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Perceiving the Communication Methods between Deaf Pilots and Air Traffic Control

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PERCEIVING THE COMMUNICATION METHODS BETWEEN DEAF PILOTS AND AIR TRAFFIC CONTROL

by

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To my parents, Arnold Tinio and Eliza Febrero, and my sister, Lynelle Tinio –
for their support in pursuing my goals.
To my partner, Tyler Lang –
for being with me and supporting me in this program and life with love.

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Being in the aviation world is a huge thing for me. I wish to express my sincere thanks to Robert Rademacher, Craig Van Winkle, and Bernard Wulle for their support with my aviation career. Each of them made an impact in my life to where I am today including the completion of this master's thesis.

First, Robert Rademacher, the President of the Deaf Pilots Association, has been supportive in ensuring that I learned how to fly when I had trouble in finding a certified flight instructor. Not only that, he knows that I want to be a professional pilot. Once he found out that I want to be an Airline Transport Pilot, we started talking about mostly on the air traffic control communications to figure out the solutions for accessibility in the communication system. Then, President Rademacher was happy to support my research at Purdue University Graduate School. Robert has been a great Deaf pilot friend for a few years.

When I was in high school at California School for the Deaf, Riverside, I was trying to decide what I wanted to do in the future, and I decided that I wanted to be a pilot. I was inspired to see an in-person Deaf pilot, Craig Van Winkle, at the school for the Deaf. He was my dorm/cottage supervising counselor, who I saw often while I was there. Somehow, he knew that I wanted to be a pilot and he told me that he is a pilot. He shared his aviation knowledge and gave me materials that made me more eager to learn. From time to time, I would borrow his Rod Machado's Private Pilot Handbook to study. It was great to get to know a Deaf pilot, and I am now a Deaf pilot as well. We have been in touch from time to time and he has been supportive too; he wrote a letter of recommendation for me to get the Able Flight scholarship to be a pilot.

Lastly, Professor Wulle from Purdue University. I am so glad that he recruited me into Purdue University Graduate School to do the research. We first knew each other when I was at Purdue University for Able Flight flight training during one summer. Professor Wulle wanted me to transfer to Purdue University to study aviation and do research related to Deaf pilots. I did not want to transfer as I was already in my last year before I graduated cum laude from San Jose State University with the Bachelor of

Science degree in Aviation and a minor in Business. However, he was stubborn, and so was I. He then thought I should come to the Graduate School at Purdue University after I graduated from SJSU and do research under him. That was a little overwhelming for me at that time, but a very good opportunity. I only had one year to work on my application to Purdue University Graduate School at that time. This was a last minute future plan to decide to go to graduate school instead of working full-time in the aviation industry. With his support and encouragement, I took the action of completing my application to Purdue University Graduate School to seek the Master of Science degree in Aviation and Aerospace Management.

I was so happy that I was accepted to the master's program at Purdue. During the two-year master's program, Professor Wulle has been so supportive, not only to my research, but to my life. He provided me a part-time job as a graduate teaching assistant under him and ensures I have access to fly at Purdue. Professor Wulle has many roles for me: Advisor, employer, chair, and professor. I am so glad to be in the program at Purdue to do this research, continue flying, and earn the master's degree.

I want to thank each of them and everyone who supported me in my aviation career. They have made my journey into aviation more successful: I became a sport pilot, then a private pilot, graduated with a bachelor's degree in aviation, and continued in the master's program in aviation. The journey has made me love aviation even more!

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ABSTRACT

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Title: Perceiving the Communication Methods between
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Major Professor: Bernard Wulle

Many people are often inspired when finding out that I, a Deaf pilot, can fly. The general population assumes that pilots must be able to communicate via radio to fly, thus resulting in the belief that deaf people cannot be pilots. Yet, there are Deaf pilots in the United States and in other countries. As Deaf pilots, we use communication methods other than the radio to communicate with air traffic controllers. The most common communication method used by Deaf pilots may be the light gun signals, but it may not be enough to support Deaf pilots in a career as a pilot. My research is to improve communications between Deaf pilots and air traffic control. The purpose of this study is to answer the research question: "What are the existing communication methods between air traffic control and Deaf pilots?" For this qualitative research, I interviewed approximately 15 Deaf pilots to explore communication methods they use with air traffic control along with their opinions and suggestions for a better air traffic control communication. This thesis discovered that many Deaf pilots still use the light gun signals method. Not only that, some pilots have a plan of action to aid with the coordination between them and air traffic controllers. Some participants from this research discussed a lot about text-based communication system that the Deaf pilots need to have full communication access with ATC. This use-inspired basic research study is to develop knowledge and processes that will increase the communication for Deaf pilots and the air traffic controllers to use. This thesis research is the beginning of my overall research on improving the communication between Deaf pilots and air traffic control.

CHAPTER 1: INTRODUCTION

This introduction chapter provides an overview of this thesis on perceiving the communication methods between Deaf pilots and air traffic control. It provides the statement of the problem, the research question, the significance of the problem, scope of this research, definitions used in the research, as well as assumptions, limitations, and delimitations of the research.

Statement of the Problem

Many Americans are unaware that Deaf pilots do, indeed, exist.[1] Some Deaf pilots have been educating people that they can easily fly in an uncontrolled airspace, where radio use is not required to communicate with air traffic control, and explain to them the "See and Be Seen" concept that helps pilots to be aware of their surroundings of other aircraft. However, explaining how Deaf pilots can fly in a controlled airspace, where radio use is required, can be complicated. Preferred communication methods with Deaf pilots vary among air traffic controllers. Some air traffic controllers can easily work with Deaf pilots on using alterative communication methods while others find it to be difficult. The complexity may lead Deaf pilots not being able to fly into controlled airspace. Current communication methods that Deaf pilots have been using are light gun signals, text, and the method depends on a hearing passenger or pilot onboard to communicate with air traffic control. These methods may not be capable in a controlled airspace at a big and busy airport; this is the primary barrier for Deaf pilots in pursing an Airline Transport Pilot (ATP) job. Deaf pilots need one standard and reliable communication method to use with any air traffic controllers easily.

[1] Capital "D" in the word "Deaf" is different to just "deaf" without capitalized. People who use "Deaf" identify themselves as culturally deaf; they use sign language to communicate, are part of Deaf community, and have a Deaf pride. The small d in the word "deaf" just represents that deaf people do not hear.

According to the United States Federal Aviation Administration (FAA):

> A deaf pilot can obtain a student pilot certificate, recreational pilot certificate, private pilot certificate, and, on a limited basis, a commercial pilot certificate; for example, agricultural aircraft operations, banner towing operations, or any operation which does not require radio communication.[2] With new interface technology for incockpit receipt of weather information and digital communication, additional pilot certificates may be available to deaf pilots in the future. (Federal Aviation Administration, 2013b).

The technology has been improving and Deaf pilots have been creating some communication methods to use to communicate with air traffic controllers. Some of the methods may work at one controlled airspace, some may work at others, and some may be very difficult for other controlled airspace. Yet, the communication between Deaf pilots and air traffic control can be improved for an increase in efficiency and safety of flight.

Research Question

The question of this research is:

- What are the existing communication methods between air traffic control and Deaf pilots?

Significance of the Problem

Deaf people have enough struggles in obtaining the job they desire. With Americans with Disabilities Act (ADA) and some rights and laws, Deaf people have been able to get the job while some jobs may still not be available for deaf people. The Airline Transport Pilot job is one example. Deaf youth would think, "I can't become a pilot, because a pilot must use a radio to communicate with air traffic control." Radio communication may be the first reason for the perceived barrier in obtaining the Airline

[2] Student, sport, recreational, and private pilots may not fly for compensation or hire. Commercial and Airline Transport Pilots may be compensated or hired to fly.

Transport Pilot job as there are currently no Deaf Airline Transport Pilots. I was not one of those Deaf youths who thought that I "can't" be what I want. I did research to see if there were Deaf pilots around, which there are, as well as being inspired by the Deaf Pilots Association (DPA) "Demonstrating to the world that Deaf Can become pilots." As a result, I decided there would be a way to become an Airline Transport Pilot (Deaf Pilots Association, Inc., 2017a). I became a student pilot in 2014, a sport pilot in 2015, a private pilot in 2016, and a commercial pilot and Airline Transport Pilot (ATP) remain future goals.

Insufficient and low-quality communications between air traffic control and Deaf pilots for a high-density controlled airspace may prevent Deaf pilots from flying for an airline nor any pilot jobs that required flying into controlled airspace. This is due to the big number of airliners flying in a high-density controlled airspace that the controllers are very busy separating all aircraft. Not only that, the Aviation Medical Examiners (AMEs) tend to put the limitation, stating "Not valid for flying where radio use is required.", on Deaf pilots' medical certificate (Federal Aviation Administration, 2015a). Also, the airlines may be concerned with liability issues with their aircraft insurance when having a Deaf pilot flying for the airlines. Airlines may be concerned that if a Deaf pilot were to crash, it would lead to a bad image and highlight a "flaw". Furthermore, the public may have a negative reaction to flying with a Deaf pilot. However, with Deaf pilots demonstrating their ability to communicate, the teamwork of the Deaf Pilots Association (DPA), the National Association of the Deaf (NAD), National Technical Institute for the Deaf (NTID) at Rochester Institute of Technology (RIT) in Rochester, New York, Gallaudet University in Washington, D.C., the Federal Aviation Administration (FAA), some other organizations, and my research at Purdue University, communication barriers may become more surmountable.

Scope

The purpose of this research for the master's thesis is to study Deaf pilots' experiences and communication methods (including mine) with air traffic controllers, analyze the communication issues, and provide practices to improve communication between Deaf pilots and air traffic control before presenting the methods that the pilots

use. Increasing air traffic control communication in the United States between Deaf pilots and controllers may lead to higher accessibility for Deaf people to become general aviation pilots and for Deaf pilots to get into professional pilot careers. In addition to the improvement in the communication and the presentation of the communication methods, air traffic controllers would be able to provide a safer and more efficient flight for all.

Currently, Deaf pilots in the United States of America can use different communication methods to communicate with air traffic controllers. It is true, various methods may tend to take time to plan with air traffic controllers before implementing an agreed communication method to use. Also, informing the air traffic controller on a phone of a Deaf pilot's plans and intentions before flying every time can be time consuming for both the controller and the pilot. Some Deaf pilots may use light gun signals as a communication method. Others may use text messages or one of some other communication methods with air traffic control. This research may lead the various communication methods used by Deaf pilots and air traffic controllers into becoming one standard communication method. With one standard communication method for Deaf pilots and air traffic controllers, all American air traffic controllers and Deaf pilots will easily communicate with each other without much discussing, if not fighting, and planning for a communication method each time. To start my research, this thesis will share the existing communication methods that Deaf pilots use to communicate with air traffic control. This will help raise awareness to all Deaf pilots, air traffic controllers, airlines, the Deaf community, as well as hearing people that Deaf people can fly and are able to communicate with air traffic control using other methods than the radio.

Definitions

Airline Transport Pilot – The highest pilot grade a pilot can become. An Airline Transport Pilot (ATP) can fly for airlines (Code of Federal Regulations, 2017l). At least 1,500 flight hours and a 1st Class Medical Certificate are required to become an ATP (Federal Aviation Administration, 2015b).

Class A Airspace – Class A Airspace is a controlled airspace that requires radio communication to communicate with air traffic control (Code of Federal Regulations, 2017g). This airspace tends to be from 18,000 feet mean sea level

(MSL) to and including flight level 600 (60,000 feet MSL) (Federal Aviation Administration Safety Team, 2017).

Class B Airspace – Class B Airspace is a controlled airspace that requires radio communication with the air traffic control and clearance from air traffic control before entering the airspace (Code of Federal Regulations, 2017f). This airspace tends to be from surface to 10,000 feet mean sea level (MSL) surrounding the busiest airports in the United States (Federal Aviation Administration Safety Team, 2017).

Class C Airspace – Class C Airspace is a controlled airspace that requires radio communication and communication to be established with air traffic control before entering the airspace (Code of Federal Regulations, 2017e). This airspace tends to be from surface to 4,000 feet above the airport elevation surrounding the busy airports with an operational control tower for up to 5 (lower) and 10 (upper) nautical miles (nm) radius in the United States (Federal Aviation Administration Safety Team, 2017).

Class D Airspace – Class D Airspace is a controlled airspace that requires radio communication and communication to be established with air traffic control before entering the airspace (Code of Federal Regulations, 2017d). This airspace tends to be from surface to 2,500 feet above the airport elevation surrounding the airports with an operational control tower in the United States (Federal Aviation Administration Safety Team, 2017).

Class E Airspace – Class E Airspace is a controlled airspace that requires radio communication and communication to be maintained with air traffic control before entering the airspace (Code of Federal Regulations, 2017c). However, for this airspace, radio communication is only required if pilots are operating under instrument flight rules (IFR). So, pilots that are operating under the visual flight rules (VFR), radio communication is not required. Class E Airspace tends to be elsewhere of other airspace. The airspace is still the controlled airspace and not Class A, B, C, or D (Federal Aviation Administration Safety Team, 2017).

Class G Airspace – Class G Airspace is an uncontrolled airspace that does not require radio communication with air traffic control (Code of Federal Regulations, 2017b). Class G Airspace tend to be from ground up to 700 or 1,200 feet above ground level (AGL) and at non-towered airport (Federal Aviation Administration Safety Team, 2017).

Commercial pilot – A commercial pilot may fly for compensation or hire (Code of Federal Regulations, 2017k). At least 250 flight hours and a 2nd Class or higher Medical Certificate are required to become a commercial pilot (Federal Aviation Administration, 2015b).

Controlled airport – A controlled airport is an airport with an operating air traffic control tower. Class B, C, D, and E airspace tend to surround controlled airports.

Controlled airspace – A controlled airspace tends to require radio communication with air traffic control. Controlled airspace has different classifications of airspace, which are Class A, B, C, D, and E airspace (Federal Aviation Administration Safety Team, 2017). Usually, Deaf pilots need to work out with an air traffic control in advance on an alternative communication method before entering their controlled airspace. Deaf pilots can also use Class E airspace without using the radio under visual flight rules (VFR) as it is a controlled airspace if operating in an instrument flight rules (IFR).

Light gun signals method – A light gun signals is a form of communication method used by an air traffic controller to a pilot for instructions or clearances. The light gun signals has three different color lights: green, red, and white. For example, the flashing green light pointing to an airplane on the ground at an airport is a signal the airplane is cleared for taxi while steady red is to stop (Code of Federal Regulations, 2017a). A steady green light for the airplane on the ground is cleared for takeoff or cleared to land if the airplane is in the air. It is a backup communication method if the radio in an airplane fails.

Private pilot – A private pilot has the least limitations compared to student, sport, and recreational pilots. However, a private pilot still cannot fly for compensation or hire (Code of Federal Regulations, 2017j). At least 40 flight hours and a 3rd Class

or higher Medical Certificate are required to become a private pilot (Federal Aviation Administration, 2015b).

Professional pilot – A professional pilot is a commercial or an Airline Transport Pilot having a professional pilot job.

Sport pilot – A sport pilot may fly up to 10,000 feet mean sea level (MSL) or 2,000 feet above ground level (AGL), whichever is higher, in a light sport aircraft during daytime only with up to one passenger (Code of Federal Regulations, 2017m). However, a sport pilot may not be compensated or hired to fly. In addition, a pilot may become a sport pilot without a medical certificate, if the pilot has a valid driver license and never had a medical certificate denied. At least 20 flight hours are required to become a sport pilot. Not many people go for a sport pilot certificate but direct to a private pilot certificate.

Student pilot – The first pilot grade. A student pilot learning to fly must be at least 16 years old, cannot be a pilot in command of an aircraft that is carrying a passenger nor carrying property for compensation or hire, and cannot fly for compensation or hire (Code of Federal Regulations, 2017h).

Radio communication method – A communication from using radio between pilots and air traffic controllers.

Recreational pilot – A recreational pilot may fly with up to one passenger within 50 nautical miles from the departure airport (Code of Federal Regulations, 2017i). However, this pilot may not carry a passenger or property for compensation or hire. A 3rd Class or higher Medical Certificate is needed to become a recreational pilot (Federal Aviation Administration, 2015b). At least 30 flight hours are required to become a recreational pilot. Not many people go for a recreational pilot certificate but direct to a private pilot certificate.

Uncontrolled airport – An uncontrolled airport is an airport without an air traffic control tower or an air traffic control tower not in operation. Class E and G airspace tend to surround uncontrolled airspaces.

Uncontrolled airspace – An uncontrolled airspace is where no communication with the air traffic control is required. Class G airspace is the only airspace that is uncontrolled (AOPA Air Safety Foundation, 2009). Deaf pilots can easily fly in this airspace without any communication requirement.

1st Class Airman Medical Certificate – A FAA 1st Class Airman Medical Certificate is required for Airline Transport Pilot to operate as an Airline Transport, commercial or private pilot. To be eligible for a 1st class airman medical certificate, a pilot must meet some physical and mental requirements as described in the Federal Aviation Regulations (FARs) Part 67, Subpart B (Code of Federal Regulations, 2017o). The only difference between the 1st and the 2nd Class Airman Medical Certificates requirements is that the pilot must pass an electrocardiogram (EKG) test for 1st Class Airman Medical Certificate. The hearing test requirement is the same between the 1st, 2nd, and 3rd classes, so Deaf people can obtain a 1st class airman medical certificate, but would have a limitation placed on the certificate, "Not valid for flying where radio use is required" (Federal Aviation Administration, 2015a).

2nd Class Airman Medical Certificate – A FAA 2nd Class Airman Medical Certificate is required for commercial pilot to operate as a commercial or private pilot. To be eligible for a 2nd class airman medical certificate, a pilot must meet some physical and mental requirements as described in the Federal Aviation Regulations (FARs) Part 67, Subpart C (Code of Federal Regulations, 2017p). The only difference between the 2nd and the 3rd Class Airman Medical Certificates requirements is that the pilot must pass a 20/20 vision test for 2nd Class Airman Medical Certificate. The hearing test requirement is the same between those classes, so Deaf people can obtain a 2nd class airman medical certificate, but would have a limitation placed on the certificate, "Not valid for flying where radio use is required" (Federal Aviation Administration, 2015a).

3rd Class Airman Medical Certificate – A FAA 3rd Class Airman Medical Certificate is required for private pilot to operate as a private pilot. To be eligible for a 3rd class airman medical certificate, a pilot must meet some physical and mental requirements as described in the Federal Aviation Regulations (FARs) Part 67,

Subpart D (Code of Federal Regulations, 2017q). Deaf people can obtain a 3rd class airman medical certificate, but would have a limitation placed on the certificate, "Not valid for flying where radio use is required" (Federal Aviation Administration, 2015a).

Assumptions

The following assumptions are inherent to the research of this thesis:

- The Deaf Pilots Association and I think that there are about 50 Deaf pilots in the United States.
- The President of the Deaf Pilots Association and I estimate that there are about 50 active Deaf pilots in the world.[3]
- Most Deaf pilots do not use radio to communicate with air traffic controllers nor pilots.
- There is no Deaf Airline Transport Pilot yet.
- All air traffic controllers are hearing.
- Participants know American Sign Language in order to be able to interview smoothly.
- Participants have at least a mean of video call for the interview.
- Participants will share all of their ATC communication methods and experiences in the interview.

Limitations

The following limitations are inherent to the research of this thesis:

- This research is limited to Deaf and Hard of Hearing (DHH) pilots' communications.
- This research is limited to collecting data mostly from pilots in the United States.
- This research is limited to analyzing pilots that know American Sign Language.

[3] Active pilot is a pilot that have earned at least a sport pilot certificate; student pilot is not included.

- This research is limited to the number of participants for interview and data from the Deaf Pilots Association, my Deaf pilot friends, and a few Deaf American pilots.

Delimitations

The following delimitations are inherent to the research of this thesis:

- This research will not focus on hearing pilots.
- This research will not discuss much on deaf pilots.
- This research may not include Deaf pilots who understand spoken language and speak language verbally with air traffic control.
- Pilots that do not hear on one ear but can hear on the other ear are not considered Deaf/deaf pilots in this research.
- Deaf student pilots with very little flight experience will not be analyzed deeply in this research.
- This research will not explore foreign governments' aviation regulations.
- The presentation of communication methods used between Deaf pilots and air traffic control in the United States of America.
- The period between the approval to interview and the middle of the last semester before graduating to interview the Deaf pilots.

Summary

The introduction chapter is intended to provide a research overview that includes statement of the problem, research question, significance of the problem, scope, definitions, assumptions, limitations, and delimitations. It concerns the need to spread the awareness of different air traffic control communication methods used by Deaf pilots to improve communication accessibility for Deaf pilots to communicate with air traffic control. The next chapter on literature review explores the evolution of air traffic control, air traffic control communication methods, Deaf pilots, Deaf culture, the new communication technologies, and Deaf people's rights.

CHAPTER 2: REVIEW OF LITERATURE

Research relating to Deaf pilots or their communications with air traffic controllers is new. There is a lack of research about Deaf pilots due to aviation having only started a bit over a century ago. Deaf people have a long Deaf history, in which much research is available related to its sign language, culture, and history. However, the number of Americans finding that Deaf pilots are able to fly is increasing. More Deaf people are starting to see that Deaf people can fly, and given my experiences, I want to contribute as a Deaf pilot in this research to inform the world that Deaf people can fly.

This literature review provides some reviews of available sources to discuss the research about communications between Deaf pilots and air traffic control. The opening sections discusses topics from the history of aviation, to air traffic control communication methods, to the Deaf pilots' communication needs. The chapter details the changes that affect Deaf pilots, explains the current communication methods they use along with possible new methods, and discusses the laws that help Deaf pilots. It then closes with a summary of importance in researching the existing communication methods in the United States that Deaf pilots use with air traffic control before presenting the data that can help people in general to know how Deaf pilots can communicate with the control when needed.

