Utilizing Online Data Sources to Improve Existing Military Aircraft Systems

by

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List of Abbreviations

CIB	Controlled Image Base
FMV	Full Motion Video
FTU	Formal Training Unit
DOD	Department of Defense
DOQ	Digital Orthoimage Quadrangle
DRG	Digital Raster Graphics
GIS	Geographic Information Systems
GEOINT	Geospatial Intelligence
HSIP	Homeland Security Infrastructure Program
LEO	Law Enforcement Officer
MMS	Mission Management System
MrSID	Multiresolution Seamless Image Database
MSO	Mission Systems Officer
OSS	Operations Support Squadron
RC	Reconnaissance/Cargo
SOS	Special Operations Squadron
TIFF	Tag Image File Format
TIGER	Topologically Integrated Geographic Encoding and Referencing
USB	Universal Serial Bus
USC	University of Southern California
RPF	Raster Product Format

Abstract

This thesis aims to improve the quality of tools available to the Air National Guard, more specifically the RC-26 mission management system (MMS). The RC-26 is an unconventional aircraft doing an unconventional mission for the military, working directly with law enforcement agencies to provide an airborne video camera for counter-narcotics activities. This aircraft has been doing this mission since the late 1990's and has undergone many hardware and software upgrades since then. However, these upgrades commonly take many years to accomplish, resulting in operators using obsolete systems and outdated information stored on the aircraft's computer systems. In some cases, operators even lack the knowledge of how to utilize the systems or update them to better accomplish the mission. The purpose of this thesis is to help rectify those shortcomings and create a simple and repeatable process for maintaining and updating those systems with the latest, most up-to-date street maps and aerial imagery from all sources available on the internet and thus improving the aircrew's effectiveness. It does so by sourcing compatible street data and imagery from government sources that is compatible with a number of government systems. Additionally, since the fleet of aircraft are spread throughout the country, this work creates an instructional aid so that the process can be fully understood and replicated. Using the sources and procedures developed in this thesis have been applied to real world law enforcement support as well as humanitarian mission in support of Hurricane Relief in Puerto Rico.

Chapter 1 Introduction

As the common saying goes “a poor craftsman blames his tools,” meaning people will excuse their poor work on not being adequately equipped. Also, according to Italian General Giulio Douhet, one the first proponents of strategic airpower after World War I, “Flexibility is the key to airpower” (Douhet 1942). The U.S. military prides itself on being the best trained and best equipped military in the world, supporting operations on a worldwide scale. While this has been true over the decades, this thesis aims to correct a shortfall in a very specific application. the mapping function of aircraft that are used by the Air National Guard to assist law enforcement. “As authorized by the National Defense Authorization Act and directed by the governor and The Adjutant General, the Counterdrug Aviation Mission is to safeguard our communities by providing state of the art Aviation reconnaissance and observation support to federal, state, and local law enforcement agencies' counterdrug operations, including the disruption and dismantling of Transnational Criminal Organizations.” (National Counterdrug Office n.d.)

The newest model of the RC-26B, also called the block 25R, uses a gimble mounted electro-optical and infrared camera on the bottom of the aircraft that can geolocate where on the earth it is looking and displays the images and an indicator of that location on a map while airborne. While airborne, the crew communicates with law enforcement agents on the ground, giving a location for sightings of suspicious activities relative to intersections and other recognizable landmarks that are visible from a vehicle. The latest version of the RC-26B is lacking this street map information, thus inhibiting the aircrew from passing this vital information and negatively affecting the mission.

Figure 1 RC-26 Aircraft

This chapter introduces the goal of the project, the motivation behind the project, and finally, an overview of the project development.

1.1. Overview of Project Goal

The goal of this research project is to instruct and enable Missions System Officers (MSO) of the RC-26B Air National Guard to access and download shapefiles containing road and imagery information that can then be transferred to the mission management system (MMS) to better accomplish its primary mission of assisting law enforcement agencies investigating illegal narcotic activities. Due to developmental problems with the software integration phase of the MMS on the RC-26B, there is no street data and very little usable imagery. The aircraft uses a mounted camera that can view cars and people from great distances, bringing powerful tools to law enforcement officers when investigating narcotic activities.

Street data is needed to enable communication with law enforcement officers on the ground and convey exactly where the aircraft is looking on the ground to track suspected drug traffickers. Verbally transmitting location by latitude and longitude alone would be too laborious and slow to keep up with a fast-moving vehicle. As an example of why this reference material is needed to be displayed on the MMS, during a flight over Kansas City, Missouri with local law enforcement during an investigation, there was no street data loaded onto the MMS of the aircraft. While the MSO kept the camera of the aircraft fixed to the target, ground units were told to keep their distance as to reduce the chance the target suspected he was being followed. While following the target with the aircraft, street information was passed to ground agents so they could follow without keeping visual contact, however that street data was from local knowledge of the Law Enforcement Officer (LEO) on board the aircraft and also a second crew member referencing an electronic street map, feeding information to the LEO, who then passed that information to the ground. In the process of tracking this vehicle and due to aircraft placement, the MSO lost sight of the target and experienced difficulty reacquiring the target. Remarkably, a ground unit had made visual contact with the target and passed the intersection of the target back to the aircraft. Only having the local knowledge of the LEO and a street reference map available, was the MSO able to find the target again and continue to track. Additionally, part of the research is searching for various sources of street data that can be utilized by the system. The target data consists of up-to-date street, highway, and county line information, essentially all the political information that can be imported for maps. Other targeted data consists of the latest aerial imagery of varying degrees of resolution while balancing data sizes, given that all data will need to be passed via an USB device to a standalone aircraft computer. A document will be created that provides step-by-step instructions for completing the entire process of locating the desired data, downloading the data, transferring and then implementing the data. Another goal is to form the shapefiles into manageable sizes, which in turn will reduce each MSO's workload and enable them to quickly integrate the data needed to better do their job.

1.2. Motivation and Background

Figure 2 Mission System

The purpose of this research project is to remedy a shortfall in the design of the computer system that is currently aboard the RC-26B aircraft, an aircraft used by ten different states in the Air National Guard. There are currently eleven aircraft in the inventory that are operated by the Air National Guard to assist law enforcement and a multitude of different agencies that require a remote viewing aircraft. The latest iteration of the mission management system (MMS), called the Block 25R, is incredibly capable and has been installed on six of the eleven aircraft but falls short in one critical area for the RC-26B's unique mission set (FAS 1999). It is lacking street imagery and information. The system was adapted from an existing platform, the U-28, which is primarily used overseas in military operations. Its primary mission is mainly tactical, so the integration of street information is not needed, as much location information is passed in coordinates, not street addresses or intersections. This lack of information makes it very difficult to work with law enforcement, as much of the information they pass to the ground units is streets the target is on and intersections they are passing through. Unless the agent on board working with the Air National Guard asset is intimately familiar with the location where they are operating, it is very challenging to pass useful information in a timely manner.

In the military, it is usually the function of a formal training unit (FTU) to address such an obstacle as the one proposed in the paper. But as much of the RC-26B community is non-standard, so is its training and development. For example, if an Air Force pilot were to become a C-130 pilot, they would go Little Rock Air Force Base for that specific training and there is an entire base that is dedicated to training aircrew for that aircraft. Similarly, for the RC-26B, the 745th Special Operations Squadron (SOS) schoolhouse was located at Hulbert Field, Florida, and was responsible for training and development of tactics for the RC-26B.

However, due to a shift in the priority of the aircraft and it no longer being used overseas operations, the schoolhouse was shut down in 2013 (Holochwost 2013) and all training became the responsibility of each state individually. In spreading that responsibility to each state in addition to all operation scheduling requirements, further development of tactics and training did not advance or keep up with aircraft development. The latest version of the mission management system was built by a third-party company fulfilling the contract requirements laid out by the special program office out of Tinker Air Force Base. Originally, they did create a well-conceived system that was built to serve both overseas missions as well as the RC-26's stateside mission working with law enforcement. However, there was one shortfall that was discovered during the testing of the software integration—the road mapping software that was used by the contracting company did not work well, was never deemed operational, and was removed from the system until a more compete and well-developed program was created. The latest version of the MMS was delivered about two years behind schedule. Given that it is unacceptable to not be able to use the aircraft for its primary mission, the best alternative is to find a work-around as it could conceivably be another two years before a solution is offered.

In the last year, an Operation Support Squadron (OSS) was formed at Key Field in Meridian Mississippi with the 186 Air Refueling Wing whose primary mission is to update the forms, publication, syllabus and training for the RC-26 to ease the burden on each state for training and staying current on publications and Air Force Manuals. Eventually, the “school house” may embrace solutions to the problems that this project resolves, yet it is low on the list of requirements. The RC-26 publications are very out of date and that is where the focus of the OSS is at for the foreseeable future.

1.3. Further Goals

One of the great challenges that organizations of any size have is managing the knowledge that its members have and preserving that knowledge when members leave or are separated from each other. According to Thomas Davenport, “many firms have come to understand that they require more than a casual (and even unconscious) approach to corporate knowledge if they are to succeed in today’s and tomorrow’s economies” (Davenport 1998), This is true of military organizations as well. While there are many manuals instructing the use of military systems, many techniques and shortcuts are not committed to paper and are primarily taught person-to-person. Occasionally, in the case of the RC-26B community, geographic separations and the lack of cross-training of units means that knowledge may only stay with a few people and is lost once that person moves on or retires.

A desired by-product of this project is to correct another problem in the community, the loss of knowledge. As an instructor/evaluator, this position involves not just teaching the various systems of the aircraft and the basic functionality of the equipment on-board, but also includes passing on lessons learned, times things have gone wrong or right, and ensuring that when the next MSO is on a mission, they are ready to do the job and do it well. Creating this project allows the work to affect all in the community in a positive manner and hopefully inspire others to do the same and to put knowledge to paper and spread it to all to be a more effective flying unit. And beyond just the RC-26, other aircraft also using this, or similar computer systems may find this process adaptable to other stateside missions, increasing the value of our military to benefit people on the home front.

The U.S. military is requiring all new technology procured to be open and compatible across many different pieces of equipment, enabling quick retrofitting of systems to when equipment changes missions. Labeled "Sensor Open System Architecture" (DOD 2017), the goal is to create common mission system architectures among all aviation platforms so different sensors and equipment packages may be interchangeable. The result will benefit the operators by rapidly acquiring the equipment that they need and being able to customize that equipment to better fit the mission. The benefits of this is future mission systems will not be proprietary and closed but able to accept user sourced data like the data used in this thesis. It seems clear that future systems will keep the customizable data that the system on the Block 25 has, so the need for this information for the users is imperative.

1.4. Project Overview

This project will have four different steps which result in a product that will remedy the problems listed above. First is to determine the desired datasets by studying what has been used on previous versions of the RC-26 and also to research other airborne systems that perform similar functions. This will be reported in the related work chapter. From those data sets, then determine what is available to the users for this project, validate the available data is compatible with the targeted MMS, and finally document the procuring and installing and use of that data into the targeted system via an instruction manual so the users may implement these data sets independently and at will.

The street data and imagery are evaluated for optimal operational use by different criteria. Street data criteria is level of detail, comprehensive coverage of the United States, the main operating area of the RC-26, its availability to the user and finally its compatibility with the MMS. Imagery has a few of the same criteria as street data, compatibility, availability and area of coverage. The other criteria for imagery are more subjective to the user's needs, that is imagery resolution. While imagery isn't vital to solve the problem this thesis presents, it has been noted to enhance the observers ability to determine the relative location of a person in a scene with significantly high accuracy compared to individual image modalities (Toet Ijspeert Dorresteijn 1996) . A certain level of resolution is needed to make the imagery useable, finding a balance between resolution and file size is part of the evaluation process., but is also left to the user to determine their needs. Additional criteria beyond operational applications are ease of implementation for the user, is there any pre or post processing required, and finally cost. All monies spent on government products need to be justified, getting that justification approved can sometimes take time, longer than this project aims to rectify the situation. While some sources of data are free on their own, the software to process that data into an acceptable form may require funding. A completely free source of data would be ideal and one that requires minimal processing by the users.

