CENTRAL FLORIDA EXPRESSWAY AUTHORITY

MEMORANDUM

TO: CFX Board Members

FROM: Aneth Williams
Director of Procurement

DATE: March 17, 2017

RE: Approval of Extension of the Inter-local Agreement between CFX and UCF for the Wrong Way Driving Phase 3 Study: Allocating and Evaluating Countermeasures, Contract 001143

Board approval is requested to extend the referenced Inter-local Agreement between Central Florida Expressway Authority and the University of Central Florida in the amount of $225,000.00. The extension will be from August 13, 2017 to August 12, 2019. The contract scope will be replaced with the amended Extension Proposal of Research Project Contract Version 5.0.

Original Contract Amount	$200,000.00
Extension	$225,000.00
Total Revised Contract Amount	$425,000.00

CFX entered into an agreement with UCF on August 13, 2015 for a period of two years, to provide research and reporting on CFX's Wrong Way Driving system first deployed in February of 2015. This agreement will expire on August 12, 2017, with the option to extend upon approval by both parties. The Wrong Way Driving (WWD) deployments on CFX system are authorized by FHWA under Request to Experiment (RTE) 4(09)-49 E. As a part of this RTE approval, CFX is required to provide bi-annual reports to FHWA. A key scope item of the UCF Phase III study includes the generation of monthly reports for CFX reference as well as the bi-annual reports required by FHWA. At the start of the Phase III study there were only five (5) WWD locations online, currently there are a total of 34 locations online which is increasing the amount of data available for review, increasing the value of the reporting. The Extension Proposal documents the continuation of all current scope items along with addition of new scope items in the research project that will help with the further development of the CFX WWD Program.

This service will be budgeted in future OM&A Budgets.

Reviewed by:
Bryan Homayouni
Manager of Traffic Operations

FINAL VERSION

EXTENSION PROPOSAL OF RESEARCH PROJECT CONTRACT

Version 5.0

Submitted to

Central Florida Expressway Authority (CFX)

EXTENSION TO PROJECT "WRONG-WAY DRIVING PHASE-3 STUDY: ALLOCATING AND EVALUATING COUNTERMEASURES ON CFX ROADWAY NETWORK"

Project Extension Period	**24 months**
Project Extension Duration	**08/13/2017-08/12/2019**
Extension Budget Amount	**$225,000**

Proposal Submitted By

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Extension Proposal Originally Submitted in February 2017
Revised in March 2017

EXTNESION TO PROJECT TITLED "WRONG-WAY DRIVING PHASE-3 STUDY: ALLOCATING AND EVALUATING COUNTERMEASURES ON CFX ROADWAY NETWORK"

Principal Investigator:
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1. RESEARCH GOAL AND OBJECTIVES

Research Main Goal

The main goal of the extension to the originally proposed study is to continue evaluating wrong-way driving (WWD) advanced countermeasures that have been deployed (and additional countermeasures that will be deployed) at ramps and medians throughout the CFX toll road network, help CFX determine the best way to warn right-way drivers of intentional wrong-way drivers that do not correct their behavior before entering the mainline, and study potential technologies that can prevent these wrong-way drivers from entering the mainline in the first place. An additional goal is to explore placing of WWD detection devices on the mainline.

Research Objectives

To achieve the main goal of this research, the following objectives need to be achieved:

1) Continue collecting data so that a sufficient sample of WWD data can be reached for the entire CFX system to evaluate their implemented WWD countermeasures. Examples of this WWD data include crashes, Computer Aided Dispatch (CAD) privileged data also known as 911 calls and events data , citations, traffic management center (TMC) logs, SunGuide reports, and detections (TAPCO logs and video recordings, mainline detections, etc.), as well as geometric design of interchange types that are known to have

higher than normal frequency of WWD events as reported in the literature and FDOT design documents (examples of this include full or partial diamond interchanges).

Extension to Objective #1:

The above WWD data will be continuously monitored every month and the trends of WWD acts and false alerts will be examined to understand how the RRFB devices are working and how wrong-way drivers are reacting to them. The WWD detections and false alerts will also be compared across radar and laser sites on CFX network to report performance of different WWD detection and deterrence technologies.