Evolution of Air Traffic Control

Prior to the air traffic control system in the early 1930s, there was no air traffic controller in the United States of America (Nolan, 2011). The method to avoid other aircraft was to "see and be seen". Pilots would fly in appropriate conditions such as daylight and clear of clouds. Additionally, pilot would fly different coordinated paths to avoid each other aircraft. Flying in good weather and staying clear of clouds at a specific distance are now called visual flight rules (VFR). The time with little or no air traffic control was a Deaf-friendly environment where deaf pilots could easily fly without the need to use any verbal communications.

Then there was a time when airports became busy with more airplanes landing and taking off; it was a bit complicated to decide which pilot can land first. In 1929, St. Louis Airport (STL) in Missouri hired the first air traffic controller in the United States, Archie W. League (Nolan, 2011). He stood at the airport next to the runway and used red and green colored flags to communicate with pilots that were taking off or landing. Red flag signaled the pilot to hold the position while green flag communicated that the pilot is cleared to proceed with the plan to takeoff or land. The colored flags method was communicable between Deaf pilots and air traffic controllers. With the colored flags as a method of communication for air traffic control, it helped to keep airport in control until more airplanes were coming at the same time. The air traffic controller using the colored flags method could not determine if the pilots received and understood the instruction that was intended for the pilot and not the others in the same line of sight. Not only that, it was difficult to communicate at night or during stormy weather.

Light gun signals soon replaced the colored flags system as a mode of communication in the 1930s. These signals had the same purpose as the colored flags system (Nolan, 2011). An air traffic controller would be in a newly built control tower with light guns at a busy airport for a better view of aircraft around the tower. This method improved the communication by directing the light gun signal to the specific pilot rather than a miscommunication signal for all pilots as happened under the colored flags system. It was also a Deaf friendly communication method and is still in use as one of a few communication methods between Deaf pilots and air traffic controllers. In addition, light gun signals method is still used today as a backup when a radio in the control tower or aircraft fails.

The radio system came as a current mode of communication between pilots and air traffic controllers. This is due to the difficulties using the light gun signals method in bad weather, the pilots could hardly see the light signals (Nolan, 2011). Not only that, hearing pilots may be too busy with flying the aircraft to constantly lookout for a light gun signal. The other difficulty is that it is a one-way communication method that the pilot was not able to communicate to the air traffic controller. The radio system solved those problems, but this became a communication barrier for Deaf pilots.

The radio communication system has its issues too. The communication can be lengthy due to procedures, difficult to understand, and errors can cause miscommunication. The procedure tends to be long, including, but not limited to, the identification, instructions, and readback. It can also cause miscommunication due to various languages, accents, and cultures, which can be a hazard to the safety of flight. Soon, the future mode of communication, the Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) Data Communications (Data Comm) will replace the current mode of communication of radio system. Data Comm is designed to increase the effectiveness, efficiency, and safety of flight and may be the best Deaf-friendly communication system, restoring communication between Deaf pilots and air traffic control once again.

Radio Communication Procedures

Rod Machado's Private Pilot Handbook stated pilots use avspeak, which is an aviation language speaking through radio in air traffic control. Rod Machado taught the steps in speaking to air traffic controller under the radio communication (Machado, 2008). The usual step starts with tuning the radio to the appropriate radio frequency for the specific air traffic control to transmit and receive messages before stating the name of the air traffic control to get the controller's attention (Machado, 2008). Then the pilot identifies his/her aircraft right after stating the ATC's name by messaging the aircraft number in aviation phonetic alphabet language before any request or comment in the proper avspeak way and then ending with saying "over". The pilot will wait and listen to the message that will be delivered by the air traffic controller before reading back the instruction delivered by the controller through radio.

The radio communication procedure as described above by Rod Machado (2008) is not accessible for deaf pilots who do not hear or speak through aviation headset under radio communication. Radio equipment in the cockpit fails to accommodate Deaf pilots. Other equipment and communication methods are used to communicate between Deaf pilots and air traffic controllers. Other ATC communication methods, old or new, may be as effective as the radio communication system, but may be better in efficiency.

Deaf Pilots Association

The Deaf Pilots Association, Inc. (DPA) consists of a group of Deaf pilot members providing the knowledge and resources to Deaf/Hard of Hearing people that want to become a pilot and they also educate the general population and aviation industry of their ability (Deaf Pilots Association, Inc., 2017b). The DPA's motto is "Demonstrating to the world that Deaf Can become pilots." Many people, Deaf and hearing, think deaf people cannot fly, especially when thinking pilots have to use the radio to communicate with air traffic control (ATC). To clear that up, the DPA justified two kinds of airports and airspace: controlled and uncontrolled (Deaf Pilots Association, Inc., 2017c). At controlled airports/airspace, pilots are required to use the radio to communicate with ATC. However, at uncontrolled airports/airspace, pilots are just encouraged to use the radio to communicate with other pilots, but they are not required to (Deaf Pilots Association, Inc., 2017c). Therefore, deaf pilots are allowed to operate in uncontrolled airports/airspace without the need to a use radio to communicate.

The DPA stated that the FAA places the limitation of "Not Valid for Flights Requiring the Use of Radio" on a qualified deaf pilot's pilot certificate (Deaf Pilots Association, Inc., 2017c). In controlled airports/airspace, pilots may not operate until radio communication has been established with the ATC or until they received approval by the ATC before operating in it. Due to that, the limitation is not necessary, because Deaf pilots know they are not supposed to operate there until other communication methods are used. The association commented that the limitation is not a big thing, because more than 18,000 airports in the United States are uncontrolled and only the other 512 airports have control towers (Deaf Pilots Association, Inc., 2017c). For deaf pilots to fly into a controlled airport, the DPA mentioned that the pilot can bring a co-pilot or a certified flight instructor (CFI) who can handle the radio communication, or can use light gun signals method by planning with the air traffic controller in advance.

The Deaf Pilots Association also provides education on how Deaf pilots can be aware of other aircraft. According to the DPA:

> Under Visual Flying Rules (VFR), under which most general aviation flights are conducted, you are responsible for seeing and avoiding other airplanes, and

> remaining well clear of clouds. As you learn to fly, you will develop a skill for spotting airplanes and adjusting your route of flight as necessary (Deaf Pilots Association, Inc., 2017c, p. 5).

Staying away from clouds helps other pilots to see the aircraft and to avoid from colliding into it. The ATC may also help to ensure all aircraft are separated at an appropriate distance from each other by seeing the radar screens of all aircraft with transponder on board that transmits the airplane's current position and altitude.

The communication between Deaf pilots and the ATC can always be improved. The DPA brought up there are some research studies underway for non-voice digital communications:

> The idea is that all air traffic control instructions, traffic advisories, and weather information will be digitally transmitted to the cockpit. The most promising projects include aeronautical datalink and ADS-B (automatic dependent surveillance broadcast). These technologies are currently being tested in commercial jets, and will likely make their way into general aviation aircraft within the next decade. (Deaf Pilots Association, Inc., 2017c).

Deaf Pilots Association's President Robert Rademacher along with some DPA officers and members support my research to improve communication between Deaf pilots and air traffic control.

Deaf Culture

Deaf people have their own culture, Deaf culture, which is different from hearing culture. According to *American Deaf Culture* book, "Members of the Deaf culture behave as Deaf people do, use the language of Deaf people, and share the beliefs of Deaf people toward themselves and other people who are not Deaf" (Padden, 1989, p. 5). Deaf people in the United States use American Sign Language (ASL) to communicate. ASL tends to be their first and primary language. ASL has different rules, grammar, and structures with these of English, and is full of 3-D visual language. In addition to hands that are used to

sign in ASL, facial expressions and body language are part of it. Deaf people have their own benefits of using sign language to communicate. Some benefits are able to talk while eating, under the water, other side of window, in a noisy environment, and in a far distance. The book pointed out that the Deaf people obtain vital and incidental information through vision instead of hearing (Stokoe, 1989). Deaf people grow up gaining the vision skill which can help them spot any movement with a broader area better and quicker than hearing people's capability. With the facts about Deaf people's skills, any visual means of communication for Deaf pilots can be helpful.

Another author in the book, Ben Bahan, identified himself as a seeing person instead of a Deaf person, "That would explain everything around me: like TTYs, decoders, flashing door-bells, lipreading, and emergence of a seeing language, American Sign language" (Bahan, Notes from a 'Seeing Person', 1989a, p. 32). This was to suggest a change in how hearing people think of deaf people by using the words "seeing people" to identify Deaf people. The term may help improve communication rather than assuming deaf people cannot communicate. Some Deaf people have been complaining that the hearing people keep deciding for Deaf people when Deaf people should be part of the decision makers. Ben Bahan also authored "It's Our World Too!" In the book, "What right do hearing people have to impose on us the dominance of their world?" (Bahan, It's our world too!, 1989b, p. 47).

There may be a hearing world and a Deaf world, but both are on the same Earth. Bahan emphasized that Deaf people should teach hearing people to sign; it is a way to bridge the both worlds together. Bahan again wrote "Our Future, Ourselves", in which he suggested that Deaf people should focus on the future, as a way to solve some problems on the way to reach the future, "Some of those problems could have been solved if I had begun to look into the future" (Bahan, Our future, ourselves, 1989c, p. 61).

I am Deaf and I want to be an Airline Transport Pilot. So, this research intended to solve some communication barriers between Deaf pilots and air traffic controllers for me and other Deaf pilots' future. "The War is Not Over" (which was wrote by Ben Bahan in another chapter title in the book) illuminated the history of "Deaf President Now!" protest at Gallaudet University, the only university for the Deaf in the world, because the Deaf community at Gallaudet had enough with hearing presidents taking in charge and

wanted a Deaf president (Bahan, The war is not over, 1989d). In Deaf history, Deaf people have been fighting for self-determination and working constantly to improve Deaf people's quality of life (Buchanan, 1999; Corker, 1998; Gannon, 1981; Jankowski, 1997; Robinson, 2006; Simms & Thumann, 2007 cited in Holcomb, 2013). They are seeking for the right to make decisions concerning themselves and not be controlled by the hearing society. The Deaf community won the protest and had I. King Jordan as a first Deaf President of Gallaudet University. Is it time for a "Deaf Airline Transport Pilot Now!"?

Deaf People have Licenses to Operate

The article *Licensing the Deaf Driver* compared the ability of Deaf and hearing drivers to drive safely (Burg, Stock, Light, & Douglass, 1970). The article discussed the U.S. Public Health Service, a monograph, that recommends licensing disabled motor vehicle operators. It is a guideline for state medical advisory boards to use it to consult with motor vehicle administrators. It has analyzed Deaf and hard of hearing drivers in comparison with hearing drivers on the ability to drive safely. It helps to better understand the Deaf person's ability. As this article is in the Deaf operators topic area, the discussions may apply to Deaf pilots as well. The Deaf community has been advocating Deaf people are better drivers than hearing people. They grew up gaining the skill on using their eyes to instantly notice any movement in a broader area of vision. However, hearing people may not have the skill to do that. Thus, the article can be valuable to support the idea that the Deaf pilots, like myself, have the benefit and the vision skill to advance their pilot career.

Licensing the Deaf Driver revealed that being deaf is not a serious defect in many situations, because Deaf people can adjust their deafness and compensate for it (Burg, Stock, Light, & Douglass, 1970). It also affirmed:

> It has been suggested that a totally deaf person, aware of his handicap and trained to cope with it, is probably a safer person than one with little or no impairment who drives with windows closed, air-conditioner operating, radio playing at high

> volume, and is unaware that he is, for practical purposes, totally deaf to outside sounds. (Burg, Stock, Light, & Douglass, 1970, p. 289).

This is due to the fact that Deaf people have the vision skill to quickly detect any movement and react faster than hearing people; they can avoid a possibility of accident faster.

The article explained three different groups to identify the different needs for each group to drive safely: Hard of hearing from before the age of 15, Became hard of hearing after 15 years of age, and has been aware of deficiency for more than four years, and Became hard of hearing after 15 years of age and has been aware of deficiency for less than four years (Burg, Stock, Light, & Douglass, 1970). For the three hard of hearing groups, the recommendations were that the agencies can issue them a private passenger vehicle license, and the drivers should drive only in vehicles that have two side mirrors and a rear-view mirror. An additional recommendation for group three was that they should complete a course that is designed for deaf drivers to ensure they can drive safely.

The limitations are that the Deaf drivers should only drive vehicles that are equipped with two side mirrors and an inside rear-view mirror and a course for the deaf driver for newly hard of hearing people. This limitation about mirrors are not necessary to be printed on the license, because hearing drivers would need to have the mirrors to drive safely too or they would have the bigger blind spots, which can be a hazard to hit another car. The same issue from the Federal Aviation Administration (FAA) that places the limitation of "Not valid for flying where radio use is required." for Deaf pilots, which is also not necessary (Federal Aviation Administration, 2015a). Any pilots, hearing or Deaf, cannot fly in controlled airspaces (where radio communication use is required) if they have not established communications or received approval to use the airspace. Therefore, the limitation for Deaf pilots is not needed as pilots know that they cannot enter the controlled airspace anyway, because they have not established communication with a controller or received an approval from a controller, and they would work with controller for a different communication method before entering the airspace. Deaf and hearing operators should have equal accesses and opportunities as the general result from

the article showed that a Deaf driver and a hearing driver have approximately the same accident rate.

Licensing for Deaf Driver is a great short article that confirms that Deaf drivers can drive safely like hearing drivers can. Even though this article that used four different sources is 47 years old, it is a good source to support my research that Deaf pilots should be able to fly commercial airliners with improved communications. There are not many journal articles that discuss Deaf people nor new FAA NextGen Data Comm due to lack of research on those, in which I research the primary sources. This article discussed that there are few deaf people who are employed as drivers of cargo transport or passenger transport vehicles. This was in 1970, the barrier for Deaf people now has been better and many more Deaf people can succeed in many different fields such as Deaf truckers, Deaf dentists, Deaf lawyers, Deaf teachers, Deaf physicians, and even hopefully soon, Deaf pilots (Holcomb, 2013).

Deaf People and Their Access to Communication

Dr. Thomas K. Holcomb, a kind Deaf gentleman that I was fortunate to meet and is one of a few who helped me to go for Purdue University Graduate School, is an author of *Introduction to American Deaf Culture* book. He rationalized in the book that not all Deaf people are alike (2013). A few examples to point out for this research, "Some deaf people sign, and others don't. Some wear hearing aids, and others don't. Some have cochlear implants or want them. Others shun them completely. Some use their speech regularly, and others decline to use their voice at all" (Holcomb, 2013, p. 63). Even though all Deaf people are different, they still need full access to communication. Dr. Holcomb wrote that because Deaf people are born into a hearing world, the struggle to communicate with hearing people is common. While this is true, I feel the world we are living in is designed for hearing people, and we Deaf people, are working to make the world more accessible for us as well. Deaf people depend on visuals for communication as Dr. Holcomb discussed, "In contrast to people who hear, Deaf people's lives revolve around the use of sight and, because of this, much of their culture is based on efficient and effortless visual access to the world (Bahan, 2008; Bauman, 2008)" (Holcomb, 2013, p. 98). With the full access to communication, Deaf people can become successful, in

which Dr. Holcomb typed, "… a successful integration within the larger, hearing society, resulting in rich and rewarding lives" (2013, p. 98).

The American Deaf Culture has some core values, in which Dr. Holcomb included are full communication access, information sharing, healthy identify formation, and self-determination. Full communication access is the focus in this research for Deaf pilots. The access includes the availability of high-quality American Sign Language (ASL) interpreting services, well captioned on all television programs, movies, and online videos, and telephone with video relay services (Holcomb, 2013). The full communication access allows Deaf people the possibility to be the full, productive Americans. The author simply reminded the reader that the basic human rights are for everyone, and Deaf people also deserve these rights.

Dr. Holcomb discussed the importance of information sharing where deaf people in the past did not have much access to information such as radio. Radio communication between Deaf pilots and air traffic controllers is not accessible to deaf people. He said that the withholding of possible valuable and helpful information from Deaf people can be considered rude and selfish, as well as unacceptable in any cultures (Holcomb, 2013). In the recent years, the Americans with Disabilities Act (ADA) has helped enormously to improve the quality of Deaf Americans' lives, but not a full access, just a "reasonable accommodation" (Holcomb, 2013). The ADA permits "deaf people to pursue jobs for which they are qualified and to be provided with appropriate support services to allow them to perform their job duties," said Dr. Holcomb (p. 260). This research explores for some appropriately communication methods that will increase communication with the air traffic controllers and is within reasonable accommodation as considered by airlines.

Technology Improves Deaf People's Communication Access

An article, *Attitudes of teachers and parents in India toward career choices for Deaf and hearing people,* stated that hearing people often feel a profession with the importance of good hearing and speech skills is not suitable for a deaf person (Parasnis, DeCaro, & Raman, 1996). A pilot job is one such example. The general population thinks deaf people cannot perform the job due to the communication issue when using radio to communicate with an air traffic controller. The authors, Ila Parasnis, James J. DeCaro,

and Marie L. Raman, expounded that Deaf people in the United States have been advancing to more career opportunities due to more appropriate higher educational training such as Gallaudet University and the National Technical Institute for the Deaf (NTID). The authors wrote, "Having educational and career opportunities and technological support has helped American deaf people overcome many of the traditional environmental and communication barriers that exist in the predominantly hearing world" (Parasnis, DeCaro, & Raman, 1996, p. 303). Deaf people finally share their needs for improvement in communication among hearing people for equal access to employment, education, information, and communication. "The availability of telecommunication systems, real time captioning technology, a decoder system for captioned television programs, access to electronic mail, and so on, has made communication among and between deaf and hearing people easier and more effective," explained the authors (Parasnis, DeCaro, & Raman, 1996, p. 303). While this article was published in 1996, many more technologies have changed over 21 years; text message, video phone, FaceTime, and Skype are some examples that increase accessibility for the Deaf people in the United States. Not only that, more and more Americans are learning American Sign Language (ASL). *Attitudes of teachers and parents in India toward career choices for Deaf and hearing people* concluded that hearing people optioned professions with less requirements on relying on hearing and speech skills are suitable for deaf people. Also, deafness is a physical handicap due to the communication limitation in the hearing world, but it is not a physical handicap in intellectual abilities and skills.

To make hearing people in the society feel that a pilot job can be suitable for deaf people, the communication between Deaf pilots and the ATC needs to be brought to attention as part of this research purpose and my overarching goal to improve the communication. The article provided a good statement that lately more American educators and employers are aware that the spoken communication limitation of deaf people does not mean it should be a barrier to success in Deaf people's careers. A final excellent quotation from this article for hearing readers judging Deaf pilots states that, "For deaf people, the availability alone of educational and career opportunities is not sufficient. Rather, hearing society's attitudes toward deaf people must also undergo a positive change since these attitudes largely shape educational and work environments as

well as career advancement of deaf people" (Parasnis, DeCaro, & Raman, 1996, p. 308). They need to watch their attitude.

Real-Time Text (RTT)

The Real-Time Text (RTT) is a new communication technology that was developed by Gallaudet University (Gallaudet University, 2017). Gallaudet explained that RTT is a real live texting system where the users can instantly see any typed characters and words instead of waiting for the other user to send the message to read before replying. The Federal Communications Commission (FCC) has recently approved the RTT to replace teletypewriter TTY. This newest communication technology, RTT, has great benefits for Deaf people: it is faster than texting, has better 911 access, and has TTY continuity during RTT phase-in (Gallaudet University, 2017). Gallaudet University clarified in a YouTube video clip on its webpage that RTT is not a replacement for video relay service (VRS), just another, and possibly better, communication technology for direct communication.

Real-Time Text is an example of some new communication technologies the Deaf community has been working on to improve communication among themselves and the hearing society they are in. When using that technology in aviation, RTT may help Deaf pilots and air traffic controllers improve communication with each other. Some airliners have a keyboard that allows for communication with the use of RTT. RTT can help improve the efficiency and safety of a flight where a Deaf pilot can instantly see the message the ATC is typing. This is no longer like a radio system, where one end user must wait for the other end user to complete before replying. This is more like a real live conversation where one can message anytime he or she wants. RTT is one of several communication methods between Deaf pilots and air traffic controllers that this research may encounter.

FAA Pilot Certificate for Deaf Pilots

The Federal Aviation Administration (FAA) has a web page specifically for Deaf Pilots, "Deaf Pilot Frequently Asked Questions". The page answers questions about pilot certification, medical certification, training, aircraft operations, and testing. The FAA

explained that a deaf individual can obtain a pilot certificate with the limitation of "Not Valid for Flights Requiring the Use of Radio" in a category of five different aircraft categories (Federal Aviation Administration, 2013b):

- airplane
- rotorcraft
- glider
- powered-life
- lighter-than-air

In addition, the FAA in the United States issues six different grades of pilot certificates, from the lowest to the highest pilot certificate:

- student pilot certificate
- sport pilot certificate
- recreational pilot certificate
- private pilot certificate
- commercial pilot certificate
- Airline Transport Pilot certificate

Each pilot certificate has different privileges and limitations as described in the Federal Aviation Regulations (FARs) Part 61: Certification: Pilots, Flight instructors, and Ground instructors. With a student pilot certificate, a student pilot may learn to fly with a certified flight instructor (CFI) and may solo with the endorsements from the CFI. The sport pilot certificate allows a sport pilot to fly in a light sport aircraft during daytime only. A recreational pilot certificate allows a recreational pilot to fly up to a specific distance from the departure point. A private pilot certificate allows a private pilot to fly with passengers for pleasure purpose only. A commercial pilot certificate allows a commercial pilot to fly for compensation or hire. Lastly, the Airline Transport Pilot (ATP) certificate allows an ATP to act as a captain of an airliner.

A deaf pilot can easily earn a student pilot certificate, sport pilot certificate, recreational pilot certificate, and private pilot certificate. A deaf pilot may be able to even earn a commercial pilot certificate and Airline Transport Pilot certificate. The FAA confirmed that a deaf pilot can earn those pilot certificates as mentioned in the first sentence in this paragraph and

> on a limited basis, a commercial pilot certificate; for example, agricultural aircraft operations, banner towing operations, or any operation which does not require radio communication. With new interface technology for incockpit receipt of weather information and digital communication, additional pilot certificates may be available to deaf pilots in the future. (Federal Aviation Administration, 2013b).