Chapter 2 Related Work

This chapter researches existing systems that are already in use for similar mission sets of the RC-26B, their roles and how this aircraft and thesis relate to geospatial intelligence (GEOINT) as well as available street mapping and imagery products that are available to both the public or to military personnel that could access that data for the output of the project.

2.1. Existing Airborne Mapping Systems

Ultichart, created by AeroComputers Inc., is the mission management system that is installed on the remaining five RC-26Bs, dubbed the Block 20, that complete the inventory. This is a robust system that has been used on countless missions and by many different aircraft. The design of the Block 25R upgrade did not utilize the Aerocomputer (Aerocomputer n.d.) system. This system utilizes a proprietary mapping program that in older systems has a side-by-side viewing system, so the video output is shown next to a map with the centroid of the camera denoted on the map allowing information to be passed to ground law enforcement units. The map has different scales and is designed to always include the name of the streets in the viewable image, so the information was always readily available This system is very effective and is ideal for the domestic mission of the RC-26B. The current versions of the Ultichart program can be seen at Aerocomputers website. Ultichart map data is called Aerostreet and is owned and maintained by Aerocomputers. This mapping system has many desirable features including many different levels of zoom, and is searchable by coordinates, address, points of interest and intersections.

Figure 3 AeroComputers Map Example

Goliath AR (Augmented Reality) is a street mapping program that was to be the street overlay on this aircraft with the upgraded equipment of the Block 25R. Installed by Boresight, the selected contractor, this program utilized its own street map that could be overlaid on the video image for easy navigation. Due to developmental difficulties and testing that deemed the program non-functional, it was abandoned and uninstalled from the MMS aboard the RC-26B, and created the shortfall which this project aims to correct. (L3 2016)

Figure 4 Boresight Goliath AR Map

The previous version of the MMS that was installed on six of the RC-26B (USAF 2008) was developed by Boresight also and called the Situation Awareness Display System (SADS). It had a proprietary map system that had only one version but could be zoomed into for more detail. This system was still functional when it was decommissioned and upgraded to the Block 25R system that exists now, but due to age and lack of spare parts as well as no longer being supported by the original contractor, it was dubbed not mission effective and is no longer installed on any aircraft.

Another system that is successfully being employed on many aircraft across the country that also has a very similar mission set to the RC-26 is the Pilatus PC-12 Spectre (Pilatus n.d.) used by Texas Department of Public Safety (Texas DPS 2017). It is also equipped with a gimble mounted electro optical infrared camera and a mission management system. The mission management system was created by Churchill Navigation (Churchil Navigation n.d.) and uses an augmented reality overlay with its camera feed. This is the ultimate for situational awareness when conducting real time remote sensing as it allows the user not to look away from the target when getting reference information for ground units. And like many other systems, it’s mapping data is proprietary. Therefore, the users are dependent upon the company providing updates.

2.2. Geospatial Intelligence

The role of the RC-26 since its inception has been that of a full motion video (FMV) platform that has been used domestically to provide law enforcement with standoff for observing and tracking illegal narcotic activity while communicating with ground-based agents. (National Counterdrug Office n.d.) and by law the imagery collected and temporarily stored on the aircraft is not retained for law enforcement purposes (National Guard Bureau 2008) leading its involvement with geospatial intelligence to be rather limited. GEOINT is defined as “the exploitation and analysis of imagery and geospatial information to describe, asses and visually depict physical features and geographically referenced activities on the earth." (Armed Forces Definitions, US Code 10 (2006), § 467) and does seem to encompass the activities of the RC-26 in its broad definition, but GEOINT activities usually involve more collection, analyzing and dissemination of imagery and is more often associated with satellite collected imagery, thus limiting the RC-26 contribution to the GEOINT community as a whole. Nor has the RC-26 traditionally not sought imagery or data from the GEOINT community and has relied on commercial mapping products, such as Aerocomputers™ or Boresight™ for their data needs.

Expanding the interaction between the operators of the RC-26 and GEOINT providers, namely the National Geospatial Intelligence Agency is a goal of this thesis. Giving the MSO's aboard the RC-26 the ability to access and use the best data available and increasing their interactions with the system should enable them to complete the mission more effectively and not be hampered by missing, incomplete or low-quality imagery or street data. Ideally this will also facilitate the MSO's ability to contribute to GEOINT by if they understand the inputs of the system, they may deepen their understanding of the possible outputs of the system and strive to adapt the system to the needs of the users. Another benefit of using current and high quality imagery and street is when providing imagery for law enforcement agencies to use for evidence, to have a quality reference image with street names natively displayed side by side with the FMV screenshot will enhance the usefulness of the product, eliminating post processing work for different agencies.

Figure 5 Churchill Navigation AR System

2.3. Available Street mapping

TIGER/Line by the U.S. Census Bureau is a very complete and detailed database that includes all the street data of each county in the United States. This will be a main source of street data for the aircraft as it is already downloadable in shapefiles. A drawback is that there are thousands of files that need to be downloaded to get a complete database of all counties and street maps of the U.S. Depending on the users to manage that many files could easily lead to missing needed counties. Another drawback is that the file's do not have an easily recognizable naming convention. For example, "tl_2017_19035_roads.zip" is the name of the street shapefile for Cherokee County Iowa from 2017. While it is easy to validate the year and the data type, where it is from is not clear by file name alone. These errors could easily impact a mission if that street data was unexpectedly missing. TIGER/Line has new data every year available at no cost.

Openstreetmap is also an ideal data source for this project. It is free and has extractable data into shapefiles by selecting the target area. The advantage of this website is that the user can define the size of the shapefile that is created and decrease the number of files that need to be downloaded. Openstreetmaps is user-created so the updates are continual. However, since it is not a government agency creating the data, incorporating this data into a government system may be met with some scrutiny from the community.

2.4. Imagery

The National Geospatial-Intelligence Agency has a wide variety of imagery available for download through an encrypted web portal. It contains Controlled Image Based imagery from 10 to 1 meters in resolution and are available for download via government systems. Also available for download via this site are numerous US Geological Survey Images, Digital Raster Graphics, Topographic Maps and Digital Orthophoto Quadrangle Imagery (DOQ). This site has vast amount of data and can allow the user to refine the data by selecting areas of land by region, country, state or several user defined shapes. The data is easy to download, but depending on the imagery resolution, can vary in download size from a few megabytes to well over a terabyte of data, much too large to download and move on portable media. This site will be the main source of data but with the challenge of determining what imagery is most useful, which will be defined by the users, while still be portable in terms of data file size.

The University of Maryland also maintains a public repository of Multiresolution Seamless Image Database (MrSID) which was collected by the LandSat 10 from 1990 to 2000 and is available to download from their file transfer protocol (ftp) website. Some of this imagery has already been loaded on to the aircrafts MMS and this site contains the mission patches of imagery. The data is accessible through a graphical user interface called the Earth Science Data Interface, which enables the user to simply check boxes for desired data, pan to desired location, and display available data for download.

An additional source of CIB 10m data collected from the SPOT satellite is available for download via the U.S. Geological Survey Earth Explorer Website, using a similar interface to the University of Maryland website.

2.5. Implementation of Data

In the article "The 2012 free and open source GIS software map – A guide to facilitate research, development and adoption" (Steiniger 2013) gives good guidance on map selection and scrutiny when implementing data for map use. A good example is attempting to use and well known commercial map service, such as Google Maps™. For base map data as it appears to be free for use, but as pointed out in this article, use of their data must only be used for certain applications and limit "free" use to non-commercial, limited personal use. Using the advice and guidance in this article, it can be inferred that using open source, free data should be used for this project so that licensing does not need to be considered, especially since this is a not profit project to enhance an existing system. Also, it would be difficult to obtain funding to purchase map data for use of the aircraft, again delaying the mission readiness of the aircraft for its current mission.

Chapter 3 Methods

This chapter discusses the data that is targeted in this thesis and the methods for identifying, acquiring and implementing that data into the mission management system. The initial method for identifying data required refers to what has been used in the past and compares that to what is easily accessible to persons that utilize the MMS. It is a requirement that the data be easy to access and implement as one of the goals of this project was to create a repeatable process that someone could do with only internet access and a set of instructions.

3.1. Data Requirements

There is one ubiquitous data set that is required, a reference map that an MSO airborne who is above any location in the United States can easily communicate the location on the ground they are looking at so that a person there can locate that position quickly. Similar to if a person was driving in a car in an unknown city and had to let someone know where they were, having a map to reference their location through streets and intersections is the fastest way to communicate a position. Past systems that were used on the RC-26 such as the AeroComputer Ultichart, similar to Figure 1 below, had their own base map that was zoomable and held enough data that would integrate easily into operational missions. However, with the Block 25R system, this type of map is not available, so a combination of data must be used to have the same effect, combining street data with imagery and thus creating the two unique data sets that must be identified and acquired. When conducting airborne observation, the oblique viewing angle the aircraft has causes distortion and does make it difficult to verify what you are looking at through a camera is in fact the intended target. It is helpful to have imagery for reference.

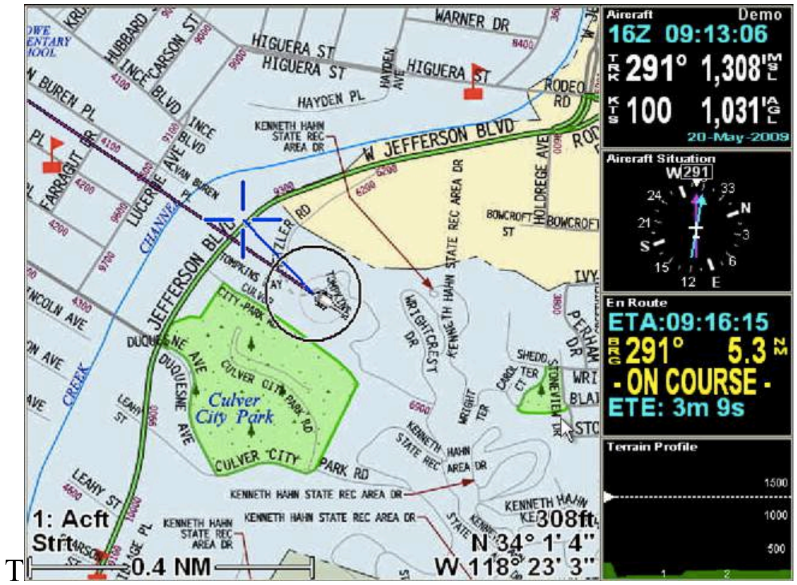

Figure 6 AeroComputers Ulitchart

3.2. Street Data

Street data is the most vital part of the target data as it is what is needed for this thesis because it contains the information that is referenced and passed to counterparts on the ground. The requirements of the street data is that it contains all primary, secondary and surface level streets to include even unpaved roads. Also required is that all streets have their names listed clearly and printed often enough so when panning along the street, the name is present most of the time for quick reference.

3.2.1. TIGER/Line

The most complete and readily available data for street information is the Census Bureau's TIGER/Line shapefile database that includes every county in the country and are available for download from the Census Bureau's website via an ftp site. These shapefiles are listed in the directory of the MMS and seem to be the most suitable. A sample test of loading the data was performed for a real-world operation supporting Hurricane Maria disaster response over Puerto Rico. It was vital to have street information as part of the mission in an effort to identify roads that had been washed out and, in turn, pass their location to ground personnel, so they may find routes to provide aid to people. TIGER/Line shapefiles were downloaded to the aircraft from the U.S. Census Bureau's website and successfully loaded and used on the aircraft, validating one of the desired outcomes of this project.

