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Design Pitot Tube Cover with Artificial Intelligence (Arduino) Based Warning System on Piper Seneca V Aircraft

Dimas Endrawan Putra[1], Untung Lestari Nur Wibowo[1], Wisnu Kuncoro[2*], Muhamad Khoirul Anam[2]

[1] Education Facilities Department, Banyuwangi Indonesian Aviation Academy, Blimbingsari, Banyuwangi, Indonesia
[2] Mechanical Engineering Department, PGRI Banyuwangi University, Kertosari, Banyuwangi, Indonesia.

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Corresponding Author:
Wisnu Kuncoro
wiisnukuncoro@gmail.com

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Abstract: The pitot tube is a component in the fuselage to measure the pressure generated by air movement or wind, while the placement of the pitot tube is usually on the wing. A trivial thing that can be fatal is that before flying, sometimes the pilot/flight instructor neglects to remove the pitot tank cover. This negligence resulted in the malfunctioning of the Air Speed Indicator (ASI), Vertical Speed Indicator and Altimeter. Appropriate technology in the form of a pitot tube cover with a warning using an ultrasonic sensor with the support of artificial intelligence technology using Arduino has been applied to the Piper Seneca V aircraft to prevent negligence in removing the pitot tube cover before flying. The Piper Seneca V has been chosen as the object of the application of technology because the Piper Seneca V type aircraft is of the low wing type so that the pitot tubes are not visible when not inspecting the underside of the aircraft's wings. During 30 days of testing with 12 hours of testing time each day and exposure to different temperatures and humidity each day, both battery life and component resistance can be ensured that they are still in optimal conditions. During testing in the simulation room, the tool worked well with a 1 meter object detection configuration. Using a 3.7 volt battery with a storage capacity of 1600 mAh can make the device last for 4 days with 2 hours of recharging time.

Keywords: Aeroplane; Piper Seneca V; Pitot Tube; Plane Malfunction

Introduction

Airplanes are one of the modes of air transportation needed to accelerate long-distance transportation (Kiracı & Bakır, 2019; Zhang & Graham, 2020). In the world of aviation whose development is relatively very rapid, there is still a need to evaluate and improve aspects of safety and security in aviation (Ancel et al., 2022; Kakaletsis et al., 2021; Lager & Melin, 2021; Majid et al., 2022; Peysakhovich et al., 2018). Overall aviation always pays attention to flight safety, flight discipline, flight efficiency and comfort (Chen & Zhang, 2022; Patel & D'cruz, 2017; Priyambodo & Nugraha, 2019). Safety factors are a top priority in the world of destination flights so that passengers and crew on flights get maximum comfort (Badi & Abdulshahed, 2019; Şenol, 2020). Airlines can measure the level of safety they have, the level of safety is not an easy job because there are many aspects related (Kim et al., 2020). In flight school, flight operations become one of the aspects that must be complied with which is regulated in ICAO (Agustini et al., 2021).

Flight operation flight area is an area on land or waters used for flight operations to ensure flight safety (Prasetyo et al., 2021). Safety priorities in aviation are standards that need to be considered in the aviation sector, so aviation facilities and infrastructure, methods, procedures and regulations are needed (Bastola, 2020; K. Ellis et al., 2021; K. K. Ellis et al., 2021). Pilots in aviation must be aware of important information in dealing with their duties and work, as well as the role of situational awareness, especially an important element in their evaluation during flight operations (Kiliç, 2019). In a case study that has been found, there was negligence in removing the pitot tube cover until the plane took off. Pitotube is an object that exists on airplane wings (Jäckel

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et al., 2021). A trivial thing but can be fatal is that before flying, sometimes a pilot / flight instructor fails to remove the pitot tube cover. This negligence resulted in malfunctions of the Air Speed Indicator (ASI), Vertical Speed Indicator and Altimeter (Kuncoro et al., 2022).

The development of appropriate technology in the form of pitot tube covers for Piper Seneca V type aircraft with a warning system using ultrasonic sensors with the support of Arduino-based Artificial Intelligence technology can be applied to prevent negligence in removing the pitot tube cover before flying. Where the ultrasonic sensor is placed on the tag "Remove Before Flight" and the sensor will be integrated with the Buzzer which will sound when there are people around the pitot with a radius of 0-100 cm. Piper Seneca V was chosen as the object of application of appropriate technology because the aircraft is a low-wing type where the location of the pitot tube is not visible when not checking the underside of the aircraft's wings (Ethell, 1986). Warning Alert / The sound issued by the buzzer will be a sign to someone who will use the aircraft that there is still a pitot cover that has not been separated from the pitot tube.

