Integration of RFID Technology: A Covid-19 Contact Tracing Method for Health Security

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Abstract:- In this pandemic, it is common knowledge for every establishment, institution, and community that contact tracing plays a crucial role in containing the COVID- 19 virus. This is where the integration of radio frequency identification (RFID) technology to contact tracing method plays a role for healthsecurity in, but not limited to, Philippine State College of Aeronautics. This study utilized experimental methods to identify the prototype's data accuracy, precision, and effectiveness compared to manual or digital contact tracing. The experiment exhibits a quick detection capability of RFID card users in varying distances and accurately reflects and records the users' information thatis only within the booth. However, upon the temperature check, the scanned values were inaccurate compared to a commercial temperature scanner but werealmost precise in terms of its consecutive temperature values. The ability of the device to determine the rights to enter to the premises based on the temperature also requires development particularly the Arduino device itself since the inconsistency of the program was assumed to be due to maxing out the storage capacity for programming codes. The findings of the study indicated that the integration of the RFID technology to contact tracing had the potential to be a candidate of a new contacttracing method viable to the institution and alike.

***Keywords**:- Arduino, Smartphones, RFID Technology, Contact Tracing, Integration.*

I. INTRODUCTION

The novel corona disease officially called Coronavirus Disease 19 or COVID-19 (Department of Health, 2020) began to spread in the Philippines on January 22, 2020, and on March 1, 2020, there are already 633 suspected cases (Edrada et al., 2020). A year has already passed, and according to the new record from the DOH Covid-19 Tracker (2021), we already have 1,006,428 total cases; 74,623 of these are currently active, 914,952 have recovered and 16,853 have died. These numbers have kept on increasing for the past monthsdespite the implementation of community quarantines, COVID-19 health and safety protocols, and contact tracing.

In order to limit the spread of the virus some areas of the country were placed in a Modified Enhanced Community Quarantine such as the NCR Plus including three other areas until April 30, 2021 (Parrocha, 2021) and had continued on until May 2021 as the Inter-Agency Task Force (IATF) planned to recommend an extension to the Office of the President the last week of April 2021 (CNN Philippines Staff, 2021). Preferably, during these times of quarantine the government conducted contact tracing. Contact tracing is a technique used in a pandemic to reduce the number of infections by identifying people that were in contact with a person who has tested positive for COVID-19 or individuals that exhibited symptoms of being infected (Subina et al., 2021). Having done this, the researchers can address the situation at the initial level and recommend them to self-isolate or quarantine for a period until symptoms subside and test negatively. This method has been proven successful if done ingeniously like how the South Koreans mapped out their contact tracing (Kim & Denyer, 2020).

As for the Philippines, unfortunately, it was inadequate compared to South Korea. According to the contact tracing czar, Baguio Mayor Benjamin Magalong, the country's tracing is 'deteriorating'. He reported in the House health panel thecountry's contact tracing statistics showing that the contact tracing ratio declined from 1:7 to 1:3 (Talabong, 2021). This means that on a national average, from tracing seven contacts, it went to only three within a month per detected COVID-19 case. The response of the government to this dilemma was to urge the localgovernment units (LGUs), business establishments, and individual users to utilize and patronize StaySafe.PH application instead of other apps (Department of the Interior and Local Government, 2021). The Interior Usec. EpimacoDensing believed that exploiting digital contact tracing, will successfully help in improving the country's contact tracing and prevent the spread of the virus.

Digital contact tracing was really a way to go for an effective contact tracing system. However, its effectiveness depends on several factors: internetconnectivity, responsive users, and smartphones (World Health Organization, 2020). Digital contact tracing depends on an internet connection, so users should have internet access before they can fill up their contact tracing form through the tracing app. In the joint study by the World Bank and National Economic and Development Authority (NEDA), it showed that the country's internet services are one of the slowest on a global scale and despite its poor performance it cost very high (Leyco, 2020). This means that if the institution or establishment does not provide free internet access to the users, the financial requirement to avail of 3G/4G mobile data will be shouldered by the users.

Aside from users accessing the internet, one of the hurdles in line with digital contact tracing was requiring people to download and use the application itself (Muscato, 2020). The survey conducted by the Oliver Wyman Forum in six different countries showed that there was less than twenty percent in every country that was very much unwilling in sharing their identity and location through the app (Kreacic & Bosch, 2020). This showed how difficult it is to encourage users to participate in the contact tracing. One of the reasons behind this act was their distrust towards concerned personnel that will handle their personal data. They were afraid of data capitalism that multi-billionaire companies may exploit on the app especially when there is a lot of history of similar data being used as a source of profit.

To use the contact tracing application, they must own a smartphone first. Nowadays, these devices have become a necessity of our daily lives and an integral part of our livelihood. According to a study by research firm Dcout, an average smartphone user touches his or her device 2,617 times every day and 5,400 for extreme cellphone users (Naftulin, 2016). If taken account of the ongoing pandemic, it could somehow deduce that smartphones can as well be a critical medium for the spread of viruses. Olsen et al. (2020) of Bond University also had the same conclusion in their research which termed our devices as a “Trojan horse” in the transmission of viruses. Despite the frequent warning to disinfect oneself, most of the time people still forget to like those in India. There was only ten percent out of all the health workers in almost all tertiary health care in India that took their time to disinfect their devices (Panigrahi et al., 2020).This showed that the tolerance to the health especially when using mobile devices in public makes people vulnerable to contracting the virus. Take note that people use phones in public in order to file contact tracing forms online and if users have a sluggish internet connection, this would prolong their exposure to pathogens in the air even more.