2) Develop a scoring methodology to identify locations where deployment of Rapid Rectangular Flashing Beacons (RRFBs) would be beneficial. This methodology will consider many factors, including WWD history (crashes, CAD data/911 calls, citations, etc.), interchange design (full diamond, partial diamond, extended left turn lanes, etc.), and other factors driven by CFX (e.g., infrastructure readiness in terms of ITS equipment at these sites and budget considerations).

Extension to Objective #2:

The above scoring methodology proposed in the original contract will be evaluated again using additional data that was not available when the methodology was initially developed to see if there are any changes in potential deployment locations. Additionally, an optimization model will be developed to determine the next locations where WWD countermeasures should be deployed. This optimization model will expand on the scoring methodology and consider WWD event data, budgetary constraints, and other factors to determine where various types of WWD countermeasures (including low-

cost improvements and advanced warning devices) should be implemented. This extension to Objective#2 is a major undertaking.

3) Study the effects of WWD countermeasures implemented at medians. The types of median countermeasures to be studied will be determined based on the results of literature review.

Extension to Objective #3:

As additional data is becoming available during the extension period, the initial model developed to meet the above objective (which had small data sample) will be revisited to include larger data sample.

4) Study various methods of warning right-way drivers about WWD events to determine the most appropriate methods for the CFX roadway network.

Extension to Objective #4:

The UCF research team will continuously monitor the introduction of new technologies that have potential for right-way driver notification about WWD events and discuss these with CFX.

5) Evaluate technologies that can physically prevent wrong-way vehicles from entering the mainline (e.g., nets or barriers) to see if these technologies are feasible and effective.

Extension to Objective #5:

The potential application of connected and automated vehicle technologies to alert and prevent wrong-way drivers from entering the mainline will be examined.

6) Analyze the WWD detection data collected from the RRFBs installed at the CFX pilot test locations to understand how drivers react to these devices (correct themselves or keep driving the wrong way).

Extension to Objective #6:

Continue to analyze WWD detection data collected from RRFBs and produce monthly detection and false alerts reports verified with SunGuide reports and report these to CFX. Locations that still have high frequencies of WWD acts even with the RRFB devices will be examined to see what other measures could be implemented to reduce the occurrence of WWD at these locations. Also, continue producing FHWA progress reports every 6 months during the two-year extension of the original project.

7) **New Objective as Part of Extension:** Assist CFX in developing a methodology for deploying WWD mainline detection systems to detect wrong-way drivers that enter the mainline. This will include determining the placement of these systems, evaluating any potential signage to use in conjunction with these systems, and collecting and analyzing the data from any potential pilot deployment of these systems.

2. EXECUTIVE SUMMARY

CFX has been proactively involved in understanding and combatting wrong-way driving (WWD) since they contracted with the University of Central Florida (UCF) in 2012 to explore the extent of WWD problem on its toll road network as part of a Phase-1 study. The results of this study, "*Wrong-Way Driving Incidents on OOCEA Toll Road Network, Phase-1 Study: What is the Extent of this Problem?*" showed that WWD is a significant problem in Central Florida and has been growing in recent years.

To reduce WWD, and based on recommendations from UCF in Phase 1 final report, CFX decided to test the use of Rapid Rectangular Flashing Beacons (RRFBs) as WWD

countermeasures in a Phase-2 study. This technology had previously been used for pedestrian crossings; it had never been used as a WWD countermeasure before UCF recommendation was made in Phase-1. During the Phase-2 study, "*Wrong-Way Driving Incidents on CFX Toll Road Network, Phase-2 Study: Developing Countermeasures,*" the RRFB technology was successfully tested, first in the CFX headquarters parking lot, then at the SR 528 and SR 520 ramp. Since the RRFBs were implemented at this location in January 2015, CFX have successfully detected several vehicles driving the wrong way on the exit ramp, as verified by the TAPCO camera and the numerous images taken of the wrong-way vehicles.