Method

The method used in design research uses direct experimental methods. The implementation of activities contains a frame of mind, product manufacturing, technology testing and evaluation.

Frame of Mind

There is a considerable risk that will be faced when there is neglect to remove the pitot tube cover, response before a fatal event occurs needs to be applied as early as possible. With the presence of the water produced by the Beep Buzzer will serve as a reminder that the pitot tube cover has not been released when trying to operate the Piper Seneca V aircraft. Pitot tube cover that has been integrated with artificial intelligence technology is expected to reduce the risk of negligence in removing the pitot tube cover before operating the Piper Seneca V aircraft. The research mindset can be seen in Figure 1**.**

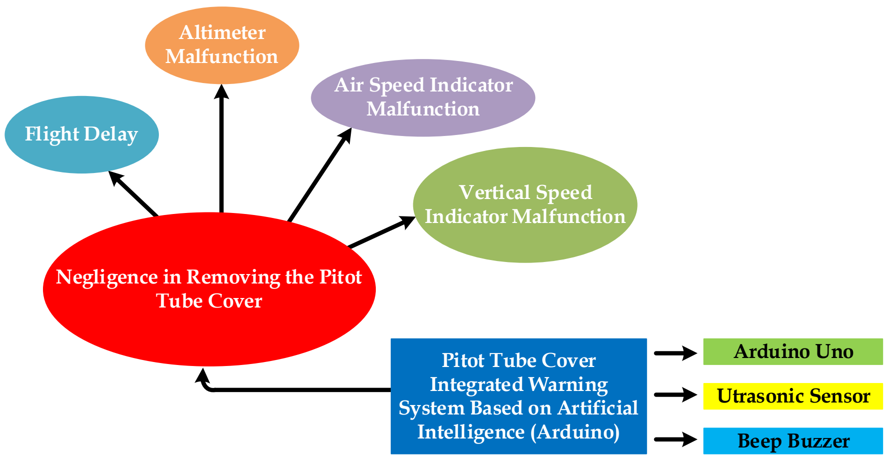

Figure 1. Frame of mind

Pitot Tube Cover Making

The implementation of making pitot tube covers is carried out based on the design of the tool that has been made and based on several supporting references including (Akkalkot et al., 2022; Ramisetti et al., 2022; Shivani et al., 2023). The stages of making implementation are as follows: Perform pitot tube cover design and layout for the placement of electronic components on the pitot tube cover; Making a pitot tube cover with a type of taslan fabric coated with perlak fabric, taslan fabric was chosen because it has waterproof properties (Wardaya et al., 2019) while perlak fabric was chosen as the outer coating because it is thick and is assumed to be able to better protect the electronic components inside; Assembling and installing electronic components including conductor pillow, arduino, battery, PCB charger and ultrasonic sensor; Coding and input coding are done to provide data to Arduino; and Conifguration of the ultrasonic sensor is that it will detect objects approaching with a distance of 1 meter by providing a warning sound through the buzzer.

Pitot Tube Cover Testing

To ensure the pitot tube cover can work properly, testing of the tool is needed. The stages implemented are as follows: Pitot tube cover testing was carried out directly on the pitot tube of the Piper Seneca V aircraft that had been detached; Pitot tube cover testing was carried out in a simulated room with air conditioning designed to resemble outdoor air with a duration of 30 days of testing, where temperature and humidity for 30 days using a zigzag matrix on day a and day b were different; The first phase of pitot tube cover testing includes the resistance of components to weather during trials; and The second stage of pitot tube cover testing is looking at the performance of battery life resistance, tool testing is carried out for 30 days with an average use of pitot tube cover per day for 12 hours.

Data Retrieval

Testing the performance of the tool will produce research data. Where there are two variables, namely independent variables and bound variables that aim to get test results

Research free variables

Table 1. Free variables of research

Indicator	Information
Test Time	a. 30 Days b. Daily 12 hours test time
Temperature and Humidity	a. Day (a) Temp: 25°c & Humidity 40% b. Day (b) Temp 35°c & Humidity 70%

Component & function

The components and functions of the components to support the work of the pitot tube cover will be shown in Table 2.