The dependency of digital contact tracing to the factors discussed above could be deemed as a weakness of the tracing mode. If one of the factors fails to perform its part, the entire process will not function. This is where the integration of Radio Frequency Identification (RFID) technology played its role. Instead of depending upon the factors that are mostly provided by the users, the RFID technology contact tracing system can be a stand-alone system that does not require any internet connection and smartphones. Since it does not employ internet access, stored data and information are safely secured and do not need any funds for internet security and connection services subscription. There is no need for physical contacts through mobile devices; thanks to RFID cards and high-frequency antennas. Through this, users’ exposure to the environment is limited and all they have to do is just walk and momentarily halt into the RFID Health Security Booth and their contact tracing form is already filed, and temperature is taken and recorded. Moreover, once people have entered the premises of the venue, contact tracers are be able to identify who, when, and which gate that person entered through time-in and time-out data recording. Through this data, concerned personnel can perform contact tracing quicker. In short, RFID technology COVID-19 contact tracing is more effective and safer method for health security.

In line with the global pandemic that continues to wreak havoc in the country, the researchers decided to conduct the study at Malolos City, Bulacan which aims to potentially be of use by the Philippine State College of Aeronautics VAB Campus; the institution where they are currently enrolled in. The study does not limit itself to the specified research locale but extends its far reach towards other schools, public or private establishments, and other functions as well. Similarly, its functionality is not limited to RFID technology but can be upgraded as well by means of integrating QR codes, contact tracing apps, and the internet. However, for the purpose of feasibility, researchers focused only on the potential of RFID technology in the field of contact tracing.

As proven effective and safer method for health security, the RFID technology as an instrument for contact tracing was able to assist the contact tracers of the LGUs quickly in identifying the people at risk of contracting the virus due to close contact with an infected individual and/or person that exhibits symptoms of COVID-19. By containing the virus in a small population and encouraging self-isolation and undergoing tests, it limited the community transmission resulting in lesser COVID-19 positives and mortality cases.

The novel coronavirus (COVID-19) pandemic has disrupted the normal life of people virtually in every co due to its widespread infection around the globe. The sudden implementation of strict measures forced schools, restaurants, shopping malls to close and the transit system at a standstill essentially shutting down most industries to a halt to slow the spread of the disease. The case numbers exploded, so did the number of deaths, hitting the healthcare system. During the disease outbreak, it spreads very quickly among people and it becomes a challenge to trace the source to control the disease. It is urgent to discover the human-to-human contact such that patients and people at higher risk can be identified and then physically isolated from the public.

In combat, these rising cases, contact tracing, isolation, and testing were some of the powerful public health interventions available. The nations that have the most effectively controlled the ongoing COVID-19 pandemic were noteworthy for conducting comprehensive tracing and testing. In doing so, a large, well-organized testing program were combined with extensive efforts to isolate infected people and trace and quarantine close contacts.

As the strict measures were gradually lifted, people go out of their homes for travel. Physical distancing measures are continued, in addition to that other public health measures which were needed to control the disease. As people were allowed again to go to shopping malls and restaurants, the government mandates these establishments to perform contact tracing as a control strategy during the de-escalation of physical distancing.

Currently, the method used by the establishments for contact tracing wasby manual means of filling up a sheet of paper or a logbook which could be also a source of transmission of the disease due to it being slower and risking moretime for human-to-human transmission and the use of common ballpoint pens. Using the pen and paper method could also introduce people with illegible writing that cannot be traced when a positive case may have close contact withthat person. Another way some establishments augment the downside of the manual pen and paper method, they also implement a Quick Response (QR) code system that a person can scan through their smartphone the downside isnot everyone has a ready access to cellular data and can be slower dependingon the cellular reception.

An automated method could be implemented using Radio Frequency Identification (RFID) technology to collect the important contact tracing data. Implementing this technology prevents illegible data to be lost, quickens the process to reduce exposure, and can be done contactless to reduce contact to any contaminated surface as well giving wide access to the public. This automated system can handle a large amount of data that can be later processed and analyzed and giving people the ability to quickly determine which people had close contact with others and preventing the spread of the disease to a minimum.

- *Conceptual and Theoretical Framework*

In order to understand the RFID technology COVID-19 contact tracing, this study used Information System Theory as a guide to understanding the nature of the study. Michael Stizza defined an information system as the communication between humans and computers which allows them to store and distribute data. On the other hand, Information System Theory serves as a means to connect the general systems theory structural purposes and the worldand technological information for a particular function through computer algorithms (Lerner, 2004). It has five distinguishable types of Information System Theory based on Shirley Gregor's research essay (2006) which are analyzing theory, explaining the theory, predicting theory, explaining and predicting theory, and design and action theory.

This theory aims to provide explanations without attempting to do a precise prediction. Basically, the technology identified the what, who, when, where, and why, and how was the suspected positive individual were able to enter the school and do community transmission of the virus. This in turn wouldassist the contact tracers in finding people that were in close contact with an infected individual.

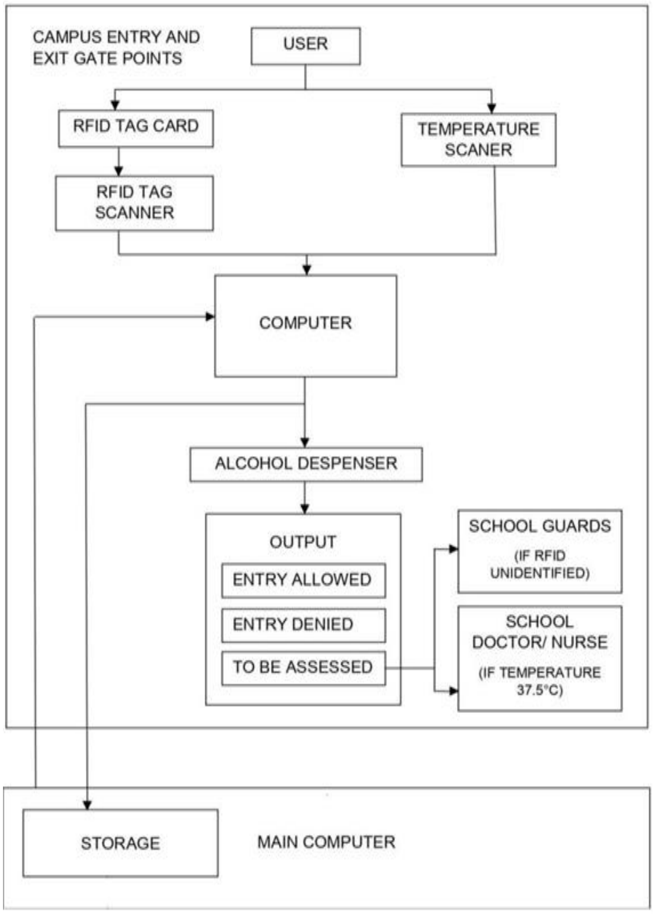

Fig 1 Conceptual Paradigm

II. METHODOLOGY

The researchers gathered the data using experimental methods. This method made use of data sheets to record the measurements, detection, and deduction the product will make. With the data gathered, the researchers were able to identify the accurateness, preciseness, and speed of the product to perform contact tracing and whether it is viable as a new and better contact tracing method.