The success of this technology has convinced CFX to implement it at additional ramps along their toll road network. A methodology and extension to the methodology originally proposed in Phase 3 will be developed by the UCF research team that will estimate WWD risk values for roadway segments including interchanges throughout the CFX network. This methodology will use real-life WWD data, examples of which include WWD crash data, CAD/911 call data and events, citation data, TMC logs, SunGuide reports, TAPCO BlinkLink detection data, TAPCO video logs, and mainline detection data (if and when it becomes available). Other considerations, such as the presence of full or partial diamond interchanges, extended left turn bays, and other CFX practical constraints (e.g., budget and infrastructure ITS equipment readiness/limitations) will also be considered when developing this methodology. The methodology will include optimization techniques as described in the extension to Objective#2 above. It is believed that no methodology like this has ever been developed that focuses solely on WWD.

In addition to exit ramps, another potential source of WWD events is median crossovers. These types of events can occur on stretches of roadway where there is only a paved or grassy median or in spaces in barriers designated for emergency or law enforcement use (also known as emergency median openings). To prevent these types of WWD events, various potential median WWD countermeasures will be studied to see which would be effective for CFX. The types of median countermeasures to be studied will be determined based on the results of literature review. The best locations to implement these countermeasures will also be determined and detection data will be collected at these implementation sites to evaluate how effective these countermeasures are.

While WWD countermeasures can help prevent confused wrong-way drivers from entering the mainline, these devices may not be effective at preventing intentional wrong-way drivers, such as suicidal drivers, from entering the mainline. Additionally, extremely intoxicated drivers might not comprehend that they are driving the wrong way when they encounter the WWD countermeasures. Therefore, it is important for CFX to be able to notify right-way drivers when a wrong-way driver has entered the system. There are many possible ways to notify these drivers of WWD events, including DMS, smartphone applications, and in-vehicle notifications. These various methods will be examined to determine the most effective options for CFX based on roadway characteristics and driver preferences. To obtain driver preferences, a customer survey has been developed and implemented with the approval of CFX administration. This survey asked CFX customers how they would like to receive WWD notifications, along with other WWD related questions. During the extension project, this survey will be analyzed thoroughly to understand expectations from WWD customers about right-way driver notification methods.

An analysis of potential ways to physically prevent intentional or intoxicated drivers from entering the mainline will also be performed to see if these technologies, which can include barriers, nets, or other similar devices, are feasible and would be effective for the CFX to implement at its ramps.

Extension Period:

Extending this research by 24 months for a total timeframe of 48 months will allow for the UCF research team to continuously monitor WWD events on the CFX network during this timeframe. The UCF research team will also develop an optimization model that CFX can use to determine the next locations for RRFB implementation, as well as where other, lower cost countermeasures could be most effectively implemented. New potential WWD countermeasures, including the use of automated and connected vehicle technologies, will also be researched to ensure CFX remains a leader in WWD detection and prevention. Additional research on WWD notification methods for right-way drivers will also be conducted to determine the best and most effective notification methods for CFX and its customers.

The UCF research team will also assist CFX in developing and deploying WWD mainline detection systems to obtain more data about wrong-way drivers who do not turn around at ramps and continue to the mainline. This assistance will include determining the most appropriate locations for these detection systems based on WWD data, evaluating any potential signage to be used with these systems to notify wrong-way and right-way drivers, and collecting and analyzing data for any pilot deployments of these systems on the CFX roadway network.

The Phase-3 project extension is a fixed lump sum 24 months with requested total budget for the extension only of $225,000. This will be billed in 4 equal invoices, $56,250 each, every 6 months during the 24 months extension period (the last invoice will be billed at the

end of the last month of the extension project). Details of the budget are provided on the last page of this proposal.