Table 2. Component & function

Component	Component functions	Component specifications
Arduino Uno	As a processor and runs the role of a pitot tube cover based on *Artificial Intelligence*. Where Arduino contains several programming languages that are inputted as a *database*.	Microcontroller AT mega328P Operating Voltage 5V Input Voltage (recommended) 7-12V Input Voltage (limit) 6-20V Length 68.6 mm Width 53.4 mm
Ultrasonic Sensor	Has a function as an input in the form of digital signals sent to Arduino for processing. The signal contains digital data in the form of readings of people's distance to ultrasonic sensors	Voltage: 5V DC Static current: < 2mA Level output: 5v – 0V Sensor angle: < 15 derajat Distance that can be detected: 2cm – 450cm (4.5m) Accuracy level: up to 0.3cm (3mm)
Arduino Jumper Wire	Serves as a connecting cable between sensor pins and Arduino	0.5 mm cable
Battery	Battery / Power supply used to *main power* arduino.	Lithium Battery 3.7V 1600 mAh
Step up DC Module	Serves as a step up voltage from 3.7 Volt to 6 Volt for Arduino power supply.	Step Up Dc Voltage 3.7 – 6 Volt
Coductor Pillow	Made of stainless steel, it functions as a connector between the pitot tube and the pitot tube cover.	Stainless Steel
Pitot Tube Cover	Serves as a component placement and cover for the pitot tube.	Waterproof Material (Taslan Fabric & Perlak Fabric)

Result and Discussion

The results in the design research include the design of the pitot tube cover, installation scheme and configuration of electronic components, durability tests of research tools, the results of the durability of electronic components and *battery* life durability.

Pitot Tube Cover Design

In order to get optimal tool work, it is necessary to plan appropriately about the design of the tool including dimensions and placement of components. The design of the tool is shown in Figure 2.

In Figure 2. It can be explained that the pitot tube cover has dimensions that are adjusted to its designation on the Piper Seneca V type aircraft. The dimensions of the pitot tube cover also adjust to the placement of electronic components and the layout has been determined for complex component sizes (Lawson et al., 2022). In the *Remove Before Flight* tag, there are several supporting components including *Battery*, *Input Charger*, Arduino, and *Ultrasonic Sensor*. All components contained in the *Remove Before Flight* tag work continuously to carry out the role of pitot tube cover with the ability to identify approaching objects as a reminder that the pitot tube cover has not been removed before carrying out flight operations.

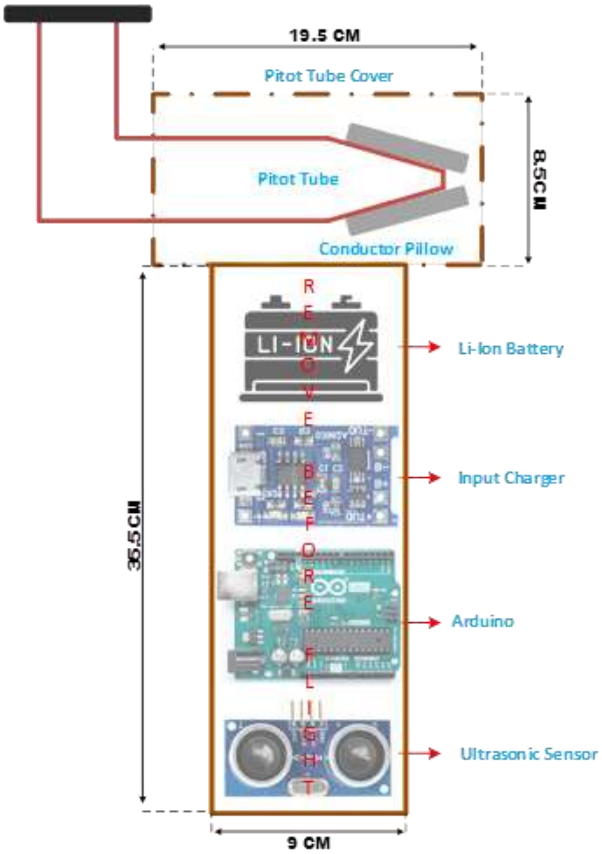

Figure 2. Pitot cover design

Installation and Configuration Scheme of Electronic Components

Pitot tube cover with Arduino-based warning system and artificial intelligence has supporting components including 3.7 Volt 1600 mAh Battery, Li-Ion Charger Type C, DC Step up 3.7 to 6 Volt, Arduino Uno, Ultrasonic Sensor, Buzzer and Conductor Pillow. The installation scheme and configuration of the components will be shown in Figure 3.

