Collegiate Aviation Review International

Volume 38 | Issue 2 Peer-Reviewed Practice #1

6-23-2020

Utilizing Flight Data Monitoring for Near Miss Incident Analysis

Samuel Pavel
Southern Illinois University

Bryan Harrison
Southern Illinois University

Ken Bro
Southern Illinois University

Avinash Sorab
Southern Illinois University

Michael Robertson
Southern Illinois University

Midair collisions (MACs) and near midair collisions (NMACs) have been a concern for pilots and regulators since the advent of flight and the creation of the national airspace system. The purpose of this paper is to explore novel analysis methods for determining and representing near miss events at a collegiate flight school utilizing standard Garmin G1000 avionics data logging. The analysis of near-miss geographic distributions revealed useful trend information that has been used systemically to reduce the number of near-miss events, by way of discussion with instructors and implementing congestion limits or traffic area dispersal. The next iteration of data modeling would benefit from heatmapping, to identify trending geographic near-miss areas in near real-time.

Recommended Citation:
Pavel, S., Harrison, B., Bro, K., Sorab, A. & Robertson, M. (2020). Utilizing Flight Data Monitoring for Near Miss Incident Analysis. *Collegiate Aviation Review International*, 38(2), (pending). Retrieved from http://ojs.library.okstate.edu/osu/index.php/CARI/article/view/8020/7399

Midair collisions (MACs) and near midair collisions (NMACs) have been a concern for pilots and regulators since the advent of flight and the creation of the national airspace system. Like most aircraft accidents, MACs are preventable through awareness of *human causal factors* such as improvement in *pilot education, operating practices, procedures, and techniques* (FAA, 1970). Unlike most aircraft accidents, MACs are almost always fatal. Most MACs occur during daylight hours in VFR conditions and within just a few miles from an airport. Because of this, midair collisions are considered one of the most feared types of accidents in the flight training environment. Midair collisions were the tenth leading cause of fatal accidents between 2001 and 2013 (Ulrich and Wild, 2015).

The purpose of this paper is to explore novel analysis methods for determining and representing near miss events at Southern Illinois University Carbondale (SIUC) utilizing standard Garmin G1000 avionics data logging. The use of Flight Data Monitoring to assist in mitigating the risk of MACs within the Safety Management System will also be discussed.

Background

The first attempts to reduce the possibility of MACs and NMACs in the 1920s were controllers such as Archie League in St Louis who communicated with pilots by waving flags. The Federal Government created an Aeronautics Branch in the Department of Commerce in 1926 to address aviation safety, including the establishment of a national airway system and enforcement of air traffic rules. The first en route air traffic control (ATC) centers were established by the airlines in 1934 to prevent aircraft collisions. The new ATC system failed to prevent 65 MACs between 1950 and 1955 due to its limitations in segregating VFR and IFR traffic. The most high-profile midair collision occurred over the Grand Canyon in 1956 when two airliners collided, killing all aboard. This collision led to the creation of what is now known as the Federal Aviation Administration and improvements in ATC that significantly reduced MACs and NMACs in the national airspace system (FAA, 2019).

Even with the increased vigilance provided by ATC services MACs and NMACs continued to occur. In 1968, there were 2,230 NMACs reported to the FAA and 38 MACs. Of the 38 MACs more than half occurred in the traffic pattern at an airport, with a large majority of these accidents occurring at an airport without an operating control tower (FAA, 1970). This prompted the FAA to release Advisory Circular (AC) 90-48 - Pilots' Role in Collision Avoidance to help mitigate the occurrence of MACs and NMACs (FAA, 1980).

The advisory guidance from the FAA continued to evolve with AC 90-48A issued in 1979 after there were 34 MACs resulting in 190 fatalities in 1978 (FAA, 1979). Another revision issued in 1980 (AC 90-48B) to re-emphasize the role of the pilots in preventing MACs. In 1983 AC 90-48C was published even though the occurrence of MACs reduced from 38 to 25 annually by 1981, NMACs increased to 2,241 between 1978 and 1982 (FAA, 1983). Over time as new technology was introduced and pilot awareness of MACs and NMACs increased, the rate of MACs and NMACs reduced significantly by 2013. Between 2009 and 2013 there were only

42 MACs and 461 reported NMACs. In 2016 AC 90-48D was published incorporating specific pilot scanning techniques, procedures, and collision-avoidance technologies to help further reduce the occurrence of MACs and NMACs (FAA, 2016).