3. UNDERSTANDING OF THE PROBLEM

Wrong-way driving (WWD) is a rare but serious event which often occurs during late night hours and typically involves impaired drivers (intoxicated, tired, or confused). Crashes caused by WWD often result in severe injuries or fatalities, especially on toll roads or other limited access facilities due to the high travel speeds. The low frequency of WWD crashes presents a difficult challenge to researchers, so other WWD data is needed to accurately research and effectively prevent WWD events. This data includes WWD CAD/911 call data, citation data, TMC logs, and detection data (e.g., video, camera, or radar). A sufficient quantity of data collected over several years is also necessary to properly understand the effects of WWD countermeasures. WWD countermeasures can prevent confused drivers from entering the mainline while traveling the wrong direction, but they will not prevent intentional wrong-way drivers (suicidal or extremely intoxicated drivers) from entering the mainline. However, the risk of crashes due to these wrong-way drivers can be reduced by notifying right-way drivers that a wrong-way driver has been spotted or by implementing technologies, such as barriers or nets, that could physically prevent a wrong-way driver from entering the mainline. These preventative technologies require a lot of study before implementation to ensure there are no adverse effects to traffic operations, safety, or emergency response and to make sure these technologies are feasible and appropriate. Methods of notifying right-way drivers can include DMS, highway advisory radio, smartphone applications, or in-vehicle devices; these methods need to be evaluated and CFX customer preferences need to be determined to decide which methods would

be the most effective. These potential methods will be discussed and approved by the CFX administration before they can be released.

4. BENEFITS TO CFX

The main benefits of this Phase-3 study and its extension to CFX are:

- Saving lives of CFX customers from the danger they could face if wrong way drivers continue to pursue their behavior to the mainline without being detected in time and/or stopped.
- Demonstrating that CFX is using their budget carefully and wisely by installing RRFBs and other effective countermeasures where they are most needed.
- Providing notifications to right-way drivers about WWD events that can allow the right-way drivers to be aware of and potentially avoid collisions.
- Evaluating the effects of RRFBs and median WWD countermeasures to understand which countermeasures are effective in which locations and which locations could require additional measures to reduce WWD.
- Contributing to development of potential innovative technologies to prevent wrong-way drivers from entering the mainline.
- Ensuring that CFX remains at the cutting edge of WWD research by investigating new potential WWD countermeasures, as well as connected and automated vehicle technologies.

- Enabling CFX to evaluate mainline detection and deterrence technologies to detect and deter wrong-way drivers who reach the mainline so they can be stopped before they cause a crash.
- Demonstrating to CFX's customers that their safety is priority.

5. PLAN FOR IMPLEMENTATION OF RESULTS

From this Phase-3 extension study, CFX will understand how the implemented WWD countermeasures at ramps and medians affect WWD. CFX will also gain valuable insight on right-way driver notification methods and potential technologies to prevent wrong-way drivers from entering the mainline. With this knowledge, CFX can effectively decide on what types of technologies to test and/or implement to reduce WWD crashes on the mainline.

Extension Plan:

The developed optimization model will allow CFX to optimally install future WWD countermeasures to provide the most benefits within a given budget. CFX will also understand how automated and connected vehicle technologies can be used for WWD prevention and notification. By evaluating the deployed mainline WWD detection systems, CFX will be able to more accurately track wrong-way drivers and evaluate the potential of stopping them before they cause a crash on the mainline.

6. PROPOSED RESEARCH APPROACH

Tasks

To achieve the stated goal and objectives of this proposed project, the University of Central Florida's (UCF) research team members under the guidance of Professor Haitham Al-Deek,

Ph.D., P.E., (UCF Principal Investigator, PI), will perform the proposed project tasks listed in this section. Their aim will be to assist CFX in optimally implementing WWD countermeasures at ramps and medians and assessing their performance, determining ways to notify right-way drivers and prevent intentional wrong-way drivers from entering the mainline, and understanding the potential applications of automated and connected vehicle technologies for WWD prevention and notification. Professor Al- Deek will be assisted by several members of his research team (e.g., students). His current research team includes: Adrian Sandt, a UCF Ph.D. student and Trustees Fellowship recipient; Md. Imrul Kayes, a UCF Ph.D. student; Omar Al-Sahili, a UCF M.S. student; Md. Omar Faruk, a UCF M.S. student; as well as additional outstanding undergraduate engineering students, including Sara Wertanen, Antony Shamma, Corin Staves, and Abigail VanLuven. Also, other graduate and/or undergraduate students may join this extension project throughout its duration as needed. Additionally, Dr. Grady Carrick of Enforcement Engineering Inc., who is a former Chief of FHP in Jacksonville area (for a period of 30 + years) with very important hands on experience in first response to WWD incidents, will also be subcontracted by UCF as consultant to assist in critical data collection on the performance of WWD countermeasures, and will provide law enforcement perspective concerning UCF innovative WWD countermeasures, right-way driver notification methods, and technologies to stop wrong-way drivers. (Formal commitment will be provided by the consultant when funding is established).