This study utilized pure experimental research. It aimed to build an RFID Health Security Booth that would automatically fill in contact tracing formtogether with body temperature, and sanitize individuals at the end of the process. This allowed the students, instructors, non-teaching staff, and visitors to enter the premises without making any contact and not be exposed to the environment for a prolonged period of time, unlike the manual and digital contact tracing method.

As of today, the virus continues to wreak havoc in the country killing 26,891 in the process, 50,562 are active cases while 1,452,813 have recovered (Department of Health, 2021). Despite the rise in numbers of recoveries, the COVID-19 still poses a threat to the country, especially now that the Delta variant discovered in India is now in our country (South China Morning Post, 2021). Even with the ongoing vaccines where Sinovac is mostly administered, people can still get infected like how the Indonesian medical

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health workers gotinfected by the Delta variant despite being vaccinated with such a kind (Reuters,2021). For this reason, a better and safer contact tracing method for enclosed facilities should still be introduced to the country, so that we may limit the contactand aid in controlling the spread of the virus.

A. Structural Design and Mechanical Design

➢ *Security Booth*

The security booth is the foundation and the mounting structure for the disinfecting machine, temperature, RFID scanner, display and ultra-high frequency antenna RFID scanner.

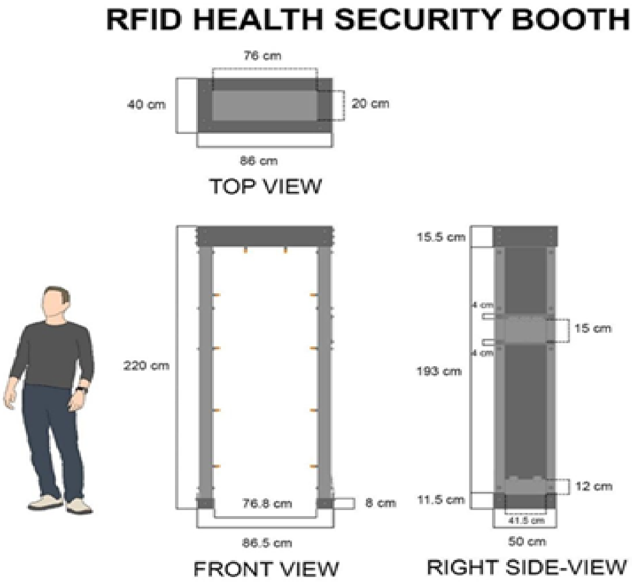

Fig 2 RAFID Health Security Booth

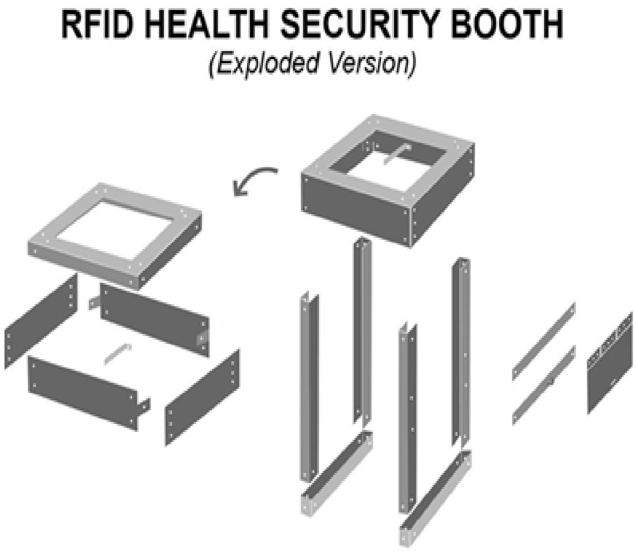

Fig 3 RAFID Health Security Booth (Exploded Version)

➢ *Disinfecting Machine*

A disinfecting system is a machine responsible for killing the bacteria and viruses on the surface through automated alcohol spraying people after they were deemed allowed by the RFID Health Security Booth's system.

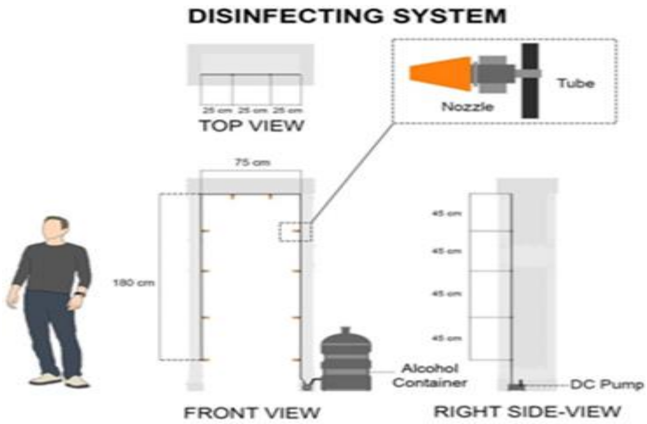

Fig 4 Desinfecting System

➢ *Temperature, RFID Scanner & Display*

The RFID health security booth panel is a mounting surface for two systems: aural and visual notification system and temperature scanner system. The first system oversees and notifies the user through displays and sound regarding its temperature and rights to enter, while the other is programmed to measure one's temperature only when the user is present inside the booth.