3.2.2. OpenStreetMap

Another dataset targeted for street map use is OpenStreetMap because it has a similar appearance to Google Maps and the AeroComputers Ultichart. It also has the utility that a polygon can be created around the desired area anywhere in the U.S. and only that data will be downloaded. The files are downloaded in *.shp format and appear to be compatible with the MMS, and testing will occur in Chapter 4.

3.3. Imagery Data

There are two types of imagery that were used in this project: (1) satellite imagery or aerial photography; and (2) political type maps that contain drawn maps, (e.g., USGS Quadrangles).

3.3.1. Satellite Imagery and Aerial Photography

There have been numerous satellite and aerial imagery compilations of the United States over the years dating from the early 1970s to the present day. All of these vary in spatial resolutions and panchromatic to color. The general requirement for imagery data is that it is of high enough spatial resolution to easily discern roads and buildings by the user so that if a road or building is obscured in real life from the air, it can still be determined what objects are along the route of travel and where the streets are located. When getting this type of data, it is important to note that it is not entirely necessary to include this imagery as long as the street imagery is present. It may be easier to have a backdrop to the street data as it is what most people are used to looking at and easy to compare the actual camera footage to the map to verify location. Below is a table listing targeted data used in this work.

Table 1: Data Types, Sources, and Format

Data Set	**Spatial Resolution**	**Temporal Resolution**	**Source**	**Data Format**	**Data Set Obtained**
Street Data (TIGER/Line)	United States	Most current available	Census Bureau TIGER/Line	Shapefile (*.shp)	Sample set (Puerto Rico)
Imagery (Controlled Image Base)	United States (10 Meter)	1986-1993	USGS	GeoTIFF	Sample Set (Greater Des Moines, IA)
Imagery (Controlled Image Base)	United States (5 and 1 Meter)	Unk	National Geospatial Intelligence Agency	Zip file (I22 files)	Sample of 5 Meter/None of 1 Meter
Digital Raster Graphics	United States 24K	2001	National Geospatial Intelligence Agency	GeoTIFF	Sample set (Greater Des Moines, IA)
Imagery Mulitresolution Seamless Image Database	United States	1990 & 2000	University of Maryland	Zip file (I22 files)	Sample set (Greater Des Moines, IA)

All of the imagery targeted in this table was verified to be compatible with the MMS and is free to the targeted users if they have internet access.

3.4. Methods

To reiterate the goal of this paper, it was to allow the users of this aircraft access and instructions to the best data available to fix the shortfall with the latest integration of the mission management system. The method for doing so will be covered in the remainder of Chapter 3.

3.4.1. Identifying data

Referencing what has been used in the past and also what is available to the user is how the data is targeted. The Block 20 and 25 had a simple street map that was scalable so that different zoom levels of the map showed more detail the closer a user zoomed into the map, allowing them to optimize the display as needed. It is not an option to retrieve those same maps that were used, as they were proprietary to the programs that were loaded on the aircraft. Trying to emulate that set up is the best that can be done as all users of the aircraft are familiar with this layout and can easily adapt and optimize the use of such a map. With that in mind and referencing the target with what is compatible with the computer system and is listed in Table 1, this paper describes the testing done with these sets to find which have to the optimized display for the MMS.

3.4.2. Documenting the process for instruction

A very important segment of this project is to create an instructional aid that will guide each user through the process of locating the data they need, downloading that data, transferring it to the aircraft and successfully integrating it with the system for use in flight. Creating this document was done by recording each step and taking screen shots with the Windows "Print Screen" function or with simply taking a picture of the screen. Instructions were broken down to the level that anyone with no GIS background could replicate the process and get basic data sets for street data and imagery onto the aircraft. The resulting product also details gaining access to the National Geospatial Intelligence Agency imagery and map downloads. This site is protected, and users must have proper credentials for access, while the products from this website are unclassified, they are for licensed users and limited distribution. The documentation process ran concurrent with research and testing of the data, but data that was found to be incompatible or too complex to be useful to the common user were omitted from the final product.

3.5. Evaluation and Testing

3.5.1. Census Bureau TIGER/Line

Street data from the Census Bureau's TIGER/Line website was the first item to be tested. All counties were included from Puerto Rico in that the RC-26 was deployed to Puerto Rico in support of the search and rescue operations in response to Hurricane Maria and the previous Hurricane Irma damage. It was imperative that street data was included for the search and rescue operations, given that many roads were destroyed and needed to be surveyed by the aircraft. There was a slight variation from Puerto Rico in comparison to all of states in the U.S. in that Puerto Rico does not have listed counties but rather uses "municipios," which is the Spanish translation for county meaning approximately the same thing. All "municipios" from Puerto Rico were downloaded and successfully transferred onto a USB drive and uploaded and integrated into the mission management system on the aircraft. While road damage could be discerned simply by observation, street information was key to communicating which roads were damaged as access to the interior of the island was key to deliver aid where needed.

To successfully load the road shapefiles into the mission system, the correct directory was located in the Windows operating system. There was a Maps and TIGER/Line subfolder created so shapefiles could be loaded and then subsequently accessed by the mission management system. It was also found that a reboot of the system was needed to correctly load the new shapefiles.

This data was found to be available, covered the entire United States to include its territories, compatible with the MMS, required no processing aside from downloading from the internet and moving to the correct subdirectory, and is free for all users.

3.5.2. Imagery (CIB 1 and HSIP)

The highest resolution imagery that could be found that is readily available and free to users was 1-meter control image base (CIB) and also home and security infrastructure program imagery (HSIP) which is 1 meter or greater from the National Geospatial Intelligence Agency's protected website. This proved to be the ideal source of data, as it provided high-resolution imagery and was available for no cost to authorized users. The user interface on the National Geospatial Intelligence Agency's website was very user-friendly and the directions were simple to create for any new user to get the imagery they need. The only limiting factor was that in instances where large areas of data were needed, the data can only be downloaded in extremely large files which, in turn, take tremendous amounts of time to download. All other areas can be covered by the 5-meter resolution imagery, and while it does not create a high-level detail, it does allow for large areas to be downloaded in a single file. Again, the process for downloading, transferring and uploading these images are documented in the instruction file. It is also suggested that only one area be loaded into the subdirectories at a time, it was observed if too many areas were uploaded at a single time, the system will slow reference data files are too large and could create problems for the software's ability to run smoothly while airborne.

Both data sets met all required evaluation criteria, available, compatible, wide spread coverage, requires minimum processing which is sorting of the individual files into the correct subdirectories and finally is free for permitted users.

3.5.3. Imagery (CIB 5 & DRG)

Imagery was found on multiple websites including the USGS and most notably the National Geospatial Intelligence Agency's websites. While the USGS is open for anybody to download and products are in GeoTIFF format, the imagery is also available from the National Geospatial Intelligence Agency if a user has permission and a need to download the information. To simplify the process of downloading imagery, a single source was selected to cover 90% of user's needs. The two data sets that were loaded were CIB imagery 5 m in 1 m including homemade security imagery which is greater than 1 m imagery and also DRG digital raster graphics or quadrangles in GeoTIFF format. GeoTIFF were found to be the easiest to load because they were downloaded as zip files and once extracted on the desktop were into format and were already geocoded. It was a simple process to load the GeoTIFF; the only complex part is each GeoTIFF must be loaded separately and will need to be loaded in each attempt to run the mission management software. This instruction will implement, not improve a method for getting this data on the aircraft. There is currently no established method for this as part of the aim of this project is to document this process, so it is easily repeatable by all targeted. On the previous models of this aircraft, the block 20 and 25, the mapping system was loaded by the manufacturer and as has already been stated, the 25R does not have native mapping systems. The software used will be a webpage builder, ArcGIS or ArcGIS online and Adobe Acrobat will be used to create an instructional aid with this project so that the entire process can be replicated by anyone as is one of the goals of this project. A synopsis of the workflow process is listed in Figure 7.

Similar to the previous imagery, these imagery sources met all criteria for evaluation, availability, compatibility, coverage, processing requirements and cost. All products have the ability to be implemented into the RC-26 MMS by the common crew person.

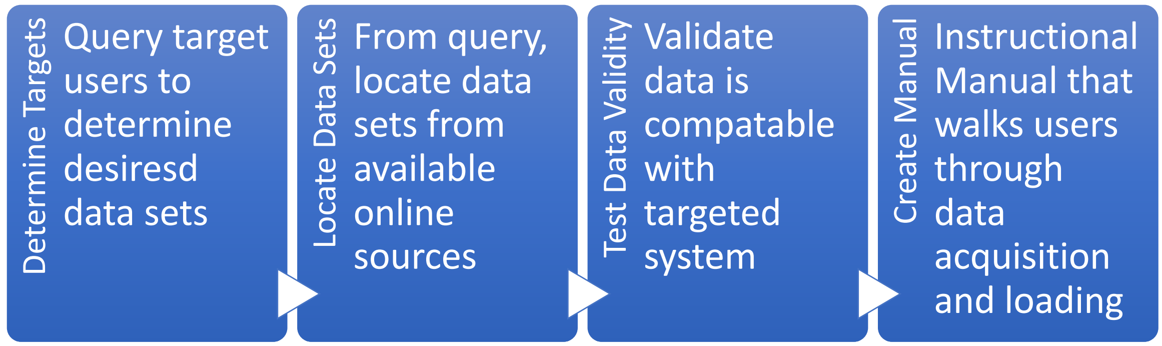

Figure 7 Work Flow

3.5.4. Testing

Once the data was identified, samples of Census Bureau's TIGER/Lines, NGA imagery including CIB 1, 5, 10 and HSIP sub 1-meter imagery for Polk County and the greater Des Moines Iowa Metro area were all loaded onto the aircraft and placed into the proper subdirectories. The system was restarted, and once the system was back up and running, all layers displayed properly with and without the street data overlay. The 5- and 10-meter imagery did require use of the zoom function in the MMS system to be able to view the street data legibly. Further iterations of this testing were completed on subsequent mission over different states. Street data was loaded onto the aircraft for surrounding states as well as 1-meter imagery for high use areas such as Kansas City Missouri. All loaded data displayed properly and worked as desired. All testing was completed by the author with the exception of testing of street data for Puerto Rico, which was loaded by the author but tested/used by a colleague of the author during Hurricane Relief work for Hurricane Maria in 2017. Operational use of the products was completed by colleagues of the author during real world operations over Kansas City, Missouri and continue to do so.

3.6. Required Research Skills

The required research skill for this project was be combining shapefiles (*.shp) in ArcGIS or ArcGIS online to produce fewer shapefiles for the user to work with. Knowledge of the mission management software that is on board the RC-26B, which was created by ForceX, a division of L3, is also required. There is literature to assist in this last step as well as formal training offered by the developer. This last step is also needed to ensure that the targeted data sets can be easily integrated and used in the current mission management system on board the aircraft. The process for integrating the data into the MMS are to locate the root directory where the data is stored and accessed from the software when it is loaded each flight. The items the user needs to keep track of are what type of imagery they are loading, its resolution and the area of interest the data covers.

Chapter 4 Results

This chapter details the results of the testing completed and display the finished product and discuss the results of testing completed by users with this product.

4.1. Data Results

There were some successful and unsuccessful data sets when testing the different sources and types. The successful data sets included the TIGER/Line shapefiles from the Census Bureau and all imagery and maps including GeoTIFFs from the National Geospatial Intelligence Agency's website. The unsuccessful imagery and street data were from the open street map website and included attempts to extract to GeoTIFF's using ESRI's ArcGIS ArcMap to create a custom GeoTIFF. While the two unsuccessful methods were not totally unsuccessful in that they would work on board the aircraft, it was the method to make the data compatible and usable with the aircraft that disqualified them from the final product. The method for creating them involved multiple steps using ESRI ArcGIS ArcMap software and a good understanding of Geotagging and the differences from a regular tiff image. The need for the specialized knowledge and software proved too complicated for the regular user of the software to complete on their own.