Warning alert on pitot tube cover will work when sheathed to pitot tube (Gardner, 2020). In the pitot tube cover has been given a switch where the switch when in contact with the pitot tube body will connect the electric voltage (-) to activate the module (arduino) (Pan & Zhu, 2018). The module will work by receiving digital signals given by ultrasonic sensors in the form of object distances approaching with a span of 1 meter. The signal received by Arduino will be processed with its AI capabilities and then activate the buzzer to provide a warning sound.

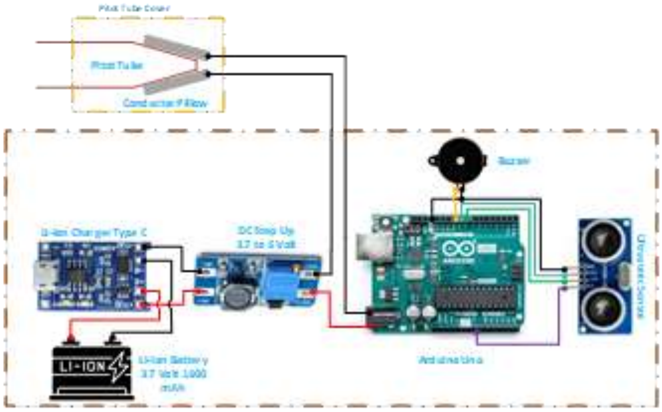

Figure 3. Installation and configuration scheme of electronic components

Research Equipment Durability Test

An illustration of research tool testing is shown in Figure 4.

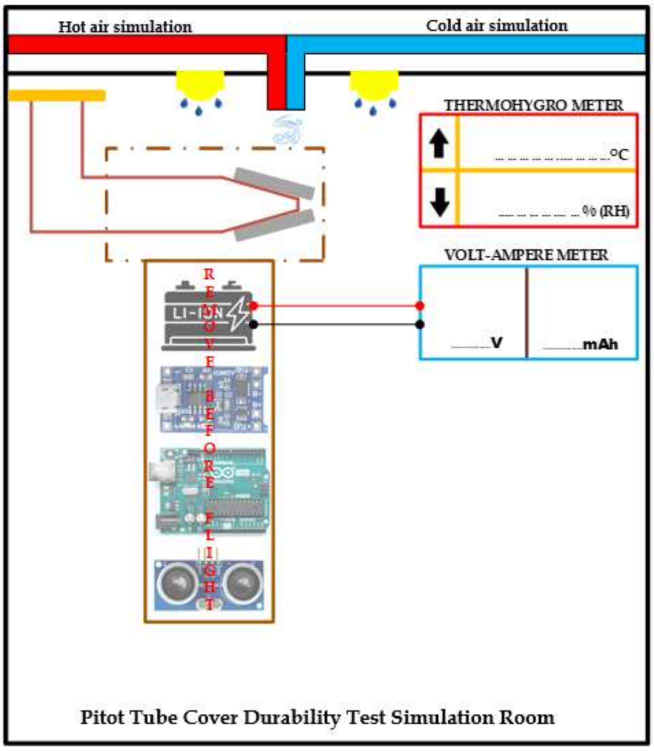

Figure 4. Durability test simulation room

In Figure 4. It can be explained related to testing the pitot tube cover against the weather simulation provided. The pitot tube cover is placed in a test simulation room which has been conditioned to obtain appropriate test results. Indoor weather conditioning tests were carried out for 30 days with a zigzag time matrix, namely on days (a) Temperature 25 o C and Humidity 40% and day (b) Temperature 35°C and Humidity 70%. During exposure to weather simulations, battery durability related to voltage and amperes is always considered

Pitot Tube Cover Test Data

Tests carried out on pitot tube covers with simulation rooms include durability tests of electronic components and *battery life*. Data collection of battery endurance tests using VoltAmpere Meters and for the durability of electronic components observed visually and functionally (de Paula et al., 2021).