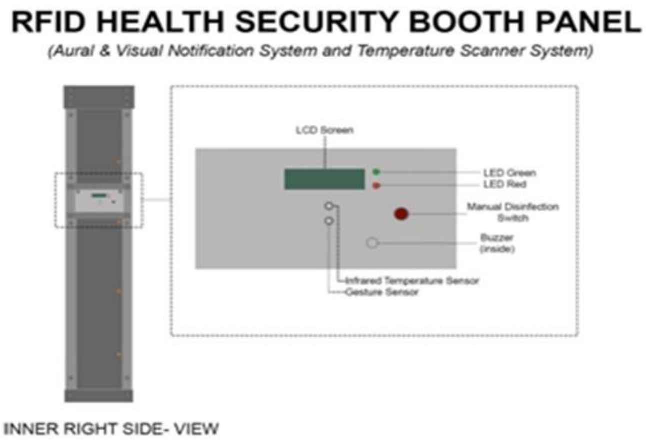

Fig 5 RFID Health Security Booth Panel

➢ *Ultra-High Frequency Antenna RFID Scanner*

The UHF antenna RFID scanner is a device that detects RFID cards within its range of operation and reads its unique ID Number.

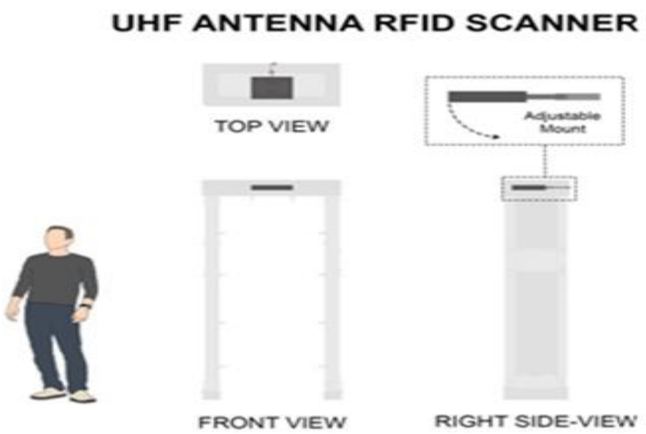

Fig 6 UHF Antenna RFID Scanner

B. Data Programming Apparatus

➢ *Arduino Uno*

The Arduino Uno Codes, make the microprocessor to interface into the different modules and transmit the data to a computer via serial communication protocol.

• *Procedure*

Due to the ongoing pandemic and limited financial resources, the procedure of making the RFID health security booth was delimited to the available resources in-stock and online and the researcher's purchasing capability. Despite the limitations encountered, critical components and devices were procured, and the mounting structure was built. With the use of proper designing, planning, and countless trials and errors with the programming, the study was able to pull off a new contact tracing method viable for enclosed facilities like the Philippine State College of Aeronautics and alike.

The first step in creating the RFID health security booth was the realization of the desperate need to aid in combating the rising number of Covid-19 positive in the country. This has been done with the use of acquired knowledge from the experience accumulated over the academic years of conducting different practical electronics activities, particularly the RFID. This led the researchers to the conceptualization of utilizing the RFID technology as the core of the device that would allow the development of a contactless contact tracing system. To makethis into reality, the researchers utilized the Arduino Uno as the main platform for developing the device as this is what the researchers are currently familiar with. In preparing for the development, it began with the procurement of needed electronic components through online shopping platforms. As the components arrived, each component was manually tested to see if they are working as intended and learn how to properly integrate it into one coherent system by reviewing its datasheets and prototyping test codes to make each electronic component work how it was needed to perform for the study. Learning how to control each electronic component, it began with prototyping using a breadboardon how each functional segment of the device is going to operate by integrating each needed component to form the functional segments. In doing so, tuning each segment was necessary to attain the intended function. After performing the prototyping for the segments, it proceeded with integrating each segment to each other and still using the breadboard, particularly on how it was supposed to work in the device itself. In this stage, finalizing how the device will work and how the segments are going to interact with each different segment of the device was exhibited. It then proceeded with the development of the recording application that was used on a computer to capture the data from the device. This was done using Microsoft's Visual Basic .NET programming language to create the windows program with a user interface and program it to work by capturing the serial information from the device, taking and recording it sequentially and adding the appropriate timestamp for bookkeeping. After programming and debugging were compiled for testing, the device is then finalized with a proper PCB connection and spacing for each component on how each will fit the device structure. In preparation for finalizing the circuit, they then proceeded to cutting wires to appropriate lengths to fit in the device structure and stripping the ends of the wires for soldering. In doing so they were able to form the circuit where each component was connected as the following; Wherethe RFID antenna's RX is connected to the digital pin 3, the TX is connected tothe digital pin 4, and the GND is connected to the Arduino's ground pins, which enables the Arduino to communicate with the antenna and receive the data being read from any RFID cards. Then for the digital pin 3 is the control pin of the relay module which controls the relay on when it can close the circuit, whileits + is connected to 3.3v while the GND is connected to the Arduino ground. As for the digital pin 6, the buzzer is connected to it while its ground is connected to the rest of the Arduino ground pins, then the digital pin 7 is connected to one of the pins of the push button while the other pin is connected to the Arduino ground. As for digital ground 8 and 9, it is connected to the positive end of the LED while its negative end is connected in series to a 220Ω resistor and is wired to Arduino ground. Then have the 16x2 LCD, infrared temperature sensor, and gesture sensor's SDA and SCL connected in series to each other where the series connection of SDA is connected to the analog pin 5 of the Arduino whilethe SCL is connected to the analog pin 4 based from the I2C protocol. And the grounds of the three components are connected in series to the ground of the Arduino. The gesture sensor's VIN is connected to the 3.3V of the Arduino, and its INT pin is connected to the digital pin 2 of the Arduino. While the 16x2 LCD and the infrared temperature's VIN are connected to 5V of the Arduino. In connecting those to the Arduino and programming the correct pins, the device is ready for testing.

