

Visualizing Sporting Event Temporary Flight Restrictions

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DEDICATION

This thesis is dedicated to my beautiful wife, Lil' G, and G2.

Without their love and support, none of this would have been possible.

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First, I would like to thank my wife Rachel for her unending love, patience, support, and encouragement. I know I could not have done this without you. Thank you, also, to Dr. Jennifer Swift for guiding me through the completion of this thesis. I appreciate your patience through the many drafts and unexpected twists. Thank you to the other members of my thesis committee, Dr. Karen Kemp and Dr. Yao-Yi Chiang, for their expertise and support. Finally, thank you to all my family and friends who helped me in many different ways. I am grateful to everyone for their support.

TABLE OF CONTENTS

Dedication.....	ii
Acknowledgements.....	iii
List of Tables	viii
List of Figures.....	ix
Definitions and Abbreviations	xi
Abstract.....	xiii
Chapter One: Introduction	1
1.1. Definition	2
1.2. History.....	3
Chapter Two: Motivation.....	5
2.1. Aviation Information.....	6
2.1.1. Federal Aviation Administration	6
2.1.2. Direct User Access Terminal Service (DUATS).....	9
2.1.3. SkyVector	10
2.1.4. Aircraft Owners and Pilots Association.....	11
2.1.5. AeroPlanner	13
2.2. Awareness Among Pilots	16
2.3. Violating a Temporary Flight Restriction	17
Chapter Three: Objective.....	19

3.1. Study Area.....	20
3.2. Audience.....	20
3.2.1. Spatial Database.....	22
3.2.2. Project Website.....	22
3.3. Proposed Uses	23
3.3.1. Project Database.....	23
3.3.2. Project Website.....	24
Chapter Four: Technology And Development.....	25
4.1. Data	25
4.1.1. Stadium/TFR Data	25
4.1.1.1. National Football League (NFL).....	25
4.1.1.2. Major League Baseball (MLB).....	26
4.1.1.3. National Collegiate Athletic Association (NCAA) Division 1 Football.....	27
4.1.1.4. National Association of Stock Car Racing (NASCAR).....	28
4.1.1.5. IndyCar.....	29
4.1.2. Airport Data	29
4.2. Choice of Software.....	30
4.2.1. CartoDB	30
4.2.2. Google Maps.....	31
4.3. Data Processing.....	32

4.4. Application Development	35
4.5. Project Development	41
Chapter Five: Methods.....	43
5.1. Programming.....	43
5.2. Evaluation Process	45
Chapter Six: Results.....	49
6.1. Sporting Event TFRs Website.....	49
6.2. Improvements Based on Evaluations	51
6.3. Spatial Database	52
6.4. User Scenario	52
6.4.1. Local Flights	52
6.4.2. Cross Country Flights	53
Chapter Seven: Conclusions	54
7.1. Limitations	54
7.2. Future Work	55
7.2.1. Regular Updates.....	55
7.2.2. Future Plans	57
References.....	60
Appendix 1 – Current FDC NOTAM.....	63
Appendix 2 – Full text of All Sporting Event NOTAMs.....	65

Appendix 3 – National Football League (NFL) Data	68
Appendix 4 – Major League Baseball (MLB) Data.....	69
Appendix 5 – National College Football Athletic Association (NCAA) Division 1 College Football Data.....	70
Appendix 6 – National Association for Stock Car Racing (NASCAR) Data.....	71
Appendix 7 – IndyCar Data	72
Appendix 8 – Complete List and description of Data Collected For each Sporting Event	73

LIST OF TABLES

Table 1 Self-reported level of knowledge about sporting event TFRs by ten respondents before and after viewing the website	47
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LIST OF FIGURES

Figure 1	www.sportingeventtfrs.com	2
Figure 2	The Federal Aviation Administration's TFR map; http://tfr.FAA.gov/tfr_map_ims/html/index.html (Federal Aviation Administration 2013a)	8
Figure 3	The FAA's image of the sporting event TFRs; http://tfr.FAA.gov/save_pages/detail_9_5151.html (Federal Aviation Administration 2009)...	9
Figure 4	A TFR shown over an aviation sectional chart from www.duats.com (Computer Sciences Corp 2013).....	10
Figure 5	SkyVector.com displaying TFRs, weather graphics, and a flight route (SkyVector 2014a)	11
Figure 6	TFR map from www.aeroplanner.com/tfr (Science Applications International Corporation 2013).....	14
Figure 7	Aeroplanner.com TFR map showing the green color used for TFRs (Science Applications International Corporation 2013).....	15
Figure 8	Free flight planning map from Aeroplanner.com (Science Applications International Corporation 2013).....	16
Figure 9	Layer selector window from SkyVector (SkyVector 2014a)	24
Figure 10	Database tables and attributes	34
Figure 11	Airports shown in blue have an operating control tower while airports shown in magenta do not have a control tower in operation (SkyVector 2014a)	36
Figure 12	Example of airport and sporting event TFR symbolization (www.sportingeventtfrs.com)	38

Figure 13 The airport data layer viewed at small scale zoom level (www.sportingeventtfrs.com)	39
.....	
Figure 14 The airport data layer with marker overlap set to "false" (www.sportingeventtfrs.com)	39
.....	
Figure 15 An example of an airport infowindow (www.sportingeventtfrs.com)	40
Figure 16 An example of a sporting event TFR infowindow (www.sportingeventtfrs.com)	41
Figure 17 Flowchart for the development of the website and spatial database	42
Figure 18 Main page of thesis website: www.sportingeventtfrs.com	43
Figure 19 Alert window notifying user to enable geolocation services within the web browser (www.sportingeventtfrs.com)	45
Figure 20 Website questionnaire sent out to pilots for feedback	46
Figure 21 Possible future spatial database design, showing the tables linked by primary keys	58
Figure 22 The image on the left shows the hand selection tool about to select Oshkosh airport. The image on the right shows the infowindow covering the airport symbol with the leader from the infowindow box pointing to nothing. (www.sportingeventtfrs.com)	59

DEFINITIONS AND ABBREVIATIONS

AGL – Altitude measured Above Ground Level

AOPA – Aircraft Owners and Pilots Association

ATC – Air Traffic Control

FAA – Federal Aviation Administration

CFR – Code of Federal Regulations

DUATS – Direct User Access Terminal Service, online version of an official, FAA sponsored weather briefing

FBS – Football Bowl Subdivision, upper tier division 1 college football, formerly division 1-A

FCS – Football Championship Subdivision, lower tier division 1 college football, formerly division 1-AA

FDC – Flight Data Center, the department of the FAA responsible for issuing NOTAMs

FSS – Flight Service Station, source of preflight information for pilots

GIS – Geographic Information System

IFR – Instrument Flight Rules, a type of flying that requires constant communication with air traffic control. Navigation and collision avoidance responsibilities are shared between the pilot and air traffic control. All airlines, most business aviation, and some general aviation flights are conducted under IFR.

INDYCAR – Trade name of the Indy Racing League, main sanctioning body of U.S. based open wheel racing

MLB – Major League Baseball

MSL – Altitude measured Above Mean Sea Level

NASCAR – National Association for Stock Car Racing

NCAA – National Collegiate Athletic Association

NFL – National Football League

NM – Nautical Mile

NMR – Nautical Mile Radius

NOTAM – Notice to Airmen. Legal notice issued by the Federal Aviation Administration advising pilots of non-standard conditions

TFR – Temporary Flight Restriction. A type of NOTAM restricting flight in certain airspace for various reasons

TSA – Transportation Security Administration

VFR – Visual Flight Rules, a type of flying where the pilot is completely responsible for navigation and collision avoidance. Communication with air traffic control is not specifically required. Used by general aviation pilots

VIP – Very Important Person, used when referring to a TFR for the President, Vice President, or First Lady

ABSTRACT

Since 2001, temporary flight restrictions (TFRs) have existed around professional baseball games, professional football games, college football games, and major races; these TFRs are commonly referred to as the sporting event TFRs. Neither the Federal Aviation Administration's (FAA) official TFR map nor the most commonly used aviation information website display the locations of these TFRs. Furthermore, an official, FAA sponsored preflight briefing does not contribute to pilots' awareness of the location or timing of these sporting event TFRs. In fact, the burden of knowing where, when, and for how long each NFL, MLB, NCAA division 1 football, NASCAR, and IndyCar event will take place is placed squarely on the shoulders of all pilots. This thesis reports on the creation of a web map specifically geared towards providing pilots with the locations and times of all sporting event TFRs in the United States. This information has been offered to the FAA and several established, popular aviation websites as both a spatial database and a web service to encourage display of these important TFRs on their web maps.

CHAPTER ONE: INTRODUCTION

Before any flight, the Federal Aviation Administration (FAA) requires pilots to become familiar with all available information concerning that flight (Federal Aviation Administration 2012a). It is a vague rule with few specific requirements. One particularly challenging aspect to compliance with this rule is the group of temporary flight restrictions (TFRs) that surround professional and collegiate sporting events. These TFRs are in existence surrounding all National League Football (NFL) games, Major League Baseball (MLB) games, National Collegiate Athletic Association (NCAA) Division 1 football games, IndyCar races, and NASCAR races. These TFRs have existed since 2001 and still are unknown to many pilots – not only because they are not visible to pilots on commonly used aviation websites, but the FAA provides little information to pilots about their existence and locations.¹

Currently, pilots are expected to individually be aware of, know the location of, and know the timing of all sporting events on or near their flight route. While there are a few websites that help pilots find this information, their limitations are discussed in section 2.1. To address this critical need, this thesis documents the creation of a spatial database containing all of the sporting event TFRs in the United States. This database is intended to be freely available to the most current and commonly used aviation data websites to date for inclusion in their online flight planning web maps, if desired. A flight planning web map typically consists of an aviation sectional basemap with an airport layer, a navigational facility layer, and multiple weather layers. Furthermore, the compilation of the database led to the development, testing and implementation of a standalone Web GIS created to improve pilots' awareness of these flight restrictions (Figure

¹ It is important to note that the author is a commercial pilot with twelve years' experience, 4000+ hours of flight time, and has been an FAA certified flight instructor for seven years.

1). This unique new website allows pilots to easily identify locations and times of these TFRs, a convenient and critical online tool which heretofore was unavailable to pilots.

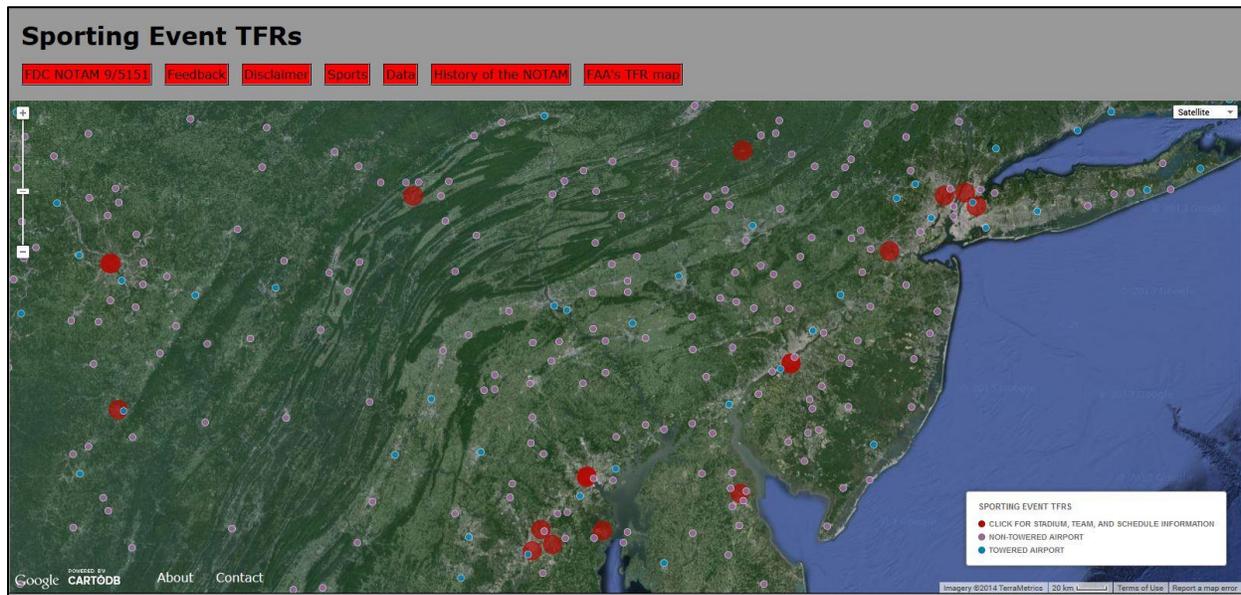


Figure 1 www.sportingeventtfrs.com

1.1. DEFINITION

A notice to airmen, or NOTAM, is a caution issued to all pilots that something is different than standard. NOTAMs are regularly issued for tower lights that have burned out or radio frequencies that are temporarily out of service. When the NOTAM is regulatory in nature, it is issued by the Flight Data Center (FDC). These FDC NOTAMs are often issued for mandatory changes to airport approach procedures. One other type of FDC NOTAM that is of concern to all pilots restricts flight in certain areas for varying reasons; these are more commonly called temporary flight restrictions (TFRs).

TFRs are usually issued for safety reasons – both the safety of persons and property on the ground underneath the TFR and the safety of pilots flying into the area. For example, every year TFRs appear throughout the western United States surrounding forest fires. Similar disaster

TFRs will appear after major tornadoes, hurricanes, or other natural disasters. TFRs are issued for less devastating reasons as well. Throughout the spring, summer, and fall, TFRs appear around airshows to allow the performers to operate freely without the fear of an aircraft entering into the area. When the President of the United States travels, a 30 nautical mile (NM) radius TFR exists wherever the president is staying. Similar, yet much smaller, VIP TFRs are created for the First Lady and the Vice President of the United States (Federal Aviation Administration 2012a).

The main topic of this thesis is TFRs that currently exist around major sporting events. After years of ambiguity that is further discussed in section 1.2, “major sporting events” was defined by the Federal Aviation Administration (FAA) in 2002 to include all regular and post season Major League Baseball (MLB) games, National Football League (NFL) games, National Collegiate Athletic Association (NCAA) Division 1 football games, National Association for Stock Car Racing (NASCAR) races, and IndyCar races (AOPA 2002a). These sporting event TFRs begin one hour prior to the start of the game or race and expire one hour after the game or race ends (Federal Aviation Administration 2009). The full text of the current NOTAM that creates these sporting event TFRs can be found in Appendix 1.

1.2. HISTORY

In the wake of the 11 September, 2001 (hereinafter “9/11”) terrorist attacks, the FAA issued many new TFRs, including the sporting event TFRs. According to Michael Brown, the FAA’s use of TFRs has grown significantly since then (Brown 2003). In its initial form, as issued on 20 September, 2001, the sporting event TFR included “all major professional and collegiate sporting events” and “all major open air assemblies” of people (Magnan 2001). Full

text of every revision of the sporting event NOTAMs can be found in Appendix 2. Uncertainty as to where, when, and how long the TFRs existed was the biggest problem from the issuance of the original sporting events TFRs. There wasn't an official definition of a major sporting event and no clarification was given regarding the definition of a major open air assembly, leaving it open to the interpretation of pilots, FAA inspectors, and Transportation Security Administration (TSA) agents. Finally, by December of 2001, the FAA identified a major open air assembly as more than 10,000 people, effectively excluding most high school and other smaller events (AOPA 2001). Nevertheless there was still uncertainty about the definition of a major sporting event and the timing of the TFRs.

In July 2002, the Aircraft Owners and Pilots Association (AOPA) petitioned the FAA and TSA to further clarify the uncertainty surrounding the sporting event TFR NOTAM (The Weekly of Business Aviation 2002, AOPA 2002b). In September 2002, the FAA reissued the sporting event TFR NOTAM with a few major changes, most of which had been recommended by the AOPA. The uncertainties surrounding open air assemblies and the definition of a major sporting event were cleared up by limiting the TFR to MLB games, NFL games, NCAA division 1 football games, and major race events with seating capacities greater than 30,000 people. Further uncertainty surrounding the times of the TFRs was also clarified by stating that the TFRs begin one hour prior to the game or race and expire one hour after the game or race concludes (AOPA 2002a), as stated previously.

In February 2009, a new revision of the sporting event TFR NOTAM was issued (Federal Aviation Administration 2009). Further clarification was given to major sporting events by specifying regular and post season games. Also, major race events were defined as NASCAR, IndyCar and Champ series races.

CHAPTER TWO: MOTIVATION

As previously mentioned, the FAA requires specific preparations of pilots prior to beginning a flight. 14 CFR 91.103 is entitled Preflight Action; generically, it requires that all pilots become familiar with all available information prior to beginning the flight. It is a vague rule with no specific information requirements other than “all.” The FAA provides a service to pilots to assist in attempts to acquire all pre-flight information. This service is a professional weather briefing from a trained weather briefer. Since 2005, the service has been contracted out by the FAA to Lockheed-Martin (Federal Aviation Administration 2011). In addition to pertinent large-scale weather events, as well as current and forecast local weather, the briefers provide pilots with important NOTAMs including any TFRs.

Because NOTAMs are issued for non-standard conditions, they are temporary, lasting only until the condition is returned to its original state or published as the new, de facto standard. TFRs are no different, with VIP and airshow TFRs usually lasting only a few hours. Disaster TFRs will last a while longer: days or sometimes weeks, but not usually longer. The sporting event TFRs are an exception to this; as of 2014, the current sporting event TFR NOTAM is five years old (the previous one lasted six years before it was revised). With the phrase “effective...until further notice” included in the text of the NOTAM, there is no end in sight (Federal Aviation Administration 2009). The sporting event TFRs are, for lack of a better description, permanent temporary flight restrictions.