This research seeks for any new interface technology that may help increase communication between Deaf pilots and air traffic control. As for now, a deaf student pilot and a CFI can work with local airport personnel to discuss for some communication opportunities (Federal Aviation Administration, 2013c). The FAA (2013c) assured, "Light gun signals are available for aircraft that do not have radios or in case of a radio failure." However, the FAA also cleared that with a prior permission of the airport personnel, light gun signals can be a communication method between a deaf pilot and an air traffic controller.

All student pilots must demonstrate three landings and three takeoffs at a controlled airport to indicate the pilots' ability to communicate with an ATC to complete one of the requirements for private pilot certificate. The administration also explained that a pilot without a radio communication is to remain out of the airport area and observe the airport traffic and windsock or segmented circle to decide an appropriate direction for landing before entering the airport traffic to land (Federal Aviation Administration, 2013a). In addition by the FAA, the Direct User Access Terminal System (DUATS) is available for deaf pilots to obtain a weather briefing or even an access to a Flight Service Station briefer by calling through a Relay Service (Federal Aviation Administration, 2013a). There are some different ways that Deaf people can obtain the weather briefing. I tend to obtain aviation weather by reading on an aviation weather app, reviewing on

ForeFlight app, and calling weather briefing through a video relay service that provides an American Sign Language interpreter on the call. New technologies always come up that can change how Deaf pilots can do better. The Deaf Frequently Asked Questions webpage on the FAA website provides good answers and explanations for Deaf pilots and hearing pilots to understand that Deaf pilots can become a pilot. It seems like the FAA is supportive for the Deaf pilots and can work with Deaf people to improve their accessibility. According to the AOPA that wrote in 1999, International Deaf Pilots Association stated that the United States of America is the only country that can certify deaf pilots and there were about 200 deaf pilots in the U.S. (AOPA, 1999). The FAA and the United States are leading in innovating aviation technologies around the world, it is time to work with the FAA to change its thought about Deaf pilots and to open up opportunities for them.

FAA Medical Certificate for Deaf Pilots

The Federal Aviation Administration medical certificate is required for pilots with a private pilot certificate or higher to fly. In general, a pilot is considered to be licensed when the pilot has both the pilot and medical certificates. The FAA website on "Deaf Pilot Frequently Asked Questions: Medical Certification" webpage mentioned that the FAA issues a 3rd or 2nd class medical certificate and a Statement of Demonstrated Ability (SODA) once a deaf pilot completes the Special Medical Flight Test (Federal Aviation Administration, 2015a). The limitation of "Not valid for flying where radio use is required" is then placed on a deaf pilot's medical certificate and SODA. Prior to obtaining a medical certificate, a deaf pilot needs to submit the hearing exam result to the aviation medical examiner (AME) or the FAA as part of the medical exam and taking a Special Medical Flight Test. The Special Medical Flight Test itself checks whether a deaf pilot can recognize an engine power loss or failure based on feeling the difference in vibration and a change in instrument; an approaching stall by feeling buffet and visual cues; and if applicable, a retractable landing gear emergency by noticing landing gear warning lights (Federal Aviation Administration, 2015a). I, as a Deaf pilot, did not have to take a Special Medical Flight Test, as I had received the 3rd, 2nd, and 1st Class Medical Certificates directly from the AMEs without the need to schedule a Special Medical

Flight Test to obtain a medical certificate. Thus, it seems not all deaf pilots have the same procedure in obtaining a medical certificate from the FAA.

Many people, including Deaf pilots, did not know a Deaf pilot can have a 1st class medical certificate such as the one I received. The Federal Aviation Regulations (FARs) Part 67 on Medical Standards and Certification displays the hearing level requirements for 1st, 2nd, and 3rd class medical certificates are all the same (Code of Federal Regulations, 2017n). Figure 1, Figure 2, and Figure 3 show a copy from the FARs of the requirements for the three classes.

§67.305 Ear, nose, throat, and equilibrium.

Ear, nose, throat, and equilibrium standards for a third-class airman medical certificate are:
(a) The person shall demonstrate acceptable hearing by at least one of the following tests:
(1) Demonstrate an ability to hear an average conversational voice in a quiet room, using both ears, at a distance of 6 feet from the examiner, with the back turned to the examiner.
(2) Demonstrate an acceptable understanding of speech as determined by audiometric speech discrimination testing to a score of at least 70 percent obtained in one ear or in a sound field environment.
(3) Provide acceptable results of pure tone audiometric testing of unaided hearing acuity according to the following table of worst acceptable thresholds, using the calibration standards of the American National Standards Institute, 1969:

Frequency (Hz)	500 Hz	1000 Hz	2000 Hz	3000 Hz
Better ear (Db)	35	30	30	40
Poorer ear (Db)	35	50	50	60

(b) No disease or condition of the middle or internal ear, nose, oral cavity, pharynx, or larynx that—
(1) Interferes with, or is aggravated by, flying or may reasonably be expected to do so; or
(2) Interferes with clear and effective speech communication.
(c) No disease or condition manifested by, or that may reasonably be expected to be manifested by, vertigo or a disturbance of equilibrium.

Figure 1. FAR 67.305 on 3rd class medical certificate hearing requirements (Code of Federal Regulations, 2017q).

§67.205 Ear, nose, throat, and equilibrium.

Ear, nose, throat, and equilibrium standards for a second-class airman medical certificate are:
(a) The person shall demonstrate acceptable hearing by at least one of the following tests:
(1) Demonstrate an ability to hear an average conversational voice in a quiet room, using both ears, at a distance of 6 feet from the examiner, with the back turned to the examiner.
(2) Demonstrate an acceptable understanding of speech as determined by audiometric speech discrimination testing to a score of at least 70 percent obtained in one ear or in a sound field environment.
(3) Provide acceptable results of pure tone audiometric testing of unaided hearing acuity according to the following table of worst acceptable thresholds, using the calibration standards of the American National Standards Institute, 1969:

Frequency (Hz)	500 Hz	1000 Hz	2000 Hz	3000 Hz
Better ear (Db)	35	30	30	40
Poorer ear (Db)	35	50	50	60

(b) No disease or condition of the middle or internal ear, nose, oral cavity, pharynx, or larynx that—
(1) Interferes with, or is aggravated by, flying or may reasonably be expected to do so; or
(2) Interferes with, or may reasonably be expected to interfere with, clear and effective speech communication.
(c) No disease or condition manifested by, or that may reasonably be expected to be manifested by, vertigo or a disturbance of equilibrium.

Figure 2. FAR 67.205 on 2nd class medical certificate hearing requirements (Code of Federal Regulations, 2017p).

§67.105 Ear, nose, throat, and equilibrium.

Ear, nose, throat, and equilibrium standards for a first-class airman medical certificate are:

(a) The person shall demonstrate acceptable hearing by at least one of the following tests:

(1) Demonstrate an ability to hear an average conversational voice in a quiet room, using both ears, at a distance of 6 feet from the examiner, with the back turned to the examiner.

(2) Demonstrate an acceptable understanding of speech as determined by audiometric speech discrimination testing to a score of at least 70 percent obtained in one ear or in a sound field environment.

(3) Provide acceptable results of pure tone audiometric testing of unaided hearing acuity according to the following table of worst acceptable thresholds, using the calibration standards of the American National Standards Institute, 1969 (11 West 42d Street, New York, NY 10036):

Frequency (Hz)	500 Hz	1000 Hz	2000 Hz	3000 Hz
Better ear (Db)	35	30	30	40
Poorer ear (Db)	35	50	50	60

(b) No disease or condition of the middle or internal ear, nose, oral cavity, pharynx, or larynx that—

(1) Interferes with, or is aggravated by, flying or may reasonably be expected to do so; or

(2) Interferes with, or may reasonably be expected to interfere with, clear and effective speech communication.

(c) No disease or condition manifested by, or that may reasonably be expected to be manifested by, vertigo or a disturbance of equilibrium.

Figure 3. FAR 67.105 on 1st class medical certificate hearing requirements (Code of Federal Regulations, 2017o).

Most words in the three different class requirements above are the same with no significant differences in meaning. The charts of acceptable results in frequency through audiometric testing from those three classes are exactly the same. This demonstrates that if a deaf pilot can obtain a 3rd class medical certificate with known deafness, deaf pilots can also obtain 2nd and 1st class medical certificates assuming the deaf pilot meets the other health requirements in those classes.

Deaf Pilots' Current Communication Methods

Currently, the primary communication method used between Deaf pilots and air traffic controllers is the light signal method. Deaf pilots also have other methods that can be used, such as texting or having another person in the aircraft take care of the radio communication, as mentioned by the Deaf Pilots Association (Deaf Pilots Association, Inc., 2017c). There are some research studies, including mine, that focus on communication for Deaf pilot specifically in improving air traffic control communication.

Since the light signals method is commonly used for Deaf pilots and hearing pilots with radio issues, the procedure for using this method is explained in the FAA's Aeronautical Information Manual (AIM) Chapter 4 Section 2.13. The procedure for the pilot when the aircraft's transmitter and receiver are inoperative, or when Deaf pilots do not use radio, is to stay outside or fly above the Class D airspace, or any controlled airspace, to observe the direction for landing and traffic flow before joining the airport

traffic pattern and watch for light signals from the tower (U.S. Department of Transportation: Federal Aviation Administration, 2015). The AIM added that the pilot should acknowledge the light signals from the ATC by rocking the airplane wings, or at night by flashing the landing or navigation light. The AIM does not, however, have any specific section to guide Deaf pilots in communication. Different ATCs have different modifications for the procedure under the light signal communication method for Deaf pilots. The goal of this research is to find other communication methods and procedures used by Deaf pilots, and share the data. Also, a part of my overall research is to create new ones by combining different methods into one strong communication method that Deaf pilots and air traffic controllers can use to communicate to each other in a way that is easier, more effective, and safer for all.

FAA NextGen Data Communications

The Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) has some new technology programs, and one of those is the Data Communications (Data Comm). The Data Comm is a text-based system where the pilots and air traffic controllers will communicate by sending digital messages that show up on the monitor in the cockpit and in the air traffic control tower cab that the receivers can view and press a button to reply for confirmation while the pilot can also press again a different button to enter the instructions from ATC into the flight management system (Federal Aviation Administration, 2016). According to Professional Services Close – Up, "DCIS will enable real-time communication among controllers and flight crews through modern digital data transmissions instead of outdated analog voice technology" (ITT Exelis taps pursuit team to build FAA's NextGen Data Communications system, 2012). Data Communications increases efficiency, capability, and safety (Federal Aviation Administration, 2016).

The FAA authorized $150 million to Harris Corporation to work on seven-year Data Communications Network Services (DCNS), an element of the FAA NextGen Data Communications Integrated Services (DCIS) program (Business Wire, 2013). In the article, *Harris Corporation Awarded $150 Million Contract for FAA's NextGen Data Communications Program*, Harris Government Communications Systems' Vice President

of Civil Business Unit NextGen Programs, John O'Sullivan, is quoted, "DCNS is a critical next step in advancing the nation's aviation system into the digital era" (Business Wire, 2013). The FAA currently uses the radio system as a mode of communication for air traffic control, which is an analog voice communication, but soon Data Communications will turn analog voice communication into digital data connectivity (Business Wire, 2013). United Airlines was the first airline to commit in equipping digital avionics into the airlines' aircraft under the FAA's NextGen Data Comm Equipage Incentive Program (Harris corporation; Harris corporation announces United airlines is first carrier to join the FAA NextGen Data Communications Avionics Equipage Program, 2013). UPS, FedEx, Scandinavian Airlines, and British Airways are the other airlines that participate in the FAA NextGen Data Communications trials (Federal Aviation Administration, 2016).

Harris Corporation is an international company on communications and information technology for government and commercial business. The Deaf Pilots Association President Robert Rademacher had told me that he tried to contact Harris to obtain a Data Comm for us to understand how Data Comm will improve the communications between Deaf pilots and ATC (Rademacher, 2016). However, President Rademacher received no luck that Harris tried to keep their product behind for probably a security reason and for high-end users such as airlines. The Data Comm seems to be a Deaf-friendly technology communication tool, because it is a text-based system without the need to speak verbally or hear to communicate. My research is to analyze more on the Data Comm and how it will help Deaf pilots to communicate easier with air traffic controllers, but may not be discussed much in this thesis, as it would be in my future doctoral dissertation.

Air Traffic Control Communications System

The Across Testbed for Future Aeronautical Data Communications article discussed the time and reliability of quality of communication to deliver from one user to the other through the Federal Aviation Administration (FAA) Next Generation Air Transportation System (NextGen) Data Communications (Data Comm) (Depoorter, Raissouni, Garriga, & Lucke, 2016). The FAA NextGen Data Communications would

soon replace the radio system for communication between pilots and air traffic controllers with a goal to increase capability, efficiency, and safety of flight. It explicated the details of what layers/systems the data goes through. The test that was performed shows that transaction time and continuity are improved when using multi-link erasure coding.

The article researched the reliability of data transfer timing from the FAA NextGen's Data Communications program between aircraft and ground to ensure CPM is met using the available air-ground links. The framework is the Required Communication Performance (RCP) metric, which International Civil Aviation Organization (ICAO) defined that it provides quality of service to aeronautical data communications. It measured reliability of transaction time, continuity, integrity, and availability (Depoorter, Raissouni, Garriga, & Lucke, 2016). Communication Performance Manager (CPM) is the important part of the ACROSS testbed for future aeronautical data communications. A transaction is defined as any information sent from one device to another. Should an air traffic controller deliver a clearance, he/she initiates the data through the ATSU system, CSP system, aircraft system, and eventually reaching a flight crew. Then the flight crew acknowledges the clearance, and the data goes the opposite direction through the systems.

The ACROSS testbed performed validation tests to analyze data of required, expected, and actual transaction time and continuity. ACROSS testbed validation performance tests show the values of aeronautical services transaction time and continuity improved by the use of multi-link erasure coding. The CRM's limitation to provide higher performance are the air ground links characteristics availability. This article helps me better understand the communication system and the systems of the Data Communications for my research. Even though the article does not explain what methods to increase communications between Deaf pilots and air traffic controllers, this would be an opportunity for future research to figure out how another system can integrate with the Data Communications to make communication better for Deaf pilots to use.

Americans with Disabilities Act (ADA)

Senator Tom Harkin: Reflections on Disability Policy by William P. McCrone (1990) is about Senator Tom Harkin and the Americans with Disabilities Act (ADA). The author had met the senator. Senator Harkin of Iowa has a Deaf brother named Frank, who

taught him American Sign Language (ASL). At Gallaudet University, Senator Harkin presented an inaugural speech for the first Deaf President of Gallaudet University, I. King Jordan. In his speech, Senator Harkin said, "Together we will not rest until every vestige of discrimination against Americans with disabilities is removed from our society and every citizen with a disability is accorded the respect and dignity he or she deserves" (McCrone, 1990, p. 8). The Americans with Disabilities Act was passed in 1989 under Senator Harkin's leadership. He is well respected by Deaf Americans. Senator Harkin told author McCrone that the founders of the United States of America founders declared that all Americans are created equal. That is a simple message where everyone is equal, including, but not limited to, races, gender, sexual orientation, age, size, class status and people with disabilities. Although the Civil Rights Act of 1964 was created, that law does not protect a qualified person with disability from a discrimination for employment (McCrone, 1990). McCrone justified the ADA protects people with disabilities by requiring a business with more than 15 employees to provide a "reasonable accommodation" for current and future employees with disabilities as long as it does not cause an "undue hardship" for the business. The ADA helps open up employment opportunities for Americans with disabilities. The article explains to non-disabled Americans that the ADA is intended to allow disabled Americans to become the taxpayers, as Senator Harkin noted, which helps reduce the spending of billions of dollars in the Federal funds on benefits and programs for Americans with disabilities (McCrone, 1990). Deaf people have the right to equal employment and full communication access. Therefore, Glynn Falcon, my former aviation professor during my undergraduate school at San Jose State University, who is also an aviation lawyer, a pilot, and a businessman, told me that Deaf pilots can become an Airline Transportation Pilot under the ADA. Therefore, the FAA and airlines must provide "reasonable accommodation" of communication available to Deaf pilots.

Federal Communications Commission (FCC)

As the Americans with Disabilities Act (ADA) requires "reasonable accommodation" such as communication access, the United States Congress put the Federal Communications Commission (FCC) in charge to fulfill the ADA requirements

in providing the telecommunication services for Deaf and hard of hearing Americans (Internet Wire, 2013). The *Sorenson Communications Congratulates New FAA Commissioners, Calls for Focus on Needs of Deaf and Hard-of-Hearing* article (2013) mentioned Sorenson Communications congratulated the FCC Chairman and Commissioner on their confirmations from the Senate and urged them to ensure that the FCC be more responsive to the deaf and hard-of hearing communities' needs. Sorenson Communications is one of the leading video relay services (VRS) providers that allows Deaf users to call anyone. Directly if calling other Deaf users or with an American Sign Language interpreter if calling a hearing person, through video phone.

The video phone call between Deaf pilots and air traffic controllers may be better than the use of radio communication. However, the signal strength on the phone while in flight may be of concern for a clear quality video phone call. Nonetheless, the FCC may need to be part of my research in finding an appropriate communication between Deaf pilots and air traffic controllers as part of ADA law.

Summary

This literature review chapter has detailed to literature under the topics related to communication methods between Deaf pilots and air traffic controllers. It has introduced Deaf pilots and people, their culture, communication methods used by Deaf pilots, the laws related to Deaf people or communication access for Deaf people, and the communication systems under the FAA. This chapter covered the available sources related to this research on finding existing air traffic control communication methods. However, the lack of sources specifically about Deaf pilots or their communication method is an opportunity to explore some communication methods for Deaf pilots to use that will be shared publicly to increase the communication between Deaf pilots and the ATC. The increase in air traffic control communication for Deaf pilots helps advance their career into professional flight and for Deaf people to become general aviation pilots easier.

CHAPTER 3: METHODOLOGY

The purpose of this research was to explore any air traffic control communication methods being used by Deaf pilots and to analyze these methods. It was an attempt to identify the communication methods that Deaf pilots use, improve the methods, and present the findings that Deaf pilots and air traffic controllers can use to communicate with each other as described in Chapter 1. Due to the study of identifying and improving the quality of communication, a qualitative approach suits this research.

This chapter provides the overview of the discussion of the research question, the research type, the framework of this research, the methodology, the population, the sampling approach, the sampling size, the unit of measurement, and the assessment instruments. It also includes the data sources, data collection methods, data analysis procedure, trustworthiness, and research bias.

Research Question

The research question for this thesis is, "What are the existing communication methods between air traffic control and Deaf pilots?" The most common communication method used by Deaf pilots and air traffic controllers is the light signals when operating in a controlled airspace. The light signal methods is a one-way communication with an acknowledging reply by means of a signal of rocking aircraft wings or flashing landing or navigation lights. This research seeks new communication methods that will improve ATC communication for Deaf pilots and air traffic controllers to use.

Research Type

The availability of research on Deaf pilots' communication with the air traffic control is limited. I explored this area to understand some communication methods that would be useful for Deaf pilots. The research type for the communications improvement was human subject-oriented. This exploratory study, which can discover a good communication method for Deaf pilots and air traffic controllers to communicate with

each other, was classified as a use-inspired basic research study. The goal of this research was to develop new knowledge and processes that will improve communication.

Framework

The framework of this thesis focused on a qualitative approach to increase the quality of Deaf pilots' and air traffic controllers' ATC communications by finding the existing communication methods that may be the best to use. To explore the communication methods, I interviewed Deaf pilots on what communication methods they used, their suggestions, and their desires for how communication could be improved. After the data collection from the interviews, I analyzed communication methods that may be useful for Deaf pilots to communicate with ATC before making a recommendation for the Federal Aviation Administration and the Deaf pilots.

Methodology

The research question was to explore the existing communication methods used by Deaf pilots and the ATC that can increase effectiveness, efficiency, and safety along with creating more opportunities for Deaf pilots. This chapter discusses the methods of the research, including identifying the type of the research, considering which data to collect, developing questions for Deaf pilots, interviewing them, collecting and analyzing the data, and concluding with a recommendation. The recommendation will be drawn from understanding the new primary sources of data and presenting the sources for everyone to recognize the communication methods that Deaf pilots and air traffic control can use.

Population

The Deaf Pilots Association has about 30 members, including myself. The number of Deaf pilots that exist in the United States and in the rest of the world is not readily available. It is possible that there are about 50 active Deaf pilots in the world, mainly in the United States of America.

Sampling Approach

Some Deaf pilots were interviewed for this research. I interviewed those people from the Deaf Pilots Association, my Deaf pilot friends, some Deaf pilots whose names were made available in the news, and myself. The sampling approach was a mixture of simple random, convenience, judgment, quota, and extreme/deviant case sampling. The simple random sampling approach was done by randomly picking some Deaf pilots in the Deaf Pilots Association. Convenience sampling happened when finding Deaf pilots in the DPA easily along with knowing some Deaf pilot friends to sample for this research; it was difficult to find Deaf pilots in the general population. Some Deaf pilots are knowledgeable about new communication methods – which means they have high valuable data for this research and thus judgment sampling happened. The other sampling approach was quota sampling, by focusing more on Deaf individuals with private pilot certificates or higher that have more experiences and knowledge than Deaf individuals with student pilot certificates that have little to no experience in communication with the ATC. Lastly, I used extreme/deviant case sampling, where I sought information from a few Deaf pilots with an instrument and/or multi-engine rating, a commercial pilot certificate, or an Airline Transport Pilot certificate - higher than what Deaf pilots tend to earn, which is a private pilot certificate. These sampling approaches allowed for the discovery of unknown communication methods they may have been using, along with their knowledgeable suggestions and desires for a better communication.

Sample Size

The number of interviewees I was to contact were about 15 Deaf pilots in the United States, and possibly a few Deaf pilots from other countries in order to gain new perspective and different experience when possible in signing in a different language. If needed, a questionnaire was to be used to survey deaf or hard of hearing pilots who did not know American Sign Language well or a difficult to use video call. Overall, this was about 15 Deaf pilots in total when including myself as a Deaf pilot in the U.S.A.

