Statement of Work for
AIRBORNE TRAFFIC SURVEILLANCE SYSTEMS

Proof of Concept Study
for
Florida Department of Transportation

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Presented to
Florida Department of Transportation
ITS Office

October 2, 2002

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ABBREVIATIONS AND ACRONYMS

ATIS:	Advanced Traveler Information Systems
ATMS:	Advanced Traffic Management Systems
ATSS:	Airborne Traffic Surveillance Systems
DOD:	Department of Defense
EMC:	Emergency Management Centers
FAA:	Federal Aviation Administration
FCC:	Federal Communications Commission
FDLE:	Florida Department of Law Enforcement
FDOT:	Florida Department of Transportation
FHP:	Florida Highway Patrol
FHWA:	Federal Highway Administration
I-10:	Interstate 10
I-4:	Interstate 4
I-75:	Interstate 75
I-95:	Interstate 95
ITS:	Intelligent Transportation Systems
MAN:	Municipal Area Network
NTCA:	North Tallahassee Commercial Airport
NTCIP:	National Transportation Communications for ITS Protocol
NTIA:	National Telecommunications and Information Administration
NTP:	Notice to Proceed
PoC:	Proof of Concept (Research Plan)
RCA:	Remote Control Aircraft
RF:	Radio Frequency
RWIS:	Road Weather Information Systems
SEOC:	State Emergency Operations Center
TAT:	Technical Advisory Team
TGC:	Telecommunications General Consultant
TMC:	Traffic Management Center
TRC:	Transportation Research Center, University of Florida
TV:	Television
UAV:	Unmanned Aerial Vehicle
UNF:	University of North Florida

AIRBORNE TRAFFIC SURVEILLANCE SYSTEMS

Proof of Concept Study for Florida ITS Applications

1. PROBLEM STATEMENT

Providing timely information on highway traffic conditions for use by a traffic management center (TMC), which ultimately affects public safety, is a major function of intelligent transportation systems (ITS). Advanced traffic management systems (ATMS) and advanced traveler information systems (ATIS) are very important when incidents or accidents occur. These systems will be extremely critical if and when emergency evacuation events are necessary.

Often, an aerial view is the best perspective of a degrading traffic situation, particularly over a long stretch of uninstrumented highway, such as an interurban highway or road. Manned aircraft are often used, particularly in urban areas and usually by private-sector traffic reporters, but these are expensive to maintain on a continuing basis, especially if they are only used intermittently, such as for major incidents.

Unmanned aircraft equipped with monitoring video cameras and/or other sensors may be able to deliver the necessary information through video images with relatively low operational costs and risks to human life. Other types of data could be collected as well, ranging from weather information to fire and flood information. Systems such as these can be referred to as airborne traffic surveillance systems (ATSS). ATSS could fly along Florida's major highway corridors, including Interstate 4 (I-4), Interstate 10 (I-10), Interstate 75 (I-75), Interstate 95 (I-95) and the Turnpike, to continuously feed information for both ATMS and ATIS, as well as for other purposes.

The most likely or promising aerial platform for such a system is the unmanned aerial vehicle (UAV), which falls under the direct jurisdiction and control of the Federal Aviation Administration (FAA). The FAA has as not yet issued governing regulations concerning their use. Indeed, the FAA is very reluctant to permit such flights over urbanized areas. The Florida Department of Transportation (FDOT), in partnership with the Federal Highway Administration’s (FHWA) Florida Division, learned this when they jointly scheduled a demonstration of UAV technology in the North Miami area in June 2001 in conjunction with the ITS America Annual Meeting. The UAV was flown autonomously by ground control and from the chase plane over severely restricted flight paths. A chase plane, however, was required by FAA in all of these flight scenarios, despite the fact that the UAV could have actually operated entirely autonomously, and with great reliability.

In addition, the Federal Communications Commission (FCC) regulates all non-Federal areas of communications and radio/television (TV) transmissions in the United States. Wireless transmissions to and from the UAVs must meet all applicable FCC rules.

Therefore, a proof of concept study is needed to determine the overall communications interfaces and operational logistics of ATSS using unmanned aircraft for traffic surveillance and other potential ITS applications in a comprehensive, yet safe, legal, and prudent manner. The major thrust of this study will be the use of UAV equipment as the framework for ATSS. Although of keen interest to the University of Florida Research Team (*see Appendix B, University of Florida UAV Research Team*) and the study sponsor, other alternatives for ATSS frameworks, for example remote control aircraft (RCA), will not be evaluated in this study.