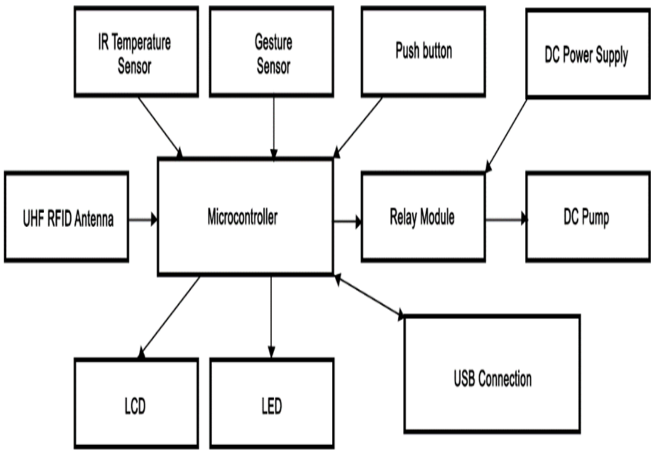

Fig 7 Block Diagram of Complete Operation

After designing, it is time to execute the plan to its physical form. Once again, it all starts with the structure. It is composed of four parts: bases, columns, wall panels, and the roof. The two bases are made up of 1 piece of L-bar steel (Figure 24) and 1 piece of flat bar steel, each is both cut with an angle grinder at 50 cm in length and welded together to create 2 pieces of fabricated U-tube steel with the dimensions of 50 cm in length, 4.85 cm in width, and two differentheight measurements, 8 cm, and 11.5 cm. The difference in height is for an increase in support and stability once assembled with the other parts. Like this process, the four columns utilized 1 piece of L-bar and 1 piece of flat bar steel but in lengths of 210 cm. After the cutting process, it is then welded together to form 4 pieces of fabricated U-tube steel with dimensions of 210 cm in length, 6.5 cm both in width and in height. As for the roof, it is divided into three parts: the square structure, roof panels A, B, and C. The square structure is formed by2 pieces of L-bar steel cut in lengths of 40 cm and another 2 pieces of L-bar cut in 86 cm length and welded all together to create a rectangular shape. This part would serve as a mounting structure for the roofing panels. Panel A, B, and C are metal sheets cut out to their respective dimensions and pieces. Panel A hasa dimension of 86 cm x 40 cm while panel B is 2 pieces of 40 cm x 15 cm, andpanel C is 2 pieces of 86 cm x 15 cm. Lastly, the wall panels utilized wood and metal materials. Metal sheets were used for the outer right wall where the two access points are located, while the rest are woods. In this part, plywood (Figure 32) is cut into four dimensions: 1 piece of 95 cm x 50 cm, 1 piece of 75 cm x 50 cm, 2 pieces of 106.5 cm x 50 cm, and 2 pieces of 86.5 cm x 50 cm while the metal sheet is cut into two dimensions: 1 piece of 95 cm x 50 cm and 1 piece of 75 cm and 50 cm. Before the researchers proceeded to the next, they cut first a rectangular shape at the width of the bottom center part of the single-piece metal sheet panel (95 cm x 50 cm) with the dimension of 40 cm x 12 cm. Since the wall panels are done, the two access points and interactive panel will be processed this time. The two access points make use of 1 piece of both L-bar steel and flat bar steel, both are cut in lengths of 50 cm and a metal sheet that is cut into two dimensions: 1 piece of 41.5 cm x 12 cm and 1 piece of 41.5 cm x15 cm. With the use of hinge, rivet (figure 34), and rivet gun permanently fasten the first metal sheet to the flat bar steel by using 6 pieces of hinges and 24 pieces of rivets. After that, the researchers did the same thing with the other metal sheet and to the modified metal sheet panel where a rectangular shape was cut out. Instead of 6 pieces of hinges, the researchers used only 2 pieces accompanied by 8 pieces of rivets. As for the interactive panel, the researchers cut 1 piece of metal sheet and 1 piece of plywood in dimensions of 41.5 cm x 15 cm, this would serve as the mounting structure for the RFID health security booth panel (Figure 5).

III. RESULTS

The system performed remarkably as it was viable to be a new and improved contact tracing method. A total of 3 sets of tests were conducted for the RFID Accuracy Test. These are Test Set A, Test Set B, and Test Set C in three separate trials. The test began with 1 person present, then 2 persons present, and lastly, 3 persons present within distances of 70-centimeters, 200- centimeters, and 400-centimeters away from the antenna. The second test was the Temperature Scanner Accuracy-Precision Test. It was a test where prototype TSS is compared with commercial TSS having 3 sets of 3 trials each. Lastly, the researchers also calculated the speed it took for the prototype to process the contact tracing form.

A total of ten tests have been conducted on the experiments of the research study, where each test has three trials. The researchers used the RFID contact tracing prototype as the point of origin, whereas the RFID card users are at distances of 70-centimeters, 200-centimeters, and 400-centimeters away from the antenna.

- On the first test, a shorter distance range has been conducted with 1 person present within 70-centimeters is enough to be detected, recorded, and be accurate to the system.
- On the second test, an increase of distance range has been conducted with 1 person present within 200-centimeters is enough or may not be enough to be detected, recorded, and be accurate to the system.
- On the third test, an increase of distance range has been conducted with 1 person present within 400-centimeters is not enough to be detected, recorded, and be accurate to the system.
- On the fourth test, a short and long-distance range has been conducted with 2 persons present within 70-centimeters is enough to be detected, recorded, and be accurate to the system but within 200-centimeters is enough to be detected but not enough to be recorded and be accurate to the system.
- On the fifth test, a short and long-distance range has been conducted with 2 persons present within 70-centimeters is enough to be detected, recorded, and be accurate to the system but within 400-centimeters is not enough to be detected, recorded, and be accurate to the system.
- On the sixth test, a long-distance range has been conducted with 2 persons present within 200-centimeters is enough to be detected, recorded, and be accurate to the system but within 400-centimeters is not enough to be detected, recorded, and be accurate to the system.
- On the seventh test, a short, medium, and long-distance range has been conducted with 3 persons present within 70-centimeters is enough to be detected, recorded, and be accurate to the system, distance within 200-centimeters is enough to be detected but not enough to be recorded and be accurate to the system but within 400-centimeters is not enough to be detected, recorded and be accurate to the system.
- On the eighth test, a shorter distance range has been conducted with 1 person present within 70-centimeters that results to be slightly inaccurate with an average 0.29% error in accuracy and 5.451% error in precision.
- On the ninth test, a shorter distance range has been conducted with 1 person present within 70-centimeters that results to be inaccurate with an average 8.278% error in accuracy and 8.193% error in precision.
- On the tenth test, a shorter distance range has been conducted with 1 person present within 70-centimeters that results to be inaccurate with an average 1.442% error in accuracy and 9.442% error in precision.