Tasks to be performed by the UCF research team include the following:

1. *Phase-3 kick-off meeting between UCF research team and CFX.*
2. *Methodology development.* A methodology will be developed to identify locations at the highest risk for WWD activity. This methodology may use some or all of the following:

historic WWD data, including crashes, CAD/911 calls and events, citations, TMC reports, and detection data, as well as design characteristics (interchange type and presence of potentially confusing features) to estimate the WWD risk of the selected ramps and other potential ramps that were not selected.

Extension to Task #2 (Methodology):

The model developed from this methodology will be updated with the most recent data to see how the high-risk locations have changed.

3. *Collection and analysis of WWD data.* Accurate and reliable data is crucial for this project. A variety of WWD data will be collected and analyzed for the entire CFX system. Examples of this data include WWD crash data, CAD/911 call and event data, citation data, TMC logs, and Sunguide reports. Additionally, WWD detection data obtained from the installed RRFBs at the pilot ramps will also be analyzed. This data includes TAPCO BlinkLink logs and video as well as other detection logs. Data will also be collected from the median WWD countermeasures that will be implemented as part of Task 7. It is highly recommended to collect as much data as possible after implementation for each site to accurately evaluate the countermeasures. The minimum period of data collection cannot be determined accurately until data is collected for several months from each location. The minimum sample size needed varies by location and will depend on the WWD activity at each location.

Extension to Task #3:

The UCF research team will continue monitoring WWD events on CFX roadway network, including the creation of monthly WWD detection and false alerts reports for the 34 sites

currently equipped with RRFBs, as well as for any additional sites where RRFBs will be implemented during the timeframe of this extension study.

4. *Literature review on median WWD countermeasures.* To determine the most effective countermeasures at preventing median crossovers, previous research will be reviewed. Many types of countermeasures ranging from signs and pavement markings to ITS technologies will be analyzed to determine which would be most effective for CFX.

   Extension to Task #4:

   The UCF research team will investigate other potential WWD countermeasures for use at ramps and/or medians. These can include new detection or warning technologies being used by other agencies, as well as technologies that are not currently being used for WWD prevention, but could be adapted or modified for this purpose.

5. *Examination of right-way driver notification systems.* There are many ways that CFX could potentially alert right-way drivers of WWD events. To determine the most effective notification methods, a literature review and a customer survey, with its questions being pre-approved by the CFX administration, has been conducted as part of this task.

   5.1. *Literature review on WWD notifications.* A literature review will be conducted on ways other agencies currently warn about wrong-way drivers. Based on this review, potential notification methods for CFX will be identified.

   5.2. *Customer survey on WWD notifications.* In addition to the literature review, a customer survey has been developed, reviewed and approved by the CFX administration, and then it was implemented to obtain the opinions of CFX's customers regarding WWD notifications and countermeasures. This survey was implemented online and customers

were asked about their preferences concerning WWD notification methods and messages, as well as about WWD countermeasures.

5.3. *Determination of notification methods.* Based on Tasks 5.1 and 5.2, the most appropriate notification methods for the CFX system will be determined. Additional research will be performed to determine the optimal deployment methods for these notification methods.

Extension to Task #5:

The literature review in Sub-Task 5.1 will be updated as needed. Further research will be conducted on notification methods, including the applications of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications for WWD notification.

6. *Review of technologies to stop intentional wrong-way drivers.* Since intentional wrong-way drivers, such as suicidal drivers, will not correct themselves when they encounter WWD countermeasures, additional technologies could be necessary to prevent these drivers from entering (or continuing on) the mainline. A literature review will be conducted on potential technologies that can physically prevent wrong-way drivers from entering the mainline to see if these technologies are feasible or would be effective for CFX to implement. Other innovative technologies that have not previously been used as WWD countermeasures will also be evaluated to see if they would be appropriate. If feasible technologies are found, testing plans and appropriate documentation for the MUTCD's Request to Experiment (RTE) will be developed.