4.1.1. Street Data

The street data that worked best with the mission management system was from the Census Bureau's TIGER/Line website. The provided data focuses down to highway secondary and tertiary road levels as shown in Figure 8, which garners enough detail for our operators to be useful for operations. The benefits of this data are it is updated every year and specific counties can be selected allowing users to select as little or as much data as the required or needed. The only disadvantage is once the files are downloaded the nomenclature for the file names is coded and does not give the user any clues as to what county or state the files belong. It requires the users to be very organized when downloading and transferring the data from the computer to the aircraft's mission management system. There is additional information in the instruction manual for keeping these files organized by state and only having the state it is in use in the active register on the aircraft.

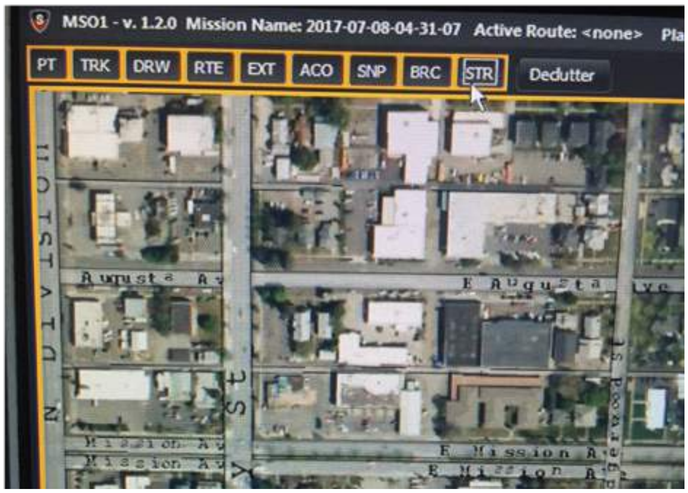

Figure 8 Combined HSIP and TIGER/Lines

4.1.2. Imagery

There were several websites that contained imagery that could be downloaded for free and was current to provide situational awareness for the mission system operator. However most free data was limited to 10-meter resolution and was more than a few years old. This low resolution and "old" imagery was not helpful with situational awareness and sometimes such low resolution that it actually obscured from the street data overlaid from the TIGER/Line files from Census Bureau. The most fitting imagery came from the National Geospatial Intelligence Agency's own website, and it was not only free, but the graphical interface for download made it very easy to target the area for which a user needed to get imagery. It is a protected site in that a user must have proper credentials and permission to access this website, ensuring that the data is available to everybody in the community and free for all users.

Figure 9 1 Meter CIB

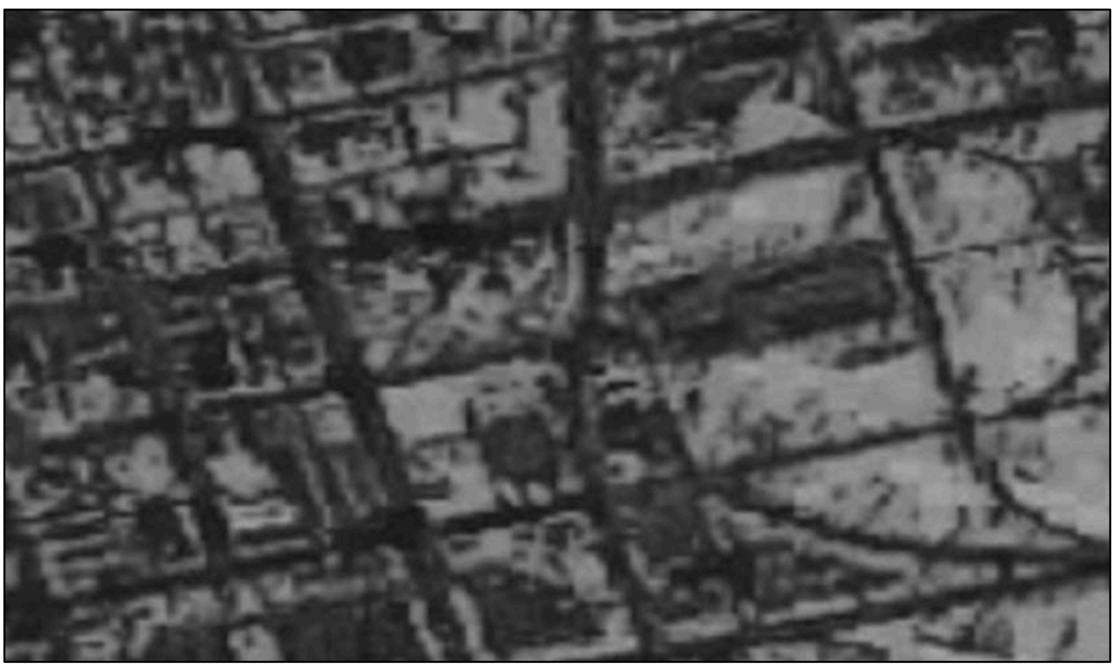

Figure 10 5 Meter CIB

Figure 11 Sub 1 Meter HSIP

Imagery from the National Geospatial Intelligence Agency's website came in several formats, but the two targeted in this project are the digital raster graphics (DRG) and the raster product format (RPF), which is used by the RC-26 mission management system. There is no conversion or editing necessary to transfer those files from the computer to the mission management system. Eliminating complex steps from the entire process is very important, as that will eliminate sources of error when transferring data from the Internet to the aircraft successfully. As seen in Figure 9 and Figure 10, there is a large difference in image detail from 1 meter and 5 meter imagery and it would be ideal to maintain imagery for all locations, the file size of 1 meter imagery would be time consuming to maintain, as an example, the imagery to cover the greater metro area for Des Moines Iowa at 5 meter was 315 megabytes, at 1 meter it was 1.5 gigabytes and sub 1 meter imagery HSIP (Figure 11) was 3.5 gigabytes. Interpolating that data to cover larger areas, it can be seen that large amounts of data will need to be downloaded and stored to have high quality imagery for entire states. It is noted in the instruction manual that it is advisable to limit high quality images to areas that are used often.

4.2. Instruction Manual

4.2.1. Creating the Process

Determining a comparable imagery and street data was the initial focus of this project, but the goal initially set forth was to create a repeatable process. To create a repeatable process, the entire process must be properly documented, recorded and include a comprehensive instructional manual created so that users will be able to replicate the process. It must be kept in mind that the intended users will not be familiar properties of the imagery and shapefiles which they are importing but have enough understanding of computer system to comfortably move data and files from one computer system to another. Once the data and sources were identified in the processes of downloading, transferring, uploading and finally implementing the data was determined and the instructional manual was created to allow users to replicate the entire process. That manual is found in Appendix A and is written for people familiar with the mission management system on board the RC-26 but not necessarily familiar with Geographic Information Systems. Omitted in these instructions is a glossary of key terms that people familiar with GIS may know.

4.2.2. Instruction Manual Document Creation

The instruction manual created by this project is in appendix A and is split into two sections with each section containing two subsections, one section for acquiring the data and the following how to integrate the different data sets. The first steps covered are the acquisition of the street data from the census bureau's TIGER/Line street data web site directing the user to the latest and most detailed shapefiles available. The 2017 data with the corresponding county level data sets gives the highest level of detail, highways, primary and secondary streets while also being small in file size (less than 1 megabyte). Special instruction is given to the user to pay particular attention to organizing these data by state for ease of access and transfer as noted earlier, the file names give no indicator as to what state or county these files represent.

The second section details loading the data onto the MMS of the aircraft and best practices for doing so. There is a directory created in the file structure for theses file types and the software can natively interpret and display them. It is just a matter or placing the desired files in this drive and not a subdirectory. The small file size insures there is plenty of available hard disk space on the computer, but it was observed that loading many states simultaneous, performance of the system slowed while accesses, what could be depending on the state, hundreds of different shapefiles at a time. It is instructed to load one state at a time into the active directory and store other states while they are not in use, elsewhere on the computer. Once the files are moved to the proper location. A system reboot is required and selection of the street data option once the system is up and running again.

The third section is the more complicated process of downloading imagery, mainly from the National Geospatial Intelligence agency. This website requires an account and a need to access the information and data contained within. The process of acquiring access is included and direction through the website to the highest quality imagery that is available. As stated previously, it is noted that while 1 meter or better imagery is available for download, it is up to the user to decide where they would like to have this high-quality imagery for as it will be large in file size (greater than 1 Gigabyte) for a large city. While there are several terabytes of storage space available on the mission management computers, it can become difficult and time-consuming to download that much data and transfer that on portable media.

The fourth section of the instruction manual details loading imagery onto the MMS, the example being loading either Controlled Image Base 1 meter or 5 meter as the process is similar for both, the subdirectory on the computer being the only difference. Once the imagery is transferred into the proper directory, it must be loaded for use into the system with an accompanying map data manager that is already installed on the computer. Like the street data, it is suggested to the users to only load data for the areas needed to accomplish the mission at hand. Loading large amounts of data into the computer notably degraded performance and stability of the mission program, which could severely affect operational mission if the program being used crashed mid-flight. During testing over Iowa, 5-meter imagery for the state was loaded into the MMS and the system was stable, however imagery was loaded for Missouri for a mission the following day while leaving imagery for Iowa in the active directory. Doing so affected the performance of the system with the Shield software program freezing and requiring a restart. Once the active directory was emptied and the Kansas Imagery was replaced, the system performed normally. A threshold of data size that the system can process and still function was not established, but testing did illicit the need to limit the amount of data loaded in the active directory to the state being used. Larger states such as Texas or California may need to be divided into regions to limit the amount of data. The directions also instruct loading HSIP data and MrSID data sets, as they are similar in process to CIB data.

The last section details loading GeoTIFF's into the program, they do not take as much time loading into directories and rebooting systems as the other file types but do need to be reloaded every time the system is cycled. It notes the particular advantage of GeoTIFF's that they can be loaded while the system is in use. This is a huge advantage over the other data sets as they allow the most flexibility while the system is operating, allowing for dynamic re-tasking of the asset.

4.3. Real World Application

This method has been used by multiple states and they have reported the most positive results from street data aiding situational awareness when tracking targets from the air. As quoted by Major Nate, a RC-26 MSO, “the street info loaded gives us back the ability to easily track targets from the air and communicate back and forth with agents on the ground”. He goes on to say, “a lot of the times with tall trees near roads, a street map is vital to make sure your looking at the right place on the ground.” He also provided figure 12 as an example.