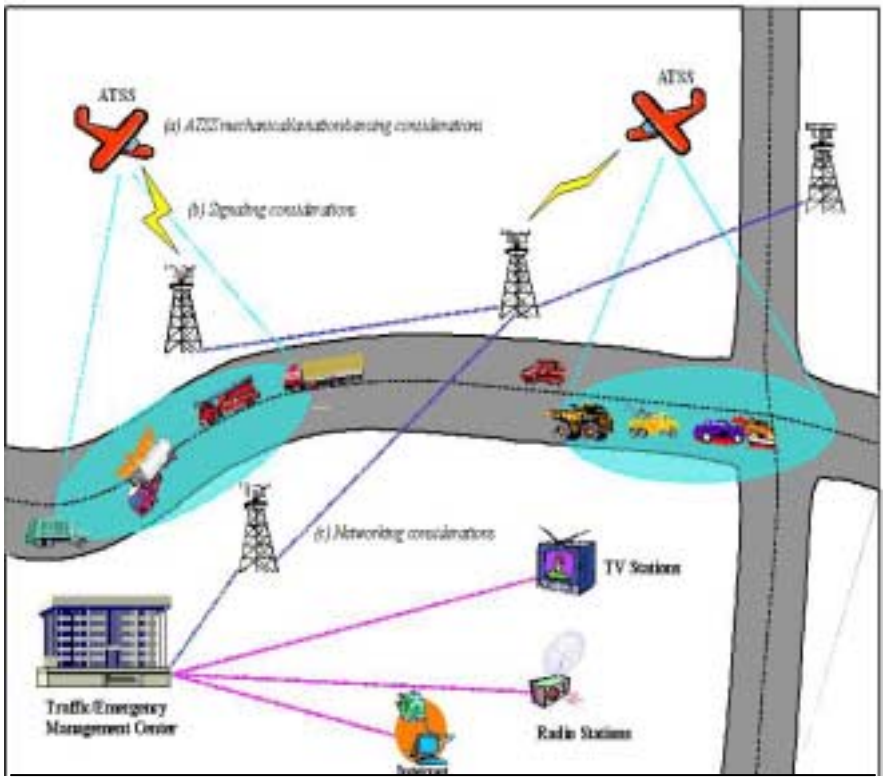
1.1 Study Properties

The overall aim of this study is to investigate the integration of ATSS into the existing network of the FDOT microwave tower system, traffic management centers (TMCs), and the State Emergency Operations Center (SEOC).

The key to this study is telecommunications. The communications system must be able to exchange information in the form of audio, video, images, data, and control signals as called for by the specific application. A UAV uses sensors such as digital video, infrared cameras, and road weather information systems (RWIS) to collect data that is relayed to ground stations. Hence, UAVs have the capability to transmit video, images, and data to ground stations in a robust manner, while control signals can also be transmitted to the aircraft to control the avionics of the aircraft, operations of data collection, and other communications demands.

Figure 1 provides an overview of the proposed system. Some considerations that will guide the study follow.

Figure 1 – A Proposed ATSS Concept for FDOT



If the coverage area is large and multiple UAVs are deployed, distributed data exchanges must be considered and routing must be investigated. To conserve power, routing protocols have to be carefully designed. For example, does a UAV transmit the data directly to the TMCs, or does it first transmit directly to the nearest ground station, so that data is relayed to the TMCs via terrestrial infrastructures? The communications system must have an optimal decision-making process to accomplish such information exchange and distribution.

Information such as real-time video demands high bandwidth from the UAV to the ground stations, so the Research Team must determine the communications system to meet these requirements. The spectrum allocated on the downlink from the UAV to the ground station must support the required bandwidth. Considering the asymmetric nature of the communications between a UAV and a ground station, the Research Team may develop a more efficient link layer protocol to support such high data rate services for ITS. Thus, the system must be adaptable to specific applications.

For emergency rescue, the communications system must be rapidly reconfigurable. For example, mobile ground stations may have to be delivered to a disaster area because existing base stations may lose power or connectivity. The ground stations and any UAVs deployed in the area must be able to quickly establish communications so that information may be gathered for more efficient rescue. If transportation or other ground rescue sensors are deployed, the communications

between sensors and UAVs and TMCs and/or emergency management centers (EMCs) have to be carefully investigated.

For ITS, ATSS provide another way to collect data. Possible integration/interaction between ITS and communications systems may provide a more efficient mechanism for achieving transportation efficiency.

1.2 Physical Layer

This study will also require that the Research Team develop a prescriptive specification for the physical layer communications between the UAV and the ground stations that will receive their signals and relay them to TMCs and the SEOC. One of the most important tasks in this regard is to evaluate what existing infrastructure can be used for communications with the UAVs. The Research Team will also have to determine the full extent of FCC and FAA regulations that impact communications with the UAVs. The design of the communications system must take into account the required bandwidth, propagation distance, and channel characteristics.

To limit the costs of the UAV communications system, existing infrastructure will be used wherever possible. The Research Team will collaborate with the FDOT ITS Office to determine what capabilities exist within the current FDOT communications system, such as its existing microwave tower communications system. The Research Team will collaborate with the FDOT ITS Office to determine if UAVs can communicate directly with the existing microwave towers and antennas. If UAVs cannot communicate directly with the existing microwave towers, additional communications equipment will have to be deployed. This additional equipment may then interface with the existing microwave tower communications system to provide connectivity to the TMCs and the SEOC.

The Research Team will identify and evaluate candidate video surveillance and airborne radio frequency (RF) subsystems that will interface with the existing FDOT microwave system to provide video and other data to the TMCs. This evaluation will involve a link budget analysis given the typical height of operation of the ATSS and existing microwave tower heights and locations.

The Research Team will also provide recommendations regarding how communications security can be achieved through existing security protocols. For formal deployment, it would be necessary to implement a more rigorous security strategy complete with an analysis of vulnerabilities. This latter aspect, though noted here, is outside the scope of this study.

1.3 Network Layer

In traditional vehicular traffic reporting, information is uplinked from a known location (e.g., stationary video equipment or traffic reporters positioned in helicopters) to a single destination (e.g., the television broadcast station). However, in the proposed ATSS, the location of the sensor platform and the nearest ground station will change continually.