This is important to pilots because every 28 days, long-standing NOTAMs are grouped together and published to ease the burden of the preflight weather briefers (Federal Aviation Administration 2012a). Published NOTAMs can still be obtained by pilots digitally through the FAA’s website or in print version from the Government Printing Office (Federal Aviation

Administration 2013b). Published NOTAMs are not included in a standard preflight weather briefing from the official, FAA-sponsored, Lockheed-Martin weather briefers (Federal Aviation Administration 2012a). The fact that the sporting event TFR NOTAM is published and not included in a standard weather briefing places an extra burden on every pilot to separately seek out information about the current sporting event NOTAM in addition to obtaining an official weather briefing.

2.1. AVIATION INFORMATION

With the current burden of finding information placed on each individual pilot, it is shocking how little information is readily available about the sporting event TFRs. The following discussion provides a review of sources of TFR data.

2.1.1. *FEDERAL AVIATION ADMINISTRATION*

Because frequent and numerous TFRs are a fact in the post 9/11 aviation world, much is written about them (Bergqvist 2012, Hoffmann 2009, Munson 2011, Perdue 2005). In a bi-monthly FAA publication entitled *FAA Aviation News*, the first eight pages are dedicated to TFR awareness. Although the sporting event TFRs are mentioned in only one paragraph (Brown 2003), the author does provide a few tips to pilots to help maintain awareness of TFRs both before and during flight. Brown's (2003) first tip is to know your airspace. This is a fine suggestion if pilots intend to only fly in the local area, but it is of little help when pilots fly into less familiar areas. Brown's second suggestion is also of little help to stay aware of the sporting event TFRs. He also suggests pilots obtain an official weather briefing prior to every flight (2003). As mentioned previously, the preflight briefings do not include long-standing, published

NOTAMs which include the sporting event TFRs. Calling the preflight weather briefers will not contribute to pilots' awareness of the sporting event TFRs relevant to the flight. Brown's (2003) final suggestion is to check resources available on the internet. These web-based TFR resources are discussed subsequently.

One of the TFR resources that Brown mentions is the FAA's online TFR map, seen in Figure 2. The map is an easy to use online geographic information system (GIS) that allows users to zoom to specific states or Air Traffic Control (ATC) areas. While the map in its smallest scale displays political boundaries and topography, once zoomed in to larger scales, the map background changes to an aviation sectional chart. This familiar aviation themed background gives pilots better awareness of the locations of TFRs relative to familiar aviation features. Clicking on a text link below the map opens an information page with detailed intelligence about the specific TFR's altitude, location, time, and affected areas (Federal Aviation Administration 2013a).

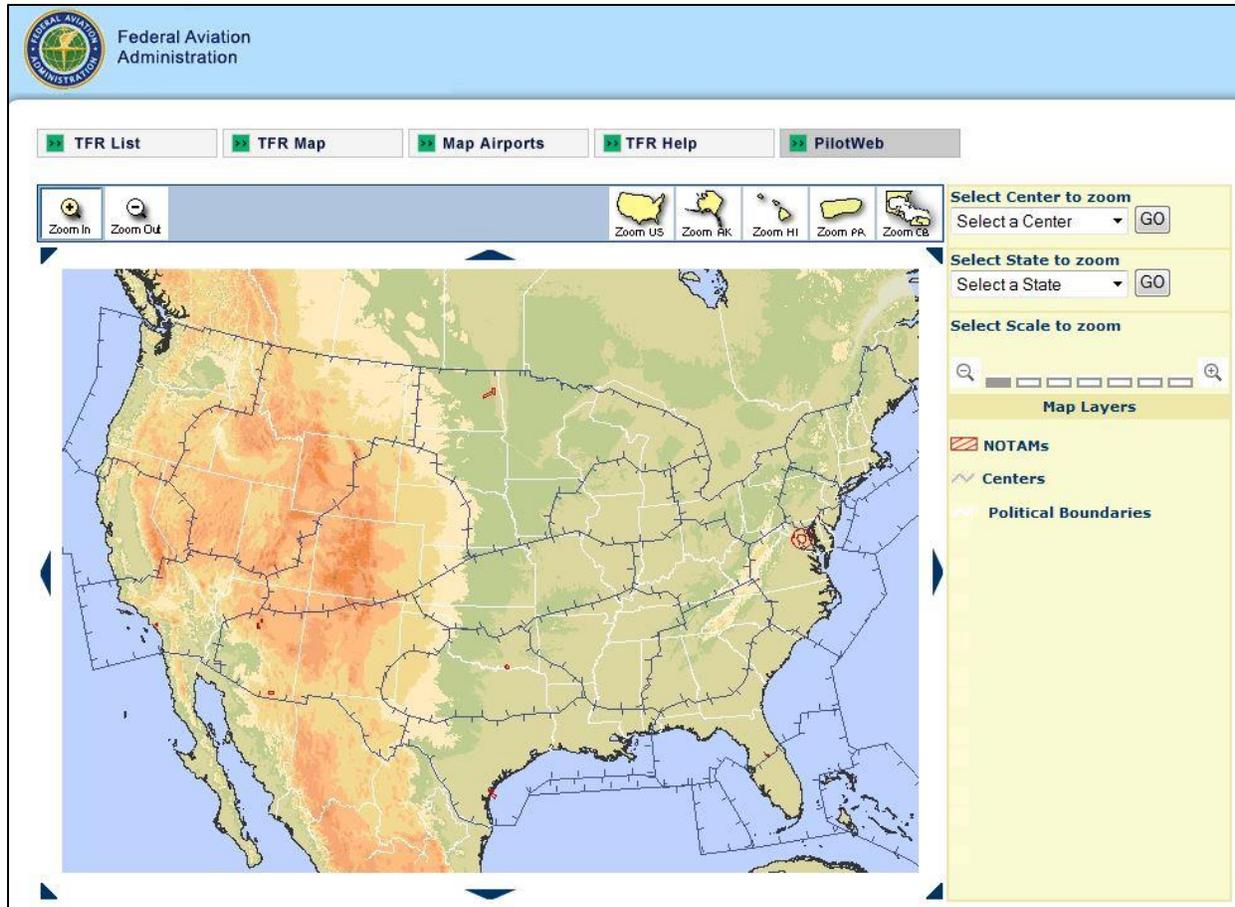


Figure 2 The Federal Aviation Administration's TFR map; http://tfr.FAA.gov/tfr_map_ims/html/index.html (Federal Aviation Administration 2013a)

While this website does display TFRs over an aviation sectional background, it does not help pilots visualize or plot their flight paths with respect to the TFRs. Additionally, the site mentions the sporting event TFRs and provides the text of the NOTAM, but it doesn't display the sporting event TFRs anywhere on the map. In fact, the image associated with the sporting event TFRs is a red "x" over the text, "No Shape Currently Available," as seen in Figure 3. Also, the information page about the sporting event TFR only contains the raw NOTAM text. There isn't even a list of affected stadiums, teams, or race tracks, leaving all of this information up to pilots to obtain.

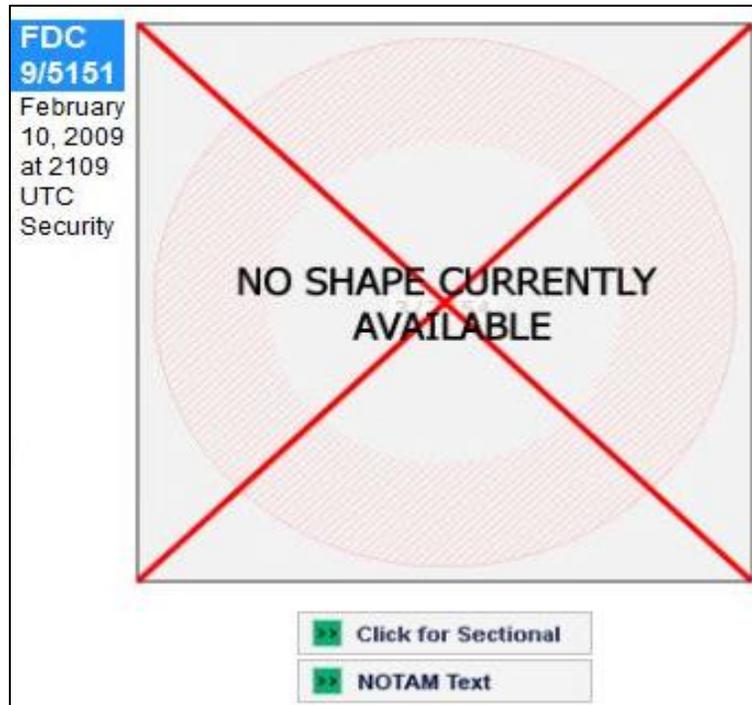


Figure 3 The FAA's image of the sporting event TFRs;
http://tfr.FAA.gov/save_pages/detail_9_5151.html (Federal Aviation Administration 2009)

2.1.2. *DIRECT USER ACCESS TERMINAL SERVICE (DUATS)*

The direct user access terminal service, or DUATS, is the online equivalent of obtaining an official FAA sponsored preflight weather briefing (Federal Aviation Administration 2012a). This site requires a username and password that can be easily obtained, for free, by any pilot with a current aviation medical certificate. Once logged in, the website provides ample weather information and a high quality flight plan.

The TFR section of the DUATS website provides a low quality web map that displays TFRs over a plain background. The map does not offer the option to change the background to display an aviation sectional or to display a flight route relative to the TFRs. Once zoomed in, detailed information is displayed about the individual TFRs and a map is shown displaying the TFR over an aviation sectional basemap. As can be seen in Figure 4, separate map tiles were

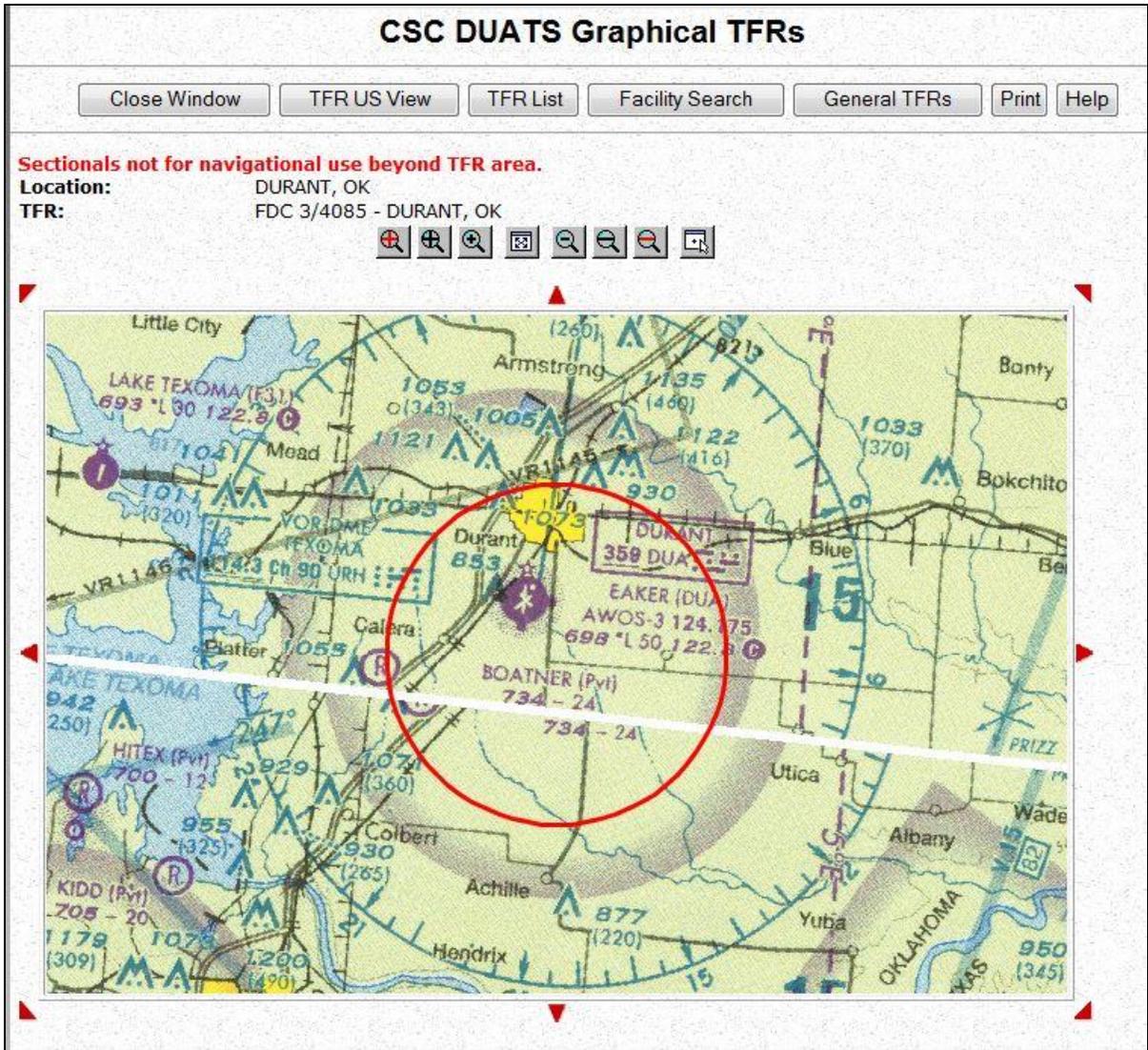


Figure 4 A TFR shown over an aviation sectional chart from www.duats.com (Computer Sciences Corp 2013)

poorly scanned and not stitched together properly, giving the map a low quality appearance. Furthermore, this website only mentions the sporting event TFRs in text form; they are not displayed on the map (Computer Sciences Corp 2013).

2.1.3. SKYVECTOR

SkyVector.com is a high quality online GIS that rapidly became very popular for preliminary preflight planning. The site has steadily added more features since its initial launch,

making it nearly a single source of preflight information for both route planning and weather (SkyVector 2014a). As seen in Figure 5, this website shows TFRs. SkyVector.com even displays the user's flight route on the aviation sectional, making it very easy for pilots to see their flight route relative to active TFRs. Despite all its useful features, it was not until learning about this thesis work that SkyVector.com began to display a limited number of sporting event TFRs, which is discussed in detail in section 6.3 (SkyVector 2014a, Graves 2014).

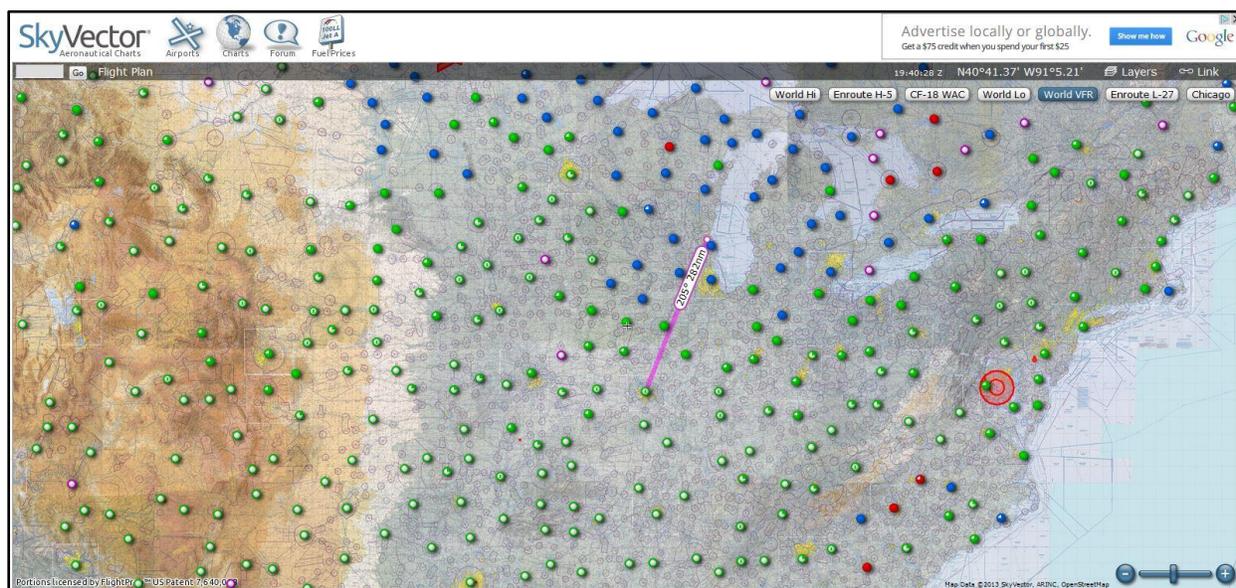


Figure 5 SkyVector.com displaying TFRs, weather graphics, and a flight route (SkyVector 2014a)

2.1.4. AIRCRAFT OWNERS AND PILOTS ASSOCIATION

In the article from *FAA Aviation News*, Brown (2003) lists online resources where pilots can obtain further information about TFRs. One of the websites he mentions is the AOPA. Unlike the other websites mentioned, the AOPA's website is not primarily for flight planning. While the site does have a flight planner that incorporates weather and TFRs, the main goals of the AOPA are advocacy, education, and promoting general aviation (AOPA 2011). Similar to

the other websites mentioned, the AOPA's online flight planner does not include the sporting event TFRs.

What the AOPA offers that other sites do not is a list of stadiums and speedways that qualify as sporting event TFRs. However, this list has many limitations. First, it has no associated interactive map, making it difficult for pilots to understand their flight paths relative to the listed stadiums and speedways. Pilots who are unfamiliar with the location of a particular sports stadium or speedway must use the provided latitude and longitude to manually plot the TFR on an aviation sectional chart (AOPA 2008).

The second limitation of the AOPA site is that it incorporates a round-about way of determining the sports schedule. Instead of a link associated with a specific team, stadium, or speedway, only one link is present for each sporting league. Both the NFL and MLB links take users to a full league schedule, forcing site users to weed through every team to find the game they are interested in. The site's NCAA schedule link takes users to a generic NCAA website which requires at least three more steps before linking to a generic sports team website for a particular college or university. Finding the football teams' schedules requires even more steps. Forcing users to search for information, especially when it requires multiple steps, only makes it less likely that the information will be found, or that the user will give up before locating the information. The racing links on the AOPA website are even worse; of the five links, as of January 2014, three are broken and one links to race results from 2008. The only link that actually opens a current racing schedule is for Formula 1 racing – which isn't one of the sporting events listed by the sporting event TFR NOTAM (AOPA 2008). Furthermore, 18 of the 19 Formula 1 races in 2013 aren't in the United States, so the sporting event TFR wouldn't apply anyway.