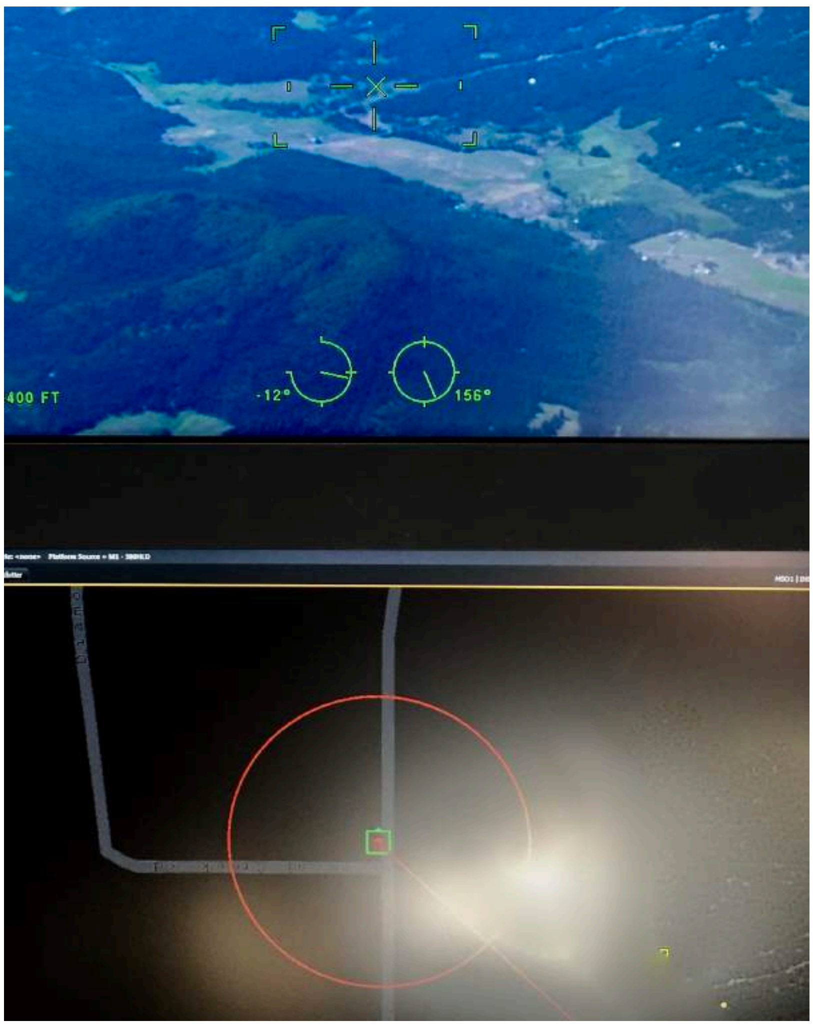

Figure 12 Road Data verify correct location. The green X above is paired with the center of the red circle, giving the user situational awareness that they are looking at the correct target.

Another instance of this process being used has been over Kansas City Missouri, where cited earlier, there had been difficulties encountered not having the data loaded into the system. Captain Mike Gryzcka, another RC-26 MSO reported loading street data TIGER/Lines and 1 Meter CIB Imagery for Kansas City Metro area. Remarking, “It did take a long time to download the imagery, now that it’s on the aircraft, it’s much easier to keep track of the target and tell the guys on the ground where to look.” He went on to remark, “they keep the street data organized by state and use one state at a time” however, “we only get imagery for places we go to a lot since it takes a long time to download the satellite imagery.”

Chapter 5 Discussion and Conclusion

This chapter discusses if and how the final project met the initial goals and how it may be used to aid other users in the community. It further discusses the future applications outside the small RC-26 community and in other applications this project may hold in the future.

5.1. Discussion

There are many places that this project was successful and a few that fell short. Some successes that were found were sources of data that are free to users can be download easily, transferred and loaded into the aircraft with minimal trouble or in-depth knowledge of aircraft systems. One of the original goals was to make a simple process for each user to be able to replicate and upload the data that is needed. This goal was met, and while it is still somewhat cumbersome to download all the data needed, transfer and move in and out of directories on the aircraft to optimize use, it is not beyond the scope of abilities of the common RC-26 mission system officer.

It was one goal of this project to create a single file that could be loaded for all maps that was similar to a Google map street map appearance and would be easy for the user to get their data from; however, the amount of data and imagery and processing that would need to be required of a user was too much to make that possible. It was attempted to create a GeoTIFF file from Openstreet maps using an ArcGIS ArcMap tool and a street map was created; however, once exported it did not retain its geo-referenced material data and would need to be manually and geo-referenced. While not an impossible task, it is beyond the scope of ability of the common RC-26 mission system officer and would also require access and acquisition of ArcGIS software. Ultimately, it was decided it is best that too complex of data thoughts would be omitted from the final product.

While imagery is not vital in conducting a mission, street data remains the most important data needed to pass information on targets on the ground to other ground units. Imagery as a base layer has a good cross-queuing reference when looking at a map and then back to the live video stream. When looking for the data that was very high-resolution date available, very high resolution has the problem of being very large in file size for the entire US or even states or counties and was determined that in the instructions to noted that in the highest resolution imagery only be downloaded for areas that are used often as the amount of time and hard drive space needed to store the data is very large.

The intended output of this thesis was to create a functional map that is simple to reference spatially between the live video stream and the stored map to verbally transmit locations to people on the ground. There was also the goal to produce a map similar to commercially created maps and exist on systems like AeroComputer and Churchill navigations products; however, it did create a process that is repeatable, customizable, will use current data and is free for all users. This process can be rapidly deployed and every user in the country can replicate this process as soon as they have the instructions in hand and access to a computer. That was ultimately the goal to make these mission systems effective for their primary mission as the way they were delivered severely hampered operations. The main two goals of this project were successfully accomplished in that the proper data was identified and successfully implemented on all the aircraft, and also the process was documented and instruction manual was completed and now any user in the entire program can repeat the process so every aircraft that has the system can fly with up-to-date information on board.

Another facet of this process enables each user to get to know the software more intimately and have a better understanding of the architecture of the software, assuming they know what kind of data is loaded, where it is loaded, and how they can get up-to-date information loaded in that place. This will create a more effective mission system officer for the RC-26 and in turn create a better product for our law enforcement officers.

It also appears that this project will in fact be used to instruct all current and new RC-26 crew members because the syllabus that has been created for the RC-26 mission management system will include this instructional manual either in whole or in part for importing street data and imagery into the mission management software. While there is other specialized training that crewmembers can receive directly from the manufacturer, that training does require time and money to complete for each crewmember. This method will enable current and future RC-26 mission system officers to incorporate the new data and because this method does allow for the creation of GeoTIFF's to be included in the mission management software, there are many new facets for which this method could be adapted.

5.2. Conclusions and Recommendations

The intended vision was to create a similar product to those that are available be commercial vendors and their proprietary map layer, style similar to Google maps or any other number online map products would have been the most user-friendly map system for operators that are already familiar with that format and it would have been possible to create maps like that, for example TIFF imagery where able to be processed from ArcGIS and then could be Geocoded by a number of different methods, however it must be kept in mind who the users are and what their capabilities and understanding of map creation and geocoding are. If any process required above average knowledge or mapping systems or computer program access above what is free and readily available, it is unlikely that many would be able or willing to complete those processes. It was most important to find current products that were also free of charge to these users.

Another factor is the missions for these aircraft are very dynamic, a single aircraft could be operating anywhere in the county inside of a day, that it would be very difficult to produce a premade product with enough resolution and detail and quality control of that product to insure no errors were produced in a timely manner. With the process detailed in the instructions, a user could have at the very least street information for the area they are going to downloaded and transferred to the aircraft inside of an hour, if imagery was need, not much longer than that, as long as they have internet access and a method to transfer data to the aircraft.

The main point learned from this project was to keep it simple, adding additional complex steps to any process will insure that they are not going to be followed if an easier, almost as complete process exists. This process has already been tested and implemented in real world search and rescue operations in response to Hurricane Maria in Puerto Rico. It was vital to have street information on board the aircraft as they would be finding routes for land-based teams to access the inland areas of the island, as seen in Figure 8. Many times, roads were so damaged, it was difficult to discern visually where the roads were originally, the street map data was needed to scan their original location or report which roads were still intact to find access to the interior of the island to aid survivors. The deployment for this mission was short notice and being able to quickly download the needed data and get onto the mission computer before departure was vital. Once the aircraft was in the operating area, there was no access to internet that would have facilitated processing and sending of data after the aircraft had departed home station. Such rapid departure and response to an incident like that is rare for this aircraft and its usual mission set, but still having that ability is highly desired.

Figure 13 Damaged Road in Puerto Rico

Recommendations for future work include sourcing a better base map that would resemble something like that created in Aerocomputer, as it has been tested by RC-26 aircrews already, that would be a logical map display to use. If a fix from the original manufacturer is not produced and installed into the system, it may be necessary to find another vendor and locate funding to create a more useful map. It was a common theme that all the best map products found in the related work section were proprietary. A custom-made map layer that is current and scalable while being relatively small in file size would be desirable as noted earlier in this project that large file sizes have an undesirable effect on the performance of the system.

To reduce the work load of each unit, downloading all street data for the United States and transferring to a thumb drive with enough space to hold that much data and also have all the data already organized and in a read only format so it cannot be accidently erased. Having this fall back of data for the crew would insure that the data is protected and is readily available at all times. One drive could be created for each aircraft and distributed from a single source.

An interesting aspect of this project that was not expected was the use of GeoTIFF's. There are few products available that can be downloaded and transferred easily with enough detail to be useful for the RC-26 mission sets. For example, the USGS digital raster graphics, the potential for creating and using GeoTIFF's for certain missions and creating a method for geo-referencing and creating GeoTIFF's for use aboard the aircraft could create a better product when often printed charts or maps are used for reference on operational mission sets.

Another data set that was not explored in this project that has a lot of potential as well is the Keyhole Markup Language or KML's that are used by Google Earth primarilyd. These data sets are easy to create and small in file size, so they can be transferred quickly. Law enforcement agencies as well as any use that the aircraft can be made available for could produce these KML files, transfer them to the aircraft crew and then insure that those crew have definite location information. It can be difficult to find a location from the air with latitude and longitude alone, which is usual the best method available for the aircraft. Having a common file type can reduce errors in communication insuring that the aircraft gets on target when needed.

An imagery resource that was not explored in this thesis was National Agriculture Imagery Program (NAIP) that offers 1-meter color imagery of the entire United States and offers that higher resolution but is about one quarter the file size compared to the CIB 1 meter imagery. It is in MrSID format, so it appears that it would be compatible with the aircraft system and is offered in GeoTIFF format as well.

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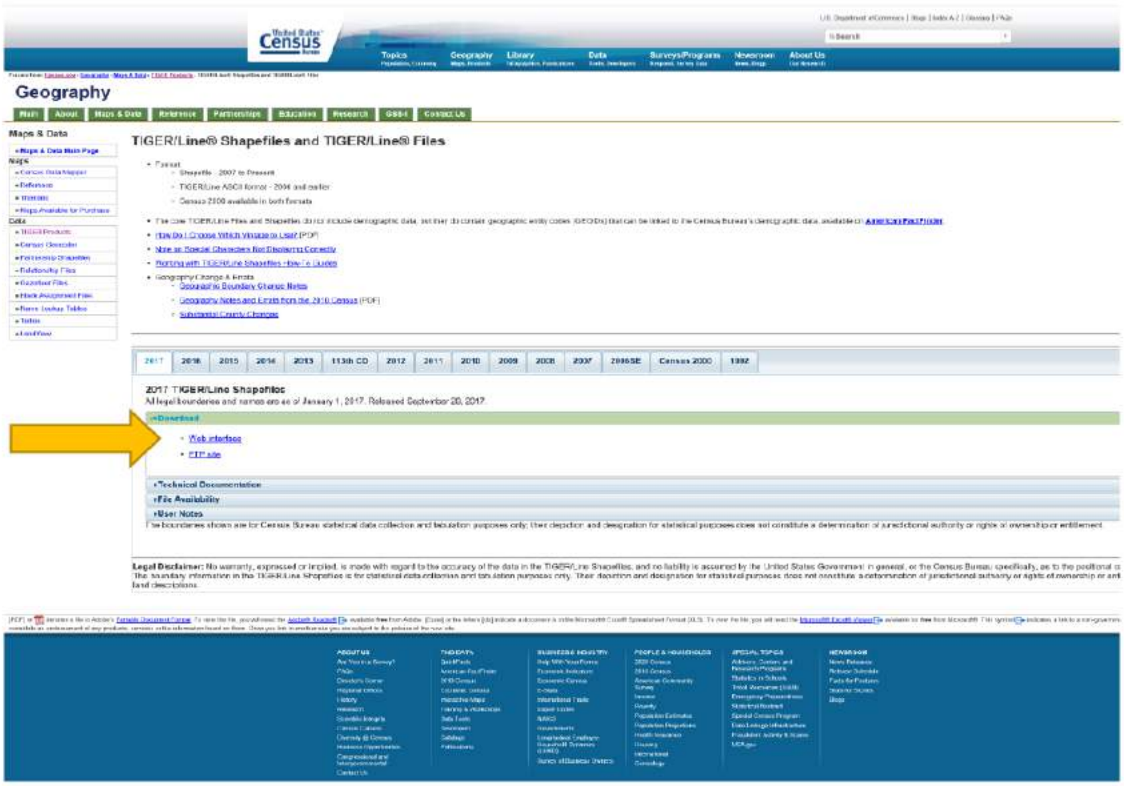
Appendix A: Instruction Document