Extension to Task #6:

The use of connected and automated vehicle technologies to stop wrong-way vehicles from entering the mainline will be investigated. If CFX desires to test any of these technologies,

The UCF research team will assist CFX in coordinating with vehicle manufacturers and any other necessary third parties.

7. *Determination of appropriate median crossover countermeasures.* Based on the literature review conducted in Task 4, appropriate countermeasures to prevent median crossovers will be determined. Appropriate sites for implementation of these countermeasures will be determined using a methodology customized for medians. Once the median locations have been selected and the countermeasures installed, WWD data at these sites will be collected, as described in Task 3.
8. *Progress reports for FHWA RTE.* Every six months, a progress report will be written for the FHWA RTE of all RRFBs installed on the CFX system at the time of each report. These progress reports will indicate the progress of this experiment, including any important observations and issues that occurred or were resolved.

   Extension to Task #8:

   The UCF research team will continue writing these FHWA progress reports every six months for the entire timeframe of this study including the 24 month extension period of the original project.
9. **New Extension Task:**

   WWD countermeasure optimization model for CFX network. In addition to the **WWD Hotspots™** identification model that was developed as part of Task 2, an optimization model will also be developed. This model will consider the use of various WWD countermeasures, including low-cost improvements (enhanced signage, increased pavement markings, etc.) and advanced technologies (RRFBs or other potential technologies discovered as part of the extension to Task 4). With this model, CFX can determine the best WWD countermeasures

to implement and where to implement them to provide the best reduction in WWD for the lowest cost.

10. **New Extension Task:**

    Evaluation of current RRFB deployment sites. Using the data collected as part of Task 3, the ramps equipped with RRFBs will be analyzed to see which ramps have higher frequencies of WWD acts and events. For any identified high-frequency ramps, potential mitigating measures to reduce the occurrence of WWD will be examined and recommended. These measures could include additional signs or markings, improved lighting, or geometric changes.

11. **New Extension Task:**

    Analysis of CFX network for mainline WWD detection deployment. The UCF research team will assist CFX in analyzing the potential of deploying mainline WWD detection systems throughout the CFX network. First, WWD event data will be analyzed to determine mainline locations where WWD seems to occur most frequently. Then, the best type of detection systems and supplementary signage or other devices will be determined for each potential deployment location. Using this information, CFX can decide where to deploy these detection systems for a pilot test. The UCF research team will collect and analyze any data from this pilot test deployment and document the results to understand whether these systems help reduce WWD crashes and help CFX more accurately track wrong-way drivers on the mainline.

12. *Recommendations for CFX.* Based on the results of the previous tasks, recommendations will be provided to CFX. Recommendations on the use of RRFBs and the applied median countermeasures will be made based on the results of Task 3 and Task 7. Effective

methods to notify right-way drivers of WWD events will be made based on the results of Task 5 and potential preventative technologies will be recommended based on the results of Task 6. These recommendations will include the types of technologies and potential testing and/or implementation methods.

Extension of Task #12:

The UCF research team will also make recommendations to CFX regarding the application of connected and automated vehicle technologies (as studied in the extension to Task 6) and where to optimally implement future WWD countermeasures based on the results of the optimization model developed in Task 9. Recommendations on the future use of mainline WWD detection systems will also be made based on the results of any pilot deployment of these systems. Task 11 will help CFX determine the best mainline locations to deploy the appropriate type of WWD detection and deterrence technologies, and to evaluate the potential and viability of these technologies.

13. *Final report and presentation of results to CFX.* At the end of the extension project, a final report will be submitted in electronic format and a final presentation will be made to CFX. This final report and final presentation will also constitute the only final report and final presentation deliverables for the entire original and extension study. The final report and presentation in the original contract will be replaced by a progress presentation only made at the end of the original 24 months contract period (that ends before the extension period), also see Task#14 below.
14. *Progress Presentations.* A progress presentation will be made to CFX approximately once every four months during the extension period of the project. These progress presentations are deliverables by themselves. The original contract final presentation deliverable will be

substituted by a regular progress presentation deliverable due on the last day of the current contract ending date (August 12, 2017).