The third limitation of the AOPA's list of sports stadiums and race tracks is that as of January 2014, it was most recently updated in 2008 (AOPA 2008). In the five years since the website was last updated, the Dallas Cowboys (NFL), New York Jets (NFL), New York Giants (NFL) (Breer 2012), Minnesota Twins (MLB), Minnesota Gophers (NCAA), New York Yankees (MLB), and Miami Marlins (MLB) all built new stadiums. While the Twins, Gophers, and Yankees moved less than two miles away, the Cowboys and Marlins built new stadiums in different cities. All of these changes are not reflected on the AOPA's list of stadiums and race tracks.

2.1.5. *AEROPLANNER*

Another online TFR resource mentioned by Brown (2003) in his article is Aeroplanner.com. At the time this research was conducted, this was the only website that displayed the sporting event TFRs. Nevertheless, this site still leaves much to be desired. The website's TFR map can be seen in Figure 6. A Google map is provided that allows users to switch the basemap between a traditional Google map and common aviation navigational charts. This is a convenient feature that allows users to see the TFRs with respect to common aviation features. However when a TFR is clicked on, the user is only provided with the name of the stadium or speedway, forcing the user to independently search elsewhere for the team name and the team's schedule.

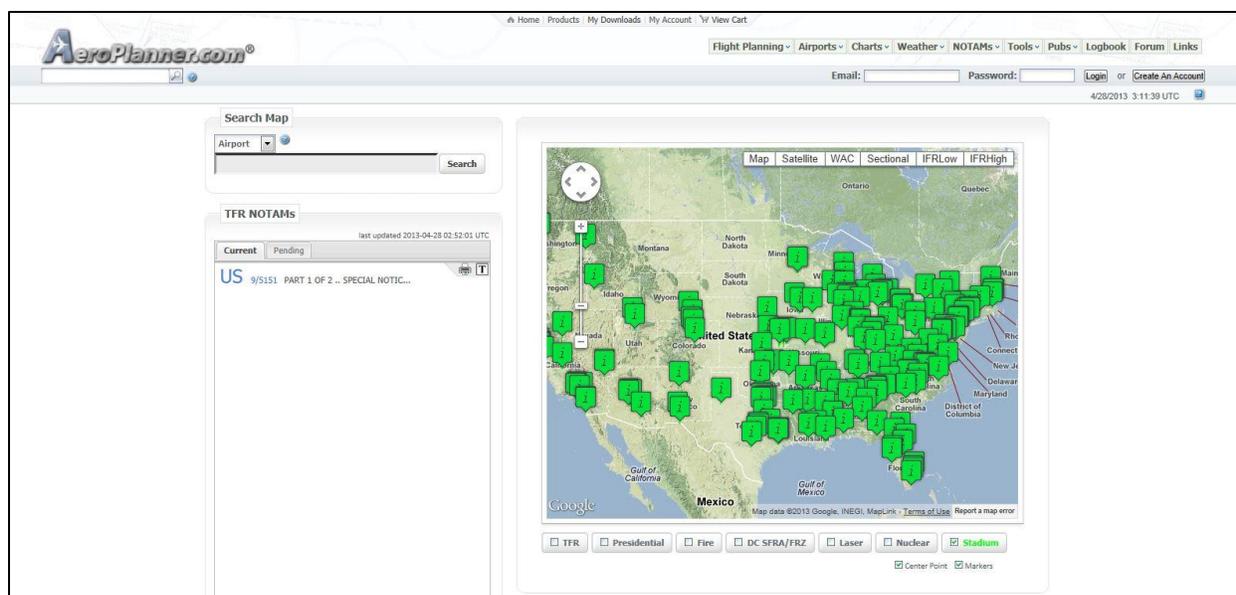


Figure 6 TFR map from www.aeroplanner.com/tfr (Science Applications International Corporation 2013)

In addition to requiring the user to search for teams and schedule information elsewhere, the site's TFR map also has other limitations. The color used to indicate a TFR is green and drawn with a very thin line. When zoomed in, the green TFRs (Figure 6) are difficult to see over any basemap used, as illustrated in Figure 7. This TFR map allows users to pan and zoom to different areas, but it does not allow users to display a flight route on the map (Science Applications International Corporation 2013).

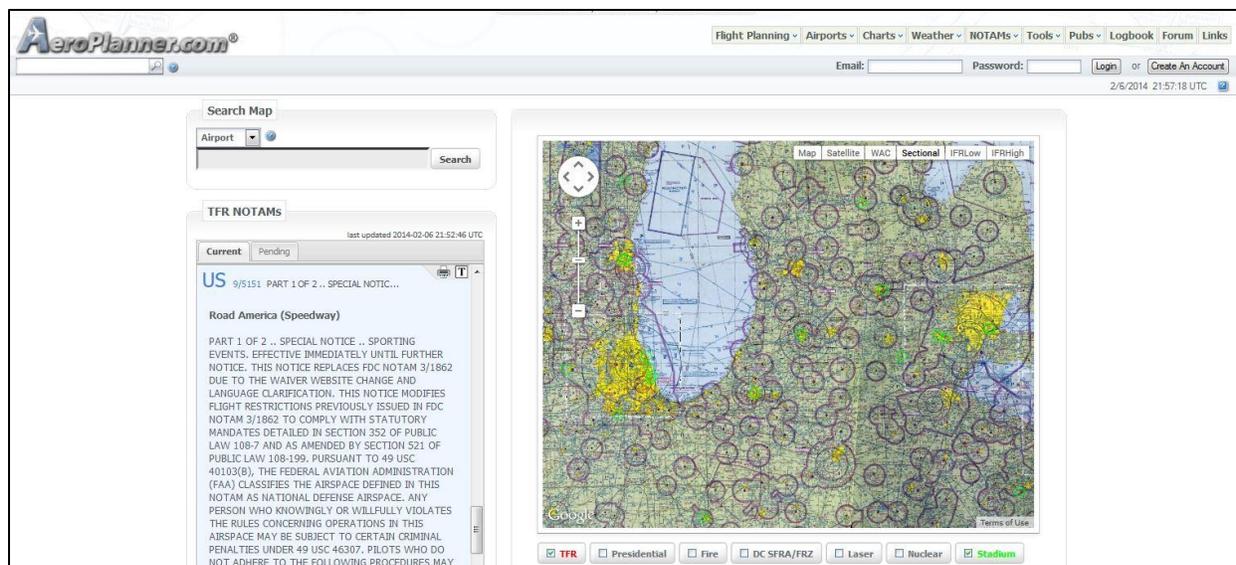


Figure 7 AeroPlanner.com TFR map showing the green color used for TFRs (Science Applications International Corporation 2013)

The AeroPlanner.com TFR map also contains misleading information. In the upper left corner of Figure 7 is the speedway Road America. According to Kallmann of the Milwaukee Journal Sentinel (2013), A NASCAR race has never been held at Road America, and an IndyCar race has not been held there since the last year of the Champ series in 2007. Kallmann mentions possibilities for future NASCAR and or IndyCar races, but neither racing league is scheduled to race at Road America in 2014 (IndyCar 2014, NASCAR 2014) . Showing Road America on the TFR map provides pilots with incorrect information regarding the existence of a sporting event TFR at Road America.

In addition to the TFR map, AeroPlanner offers four different levels of web-based flight planning service to pilots; one free and three levels of paid services. The free flight planning service, which is preferred by many general aviation pilots, does offer users the ability to plot a flight and show the flight relative to TFRs and other special use airspace. As seen in the example in Figure 8, the map area is very cluttered and hard to read, with no obvious legend. The

map display is also very small, taking up less than half of the usable white space in the site main frame. Unlike the TFR map, the flight planning service map does not allow users to pan or zoom. It does display the sporting event TFRs as green circles, but these features are not interactive, i.e. clicking on a TFR symbol does not provide the user with further information. At most zoom levels, the TFR circles are small and hard to see (Science Applications International Corporation 2013). Using the color green to symbolize a TFR does not help site users visually interpret the meaning of the map symbol. Green color implies go, whereas red is the industry standard color for TFRs. Using a nonstandard color could cause a misinterpretation of the symbol and possibly cause a TFR incursion by a site user.

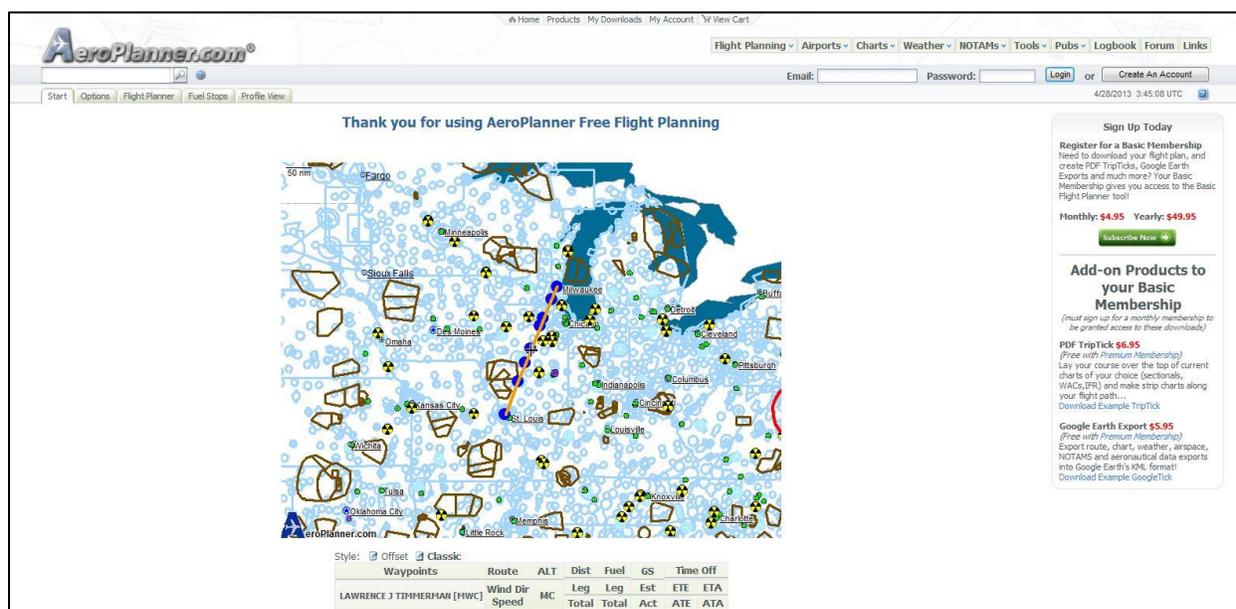


Figure 8 Free flight planning map from AeroPlanner.com (Science Applications International Corporation 2013)

2.2. AWARENESS AMONG PILOTS

In the article *Father's Day TFR* posted on AvWeb, a 35 year veteran pilot and lawyer discusses his own lack of knowledge about the sporting event TFRs (Hayes 2005). He was planning a flight for the following day when his son happened to mention a NASCAR race at

Michigan International Speedway scheduled for the same day. Much of the article describes his confusion as to why the TFR over the speedway was not displayed on any device he normally used for flight. Fortunately for Hayes and his son, a mechanical issue grounded the airplane, so they were forced to drive instead of fly. Had they flown, they may have unknowingly violated the TFR (Hayes 2005).

A shocking lack of awareness about these sporting event TFRs can be seen by reading online message board posts by pilots. One such message board is at PilotsOfAmerica.com. One particular thread is entitled, “Dinged on a Non Published TFR.” The thread was initiated by a user recapping a recent flight his friend took. After landing, his friend was informed by Air Traffic Control (ATC) that he had violated the TFR around the West Point NCAA D1 football stadium (Pilots of America 2011). The comments and responses to the initial post further display the lack of knowledge about these sporting event TFRs. Many comments lament the lack of information from the FAA about these TFRs. Others indicate shock at the immense amount of information required by pilots about the locations of the sporting events in order to prevent any violations (Pilots of America 2011).

2.3. VIOLATING A TEMPORARY FLIGHT RESTRICTION

Confusion among pilots surrounding sporting event TFRs can be dangerous and costly. Violation of any FAA rule or regulation could result in a fine or a suspension or revocation of flying privileges. All TFRs, including sporting event TFRs, are regulated under parts 91 and 99 of the Federal Aviation Regulations (Federal Aviation Administration 2012a). Within the text of the NOTAM, the FAA outlines the possible penalties for pilots who violate the TFR. Pilots flying into the TFR without proper authorization “may be subject to certain criminal penalties

under 49 USC 46307. Pilots... may be intercepted, detained (sic) and interviewed by law enforcement/security personnel” (Federal Aviation Administration 2009). These are some of the primary impetus motivating this project, described in detail in the next chapter.

CHAPTER THREE: OBJECTIVE

There are two primary goals of this thesis. The first is to create a complete spatial database of the locations of the sporting event TFRs. As identified in section 2.1, most websites that provide TFR information don't display any of the sporting event TFRs as text or as features on maps. Of the few websites that do mention these TFRs, they do not have a visual component, are not updated recently or regularly, contain inaccurate or incomplete data, and/or require pilots to seek additional information elsewhere. The database created as part of this thesis includes a spatial component for easy visualization. The plan to update the database regularly is discussed in section 7.2.1. A major component of this database is direct access to the schedule of the team and the stadium, speedway, or league, making it easier for pilots to determine when the TFR will be active. Future plans to incorporate a temporal component into the database are discussed in section 7.2.2.

The second main objective of this thesis is to create a simple, easy to use web map of existing TFRs geared towards pilots. As identified in section 2.2, many pilots are unaware of the existence of these sporting event TFRs. Pilots who are aware that they exist may not be familiar with *every* stadium and speedway where a TFR exists. This website will help increase awareness and knowledge of the sporting event TFRs by focusing on their existence and including a plain English explanation of the NOTAM. Pilots who use this site have the opportunity to gain better knowledge of all locations of the TFRs through the web map. Furthermore, while all other websites require pilots to do independent i.e. web searches elsewhere to find team/race schedules, this project website aids pilots in determining when the TFRs are active by providing links to the teams' schedules with one simple click of the mouse.

3.1. STUDY AREA

The Federal Aviation Administration has jurisdiction over the entire United States and can issue TFRs in any state. As of 2014, there are sporting event TFRs in 43 states; Alaska, Montana, North Dakota, South Dakota, Maine, Vermont, and Rhode Island do not have any sporting events that require a TFR. However, the possibility exists in the future for a NASCAR or IndyCar race to be held in one of those states or for a NCAA football program located in one of those states to transition into division 1. Some sporting events that require a TFR are held outside of the United States. Those are discussed individually in section 4.1.1.

Because of the overlap of the sports seasons, these sporting event TFRs exist year round. The majority of the TFRs occur during the summer months with baseball games occurring nearly every day from April through September. With the lengths of the seasons, number of teams, and quantity of games or races each year, there are over 3300 sporting event TFRs throughout the United States every year.

3.2. AUDIENCE

It is the responsibility of all pilots to be aware of all available information concerning their flight (Federal Aviation Administration 2012a). This FAA requirement implies knowledge of airport information, current and forecast weather, airplane performance, alternate planes, and any other pertinent information including NOTAMs and TFRs. A pilot who is in communication with an ATC facility will receive assistance from that facility in maintaining awareness of weather, NOTAMs, and TFRs, but pilots cannot completely rely on ATC.

Pilots flying under Visual Flight Rules (VFR) are not required to communicate with ATC as pilots flying under Instrument Flight Rules (IFR) are. VFR is a type of flying that requires the

pilot to maintain visual reference to the outside while IFR is a type of flying that allows a pilot to operate in clouds and poor weather while maintaining control of the aircraft solely by reference to the aircraft's flight instruments. In reality, communication with ATC is not required in most airspace within the United States for pilots operating under VFR. While communication with ATC is still an option for these pilots, many choose to navigate on their own and forgo the added benefits of communication with ATC. Some pilots choose not to communicate with ATC because of inexperience, lack of practice, fear of talking on the radio, or lack of proper aircraft equipment. Furthermore, ATC services provided to these VFR pilots are on a workload-permitting basis only (Federal Aviation Administration 2012a). This means that even if the pilot is in communication with ATC, the controller is not required to provide any navigation, collision avoidance, or other services to the pilot. During busy times of the day or in busy airspace, ATC will occasionally refuse or terminate services to general aviation pilots flying under VFR.

Pilots flying under Instrument Flight Rules (IFR) are required to maintain constant communication with ATC, thus ATC cannot refuse or terminate services (Federal Aviation Administration 2012a). Even when flying IFR, pilots are required to maintain situational awareness, as communication with ATC does not relieve a pilot of his or her responsibility towards the safety or legality of the flight (Federal Aviation Administration 2012a). This means that all pilots must stay aware of the airspace they are flying in, other traffic in the area, and all other aspects of the flight.

All pilots are responsible for obtaining all available information concerning the flight, regardless of whether the pilot will be flying VFR or IFR, and regardless of whether the pilot will be talking to ATC or not (see discussion of the website's disclaimer in section 6.1). Both

the spatial database and the website are designed to help pilots become better aware of the locations and times of the TFRs surrounding sporting events.

3.2.1. *SPATIAL DATABASE*

The websites discussed in section 2.1 are many of the most common online flight planning tools preferred by pilots. Many pilots already have a favorite flight planning tool that they reference for preflight and in flight information. It is outside the scope of this thesis to create a competing flight planning website, however it is still important that pilots have access to this important sporting event TFR information. While pilots are the primary audience for the information contained within the spatial database created as part of this thesis work, the database itself is designed to be shared with the existing web and mobile flight planning websites and application with the hope that they will display the information on their flight planning map for the benefit of pilots.