1. Downloading Street Data

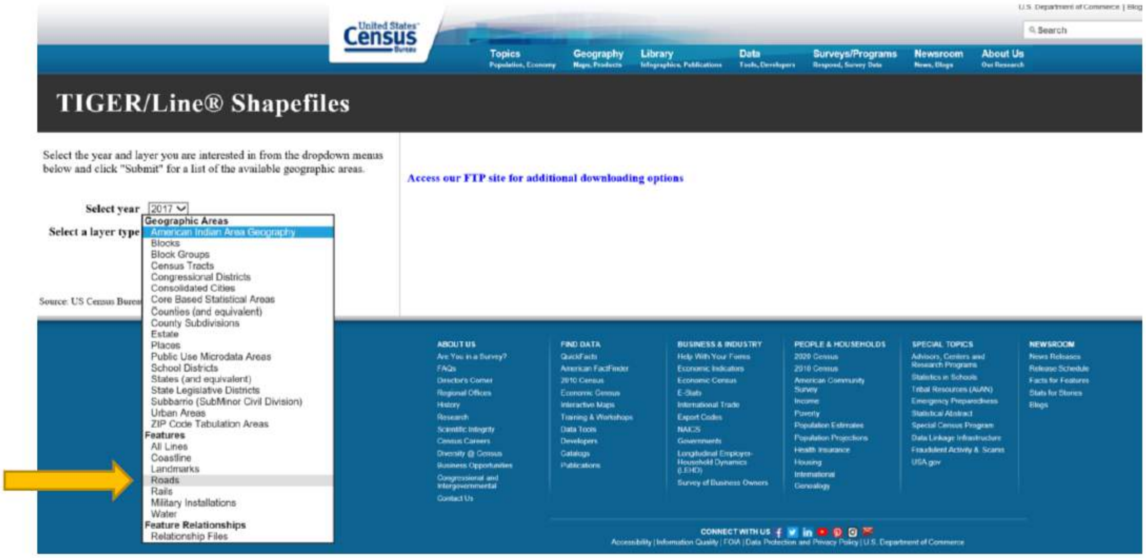
Data for Primary and Secondary Roads is sourced from Census Bureau's TigerLine Database. The file format that will be downloaded is in shapefile (*.shp) and can be transferred via USB thumb drive or CD-ROM disc. Note that if a USB thumb drive is used, it must be from a non-DOD computer or approved by local Cyber Squadron.

https://www.census.gov/geo/maps-data/data/tiger-line.html

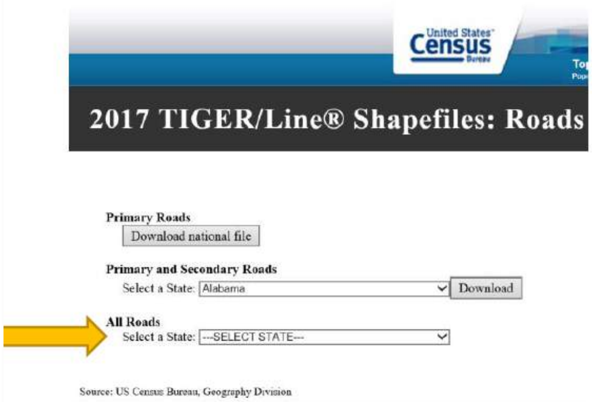


Click the 2017 (or latest year) data tab and then the Web interface link

3

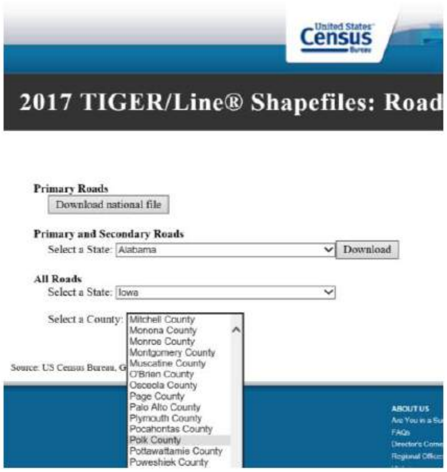


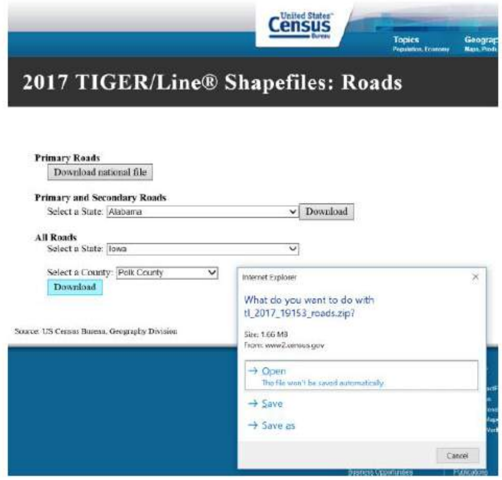
Insure that 2017 (or latest year) is still selected in the "Select year" drop down and then in the "Select a layer type", select "Roads". Then click "submit".



The first selection is for the national file of Primary roads, this includes interstates and state highways. The second selection is by state and includes Primary and Secondary roads but does not include most surface streets, tertiary and alleyways. For the most detailed information, select the third option, "All Roads" and select the targeted state, this includes all fifty states and territories to include Puerto Rico, U.S. Virgin Islands.

Select State, then select County and then click to the "Download" button which should appear after the county is selected.





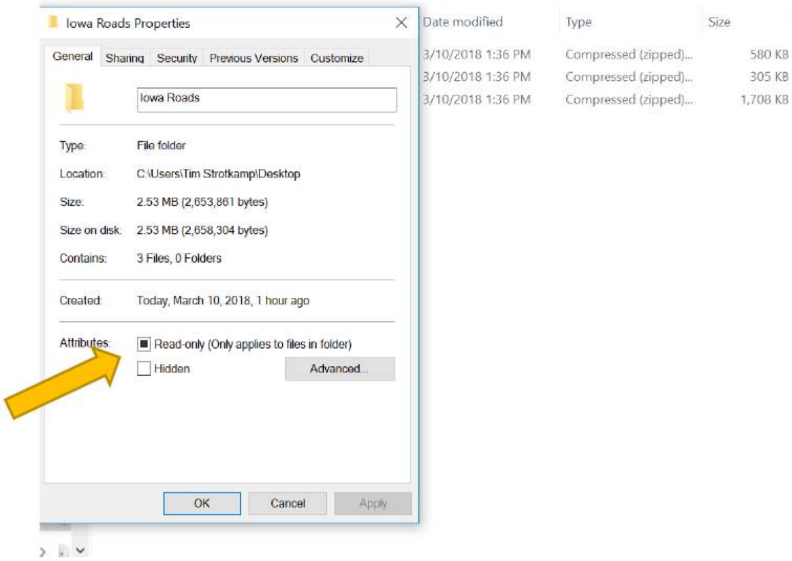
It is recommended that if multiple counties are downloaded, that they are arranged by state in a folder for easier loading to the aircraft, as the naming convention of the files does not indicate what state or county the shapefile is.

Be sure to safely remove thumb drive from computer so the files do not become corrupted.

2. Loading Street Data

Street Data can be transferred via USB thumb drive 2.0 or 3.0, recommend USB 3.0 for faster transfer rates and large enough to hold to data being transferred. Insert USB thumb drive into one of two ports at the MSO station or insert the CD-ROM into Rear Auxiliary Rack.

With the system turned on and drivers loaded, access the thumb drive location and copy and paste state folders to the mission system desktop. It is recommended to copy and paste data and not cut and paste in case folders and files on desktop are accidently deleted or moved.



To protect data, right click inside folder and select properties, then select Read-only attribute to prevent accidental deletion. Press Apply, then OK.

Open State Folder with multiple shapefiles and move to one half of screen. Click on the Start button in the lower left-hand corner of the desktop, select Computer on the right side of the pop up, then navigate to:

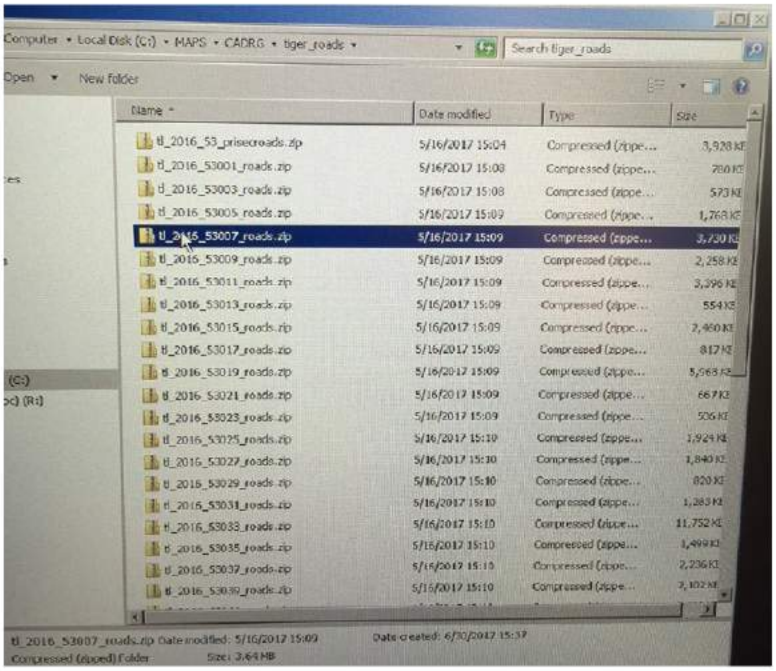
Local Disk (C:) → MAPS → CADRG → tiger_roads

Move this window to the other side of the desktop, it may or may not contain any files, if there are any files either delete them or create a folder on the desktop and cut and paste them to that folder.