Traffic pattern entry at non-towered airports has been a key factor in reducing aircraft accidents because most MACs and reported NMACs prior to the year 2000 occurred at airports without an operating control tower. Many flight training programs are located at airports without an operating control tower are keenly interested improving procedures and training that will mitigate the possibility of MACs and NMACs. Teresa Sloan at Central Washington University conducted a survey of flight instructors attending Flight Instructor Refresher Courses in Washington State in 1999 and 2000 (Sloan, 2000) to find out if flight training of procedures of flight pattern entry an non-towered airport contributed to the problem. Sloan was particularly interested in the way flight instructors trained pilots to enter traffic patterns at airports without an operating control tower. What she found out was there was no standard method of entering traffic patterns being taught. In fact, several frightening trends were identified in training that would actually increase the risk of a MAC. Sloan concluded that until the FAA publishes an AC on entering traffic patterns at non-towered airports pilots need to comply with the FAA's Aeronautical Information Manual and existing Advisory Circulars (Sloan, 2000).

In 2019 researchers at Liberty University and the AOPA Air Safety Institute published the results of their study of fatal accidents in the flight training environment (Walton, Bauman & Geske, 2019). They found between 2000 and 2015 there were 240 fatal accidents involving flight training aircraft, although the accident rate deceased 35% over then time period of the study. The majority (54%) of the accidents were loss of control inflight. Ten percent (10%) of the accidents were MACs. Overall, MACs decreased between 2000 and 2015 which they attribute to the use of traffic awareness technology, deconflicting practice areas, and use of ATC flight following (Liberty, 2019). They also found MACs at airports without an operating control tower has reduced significantly from earlier studies. Of the 24 fatalities from MACs 71% occurred outside the airport environment, 32% occurred in Class D airspace, and only 8% occurred at non-towered airports.

Since 2015 there have been 2 fatal MACs involving aircraft used in flight training (NTSB, 2019). One occurred at an airport without an operating control tower and the other occurred 9 miles northeast of an airport with an operating control tower. In the case of the MAC outside of the Class D airspace one aircraft was in contract with ATC and had been issued a traffic advisory.

The 2019 Liberty/AOPA study stated that deconflicting practice areas was a factor in the reduction of MACs involving training aircraft. Although not defined in the report, deconflicting practice areas implies there would be less flight training in a particular area and therefore the probability of a MAC would be reduced. However, would the reduction in MACs be simply based on a simple reduced frequency probability of two aircraft colliding because of the reduced number of flight training aircraft in the area? Do NMACs still occur and at what frequency? To help answer this question, researchers at SIU Aviation at Southern Illinois University Carbondale have developed a methodology using Garmin G-1000 avionics data to determine whether NMACs occur, even in deconflicted practice areas. This data analysis technique will give flight schools another tool to further reduce the possibility of MACs and increase the safety of flight training programs.

Methodology

A near miss, for this research, is defined as two or more aircraft being within 500 feet, absolute distance, excluding aircraft-on-ground. Using this definition, a query of all the department's flight data is performed to determine local time, aircraft identification, and positional information. The data is represented in various formats (satellite-view map, closure-rate chart, and histogram) for different analytic purposes.

In defining a near miss with absolute distance, three coordinate positions are compared across the aggregate of all flight data. To determine the absolute distance between any two aircraft, the following simple Euclidean representation is used (Figure 1).

$$Distance = \sqrt{\sum |Latitude_1 - Latitude_2|^2, |Longitude_1 - Longitude_2|^2, |Altitude_1 - Altitude_2|^2}$$