The ATSS network layer must coordinate data delivery and control signaling between the UAV and the ground stations, as well as between the ground stations and the TMCs. The Research Team will work with equipment vendors and FDOT to address the issue of signal handoff to adjacent microwave receivers as the ATSS traverses larger coverage areas.

1.4 Key Issues to be Addressed

Some of the key issues that will be addressed in this study are summarized below.

1.4.1 Physical Layer Issues

- Required locations of ground base stations (i.e., microwave towers) with respect to desired aerial flight alignment and related issues such as deployability, control transfer, and degree of autonomy possible;
- Bandwidth requirement;
- Current network ground base stations and existing FDOT microwave towers;
- Link budgets;
- Channel characteristics (fading and mobility);
- Transceiver design;
- Modulation and coding techniques;
- Communications security;
- Range of aerial platform to ground base stations; and
- Power and fuel consumption.

1.4.2 Communications Properties Issues

- Ability to transmit video, data, and control signals to and from the TMCs in a reliable/failsafe manner;
- Ability to transmit video, data, and control signals to and from the UAV in a reliable/failsafe manner;
- Distributed data exchange;
- High-bandwidth requirements;
- Asymmetric data communications (aircraft-to-tower requires much higher bandwidths);
- Rapid requirements reconfigurability;
- Integration with ground sensors;
- Interaction with models for forecasting: and
- Potential real-time communications with an incident commander.

1.4.3 Communications Network Layer Issues:

- Mobility management (location update and handoff);
- Network configuration and reconfiguration;
- Fixed infrastructure versus ad hoc network (in disaster situations);
- Adaptive quality-of-service;

- Ground station (tower) location and distribution; and
- Data and control signaling between TMCs and network nodes (towers and ATSS).

1.4.4 Institutional Issues:

- FAA and FCC regulations;
- Florida Department of Law Enforcement (FDLE) notifications;
- Spectrum allocation (unlicensed versus licensed);
- Data security; and
- Public and political acceptability.

2. WORK TASKS

Generally, the FDOT ITS Office will coordinate all necessary activities with the FAA, FCC, and the Department of Defense (DOD). The Research Team, therefore, will coordinate all remaining activities [i.e., with the UAV vendor(s) and the video and infrared camera manufacturers, the North Tallahassee Commercial Airport (NTCA), the University of North Florida (UNF) and any other related organizations and companies needed to conduct the study activities]. The Research Team's study work tasks are outlined below. Note that the primary focus of this study shall be on supporting a "proof of concept" test of the ATSS on the I-10 corridor between Tallahassee and the I-10 interchange with I-75.

The test will involve a UAV traveling from the NTCA to I-10, from there to the I-10/I-75 interchange, and then orbiting the interchange. Live video, weather sensor, and other data will be transmitted to two or three selected FDOT microwave towers then the signals will be transmitted through the following proposed path:

1. FDOT microwave backbone;
2. Tallahassee FHP Center;
3. Tallahassee Municipal Area Network (MAN); and
4. SEOC.

Additional consideration will be given to making the video feed available to other TMCs and/or Internet websites.

2.1 Discovery

This task deals with information gathering and is divided into the following subtasks:

2.1.1 Needs Assessment

This involves a thorough needs assessment of the functional and communications requirements of the ATSS study. It will include the following activities:

2.1.1.1 Inventory the FDOT microwave tower system in the test corridor (*see Appendix C, Microwave Tower System Map*) and the other links in the above-described key issues to be addressed.

2.1.1.2 Develop a Proof of Concept (PoC) Research Plan for applying a UAV equipped with video, infrared, and possibly other cameras to monitor the I-10 and I-75 corridors in accordance with *Appendix D, Proposed Flight Alignment*. The UAV should also be equipped with a weather sensor. The sensors shall be capable of communicating the images and data and of sharing control with the TMC and the SEOC.

2.1.1.3 Analyze communications between the UAV and the FDOT microwave tower system, and between the FDOT microwave tower system and the SEOC. Determine the communications system functional requirements for this study based on current FDOT-owned microwave radio systems.

2.1.1.4 Determine the impact of various weather and nighttime conditions on flight operations and image quality.

2.1.1.5 Determine the acceptable quality of video (and other potential image generation devices) including snapshot still-frame picture quality.

2.2 Design Assessment

This Design Assesment task includes the following design, develop, and schedule subtasks:

2.2.1 From the communications system functional requirements, the Research Team, in close consultation with the FDOT ITS Office, Florida Highway Patrol (FHP) and SEOC, shall develop a detailed systems requirements document.

The Research Team shall determine the availability of commercial off-the-shelf equipment needed for the FDOT microwave tower system and the SEOC facility to meet the needs of this study.

The Research Team shall also determine the need for any customized equipment and its impact upon this study.

2.2.2 The Research Team shall provide the FDOT ITS Office with a detailed Microsoft Project Schedule, including a Gantt chart and resource information, of all activities related to this study. Whenever there is a schedule change, the Research Team shall immediately provide FDOT with an updated schedule.

2.2.3 Develop and submit to the FDOT a Discovery and Design Assessment White Paper. The Discovery Task White Paper shall address the needs assessment activities that include the inventory, equipment availability and costs, PoC Research Plan, system functional requirements, impact of various weather and nighttime conditions, and quality of video.