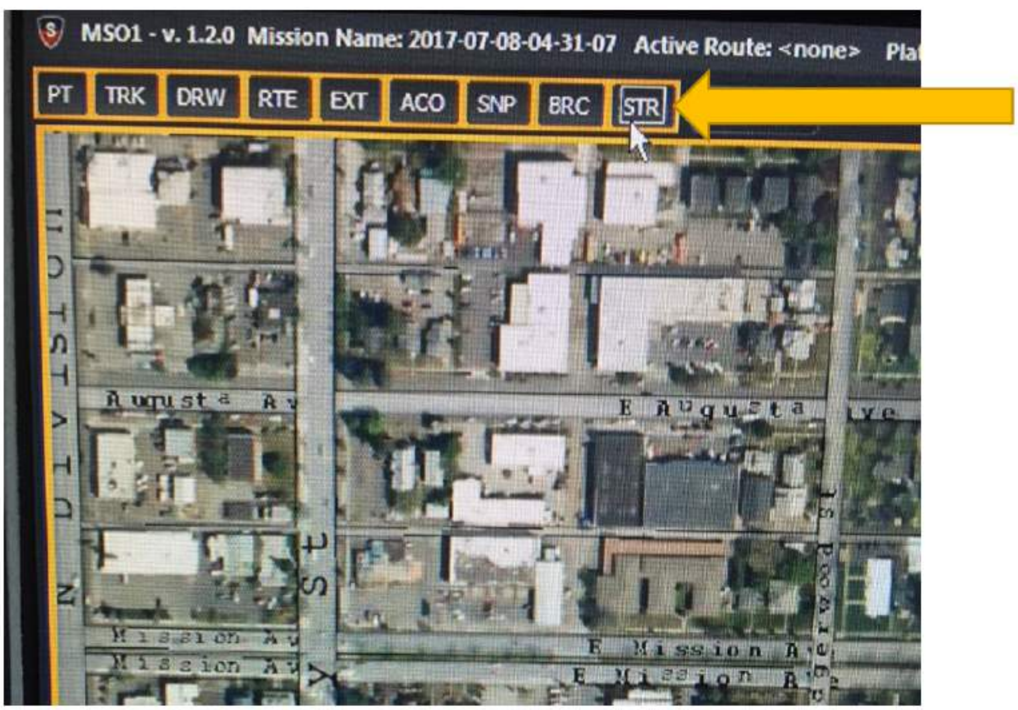
Then select all files in the State Folder, click one shapefile, then press CTRL+A to select all, left click with the mouse and select COPY, left click in the tiger_roads folder and select paste. All files select from the other folder should populate.

*Note: Do not just move the entire folder named for the state as the program is only referencing the tiger_roads folder for the shapefiles and not any subfolders.

**Note: If operating in a different state, it is best to remove unused street data from the tiger_roads folder as too many files may slow the program



Once the desired files are loaded, shutdown and restart the MSO station and launch Shield as normal. Zoom into max extent, select STR on the top of the map screen to display streets.



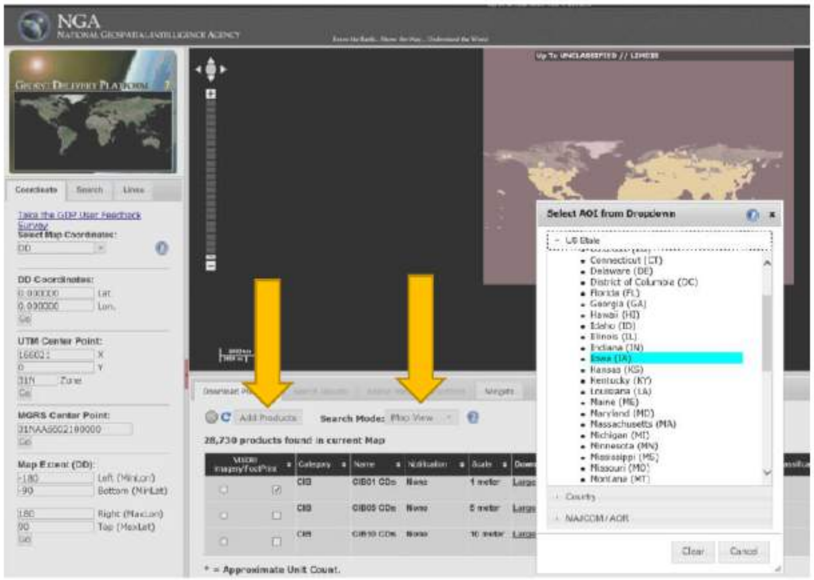
3. Downloading Imagery

The majority of free high-quality data available for download for military members is the National Geospatial-Intelligence Agency. A user must request permission to access this site by registering and stating justification for use. Use someone in your chain of command as a approving official to be approved for access. A Common Access Card (CAC) and reader will be needed for accessing and downloading information, but can be access from any internet connection, does not need to be from a military computer.

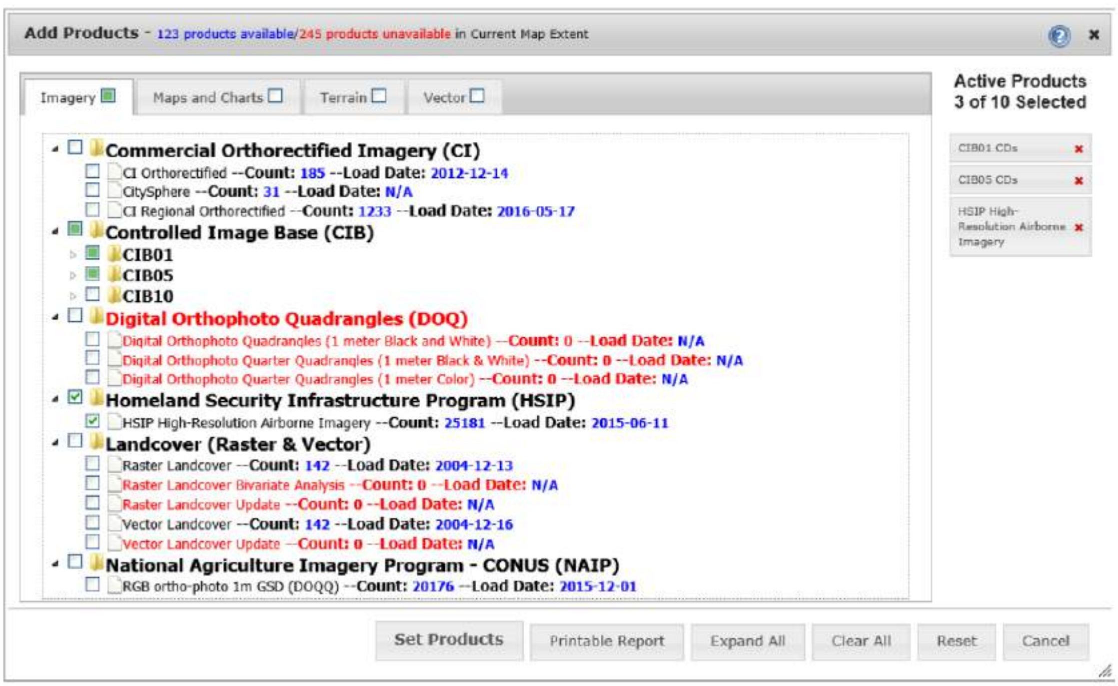
https://websvcs.geo.nga.mil/gdp/

Select Ortho Imagery, covered later will be using Raster Graphics.

To search by state, select Search Mode drop-down, Country/ State/ MAJCOM, then in the Pop-up window, US State and select state.



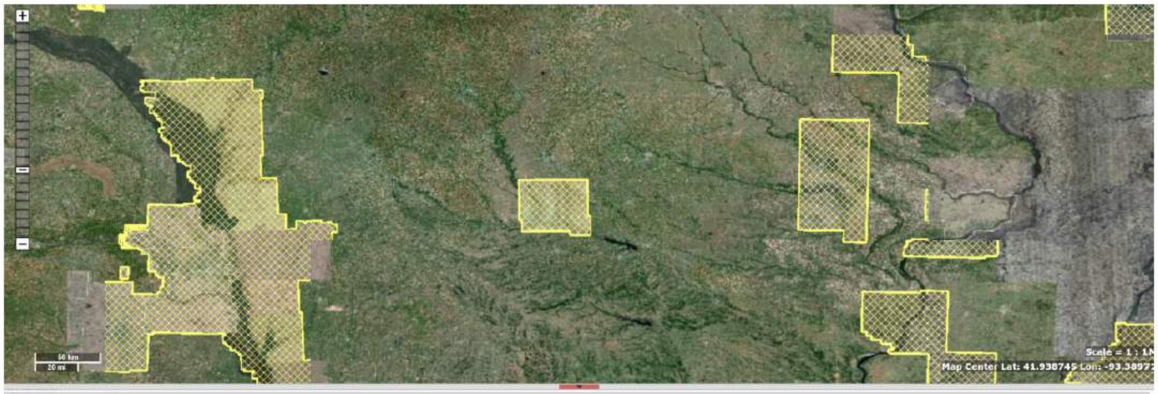
Click "Add Products"



Select CIB01, CIB05, and HSIP and click "Set Products" You will see the selected products on the right side of the window.

It is recommended to have 5 meter imagery in your entire state. Save 1 meter and HSIP (Homeland Security Infrastructure Program) for cities you fly in often as files are very large. 10 meter imagery will offer little for situational awareness.

Current Aeronautical Charts are also available if needed.



Download Products | Search Results | Raster Metadata/FootPrint | Widgets

Add Products   **Search Mode:** Iowa (IA)

17,041 products found in Iowa (IA) Hint: The product table is displaying results over entire area of Iowa (IA). To download products over smaller/zoomed area, switch to Search Mode: Map View.

Visible Imagery/FootPrint	Category	Name	Notification	Scale	Download	Unit Count	Estimated Size	Classification	Release Description	GRLS
○ ☐	CIB	CIB01 CDs	None	1 meter	Large Download Options	28	7.95 GB	U	LIMITED DISTRIBUTION	Specialized-Urban
○ ☐	CIB	CIB05 CDs	None	5 meter	Large Download Options	7	2.09 GB	U	LIMITED DISTRIBUTION	Specialized-Urban
◉ ☑	HSIP	HSIP High-Resolution Airborne Imagery	None	3 inches to 1 foot	Large Download Options	17,006	124.54 GB	U	PUBLIC SALE	Specialized-Urban

*** = Approximate Unit Count.**

To refine the search area for high resolution imagery download, click the search mode again and select User Defined Shapes to outline the selected area. When creating a polygon, double click the last point to finish the shape. Press apply and only the selected are will be downloaded.

Under download, it may display “Large Download Options”. If this is the case, click “Large Download Options”, Paginated Results, check box for desired imagery, “Download Selected Results” Windows ZIP file type is selected and submit for download. Select download once the files have been prepared for download.

Process has Completed
Download May Proceed
Windows ZIP file created.

- File Name: CIB05CDS_28685_0.zip
- File Size: 278.12MBytes

You can download via HTTPS protocol only:

- Download via HTTPS

Close this window

For Digital Raster Graphics from the USGS, select Add Products as before and from the Maps and Charts Tab, select the USGS DRG Charts 24K, meaning 24000:1 Scale.

Download the associated files but note that these files will be loaded differently than other imagery.

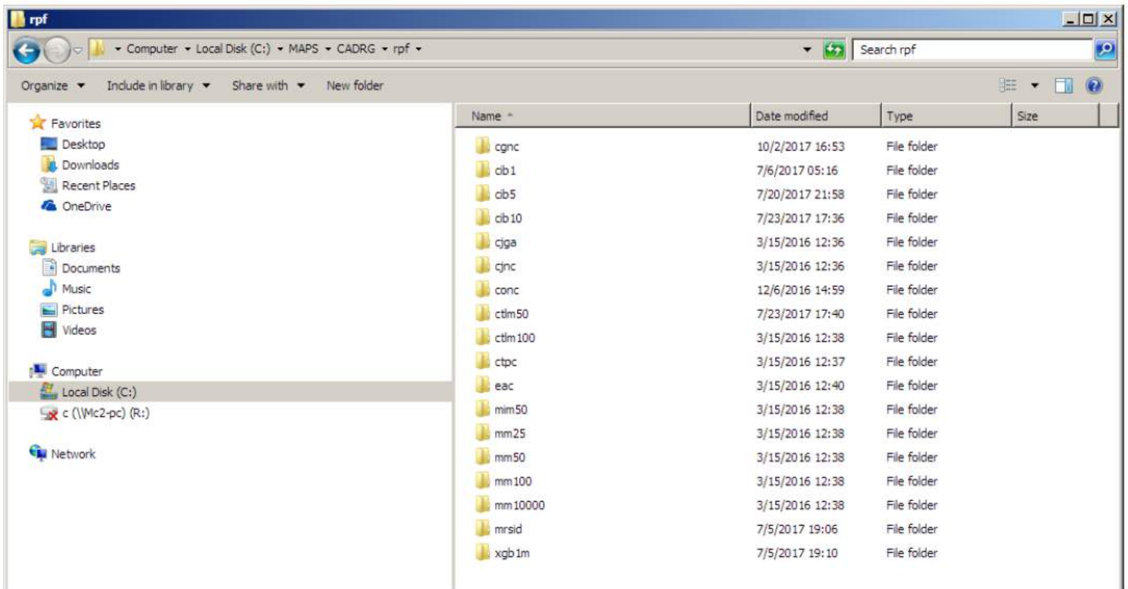
4. Loading Imagery into Shield

As with road data, transfer data to the MSO station via USB thumb drive or CD-ROM disc.