Table 1 RFID Accuracy Test Set A - 1 person present at 70-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	70cm	0.53	Detected	Recorded	Accurate
2	70cm	1.24	Detected	Recorded	Accurate
3	70cm	0.63	Detected	Recorded	Accurate

On the first RFID Accuracy Test with 1 person present at a 70-centimeter distance, all results were accurate since it reflected and recorded the user's personal information from the detected RFID card.

Table 2 RFID Accuracy Test Set A - 1 person present at 200-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	200cm	8.16	Detected	Not recorded	Not Accurate
2	200cm	-	Not detected	Not recorded	Not Accurate
3	200cm	4.95	Detected	Not recorded	Not Accurate

On the second RFID Accuracy Test with 1 person present at a 200- centimeters distance, all results were not accurate with only one trial not detected and the information was not recorded on the system.

Table 3 RFID Accuracy Test Set A - 1 person present at 400-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	200cm	8.16	Detected	Not recorded	Not Accurate
2	200cm	-	Not detected	Not recorded	Not Accurate
3	200cm	4.95	Detected	Not recorded	Not Accurate

On the third Accuracy Test with 1 person present at a 400-centimeters distance, all results were not accurate since no detection occurred and the information was not recorded on the system.

Table 4 RFID Accuracy Test Set B - 2 persons present at 70-centimeters and 200-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	70cm 200cm	0.48 2.15	Detected Detected	Recorded Not Recorded	Accurate Not Accurate
2	70cm 200cm	0.73 2.6	Detected Detected	Recorded Not Recorded	Accurate Not Accurate
3	70cm 200cm	0.46 2.94	Detected Detected	Recorded Not Recorded	Accurate Not Accurate

On the fourth RFID Accuracy Test with 2 persons present at a 70- centimeters and 200-centimeters distance, all results of the first person at 70- centimeters were accurate since it reflected and recorded the user's personal information from the detected RFID card. The results for the second person at 200-centimeters were not accurate even though detection occurred since it did not meet the condition for the information to be recorded on the system.

Table 5 RFID Accuracy Test Set B - 2 persons present at 70-centimeters and 400-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	70cm 400cm	0.53 -	Detected Not Detected	Recorded Not Recorded	Accurate Not Accurate
2	70cm 400cm	0.65 -	Detected Not Detected	Recorded Not Recorded	Accurate Not Accurate
3	70cm 400cm	0.38 -	Detected Not Detected	Recorded Not Recorded	Accurate Not Accurate

On the fifth RFID Accuracy Test with 2 persons present at a 70-centimeters and 400-centimeters distance, all results of the first person at 70-centimeter were accurate since it reflected and recorded the user's personal information from the detected RFID card. The results for the second person at 400-centimeters were not accurate since detection did not occur and the information was not recorded on the system.

Table 6 RFID Accuracy Test Set B - 2 persons present at 200-centimeters and 400-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	200cm 400cm	6.48 -	Detected Not Detected	Not Recorded Not Recorded	Not Accurate Not Accurate
2	200cm 400cm	10.53 -	Detected Not Detected	Not Recorded Not Recorded	Not Accurate Not Accurate
3	200cm 400cm	1.93 -	Detected Not Detected	Not Recorded Not Recorded	Not Accurate Not Accurate

On the sixth RFID Accuracy Test with 2 persons present at a 200- centimeters and 400-centimeters distance, all results of the first person at 200- centimeters were not accurate even though detection occurred since it did not meet the condition for the information to be recorded on the system. The results for the second person at 400-centimeters were not accurate since detection did not occur and the information was not recorded on the system.

Table 7 RFID Accuracy Test Set C - 3 persons present at 70-Centimeters, 200-centimeters and 400-centimeters.

TRIAL	DISTANCE	TIME	DETECTION	RECORD	RESULT
1	70cm 200cm 400cm	0.54 2.53 -	Detected Detected Not Detected	Recorded Not Recorded Not Recorded	Accurate Not Accurate Not Accurate
2	70cm 200cm 400cm	0.65 2.11 -	Detected Detected Not Detected	Recorded Not Recorded Not Recorded	Accurate Not Accurate Not Accurate
3	70cm 200cm 400cm	0.69 2.27 -	Detected Detected Not Detected	Recorded Not Recorded Not Recorded	Accurate Not Accurate Not Accurate

On the seventh RFID Accuracy Test with 3 persons present at distances of 70-centimeters, 200-centimeters, and 400-centimeters, all results of the first person at 70-centimeters were accurate since detection occurred and the information was recorded on the system. The result for the 2nd persons at 200-centimeters were not accurate even though detection occurred since it did not meet the condition for the information to be recorded on the system. The results for the third person at 400-centimeters were not accurate since detection did not occur and the information was not recorded on the system.

Table 8 RFID Speed Detection - 1 person present at 70-centimeters

TRIAL	DISTANCE	TIME	SPEED
1	70cm	0.53 s	1.32076 m/s
2	70cm	1.24 s	0.56452 m/s
3	70cm	0.63 s	1.11111 m/s
AVE	70 cm	0.80 s	0.99879 m/s

On the first RFID Accuracy Test with 1 person present at 70-centimeters distance, the average time it took for the RFID card to be detected, recorded, and accurately reflected for the three trials is 0.80-seconds. In terms of the speed, it took to detect the RFID card, Trial 1 got 1.32075 m/s, Trial 2 got 0.564516 m/s, and Trial 3 got 1.11111 m/s. As for the average speed for the three trials, it is 0.99879 m/s or approximately 1 m/s.