Battery Life Data

Test data related to battery life endurance are presented in Table 3.

Table 3. Battery life data

Day	Use	Battery Capacity		Information
		Volt (V)	Ampere (mAh)	
1	-	3.7	1600	Temp Test 25°c & Humidity 40%
2	12 H	3.2	987	Temp Test 35°c & Humidity 70%
3	12 H	2.7	735	Temp Test 25°c & Humidity 40%
4	12 H	2.3	735	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
5	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
6	12 H	3.1	980	Temp Test 35°c & Humidity 70%
7	12 H	2.8	736	Temp Test 25°c & Humidity 40%
8	12 H	2.3	124	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
9	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
10	12 H	3	976	Temp Test 35°c & Humidity 70%
11	12 H	2.6	722	Temp Test 25°c & Humidity 40%
12	12 H	2.2	119	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
13	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
14	12 H	3.3	996	Temp Test 35°c & Humidity 70%
15	12 H	2.8	740	Temp Test 25°c & Humidity 40%
16	12 H	2.4	130	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
17	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
18	12 H	3.1	990	Temp Test 35°c & Humidity 70%
19	12 H	2.6	698	Temp Test 25°c & Humidity 40%
20	12 H	2.3	122	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
21	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
22	12 H	3.2	1001	Temp Test 35°c & Humidity 70%
23	12 H	2.4	537	Temp Test 25°c & Humidity 40%
24	12 H	2.1	105	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
25	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
26	12 H	3.3	999	Temp Test 35°c & Humidity 70%
27	12 H	2.6	685	Temp Test 25°c & Humidity 40%
28	12 H	2	97	Temp Test 35°c & Humidity 70% - Recharges for 2 hours
29	12 H	3.7	1600	Temp Test 25°c & Humidity 40%
30	12 H	3.1	995	Temp Test 35°c & Humidity 70%