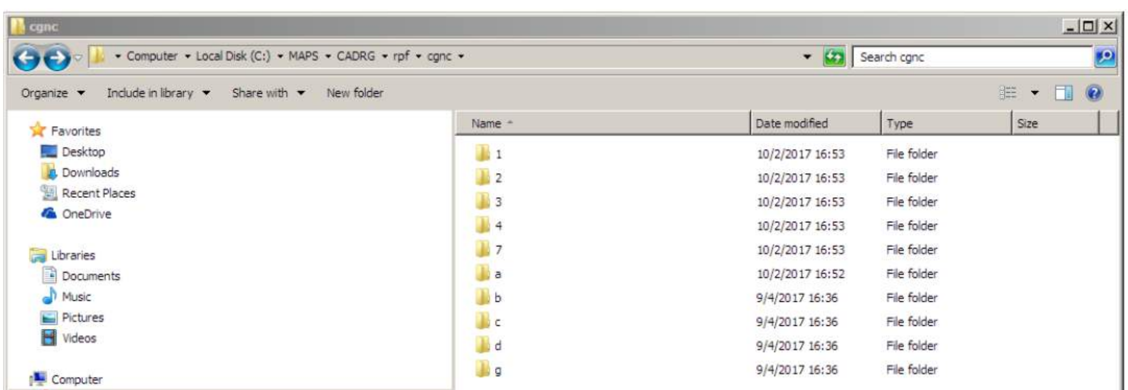
The imagery files must be unzipped before being moved to the map directories.

Imagery is loaded on Local Disk (C:) MAPS →CADGR → rpf

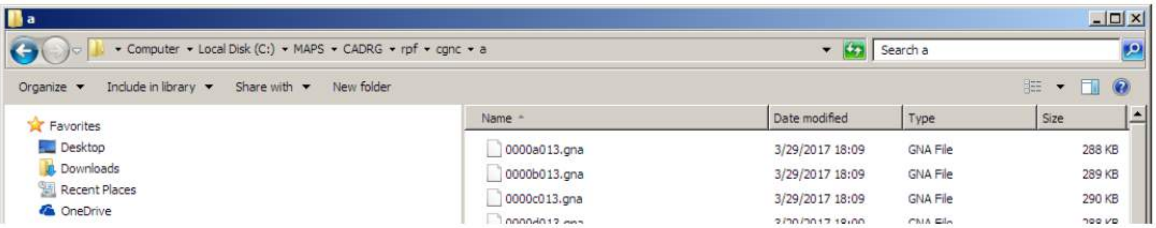
Insure it is placed in the directory correctly, this is how it should look within the *.rpf folder



You will need to create folders within each type of imagery based on the file extension of the files. Here is an example of what is within the cgnc folder, or select cib5 or cib1 and follow the same steps if that's the imagery that was downloaded.



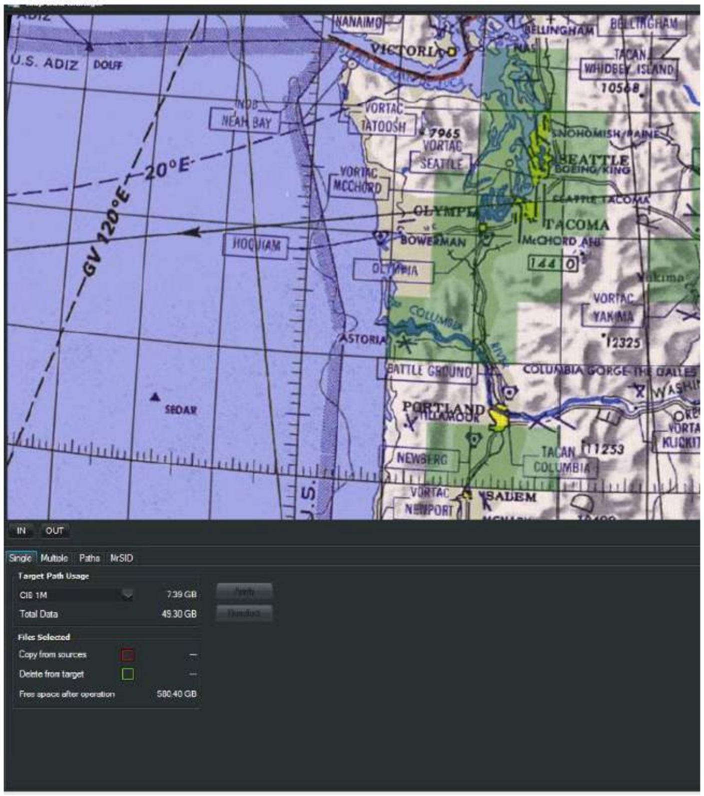
Within folder "a" are files that end with extension *.gna. Within folder "b" would be *.gnb files and so on. Open the files to be loaded, and look at the individual file extensions.



MrSID is a little different in that you have to create mrSID files using map data manager where the HSIP files are converted.

Before opening Shield go to Start Menu>>Shield>Map Data Manager

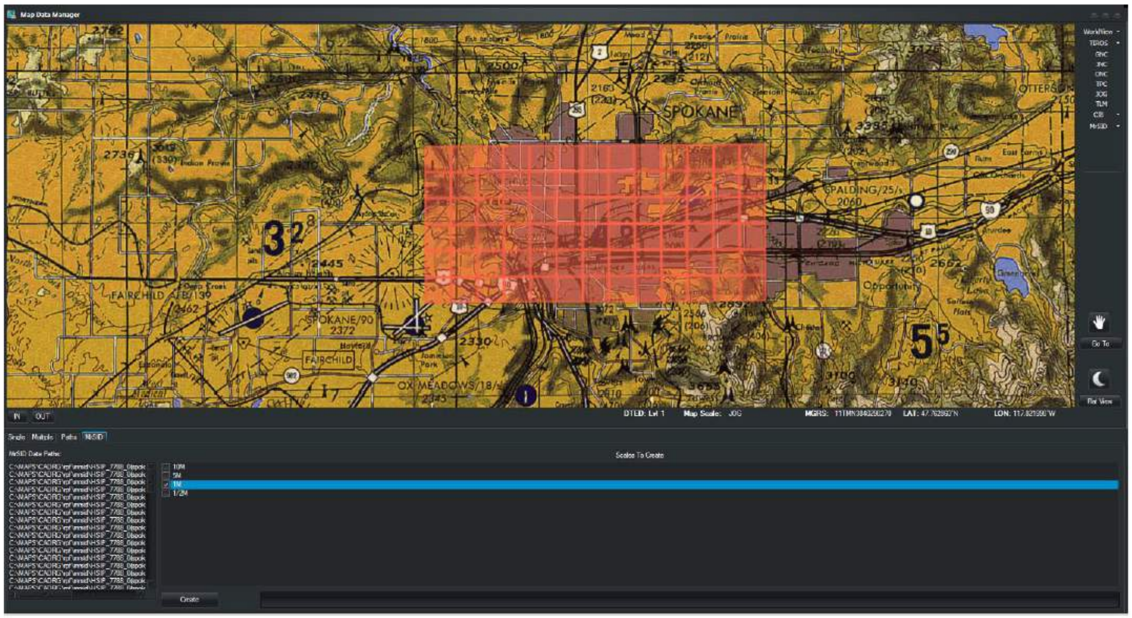
This allows you to see which imagery you have loaded currently and allows you to add MrSID imagery. In the example below, 1m imagery selected (bottom left) and GNC is selected (upper right). The green area shows where I have 1m imagery uploaded.



Move old unused data from the directory in use so the program can perform optimally. Do not delete, just move to another folder for future use.

The 1 meter HSIP files will be downloaded and transferred in the same way as all imagery, but will be loaded differently into Sheild with the map data manager.

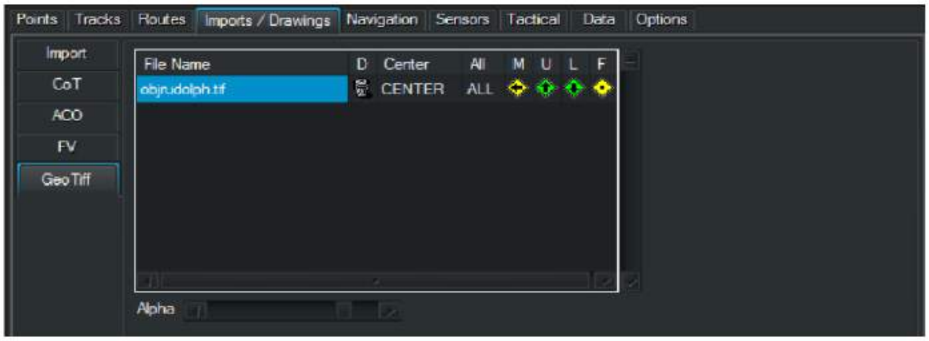
For mrSID, first upload your HSIP files into C:/MAPS/rpf/mrSID/HSIP folder. Within map data manager select the mrSID tab. Center your map and zoom into the area. You should see multiple red boxes. Hold left button and drag a box around all of them. Check the box of the HSIP that you are uploading (typically 1m). Click create. After it is completed you should see .sid files within the HSIP folder.

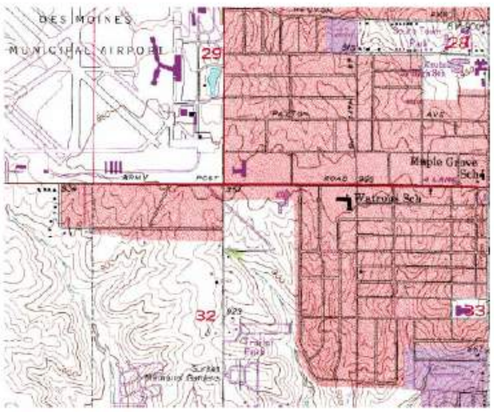


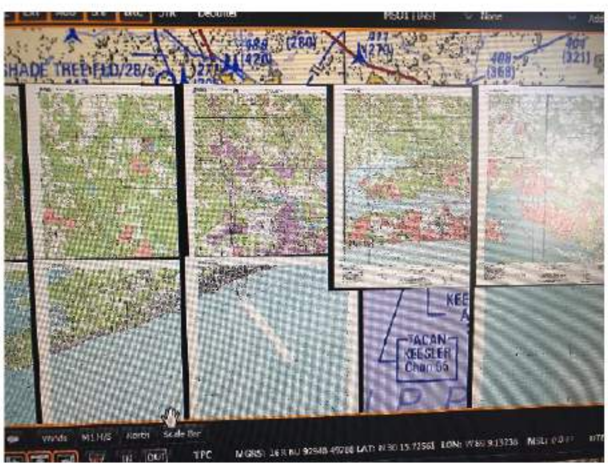
Close Map data manager and open Shield to view your uploaded imagery.

5. Loading GeoTIFF's

The USGS DRG's can be loaded directly into Shield with the Imports/Drawings Tab. Import first each file, then on the left side click GeoTiff and click each file and select "CENTER" on each file. The downloaded files will need to be unzipped and the file extensions are *.tif.







The advantage to this method is each file can be added and removed while operating the Shield application.