2.3 Systems Design

The Systems Design task includes design, coordination, and completion of the entire system. The Research Team, in close coordination with the FDOT, SEOC, FHP, UNF, and the UAV vendor(s), will develop a detailed systems design. In addition, the PoC Research Plan shall be finalized during this task.

2.3.1 The Research Team shall negotiate and coordinate with communications systems vendors (See Section 6 - Equipment).

2.3.2 The Research Team shall negotiate and coordinate with the UAV vendor(s).

2.3.3 The Research Team shall negotiate and coordinate with the NTCA.

2.3.4 The Research Team shall complete the detailed systems design. The detailed systems design includes all agreements needed to deliver the ATSS PoC Research Plan. The Research Team will develop a procurement plan, including cost estimates.

2.4 Proof of Concept (PoC) Test

This task requires the Research Team to implement the PoC Research Plan and associated detailed systems design by conducting the following PoC test.

2.4.1 The Research Team and the UAV vendor(s) shall coordinate the provision of a UAV and sensors suitable for this study to meet FDOT requirements. A UAV shall be the class type of aircraft utilized in this study.

2.4.2 The Research Team shall coordinate and base all UAV flight operations for this study at the NTCA located at 6601 North Monroe St., Tallahassee, Florida 32303.

2.4.3 The FDOT ITS Office with inputs from the FAA, Research Team and UAV vendor(s) shall determine and develop the flight alignment. The FAA shall approve the ultimate flight alignment. The Research Team shall coordinate with the FDOT ITS Office to confirm the approved flight alignment.

2.4.4 The FDOT ITS Office shall coordinate with the FAA[1] about specific flight restrictions. The flight alignment shall avoid any populated areas to the greatest extent possible. Flight operations should desirably include loitering over the I-75/I-10 interchange. (Refer to *Appendix D, Proposed Flight Alignment,* for preliminary details.) The FDOT ITS Office shall be responsible for all correspondence and approval documents related to the flight alignment with the FAA.

2.4.5 The FDOT ITS Office shall coordinate the communications requirements and necessary approval documentation by the FCC and/or DOD as required[2].

[1] The Research Team recognizes that all communications with FAA will be through FDOT.

[2] FDOT's Telecommunications General Consultant (TGC) will coordinate with the FCC, National Telecommunications and Information Administration (NTIA), and DOD to receive the needed approvals and documentation.

2.4.6 The Research Team shall coordinate with FDOT to specify the explicit microwave tower system and other communications equipment requirements[3]. *See Appendix C, Microwave Tower System Map.*

2.4.7 The Research Team shall secure a complete communications network for flight operations and video broadcasts to the SEOC.

2.4.8 The Research Team shall coordinate the procurement all needed communications equipment, accessories, connectors for microwave towers, and FHP and EOC equipment for this study. (See Section 6 – Equipment)

2.4.9 The FDOT ITS Office shall have its communications contractors install all needed communications equipment procured by the Research Team on at least two, and preferably three, FDOT microwave towers to receive the video broadcasts from the UAV.

2.4.10 The Research Team shall coordinate with the FHP Tallahassee Tennessee Street Station about microwave tower and Municipal Area Network (MAN) accesses. This subtask shall complete the network from the FDOT microwave tower system to the SEOC.

2.4.11 The FDOT ITS Office shall coordinate with the DOD about flight operations and communications.

2.4.12 The Research Team should ideally enlist the services of Meggitt Defense Systems as the UAV vendor(s)[4], **if the costs are within budget**. The FDOT ITS Office prefers Meggitt Defenses Systems because of their prior successful UAV flight operations experiences in North Miami in June 2001. However, the Research Team should also explore other UAV vendor(s) participation options for cost and benefit comparison.

2.4.13 The Research Team shall coordinate with the NTCA and UAV vendor(s) to provide flight operations according to the approved flight alignment, and FAA and FCC requirements.

2.4.14 The UAV vendor(s) shall install a meteorological sensor package provided by UNF for UAV flight operations to determine the efficacy of collecting weather information.

2.4.15 The FDOT ITS Office shall coordinate with the FAA about whether a chase plane will be needed and whether nighttime flight operations will be allowed.

[3] FDOT's TGC has recommended that the Research Team work with the TGC to provide functional specifications. Since the TGC is familiar with the current microwave equipment and linkage, the TGC will prepare an aeronautical chart with microwave tower locations.

[4] The Research Team will budget $50K for this effort. If Meggitt is not available, or too costly, the Research Team will solicit other UAV providers.

2.4.16 The FDOT ITS Office shall advise the FDLE of the flight operations schedule. The FDLE shall provide its approval to FDOT prior to any flight operations.

2.4.17 The Research Team shall coordinate with the SEOC about the broadcast terminus for UAV video surveillance images.

2.4.18 The Research Team and the UAV vendor(s) shall determine and fulfill the legal and liability aspects of this research and any insurance requirements. (See Section 10.)

2.4.19 The FDOT ITS and Public Information Offices shall coordinate and interface all activities with the media, if any.

2.4.20 The Research Team and the UAV vendor(s) shall conduct flight operations to demonstrate both the daytime and nighttime capabilities of the UAV and its sensors. The flight operations shall include at least ten (10) days and nights of flight operations to meet the needs of this study. The flight operations shall include at least one daytime flight every day and one nighttime flight every other night. Each flight shall include two round trips from NTCA to the interchange of I-10 and I-75.