Unit of Measurement

All Deaf pilots may have different experiences in communication; it is wise to separate them into groups based on similar pilot experiences. Nominal/Categorical scale is best used to categorize three different Deaf pilot groups: Deaf student, sport, and recreational pilots; Deaf private pilots; and Deaf commercial and Airline Transport pilots as well as Deaf pilots with instrument and/or multi-engine ratings. The nominal scale may help with the explanation of a Deaf pilot's communication method due to his/her pilot level that may be similar with other Deaf pilots in the group.

Assessment Instruments

The interview questions were mostly about the biography of the Deaf pilots. This allowed me to see the quality of communication methods a Deaf pilot may use. The interview also discovered phenomenology by understanding their experience with a communication method that they select. The author of *Interviewing as Qualitative Research*, Irving Seidman, explained the purpose of interviewing, "An interest in understanding the lived experience of other people and the meaning they make of that experience." (Seidman, 2013, p. 9). Learning the stories of interviewees' experiences was a way to know more about their communication methods (Seidman, 2013, p. 7). The experiences may be both positive and negative. A positive experience with a communication method would allow me to consider keeping the method, while a negative experience would need to be analyzed to then seek a solution. The interviews revealed the types and repeatable communication methods used by Deaf pilots. The type of communication method that was the most repetitive was considered the most used by Deaf pilots in general and became a reliable source in this research. Interviewing about 15 Deaf pilots was a significant representation for about an assumed 50 Deaf pilots in the United States. Due to the large number of sample size, it improved the content validity in this research.

Data Sources

This research includes both primary data and secondary data. Primary data was obtained by interviewing Deaf pilots directly in person or through video call using the first or primary language of Deaf Americans - American Sign Language. The secondary data was obtained by researching some appropriate communication methods suggested by Deaf pilots for Deaf pilots and air traffic controllers to use.

Data Collection Methods

The data collection method was the interviews by asking Deaf pilots through video call or in-person. Deaf pilots in the United States are the focus for this thesis. Other countries may have different aviation laws than the United States', possibly making it difficult to propose a solution for U.S. Deaf pilots and the FAA. The interviews with Deaf pilots across the United States were best done through one of some means of a video call: video phone, FaceTime, and Skype. In-person interviews were done when possible. The use of American Sign Language when interviewing other Deaf pilots was the best method for the least amount of misunderstanding, in contrast to using English, their secondary language, in questionnaires. The advantages were such that I could clarify any questions a Deaf pilot might have during the interview process, and to expand the dialogue to a discussion that will help me explore new information. The disadvantages were the large amount of time needed to interview certain Deaf pilots and possible scheduling conflicts. Nonetheless, good quality data collected from the Deaf pilots is highly valuable.

Questionnaires, a data collection method, were considered, but due to the language difference, interviews were best done with American Sign Language. While interviewing was the primary method in the data collection, questionnaires were available for the pilots who could not do the interview. To improve reliability of answers through interviews, similar to what would be done in the questionnaires, the type of questions used were both open-ended questions and closed questions to increase the reliability of answers when asking the same question twice in a different way. The questions were also both positively and negatively worded for the same purpose - to increase the reliability of

the answers by ensuring the interviewees understood the questions when noticing the answers were different. The interview was mainly the structured interviews to ensure the same questions were asked and collect all answers needed while a little bit of the unstructured interviews was an opportunity to explore and collect unexpectedly good data. The interview was comprised of two sections: Part 1 and Part 2. Part 1 in the interview was mostly about learning the background of the pilots. If I discovered the interviewee only used radio communication to communicate with ATC like hearing pilots can do, Part 2 was not used. Otherwise, Part 2 was used to explore the interviewee's communication method other than radio as well as their suggestions for a better communication method for Deaf pilots. While the number of Deaf pilots is not large, and there was a lack of Deaf pilots nearby to work with, I was the only interviewer to collect the data. During the interviews, I took notes and recorded video when possible to prevent losing the answers.

Data Analysis Procedure

During the interviews, I took notes of the answers given by the Deaf pilots, and recorded videos in American Sign Language, which were collected for qualitative data analysis. The interviews that completed both parts were researched in this thesis while the interviews that completed only Part 1 could have been stored for possible future research. I tried my best to translate the completed two-part interviews from American Sign Language to English into transcripts. This was time-consuming and the use of a service or software can be costly (Seidman, 2013, p. 118). It was likely I was the one that did the work to ensure the best quality of data due to an inability of a general service or software to translate aviation lingo in American Sign Language into a transcript in English. I can always go back to the recorded video for accuracy in original data if something in a transcript is not clear (Seidman, 2013, p. 117).

In terms of categorization, the qualitative data had three categories: "The Most Common ATC Communication Methods", "Useful ATC Communication Methods", and "Unknown ATC Communication Methods". The category titled "The Most Common ATC Communication Methods" can be like the light gun signals and any method that Deaf pilots tend to use. This category would be studied less intensively if these methods

were already very familiar to most pilots, but still could be used to factualize which methods Deaf pilots tend to use. The "Useful ATC Communication Methods" category included communication methods that Deaf pilots and I felt are useful and will be analyzed in the future to seek for improvements in communication and work to make it a standard for all. The "Unknown ATC Communication Methods" category included communication methods that I and most Deaf pilots were not familiar with and will be studied to see how these methods may help with the communication for Deaf pilots.

The communication methods used by Deaf pilots in the data was compared to the Deaf Pilots Association's information in order to find any new communication methods that the general population may not have heard of. In addition, the popular current communication method by Deaf pilots and their suggestions for a better communication method can be analyzed to aid in the process of creating one standard communication method for Deaf pilots and ATC as part of my overall research. Not only that, the exploration and the creation of other communication methods suggested by Deaf pilots may integrate into one great communication method for them. Communication methods used by Deaf pilots were assessed for the quality of communication and development a better communication method to be shared to raise awareness of it. Thus, analytic induction was the method to gather and analyze qualitative data to understand why a Deaf pilot used or suggested a particular communication method, as well as to explain the reliability of that particular communication method. This research determines if there is a communication method that is better than the current light gun signals method often used for Deaf pilots.

Trustworthiness

The data that was collected is trustworthy mainly due to its being collected from a primary source – directly from the Deaf pilots themselves, who were sharing their own personal experiences and opinions. Furthermore, due to my being a Deaf pilot myself, I was able to understand the population I was interviewing better than the general public, due to my shared fluency in both American Sign Language and aviation lingo. This ability to understand the data I collected reduces any chance of misunderstanding or misusing it.

Researcher Bias

I am a Deaf pilot that has earned the FAA's student, sport, and private pilot certificates; 3rd, 2nd, and 1st class airman medical certificates; a university cum laude award with a Bachelor of Science degree in aviation and a minor in business; and am currently an aviation graduate student wanting to become a professional pilot. Thus, I may have a higher knowledge in the fields of aviation and piloting than the average Deaf pilot in the United States. I may have a bias stemming from my search for more information about new communication methods, especially the FAA NextGen Data Communications, which would increase the effectiveness of communication between air traffic controllers and Deaf pilots. This search may result in an expansion of data for collection. If necessary, I discuss communication methods and the reasons or issues of that method that a Deaf pilot may not know which it may change his/her opinions or bring him/her new ideas during the interview. However, I was to be sure to only record their messages without adding my own commentary among their data.

Summary

This chapter on methodology detailed the methodology and framework of the research on perceiving the communication methods between Deaf pilots and air traffic control. The next chapter will present the data and findings of the research. Chapter 4 also provides the analysis of the data in finding new communication methods that Deaf pilots may use.

CHAPTER 4: PRESENTATION OF DATA AND FINDINGS

This chapter presents data and findings for this thesis on perceiving the communication methods between Deaf pilots and air traffic control. The overview includes the description of data conditioning and analyses, presentation of the data, and discussion on the data and findings. Then, in the next section, a summary of some key findings that are important to know when discussing the next chapter on conclusions, discussion, and recommendations.

Description of Data Conditioning and Analyses

As described in the last chapter on methodology, this exploratory study is to collect qualitative data about air traffic control communication methods from about 15 Deaf pilots by interviewing them or having them filling out the questionnaire if needed. After about 30 direct contacts with individuals and the post, 17 d/Deaf pilots participated in this thesis research. All of them are from the United States of America from the west coast to the east coast, including California, Texas, and Florida. The pilot grades of those pilots include 3 student pilots, 1 sport pilot, 9 private pilots, and 4 commercial pilots. Some of them have the ratings such as instrument ratings and some of them have the endorsements such as tailwheel endorsement. A few of them have their A&P certificates. This shows there are various of skills that Deaf pilots have.

The Deaf pilots were recruited through email, Facebook message, and the post on Deaf Aviators page on Facebook. Emailing was still under convenience and quota sampling approaches as discussed in Chapter 3. Then contacting through Facebook message was under simple random, judgement, and extreme/deviant case sampling approaches. Lastly, posting on the Facebook page was out of convenience to seek more Deaf pilots to participate in this exploratory study. Some of the pilots replied their willingness to contribute to this research. A few pilots had expressed their support but did not have enough experience in interacting with air traffic control. Out of 50 active Deaf pilots, 17 d/Deaf pilots were interviewed or had filled out questionnaire. Twelve of them did the interview through one of the means of video call; 11 through video phone and one

through Skype. Five of them filled out questionnaire instead of the interview for some reasons including unavailable to be on video phone or not wanting to use video phone. The participants in this research represent about a third of Deaf pilots, a great amount of representation.

Near the end of this chapter, there is a data reduction using categorization of the communication methods to aid in qualitative data analysis on identifying some ATC communication methods to its category. Not only that, there will be some data displays to present the conclusions of qualitative data in charts and tables in this chapter. This research involves conceptual and content analyses. Conceptual analysis is part of this study as it will discover which methods that Deaf pilots tend to use. Content analysis is reserved for secondary data, which I will analyze some additional data besides the interviews/questionnaires. Drawing conclusions of the analytical activity will be discussed in Chapter 5.

A few things to mention here. This research did not collect data from Deaf pilots in foreign countries of the United States due to the time and complication in obtaining Purdue's Institutional Review Board (IRB). Nonetheless, this research is mostly about the air traffic control communication methods in the United States. In addition, all of the participants had completed both sections of interview/questionnaire: Part 1 and Part 2. They were not stopped into Part 2 after Part 1 on background, because I had determined that each of 17 participants were Deaf and did not really use radio as a sole communication method.

Presentation of the Data

The data will have three Deaf pilot groups to be presented as described in the previous chapter on methodology: 1) Deaf student, sport, and recreational pilots, 2) Deaf private pilots, and 3) Deaf commercial and Airline Transport pilots as well as Deaf pilots with instrument and/or multi-engine ratings. These groups can be reflected as Group 1, Group 2, and Group 3 respectively. The presentation will begin with the Part 1 on their background before Part 2 on their communication experiences, ideas, and recommendations. Instead of the names of the participants, 4-digit number is used in this

thesis. Below is a table showing the number of pilots and the number of their identity in each group.

Table 1

Numbers of Deaf Pilots in Each Group

Groups	Total	%	Deaf	deaf	d/Deaf
Deaf student, sport, and recreational pilots	4	23.5	2	1	1
Deaf private pilots	8	47.1	7	0	1
Deaf commercial and Airline Transport pilots as well as Deaf pilots with instrument and/or multi-engine ratings	5	29.4	4	0	1

Part 1

Part 1 of the interview/questionnaire focuses on the background of the pilots before advancing to Part 2. This is like a screening for Part 2 and to better understand about each pilot. Some questions include their deafness, pilot certificates and ratings they have earned, medical certificates they obtained, and whether or not they use radio solely.

Group 1

The first Deaf pilots group of three include pilots who have student, sport, or recreational pilot certificates. There are four pilots in this group who have shared their background and experiences. There may be many Deaf student pilots out there who are still learning to fly and may not have enough experience or yet trained in Class B, C, or D airspace. These four pilots in this group include three student pilots and one sport pilot.

Participant 7204

This pilot is from the United States of America and identified him/herself Deaf. The pilot currently holds a student pilot and third class medical certificates. The

participant mentioned he/she has a limitation like other Deaf pilots, “Not valid for flying where radio use is required.” The Deaf pilot is learning to fly, so he/she can use the next pilot certificate for personal flying. This interviewee answered that he/she does not use radio in air traffic control.

Participant 3702

This pilot is from the United States of America and identified him/herself either deaf or Deaf, d/Deaf. The pilot currently holds a student pilot certificate with over 100 hours of flying in 2017. He/she is also an advanced ground instructor and flies a FAR Part 103 ultralight. He/she answered that he/she does not have a medical certificate, “None needed.” This interviewee is a pilot because he/she loves to fly. When I asked if he/she feels that the radio system is a good communication method to use, his/her response is “Radio is not required outside of Class B, C, and D airspace.”

Participant 8630

This pilot is from the United States of America and identified him/herself deaf as he/she is Hard-of-Hearing. He/she had a student pilot certificate and a second-class airman medical certificate. He/she has the restrictions of wearing glasses and “must wear hearing aids.” When the pilot applied for the medical certificate, he/she was initially denied by the FAA, the pilot explained, “Both my father and I immediately corrected the FAA to fix their error.” The interviewee wanted to be a corporate pilot, and even an airline pilot. When I asked if he/she feels that the radio system is a good communication method to use, his/her response is below showing the radio system is not really good for this deaf pilot:

> This is a two parts answer to your question for the reasons I will state shortly. Yes, the radio system is a good communication tool to use for certain airports that one is familiar with. Unknown airports can be nerve-wracking for student pilots, and communications tend to fall apart due to confusion on both ends. The "No" is largely because of the high volumes of radio chatter involved. There are times when controllers and pilots tend to carry on an unnecessary conversation, and it is

> very distracting. I guess you could call me a pilot that wants things simple and concise rather than the long-winded transmissions that can cause problems for other pilots that may need to report an emergency.

Participant 7267

This pilot is from the United States of America and identified him/herself Deaf. He/she has a sport pilot certificate with no rating, limitation, or restriction. He/she does not have a medical certificate. The Deaf sport pilot flies for hobby, but he/she has a long-term goal of becoming a commercial pilot. The pilot does not use radio, but he/she explained that he/she calls air traffic control through video phone to explain his/her plan of flying from one destination to the other. More information is in Part 2.

Group 2

The second Deaf pilots group of three include pilots who have private pilot certificates. There are eight pilots in this group who have shared their background and experiences. There may be many more Deaf private pilots out there who are satisfied with their pilot certificates, may think they cannot advance higher pilot certificate grade, or are working on advancing one. I have mentioned there are nine private pilots in this research, one of them has an instrument rating, therefore he/she is in the next group along with pilots with commercial pilot certificates.

Participant 1145

This pilot is from the United States of America and identified him/herself Deaf. He/she has generations in the family that attended Texas School for the Deaf, and he/she had attended a school for the Deaf. So, the pilot feels he/she is culturally Deaf. This Deaf pilot has a private pilot certificate with an airline single engine land (ASEL) rating. The private pilot has a third-class airman medical certificate and the limitations on the certificate are “Must wear corrective lenses” and “Not valid for flying where radio use is required.” The participant flies for recreational. When I asked if he/she feels that the radio system is a good communication method to use, he/she answered yes and no with

explanations. For yes, it is because it helps the pilot to hear what is going on around in the traffic, but that does not mean he/she understands the radio conversation. He/she can speak vocally, but it is a one-way communication as the Deaf pilot does not understand the radio communication audibly. The problem is when he/she speaks vocally, it sets a false expectation for hearing pilots or air traffic controllers that if he/she can speak vocally, he/she can understand others that they replied back to him/her even if he/she informed others that he/she is Deaf.

Participant 1177

This pilot is from the United States of America and identified him/herself Deaf, born deaf. He/she has a private pilot certificate with the limitation of "Not valid for flights requiring the use of radio." The Deaf pilot has a third-class airman medical certificate with the limitations of "Must have available glasses for near vision." and "Not valid for flying where radio use is required." The participant answered his/her reason for being a pilot that when he/she was younger, he/she thought of wanting to be in the air force, but realized that he/she is Deaf and cannot be in because of military regulation issue on deafness. So, he/she shifted his/her focus flying as a hobby, not a professional pilot. When I asked about radio question, the interviewee answered that he/she cannot use radio, because he/she is Deaf, and said radio is worthless to him/her.

Participant 4262

This pilot is from the United States of America and identified him/herself Deaf, being deaf since two. He/she has a private pilot certificate with an ASEL rating. He/she is currently working on earning a multi-engine rating. The Deaf pilot has a third-class airman medical certificate. The participant said it was hard growing up trying to fly, but he/she decided to earn a private pilot certificate and earned it! The private pilot explained that there is a technology soon that allows Deaf pilots to become a professional pilot; his/her goal will be to become a professional pilot. When I asked the pilot about radio, the interviewee answered "No, I think it needs to be updated. Europe has a better technology that we need to keep up with other part of the world; better technology."

Participant 6150

This pilot is from the United States of America and identified him/herself Deaf. He/she is culturally Deaf and uses American Sign Language (ASL). He/she has a private pilot certificate with an ASEL rating. He/she is currently working on earning an instrument rating, and will work on higher pilot certificates and ratings after that. The limitations are "English proficient" and "May not serve as a pilot in command or a required pilot crewmember for flights requiring the use of radio communications." The private pilot has a first-class airman medical certificate with a limitation of "Not valid for flying where radio use is required." His/her reason for becoming a pilot is to fly for fun and to be a professional pilot. This Deaf pilot wants to be an Airline Transport Pilot. When I asked if this pilot feels that the radio system is a good communication method to use, the pilot answered, "No, I cannot understand vocal instructions from air traffic controllers nor being able to vocal speak clearly."

Participant 9214

This pilot is from the United States of America and identified him/herself Deaf. He/she grew up oralism and later found out he/she is deaf. This individual later learned to sign after so much frustration in communication and became involved in the Deaf community. The Deaf person has a private pilot certificate with a limitation of "Not valid for flights requiring use of two way radio." He/she also has endorsements for high performance, complex, and tailwheel. This private pilot has a second-class airman medical certificate with a limitation of "Not valid for flying where radio use is required." The Deaf pilot is also a ground instructor, advanced, and an instrument ground instructor. This pilot is working on earning an A&P (Airframe and Powerplant) mechanic certificate. His/her reasons for being a pilot are for fun, explore, travel, recreational, and challenges. When I asked about radio communication, he/she thought that for those who are able to use radio communication is fine. However, he/she explained that in some way that he/she does not think so, because the radio communication can have issues such as accent, hard to understand, repetitive, extra time, and not very accessible for hard of

hearing or Deaf people. He/she wondered if radio communication is still a good method to use for people who are older who lose hearing over time.

Participant 8265

This pilot is from the United States of America and identified him/herself Deaf, the 4th generation Deaf. He/she is the first Deaf pilot in the family. That person has a private pilot certificate, and he/she has many courses that he/she has not completed yet such as multi-engine rating course. The Deaf private pilot has flown in many different aircraft such as glider, trike, helicopter, seaplane, multi-engine airplane, turbine engine aircraft, and even Boeing 707. The limitation on the pilot certificate is "Not valid for flights requiring the use of radio." This individual has a third-class airman medical certificate with limitations of "Not valid for flying where radio use is required." and "Must wear corrective lenses for distant vision and have glasses for near vision." His/her reason for being a pilot was due to that he/she majored in pilot, but after seeing many barriers in the past, he/she ended up building aircraft. Yet, he/she has many flight hours and is almost done for commercial pilot certificate. As for the radio question that I asked, the Deaf pilot saw it works fine when having hearing pilot taking care of radio communication. He/she cannot hear the communication, but he/she has seen that hearing people complained that radio system has problems like statics noise. The pilot said the radio system is 1950's, so it is an old system. He/she added that the radio is worthless to him/her.

Participant 8185

This pilot is from the United States of America and profound deaf, but can hear loud noise and speak fairly well. He/she has a private pilot certificate and is in process of earning tailwheel endorsement, seaplane rating, and multi-engine rating. The one limitation is "Not valid for flights requiring the use of radio." The private pilot obtained a third-class airman medical certificate with a limitation of "Not valid for flying where radio use is required." This pilot flies for business as he/she owns five companies that the owner flies to see his/her customers. He/she does not use radio, but he/she is working on using radio to use his/her technology. This pilot is an electrical engineer. So, this works

by connecting the hardware he/she designed to the radio, and his/her app will connect to his/her call center that his/her employees there will translate voice to text and the engineer can text back where the employees will then speak vocally on radio.

Participant 7258

This pilot is from the United States of America and identified him/herself Deaf. He/she cannot hear on phone, television, or aircraft radios. He/she has a private pilot and airframe and powerplant mechanic certificates. He/she obtained a third-class airman medical certificate with a limitation stating, "Not valid for flights where radio use is required." The private pilot likes to fly for fun; no desire to be a commercial pilot or Airline Transport Pilot. The Deaf pilot said he/she does not really use the radio, but is able to speak well that he/she gives position reports.

Group 3

The third Deaf pilots group of the three include pilots who have commercial or Airline Transport pilot certificates as well as pilots with instrument and/or multi-engine ratings. There are five pilots in this group who have shared their background and experiences. There may not be many Deaf commercial pilots out there and I am fortunate to have these pilots participating in this research. I believe there is no Deaf Airline Transport Pilot yet; none of the five participants is an ATP. These pilots are sure to have a lot of experiences as pilots due to the minimum total flight hours requirement for a certificate or rating; 250 flight hours for commercial pilot certificate and 50 hours of cross-country flight as a pilot in command and 40 hours of instrument time for instrument rating (Code of Federal Regulations, 2018).