Table 9 Temperature Scanner Accuracy Test A - 1 person present at 70- centimeters

TRIAL	PROTOTYPE TSS	COMMERCIAL TSS	PERCENT OF ERROR IN ACCURACY $\left(\frac{\lvert CTSS - PTSS\rvert}{CTSS} x\ 100\%\right)$
1	33.3°C	35.6°C	6.461%
2	33.4°C	35°C	4.571%
3	36.6°C	33°C	10.909%
MEAN	34.433°C	34.533°C	0.29%

On the Temperature Scanner Accuracy, Test A with 1 person present at 70-centimeters distance, the resulting values showed that the Prototype Temperature Scanner were slightly inaccurate compared to the Commercial Temperature Scanner having an average of 0.29% error in accuracy.

Table 10 Temperature Scanner Precision Test A - 1 person present at 70- centimeters

MEAN $\bar{x} = \frac{\sum x}{N}$	SIGMA $\sigma = \sqrt{\frac{\sum(x - x_1)^2}{N-1}}$	PERCENT OF ERROR IN PRECISION $\left(\frac{\sigma}{\bar{x}}\ x\ 100\%\right)$
34.433°C	1.877°C	5.451%

On the Temperature Scanner Precision, Test A with 1 person present at 70-centimeters distance, the resulting values showed that the Prototype Temperature Scanner has a 5.451% error in precision.

Table 11 Temperature Scanner Accuracy Test B - 1 Person present at 70-Centimeters

TRIAL	PROTOTYPE TSS	COMMERCIAL TSS	PERCENT OF ERROR IN ACCURACY $\left(\frac{\lvert CTSS - PTSS\rvert}{CTSS} x\ 100\%\right)$
1	32.2°C	35.8°C	10.056%
2	30°C	35.6°C	15.73%
3	35.3°C	34.9°C	1.146%
MEAN	32.5°C	35.433°C	8.278%

On the Temperature Scanner Accuracy, Test B with 1 person present at 70- centimeters distance, the resulting values showed that the Prototype Temperature Scanner were inaccurate compared to the Commercial Temperature Scanner having an average of 8.278% error in accuracy.

Table 12 Temperature Scanner Precision Test B - 1 person present at 70-centimeters

MEAN $\bar{x} = \frac{\sum x}{N}$	SIGMA $\sigma = \sqrt{\frac{\sum(x - x_1)^2}{N-1}}$	PERCENT OF ERROR IN PRECISION $\left(\frac{\sigma}{\bar{x}}\ x\ 100\%\right)$
32.5°C	2.66°C	8.193%

On the Temperature Scanner Precision, Test B with 1 person present at 70-centimeters distance, the resulting values showed that the Prototype Temperature Scanner has an 8.193% error in precision.

Table 13 Temperature Scanner Accuracy Test C - 1 person present at 70-centimeters

TRIAL	PROTOTYPE TSS	COMMERCIAL TSS	PERCENT OF ERROR IN ACCURACY $\left(\frac{\lvert CTSS - PTSS \rvert}{CTSS}\ x\ 100\%\right)$
1	37.6°C	35.2°C	6.818%
2	31.2°C	33.2°C	6.024%
3	33.7°C	35.6°C	5.337%
MEAN	34.167°C	34.667°C	1.442%

On the Temperature Scanner Accuracy, Test C with 1 person present at 70-centimeters distance, the resulting values showed that the Prototype Temperature Scanner were slightly inaccurate compared to the Commercial Temperature Scanner having an average of 1.442 % error in accuracy.

Table 14 Temperature Scanner Precision Test C - 1 person present at 70-centimeters

MEAN $\bar{x} = \frac{\sum x}{N}$	SIGMA $\sigma = \sqrt{\frac{\sum(x - x_1)^2}{N-1}}$	PERCENT OF ERROR IN PRECISION $\left(\frac{\sigma}{\bar{x}}\ x\ 100\%\right)$
34.167°C	3.225°C	9.442%

On the Temperature Scanner Precision Test C with 1 person present at 70-centimeters distance, the resulting values showed that the Prototype Temperature Scanner has an 9.442% error in precision.

IV. DISCUSSION

The researchers noticed that the RFID Health Security Booth structure was sturdy and almost like a commercially available walk-through metal detector door in terms of its appearance. In addition to that, it was also helpful for long-distance transfer since it can be assembled and disassembled. However, the moment that it is built, one will find difficulty in moving or storing it away since one has to take it all apart one by one just to move it a few meters away from its original position. If forced to drag, push, or pull, the booth would experience stress that may cause degradation to the integrity of the structure and possibly damage to the systems mounted to it as well. Not to mention, it was considerably heavy once assembled all together.

As for individual systems, it was observed that UHF Antenna RFID Scanner has its own aural notification which is deemed to be a nuisance since it would always give a beeping sound whenever it detects a nearby RFID card. Despite that, this is where the antenna exhibits great function. It was discovered that the detection capability can only reach up to 200cm away from the booth and it did not cause any radio interference to the RFID card present at 70cm whether there were people at 200cm or 400cm simultaneously. This is because the RFID Contact Tracing Method Prototype is programmed to not prioritize the RFID card at the furthest distance but the one present inside the booth. In short, aside from being detected by the antenna, users are required to be physically present inside the booth so that the gesture sensor would allow the process of temperature scanning to meet the condition of processing and recording the data. However, it was also determined that if a guard knowingly or unknowingly let a person without an RFID card enter the booth and coincidentally the antenna detected a nearby person's RFID card, it would show in the record that the person with the RFID card has entered the booth with a different person's temperature even though the person with the RFID card has not yet entered the premises. This means the possibility of the prototype exhibiting faulty data recording falls on to the responsibility of the officer-in-charge and not the device itself. Overall, the antenna can detect RFID cards, and the program accurately reflects and records the contact tracing information of that person; user's unique RFID number, temperature, date, and time entered and exited. Take note that the RFID number can be used to determine whose RFID is used, particularly the name and from what course, year, and section the user belongs only during actual contact tracing. However, in terms of real time validation of the user's identity it was noted that there was a need to further develop the visual basic program since the current setup was limited to the skill set of the researcher.