2.4.21 The Research Team and the UAV vendor(s) shall conduct flight operations to demonstrate dynamic video broadcast reception capability (i.e., broadcast handoff) from one microwave tower to adjacent towers.

2.4.22 The Research Team, in conjunction with the UAV vendor(s), shall create a video log of all flight operations. The video log shall principally include in-flight video and images captured by the UAV.

2.4.23 The FDOT ITS Office shall review the project progress and review all deliverables including technical reports.

2.5 ATSS Implementation Plan

Based on PoC tests, this task provides the information for future ATSS implementation and deployment. No work in this task shall be performed by the Research Team until specifically authorized in writing by the FDOT ITS Office and additional funding is mutually agreed by the FDOT and the Research Team.. Based on the results of the PoC test and the FDOT ITS Office's written authorization, the Research Team shall prepare a full, statewide ATSS implementation plan including, but not limited to, the following:

1. A state-wide technical requirements plan;
2. Institutional issues including the nature of proposed provisions of future federal and state rules, regulations, and/or policies;
3. Expandability of the ATSS to other platforms, possibly including RCAs, mini-helicopters, tethered balloons, and satellites;
4. Any additional research needs; and

5. Complete documentation of implementation including the ATSS prescriptive specification, processes and application forms for FAA and FCC approvals, needed equipment, needed personnel, and operational costs.

The implementation plan shall cover the following:

2.5.1 Determine appropriate FAA regulations and provide necessary input for FAA rulemaking with regard to autonomous flights. Such items as altitude restrictions, flights into Class B airspace, etc., must be addressed.

2.5.2 Determine FCC requirements and provide necessary input for the update of FCC rules and regulations with regard to ground-to-air-to-ground communications.

2.5.3 Determine FDLE and other state governmental agency requirements. Provide necessary input to update regulations regarding security, safety, and UAV operations.

2.5.4 Determine other complementary surveillance techniques, minimally including airborne manned vehicles (for rich data collection such as high resolution airborne laser swath mapping systems and water-penetrating airborne laser techniques) in conjunction with satellite imagery.

2.5.5 Determine the potential applications of modeling for use in conjunction with UAVs, including traffic flow, planning, and dispersion models.

2.5.6 Provide performance measures and cost benefit analysis of ATSS.

2.5.7 Update the Statewide ITS Architecture (SITSA) to include institution, communications, and transportation interfaces.

2.5.8 Incorporate available National Transportation Communications for ITS Protocol (NTCIP) communications standards applications.

2.5.9 Provide interface software between the UAV and TMCs or SEOC.

2.5.10 Document all processes, procedures of flight operations, and communications setups for ongoing and future deployments.

2.5.11 Provide the final ATSS PoC Study Report.

2.5.12 Provide a statewide deployment guidebook.

3. PROJECT TEAM WORK TASKS

This section associates the various study tasks and sub tasks with the Research Team and the four teams assisting in the study. The four teams assisting the Research Team are:

1. FDOT's ITS Office;
2. NTCA;
3. UAV vendor(s) (to be determined); and
4. UNF (RWIS researcher).

For consistency and convenience, the work tasks numbering convention of Section 2 is reproduced here.

3.1 Research Team Primary Responsibilities

2.1 Discovery

This task deals with information gathering and is divided into the following subtasks:

2.1.1 Needs Assessment

This involves a thorough needs assessment of the functional and communications requirements of the ATSS study. It will include the following activities:

2.1.1.1 Inventory the FDOT microwave tower system in the test corridor (*see Appendix C, Microwave Tower System Map*) and the other links in the above-described key issues to be addressed.

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2.1.1.4 Determine the impact of various weather and nighttime conditions on flight operation and image quality.

2.1.1.5 Determine the acceptable quality of video (and other potential image generation devices) including snapshot still-frame picture quality.

2.1.2 Develop a Discovery Task White Paper. The Discovery Task White Paper shall address the needs assessment activities that include the inventory, PoC Research Plan, system functional requirements, impact of various weather and nighttime conditions, and quality of video.

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This Design Assesment task includes the following design, develop, and schedule subtasks:

2.2.1 From the communications systems functional requirements, the Research Team, in close consultation with the FDOT ITS Office, Florida Highway Patrol (FHP) and SEOC, shall develop a detailed systems requirements document.

The Research Team shall determine the availability of commercial off-the-shelf equipment needed for the FDOT microwave tower system and the SEOC facility to meet the needs of this study.

The Research Team shall also determine the need for any customized equipment and its impact upon this study.

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2.3 Systems Design

The Systems Design task includes design, coordination, and completion of the entire system. The Research Team, in close coordination with the FDOT, SEOC, FHP, UNF, and the UAV vendor(s), will develop a detailed systems design. In addition, the PoC Research Plan shall be finalized during this task.

2.3.1 The Research Team shall negotiate and coordinate with communications systems vendors.

2.3.2 The Research Team shall negotiate and coordinate with the UAV vendor(s).

2.3.3 The Research Team shall negotiate and coordinate with the NTCA.

2.3.4 The Research Team shall complete the detailed systems design. The detailed systems design includes all agreements needed to deliver the ATSS PoC Research Plan. The Research Team will develop a procurement plan, including cost estimates.