3.2.2. *PROJECT WEBSITE*

The website created as part of this thesis work is designed as a place to display the contents of the spatial database that any pilot can access, regardless of whether or not any other websites decide to display the information. Furthermore, the website is designed to increase awareness and improve knowledge of these sporting event TFRs. As discussed in section 2.2, many pilots are unaware of the existence and location of these sporting event TFRs. Thus the website is simply intended to be an information source for pilots, to provide easy access to the location and schedule of sporting event TFRs.

3.3. Proposed USES

The following discussions in this chapter describe the proposed uses for the spatial database and website created for this thesis.

3.3.1. *PROJECT DATABASE*

As discussed in section 3.2.1, the spatial database created as part of this thesis work is designed to be shared with current aviation flight planning websites and applications. As shown in Figure 9, most of the online flight planning programs give pilots the ability to select different aviation-related layers to be displayed on the map. For example, Figure 9 displays all the weather layers available to a map user. The sporting event TFR database features could be added to this map as an additional selectable polygon layer. Giving pilots the ability to display the sporting event TFRs on a website such as SkyVector.com will give pilots the added benefit of being able to visualize the sporting events TFRs relative to their plotted flight path as shown previously in Figure 5.

JavaScript code and HTML code are used to display the spatial database on a Google map. Additional programming beyond the scope of this project would be necessary to add the layer to a layer selector window and give the user the ability to turn the layer on and off, such as the dialog shown in Figure 9 from SkyVector.com.



Figure 9 Layer selector window from SkyVector (SkyVector 2014a)

3.3.2. PROJECT WEBSITE

Any pilot interested in obtaining information about sporting event TFRs can visit the current website created as part of this thesis. The user is able to scroll around the map and zoom in and out in order to find sporting events or stadiums of interest. Clicking on the TFR symbol opens up a popup window. Within the window, the pilot is able to click on a link which takes the user directly to a schedule of the home team's games. Based on a particular schedule, the pilot will know if there is a game scheduled that particular day or not. The intention is that access to the schedule will help the pilot determine the start of the game, which will define the start time of the TFR.

The next chapter provides a detailed discussion of the technology utilized to create the spatial database that is the main data source in the website.

CHAPTER FOUR: TECHNOLOGY AND DEVELOPMENT

This chapter details the development of the spatial database, from data collection through software choices, to application development.

4.1. DATA

Two spatial data sources were necessary for this thesis. The primary features are the locations of the stadiums and speedways where sporting events are held that qualify for a TFR. Additionally, a feature layer of public use airports was also added for reference, for map navigation purposes.

4.1.1. *STADIUM/TFR DATA*

A single, reliable source of all stadiums and speedways qualifying for a TFR was not found on the internet or in the published literature. The only list of locations freely available was obtained from the Aircraft Owners and Pilots Association, which, as discussed in section 2.1.4, was outdated, incomplete, and inaccurate. It was apparent that creating a new, complete list of stadiums and speedways and collecting accurate data on these spatial features was the best way to proceed.

4.1.1.1. *NATIONAL FOOTBALL LEAGUE (NFL)*

There are thirty-two teams in the National Football League (NFL). The complete list of NFL teams was obtained from nfl.com in July 2013. For each team, stadium name, address information, phone number, team homepage website, and team schedule website were obtained

from nfl.com (NFL 2013a). Additionally for each team, precise latitude and longitude coordinates were obtained from Google Maps by zooming in on the stadium, right clicking on the map, and selecting, “What’s here?” from the menu. For consistency, the center of the team’s logo on the 50 yard line was used for the latitude and longitude coordinates. In instances where the logo was not visible, i.e. a domed stadium or field markings were not present, a point close to the center of the stadium was approximated. For consistency with other leagues, a URL link to the team’s schedule was also obtained from espn.com.

The National Football League has been sending teams to London for a feature game each season (NFL 2013b). Additionally, the Buffalo Bills play one home game each season in Toronto, Canada (Rodak 2013). Because these games are outside U.S. airspace, a sporting event TFR does not exist over those games. See Appendix 3 for a sample of NFL data and Appendix 8 for a description of all data collected.

4.1.1.2. MAJOR LEAGUE BASEBALL (MLB)

There are 30 Major League Baseball (MLB) teams. The complete list of teams was obtained from mlb.com in July 2012. For each team, stadium name, address information, phone number, team homepage website, and team schedule website were obtained from mlb.com (MLB 2013). Additionally for each team, precise latitude and longitude coordinates were obtained from Google Maps by zooming in on the stadium, right clicking on the map, and selecting, “What’s here?” from the menu. For consistency, home plate was used for the latitude and longitude coordinates. In instances where home plate was not visible, i.e. a domed stadium or bases were not present, a point as close to the center of the stadium was approximated. For

consistency with other leagues, a URL link to the team's schedule was also obtained from espn.com.

The Toronto Blue Jays, a Major League Baseball team, are based in Toronto, Ontario, Canada. Because it is more than three nautical miles away from U.S. airspace, no sporting event TFRs exist over that stadium. See Appendix 4 for a sample of MLB data and Appendix 8 for a description of all data collected.

4.1.1.3. NATIONAL COLLEGIATE ATHLETIC ASSOCIATION (NCAA) DIVISION 1 FOOTBALL

The text of the sporting event TFR NOTAM creates some uncertainty with NCAA football. The NOTAM mentions NCAA Division 1 football. As of 2006, NCAA Division 1 football was reorganized, eliminating the use of the Division 1 label. Prior to 2006, Division 1 was broken down into Division 1A and Division 1AA. In 2006, the Division 1 label was replaced with Football Bowl Subdivision (FBS) and Football Championship Subdivision (FCS). The FBS is comprised of the former Division 1A schools and the FCS is comprised of the former Division 1AA schools (Genessy 2007). As of January 2014, it is unclear whether the FAA, when using the Division 1 label, is referencing both FBS and FCS schools or just the upper tier FBS schools. Until the NOTAM is further clarified by the FAA, all Division 1 schools, both FBS and FCS, are considered for the list of sporting event TFRs.

The complete list of NCAA football teams was obtained from espn.com (ESPN 2013a). As of the 2013 football season, there are a total of 252 NCAA Division 1 football programs combined with 126 schools in the FBS and 126 schools in the FCS. None of the FCS schools have a stadium with a seating capacity greater than 30,000 people

(Championshipsubdivision.com 2013), eliminating all FCS schools from qualifying for a sporting event TFR. Additionally, 15 schools in the FBS have stadiums with fewer than 30,000 person seating capacity (Collegegridirons.com 2013). See section 7.2.1 for more information about regular updates to the spatial database should a school renovate its stadium and increase the seating capacity above the 30,000 person seating capacity mark.

For each team, stadium name, address information, phone number, and team schedule website were obtained from each team's football homepage. Seating capacity for each stadium was obtained in 2013 from ESPN, collegegridirons.com, championshipsubdivision.com, or the team's website. Additionally for each team, precise latitude and longitude coordinates were obtained from Google Maps by zooming in on the stadium, right clicking on the map, and selecting, "What's here?" from the menu. For consistency, the center of the team's logo on the 50 yard line was used for the latitude and longitude coordinates. In instances where the logo was not visible, i.e. a domed stadium or field markings were not present, a point as close to the center of the stadium was approximated. For consistency with other leagues, a URL link to the team's schedule was also obtained from espn.com. See Appendix 5 for a sample of NCAA Football data and Appendix 8 for a description of all data collected.

4.1.1.4. NATIONAL ASSOCIATION OF STOCK CAR RACING (NASCAR)

The 2013 NASCAR season consists of 41 races on 23 different racetracks (NASCAR 2014). For each racetrack, address and phone numbers were obtained from the track's website. Precise latitude and longitude coordinates were obtained from Google Maps by zooming in on the racetrack, right clicking on the map, and selecting, "What's here?" from the menu. For consistency with other leagues, a URL link to the NASCAR schedule was also obtained from

espn.com. See Appendix 6 for a sample of NASCAR data and Appendix 8 for a description of all data collected.

4.1.1.5. INDYCAR

The 2013 IndyCar season consists of nineteen races on seventeen different racetracks (IndyCar 2014). For each racetrack, address and phone numbers were obtained from the track's website. Precise latitude and longitude coordinates were obtained from Google Maps by zooming in on the racetrack, right clicking on the map, and selecting, "What's here?" from the menu. For consistency with other leagues, a URL link to the IndyCar schedule was also obtained from espn.com.

Each season, IndyCar holds races in San Paolo, Brazil and Toronto, Ontario, Canada (IndyCar 2014). Because they are more than three nautical miles away from U.S. airspace, no sporting event TFRs exist over either stadium. See Appendix 7 for a sample of IndyCar data and Appendix 8 for a description of all data collected.

4.1.2. AIRPORT DATA

It was determined that a layer of airports would be necessary for the website map for reference or navigation purposes. Being able to see airports on the map will help pilots better understand the locations of the sporting event TFRs with respect to their home and destination airports. A shapefile of public use airports was obtained from the National Transportation Atlas Database (United States Department of Transportation 2013). This is a spatial database of transportation facilities, including airports. The Bureau of Transportation Statistics, a division of

the Department of Transportation, updates their databases yearly and offers free downloads of data layers from the website (United States Department of Transportation 2013).

4.2. CHOICE OF SOFTWARE

Adobe Dreamweaver CS6 was used to create the HTML, JavaScript, and CSS files for the project website. In addition to writing the code for the website, a spatial database in which to store the spatial data and a method to display the data needed to be chosen.

In order to make the web map accessible to all pilots, a simple to use map has to be created that doesn't require users to download software onto a computer. Many pilots perform last minute preflight checks at the airport shortly before takeoff. In this situation, users would not likely have administrative access on a public use computer provided by the airport and wouldn't be able to download any software onto the computer. This limitation led to the following choice of Web GIS and other software.

4.2.1. *CARTODB*

A spatial database management system was necessary to manage the database of sporting event TFRs. A mandatory feature of the website created as part of this thesis is the ability to share the database, as discussed in section 3.2.1. While Esri's ArcMap and ArcServer would satisfy the need for a sharable database, access to those programs through the University of Southern California will end upon completion of this thesis. In order to create a database that will be able to exist beyond that time, an alternate system was needed. CartoDB is an open-source, cloud-based spatial database management system offering up to five MB of data storage

within a maximum of five tables for free. Increased data storage capacity and more tables can be purchased for a monthly or yearly fee; however the free service level is adequate for this thesis.

Data can be uploaded into CartoDB in a Microsoft Excel spreadsheet, KML file, GEOJson file, or Esri shapefile. Once data is uploaded into CartoDB, visualizations can be created. CSS can be applied to stylize the layer on a map and custom info windows can be created for every feature. Visualizations can then be shared through a URL linking viewers to the CartoDB visualization, HTML text to imbed the map into a webpage, or an API to add the data layer to an existing map.

4.2.2. *GOOGLE MAPS*

As previously mentioned, CartoDB offers the ability to imbed a web map into an existing webpage. The free version of CartoDB only allows 10,000 map views by website users per month. As the thesis website becomes more widely known and more frequently visited, having a limit to the number of map views could cause a poor experience for users and a bad impression of the website.

Google Maps offers a fully functional, free, easy to use, and stable platform for web mapping. Using the CartoDB API to display the data layer on a Google map does not affect the number of map views. Therefore a Google map was implemented via a web browser through HTML and JavaScript, commonly used web scripting languages understood by any web browser regardless of the operating system or platform. In addition to the intuitive design and familiarity among many internet users, this universal usability is desirable to make the map easily accessible to as many viewers as possible.

4.3. DATA PROCESSING

As mentioned in section 4.2.1, data can be uploaded into CartoDB in many different ways. Initially, a Microsoft Excel Spreadsheet was used to collect and upload the data, however the results were less than desirable. The spreadsheet contained latitude and longitude coordinates that were turned into a point layer in CartoDB. This was undesirable because the point layer did not accurately represent on the map the actual three nautical mile radius size of the sporting event TFRs, the intended geovisualization.

To fix this problem, the Microsoft Excel spreadsheet was uploaded into Esri's ArcMap as a table. A point layer was created using the latitude and longitude coordinates obtained from Google Maps as discussed in section 4.1.1. The WGS 84 geographic coordinate system was selected to display this layer, which is consistent with the coordinate system used for Google Maps. Once the data was displayed in ArcMap as a point layer, a three nautical mile buffer was applied to all points, creating a polygon layer appropriately sized to accurately represent the sporting event TFRs. While buffers created in a geographic coordinate system are not necessarily accurate on a map using a rectangular Mercator projection like a Google map, it is the author's experience that, at larger scales, circular rather than oval polygons on a map make more visual sense to pilots and that the pilots would be able to adequately avoid the TFRs.

Upon inspection of the data layer, eleven instances were found where two sports teams shared the same stadium. Additionally, a NASCAR and an IndyCar race are both held at the same five race tracks. This caused a data visualization problem with one polygon completely overlapping the other, preventing the user from having access to a team's or race league's information. All duplicate locations were manually deleted from the primary table and a second table was created. In the second table, additional data fields were added to reflect multiple teams

or multiple racing leagues. The second table was processed through ArcMap as described above. The two sporting event TFR layers were then exported out of ArcMap as two separate shapefiles. The shapefiles were compressed and the resulting .zip files were uploaded into CartoDB.

As mentioned in section 4.1.2, an Esri Shapefile was downloaded from the National Transportation Atlas Database. The shapefile was a point layer of all airports within the United States, both public and private. It was determined that since the airport data layer is for reference only, the private airports were not necessary and thus were not included in the web map. The airport data layer table was opened in ArcMap. A selection was created to highlight only the public use airports. This selection was exported as a separate data layer and uploaded into CartoDB as a shapefile, replacing the original airport data layer. This process reduced the number of airport points from over 21,000 to about 6,000, significantly reducing the visual clutter on the map, yet still leaving enough airports for sufficient reference.

Because CartoDB limits the number of database tables allowed in the free version, it was intended to have one table for airports and one table for sporting event TFRs. The current database schema can be seen in Figure 10. As described above, a second sporting event TFR table was created as a workaround for multiple sporting events being held at the same stadium or speedway. Because the airport data layer is for reference only, there is no common primary key or relationship between the airport table and the sporting event TFR tables. Plans to redesign the database to increase its efficiency in regards to data organization and facilitate improvements are discussed in section 7.2.2.

Public_Airports	
cartodb_ID	int
the_geom	decimal
act_date	date
aero_chart	text
air_taxi	text
arrivals	int
cbd_direct	text
cbd_dist	int
Cert_type	text
city_name	text
cntl_twr	boolean
comm_serv	text
county_nam	text
county_st	text
cust_Indg	boolean
departures	int
eff_date	date
elev	int
enplanemen	int
faa_distri	text
faa_region	text
faa_st	text
fac_cystzp	text
fac_use	text
fed_agree	text
fullname	text
helicopter	int
internatio	boolean
itin_ops	int

Public_Airports (ctd)	
jet_en_ga	int
joint_use	boolean
lan_fa_ty	text
latitude	decimal
local_ops	int
locid	text
longitude	decimal
m_eng_ga	int
mil_Indg_r	boolean
mil_ops	int
objectid	int
oper_glide	int
oper_mil	int
owner_type	text
passengers	int
s_eng_ga	int
site_no	text
st_postal	text
state_name	text
stfips	text
ultralight	text
created_at	date
updated_at	date

Stadium_TFRs_3_NM	
cartodb_id	int
the_geom	text
address	text
buff_dist	int
capacity_r	text
city	text
conference_1	text
conference	text
date_capac	date
espn_sched	text
event_type	text
lat	decimal
long	decimal
object_id	int
phone	text
shape_area	decimal
shape_leng	decimal
stadium	text
stadium_se	int
state	text
team	text
team_sched	text
team_websi	text
where	text
zip	int
created_at	date
updated_at	date

Stadium_TFRs__duplicates_3_NM	
cartodb_id	int
the_geom	text
address	text
buff_dist	int
capacity_r	text
city	text
conference_1	text
conference_2	text
conference_3	text
conference	text
date_capac	date
espn_sched_1	text
espn_sched	text
event_type	text
lat	decimal
long	decimal
object_id	int
phone	text
shape_area	decimal
shape_leng	decimal
stadium	text
stadium_se	int
state	text
team_1	text
team_1_sch	text
team_1_web	text
team_2	text
team_2_sch	text
team_2_web	text
where	text
zip	int
created_at	date
updated_at	date

Figure 10 Database tables and attributes

4.4. APPLICATION DEVELOPMENT

CartoDB uses visualizations or scenarios to combine data from separate tables into maps. Additionally, a visualization is necessary to share a data layer as a map service. For this thesis, two visualizations were created. An “all data” visualization was created to combine the airport data with the sporting event TFR data. The three tables of data described in section 4.3 were added to this visualization. This visualization is intended for sharing with and use on websites that do not have an existing airport data layer. A “sporting event TFR” visualization contains only the two sporting event TFR data tables discussed in section 4.3 without the airport data layer. This visualization is intended for sharing and use with aviation websites that already incorporate an airport data layer.

Because the airport layer is for reference only, it is stylized in a manner familiar to pilots. On the official FAA aeronautical navigation sectional, an example of which can be seen in Figure 11, airports are stylized in one of two colors: blue is used for airports with an operating control tower, and magenta is used for airports without a control tower.