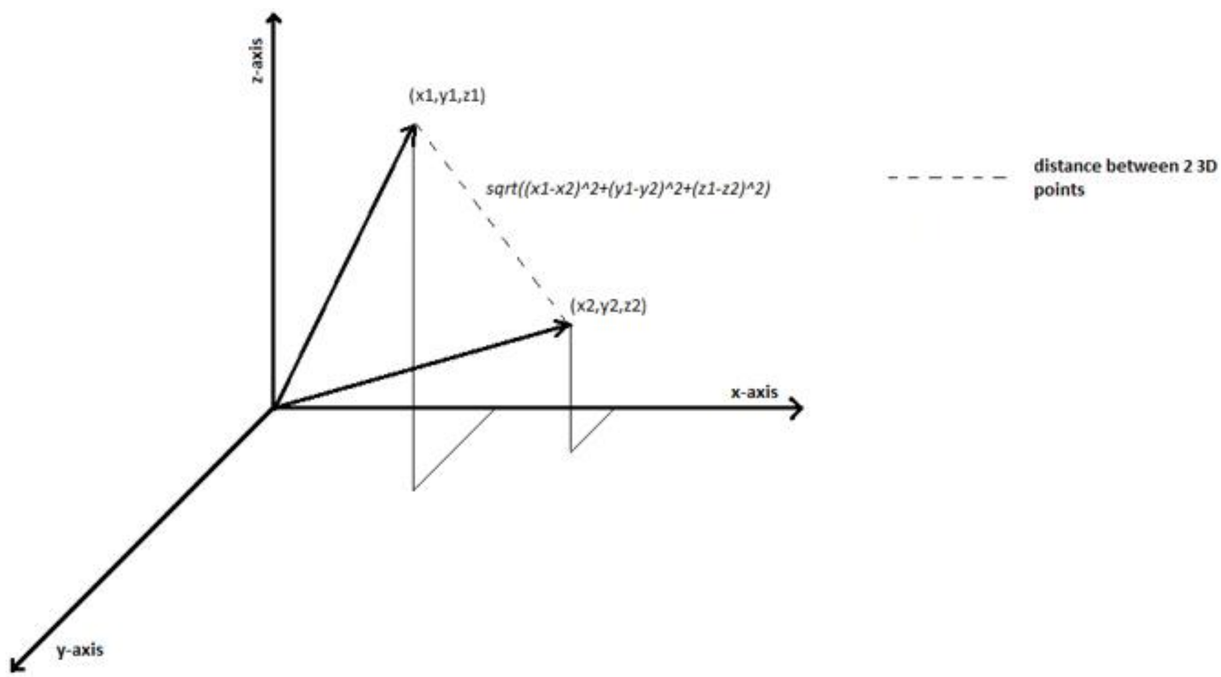

Figure 1. Calculating distance between two points in Euclidean space.

For the purposes of this research the curvature of the earth is ignored; latitude and longitude are treated as conserved values. To efficiently determine absolute distance between aircraft, longitude and latitude are treated as conserved quantities (no haversine adjustment is made). If a greater degree of accuracy is required (aircraft flying at higher latitudes), the Haversine formula or equivalent could readily be utilized. Since the aircraft in this dataset remain within a few hundred miles of the origin latitude, the proximal figures will remain accurate within a small percentage.

To exclude aircraft-on-ground efficiently from the search query, it is assumed that an aircraft is flying based on an airspeed value greater than 25 knots. In using this airspeed, an aircraft approaching a runway where another aircraft is holding short is excluded, two aircraft taxiing or parked are excluded, and only aircraft-in-air have been captured. Potential limitations to this assumption include high-speed taxis, in which an aircraft taxiing greater than 25 knots parallel to an aircraft landing could be captured. However, there is utility in keeping the exclusion value close to 25 knots, such that a high-speed turnoff with aircraft in close proximity, or a close go-around with an aircraft on rollout could be captured , although this event has not yet been seen in the data.

Initial Modeling Framework

In the first attempt at data query, a local workstation and SPSS were utilized. Runtimes with a large (10GB) data set are in the multiple-hour range, and not pragmatic for routine data analysis. In this method, individual events are identified as cases of CSV data, which require further efforts to represent visually. In this first iteration, the cases are converted to KML files using proprietary VB scripts to visualize flight paths in Google Earth. This representation is satisfactory, although it is requiring substantial human resources to produce appropriate visuals for a large data set. See original framework below in Figure 2.