Participant 3164

This pilot is from the United States of America and identified him/herself Deaf. He/she is a private pilot with an instrument rating. He/she currently focuses on aerobatic and has a tailwheel endorsement. The limitation he/she has for instrument rating is that he/she can only fly with a hearing pilot who is instrument rated. This aerobatic pilot has a second-class airman medical certificate with the limitations of wearing lenses and hearing

aids as well as “not valid for flying where radio use is required.” This Deaf pilot is not looking to be a professional pilot, “Just recreational, more independent, freedom, and boosting self-esteem,” said the pilot. When I asked about radio, he/she said he/she can talk on radio, but does not understand it. The interviewee added that he/she is really good on communicating through radio and people can understand him/her well, but he/she cannot understand the sounded words. This Deaf pilot can hear the traffic, but not what they said as it does not have a speech discrimination. He/she said that the radio is good for hearing pilots, but not for Deaf.

Participant 3941

This pilot is from the United States of America and identified him/herself Deaf. He/she loves Deaf community and uses ASL as his/her language, and can communicate with hearing people by writing back or forth or trying vocal language. This Deaf pilot has a commercial pilot certificate and is about to have a checkride for a multi-engine rating. The limitation is that he/she must use glasses and cannot fly where radio use is required. He/she obtained a second-class airman medical certificate with a Statement of Demonstrated Ability (SODA). The limitations are the same on his/her pilot certificate. He/she does not want to be an ATP, but thought of a small pilot job such as flying around forest, for the Department of Natural Resources, or small cargo flying. The Deaf commercial pilot answered about the radio, “Radio system for me is no good, because I am deaf.”

Participant 2656

This pilot is from the United States of America and identified him/herself Deaf. He/she has earned a private pilot and commercial pilot certificates. He/she is currently studying for instrument rating, multi-engine rating, and others afterward. The limitations for his/her commercial pilot certificate are 50 miles radius and night flying, but the limitations will be removed once earning an instrument rating. He/she has a third-class airman medical certificate. I followed up how he/she earned a commercial pilot certificate if he/she holds less than a second-class airman medical certificate. The interviewee explained that it is separate from a commercial pilot practical test. The

limitation on the medical certificate is “Not valid for flying where radio use is required.” The Deaf person wants to be an ATP where he/she can fly a passenger airliner. When I asked about radio, the commercial pilot said it is hard to use and has to use someone interpreting the radio communication sometimes.

Participant 9296

This pilot is from the United States of America. He/she is d/Deaf, he/she uses hearing aid that he/she can hear ok, but not perfect. The pilot earned a commercial pilot certificate with a single engine land rating. He/she also has a private pilot certificate with a multi-engine land. Additionally, he/she is a ground instructor advanced with instrument (CGII). He/she is working on an instrument airplane rating and CFI-S/CFI-A. The commercial pilot has a current second-class airman medical certificate with a limitation of “Not valid for flights requiring the use of radios.” I asked this pilot what is his/her purpose for being a pilot, he/she answered “At first, was just for pleasure and a personal dream since childhood. Then, decided a commercial rating, why not, to get paid for something I love to do. Teaching is the next thing!” Then, I asked if a radio is a good communication method to use, interviewee’s answer is below:

> Radio is the “preferred” method to use, and “yes” I use it if I have accompaniment with a hearing crewmember to help relay the said ATC messages to myself. Radio is the communication I use and what we should all use regardless of your hearing situation. Safety is paramount, and voice messaging is quick and gets the message out there on the fly.

Participant 5890

This pilot is from the United States of America and identified him/herself Deaf, born deaf. He/she earned a student pilot, private pilot, private pilot with multi-engine rating, commercial pilot with a single engine, and commercial pilot with multi-engine rating certificates. The limitation the commercial pilot has is 50 miles radius and night flying until earning an instrument rating. The other limitations are having to use hearing

aids and glasses as well as the standard limitation of no flying where radio use is required." The Deaf commercial pilot with multi-engine rating has a second-class airman medical certificate. He/she wants to have an ATP certificate in the future, he/she needs more hours for that. When I asked about radio, the interviewee said he/she does not use radio communication as he/she does not speak on radio, but uses aviation headset to hear VOR beeping sounds as well as some sounds in aircraft such as warning horns.

Radio question

The chart below shows whether or not the participants use radio to communicate with air traffic controllers. The chart shows that no one answered yes completely that they use radio. All participants are d/Deaf pilots and they do not use radio solely to communicate with ATC. There are five participants that answered yes and no. Some of them explained that they use radio to speak vocally on their side, but not hear from other side; others use it to hear the traffic, but that does not mean they understand the messages, and some use it with the help of a hearing pilot. Lastly, 12 participants answered no to the question, because some of them do not hear the radio conversation and others do not understand the vocal messages on radio. 71% of the participants do not use radio at all, while 29% of them may use it sometimes.

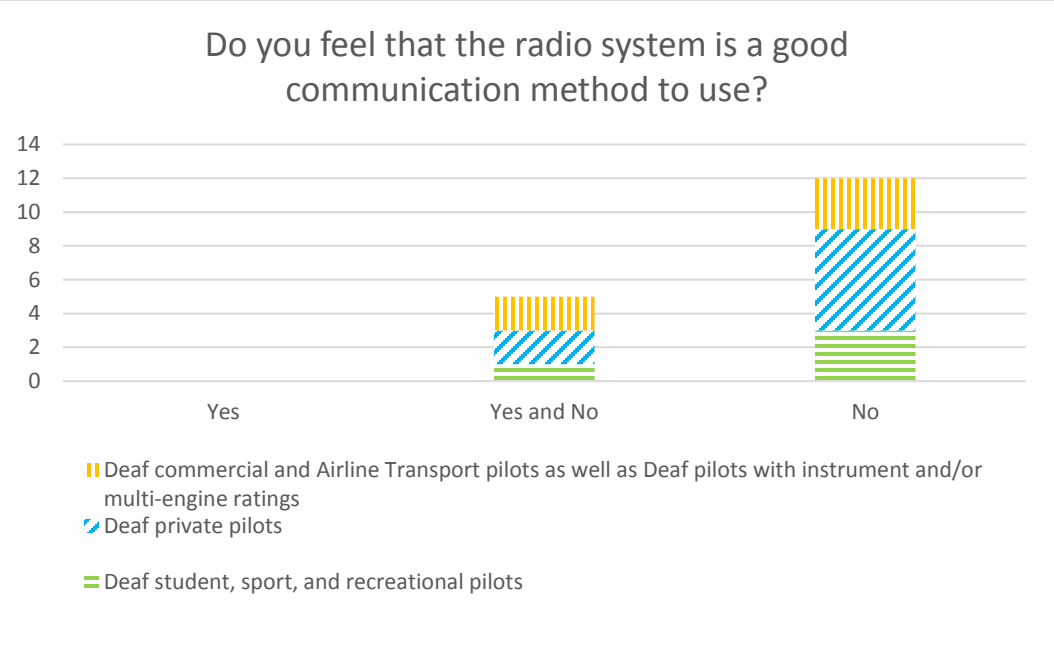

Figure 4. Stacked column chart related to the question on radio.

Part 2

Part 2 of the interview/questionnaire focuses on air traffic control communication methods between Deaf pilots and air traffic control. This is to explore more communication methods and experiences that have not shown in research elsewhere and to better understand on how to improve the communication for future researches. This is also the part where it can help spread awareness for other d/Deaf pilots and air traffic controllers on how to work and communicate together. Some questions in this part, which are questions from 8 to 14, include their opinions of a light gun signals communication method, their other communication methods they use or have used, their recommendations as well as wants regarding air traffic control communication methods.

Participants' thoughts on light gun signals method

Question 8 for the interview is, "Do you feel the light gun signal is a good communication method? Please explain your answer. Are there any limitations of the light gun signal communication method? Why or why not?" Out of 17 participants, 7 pilots have agreed that it is a good method (41%), 3 disagreed (18%), 6 are in between

(35%), and 1 does not have an experience (6%). Below is a chart, and their responses and explanations.

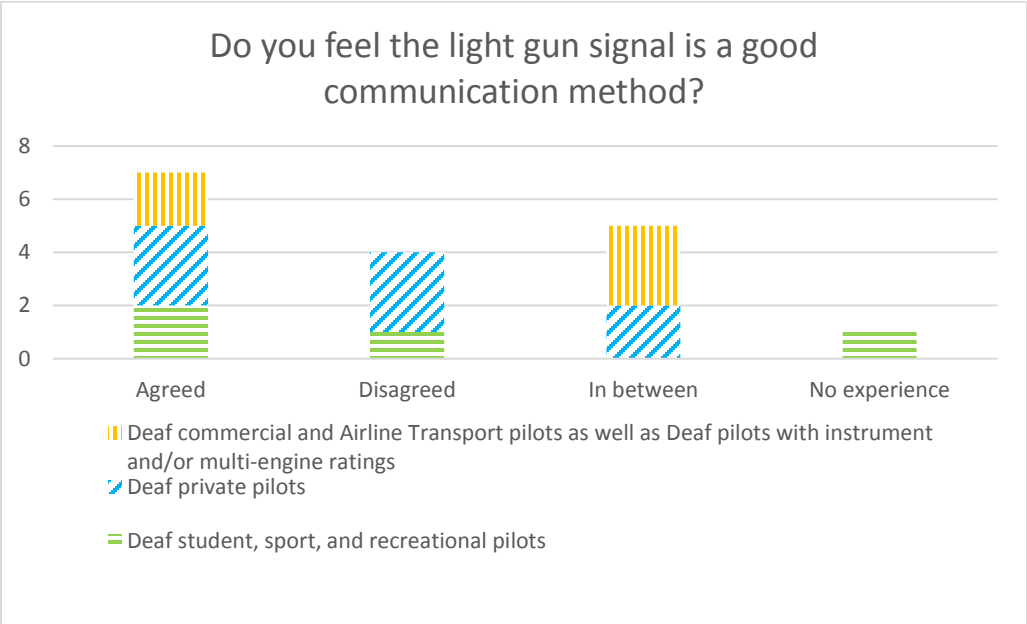

Figure 5. Stacked column chart related to light gun signals question.

There are some pilots that agreed having the light gun signals is a good communication method. Participant 7204 said it is better than nothing. Participants 9214 and 5890 explained that it is a good method after making arrangement with an air traffic control tower (ATCT) beforehand. The arrangement includes agreeing to the procedures between air traffic controller(s) and Deaf pilot(s). Then, the pilot can inform ATCT of the departure/arrival time, the direction of departure/arrival, aircraft type and tail number, and some information. Once the ATCT collects the information, the ATCT can inform the pilot of the instructions such as the runway to use and assign a transponder code. Then the pilot and ATC can use the light gun signals to communicate with each other.

On the other hand, there are some pilots who disagreed that the light gun signals is a good communication method. “I don’t think light gun signals is safe,” objected by Participant 8185. This participant explained that he/she flew to very busy airports and he/she used satellite phone to communicate with ATC; it works like VFR communication, but by using text communication. Participant 1145 stated that the basic barebone safety is ok, but pretty limitation. He/she added that light gun signals is not a

proper reflection of a current technology and believed that it is outdated. Participant 8630 answered:

> The light gun signal is VERY confusing for the reason that one may not know who the tower is communicating with. A very big limitation to light gun signals is line-of-sight contact: the pilot and controller NEED to see each other in order to complete the communication sequence. Another limitation is being at a busy airport where you're burning off precious fuel awaiting light gun communications.

Participant 7258 also disagreed about light gun signals:

> It can be often difficult to see the light gun, sometimes depending on where you are in relation to tower, and time of the day, and angle of the sun (rising in morning/setting in evening) plus many towers have sun screen shades which make it harder to see light gun. I have also been looking away (at flaps) or gauges when tower gave light gun signal and missed seeing it.

Some participants thought the light gun signals is both good and bad, or in between, communication method. Participant 3164 thought it is good for small airports, but not big airports with a lot of traffic. Some participants mentioned that sometimes the light gun signals is hard to see. Participant 7267 said it depends on the location, like some ATCTs have old light gun that does not have enough power to beam the light. Participant 6150 explained:

> It is a one-way communication method, in which air traffic control sends message to pilot, the other way around cannot be really done. That is one of the limitations. Other limitations are that it can be hard to see sometimes, and it does not send enough messages other than a few like clearance for takeoff or land.

Participant 9296 explained the limitations of light gun signals:

> Light guns have big limitations and are pretty useless unless it is pointed directly line of sight to you in the airplane, since the light lenses only work as a direct line of sight. I have struggled to see it, at the departure holding and even on an approach until the last minute, during daylight hours, but during night hours they are more predictable. Some work could be addressed there.

Participant 4262 thought there are variety of things could happen, but light gun signals is good for a secondary choice. This pilot thought Deaf pilots prefer the idea of texting, if possible. “Sometimes we need more communication than required,” added by Participant 4262.

Participants in general have shared some issues with light gun signals. One pilot had experienced waiting too long for a light gun signal while circling near the air traffic control tower. The pilot expressed his/her thought that he/she did not know if the controllers did not see the Deaf pilot and his/her aircraft or waited until the traffic was clear. This pilot explained that it was easy when taking off, but harder when arriving back since he/she had to wait too long in the air. Other participants explained that some air traffic controllers see the light gun signals as an emergency communication, not as an alternative communication. Some of the controllers are afraid to use the light gun signals; it seems like they do not have adequate training or unable to find aircraft, especially the high-speed aircraft like two-engine aircraft that can be hard for them to point the light gun signal at the aircraft. One of them noticed that the FAA ATC is fine with using the light gun signals while private contract ATC does not due to a fear of liability. This is the common limitation that many air traffic controllers consider light gun signals method is only for the emergency. Other participants said that the light gun signals helps a lot when flying in Class D airports, especially when informing ATC in advance to make a communication plan such as texting. One explained that he/she needed to inform ATC in advance of the aircraft type, tail number, time of arrival, and some plans. So, when the pilot arrives closer, he/she texts the tower and the tower communicates using the light gun signals method. The other struggled with the limitation of communication in this

method. He/she explained that suppose he/she calls ATC and received a runway number to land, then after an hour of flying and the pilot may not know if the ATC changed the runway number, "How will I be informed?" that pilot said. The light gun signals does not inform the runway number and is a one-way communication system. This pilot, however, can speak vocally, but not hear, and asked the tower if he/she can land on an arbitrary runway number, the tower would give a green or red light gun signal as a yes or no respectively until the pilot finds the right runway to land. However, if all answers are a no, the pilot would have to land at another smaller airport and call the ATC to find the problem.

The pilots had shared a lot of opinions of their experiences with the light gun signals communication method. Some had a positive experience while others did not. The data shows that the d/Deaf pilots need to contact ATC in advance to be able to use the light gun signals to communicate.

Communication methods that participants use

For Question 9, "What communication method do you tend to use? What are the other methods you also use/have used? How was that communication experience? Is there any limitation to those methods? Please explain." The participants' answers are a bit varied. A few said that they do not fly to non-towered airports while others use light gun signals and/or text communications.

Participant 1177 explained in detail on how he/she can communicate with ATC. He/she said that 1 or 2 days in advance, he/she talks to the ATC manager of his/her plans for his/her flight such as the route, time, and back arrival expectation time. Then the manager shares with his/her staff workers, so that they know about it. During the day of the flight, the pilot calls ATC for instructions such as runway number, winds, and weather after completing the preflight. Then the pilot taxies to a runup area to do the runup checklist, then moves the nose of the aircraft toward to the tower and flashes the light to give the signal of being ready for the takeoff clearance and waits for the light gun signal. Then the pilot takes off after receiving the clearance. Once the pilot is ready to return to the origin airport from another airport he/she visited, he/she calls the ATC to give the approximate time of arrival and they instruct him/her the area to circle of the

tower and look for the light gun signals for clearance to land. This is how the Deaf pilots can use towered airports in this way. Participant 6150 shared the similar procedure:

> Currently at one Class D airport, the ATC and I created and agreed a procedure to follow. It starts with me calling ATC of my intentions of flying such as the time and date of departure, the directions of outbound and inbound, and the expected time of return along with flight information such as tail number and aircraft make and model. Then I will show up at the airport, preform my preflight, and when ready, call again for the latest update such as which taxiways and runway to use. After that, I taxi to where I can see the tower and point the nose of the aircraft toward to it to show the tower that I am ready and waiting for a light gun signals instruction. Once receiving a flashing green light, I can taxi on taxiways to a run-up area near a runway as instructed in advance on the phone. While taxiing, I keep my eyes on the tower from time to time for any light signals. Once I arrive at a run-up area near the runway, I perform a run up check before pointing the aircraft nose to ATCT for takeoff clearance. Once I have a takeoff clearance of steady green light signal, I take off. When returning, I would go circle at a specific area and altitude and wait for a light gun signals to land. If I cannot see the light signals while waiting for 10 minutes, then the ATC will ensure that the air is clear for me to land as an expected procedure. This is part of the procedure that we have agreed. Sometimes I use my phone to send and receive messages with an air traffic controller for a better communication while still using the light gun signals if possible. I think the experience without texting would be good, but could be better if I can communicate more such as by texting.

Some participants have hearing pilots such as a certified flight instructor (CFI) to handle with radio communication. For Participant 1145, when he/she has a CFI, he/she asks CFI to communicate with ATC when they fly in Class D airport. They had created some home aviation signs to be able to communicate with each other. Participant 8630 has a different method in communicating with ATC. This pilot had the volume turned up on both the headset and the radio to hear the controllers. His/her instructor radioed the

ATC to inform that he/she was a hard of hearing and can communicate as long they keep their transmissions short and sweet.

Other participants do not use towered airports. Participant 4262 explained that there are more than 5,000 airports in the United States, less than 500 airports required radio. So, he/she easily avoids those towered airports. He/she added that if he/she is forced to use radio, he/she can, but it would be somewhat hard for this pilot to hear and understand. Participant 9214 also does not tend to use towered airports, but if he/she has to, he/she will ask the ATC to use light gun signals. This pilot added that if the ATC is not willing to use the light gun signals, he/she just waits until the tower is closed, like Class D airports become Class E or G at night when the tower is closed. His/her other option is asking for a hearing pilot to join and take care of radio communication. That option is his/her least preference due to the complexity of scheduling, contacting, etc. Participant 8265 looked back and found that the texting system was not available, so his/her flight was limited and only flew in airports that he/she knows were uncontrolled airports. It was until 2005 that the texting system came up and the technology was ok in that time, and he/she used texting method while flying; a keyboard was on his/her lap while flying. The participant explained present text system is getting better and he/she thought text-to-text is good, yet he/she said the FAA does not think it is a good system, because other pilots in the traffic cannot hear the text messages as these just go between ATC and pilot. Radio is the one that all can hear (except Deaf people), not the text and it is the issue. He/she added that the other issue is that texting works when flying near the airports with more cell towers than being far from those where texting can have a signal connection issue.

Participant 7258 shared a positive experience of using text message and the light gun signals to communicate between the pilot and air traffic control:

> Tower manager at first denied use of light gun, but when we gave her the letter from FAA chief legal counsel she agreed to try text message with light gun. Tower Manager felt that text message system was better and worked very well. She also said it was the first time they ever tried it. After we landed there, toured Boeing 747-777 -767 -787 factory, I sent her a text thanking her for working with

> us, as well as a letter via US mail. Tower Manager said that was the first time they used text message with deaf pilots and they liked it as they could communicate with us outside of visual range [light gun].

One Deaf pilot had a strange experience, in which Participant 7267 answered the question:

> What I do is video phone call ATC for pre-flight plan. ATC gives me the specific phone number for other ATC location. I keep it in my list and it saved my time from checking on the internet. I noticed a few or more air traffic controllers are not familiar how to accept relay call as they thought it is a scam or terrorists call. They thought I was a terrorist and I told them no. One airport ATC that I called and said, "I need to make a plan…" and they got scared already. "Why don't you make a plan on the website through the FAA and file there?" said the ATC. "No, I am Deaf and I need to get a permission to get into Class B," I said. They questioned why I need the permission and I hung up, because I didn't want to continue the conversation because I didn't feel comfortable due to the phone being recorded for public reasons, like FBI and police that need to listen the call. I waited for a few minutes and then called again with a different male interpreter (different voice). I told the interpreter to not announce the relay service announcement and its ID and want to call the ATC manager directly. I explained to the manager, the ATC manager said he/she has experiences working at ATC there for 28 years, but never heard of a relay service. So, I explained and everything worked out well. As for junior ATC or newbies ATC, new controllers with 5 years or less, they never had worked with Deaf pilots flying in their Class B airspace. I explained to the ATC manager about junior air traffic controllers and the manager said to just drop that and keep doing what I need to do, he/she will call for me, asked what I need, gave me the phone number for other location, and whatever. He/she gave me a special squawk code for transponder, so that they can identify me on their radar and I don't have to rely on radio for communication. Then, the manager told me to just go and fly. "We will monitor your tail number,

> I will inform other airspace, Class B and military, to expect you," the manager said. So, he/she did that for me and it was nice! No issue for me so far. Just an issue with junior air traffic controllers that don't know about Deaf pilots. Participant 8185 told me as we were discussing our concern about ATC issue. We were talking about how to discuss with the FAA headquarter on how to add training for ATC all over the U.S. about Deaf pilots, so that we don't have to repeatedly explain ourselves to ATC same thing over and over, because it is a negative for me.

Participant 8185 explained that each airport is different:

> Every airport has their own unique unwritten rules on communication methods. I have flown to many Class C and D airports. For example, some small regional airports like Class Delta airport, they requested me to squawk the code that was given to me on the phone that I had called in advance. By calling in advance, I shared the information such as my schedule of flying and time frame, when flying to the airport, I squawk the code that was applied to me for that airport. So, when I see the green light, it means I can land there. It worked out fine. It is important that they have instructed me which runway to land. As for another airport, I use satellite phone where they contact me on my phone. It is already arranged in advance on the phone to discuss the arrangements and I had sent the FAA letter explaining the laws that they can have a final decision about communication requirement. I also gave them the guideline on how to control with me. Advance is like one week, but for a very busy airport, I plan in really advance like two or three months to give them more time to familiar with the procedure and something. So, it is really individual for each airport. Nothing is the same when flying in their airports.

