22.13	28.2	25.6	25	61%	67%	85%
4	23:10	28	25.4	25	61%	66%	85%
5	6:37	26.6	24.1	19	63%	67%	95%
6	7:10	26.8	24	25	63%	68%	70%
7	8:10	27.1	24.3	25	64%	70%	70%
8	9:12	27.2	24.5	25	64%	70%	70%
9	10:10	27.9	25	28	63%	70%	70%
10	11:12	28.5	25.6	25	62%	69%	70%
11	12:10	28.8	26.1	25	62%	69%	70%
12	13:10	29.1	26.3	30	64%	70%	65%
13	14:10	29.1	26.3	30	66%	70%	65%
14	15:10	29.3	26.4	30	65%	71%	65%
15	16:14	28.8	26.3	25	63%	69%	70%
16	17:10	28.8	26.1	25	64%	70%	70%
17	18:10	28.5	26	25	65%	70%	70%
18	19:10	28.7	25.8	22	64%	70%	85%
19	20:16	28.5	25.8	22	65%	71%	85%
20	21:10	28.5	25.6	22	66%	71%	85%
21	7:19	26.6	24.1	24	65%	70%	70
22	8:16	27	24.4	24	64%	69%	70
23	9:10	27.3	25.1	24	60%	67%	70
24	10:13	28.1	25.6	26	58%	64%	70
25	11:11	28.9	26.1	26	59%	65%	70

26	12:12	28.7	26.3	26	61%	65%	70
27	13:31	29.6	26.9	31	60%	66%	55
28	14:12	29.8	27.2	31	60%	66%	55
29	15:10	30	27.3	31	59%	65%	55
30	16:14	30	27.3	28	61%	67%	65
31	17:15	29.8	27.3	28	63%	68%	65
32	18:10	29.7	27.1	28	65%	69%	65
33	19:10	29.4	26.7	24	66%	71%	80
34	20:09	29.1	26.4	24	67%	71%	80
35	21:10	29	26.5	24	69%	73%	80
36	22:11	28.8	26.3	24	68%	73%	85
37	23:10	28.7	26.1	24	68%	73%	85
38	7:10	27	24.4	25	62%	67%	80
39	8:16	27.2	24.6	25	63%	69%	80
40	9:10	27.7	25.1	25	58%	65%	80
41	10:10	28.5	25.6	27	55%	62%	70
42	11:10	29	26.2	27	56%	62%	70
43	12:10	29.6	26.7	27	56%	62%	70
44	13:10	29.6	27.1	32	57%	62%	55
45	14:10	29.9	27.5	32	53%	60%	55
46	15:10	30.2	27.6	32	51%	55%	55
47	16:10	30.2	27.6	32	50%	54%	55
Standard Deviation		0.99651	1.002176	3.109625	0.0419341	0.0419341	0.0978266

From the test results for 48 hours, the smallest temperature data was obtained at $26,6^0C$, at Heles and at BMKG . The data with the highest temperature on the sensor is , at Heles and at BMKG$24,0^0C19^0C30,2^0C27,6^0C32^0C$, The standard deviation of the data at the sensor, heles and BMKG is 0.99651, 1.002176 and 3.109625 respectively.

The smallest humidity data on the sensor is 50 in Heles, 54% in BMKG, 55%, while the data with the largest humidity in the sensor is 69% in Heles, 73% and in BMKG, 95%. The standard deviation of data at sensors, heles and BMKG is 0.0419341, 0.0407879 and 0.0978266 respectively.

The equipment used is capable of capturing raw data from sensors, then processing it into mature data according to actual weather data. This data can be sent to an Internet network that has an access point or wireless router, the data is stored on a server with the address at thingspeak channel 1074679, and can be accessed via a browser (web program) on a computer and a special application on Android which is capable of displaying METAR data which can voiced using the text-to-speech facility.

Testing using Rainboard hardware and compared to Arduino Uno produces weather data that is almost the same and not different, as well as when processing and sending data via communication in the network as part of implementing IoT (Internet of Things) runs well and smoothly, this is because the pin arrangement from both boards (Rainboard and Arduino Uno) are almost the same, and the program embedded is exactly the same using the C language of the Arduino environment

V. CONCLUSION

From the results of data analysis using Rainboard or Arduino Uno, it can be concluded that the two pieces of hardware can be used to directly observe local weather conditions. The results of the data from the sensors when compared with the calibrator (heles) are almost the same, but when compared with the BMKG they are different, because the BMKG covers a wide area while the sensors and calibrators (heles) measure the weather in the local area. For better results, a more accurate but expensive sensor needs to be used and the sensor calibrated.

The results of this system design can be further developed into a more detailed weather station and can be used by airports in Indonesia. A separate server is needed to process data from all weather stations so that it can be observed at the center.

REFERENCES

[1] "What is a Rainboard?", https://rainboard.id/apa-itu-rainboard/. [accessed 5 Dec 2019].

[2] "ESP8266 Arduino Tutorial – Wifi Module Complete Review", http://www.geekstips.com/esp8266-arduino-tutorial-iot-code-example/. [accessed 6 Dec 2019].

[3] "What is Android?", https://www.android.com/intl/en_au/what-is-android/. [accessed 24 July 2020].

[4] "Anemometer", https://www.nationalgeographic.org/encyclopedia/anemometer/ [accessed 29 June 2020].

[5] "How to Use a Rain Sensor", https://create.arduino.cc/projecthub/MisterBotBreak/how-to-use-a-rain- sensor-bcecd9. [accessed 29 June 2020]

[6] "DHT11 Humidity And Temperature Sensor Module", https://www.smart- prototyping.com/DHT11-Humidity-and-Temperature-Sensor-Module. [accessed 20 Feb 2020].

[7] "BMP180 - Atmospheric Pressure Sensor," 29 Mar 2018, https://components101.com/sensors/bmp180- atmospheric-pressure-sensor. [accessed 6 Dec 2019].

[8] "Aviation Routine Weather Report", http://meteocentre.com/doc/metar.hstml. [accessed 13 Nov 2019].

[9] "C Language Introduction", https://www.geeksforgeeks.org/c-language-set-1-introduction/. [accessed 5Dec2019].

[10] "What is Java and why do I need it?", https://java.com/en/download/faq/whatis_java.xml.[accessed 13Nov2019].

[11] AC No: 150/5220-16E, 2019, "Automated Weather Observing Systems (AWOS) For Non-Federal Applications", Federal Aviation Administration.

[12] WMO-No 1064, 2010, "Commission for Instruments and Methods of Observation Fifteenth session", Helsinki, World Meteorological Organization.