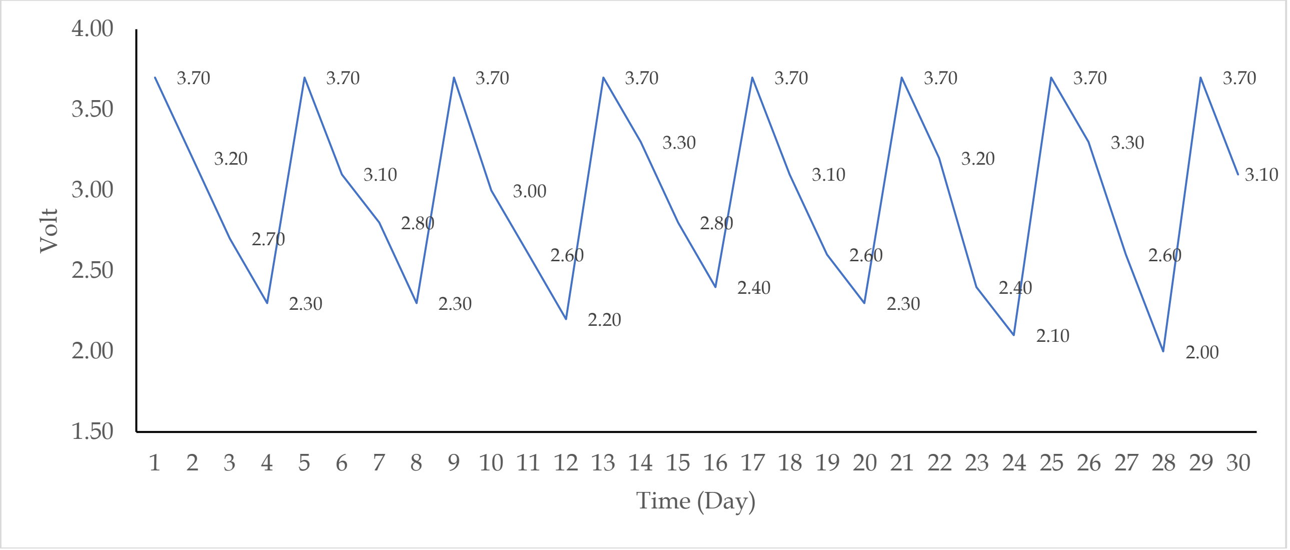

Figure 5. Graph of changes in battery voltage for 30 days of use

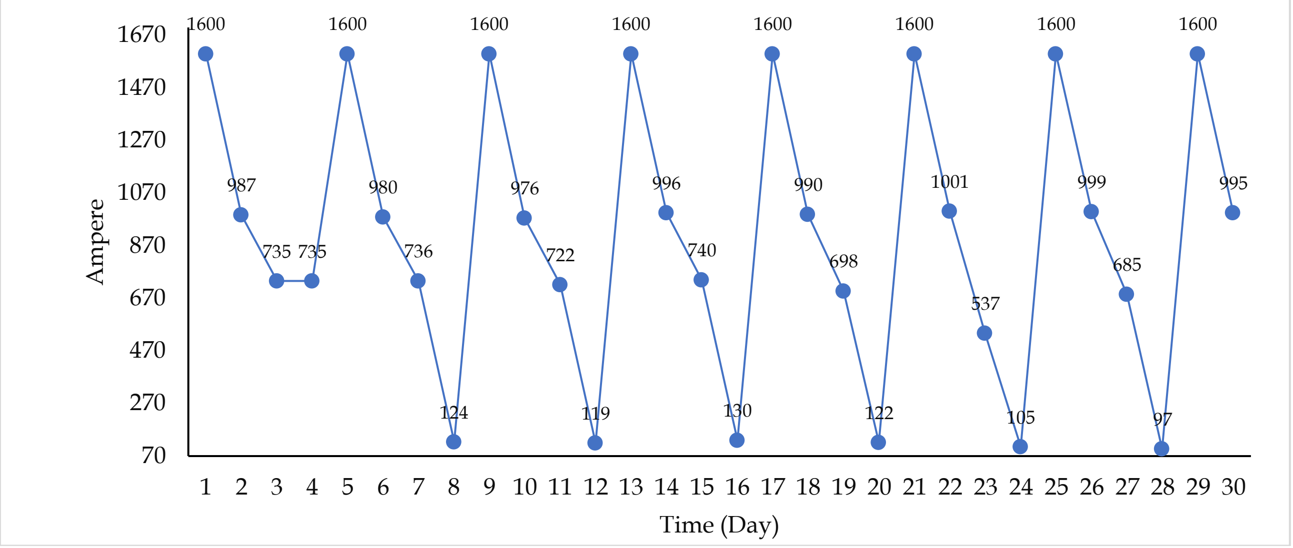

Figure 6. Graph of changes in battery amperes for 30 days of use

In Table 3. Complete information is presented regarding the trend of testing the battery for 30 days where each test takes 12 hours every day. The treatment given to component tests uses different temperature and humidity variations including 25°C Temperature Test and 40% humidity and 35°C Temperature Test and 70% humidity. When viewed in Figure 5 & Figure 6 it can be concluded that from the test day 1 to day 30 both voltage and ampere battery did not experience a significant decrease in capacity and power and with battery specifications with a power of 3.7 Volt 1600 Ampere is able to carry out its role by recharging every 4 days which takes 2 hours on a single charge.

Durability of Electronic Components

The durability of electronic components can be seen visually presented in Figure 7.


Figure 7. Electronic Component Checking Visualization

Visual component checking includes the presence or absence of water deposits on electronic components, the normal function of electronic components and ensuring the presence or absence of corrosive spots on each *connector*. After a visual check of electronic components, it can be ascertained that after 30 days of testing with varying temperatures and humidity, electronic components are confirmed to be safe and still suitable for reuse.

Conclusion

Piper Seneca V was chosen as the object of application because the aircraft is a low-wing type where the location of the pitot tube is not visible when not checking the underside of the aircraft's wings. During testing within 30 days with a test time of 12 hours every day and given exposure to different temperatures and humidity every day, both battery life and component durability can be ensured to be still in optimal condition. During tests in a simulated chamber, the tool works well with a 1-meter object detection configuration. The application of a 3.7 volt battery with a storage capacity of 1600 mAh is able to make the tool last for 4 days with a recharge time of 2 hours.

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Conflicts of Interest
The authors declare no conflict of interest.

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