Participant 3941 said that few times, the person in ATC will be willing to give text number. "That would be smooth," said the pilot. However, he/she expressed his/her frustration that most do not want to give him/her text number. The pilot recalled that one

time, an ATC controller asked for his/her text number, and it was great and the text communication along with light gun signals went well! Participant 5890 has another procedure that is different from others, for when he/she flew in an IMC. He/she explained that when the flight was in drizzle weather and at a Class C airport, he/she informed the ATC by squawking a general emergency code for a minute, then switched squawking to lost communications code when he/she was at 20 miles. It is already planned he/she mentioned. The pilot and ATC did not use the light gun signals method, because it was IMC and the pilot followed the protocol and proceeded to land. Participant 2656 shared his/her communication experience:

> I only communicate with light gun signals. It is a so-so experience since I have to inform ATC and it is a lot of work by letting them know the time and stuff, and it is boring. I want the freedom of just fly rather than being stuck of the need to inform ATC a day or so advance.

Thoughts on creating a new communication method

This section shows the data of Deaf pilots' thoughts of creating a new communication method. Question 10 stated, "Should we create a new communication method that is better for Deaf pilots and air traffic controllers to replace the light signal method for Deaf pilots? If so, how?" 15 out of 17 participants or 88% supported the idea of creating a new communication method while just 2 participants or 12% were unsure. Many of them talked about text communication system and the FAA NextGen Data Communications.

Many participants answered, "Yes" to having a text-based communication. Participant 6150 explained:

> I would like to have a good two-way communication method between me and ATC. It would be like the FAA NextGen Data Communications, which is a text-based system that can transmit and receive digital messages between pilots and air traffic control. It may be users friendly for both hearing and Deaf pilots.

Participant 9296 discussed the access to text:

> Well, we all know that the cell phone and texting method for some works. If we can iron out the quirks between the ATC and PIC I could see this as a good thing. But again, I highly prefer the voice communication as the initial contact, your intentions, then ask for help with text messaging if they so wish to help. Otherwise stay out of the controlled airspace if you cannot come to an agreement beforehand a communication non-barrier method. Most controllers cannot be bothered with having to text around, this is another setback for hearing disabled pilots. I have tried in my local area, the ATC will do it, but the ATC general area manager says no, and he/she has the final say for those working under the General manager. So, no go for me in my local towered airport, I go to another non-towered local airport.

Participant 1177 thought it is nice to have text communication, but questioned if it will succeed. He/she thought texting would be faster in communicating between the pilot and ATC, so that he/she does not have to wait in a circle too long. Participant 1145 is unsure about the safety of texting:

> Granted research showed that texting while driving a car is dangerous. Would it mean that texting is safe while flying? And of course, flying, you know, human factors is a big thing in pilotage. So, we must monitor visually around while we aviate. We are less ok to daydream while flying than in car. In airplanes, we have a lot to monitor, such as 6 packs, traffic, and everything. So, now needing to text would distract from the focus on 6 packs and instruments on panel. So… I struggle to say yes to texting is the right answer. I am a little at a loss.

Participant 9214 thought we should create a new communication method that is text-based communication and discussed the need to improve the reliability of texting:

> Yes, everything that is text-based communication. I have an experience one time where I did a XC flight to towered airport, the tower texted me where I was and I replied where I was. It was an interesting experience. It was nice sending back and forth to keep in communication. It worked out really well. I know the FAA's biggest concern is the reliability of texting. Sometimes texts may not send out until 10 or 15 minutes later that can be of a concern because of the importance of the safety of flight, so… Maybe it needs to be improved some way in the reliability of texting.

Participant 5890 explained that the ATC light gun signals is not enough in communication and said we need to add texting method. He/she said ATC needs to provide access for us to see the information in text while enrouting, such as text system that can be connected to the phone and read text messages about weather information rather than use radio like hearing pilots do. Participant 3941 wanted text communication to be added to the system. He/she questioned that hearing people can use radio to communication, but how can Deaf people do that? He/she wished that the ATC would be willing to text or type the messages to cell phones, in which they should do that for equal access for both Deaf and hearing people.

Participant 7267 said he/she heard about the NextGen that has a new texting communication. With that, he/she suggested the light gun signals as a backup communication. Participant 4262 said that for a long time now, there has been discussion about the FAA Next Generation Air Transportation System. They are eager to see how well it will work and succeed. He/she said, "I think Europe is working on that as well. It is nice to see the options, but the FAA made it complex with red tapes." Participant 3164 mentioned datalink, in which airlines on transcontinental flights use this text communication technology. He/she said it is what we need in general aviation. Participant 8185 also discussed NextGen Data Comm, but has issues:

> NextGen Data Comm service, that. There is a political thing going on that it is for between companies and the government that prevents the use and available for general aviation. That is one problem. Second problem, some ATC around are not

> comfortable with Deaf pilots. One won't let me land there because I am Deaf. They emphasized that I must use radio and therefore refused to let me land. If I land there, my pilot license can be suspended. That is the problem.

The FAA NextGen Data Communications can be very expensive to install for general aviation airplanes. Participant 3702 expressed, "My primary area of interest is affordable flying." Participant 7204 is already working on an app that can do speech-to-text. He/she said the technology is there, but designing the app is challenging though.

Participant 8630 had a great idea about creating a new communication method like a few others thought about it:

> What needs to be implemented for safer and more efficient communications for ALL pilots (believe me, there are some hearing pilots that have difficulty communicating while flying) is some sort of a text-relay/SMS system that has pre-generated response prompts that are customized to the aircraft they fly. For example, Deaf pilot "Joe" has a Piper Cub with reg. number N123AB, and his system would have the pre-generated prompts that include "Cub 3-Alpha-Bravo (D)" in the transmission to ATC. The (D) would indicate "Deaf pilot". For foreign pilots that have difficulty with the English language, their callsigns would have country of origin with their tag, like (UK) for British, (FR) for French, (GR) for German, (SI) for Singapore, (DRK) for South Korea, etc...

Participant 8265 discussed other methods to use, but would like to keep light gun signals for emergency:

> I prefer to keep the light gun signals, it is best for low technology. Like what happens if an aircraft has lost a power along with texting system, light gun signals is the best system to keep in communication. So, I see light gun signals should be saved as for emergency use. Keep it, but not a priority communication to use. I don't want ATC to keep looking for my aircraft and use light gun signals every day and exhausted them, it is not my intention. So, I want ATC to communicate

> with me through texting, videophone or video relay service to keep in standard with other hearing people to keep deafness thing hidden and covered. Like ATC can know I am Deaf, but using text system with radio that can translate from text-to-voice system through radio system. So, it doesn't have to really change the system for only deaf pilots as it costs money that the FAA may not be interested to it. Hearing pilots said radio system is confusing as well and they like texting. Texting is clear, and the phone has been improved that hearing pilots can use texting that Deaf pilots can as well. So, it is best to use a system that hearing pilots use where Deaf pilots can also use. So that the FAA is more willing to support for all. That will be an advantage when the FAA can see texting system is safe, like if there is a terrorist has a gun at a pilot's head and the pilot can send a text, that is one way. So, if hearing and Deaf pilots use text communication, it will solve the problem later.

Participants' recommendations for improving the methods

This section includes the recommendations from the participants in improving air traffic control communication methods. Question 11 stated, "What do you recommend for improving ATC communication methods?" Many participants recommended text-based communication. "I want text instead of light gun signal," said Participant 1177.

Participant 6150 explained that for now that the Data Comm is not available for Deaf pilots or general aviation to use, he/she would recommend the procedure as described in the last question with the hope of being able to use text communication as well. This procedure will help ensure both the Deaf pilot and ATC to know what to expect of each other as it is arranged and agreed in advance. Participant 4262 said that for the short-term goal, texting is best, or maybe signing if possible. For future, he/she hopes the NextGen or other technology that needs to update and improve the communication will help a lot. Participant 9296 said:

> Unless they're willing to work with you, you could request your departure time and arrival time back ahead of scheduled departure time and request to use texting as your communication method whilst in the airplane. If this succeeds, it works.

Participant 3164 added that the ATC needs to be open to Deaf pilots:

> ATC needs to understand that there are Deaf pilots out there and be more willing to communicate with Deaf pilots and work out a communication plan for arrival and departure. Some ATCs don't like Deaf pilots, or might not feel comfortable, but ATC has the authorization to tell you yes or no. I have Deaf pilot friends who were denied to land there because they are Deaf. So, they went to another airport. So, ATC needs a better understanding and opening mind of Deaf people and pilots too.

Participant 5890 recommended text system to be added to ATC system in addition to the radio. The recommendation is to have vocal messages from radio to be translated into text like the Google system. Participant 8265 has the similar recommendation:

> I would recommend text-to-voice or new with text-to-text if the ATC is willing to change the system. Or hearing pilots can speak-to-text automatically to ATC. With text, it can send the message far while radio can be unclear with static unless they are close to ATC. Hearing pilots have to talk over and over until they are closer and clear. Radio can't while text can. Text can go to satellite or tower to tower. That is one advantage that I hope hearing people can see the advantage of it and change the system. That will be easier for us as Deaf pilots and we can text-to-text without having to speak vocally.

Participant 1145 recommended a way to have ATC to be accessible for us by looking at the safety and reliability of texting:

> How I would recommend ATC to improve to be in order for ATC to be accessible for us Deaf pilots? If texting can be demonstrable, reliable, not impede with our ability to aviate, and not compromise. It can be demonstrated by the FAA or development with the FAA oversaw, they can see if it is not compromise safety, be reliable, permit us Deaf pilots to aviate, and still see and avoid. Because, you know that all of us never become too complement. We have VFR maps on to use, with E6B, etc. I am not that confident to say that texting is the answer yet.

Participant 8630 added a recommendation of having a visual alert:

> What I would recommend is the SMS/text-relay system with a visual/audio alert in the cockpit for Deaf/HOH pilots to indicate that a transmission is received or sent. I had learned as a student pilot that even hearing pilots miss radio calls, and that's when things unravel in a very scary way. I had to teach myself to remind everyone in the airplane to suspend conversations while flying in controlled airspace. I once had the Chief Instructor pilot in the back seat of the aircraft I was training in with a second instructor after my first one had "jumped ship." The Chief pilot kept muttering, and I called ATC to let them know I was leaving the airspace for a few minutes due to an uncooperative passenger, and my CFII looked at me with wide eyes. She asked me why I decided to do that, and I pointed out that I could not operate the aircraft in a safe manner if the passenger was going to interrupt radio transmissions. Mind you, this was 1996, and it was difficult enough for me to handle efficient communications. I had visited the tower a few times and let them know that they would be hearing me while flying, and I've had tremendous support from them during my short time at a university.

Participant 8185, an electric engineer, recommended the NextGen service and flight management system (FMS) prices be lower. However, he/she said two companies are willing to put the system in iPad instead of hardware basis. The technology is there, but he/she said that the FAA needs to adapt to that technology for general aviation. Participant 2656 said the communication method needs more new update technologies

such as precision location, new communication methods, and not the old fashion stuff that is still been in use. “Digital messages, not analog like voice, but text. There are some technologies out there to use like ADS-B under the NextGen. Some airports support it, but not small airports,” explained by Participant 7204. Participant 9214 recommended the ATC be proactive in finding solutions in the communication:

> Best thing ATC should find something and be proactive to find solutions than making excuses like many times. They should try this or try that than saying no and it is becoming the end. It is frustrating. Should be more proactive. If they are busy at the time, that is ok and should discuss in 30 minutes to work out something for me to arrive with light gun signals or something. They should find solutions as they know what they can do while I know is just limited. They know the specific situation, time, etc. and can find other ways to make it work than saying no.

Participant 7267 recommended a training for ATC on Deaf or Hard of Hearing pilots:

> I recommend the FAA to make a new enhanced training specify on Deaf/Hard of Hearing pilots, so that they can work together better. I remember ATC manager, I have the email form him/her, a great manager, he/she knew how frustrating I have and he/she will take care for me. I just need to call to make a plan, to allow time for them to coordinate with stuff.

Participants’ wishes for improving ATC communication method

Question 12 stated, “What do you wish for in terms of improving the ATC communication method?” Participant 1177 said it would be nice to have a video phone in cockpit and sign (with video relay service if needed). That would be faster in communication than texting. Participant 6150 wished that the Data Communications can be available now for them to better understand how this communication system works and probably use it. He/she explained that it is a two-way communication system that

Deaf pilots may be able to use. Participant 3164 wished that the FAA ATC works on bringing datalink to their airports. There are some participants that wished that the FAA ATC would add the texting method in the system to be allowed to use controlled airports and not have to use radio to communicate. “Clear communication with no barrier,” said Participant 7204. Participant 8265 wants the system to be changed:

> Change the system. Radio is really 1950’s function system, the FAA is afraid to change the system to digital. It is still analog like a watch and big bulge TV, that many things have changed but not the radio. It is time to change the system.

Participant 9214 wished to go ahead with a text-based communication:

> I wish we can go ahead with a technology, text-based communication. It is available out there like right now that airlines use it. I know there is a huge concern with the cost of equipment, but if there is no issue with the cost, no issue with the regulations, then set the text-based communication for everyone equally. There are many benefits to that; can’t misunderstand the message, no problem with accent, send the message once as you can read it if missed, can’t misunderstand it, well, should not misunderstood, there would be always something little things that can be error, but should be less compares to radio communication.

Participant 7267 had something to say about ATC:

> All I can say thing is, I wish ATC works with Deaf pilots smoothly, plans throughout, including special transponder squawk codes ready, not wasting our time explaining over and over. I wish they have readily programs that is ready up on the screen to type, I don’t know what exactly is that as I am not an expert in aviation technology things.

Participant 9296 explained, “Much needed co-operation between the PIC and the ATC personnel and perhaps the regional managers, at what you need and if those needs can be accommodated.” Participant 1145 wished the communication method is accessible for all, “not just bringing the accessible for the disabled pilots” or “special service for the Deaf pilots.” He/she wants this to improve overall experience, overall aviation safety, and overall approach. “Make it like a universal design,” he/she added.

With today’s technologies, Participant 8630 wished the communication can be done via text/SMS:

> Interactive communications with ATC via text/SMS with taxi directions. A lot of pilots today have iPads which can be used in this way, and with interactive communications, a lot of the communications would be simplified and there would be less confusion.

Participant 3941 wished there is an equipment for typing communication:

> I wish that they add like what I just said for someone to create equipment for typing communication in plane or texting. My point is written communication, not spoken or audio. Most Deaf people can’t talk nor hear, so that means we need written, texting, or pressing on a device in an airplane. Technology is already there and need to put in small airplanes or ATC willing to give us text number, please, for communication back and forth through texting.

Participant 4262 wished there is a system that has texts that are already typed and ready to be sent:

> I wish there are more words that can be readily sent. Like on the smartphones that there is predictive text that can show up and ready to send. So, it would be nice to have some sentences there ready to send. It would be really cool. Readily sentences like “5 miles southeast toward airport name”, so with the sentence

ready, can just tap send that sentence, and then tap another sentence when at 2 miles. All ready.

Participants' wants for the better communication

This section focuses on what the Deaf pilots want for a better communication between themselves and ATC. Question 13 asked, "What do you want for better communication between Deaf pilots and air traffic controllers?" A few participants may had answered the same as previous questions, because the questions were similar. However, this question helped draw more answers from participants as it differs from their recommendations, wishes, and wants on the communication method. In addition, it can increase the reliability of their answers in this research.

Participant 6150 answered, "I want a two-way communication system that is easy for Deaf pilots to communicate with ATC effectively and efficiency." Participant 2656 pointed out, "Data Comm, where we can text and send and receive messages with ATC. Easy to communicate." Participant 1145 wanted to update the system, "Robust system that allows for connection between ATC and pilots that meets the current technologies and current realistic instead of depending on something that I see as outdated: radio communication. Participant 3702 stated, "We have to go with the technology we have now and make it works." Participant 1177 wants to use video relay service (VRS) where Deaf pilots can be on the phone with air traffic controllers by using a video phone with an American Sign Language interpreter relaying the call. Participant 5890 answered, "I want Deaf pilots that are the PICs to be responsible for ensuring the safety of flight by keeping up with the communication." This seems to mean Deaf pilots need access to a communication system.

There are some ideas that were discussed in the last questions. Participant 7204 wanted a text-to-text app with scripts ready to send to keep it simple for pilots. Participant 3164 wanted more text usage than voice communication. Participant 3941 wanted some kind of typed written communication between Deaf pilot in an airplane and ATC. Participant 6150 hoped that we can create one communication method for all to use:

> I hope we will be able to create one communication method for all Deaf pilots to use, so that Deaf pilots do not have to talk to many different air traffic controls to discuss a way to enter their airspace. If there is a system sets in place, ATC would already know the procedure to use and would save a lot of time in discussing with ATC to create a procedure.

Participant 9296 wanted more training for ATC:

> Maybe more local training and awareness of needs of the deaf pilot and the ATC controlling facility personnel. Again, if they agree to their help. Legally they have the jurisdiction and control of that airspace and our SODA or hearing limitation prohibits entry or exit at controlled airports and we are at their mercy. If they help, then the SODA or limitations is removed temporarily at that controlling agency.

Participant 4262 stated, "Really, we need to improve political relations between ATC and pilots." Participant 8630 suggested air traffic controllers and Deaf pilots to be patient with each other, his/her response to the question below:

> My suggestion would be to make friends with Air Traffic Controllers. All kidding aside, the main thing that will make things better between Deaf pilots and ATC controllers is patience. Things get hectic, I know, and as long as everyone is on the same page with clearances and assignments, things will progress a lot smoother from initial contact. One BIG suggestion I would make is that Deaf pilots be able to communicate with ATC via text/SMS at least 1.5 hours prior to departure to allow time for last-minute changes, and to minimize long idle times. If possible, it would be nice for ATC to allow Deaf pilots to taxi to a point on the field for engine run-up and minor changes in flight plans before taking off.

Participant 8265 had a long answer about technologies and the views of others:

> Just radio that needs to change and improve the communication. Deaf pilots' skill is no different with hearing pilots, just the communication. With better communication, it will be easier for us to have IFR rating and even ATP, communication would be a no problem. Hearing people's view that if Deaf pilots along with no communication can be considered very dangerous pilots. Pilots with no arms, using wheelchair, etc. have less barrier compared to Deaf pilots with the most barriers of all disabled pilots due to communication. Blind pilots have a lot of barriers, but the FAA views blind pilots the better pilots than Deaf pilots. It is because blind pilots need to be with another pilot to see and tell blind pilot. However, with Deaf pilots with hearing pilots who can handle radio, but the communication between them may be hard, due to lack of communication. The FAA says without communication, it is not safe. I fly in a major city and there are many aircraft around. They are sick of me because they use radio and they have to clear the way for me to fly around. They would ask how I would know the weather information while flying, there are technologies that I can see the weather information. They are limited in technology and that is the problem. With technologies, my barrier is less like ADS-B that helps a lot that I don't have to rely on ATC. It is like a radar that I finally can use. Now, I am waiting for others to change like radio. I applaud that the ADS-B is there, but the FAA won't give up their old system of radio. I am waiting for new generations of people at the FAA to be more opened mind, understanding, and attitude change; that will help.

Participant 8185 had a frustration experience with an air traffic controller that would not accommodate:

> I think I already said it. Really, it is up to an ATC manager. Some won't meet with us. For example, one airport that I informed them that I was hearing impaired and they asked if I can use radio. I said no and would like to use text communication or light gun if text is not available. They don't accept that and

> asked, “The license said the limitation, right?” And they said sorry, they won’t help, and told me to not come to the airport. I tried to explain about other airports and had the FAA letter that shows I have the right to ask for a waiver. They never heard of it and it is not in the book. I know and I have contacted with legal department to check that and it is explained in the letter. So, the ATC manager read it, “Oh, that means I can decide to waive you. So, I will not grant you a waiver. Sorry. Have a good day.” I went through a lot more than most Deaf pilots out there.

Participant 7267 had an amazing experience with one air traffic control and wanted to share his/her story:

> When I flew to an airport, there were one or two positive cool experiences that I had when ATC manager was looking and giving me a light gun signal for my arrival landing. Once I parked the aircraft, the air traffic controllers drove a government van to me, I thought I was in trouble, but not, they wanted to come and check on me to make sure I was ok and everything was well; checking to see if I needed anything. That was cool. I felt more of a serviced. ATC said hello and already typed something for me to read, “Hello 7267, my name is (name) and I am an ATC manager, let me know if you need anything, like service from me or aviation longue. If you need, please give me a text when you decide to go back home.” I shook the hands and asked what made him come and he answered, “I want to work with you.” I wish it is the same with other air traffic controllers.

Additional messages by the participants

This section concerns the last question of the interview, “Anything else you would like to add?” The answers vary among participants. Some shared their experiences, some asked for something, and some have ideas to help improve the communication.

Participant 3941 wished that the FAA would provide ATC staff with sensitivity training, so that ATC will not get freaked out by Deaf pilots. Participant 3164

emphasized that not all Deaf pilots have the same hearing loss/level. Participant 5890 would like to say that we need to use hearing aids, if possible, to hear the sounds in the aircraft, such as the warning horns. He/she knows that we do not understand the words on the radio, but may hear the warning sounds. Participant 1177 added that he/she had met an air traffic control manager in person to create a bonding feel. He/she said it would be strange to just call the manager to inform the flight plan/intentions without knowing what the manager looks like or the manager knowing what the Deaf pilot looks like. The bonding helps make the connection better. Another thing the pilot wanted to add is that we need to make a procedure to ensure the mindset is the same for the safety of flight, then the controller and the pilot will know what to do. The last thing he/she wanted to add is that he/she had a bad experience when he/she aborted the flight a bit after taking off from a towered airport by flying back to the airport unexpectedly and that it was hard to communicate in this event. Fortunately, the pilot sent an email to the manager and he/she replied, but the connection was on and off during the flight. The pilot flew closer and kept circling until the manager saw the aircraft and gave the pilot a light gun signal to land. They were discussing how to make this situation better, and the manager suggested that the pilot could squawk an emergency code. The pilot said he/she would do that if texting would not work.