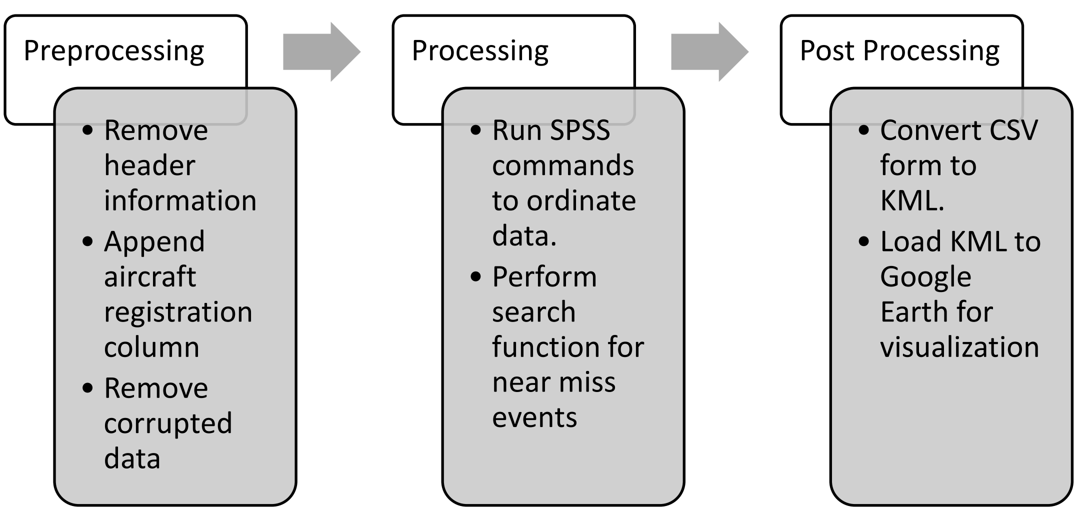

Figure 2. Original framework for near-miss analysis.

Revised Modeling Framework

In the second and current generation of data query (Figure 3), an entirely new approach was utilized. First, to improve run-time, cloud storage and computing is utilized. Multiple vendors were investigated to assess cost, CPU availability, and server-side analysis tools. Google Cloud, Big Query and Cloud Compute constitute the primary cloud resources. These tools also offer the ability to integrate neatly with various visualizations.

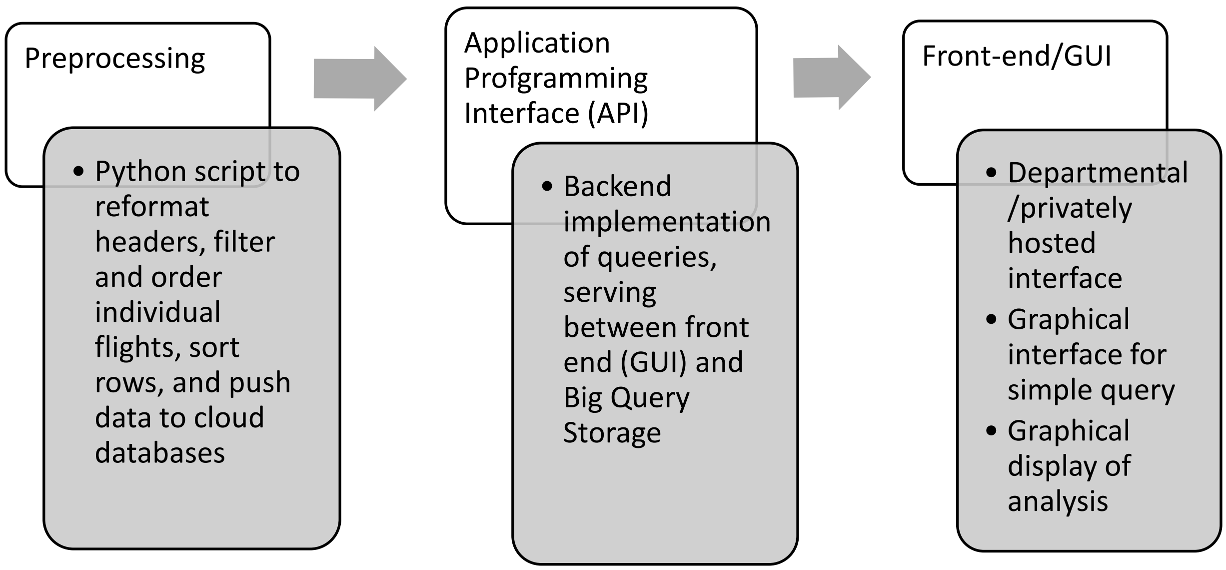

Figure 3. Improved framework for near-miss analysis and representation.

An important feature to promote departmental use of the analysis is the front-end application. The current iteration is a departmentally-hosted website that affords various stakeholders the ability to run data in near real-time. With this interface, once data is uploaded to the cloud users are able to quickly perform various analyses and are provided with user-friendly graphical displays.

As shown in Figure 4, two aircraft converge on an approach to the airport's Runway 18R. The aircraft represented by the blue line is converging with the aircraft on final, shown in red. To capture enough data to visualize an event like this, when a near-miss is discovered, the visualization will also include a few seconds before and after the proximity trigger.

Figure 4. Map-view of two aircraft converging. Note: Identifying data (Aircraft Registration) removed.