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This task requires the Research Team to implement the PoC Research Plan and associated detailed systems design by conducting the following PoC test.

2.4.1 The Research Team and the UAV vendor(s) shall provide a UAV and sensors suitable for this study to meet FDOT requirements. A UAV shall be the class type of aircraft utilized in this study.

2.4.2 The Research Team shall coordinate and base all UAV flight operations for this study at the NTCA located at 6601 North Monroe St., Tallahassee, Florida 32303.

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2.5 ATSS Implementation Plan

2.5.1 Determine appropriate FAA regulations and provide necessary input for FAA rulemaking with regard to autonomous flights. Such items as altitude restrictions, flights into Class B airspace, etc., must be addressed.

2.5.2 Determine FCC requirements and provide necessary input for the update of FCC rules and regulations with regard to ground-to-air-to-ground communications.

2.5.3 Determine FDLE and other state governmental agency requirements. Provide necessary input to update regulations regarding security, safety, and UAV operations.

2.5.4 Determine other complementary surveillance techniques, minimally including airborne manned vehicles (for rich data collection such as high resolution airborne laser swath mapping systems and water-penetrating airborne laser techniques) in conjunction with satellite imagery.

2.5.5 Determine the potential applications of modeling for use in conjunction with UAVs, including traffic flow, planning, and dispersion models.

2.5.6 Provide performance measures and cost benefit analysis of ATSS.

2.5.7 Update the Statewide ITS Architecture (SITSA) to include institution, communications, and transportation interfaces.

2.5.8 Incorporate available National Transportation Communications for ITS Protocol (NTCIP) communications standards applications.

2.5.9 Provide interface software between the UAV and TMCs or SEOC.

2.5.10 Document all processes, procedures of flight operations, and communications setups for ongoing and future deployments.

2.5.11 Provide the final ATSS PoC Study Report.

2.5.12 Provide a statewide deployment guidebook.

3.2 FDOT ITS Office Supporting Tasks

2.4 Proof of Concept (PoC) Test

2.4.3 The FDOT ITS Office with inputs from the FAA, Research Team and UAV vendor(s) shall determine and develop the flight alignment. The FAA shall approve the ultimate flight alignment. The Research Team shall coordinate with the FDOT ITS Office to confirm the approved flight alignment.

2.4.4 The FDOT ITS Office shall coordinate with the FAA[9] about specific flight restrictions. The flight alignment shall avoid any populated areas to the greatest extent possible. Flight operations should desirably include loitering over the I-75/I-10 interchange. (See *Appendix D, Proposed Flight Alignment,* for preliminary details.) The FDOT ITS Office shall be responsible for all correspondence and approval documents related to the flight alignment with the FAA.

2.4.5 The FDOT ITS Office shall coordinate the communications requirements and necessary approval documentation by the FCC and/or DOD as required[10].

2.4.6 The Research Team shall coordinate with FDOT to specify the explicit microwave tower system and other communications equipment requirements[11]. (See *Appendix C, Microwave Tower System Map.*)

2.4.9 The FDOT ITS Office shall have its communications' contractors install all needed communications equipment procured by the Research Team on at least two, and preferably three, FDOT microwave towers to receive the video broadcasts from the UAV.

[9] The Research Team recognizes that all communications with FAA will be through FDOT.

[10] FDOT's Telecommunications General Consultant (TGC) will coordinate with the FCC, National Telecommunications and Information Administration (NTIA), and DOD to receive the needed approvals and documentation.

[11] FDOT's TGC has recommended that the Research Team work with the TGC to provide functional specifications. Since the TGC is familiar with the current microwave equipment and linkage, the TGC will prepare an aeronautical chart with microwave tower locations.

2.4.11 The FDOT ITS Office shall coordinate with the DOD about flight operations and communications.

2.4.15 The FDOT ITS Office shall coordinate with the FAA about whether a chase plane will be needed and whether nighttime flight operations will be allowed.

2.4.16 The FDOT ITS Office shall advise the FDLE of the flight operations schedule. The FDLE shall provide its approval to FDOT prior to any flight operations.

2.4.19 The FDOT ITS and Public Information Offices shall coordinate and interface all activities with the media, if any.

2.4.23 The FDOT ITS Office shall review the project progress and review all deliverables including technical reports.

3.3 North Tallahassee Commercial Airport (NTCA) Supporting Tasks

2.4 Proof of Concept Test

2.4.2 The Research Team shall coordinate and base all UAV flight operations for this study at the NTCA located at 6601 North Monroe St., Tallahassee, Florida 32303.

2.4.14 The UAV vendor(s) shall install a meteorological sensor package provided by UNF for UAV flight operations to determine the efficacy of collecting weather information.

3.4 UAV Vendor(s) Supporting Tasks

2.4 Proof of Concept Test

2.4.1 The Research Team and the UAV vendor(s) shall provide a UAV and sensors suitable for this study to meet FDOT requirements. A UAV shall be the class type of aircraft utilized in this study.

2.4.12 The Research Team should ideally enlist the services of Meggitt Defense Systems as the UAV vendor(s)[12], **if the costs are within budget**. The FDOT ITS Office prefers Meggitt Defenses Systems because of their prior successful UAV flight operations experiences in North Miami in June 2001. However, the Research Team should also explore other UAV vendor(s) participation options for cost and benefit comparison.