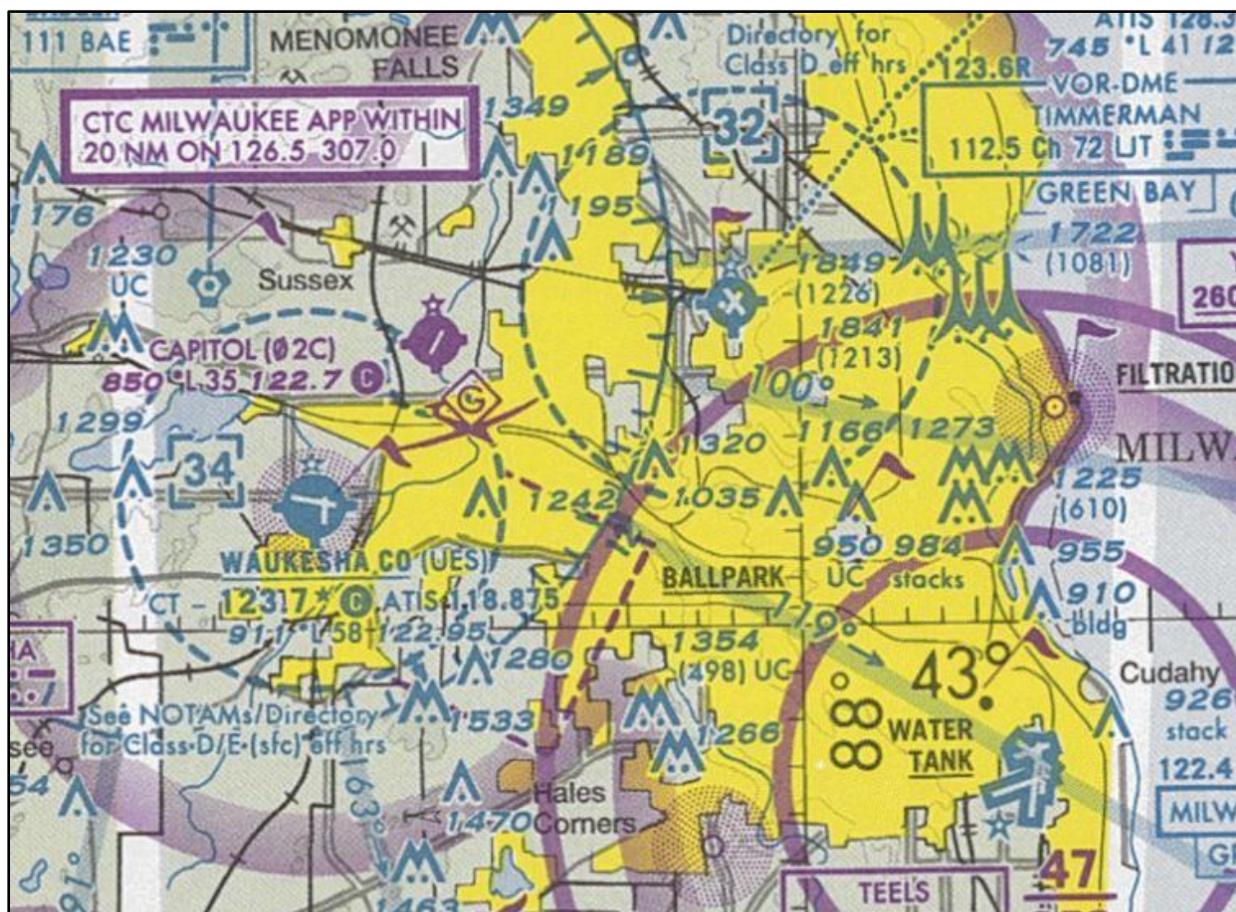


Figure 11 Airports shown in blue have an operating control tower while airports shown in magenta do not have a control tower in operation (SkyVector 2014a)

For symbolizing the CartoDB visualization, an FAA publication entitled *Aeronautical Chart User's Guide* was consulted (Federal Aviation Administration 2012b). This publication describes all symbology commonly used on aviation sectional charts. Unfortunately it does not contain any specific color information. In place of specific color information from the FAA, a Firefox extension entitled *ColorZilla* was used (Sirota 2013). *ColorZilla* is a tool that samples colors within a web browser and reports the hex color. Initially, color samples were taken from the website *SkyVector.com*. It was challenging to obtain an accurate color sample because the website displays digital raster images of the FAA's aviation sectional charts. In a raster format,

every pixel is a different color, making it very difficult to obtain a precise match color sampling of the blue and magenta colors used.

The Aeronautical Chart User's Guide, however, is a PDF download from the FAA's website. PDF files use vector polygons to store shapes and colors. This format allowed for a more accurate color sample because all neighboring pixels within a vector polygon are the same color. From the ColorZilla sampling of the FAA's pdf file, it was determined that the FAA uses the blue color #0086BE for symbolizing airports with operating control towers and the magenta color #9C6A9E for symbolizing airports without an operating control tower.

While the airport layer is not the main feature of the sporting event TFRs website, it is important for reference purposes so pilots can see the location of sporting event TFRs relative to airports they intend to fly to. In the interest of familiarity among pilots, the same colors used for airports on an aviation sectional chart were also used on the thesis website. The colors samples obtained using ColorZilla from the FAA's pdf file as described above were used to symbolize airports (blue) with a control tower and airports (magenta) without a control tower. The marker size was chosen to be large enough to be easily seen by a user, but not so large as to overpower the sporting event TFRs layer. A white border was added to the symbol to help the marker stand out against darker basemaps. An example of the airport layer symbolization can be seen in Figure 12.

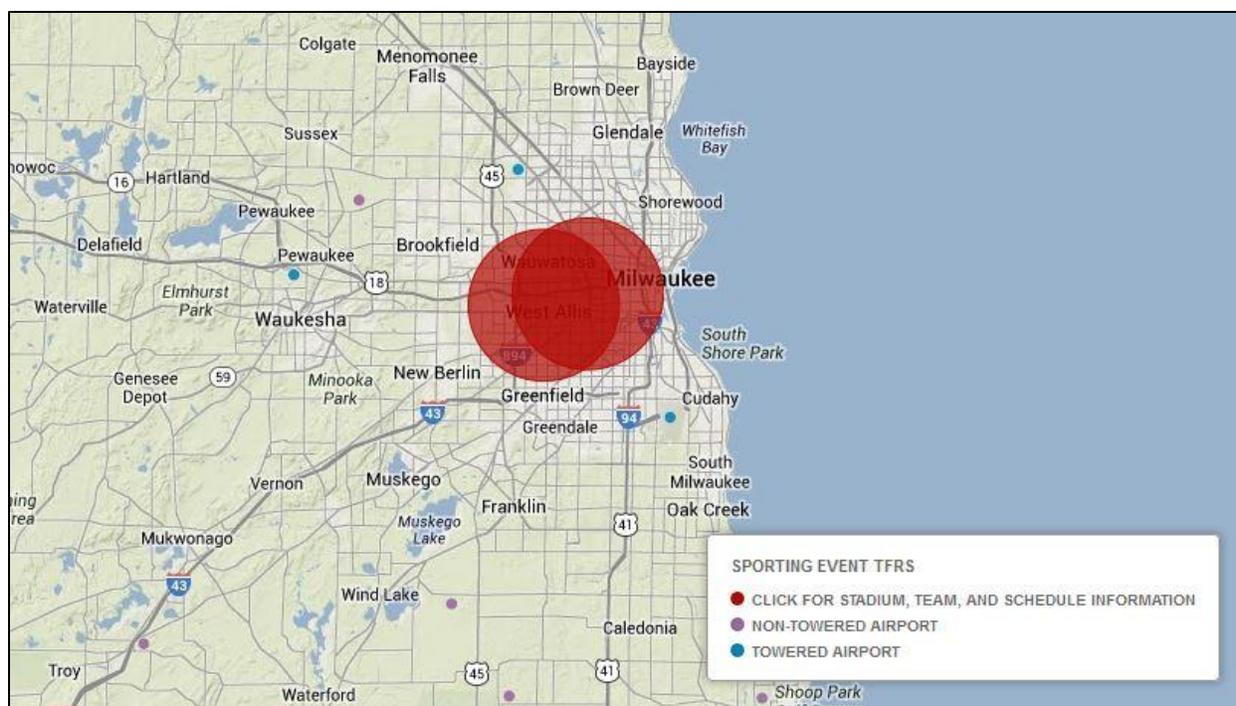


Figure 12 Example of airport and sporting event TFR symbolization (www.sportingeventtfrs.com)

The sporting event TFRs layer was also symbolized to be consistent with aviation industry standards. Red is the color used for any TFR. CartoDB's default red color #B40903 was used to symbolize the sporting event TFRs layers. An example of the sporting event TFR symbolization can also be seen in Figure 12.

Because there are over 5,000 data points on the airport layer, the web map became overly cluttered with markers when viewed at smaller scale zoom levels. An example of the overcrowded map can be seen in Figure 13. For a cleaner looking map, a map style setting was changed to prevent marker overlap which can be seen in Figure 14. It was determined that preventing symbol overlap and allowing the number of markers visible to increase at smaller scale zoom levels, would not adversely affect the website because the airport layer is used strictly for reference purposes only, usually at local map scales (zoomed in).

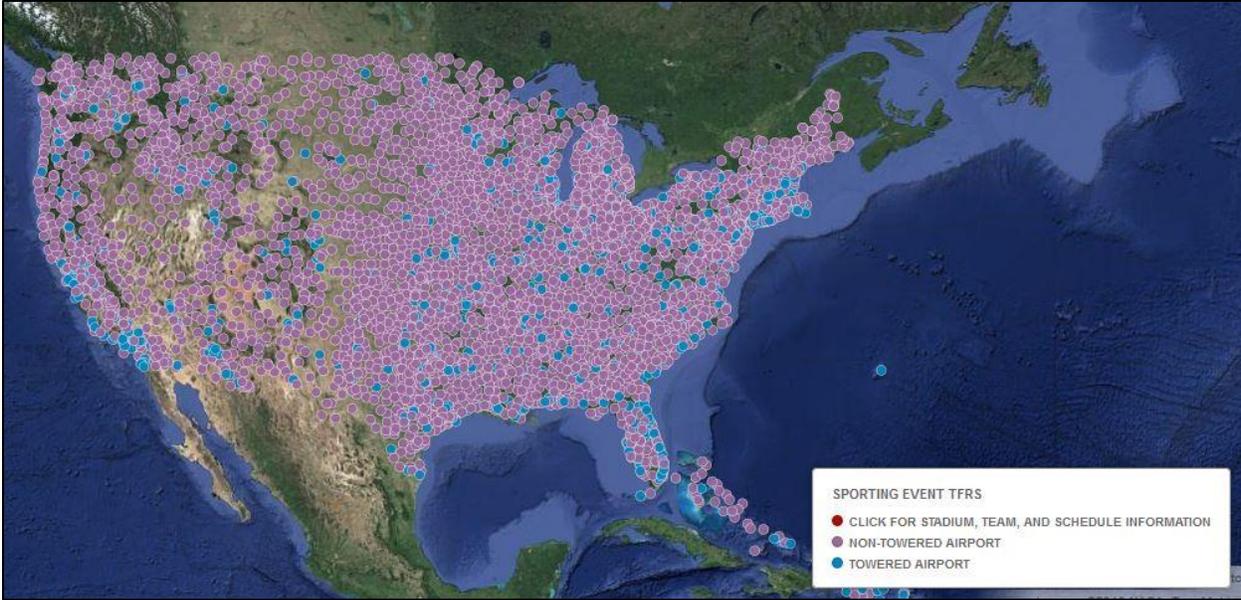


Figure 13 The airport data layer viewed at small scale zoom level (www.sportingeventtfrs.com)

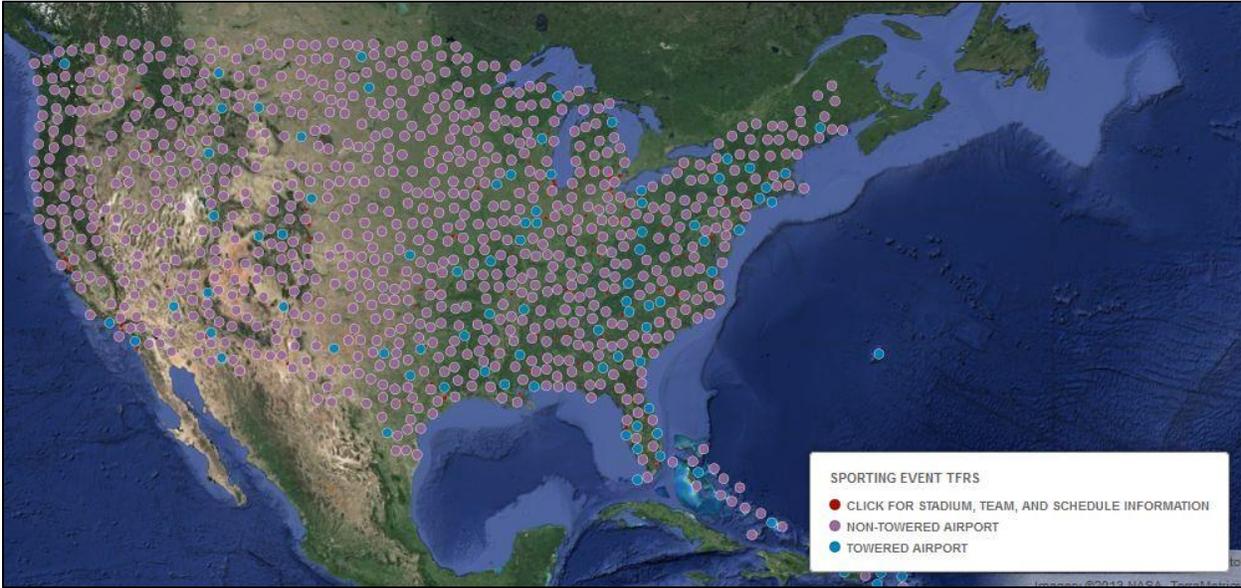


Figure 14 The airport data layer with marker overlap set to "false" (www.sportingeventtfrs.com)

Once the data layers were stylized properly, it was necessary to select the fields for the infowindows. For the airport layer, fields containing airport name, three digit airport identifier, city, and state were selected. An example airport infowindow can be seen in Figure 15.

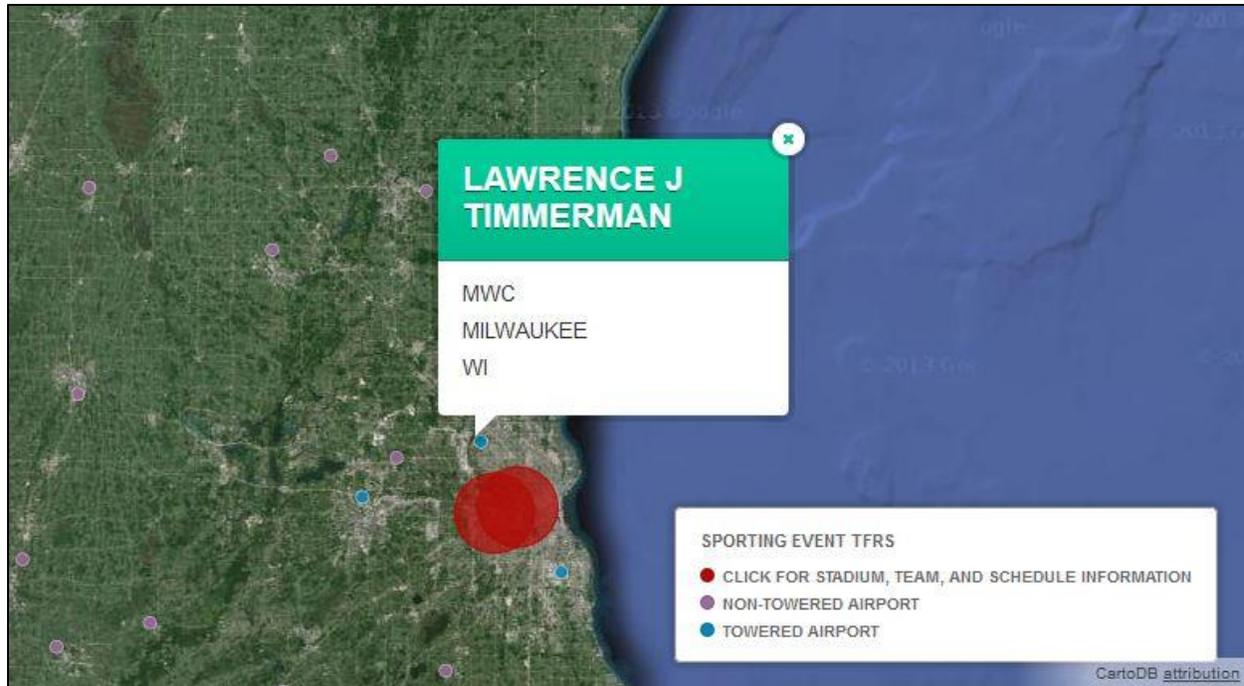


Figure 15 An example of an airport infowindow (www.sportingeventtfrs.com)

Five fields were chosen for the sporting event TFRs infowindow. The name of the stadium or race track and the name of the team are the first two fields in the infowindow. For races, the team name is either NASCAR or IndyCar. For informative purposes, the type of sporting event - professional baseball, professional football, college football, or race – is also included. The team’s website - or racing league website for NASCAR and IndyCar – is included in the infowindow because it most likely contains the most up-to-date information about the team. However, every team’s website is different, so to create a sense of consistency across all the sports teams and leagues, a link to the team’s schedule on the ESPN website was also included in the infowindow. An example of a sporting event TFR infowindow can be seen in Figure 16.