A typical near-miss proximity chart should be a parabolic curve, indicating a convergence (negative slope, left of vertex) then divergence (positive slope, right of vertex). The steepness of the curve left of vertex indicates the closure rate. Zero slope, or a flat line, indicates aircraft typically in formation, where absolute distance is roughly constant for some time. Often the slope to the right of the vertex is steeper, indicating a maneuver performed to increase the rate of divergence (Figure 5). As with the map-view, it is important to include a few seconds before and after the data meeting the definition of near miss, to contextualize the analysis.

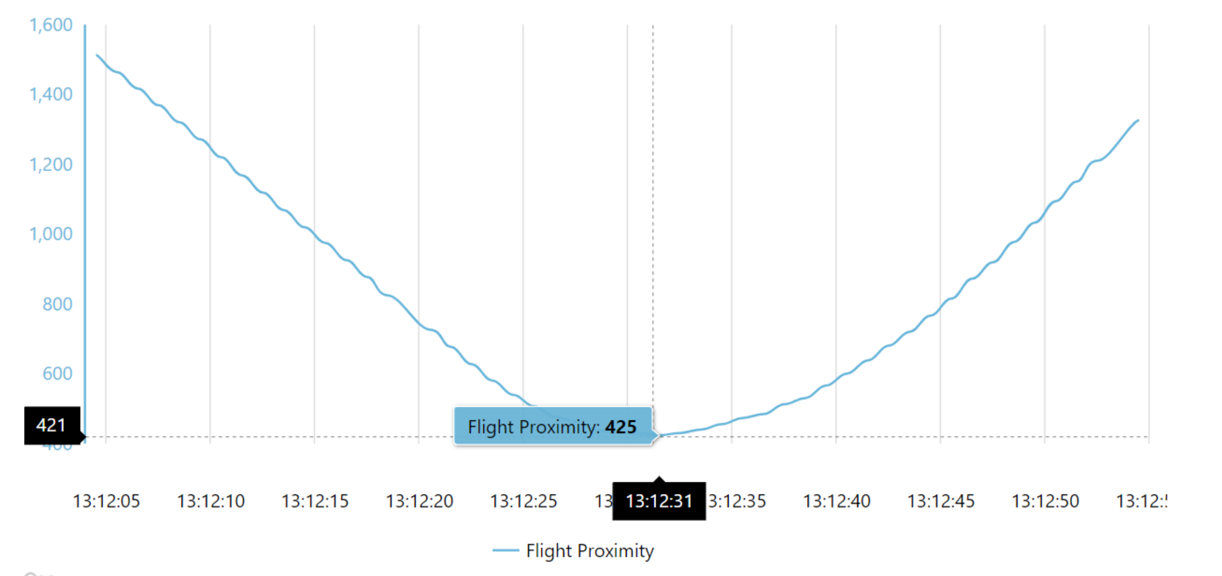

Figure 5. Proximity Visualization. Absolute distance represented by Y-axis, and time the X-axis.