[12] The Research Team will budget $50K for this effort. If Meggitt is not available, or too costly, the Research Team will solicit other UAV providers.

2.4.13 The Research Team shall coordinate with the NTCA and UAV vendor(s) to provide flight operations according to the approved flight alignment, and FAA and FCC requirements.

2.4.20 The Research Team and the UAV vendor(s) shall conduct flight operations to demonstrate both the daytime and nighttime capabilities of the UAV and its sensors. The flight operations shall include at least ten (10) days and nights of flight operations to meet the needs of this study. The flight operations shall include at least one daytime flight every day and one nighttime flight every other night. Each flight shall include two round trips from NTCA to the interchange of I-10 and I-75.

2.4.21 The Research Team and the UAV vendor(s) shall conduct flight operations to demonstrate dynamic video broadcast reception capability (i.e., broadcast handoff) from one microwave tower to adjacent towers.

2.4.22 The Research Team, in conjunction with the UAV vendor(s), shall create a video log of all flight operations. The video log shall principally include in-flight video and images captured by the UAV.

3.5 University of North Florida (RWIS Researcher) Supporting Tasks

2.4 Proof of Concept Test

2.4.14 The UAV vendor(s) shall install a meteorological sensor package provided by UNF for UAV flight operations to determine the efficacy of collecting weather information.

4. STUDY SCHEDULE

The study should be completed within 18 months of the notice to proceed (NTP). The milestone activities reflective of the work tasks to be performed are identified and scheduled as follows. The Research Team shall update and maintain the corresponding Microsoft Project Schedule and provide FDOT with the most current schedule.

Please visit http://www.list.ufl.edu/uav/final_schedule.pdf to view the final schedule.

5. STUDY DELIVERABLES

The following specific deliverables will be provided during or at the end of this study:

5.1 A quarterly study status report;

5.2 Discovery Task White Paper;

5.3 A prescriptive specification for ATSS in both Adobe Acrobat PDF and Microsoft Word formats for ATSS communications (including data, video, etc.) from a UAV to the FDOT microwave tower system.

5.4 A study journal that captures daily observations of activities related to the study.

5.5 A complete video log of UAV flight operations.

5.6 An analysis of current and proposed FAA rulemakings with regard to UAV applications.

5.7 An analysis of current FCC regulations regarding air to ground communications as they relate to the proposed UAV traffic monitoring project, as well as recommendations for rules or other changes which could be brought to the attention of the FCC.

5.8 An assessment on acceptable video, image quality, and other sensor data for ITS applications.

5.9 An analysis of the impact of weather phenomena and nighttime observational constraints on UAV operations and associated image or video quality.

5.10 An analysis of other complementary surveillance techniques such as manned airborne vehicles and satellite imagery in comparison with the proposed ATSS project, in terms of ITS applications.

5.11 Draft and final reports of this study in both Adobe Acrobat PDF and Microsoft Word electronic format.

5.12 Complete documentation of the ATSS communications processes and setup, including interfaces, in both Adobe Acrobat PDF and Microsoft Word electronic formats.

5.13 An electrical or telecommunications engineering analysis of the observed communications between the ATSS and the microwave tower system.

6. EQUIPMENT

6.1 Equipment provided by the Research Team:

- Computational and video processing facilities for distribution of video from the ATSS via the Internet.

6.2 Equipment provided by the UAV Vendor(s)/Operator(s):

- ATSS platform with video camera and RF subsystems.

6.3 Equipment provided by FDOT:

- Microwave communications equipment and programming to allow the receipt of RF signals from the ATSS at the communications towers and the delivery of those signals to the TMCs via the existing FDOT microwave radio network.

6.4 Equipment provided by the SEOC and TMCs:

- Video and data terminals to receive and display the video and other data monitored by the ATSS.

6.5 Equipment provided by the FHP:

- Equipment to receive signals from the SEOC via FDOT telecommunications links or via the Internet.

6.6 Equipment provided by the NTCA:

- N/A.

6.7 Equipment provided by UNF:

- Weather monitoring hardware for the ATSS payload and interfaces for integration with the ATSS communications subsystems.

7. SIMILAR EFFORTS

Literature searches indicates reports of UAV operations for traffic management from San Diego, California, and New Mexico State University. Mr. Glenn Anderson, P.E., with Kentucky Transportation Cabinet, Division of Operations-ITS Branch, has applied a simple UAV for aerial photography. Mr. Anderson can be reached at 502-564-4556, 502-564-6640 (fax), or ganderson@mail.kytc.state.ky.us. The University has been experimenting with UAVs fro related applications for about twelve (12) months.

The FHWA recently awarded a research contract to DBR Associates and GeoData Systems to evaluate the potential use of a Remote Control Aircraft (RCA) for a limited spot-surveillance mission. The Research Team will collaborate with the FHWA Research Team to complement this effort.

8. AFFECTED FUNCTIONAL AREAS

The information and research results of this study will provide statewide advanced traveler Information Systems (ATIS) that include FDOT' s Central, District Traffic Operations, ITS, Construction, Maintenance Offices, Department of Community Affairs Emergency Operations Center, Department of Forest Services, FDLE, and FHP.

9. RELEASE AND INDEMNITY

The Research Team and the UAV vendor(s) shall determine, fulfill the legal, liability aspects of this study and any insurance requirements.