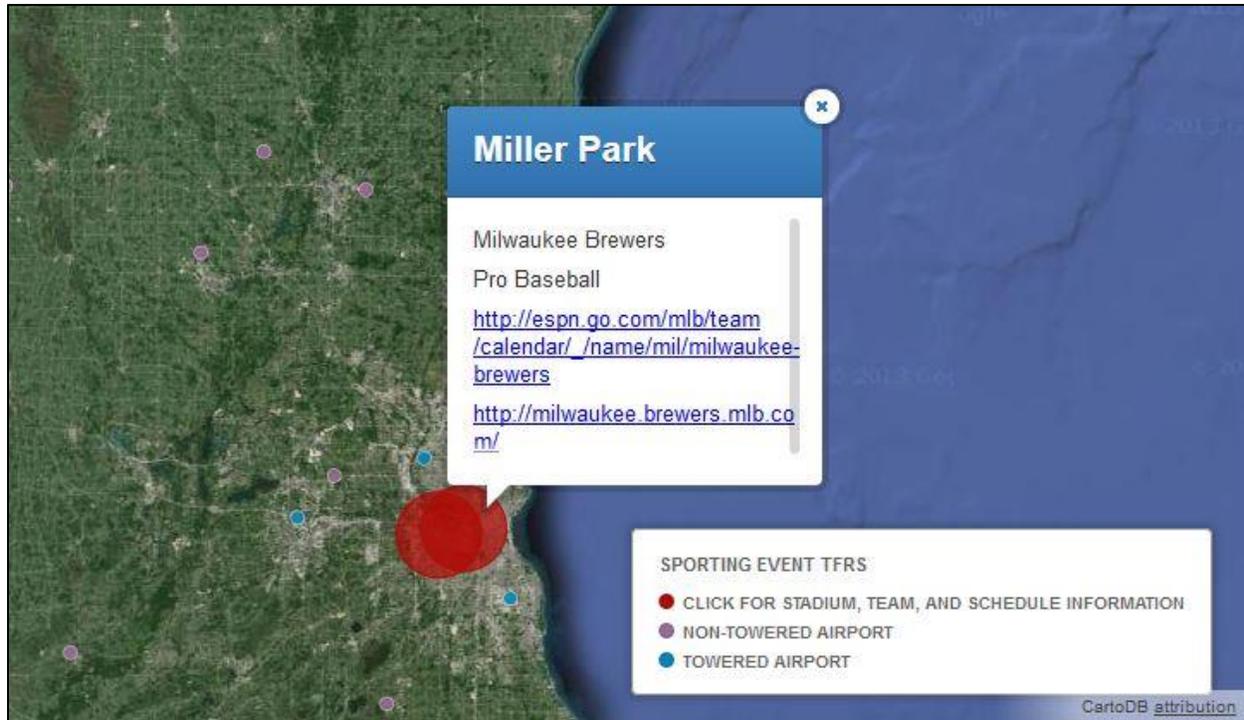


Figure 16 An example of a sporting event TFR infowindow (www.sportingeventtfrs.com)

4.5. PROJECT DEVELOPMENT

The flowchart in Figure 17 offers a graphical representation or summary of all stages of project development in this thesis work. The arrows indicate the order of project development steps taken, from the beginning research to the end result. Each box in the flowchart represents a complete data processing or programming step. Text written in blue represents an end product, such as the creation of the website or the spatial database.

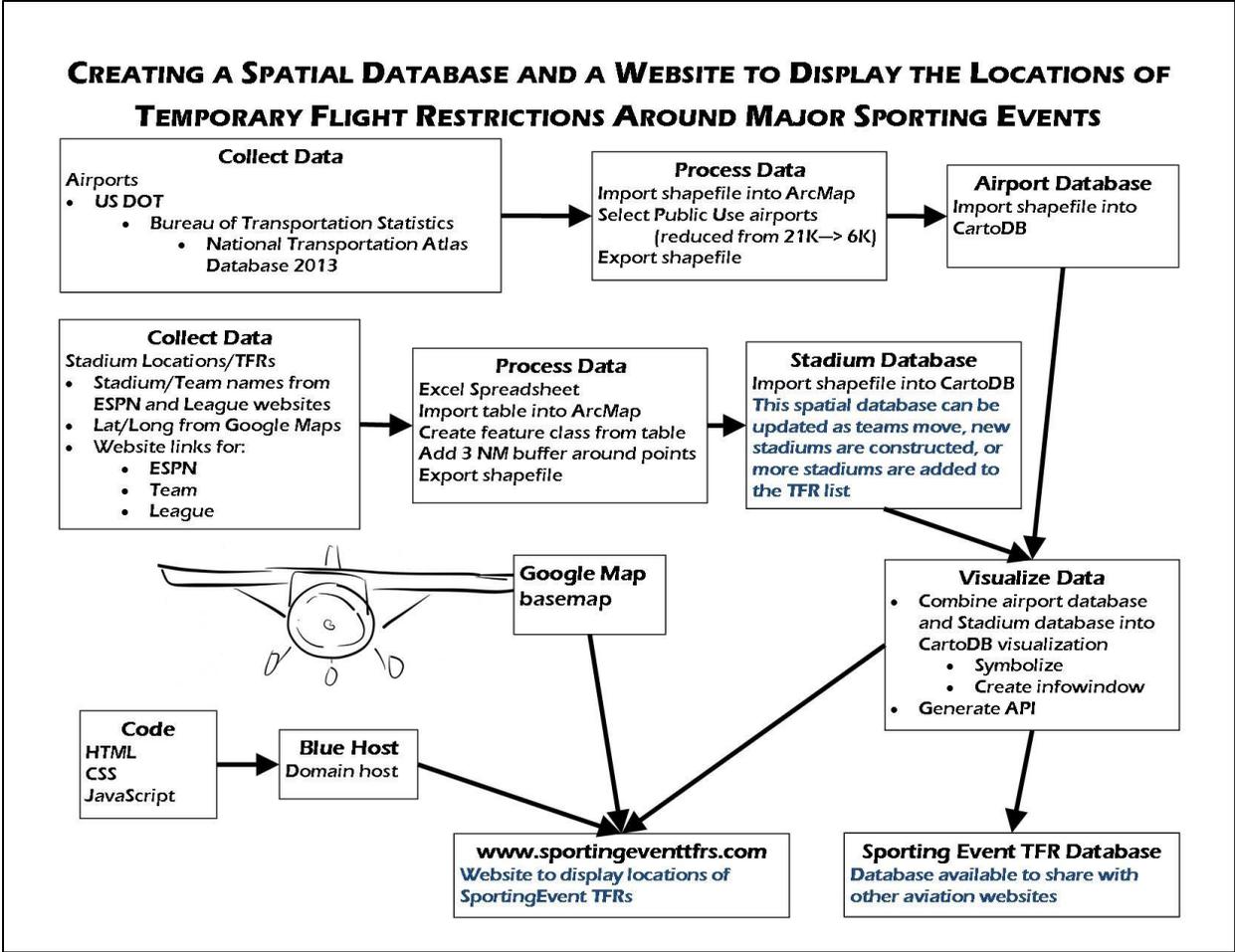


Figure 17 Flowchart for the development of the website and spatial database

CHAPTER FIVE: METHODS

This chapter discusses the methods taken to design, program, and host the website as well as the steps taken to obtain feedback about the website, and lastly improvements made based on that feedback.

5.1. PROGRAMMING

As stated previously in section 4.2, Adobe Dreamweaver was used for writing and coding the website. It was chosen based on multiple recommendations and because of its advanced site management tools. Dreamweaver was used for compiling the HTML, JavaScript, and CSS code. The website code is written using HTML 5 specifications. To provide a similar structure to each individual page, the body of each page is divided into four parts, header, nav, article, and footer as seen in Figure 18. Specifics about each page can be found in section 6.1.

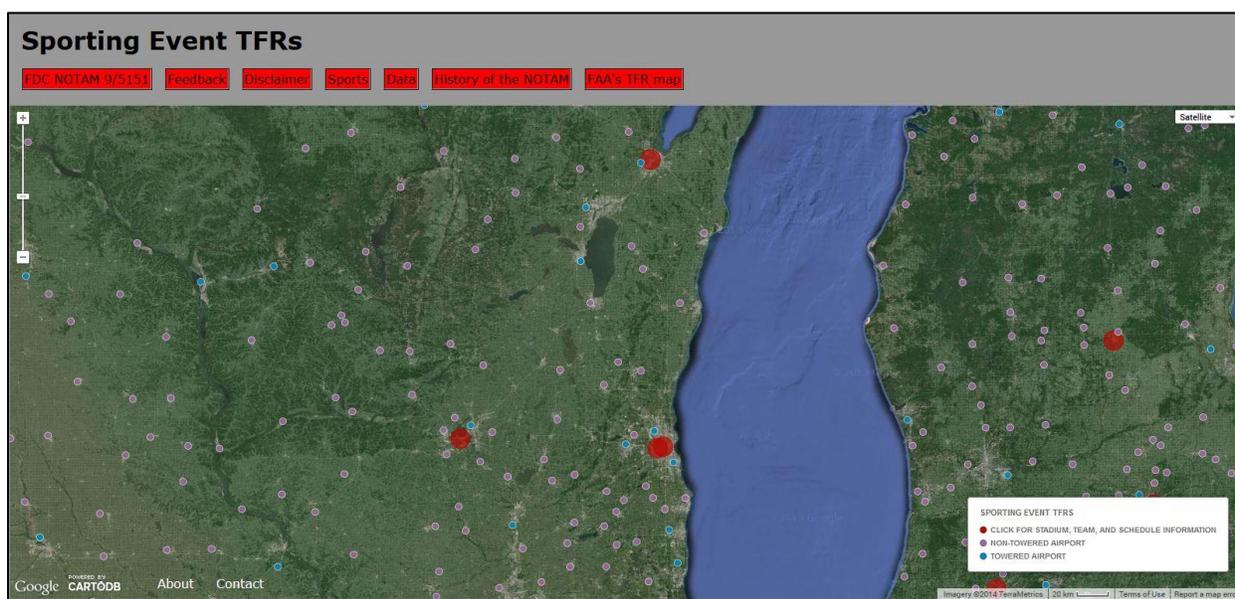


Figure 18 Main page of thesis website: www.sportingeventtfrs.com

For all webpages, the header contains a page title representing the main content of that page; the navigation section contains links to other pages on the website organized into a horizontal list; the footer contains links to a ‘contact’ page and an ‘about’ page. The article section is the primary content for each page. All pages are written entirely with HTML and styled with CSS. The map page is the only page on the website that incorporates JavaScript. The JavaScript pulls a map service from Google and the “all data” map layer from CartoDB. Creating the web map is accomplished through various JavaScript functions. The functions that run the map include initialize which control zoom actions and the map background, and script which is necessary to add the CartoDB visualization containing the airport layer and the two TFR layers discussed in section 4.4 to the Google map.

The script necessary for the initialize function was copied from the map developer section of Google’s website and the developer section of CartoDB website. A final function uses geolocation technology incorporated into HTML 5 to center the map on the user’s location upon initial loading of the webpage. This function requires that users agree to share their location with the web browser. If the user has disabled geolocation services, he or she will receive an alert window with a message saying, “Geolocation services failed. If you enable geolocation services, the map will center to your current location.” An example of this alert window can be seen in Figure 19.

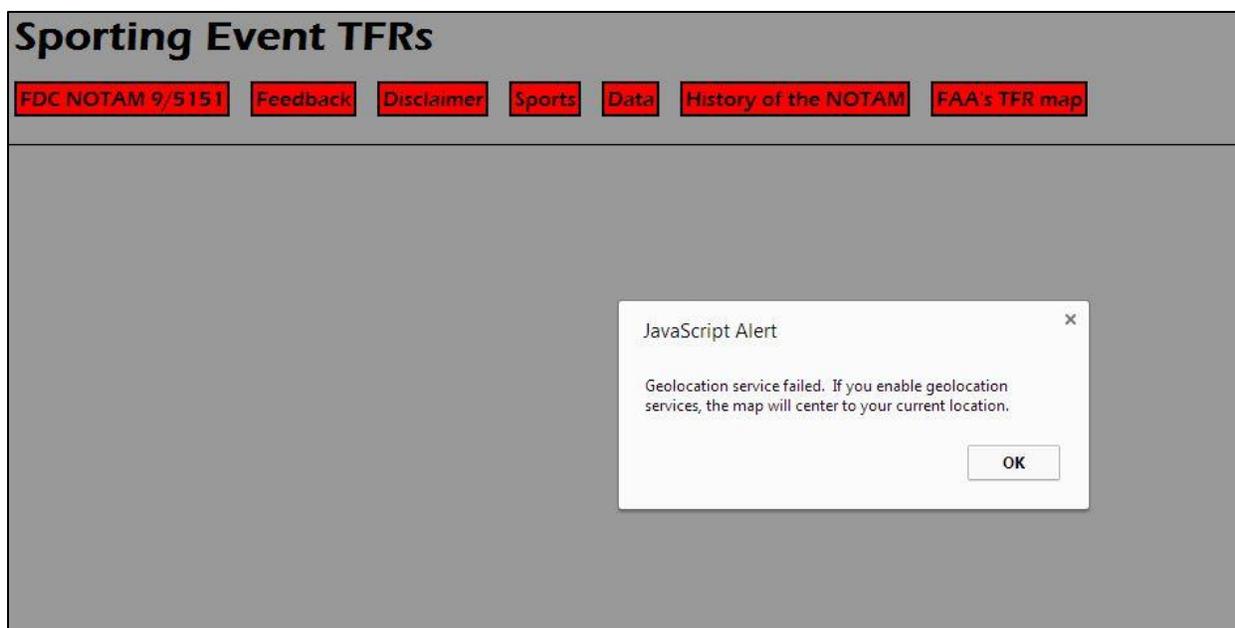


Figure 19 Alert window notifying user to enable geolocation services within the web browser (www.sportingeventtfrs.com)

After clicking OK, the map will center on New York, NY. Once the user enables geolocation, the map will re-center on the user's location. For web browsers without geolocation capability, the user will receive a message saying, "Your browser doesn't support geolocation. You've been placed in New York. If you use a browser that supports geolocation, the map will center to your current location."

5.2. EVALUATION PROCESS

In order to determine the effectiveness of the website, a Google form was created with 6 questions. The questionnaire was sent to 20 pilots as well as added as a link in the navigation bar on the website. A total of 10 pilots responded to the survey; overall the results were considered positive and the main goals of the website were achieved. The form can be seen in Figure 20.

Sporting Event TFRs

This website was created to increase awareness of the existence and locations of the sporting event TFRs. It is not intended as a replacement of current online flight planning websites nor as a sole source of preflight planning information. Thank you for taking you time to give me some feedback.

*** Required**

Prior to visiting this website, how would you have rated your knowledge of the Sporting Event TFRs? *

1 2 3 4 5

Little to no knowledge Extremely knowledgeable

After visiting the website, how would you rate your knowledge of the Sporting Event TFRs? *

1 2 3 4 5

Little to no knowledge Extremely knowledgeable

Is the website easy to understand and use? *
If not, please try to explain what you feel needs work

Are you going to tell other pilots about this website? *

Yes
 No
 Maybe

Do you plan to check this website as part of your preflight planning? *

Yes
 No
 Maybe

Please provide any general comments

Figure 20 Website questionnaire sent out to pilots for feedback

To summarize the results of this survey, the average level of a pilot's knowledge about sporting event TFRs was requested within a scale of 1-5, with 1 being little to no knowledge and 5 being extremely knowledgeable (Table 1). The average knowledge levels reported ranged from 2.9 prior to visiting the website to 4.2 after visiting the website, an increase of 45%. The ten responses can be seen in Table 1.

Response	Knowledge level before	Knowledge level after
1	3	4
2	4	4
3	2	4
4	2	4
5	4	4
6	4	5
7	2	4
8	4	4
9	1	4
10	3	5
Average	2.9	4.2

Table 1 Self-reported level of knowledge about sporting event TFRs by ten respondents before and after viewing the website

Additionally five of the ten responders indicated that he or she would visit the website again. Furthermore eight of the ten responders indicated that he or she would tell another pilot about the website. Overall, extremely positive feedback was received. In instances where a responder did not say he or she would visit the site again, comments he or she wrote to questions three ("Is the website easy to understand and use?") and/or six ("Please provide any general

comments”) indicate a high level of misunderstanding surrounding the definition of sporting event TFRs. For example, one responder wrote that he or she already uses the FAA’s TFR website for preflight planning and doubts he or she would remember to look at both. As discussed in section 2.1.1, the FAA’s TFR website does not display sporting event TFRs. Responses like this further illustrate the lack of knowledge in the aviation industry surrounding the sporting event TFRs as discussed in section 2.2 and emphasize the importance of this thesis spatial database and website providing easily accessible and accurate information about the sporting event TFRs.

CHAPTER SIX: RESULTS

This chapter discusses the layout and use of the website as well as the actions taken based on feedback received.

6.1. SPORTING EVENT TFRS WEBSITE

The main page of the website, the “all data” visualization”, is the sporting event TFR map. Upon initial loading, the browser attempts to center on the user’s location, depending on the user’s internet settings (see section 5.1). The web map initializes with a satellite basemap and displays the airport layer and sporting event TFR layer. A legend showing TFRs, towered airports, and non-towered airports appears in the lower right corner. Users can zoom in or out and use the mouse to pan the map in any direction.

The website also contains other webpages with supplemental information about the sporting event TFRs. The first supplemental page is entitled ‘FDC NOTAM 9/5151.’ This webpage contains the full text of the current sporting event TFR NOTAM as seen in Appendix 1 as well as an unofficial plain English interpretation of the NOTAM:

Completely unofficial plain English interpretation

The FAA prohibits flight at and below 3,000 feet above ground level within a 3 nautical mile radius of all sporting event stadiums having a seating capacity greater than 30,000 people. This temporary flight restriction includes all Major League Baseball stadiums, National Football League stadiums, NCAA division one football stadiums, NASCAR Sprint Cup races, and INDY Car races. The temporary flight restrictions begin one hour prior to the start of the sporting event and end one hour after the sporting event has concluded.

The purpose of this webpage is to provide the official text as well as an easier to understand interpretation of the rule.

The second supplemental webpage is a disclaimer. The Federal Aviation Regulations state that it is the pilot's responsibility to become familiar with all information concerning the flight (Federal Aviation Administration 2012a). The purpose of the disclaimer webpage is to remind visitors that this website does not relieve them of their FAA required preflight activities.

The disclaimer is as follows:

Disclaimer

14 CFR 91.103 Preflight Action

As with most other information you find on the internet, especially information of a legal nature as these Sporting Event TFRs are, you should use this website for advisory purposes only. As the pilot in command, you are directed by the FAA to have all available information concerning the flight. Reliance should not be placed solely on a single website for obtaining all useful information and a website is not a sufficient substitute for obtaining an official weather briefing from a weather briefer or through DUATS.