7. QUALIFICATIONS OF THE UCF PI AND HIS RESEARCH TEAM AS EVIDENCED BY PAST EXPERIENCE IN THE FIELD

Professor Haitham Al-Deek, Ph.D., P.E., is the Principal Investigator (PI) of this proposed extension of CFX WWD phase-3 study. He is the PI for the original CFX WWD Phase-3 study. He has more than **thirty years** of experience in transportation engineering, planning, and operations. He is **nationally recognized in his field and received the best paper award on developing wrong way driving risk models for Florida limited access highway network granted to him and his research team by the Freeway Operations Committee of the National Research Council-Transportation Research Board (TRB) in April 2015. His Ph.D. student, Adrian Sandt, who is the lead graduate student researcher in Professor Al-Deek's WWD projects, has won the 2017 Best Freeway Operations Student Paper Award. The paper was titled "Identifying Wrong-Way Driving Hotspots by Modeling Crash Risk and Assessing Durations of Wrong-Way Driving Events." This paper was also nominated for the 2017 Cunard Award (TRB Operations Section committees including freeway operations, Regional Transportation Systems Management and Operations or Regional TSMO, safety, ITS, Traffic Flow Theory, Networks, and many others). Professor Al-Deek also received two Chairman Awards from TRB for his significant contributions to the fields of *Freeway Operations*, and *Regional Transportation Systems Management and Operations* in January 2012. In addition, he received the best TRB freeway operations paper award in**

2010, which was about the impact of Dynamic Message Signs on CFX drivers, and another best paper award by the TRB Freeway Operations Committee on travel time prediction on I-4 in 2003. He also received the best TRB paper award in Regional Transportation Systems Management and Operations in January 2017, 2016, and January 2014. In 2015, he won a competitive national research project in collaboration with Texas A&M Transportation Institute (TTI) on wrong way driving countermeasures (NCHRP 03-117). He had numerous media interviews on wrong-way driving such as Channel 9 News and FOX 19 NOW News in 2016, and Channel 9 News in 2015 and 2014 featuring the innovative wrong-way driving countermeasure he and his research team came up with, which was later implemented for the first time in Central Florida. Professor Al-Deek has two US patents related to WWD, two US trademarks one of them is related to WWD, and eight software copyrights. Professor Al-Deek was invited as keynote speaker to talk about innovative research methodology and countermeasures for combating wrong way driving at the 7th Traffic Safety Conference in Amman, Jordan, May 12-13, 2015. He was featured as a distinguished researcher by the UCF College of Engineering and Computer Science in 2003. He received the Research Incentive Award in 2001 and the UCF Researcher of the Year 1999 Award (this is a very prestigious award given to the best professor researcher of the year out of the entire UCF's 1500+ faculty). He earned his Ph.D. and MS degrees from the University of California at Berkeley in 1991 and 1987 respectively. Professor Al-Deek was the principal (or co-principal) investigator of more than **70** applied research projects at UCF and elsewhere, and a large number of them were on toll roads. Since joining UCF in 1992, the total budget of applied research projects he attracted to UCF exceeded $7.7 million. He has published more than 350 papers and technical reports in peer-reviewed journals and conferences, and more than half of these publications are related to traffic

operations and **toll roads**. He chaired 11 Ph.D. dissertations and 26 MS theses to completion. Presently, and for the past 17 years, he has been the Chair of TRB's paper review for all papers submitted to two key TRB committees: *Freeway Operations* and *Regional Transportation Systems Management and Operations*. These two committees review nearly all papers submitted to TRB's annual meeting on freeway and toll operations and management every year. Professor Al-Deek has been an associate editor of the Journal of Intelligent Transportation Systems (J-ITS) since 2007.

Professor Al-Deek teaches undergraduate and graduate courses at UCF. He developed *new* courses such as Intelligent Transportation Systems (ITS), Highway Capacity, Traffic Operations, Mass Transit, Transportation Engineering Systems, and Highway Engineering. He also teaches Transportation Engineering courses on a regular basis. Professor Al- Deek has been an active registered Professional Engineer in Florida since 1998. Professor Al- Deek has completed three federally mandated training courses required for all principal investigators and key personnel working on projects dealing with human subjects in surveys and/or interviews.