Participant 8185 added about finding a right aviation lawyer that can write a rule to make flying more accessible for Deaf pilots at all airports:

> We need to find the right aviation lawyer who is familiar with Vocational Rehabilitation Act, pushes the FAA to set the rule for all airports, and requires them to accommodate to our needs. Law is there, we need someone to write the rule to make it clears that they are required to meet Vocational Rehabilitation Act of 1973, a Federal Act, that required federal agencies, including the FAA, to accommodate to us Deaf pilots' need. That means they cannot refuse our service. "Hey, I request for text communication, they must get a cell phone." Law is there. The rule letter can make it cooperate between Deaf pilots and ATC all over the U.S.

Participant 9214 discussed many things:

Yeah, one last message. I would like to see the FAA be very consistent with their expectation of procedure, medical flight test if required, which I don't see it is really necessary for it because regulations already spelled out what we can do or cannot do. If there is no restriction on my license, I can still fly to towered airport without radio? Can't as it is required to set a radio communication unless they put another plan as it is already there in FARs. For example with Class D, FAR Part 91.129 already spelled out. Class C already spelled out. There is flexibility there, so what is the limitation on the certificates for? Planes don't know any different. There are few other things. I would like to see FAA more compliant with ADA. For example, FAA safety seminar, they provide interpreting service most of the time. But the problem is that the FAA sent out the seminar information two weeks in advance, but most interpreting agency required at least two weeks' notice to find interpreters. I really have no window of opportunity to respond or figure out if I can go or not. Or maybe I need a few days to decide if I can go as I need to check for other plans to ensure it won't conflict with the plan. I would like to go to become a safer pilot, but why Deaf people tend to be the most neglected if the FAA concerns safety is the more issue with the group of Deaf pilots? Why not provide education, an opportunity to learn become a safer pilot like hearing pilots if in their view? We know we tend to be motivated in topics to be safer pilots too. That is one big downside thing. Another example, some flight training, we would like to see more instructors that know sign language or is Deaf. Because many instructors aren't comfortable flying with you without radio and cancel the flights. Cancel the flight? They didn't have to cancel the flight as I have 600 hours of flying without radio. No issue and they should get used to it. Anyway, my point is that I would like to see that the FAA allows them to become flight instructors. So far I know one Deaf CFI that teaches for private pilot while other teaches for sport pilot. That's it. He is very lucky. Because if you required an interpreter for CFI checkride, you can't do it because of the policy of not being able to use ASL to communicate. What if the examiner knows ASL and I know as well that we can

use, but can't because of the policy? FAA handbook for DPE in the checklist about the policy that shows what can do and can't do, there is a thing that says ASL is not allowed to use. They don't seem comply with the ADA. This can be a safety issue for me, because CFIs don't know ASL and can't train me well without ASL interpreting service. We could be benefited a lot with the interpreting service that we can receive a lot of instructions with the same amount of time to teach me the theory behind, reasons, and stuff and not just demonstrate the procedure and follow it. I am old now to fight with the FAA and already gassed out. Now I am passing out to younger people to fire up.

Participant 9296 wanted to send a message to non-rated pilots:

Ultimately, safety is paramount for all deaf/hard of hearing pilots and they cannot decide to exclude safety parameters because they are deaf. All too many a times, there are deaf wannabe non-rated pilots that are trike, paramotor kite flyers that do NOT adhere to safety standards, and may use that as an excuse to penetrate uncontrolled out even controlled airspace and can cause friction with hearing abled pilots. We, as rated pilots must get the message out that it is not okay for hearing disabled non-rated folks to fly in airports where there are rated pilots that know the NAS system and cause a possible mishap. This could cause issues among the deaf/hard of hearing pilots with the FAA. Thank you!

Participant 4262 gave advice:

I think Deaf pilots really supporting with each other to have a power, but we need more support from other hearing people too. So, we have to be careful on how we bridge the communication with respect between ATC and Deaf pilots. Like what had happened with one Deaf pilot who was in trouble with the ATC, because the pilot protested, "It is my right to land and don't care about communication." That created conflict and ATC blocked that pilot and never allowed the pilot to land there, period. Bully. So, we have to be careful, ATC has a lot of power and we

> need to be careful how to explain yourself. So, start by being friendly and be easy in communicating on how that we are pilots and hopefully we can land at their airport by asking some options if they are willing to try. That will be better. So, that when there are other Deaf pilots coming to the airport, ATC can be more friendly and open to allow them to land at their airport due to the experience they had with other Deaf pilot and it was a success. Really important. Like everything if we want to succeed in life, including college, work, or professional, we have to play the game. Meaning, find out more about the controllers from the ATC, and get along with them. You may not agree with how they control, but it is not your place to decide how to control the situation. You have to play their game until you get what you want. It is how the world works, if you decided to be upright snobby saying, "I am doing my way and it is my right." You will not accomplish anything with the ATC.

Participant 7204 mentioned one interesting thing, "There was a hearing pilot that had a radio not working. So, the pilot had to use the phone to text and it worked in communicating with ATC. That was during a night time and the pilot landed." Participant 8630 wished me the very best with my research:

> I wish you the very best in your project, and as I've mentioned before, information is scarce for history of Deaf pilots. A lot of it is Society and cultural inhibitions that scare potential pilots away from getting in the airplane.

Participant 1145 had a nice message for me:

> Nothing, except one thing, because it is important to me. I don't know if it will benefit your research, but thank you for doing this, because we are a very minority disabled group within an already small aviation group. So, we are like a dot of everyone all over, like we are endangered species. So, any effort that is real like this research is very appreciated by this pilot, so thank you!

Chart on communication methods participants use

The stacked column chart below shows the overall result of the communication methods the participants use. Some of them may use more than one way to communicate between them and air traffic control. The stacked chart is of three different pilot groups to aid in finding the data that each group tends to use one or more communication systems.

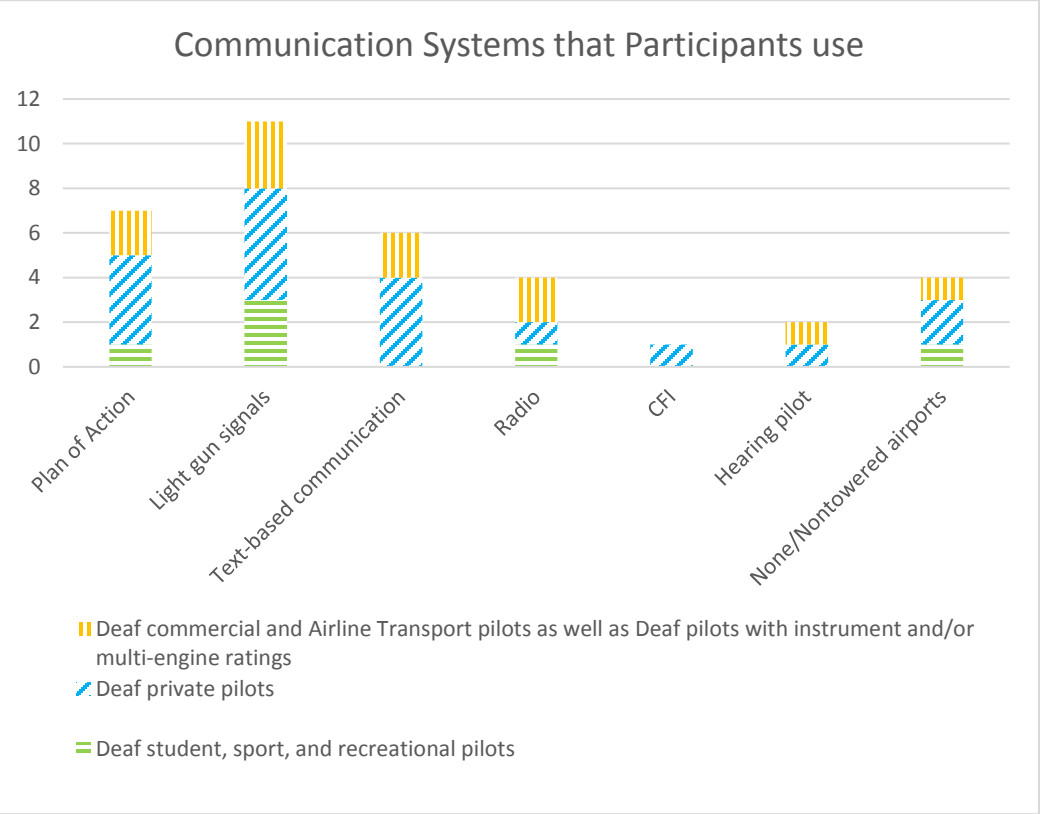

Figure 6. Stacked column chart: Communication systems that participants use.

The chart with the highest number shows that eleven out of 17 participants (65%) at least use a light gun signals system to communicate with ATC. Some of them mentioned that they want to update the system, but it is better than nothing for now. Seven of the pilots have a plan of action/procedure already agreed upon with air traffic control to use their controlled airspace. The plan of action includes the procedure on what the air traffic control will expect of the pilot's action and vice versa. It is a communication system already set in place in advance. The plan of action may involve the use of light gun signals or texting to keep them in contact. Six of the participants are

able to use text-based communication, such as texting on the phone, to communicate two-way with air traffic control. Four participants use radio at least to communicate with air traffic control; they may speak vocally, but not understand the vocal instructions given verbally and may use a hearing pilot to handle radio communication. One private pilot participant uses at least a CFI to handle with radio communication. If having a CFI for flight training, it may be a good idea to have the CFI to handle radio communication rather than using light gun signals with the expected time of arrival, because the CFI may change the time of arrival that an air traffic controller may not expect. Two participants also use a hearing pilot to do radio communication sometimes. Four pilots do not have any experience of using controlled airspace, therefore, no communication plan, or they tend to go to non-towered airports and use see and been seen and VFR rules.

Chart on participants' recommendations, wishes, and wants

The chart below shows the communication methods itself or related to those the participants recommended, wished for, and wanted. Some participants may have more than one input, as seen on the previous chart, resulting the amount of inputs exceeding 17.

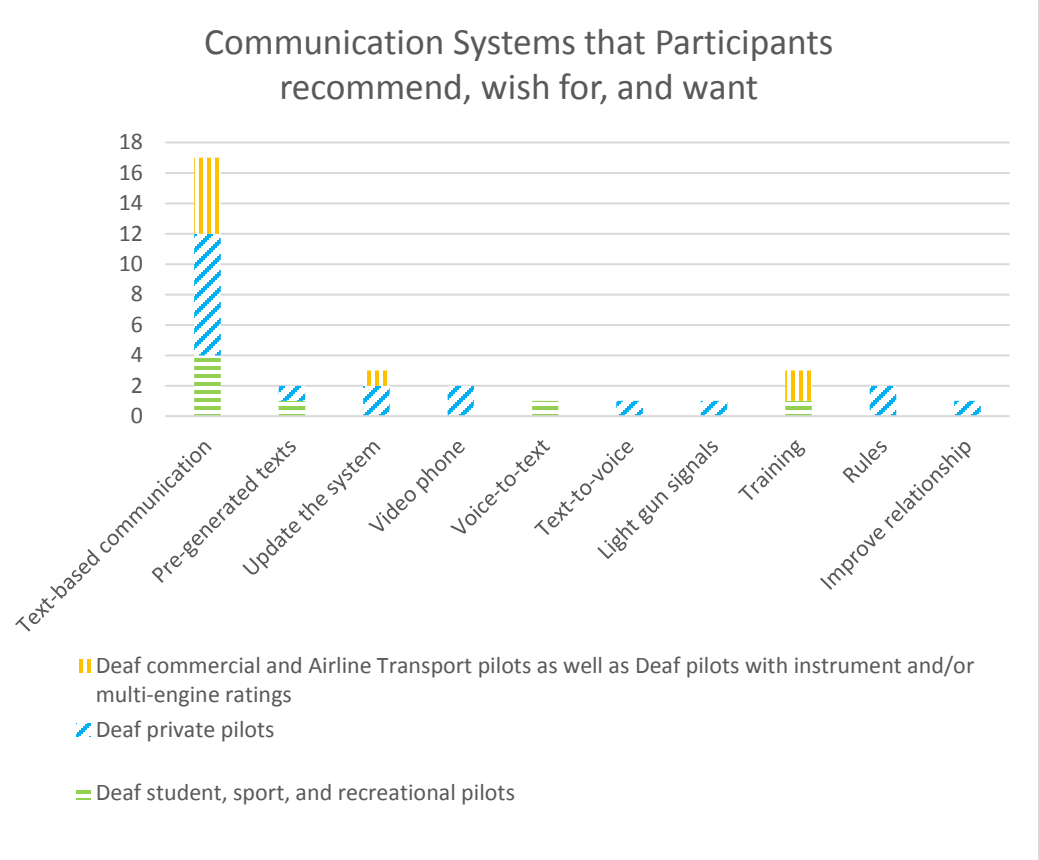

Figure 7. Systems that participants recommend, wish for, and want.

The stacked column chart above shows that all participants from all three d/Deaf pilot groups recommend, wish for, and/or want a text-based communication method to be used to communicate between pilots and air traffic control. One participant mentioned adding "(D)" in the transmission from a Deaf pilot to ATC to indicate a Deaf pilot sending the message. Other participant wished that all towered airports would have a text-based communication service, so that pilots could go to any airports and use a texting method when required. Two participants had the great idea of having pre-generated texts in a text-based communication method. Pre-generated texts are frequency texts that are already typed and stored in the system and the pilot can click a chosen text to be sent. This will help pilots to better focus on flying the aircraft by reducing the time in typing a message.

Three participants recommended, wished for, and/or wanted to update the air traffic control communication system. It seems that they want to update radio and light gun signals to be more like the FAA NextGen Data Communications, where they can text

with a controller. They felt it is time to improve the system since the radio and light gun signals have been old for a long time while there are many technologies today that we can use.

Two participants had thought about a video phone communication method. A video phone device can be installed in cockpit for a Deaf pilot to communicate in their primary language of American Sign Language (ASL) through a video phone with a video relay service (VRS) if needed (for air traffic controllers that do not know ASL). They explained that would be faster and smoother in communication.

One pilot mentioned about a voice-to-text system, where Deaf pilots can receive vocal instructions and understand it by reading in texts under that system. Another pilot thought of a text-to-voice system, where Deaf pilots can send a message in text and the system can voice it out for hearing air traffic controllers and pilots to hear the message. A third participant suggested to keep light gun signals as a backup emergency communication, such as when aircraft loses its power and has no way to communicate except receiving signal messages from ATC.

Three participants recommended, wished for, and/or wanted some form of training for air traffic controllers on the topic of Deaf pilots and related communication methods. The training would include sensitivity and awareness training about Deaf pilots' needs for their communication with ATC. They want air traffic controllers to better understand and know how to work with Deaf pilots and even communicate with them easier. This includes having a procedure set in place for all air traffic controllers to know, so that a Deaf pilot does not have to discuss with an air traffic controller or air traffic control manager about a procedure or plan of action every time at a new airport. This will save a lot of time and energy for them both. With a standard procedure for all Deaf pilots, it will make lives easier for Deaf pilots and air traffic controllers when they all are already familiar with the procedure and ready to use it.

Regarding the rules set in place that two participants mentioned, the rules can be helpful for the FAA and ATC to better understand the FARs and the ADA regarding the communication methods for Deaf pilots and ATC to use. Not only that, one of them wants to see the FAA to be consistent with the rules all over the United States to stay in standard with every place in the U.S. for every Deaf pilot. One last thing that a

participant wanted is an improvement in political relations between Deaf pilots and air traffic controllers. There have been a few stories where air traffic controllers do not get along with Deaf pilots due to their attitude on deaf people and became stubborn about not letting Deaf pilots use their controlled airspace, even when a communication method other than radio can be used. This participant wants both to be very patient, friendly, and respectful to each other in working an arrangement together. With this, they both can have a successful plan of action and enjoy their job or flight.

Categorization of the Communication Methods

The last two sections discussed many different communication methods that the participants used or suggested. To perform a data reduction, the three categories which divide the communication methods into proper quality categorization as described in Chapter 3 are The Most Common ATC Communication Methods, Useful ATC Communication Methods, and Unknown ATC Communication Methods. This section is to help with a general knowledge of what methods Deaf pilots tend to use and the quality of those to communicate with ATC as well as with this research to discover the methods that can be useful or to seek a better understanding.

The Most Common ATC Communication Methods

In Figure 6, the chart showed that the light gun signals is the most common air traffic control communication method that air traffic control uses to communicate with Deaf pilots. The result is 11 out of 17 participants. The other most common method can be having a hearing co-pilot handling a radio communication. This can be especially true during flight training with a hearing CFI that some may have not mentioned in the interview or questionnaire. The chart may not be explicit in that. Some of us may not want to depend on hearing co-pilot for communication, so we may have answered the questions regarding how we communicate without the aid of hearing pilots. These two common methods, light gun signals and hearing pilots, seem to match the Deaf Pilots Association (DPA) website showing some methods a deaf pilot can use,

> If a deaf pilot wants to fly into a controlled airport, he or she can bring along a qualified co-pilot or flight instructor who can handle the necessary radio communications with ATC. Sometimes, special arrangements for a "no-radio arrival" (or departure), using light signals, can be made with the control tower in advance (Deaf Pilots Association, Inc., 2017c).

The data display and the DPA website show that there is a validity that the ATC light gun signals is the common method used by Deaf pilots. Not only that, the qualitative data in this research is reliability due to the fact that there is consistency between participants' contributions.

Useful ATC Communication Methods

A useful ATC communication method is a text-based communication. Figure 6 shows some pilots use text communication and it is useful due to it being a two-way communication system. All participants asked for a text-based communication as shown in Figure 7, 17 out of 17 (100%). Some d/Deaf pilots and air traffic controllers are able to use their phones and text to each other for instructions or requests. It seems some are successful, especially when still on the ground or at a low altitude, but some may struggle in connecting to the signal to keep in touch. Yet, it is still useful as this method can transmit or receive any messages and words while the light gun signals has its limits.

Another useful method is a plan of action. Seven pilots, as shown on Figure 6, mentioned they use a plan of action with ATC to help with a smooth flying experience. This involves agreeing to the procedure on what the ATC expects the d/Deaf pilot will do and on how they will communicate with each other. This plan of action takes time in planning, and creating one needs to be done in advance before flying to ensure everyone involved knows what they need to do. It is useful to keep airports and sky safe.

Unknown ATC Communication Methods

There are some new ideas that can improve the interaction experience for Deaf pilots with ATC. Also, there are other methods that need to be researched heavily to figure the capability of user-friendly methods for Deaf pilots to use. These are under the

unknown ATC communication methods category. The biggest one that some of Deaf pilots have talked about is the FAA NextGen Data Communications. None of us has any experience with Data Comm to fully understand the system, therefore, it is still unknown if it will be useful for Deaf pilots to text or receive digital messages accessibly with ATC.

The other unknown method is a text-based communication with satellite phone. It is not yet fully understood nor experienced by me. What I understand at this time is that it helps improve signal strength even when a pilot is flying at a high altitude where a regular phone may not have any connection. As other pilots mentioned, they do not have signal connection sometimes, and this satellite phone may help. It can be expensive as it costs a several hundred dollars to purchase one along with a monthly subscription (sporty's pilot shop, 2018). The benefit of it would be for general aviation pilots to keep in touch with ATC better than a regular phone.

The other new idea related to text-based communication is the pre-generated texts. Two participants discussed this idea as shown in Figure 7. This idea is to store some pre-typed messages that are common in ATC communication and be ready to send when a pilot clicks a selected word or sentence. Or the text communication system can have a predictive text in ATC lingo system like a pilot mentioned. These ideas can help save time for pilots from typing the repetitive words and improve pilots' concentration on other tasks.

One last thing that is not yet experimented is the use of video phone for ATC communication. Deaf people now use video phone to call other Deaf people face-to-face, a better-quality version of FaceTime specifically for Deaf users. This is the modern technology that Deaf people use instead of old TTY system. Should a Deaf person want to call a hearing person, it can still be done through a video phone and there will be an American Sign Language interpreter ready to relay the call, like a TTY system does. The idea of installing a video phone device in a cockpit would be amazing to some Deaf pilots to use to communicate with others in their primary language of American Sign Language. This can be smoother and faster in understanding the instructions. The high-speed internet and great connection are required to make video phone call works.

The three categories

The above categories have shown many methods and ideas for ATC communication system. Each of the three categories are grouped to the most repetitive methods that Deaf pilots use, the useful methods that Deaf pilots can use, and the new ideas that will be helpful for Deaf pilots. This seems like the common methods are the ones that are more like the past, useful methods are like the present time to use, and unknown methods are like the future communication system.

Secondary Data

As described in Chapter 3, there are primary data and secondary data. Primary data is the sources received directly from Deaf pilots through the interviews or questionnaires. Secondary data is the additional sources researched through internet or elsewhere, which content analysis is performed in this section. Most participants discussed the FAA NextGen Data Communications. There have to be some new updates regarding to the NextGen as it is still in implementation.

The Data Comm is currently in operation at 57 airports (Federal Aviation Administration, 2018). Some participants mentioned that the current communication methods are analog technologies and these should be updated to digital technologies. The FAA website (2018) on Data Comm shows that the Data Communications is the digital system, "Digital delivery, as opposed to analog radio, ensures electronic, messages can be easily and quickly understood." To better understand how this system works in communicating between pilots and air traffic controllers, the explanation from the FAA is below:

> In use at 57 airports, Data Communications (Data Comm) enables air traffic controllers to send text-based departure clearance instructions to flight crews of equipped aircraft instead of speaking over the radio. Air carrier dispatchers simultaneously receive the same information, giving all decision makers a shared awareness for faster reactions to changes. Flight crews review the instructions and signal acceptance by pushing a button, and the instructions are then loaded into

the aircraft's flight management system. If plans change, this process can be repeated as often as necessary until the aircraft is ready for takeoff. (Federal Aviation Administration, 2018).

Below is a figure of the Data Communications in an aircraft that is equipped for this system,

Figure 8. Data Communications in flight management system.

In addition, a participant mentioned data link, which is called as “Controller-Pilot Data Link Communications (CPDLC)” by the FAA (Federal Aviation Administration, 2017). It seems like it is part of the Data Communications. I learned in the past that the Data Link is used for transcontinental flights between the United States and Europe where radio is unavailable overseas. From what I remember, CPDLC is a way a controller and pilot can communicate together using digital messages like the Data

Communications. Now, with the Data Comm, it would be used on the ground and over the land, not just overseas like CPDLC.