Please keep in mind, however, that, due to the nature of the FDC NOTAM under which the Sporting Event TFRs are issued, it is unlikely that a weather briefer or DUATS briefing will include any information about any Sporting Event TFRs. This leaves it up to you, as the pilot in command, to know of the locations, times, and durations of all sporting events for which one of these TFRs is issued.

The third supplemental webpage entitled, "Sports" contains supplemental information about the sporting events and the leagues included in the sporting event TFRs for non-sports fans. This webpage provides information about the beginning and end of the sport's season as well as usual days and times for the sporting events to take place. While most sports fans will take this information for granted, not all pilots are sports fans, and not all sports fans are fans of every sport that has a TFR. So the ultimate purpose of including this webpage is to help non-sports fans develop a basic understanding of the format of each sport's season for a better understanding of when to expect a sporting event TFR to exist.

The fourth supplemental webpage is all about the data collected and used for the sporting event TFR layer. This page summarizes the information discussed in section 4.1.1, specifically a list of the stadiums, racetracks, teams, cities, and states where the sporting event TFRs exist. Most importantly, as discussed in section 2.1.4, currency of spatial data was a concern on other

websites used by pilots; the data page states the date the information was last updated so pilots can ensure they have the most up-to-date location information about the stadiums and racetracks. Despite the burden of information placed on the pilot, the main goal is to help pilots realize that the information contained on the website is accurate, current, and believable.

The last supplemental information webpage contains historic information about the sporting event TFRs, the same information found in section 1.2 and Appendix 2. While not necessary to understanding or complying with the current sporting event TFR NOTAM, many pilots might be interested in how the NOTAM has changed over time. Additionally the website contains a link to the feedback form discussed in 5.2, a website developer contact webpage, and an about webpage with related definitions and abbreviations.

6.2. IMPROVEMENTS BASED ON EVALUATIONS

Overall, of the ten responses received from the questionnaire described in section 5.2, the responses were positive and included valuable suggestions. One response suggested adding a time element to the web map. This is a desirable feature and will be discussed further in section 7.2.2. The same response also suggested contacting other aviation websites for inclusion on those websites instead of a stand-alone website. Details about this effort as of the date of completion of this thesis can be found in section 6.3.

Another responder pointed out the inclusion of every airport within the U.S., including private airports. This amounted to more than 21,000 airports. Because the airport layer is for reference only, it was determined that pilots would be able to adequately determine locations with only public airports. Reducing the number of airport data points by almost 75% allowed for a less cluttered, easier to view map without adversely affecting the quality and usefulness.

6.3. SPATIAL DATABASE

An attempt was made to share the spatial database with SkyVector. After a brief email conversation between the author and the founder of SkyVector between 8 February 2014 and 10 February 2014, it became clear that he was interested in the idea of adding a layer to the current map. This idea had not been part of their programming before. However, after engaging in the conversation and asking clarification questions, the webmaster decided to create a sporting event TFR layer of his own instead of utilizing the database created for this thesis (Per. Com. Graves 2014).

While this was not the outcome the author was seeking, it is assumed that SkyVector noted the absence of the information and saw a need for inclusion of the sporting event TFRs on the web map. Although the spatial database created for this thesis will not be used for SkyVector, the author's desire to increase education for pilots was met.

6.4. USER SCENARIO

Based on the author's personal experience as a pilot, the following two user scenarios estimate what the average pilot will experience when using the website to plan a standard flight.

6.4.1. *LOCAL FLIGHTS*

In preparation for local flights, pilots visit the www.sportingeventtfrs.com website. Because the website centers on user's location, pilots will be able to see all stadiums and speedways within the local flying areas. Pilots will be able to first click on the TFR symbol of any of the local stadiums and speedways and get easy access to the schedule. From the schedule,

pilots will readily be able to determine if there is a game or race occurring during their intended flight time. Pilots should plan their flight accordingly, keeping the TFRs in mind.

6.4.2. *CROSS COUNTRY FLIGHTS*

Cross country flights differ from local flights because the pilots have to check a larger area prior to flight. Pilots planning cross country flights need to first prepare a detailed flight plan using their preferred method. The next step is to manually compare their planned flight route to the www.sportingeventtfrs.com website to determine if any sporting event TFRs exist along the flight route. Pilots will be able to first click on the TFR symbol of any of the stadiums and speedways along the flight route for easy access to the schedule. From the schedule, pilots will easily be able to determine if there is a game or race occurring during their intended flight time and along their planned route. Pilots should plan their flight keeping the TFRs in mind. This scenario will be improved if this data is displayed on commonly used aviation flight planning web maps in the future.

CHAPTER SEVEN: CONCLUSIONS

In conclusion, overall this project was highly successful in creating a current, sharable spatial database of sporting event TFRs and a corresponding website to efficiently disseminate this information. The path forward in regards to needed improvements and expansion is described in detail in the following sections of this chapter.

7.1. LIMITATIONS

As complete as the spatial database of TFRs and sportingeventtfrs.com website were intended to be at the time of completion of this thesis project, there are still some limitations. Just like any other website or internet service, users are dependent on an internet connection. Without internet, the web map won't display nor will the sporting event TFR data layer display. Furthermore, the data is stored with the CartoDB website. Should their servers lose internet connection or go down, the database would not be accessible. Additionally, URL links are incorporated into the database to link pilots to helpful websites. Should the owner of the website change the URL, the links would be broken and require updating. The links also help pilots determine the starting time of the sporting event. See section 7.2.1 for more about regularly checking website links. The database does not control nor have any input at all over the quality and accuracy of the data contained on websites that the links direct users to.

Another major limitation of this study is brought on by the league. The website and spatial database assume each team is playing home games at the team's usual stadium. This is not always the case. For example, in 2008, the Chicago Cubs and Houston Astros (MLB) played a game in Milwaukee's Miller Park with Houston as the home team. This game was changed at the last minute because of damage to Houston's stadium and hurricane relief efforts in Houston

following Hurricane Ike (Haudricourt 2008) . The current website and database are not set up to compensate for last minute changes like this. This is an additional reason for the need of the disclaimer discussed in section 6.1.

7.2. FUTURE WORK

The TFRs contained within this spatial database are constantly being updated by the author. Every year sports leagues change. While most changes are in rules or procedures, some changes happen that affect the TFRs. As seen in section 2.1.4, sports teams move to new stadiums, some even move to new cities. Making sure the database stays current is important to ensure pilots using the website have the most up-to-date information.

7.2.1. *REGULAR UPDATES*

To ensure that all important changes are accurately reflected in the spatial database, it is planned to verify the accuracy of information and update the database of TFRs before the beginning of the individual sports seasons every year. It is estimated that updates will take between thirty minutes and two hours per sport per year to verify the accuracy of the data and the links. NASCAR begins every year in February and IndyCar begins every year in March (NASCAR 2014, IndyCar 2014). Both racing leagues vary their schedule from year to year; while the majority of the speedways used are the same every year, it is possible that a new track will be constructed, an old track will be moved, or the leagues will add different speedways to the yearly schedule.

In January of every year, the list of speedways used for the upcoming NASCAR and IndyCar seasons will be compared to the speedways currently in the spatial database and the

database will be updated by removing unused speedways and adding new speedways. Additionally, links used to access the league schedule on ESPN.com and the speedways' homepages will be verified for accuracy.

The MLB season starts every year at the end of March or beginning of April (MLB 2013). Unlike racing, where the race is held in a different location each week, every baseball team has its own stadium. Every February the baseball stadiums listed in the spatial database will be reviewed to ensure locations of stadiums are accurate and website links are valid.

The NFL season starts every year in September (NFL 2013a). Similar to baseball, every team has a home stadium. The locations of each stadium will be verified and website links will be checked every August.

Finally, the college football season starts in August every year (ESPN 2013b). The teams included in NCAA Division 1 football change regularly (Barnhart 2012). The last time the AOPA updated their list of sporting event TFRs in 2008, they listed 111 college football teams (AOPA 2008). As of the 2013 college football schedule there are 126 teams in NCAA Division 1 FBS (ESPN 2013a). Every July, the spatial database will be updated to include any new teams joining a division 1 conference. As mentioned previously in section 4.1.1.3, some college football stadiums don't exceed the 30,000 seating capacity mark, excluding them from the sporting event TFR NOTAM. If those teams renovate the stadium and add seats, bringing the seating capacity above 30,000 people, those teams will need to be added to the database as well. As with the other leagues, the NCAA football stadiums in the database will also be checked for location accuracy and accuracy of the website links.

7.2.2. *FUTURE PLANS*

Because the sporting event TFRs are time sensitive, adding a temporal data visualization control will significantly improve the quality and usefulness of the spatial database and the website. Such a tool is currently outside the scope of the thesis, but it is a top coding priority for future development. CartoDB incorporates SQL into the spatial database, and a GETDATE or GETTIME query might be helpful with this development. Once developed, TFRs will be symbolized in a gray color when the sporting event is more than one day in the future, in a yellow color when the sporting event is within one day, and in a red color on the day of the sporting event.

As described in section 4.3, at present the spatial database design is challenging to update. As the database is modified to incorporate temporal data, it will also be redesigned to streamline the update process. A possible future database schema can be seen in Figure 21 which would improve data organization by linking the tables via primary keys, and eliminating redundancy of attributes. Furthermore, advanced SQL commands can be incorporated to apply the three NM buffer, replacing the current method of manually applying the buffer to a point layer in ArcGIS.

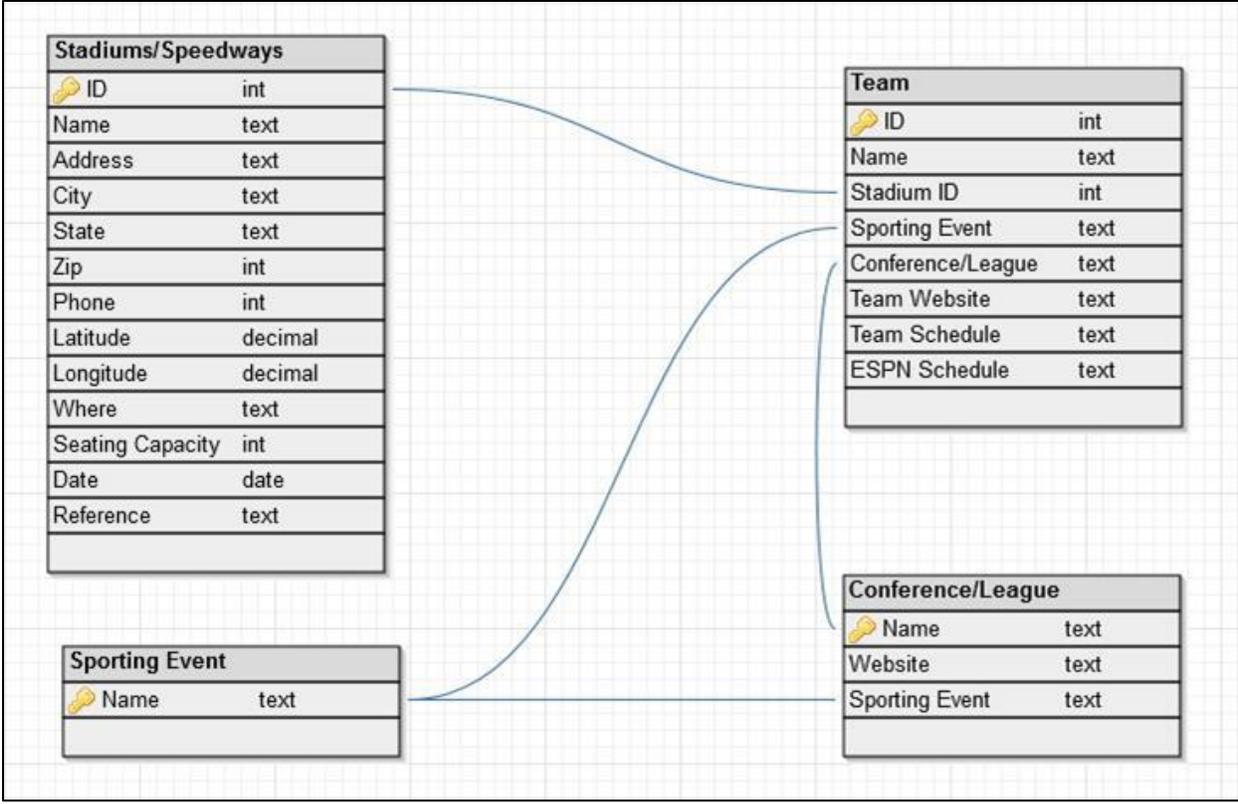


Figure 21 Possible future spatial database design, showing the tables linked by primary keys

One functionality of the map will be improved pending a CartoDB version update that supports a fix. When a user clicks on an airport or TFR, an infowindow pops up. The infowindows are a product of the CartoDB API, not Google Maps infowindows. Unfortunately, when the infowindows open, the leader (small triangle pointing from the infowindow to the map) does not point at a map feature, such as an airport. An example of this issue can be seen in Figure 22.

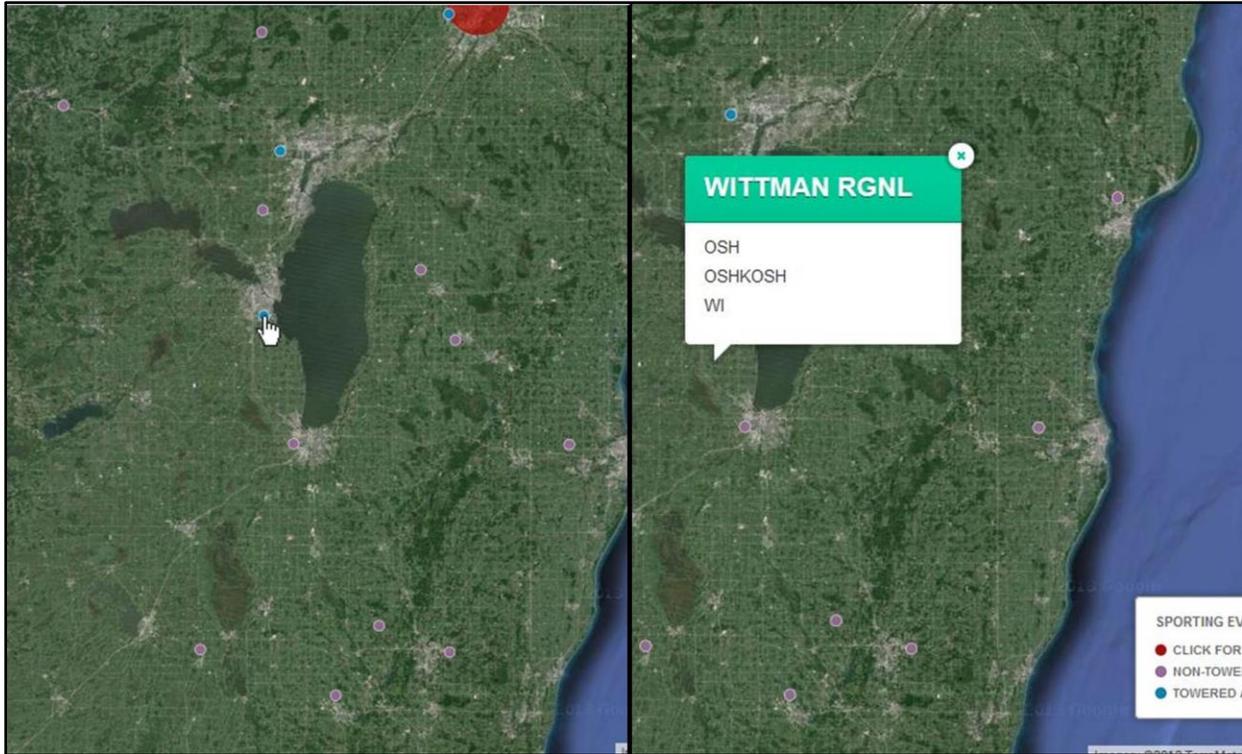


Figure 22 The image on the left shows the hand selection tool about to select Oshkosh airport. The image on the right shows the infowindow covering the airport symbol with the leader from the infowindow box pointing to nothing. (www.sportingeventffrs.com)

Finally, the website is very simple and plain. Due to programming and design limitations, having an eye-catching, well designed website is outside the scope of this thesis. Future versions of the website will have a more visually appealing appearance, and better rendering on mobile devices.

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APPENDIX 1 – CURRENT FDC NOTAM

Issued 2/10/2009 (Federal Aviation Administration 2009)

“FDC 9/5151 FDC part 1 of 2.. Special notice.. Sporting events. Effective immediately until further notice. This notice replaces FDC NOTAM 3/1862 due to the waiver website change and language clarification. This notice modifies flight restrictions previously issued in FDC NOTAM 3/1862 to comply with statutory mandates detailed in section 352 of public law 108-7 and as amended by section 521 of public law 108-199. Pursuant to 49 USC 40103(b), the Federal Aviation Administration (FAA) classifies the airspace defined in this NOTAM as 'national defense airspace'. Any person who knowingly or willfully violates the rules concerning operations in this airspace may be subject to certain criminal penalties under 49 USC 46307. Pilots who do not adhere to the following procedures may be intercepted, detained and interviewed by law enforcement/security personnel. Pursuant to 14 CFR section 99.7, special security instructions, commencing one hour before the scheduled time of the event until one hour after the end of the event. All aircraft and parachute operations are prohibited within a 3 NMR up to and including 3000 ft AGL of any stadium having a seating capacity of 30,000 or more people where either a regular or post season major league baseball, national football league, or NCAA division one football game is occurring. This NOTAM also applies to NASCAR sprint cup, Indy car, end part 1 of 2 FDC 9/5151 FDC part 2 of 2 .. Special notice .. Sporting events. Effective and champ series races excluding qualifying and pre-race events. Flights conducted for operational purposes of any event, stadium or venue and broadcast coverage for the broadcast rights holder are authorized with an approved waiver. The restrictions do not apply to those aircraft authorized by and in contact with ATC for operational or safety of flight purposes, department of defense, law enforcement, and air ambulance flight operations. All previously

issued waivers to FDC NOTAM 3/1862 remain valid until the specified end date but not to exceed 90 days following the effective date of this NOTAM. Information about waiver applications and TSA security authorizations can be found at http://www.tsa.gov/what_we_do/tsnm/general_aviation/airspace_waivers.shtm (case sensitive use lower case only) or by calling TSA at 571-227-2071. Individuals may submit a request for a FAA waiver at <https://waiver.c3.faa.gov>. End part 2 of 2”

APPENDIX 2 – FULL TEXT OF ALL SPORTING EVENT NOTAMS

FDC NOTAM 1/0257

Issued 9/20/2001 (Magnan 2001)

“FDC 1/0257 FDC flight restrictions effective immediately until further notice. Pursuant to 14 CFR section 91.137a(1) temporary flight restrictions - for reasons of national security all aircraft operations are prohibited within a three nautical mile radius/3,000 feet AGL and below over any major professional or collegiate sporting event or any other major open air assembly of people. Unless authorized by ATC for purposes of conducting arrival/departure operations.”