In terms of disinfection, it was determined to be functional and operational since it not only automatically disinfects after the process but can also be turned on by pushing the switch for manual disinfection. Having said that, it was also pointed out that there is a need to conduct a test for the Disinfecting System that would measure the rate of volume of consumption of isopropyl alcohol per user and how much surface area is covered for single disinfection.

The Temperature Scanner system, on the other hand, requires improvement. After testing its accuracy and precision, it was considered inaccurate compared to commercial temperature scanners and not precise in its consecutive data recordings for each test. It was also discovered that the program needs to be improved as well, particularly the rights of a person to enter since it continually allowed a person to enter despite having a temperature that should be denied access.

As discussed, the program has both successfully performed and failed its task in different areas of the prototype. It was assumed that the reason behind this inconsistency is that the prototype has maxed out the Arduino Uno's capacity to store program codes. This means if an upgraded version of Arduino was used, it would not only have consistent results, but it can also provide improvements to coding storage capacity, prevention of data loss, additional features for security and system redundancy which will be discussed in the recommendation section.

Aside from the problem of storing program codes, it was also noted that there is a need to test the longevity and frequency of the device to malfunction when it operates for almost an entire day. Similarly, life expectancy of computers should also be considered since as of its current stage of development, it is still a necessity when operating the device.

Generally, this study identified that the RFID Contact Tracing Prototype is viable as a new contact tracing method that may be used at the Philippine State College of Aeronautics.

V. CONCLUSIONS

Given the results and the findings of data on this study, the researchers, therefore, concluded that the RFID Health Security Prototype is viable to be a new contact tracing method that may be utilized at the Philippine State College of Aeronautics to isolate and prevent the spread of the Covid-19 virus. Also, the researchers concluded that the device requires further test and development to reach its full potential.

- *What are the capabilities of the RFID contact tracing device in identifying and recording the RFID card owner's basic information?*

The RFID contact tracing prototype can identify and record the RFID card owner's unique RFID card number, temperature, date, and time entered and exited. As for the name, course, year, and section, it can be identified separately by means of backtracking whose RFID card number it belongs to.

- *What are the capabilities of the RFID contact tracing device in determining the rights of the RFID card owner to enter the premises?*

The RFID contact tracing prototype was not able to determine whether a person is allowed, denied, or needs to be assessed/evaluated by the school nurse. The problem lies with its coding which was assumed to be affected by the maxing out of coding storage capacity of Arduino Uno.

- *What are the capabilities of the RFID contact tracing device in determining the rights of the RFID card owner to enter the premises?*

The RFID contact tracing prototype was not able to determine whether a person is allowed, denied, or needs to be assessed/evaluated by the school nurse. The problem lies with its coding which was assumed to be affected by the maxing out of coding storage capacity of Arduino Uno.

- *How far can the antenna reach the RFID tag?*

The antenna can detect the RFID tag up to 200 cm distance only. If the RFID tag exceeds the 200 cm distance, then it will not be detected by the antenna.

- *How much time did the antenna take to detect the RFID tag?*

The shortest time that the antenna took to detect the RFID tag was 0.38 seconds at 70cm distance, and the longest time was 10.53 seconds at 200cm distance. It took an average time of 0.80 seconds for the 70-centimeters, while at 200-centimeters it ranges between 1.93 to 10.53 seconds.

- *How fast (speed) did the antenna take to detect the RFID tag?*

The calculated speeds of detection for the RFID tag at 70-centimeters by the UHF antenna RFID scanner were 1.32076 m/s, 0.56452 m/s, and 1.11111 m/s having an average speed of approximately 1 meter per second.

- *How much time is consumed by the user to complete the health declaration form?*

- *How effective is RFID contact tracing compared to digital and manual methods?*

RFID Contact Tracing is highly effective compared to the digital and manual methods of contact tracing as it can break the chains of transmission since it uses radio waves to send information in conducting rapid identification. RFID Contact Tracing can contribute substantially to reducing infection rates from one person to another since it does not need to share objects like ball pens or pencils in writing one's information like in manual contact tracing method, instead, the RFID tag holder must point the card near the RFID scanner to detect. Moreover, RFID Contact Tracing also does not require a person to have his/her gadget(s) and personal internet connection like what the digital contact tracing requires. This means whether digital or manual, there would be less contact to objects for potential transmission of virus.

RECOMMENDATIONS

In this research study, the researchers have recommendations that can help to improve and develop this project.

It is highly recommended to use a higher model of temperature scanner than what has been used to improve the accuracy and precision of the temperature being assessed in the system. As for the system's accuracy in determining whether a person is allowed, to be denied, or to be assessed, it should be further reviewed by fixing the program code that has been input to the system.

The researchers also suggested upgrading the Arduino with more storage for codes and pins to make it viable for a stand-alone system where it has its own battery and memory card where data can be stored as backup storage and power since it is overly reliant on a computer for these two aspects. Having an RFID short range reader will also be included upon upgrade. This module would serve as a backup for the UHF antenna RFID scanner.

It is also recommended to test the disinfection system to determine whether the people who will be entering the booth will be thoroughly disinfected all throughout. Furthermore, it would be better to provide multiple sets of RFID contact tracing prototypes and be used as a holistic network for a better contact tracing system at the entry and exit points of the school and buildings within it. If implemented to schools or universities, researchers can make an instructional guideline on how to operate and maintain it to avoid damage to the device.

For future researchers, it is recommended to get an effectivity rate and pattern on how the mist will be spread while disinfecting 100 people or passerby who will be entering and exiting the booth. It is also recommended to name the kind of UPS that will be used on the product. A suggestion was made that an X- ray machine can be an alternate or be used in the product for faster scanning of the people in having effectivity rate for contact tracing.

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