Discussion

The 17 participants have provided so much information that has been helpful in this exploratory study. Qualitative data showed that most Deaf pilots want to update the air traffic control communication system, where it can be a text-based communication system. Some have discussed that the text-based communication can be beneficial for both Deaf and hearing pilots to use. The Federal Aviation Administration is already in process of using the Data Communications, the text-based communication system. Some of us Deaf pilots are looking forward to understanding more on how to use Data Comm and seeing if it will help improve our communication with the air traffic control.

Summary

This chapter on presentation of data and findings included participants' responses and analysis of their responses. It began with the background of each d/Deaf pilot participant and continued to their opinions and suggestions on air traffic control communication methods. Many have expressed interest in text-based communication method, such as the FAA NextGen Data Communications. This method can be user-friendly for both Deaf and hearing pilots. Some suggested a training for air traffic controllers to better work with Deaf pilots. Many good ideas were presented in this chapter. The next chapter will conclude with discussion and recommendations about the communication methods between Deaf pilots and air traffic control.

CHAPTER 5: CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Chapter 1 introduced this research on the communication methods related to Deaf pilots. Chapter 2 reviewed the literature on the history of air traffic control, Deaf people, communication methods, and regulations. Chapter 3 discussed the methodology of this research. Chapter 4 presented the data and findings from the interviews with Deaf pilots. This final chapter closes with conclusions, discussion, and recommendations on air traffic control communication methods for Deaf pilots and air traffic controllers to use.

Conclusions

This qualitative research began with an eager to explore more about Deaf pilots and their communication methods. It is the beginning of the overall research to improve communication between air traffic control and Deaf pilots. After interviewing many Deaf pilots, I have discovered many methods and ideas that are helpful in spreading the awareness of how we can fly, and communicate if required. The methods that Deaf pilots use include, but are not limited to, light gun signals, texting, hearing co-pilot handling radio communication, and plan of action to set things up for Deaf pilot to fly in controlled airspace. Some ideas include the use of video phone, pre-generated digital messages, text-based communication system, and training to help with both air traffic controllers and Deaf pilots to know the procedure of using controlled airspace. These methods and ideas are helpful to improve the communication method, which the next two sections will discuss and recommend from this research.

Answer to the Research Question

Before we go to the next two sections of discussion and recommendations, we will focus on the research question and my answer to the question. The research question as introduced in Chapter 1 is, “What are the existing communication methods between air traffic control and Deaf pilots?” In Chapter 4: Presentation of Data and Findings, we have seen some methods that the Deaf pilots use. In Figure 6, the chart shows that the most

pilots use light gun signals and/or texting method. Some of them use the plan of action that aids the coordination among all who are involving in it. Also, some of them use radio communication; most use it just for transmitting vocally, not for receiving as it is hard to understand, and some use it when hearing pilot such as CFI is handling the radio communication. These are the existing communication methods between air traffic control and Deaf pilots. There is no unique method such as the use of video phone communication discovered in this research. Just a few helpful things in some methods such as satellite phone to boost the signal strength for texting communication. The unique methods are currently the ideas that the pilots would want to use in the future, which I will discuss in the recommendations section.

Table 2

Numbers of Users in Each Method

ATC Communication Methods	Group 1	Group 2	Group 3	%
Light gun signals	3	5	3	64.7
Text-based communication	0	4	2	35.3
Radio	1	1	2	23.5

The table above shows the numbers of users in each air traffic control communication method: Light gun signals, text-based communication, and radio. Some users may use more than one method. So, the percentages represent the number of participants out of 17 that use the method. This table shows that most Deaf pilots use light gun signals currently with texting method being the second. Texting from the phone while in the flight may not be at the best quality at this time. One pilot uses a satellite phone that may be helpful. We hope that the text-based communication will be the primary mode of communication for Deaf pilots, and hearing pilots, in the near future. As one pilot stated, the light gun signals should be kept as a backup or an emergency method of communication for everyone should any communication system fail either in aircraft or air traffic control tower.

Discussion

Many people, both hearing and Deaf, thought Deaf people could not be pilots due to the barrier of radio communication. Some people have met Deaf pilots and still wonder how they can be pilots for the same reason. This research presented the qualitative data that many Deaf pilots tend to be communicated with by air traffic control through a light gun signals. Or even some use a method of texting to be able to have two-way communication rather than just being communicated with by ATC like the light signals. Hearing pilots are able to use radio while we, Deaf pilots, do not. Light gun signals is not as good as radio system, but it is better than nothing for now. Light gun signals can be used as a backup communication method if texting method became unreliable during the flight, like a weak to no signal. Using radio will allow more access to towered airports easily while light gun signals can be a struggle to establish a plan with some towered airports every time, as it is not yet a standard for all ATC with Deaf pilots. Text-based communication method is what should be the update of both light gun signals and radio methods that both hearing and Deaf pilots can use. They would be able to use the same procedure and that can help save a lot of time for Deaf pilots and air traffic controllers in planning and agreeing to a special procedure.

Before we move to the recommendations section, I want to add a note to mention, while the majority of the participants in this thesis research are Deaf, there are deaf participants in this research that I considered as Deaf pilots for this research. The Table 1 showed that there are thirteen Deaf participants (76.5%), one deaf participant (5.9%), and three participants who are either deaf or Deaf without knowing or answering by which term they identify themselves (17.6%). My reasons are that I do not see that they use radio solely two-way without the aid of a hearing pilot. They at least know about Deaf pilots, probably know American Sign Language, and are seeking for a better communication system. They still make important contributions in the research.

Table 3

Participants' d/Deaf Self-identification

d/Deaf identify	Group 1	Group 2	Group 3	%
Deaf	2	7	4	76.5
deaf	1	0	0	5.9
d/Deaf	1	1	1	17.6

Table 3 above summarizes what is discussed on the percentages of Deaf pilots, deaf pilots, and d/Deaf pilots. There seems to be equal number among of identifications in each of the three pilot groups; it is not that Group 3 of commercial pilots or Airline Transport Pilots have more deaf or hard of hearing pilots. There may be deaf or hard of hearing pilots out there, which are not included in this research, who are commercial pilots or ATPs. These pilots may not be culturally deaf, they can be like late-deafness who lose hearing as they get older, yet can hear or speak well with hearing aids.

Recommendations

With so many data and findings from Chapter 4 of this thesis, there are some recommendations I would like to make from the conclusion of this research. These include the communication system, the procedure, and the training. The goal of the recommendations is to improve the overall experience for both Deaf pilots and air traffic control in communicating with each other.

Text-based communication system

We have been looking forward to seeing what the Federal Aviation Administration's Next Generation Air Transportation System Data Communications can do for Deaf pilots. This is the next communication method to radio system, to light gun signals, to colored flags system, and to no air traffic control system. It is a text-based communication system where pilots and controllers can transmit and receive digital

messages. With that, Deaf pilots will be able to use this, and the skies can be more opening for them to fly with a new communication technology.

Unfortunately, the access to learn and experience hands-on on the Data Comm is not easy. The Data Comm program is still in the process of equipping airliners and installing at some towered airports, and the program is limited for general aviation at this time. Most of us, Deaf pilots, are still in general aviation, and some of us are trying to get into air transportation industry, such as by becoming a professional pilot. Yet, there may be barriers due to radio communication while still trying to understand the Data Communications system. It is my hope that I, along with a few Deaf pilots and researchers, will work with the FAA in researching more about the Data Communications on how accessible this system will be for Deaf pilots and seek for solutions, if any, to make it a Deaf-friendly device.

While the Data Communications is not available to use at this time, I would recommend the use of phones for texting that both d/Deaf pilots and air traffic controllers can use. With the ideas from others, it would be a great idea to create some pre-generated messages set in place. For example, in an iPhone iOS, this can be done by using text replacement, where a Deaf pilot can type a few letters as a code that will automatically replace with one or some words. This can be found by going to the settings app, general, keyboard, and then text replacement to add a phrase and a shortcut text. Also, if texting with ATC frequently enough that iPhone can pick up its lingo, the predictive text system may help in adding words that the sender is about to type and can tap the chosen word to add into the text before sending. One last thing: using a satellite phone may be helpful to be in touch with ATC better. If not, flying at low altitude (while still maintaining at legal flying altitude) near a city with cell towers may help in connecting to the signal.

Safety on using text-based communication

While we are discussing about the use of text-based communication in air traffic control system, I would like to emphasize that safety is the first thing. We all know that safety is the top priority in aviation and flights. The pilots should know that flying is the first thing while in flight.

While some pilots may use phones to text and receive messages with ATC, texting is best to be done while the flight is in cruise and stable when the tasks are less intense. In traffic pattern, landing, or departing, it is best to avoid the use of texting excessively and focus on aviating first. If using the phone for texting, I recommend bringing the phone up rather than down on the lap to help with seeing other things within the line of sight such as seeing outside of cockpit or instruments while texting. It increases situation awareness while using the phone.

I also would like to recommend that the use of phone for non-aviation situations to be kept at the most minimum. There may be some pilots that use phones for aviation situations such as aviation/pilot's app for the weather, traffic, GPS, maps, and communication. The pilots should know safety is first and the importance of flight safety.

Light Gun Signals

There may be a time that air traffic control and pilots would have to use light gun signals. There are some issues as explained in the Chapter 4. This thesis is not implying that the light gun signals should be used as a communication method between Deaf pilots and ATC, just a few recommendations to improve the experiences for all. First, air traffic controllers need to roll up the sunshades in the tower cab in front of them to allow the pilot to see the light signals. With the window shades down, it would be hard for pilots to see a signal. In addition, it would be helpful with the window shades at the front up, the back window shades down to reduce the brightness from behind the light gun signals to make it easier for pilots to detect the light from the light gun signals rather than the daylight that can cover the light gun signals. Second, each tower should ensure the light gun is new with a strong beam that makes it easier for pilots to see light gun signals, not an old light gun that has weak power and beam. These are the two recommendations related to light gun signals in case any pilots or ATC need to use this method.

Procedure

At this time, I recommend all d/Deaf pilots and air traffic controllers to arrange together a plan of action in advance for each airport that d/Deaf pilots would use. Without a plan of action or any information in advance with an air traffic control tower, an air

traffic controller may not know if a pilot in an aircraft is Deaf and may keep on using radio communication until light gun signals may be used awkwardly, not knowing what the pilot or air traffic controller want to do. The plan of action or procedure will help them to know what the other will expect of each other's action to avoid any surprises.

To have a procedure at an airport set in place for a Deaf pilot, a Deaf pilot should start by contacting an air traffic control tower (ATCT) and introducing him/herself to the tower and explain the need of using other than radio communication method. The phone number for the airport can be found in an airport/facility directory (A/FD). Once the tower understands the necessity to work with a Deaf pilot, they may want to meet in-person or talk over the phone to create a plan of action or a procedure. The plan of action can explain what the pilot should do, such as pointing the nose of the aircraft to the tower when ready for a further instruction under the light gun signals, and which taxiway(s) the pilot should use for a specific runway. Not only that, the plan of action can include the proper traffic pattern turn for each runway for outbound or inbound flights. In addition, there may be a point near the tower (depending on the direction of inbound) for an arrival aircraft to circle until receiving a steady green light gun signal to land.

Once the plan of action is set in place, the d/Deaf pilot can use the guideline of the FAA NORDO (no radio) coordination worksheet to inform the tower the necessary information before using the controlled airspace. Below is a list of information needed to share:

- Pilot-in-command
- Date of flight
- Approximate time of departure (if needed)
- Aircraft callsign (tail number)
- Aircraft make and model
- Ramp location
- ATIS received (can be done by calling ATIS phone number)
- Pilot's intentions (e.g., depart to the North, remain in the traffic pattern)
- Expected time of return (if needed)
- Inbound from (direction) (if needed)

Once the tower has received all the information, the tower can then assign a Deaf pilot a special transponder code and any special instructions (e.g., return to airport at 1,500 feet MSL). The special transponder code that the tower has for Deaf pilot can be helpful for the tower to detect the Deaf pilot easier on their radar, and therefore aiding in separating hearing pilots flying from the Deaf pilot.

Speaking of a special transponder code for Deaf pilots to squawk, I would like to recommend a group of special transponder codes reserved for Deaf pilots to use. That will identify the aircraft with Deaf pilot(s) on air traffic control's radar. This will be the easiest way to inform ATC that the pilot is Deaf rather than squawking a "can't talk" emergency transponder code, and the ATC should be ready to use a light gun signals to signal an instruction.

For future use, I would like to recommend a standard procedure for all Deaf pilots and air traffic controllers to use. This will help save time in planning each time at every airport and improve the experience for both the pilot and the controller. To make it happen, a training would be needed, and this training is discussed in the next section.

Training

The purpose of the training is to help bring an overall positive experience in interaction of air traffic control personnel and d/Deaf pilots. The training includes sensitivity training, awareness, and rules. I would recommend them to have the training with the help of Deaf aviation experts and hearing air traffic control experts that bring different perspectives for others to learn.

The sensitivity training is to have both parties understand, respect, and be patient with one other. Deaf people grew up to be patient of hearing people trying to make an interaction, and hearing people will need to try to be patient as well to get to the point where both can feel satisfied with the conversation. We hope ATC personnel understand our need to use a different method than radio to make communication work and respect that needs.

As for awareness, I would like all air traffic controllers to know about Deaf pilots and their ability to fly and communicate. Some people may have never met a Deaf person

and may have no idea how to start a conversation with a Deaf person. Some may think speaking loudly and slowly may help, but it does not work for Deaf people. With spreading awareness, the controllers can expect a Deaf pilot in their airspace and be ready to correspond with the pilot.

Lastly, having rules set up to clearly show that the ATC has authority to do noncompliance regarding to the radio use regulation. In addition to the rules that help with the understanding of ADA to provide communication access for Deaf pilots. The rules will help all ATC personnel on the same page while being consistent and allowing Deaf pilots to use controlled airspace when needed.

Summary

This last chapter closed this thesis research with my recommendations on communication methods and advices for both Deaf pilots and air traffic control personnel. My overall research goal is to improve air traffic control communication between Deaf pilots and ATC. With the improvements of the communication, the ATC and Deaf pilots can easily communicate with each other, opening more doors for Deaf pilots to advance their career opportunities. I hope this thesis increases the awareness and knowledge about Deaf pilots and their communication methods and access needs. May the Deaf pilots soar high and far!

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APPENDIX A. SURVEYS

The following are the interview questions:

PART 1

1) The purpose of this interview is to explore more about the ATC communication methods between Deaf pilots and air traffic control. Would you like me to keep your personal information private?

2) What is your name? Where are you from?

3) How deaf are you? How would you identify yourself? As a big “D” or a small “d” deaf? Why?

4) How many pilot certificates have you earned? What are the pilot certificates and ratings that you have earned? Do you have a limitation on your current one? If so, what is it?

5) What class of medical certification have you obtained? Do you have a limitation on it? If so, what is it?

6) What is your purpose for being a pilot? Do you want to be a professional pilot: Commercial pilot or Airline Transport Pilot?

7) Do you feel that the radio system is a good communication method to use? Why or why not? If yes, is the radio system the only communication method you use?

PART 2

8) Do you feel the light gun signal is a good communication method? Please explain your answer. Are there any limitations of the light gun signal communication method? Why or why not?

9) What communication method do you tend to use? What are the other methods you also use/have used? How was that communication experience? Is there any limitation to those methods? Please explain.

10) Should we create a new communication method that is better for Deaf pilots and air traffic controllers to replace the light signal method for Deaf pilots? If so, how?

11) What do you recommend for improving ATC communication methods?

12) What do you wish for in terms of improving the ATC communication method?

13) What do you want for better communication between Deaf pilots and air traffic controllers?

14) Anything else you would like to add?

APPENDIX B. IRB APPROVAL DOCUMENT

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	WULLE, BERNARD W
From:	DICLEMENTI, JEANNIE D, Chair Social Science IRB
Date:	03/12/2018
Committee Action:(2) (3)	Determined Exempt, Category (2) (3)
IRB Action Date:	03 / 09 / 2018
IRB Protocol #:	1802020265
Study Title:	Perceiving the Communication Methods Between Deaf Pilots and Air Traffic Control

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b).

Before making changes to the study procedures, please submit an Amendment to ensure that the regulatory status of the study has not changed. Changes in key research personnel should also be submitted to the IRB through an amendment.

General

- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student's attendance and enrollment decision will not be shared with those administering the course.
- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
- When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution's IRB to determine requirements for conducting research at that institution.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). Submit this documentation as an FYI through Coeus. This is an institutional requirement.

Categories 2 and 3

- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator's name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.

Category 6

- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

You are required to retain a copy of this letter for your records. We appreciate your commitment towards ensuring the ethical conduct of human subjects research and wish you luck with your study.

VITA

RAYMART F. TINIO

NATIONALITY
United States of America

LANGUAGES
American Sign Language
English

SKILLS
Microsoft Word
Microsoft PowerPoint
Microsoft Excel
Microsoft Publisher
Piloting
Leadership
Customer Service
Program Management
Event Planning
Teaching
Public Speaking

INTERESTS
Flying
Swimming
Biking
Hiking
Building
Cooking

GOALS
Instrument Rating
Commercial Pilot Certificate
Multi-Engine Rating
Airline Transport Pilot Certificate
M.S. degree in Aviation
Ph.D. degree

CERTIFICATIONS
FERPA of 1974 Enterprise Certification
Purdue Passenger Van Training
Certificate of Training
Community Emergency Response Team
Certificate of Completion
Mental Health First Aid USA course
USPA Certificate of Achievement
Ground & Aerial Training - Skydiving

https://www.linkedin.com/in/RaymartTinio

EDUCATION

Purdue University — **West Lafayette, IN**

Master of Science in Aviation and Aerospace Management
Current GPA: 3.81
Thesis: Perceiving the Communication Methods between Deaf Pilots and Air Traffic Control
Expected date of graduation: May 2018
Related course work

Research MS Thesis	Quality And Productivity In Industry And Tech.
International Civil Aviation Regulatory Systems	Human Error And Safety
Process Improvement And Simulation	Analysis Of Research In Industry And Technology
Multi-Cultural Issues In Team Operations	Introduction To Semiotics

San Jose State University — **San Jose, CA**

Bachelor of Science in Aviation and minor in Business, cum laude
GPA: 3.67
Date of graduation: May 28, 2016
Related course work

Introduction to Aviation	Aircraft Theory and Design
Introduction to Aviation Management	Aircraft Systems
Aviation Law	General Aviation Operations and Management
Air Traffic Control	Airline Operations and Management
Aviation Safety and Security	Advanced Airport Planning and Management
Human Factors in the Aviation Environment	Professional and Business Ethics

California School for the Deaf, Riverside — **Riverside, CA**

High School Diploma, Valedictorian
GPA: 3.98
Date of graduation: June 16, 2011

FLIGHT TRAINING

Purdue Aviation — **West Lafayette, IN**
Instrument Rating — In training

CP Aviation — **Santa Paula, CA**
Private Pilot Certificate (ASEL) — January 4, 2016

Able Flight at Purdue University — **West Lafayette, IN**
Sport Pilot Certificate (ASEL) — July 1, 2015

EMPLOYMENT

Graduate Teaching Assistant — August 2016 - May 2018
Purdue University — *West Lafayette, IN*
Graduate teaching assistant for some of aviation professor's and ASL professor's classes at Purdue University. I take attendance, make PowerPoint slides available for students, help with grading papers, record grades in the system, organize papers, and assume the professor's duties, such as teaching, when he is otherwise engaged.

Warehouse Aide — February 2010 - June 2011
California School for the Deaf, Riverside — *Riverside, CA*
Checked the inventory list before processing the paperwork, delivered packages around campus, and committed myself to being a successful worker, which helped me establish good working relationships with my employers.

HONORS

- Able Flight Career Training Scholarship
- Dean's Scholar, SJSU
- Awarded Aero Club of Northern CA
- Awarded Able Flight Full Scholarship
- Awarded August Scherer Scholarship
- Daughters of the American Revolution
- Best Employee of 2nd Quarter, 2/11/11
- Perfect Attendance Awards, CSDR
- Certificates of Top Cub, CSDR
- Best T.P.P. Employee, CSDR

ACTIVITIES

2017 - Present	Purdue University ASL Club, Member
2017 - Present	Civil Air Patrol, Second Lieutenant
2016 - Present	Purdue Pilots, Inc., Pilot Member
2016 - Present	Purdue Professional Pilots, Member
2015 - Present	Able Flight, Pilot
2015 - Present	Deaf Pilots Association, Active Member
2014 - Present	CERT, Emergency Response Volunteer
2009 - Present	CSDR Class of 2011, Treasurer
2011 - 2012	ASL Club at Oxnard College, President
2010 - 2011	CSDR ASBG, Director of Social Affairs
2010 - 2011	CSDR Jr. National Association of the Deaf, Board
2010 - 2011	CSDR Cottage Council, HSBC 1 Representative
2010 - 2011	CSDR Pageant, Back Stage Manager
2008 - 2011	CSDR Deaf Academic Bowl, Participant
2007 - 2011	CSDR Baseball, Player
2010	CSDR Homecoming, Chairperson
2010	Lion Camp Pacifica, Camper in Leadership Training
2009 - 2010	CSDR Assoc. Student Body Gov., Dir. of Welfare
2007 - 2010	CSDR Dorm Council, Palomar Representative
2007	CSDR Sadie Hawkins Committee, Member

PUBLICATIONS

Refereed journal article:

Major, W. L., Tinio, R., & Hubbard, S. M. (submitted). Able Flight at Purdue University: A case study documenting an inclusive flight program and the associated benefits. Collegiate Aviation Review – International (CARi).

Refereed conference or symposium proceeding:

Major, W. L., Tinio, R., & Hubbard S. M. (2017). Able Flight at Purdue. Proceedings of the 19th International Symposium on Aviation Psychology, Dayton, OH.