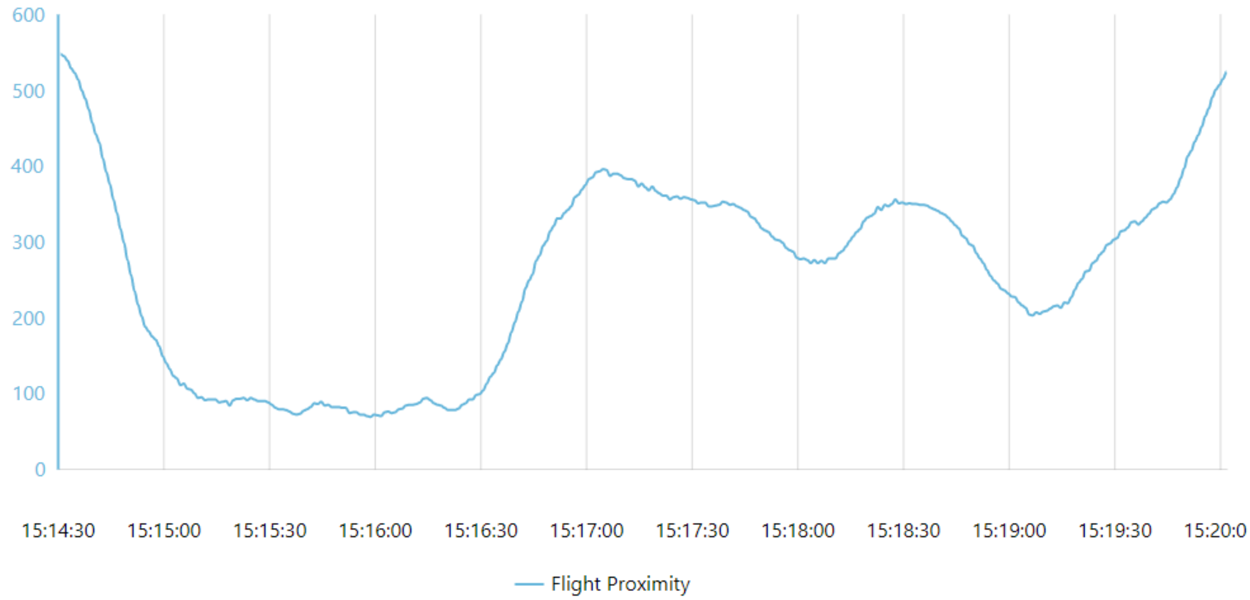

Figure 6. Atypical proximity distribution.

Limitations

While data modeling provides many opportunities for identifying near misses in the past, there are limitations with the collection and timely processing of data. Currently, only eight training airplanes are equipped with avionics (G1000, G500) capable of gathering accurate position data. At present, near midair collisions can only be identified when two or more of these aircraft are involved in the NMAC event.

At present, data cards of the training airplanes are only analyzed every two weeks causing a lag in the timely analysis of data. ADS-B data could be processed nearly instantaneously and cover all training airplanes, though is not feasible due to poor low-altitude ADS-B coverage in southern Illinois.

Conclusions & Future Development of Data Monitoring

A Flight Data Monitoring (FDM) program has the goal of improving the safety of the flight training environment. FDM is a key process within a Safety Management System (SMS) and the Safety Assurance component. The procedure for data collection is as follows: An FDM analyst removes the SD cards of the G1000 equipped aircraft two times per week during the semester. The FDM analyst will upload the data for analysis. The data is collected by the SMS Coordinator and is Reviewed by the Safety Review Committee (SRC). It is the responsibility of the FDM analyst and the Safety Review Committee to keep all recorded flight data under the FDM program confidential. The SRC will review FDM reports and make procedural or program changes to the Chief Flight Instructor and Accountable Executive if applicable.

Post-hoc metanalysis of near-miss geographic distributions reveals useful trends—the near miss events occur primarily in the traffic pattern, secondarily at a neighboring airport, and tertiarily in specific practice areas. To date, this distribution has been used systemically to reduce the number of near-miss events by way of discussion with instructors and implementing congestion limits or traffic area dispersal. The SRC and SMS Coordinator continually monitor the data so that continuous improvement within the SMS takes place and the risk of an MAC is as low as possible.

The next iteration of data modeling would benefit from heatmapping to identify trending geographic near-miss areas in near real-time. This can be accomplished as more airplanes are upgraded to advanced avionics or with better ADS-B coverage of the practice areas.

References

Federal Aviation Administration (FAA). (1970). Pilots' Role in Collision Avoidance (Advisory Circular 90-48). Washington, DC: U.S. G.P.O.

Federal Aviation Administration (FAA). (1979). Pilots' Role in Collision Avoidance (Advisory Circular 90-48A). Washington, DC: U.S. G.P.O.

Federal Aviation Administration (FAA). (1980). Pilots' Role in Collision Avoidance (Advisory Circular 90-48B). Washington, DC: U.S. G.P.O.

Federal Aviation Administration (FAA). (1983). Pilots' Role in Collision Avoidance (Advisory Circular 90-48C). Washington, DC: U.S. G.P.O.

Federal Aviation Administration (FAA). (2016). Pilots' Role in Collision Avoidance (Advisory Circular 90-48D). Washington, DC: U.S. G.P.O.

National Transportation Safety Board (NTSB). (2019). *Aviation Accident Database & Synopses.* Retrieved from https://www.ntsb.gov/_layouts/ntsb.aviation/index.aspx

Sloan, T.A. (2000). Collision Avoidance at NonTowered Airports. Collegiate Aviation Review, 18(1), 70-91.

Ullrich, G. M. & Wild, B. W., "Aviation Safety – The Basics" (2015). Open Educational Resources. 11. Retrieved from https://commons.und.edu/oers/11

Walton, A., Bauman, C., Geske, R.C. (2019). Fatal Flight Training Accident Report 2000-2015. Liberty University & AOPA Air Safety Institute.