In addition to the standard research contract's legal clauses that cover state agencies, including FDOT and the Research Team, the Research Team, UAV vendor(s), NTCA, and UNF shall be required to indemnify FDOT against damages, loss, injury, or anther legal claims.

10. IMPACT TO PRACTICE

An aerial view is the best perspective of a degrading traffic situation, particularly over a long stretch of un-instrumented highway, such as an interurban highway or rural road.

UAV equipped with monitoring video cameras and/or other sensors may be able to deliver the necessary information through video images with relatively low operational costs and risks to human life. Other types of data could be collected as well, ranging from weather information to fire and flood information. The UAV may continuously feed information for both ATMS and ATIS, as well as for other purposes.

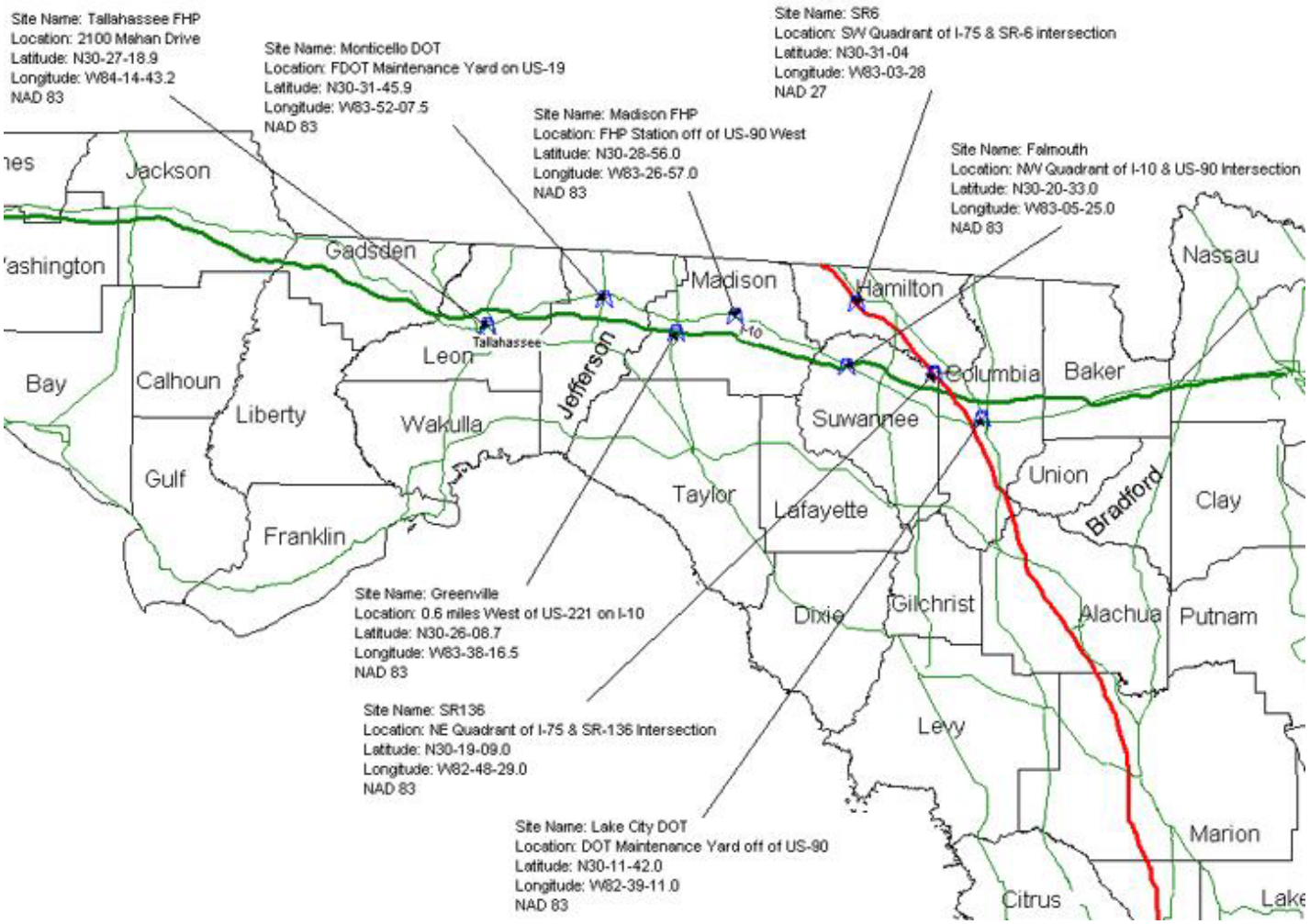
The proof of concept study will determine the overall communications interfaces and operational logistics of ATSS using unmanned aircraft for traffic surveillance and other potential ITS

applications in a comprehensive, yet safe, legal, and prudent manner. The major thrust of this study will be the use of UAV equipment as the framework for ATSS.

11. BENEFITS TO THE DEPARTMENT

This study will provide timely information on highway traffic conditions for use by a traffic management center (TMC). This information, which will improve public safety, is a major function of intelligent transportation systems (ITS). Advanced traffic management systems (ATMS) and advanced traveler information systems (ATIS). This information and communications links are very important when incidents or accidents occur. These systems will be extremely critical if and when emergency evacuation events are necessary

Appendix A – Microwave Tower System Map



Appendix B – Proposed Flight Alignment