FDC NOTAM 1/3090

Issued 12/3/2001 and 12/13/2001 (Magnan 2002)

“FDC 1/3090 FDC flight restrictions effective immediately until further notice. Pursuant to 14 CFR section 91.137a(1) temporary flight restrictions - for reasons of national [sic] security all aircraft operations are prohibited within a three nautical mile radius/3,000 feet AGL and below over any major professional or collegiate sporting event or any other major open air assembly of people. Unless authorized by ATC for purposes of conducting arrival/departure operations.”

FDC NOTAM 1/3353

Issued 12/19/2001 (Magnan 2002)

“1/3353 ... Special notice ... Flight restrictions effective immediately until further notice. Pursuant to 14 CFR section 99.7, special security instructions. This is a restatement of a previous restriction. All aircraft operations are prohibited within a three nautical mile radius/ 3000 feet

AGL and below over any major professional or collegiate sporting event or any other major open air assembly of people unless authorized by ATC. wie until ufn”

FDC NOTAM 2/0199

Issued 2002

Unfortunately the text for this NOTAM cannot be located

FDC NOTAM 3/1862

Issued 2/10/2003 (NAPPF 2005)

“Pursuant to 14 CFR section 99.7, special security instructions, commencing one hour before the scheduled time of the event until one hour after the end of the event, all aircraft and parachute operations are prohibited at and below 3,000 feet AGL within a three nautical mile radius of any stadium having a seating capacity of 30,000 or more people in which a major league baseball, national football league, NCAA division one football, or major motor speedway event is occurring. All previously issued waivers to FDC NOTAM 2/0199 are rescinded.”

FDC NOTAM 9/5151

Issued 2/10/2009 (Federal Aviation Administration 2009)

“FDC 9/5151 FDC part 1 of 2.. Special notice.. Sporting events. Effective immediately until further notice. This notice replaces FDC NOTAM 3/1862 due to the waiver website change and language clarification. This notice modifies flight restrictions previously issued in FDC NOTAM 3/1862 to comply with statutory mandates detailed in section 352 of public law 108-7 and as amended by section 521 of public law 108-199. Pursuant to 49 USC 40103(b), the Federal Aviation Administration (FAA) classifies the airspace defined in this NOTAM as 'national defense airspace'. Any person who knowingly or willfully violates the rules concerning operations in this airspace may be subject to certain criminal penalties under 49 USC 46307.

Pilots who do not adhere to the following procedures may be intercepted, detained and interviewed by law enforcement/security personnel. Pursuant to 14 CFR section 99.7, special security instructions, commencing one hour before the scheduled time of the event until one hour after the end of the event. All aircraft and parachute operations are prohibited within a 3 NMR up to and including 3000 ft AGL of any stadium having a seating capacity of 30,000 or more people where either a regular or post season major league baseball, national football league, or NCAA division one football game is occurring. This NOTAM also applies to NASCAR sprint cup, Indy car, end part 1 of 2 FDC 9/5151 FDC part 2 of 2 .. Special notice .. Sporting events. Effective and champ series races excluding qualifying and pre-race events. Flights conducted for operational purposes of any event, stadium or venue and broadcast coverage for the broadcast rights holder are authorized with an approved waiver. The restrictions do not apply to those aircraft authorized by and in contact with ATC for operational or safety of flight purposes, department of defense, law enforcement, and air ambulance flight operations. All previously issued waivers to FDC NOTAM 3/1862 remain valid until the specified end date but not to exceed 90 days following the effective date of this NOTAM. Information about waiver applications and TSA security authorizations can be found at http://www.tsa.gov/what_we_do/tsnm/general_aviation/airspace_waivers.shtm (case sensitive use lower case only) or by calling TSA at 571-227-2071. Individuals may submit a request for a FAA waiver at <https://waiver.c3.faa.gov>. End part 2 of 2”

APPENDIX 3 – NATIONAL FOOTBALL LEAGUE (NFL)

DATA

Sample of National Football League Data, as of 02/08/2014

Stadium	Team	Team Website
MetLife Stadium	New York Giants	http://www.giants.com/
MetLife Stadium	New York Jets	http://www.newyorkjets.com/
Cowboys Stadium	Dallas Cowboys	http://www.dallascowboys.com/
FedEx Field	Washington Redskins	http://www.redskins.com/
Mercedes-Benz Superdome	New Orleans Saints	http://www.neworleanssaints.com/
Arrowhead Stadium	Kansas City Chiefs	http://www.kcchiefs.com/
Sports Authority Field at Mile High	Denver Broncos	http://www.denverbroncos.com/
Sun Life Stadium	Miami Dolphins	http://www.miamidolphins.com/
Bank of America Stadium	Carolina Panthers	http://www.panthers.com/
Cleveland Browns Stadium	Cleveland Browns	http://www.clevelandbrowns.com/
Lambeau Field	Green Bay Packers	http://www.packers.com/
Ralph Wilson Stadium	Buffalo Bills	http://www.buffalobills.com/
Qualcomm Stadium	San Diego Chargers	http://www.chargers.com/
Georgia Dome	Atlanta Falcons	http://www.atlantafalcons.com/
Reliant Stadium	Houston Texans	http://www.houstontexans.com/
M&T Bank Stadium	Baltimore Ravens	http://www.baltimoreravens.com/
Candlestick Park	San Francisco 49ers	http://www.sf49ers.com/
Lincoln Financial Field	Philadelphia Eagles	http://www.philadelphiaeagles.com/
LP Field	Tennessee Titans	http://www.titansonline.com/
Gillette Stadium	New England Patriots	http://www.patriots.com/
EverBank Field	Jacksonville Jaguars	http://www.jaguars.com/
CenturyLink Field	Seattle Seahawks	http://www.seahawks.com/
Edward Jones Dome	St. Louis Rams	http://www.stlouisrams.com/
Raymond James Stadium	Tampa Bay Buccaneers	http://www.buccaneers.com/
Paul Brown Stadium	Cincinnati Bengals	http://www.bengals.com/
Heinz Field	Pittsburgh Steelers	http://www.steelers.com/
Ford Field	Detroit Lions	http://www.detroitlions.com/
Hubert H. Humphrey Metrodome	Minnesota Vikings	http://www.vikings.com/
University of Phoenix Stadium	Arizona Cardinals	http://www.azcardinals.com/
O.co Coliseum	Oakland Raiders	http://www.raiders.com/
Lucas Oil Stadium	Indianapolis Colts	http://www.colts.com/
Soldier Field	Chicago Bears	http://www.chicagobears.com/

For a complete list and description of all data fields, see Appendix 8

APPENDIX 4 – MAJOR LEAGUE BASEBALL (MLB)

DATA

Sample of Major League Baseball Data as of 02/08/2014

Stadium	Team	Team Website
Chase Field	Arizona Diamondbacks	http://arizona.diamondbacks.mlb.com/
Turner Field	Atlanta Braves	http://atlanta.braves.mlb.com/
Oriole Park	Baltimore Orioles	http://baltimore.orioles.mlb.com/
Fenway Park	Boston Red Sox	http://boston.redsox.mlb.com/
Wrigley Field	Chicago Cubs	http://chicago.cubs.mlb.com/
U.S. Cellular Field	Chicago White Sox	http://chicago.whitesox.mlb.com/
Great American Ballpark	Cincinnati Reds	http://cincinnati.reds.mlb.com/
Progressive Field	Cleveland Indians	http://cleveland.indians.mlb.com/
Coors Field	Colorado Rockies	http://colorado.rockies.mlb.com/
Comerica Park	Detroit Tigers	http://detroit.tigers.mlb.com/
Minute Maid Park	Houston Astros	http://houston.astros.mlb.com/
Kauffman Stadium	Kansas City Royals	http://kansascity.royals.mlb.com/
Angel Stadium	Los Angeles Angles	http://losangeles.angels.mlb.com/
Dodger Stadium	Los Angeles Dodgers	http://losangeles.dodgers.mlb.com/
Marlins Park	Miami Marlins	http://miami.marlins.mlb.com/
Miller Park	Milwaukee Brewers	http://milwaukee.brewers.mlb.com/
Target Field	Minnesota Twins	http://minnesota.twins.mlb.com/
Citi Field	New York Mets	http://newyork.mets.mlb.com/
Yankee Stadium	New York Yankees	http://newyork.yankees.mlb.com/
The Coliseum	Oakland Athletics	http://oakland.athletics.mlb.com/
Citizens Bank Park	Philadelphia Phillies	http://philadelphia.phillies.mlb.com/
PNC Park	Pittsburgh Pirates	http://pittsburgh.pirates.mlb.com/
PETCO Park	San Diego Padres	http://sandiego.padres.mlb.com/
AT&T Park	San Francisco Giants	http://sanfrancisco.giants.mlb.com/
Safeco Field	Seattle Mariners	http://seattle.mariners.mlb.com/
Busch Stadium	St. Louis Cardinals	http://stlouis.cardinals.mlb.com/
Tropicana Field	Tampa Bay Rays	http://tampabay.rays.mlb.com/
Rangers Ballpark in Arlington	Texas Rangers	http://texas.rangers.mlb.com/
Nationals Park	Washington Nationals	http://washington.nationals.mlb.com/

For a complete list and description of all data fields, see Appendix 8

APPENDIX 5 – NATIONAL COLLEGE FOOTBALL ATHLETIC ASSOCIATION (NCAA) DIVISION 1 COLLEGE FOOTBALL DATA

Sample of NCAA Football Data as of 02/08/2014

Stadium	Team	Team Website
Nippert Stadium	Cincinnati Bearcats	http://www.gobearcats.com/sports/m-f
Rentschler Field	Connecticut Huskies	http://www.uconnhuskies.com/sports/r
Reliant Stadium	Houston Cougars	http://www.uhcougars.com/sports/m-fc
Papa John's Cardinal Stadium	Louisville Cardinals	http://www.gocards.com/sports/m-foot
Liberty Bowl	Memphis Tigers	http://www.gotigersgo.com/sports/m-f
High Point Solutions Stadium	Rutgers Scarlet Knights	http://www.scarletknights.com/football
Raymond James Stadium	South Florida Bulls	http://www.gousfbulls.com/SportSelect
Gerald J. Ford Stadium	Southern Methodist Mustangs	http://www.smumustangs.com/sports/r
Lincoln Financial Field	Temple Owls	http://www.owlsports.com/?path=footb
Bright House Networks Stadi	UCF Golden Knights	http://www.ucfknight.com/sports/m-fc
Alumni Stadium	Boston College Eagles	http://www.bceagles.com/sports/m-foc
Memorial Stadium	Clemson Tigers	http://www.clemsontigers.com/SportSe
Wallace Wade Stadium	Duke Blue Devils	http://www.goduke.com/SportSelect.dk
Doak Campbell Stadium	Florida State Seminoles	http://www.seminoles.com/sports/m-fc
Bobby Dodd Stadium	Georgia Tech Yellow Jackets	http://www.ramblinwreck.com/sports/r
Byrd Stadium	Maryland Terrapins	http://www.umterps.com/SportSelect.c
Sun Life Stadium	Miami (FL) Hurricanes	http://www.hurricanesports.com/Sport
Kenan Memorial Stadium	North Carolina Tarheels	http://www.goheels.com/SportSelect.d
Carter-Finley Stadium	North Carolina State Wolfpac	http://www.gopack.com/sports/m-footl
Heinz Field	Pittsburgh Panthers	http://www.pittsburghpanthers.com/sp
Carrier Dome	Syracuse Orange	http://suathletics.syr.edu/?path=footba
Scott Stadium	Virginia Cavaliers	http://www.virginiasports.com/sports/r
Lane Stadium	Virginia Tech Hokies	http://www.hokiesports.com/football/
BB&T Field	Wake Forest Demon Deacons	http://www.wakeforestsports.com/spor
Floyd Casey Stadium	Baylor Bearcats	http://www.baylorbears.com/sports/m-
Jack Trice Stadium	Iowa State Cyclones	http://www.cyclones.com/SportSelect.c
Memorial Stadium	Kansas Jayhawks	http://www.kuathletics.com/index.aspx
Bill Snyder Family Stadium	Kansas State Wildcats	http://www.kstatesports.com/sports/m
Gaylord Family-Oklahoma M	Oklahoma Sooners	http://www.soonersports.com/SportSel
Boone Pickens Stadium	Oklahoma State Cowboys	http://www.okstate.com/sports/m-foot
Amon G. Carter Stadium	TCU Horned Frogs	http://gofrogs.cstv.com/sports/m-footb
Darrell K. Royal-Texas Memo	Texas Longhorns	http://texassports.com/index.aspx?path

For a complete list and description of all data fields, see Appendix 8

APPENDIX 6 – NATIONAL ASSOCIATION FOR STOCK CAR RACING (NASCAR) DATA

Sample of NASCAR Data as of 02/08/2014

Stadium	Team Website
Daytona International Speedway	http://www.daytonainternationalspeedway.com/?homepage=
Phoenix International Raceway	http://www.phoenixraceway.com/?homepage=true
Las Vegas Motor Speedway	http://www.lvms.com/
Bristol Motor Speedway	http://www.bristolmotorspeedway.com/
Auto Club Speedway	http://www.autoclubspeedway.com/?homepage=true
Martinsville Speedway	http://www.martinsvillespeedway.com/?homepage=true
Texas Motor Speedway	http://www.texasmotorspeedway.com/Home.aspx
Kansas Speedway	http://www.kansasspeedway.com/?homepage=true
Richmond International Raceway	http://www.rir.com/?homepage=true
Talladega Superspeedway	http://www.talladegasuperspeedway.com/?homepage=true
Darlington Raceway	http://www.darlingtonraceway.com/?homepage=true
Charlotte Motor Speedway	http://www.charlottemotorspeedway.com/
Dover International Speedway	http://www.doverspeedway.com/
Pocono Raceway	http://www.poconoraceway.com/
Michigan International Speedway	http://www.mispeedway.com/?homepage=true
Sonoma	http://www.racesonoma.com/
Kentucky Speedway	http://www.kentuckyspeedway.com/
New Hampshire Motor Speedway	http://www.nhms.com/
Indianapolis Motor Speedway	http://www.indianapolismotorspeedway.com/
Watkins Glen International	http://www.theglen.com/?homepage=true
Atlanta Motor Speedway	http://www.atlantamotorspeedway.com/
Chicagoland Speedway	http://www.chicagolandspeedway.com/?homepage=true

For a complete list and description of all data fields, see Appendix 8

APPENDIX 7 – INDYCAR DATA

Sample of IndyCar Data as of 02/08/2014

Stadium	Team Website
Streets of St. Petersburg	http://www.gpstpete.com/
Barber Motorsports Park	http://barbermotorsports.com/indy/index-original.php
Streets of Long Beach	http://www.gplb.com/index.html
Indianapolis Motor Speedway	http://www.indianapolismotorspeedway.com/
Raceway at Belle Isle Park	http://www.detroitgp.com/
Texas Motor Speedway	http://www.texasmotorspeedway.com/Home.aspx
The Milwaukee Mile	http://www.milwaukeeindyfest.com/
Iowa Speedway	http://www.iowaspeedway.com/default.aspx
Mid-Ohio Sports Car Course	http://www.midohio.com/
Sonoma	http://www.racesonoma.com/
Streets of Baltimore	http://www.grandprixofbaltimore.com/
Auto Club Speedway	http://www.autoclubspeedway.com/?homepage=true
Reliant Park	http://www.grandprixofhouston.com/
Pocono Raceway	http://www.poconoraceway.com/

For a complete list and description of all data fields, see Appendix 8

APPENDIX 8 – COMPLETE LIST AND DESCRIPTION OF DATA COLLECTED FOR EACH SPORTING EVENT

- Event Type – Pro Football, Pro Baseball, College Football, or Race
- Stadium – Name of the venue or racetrack
- Team – Name of the home team for each venue
- Address – street name and number
- City – city where the stadium/racetrack is located
- State – state where the stadium/racetrack is located
- Zip – zip code
- Phone – contact phone number
- Lat – Latitude
- Long – Longitude
- Where – location of the latitude and longitude coordinates
- Conference/League – NFL, MLB, NASCAR, IndyCar, individual college football conference names i.e. Big 10, SEC, Pac 12
- Conference/League website – URL link to the college football conference or professional league homepage
- Team Website – URL link to the team’s or racetrack’s homepage
- Team Schedule – URL link to the team’s schedule located on the team’s website
- ESPN Schedule – URL link to the team’s schedule located on espn.com
- Stadium Seating Capacity – seating capacity of the stadium, necessary because the NOTAM identifies stadiums larger than 30,000 seating capacity
- Date Capacity Last Checked – necessary for currency of data, especially for the few college teams that have seating capacities less than 30,000 people.
- Capacity reference – URL link to website where seating capacity was obtained