Adrian Sandt, Ph.D. student, is currently a graduate research assistant at the University of Central Florida under the supervision of Professor Al-Deek. He obtained his B.S. in Civil Engineering from UCF and is currently pursuing his Ph.D. with Professor Al-Deek as his major academic and research adviser. Mr. Sandt is a recipient of the UCF Trustees Fellowship. He won the University Transportation Center (UTC) Student of the Year (SOY) Award representing the Southeastern Transportation Center (STC) competing with students from ten universities that are members of the STC consortium including UCF. This award was presented to him by the

Consortium for University Transportation Centers (CUTC) on January 7, 2017 at the 96th TRB annual meeting in Washington, D.C. He is extremely proficient in technical writing, and he has been involved with CFX's Phase-1, Phase-2, and Phase-3 WWD studies.

Md Imrul Kayes, Ph.D. student, is a graduate research assistant at the University of Central Florida under the supervision of Professor Al-Deek. He obtained his B.Sc. in Civil Engineering in July 2014 from Bangladesh University of Engineering and Technology (BUET), the top university in Bangladesh, and was admitted to the Civil Engineering Ph.D. program at UCF in Fall 2015. Imrul Kayes has been involved in CFX WWD Phase-3 study.

Omar Al-Sahili, MS student, is a graduate research assistant under the supervision of Professor Al-Deek. He obtained his B.S. in Civil Engineering in December 2014 from An-Najah University (NNU) overseas. He worked in a transportation engineering professional consultancy firm for one year before being admitted to UCF in Spring 2016. He is also the current treasurer of the UCF student chapter of the Institute of Transportation Engineers (UCF-ITE). Omar Al-Sahili has been involved in CFX WWD Phase-3 study.

Md Omar Faruk, MS student, is a graduate research assistant at the University of Central Florida under the supervision of Professor Al-Deek. He obtained his B.Sc. in Civil Engineering, in September 2015 from Bangladesh University of Engineering and Technology (BUET), the top university in Bangladesh, and he worked in a consultancy service with this same university before being admitted to the Masters of Science in Transportation Engineering Systems (MSTS) program at UCF in Fall 2016. Omar Faruk has been involved in CFX WWD Phase-3 study.

Sara Wertanen, Undergraduate student researcher, is working on her Bachelor of Science Degree in Environmental Engineering with electives in transportation. She is a research assistant working under the supervision of Professor Al-Deek and is the UCF-ITE student chapter vice president. She is set to obtain her B.S. in Environmental Engineering in December 2017 and plans on starting in the UCF transportation engineering graduate program in spring 2018. Sara has been involved in CFX WWD Phase-3 study.

Antony Shamma, Undergraduate student researcher, is working on his Bachelor of Science Degree in Civil Engineering at UCF with a focus in Transportation. He is a research assistant working under the supervision of Professor Al-Deek and is the current president of the UCF student chapter of the Institute of Transportation Engineers (UCF-ITE). Antony has been involved in CFX WWD Phase-3 study

Corin Staves, Undergraduate student researcher, is working on his Bachelor of Science degree in Civil Engineering at UCF with a focus in Transportation. He is concurrently working on a Bachelor of Science degree in mathematics and a Bachelor of Music degree. He is a research assistant working under the supervision of Professor Al-Deek and a member of UCF-ITE. He plans to graduate in December 2017 and continue studying transportation engineering at the graduate level, through either an M.S. or direct to Ph.D. track.

Abigail VanLuven, Undergraduate student researcher, is working on her Bachelor of Science degree in Civil Engineering at UCF with a focus in Transportation and Structures. She is a

research assistant working under the supervision of Professor Al-Deek and plans to graduate in December 2018.

Grady Carrick, Ph.D., is a thirty year plus veteran of the Florida Highway Patrol, who retired at the rank of Chief in 2012. Dr. Carrick has spent his career building bridges between the law enforcement and transportation professions. He has a national reputation as an advocate for traffic safety and traffic incident management. His leadership in the Florida Strategic Highway Safety Plan, the Florida Bicycle and Pedestrian Advisory Board, and numerous Community Traffic Safety Teams are a few accomplishments. Carrick has participated in several traffic safety initiatives as a member of The International Association of Chiefs of Police (IACP). In his current position as principal for the firm Enforcement Engineering Inc., he seeks to improve transportation safety through the integration of transportation engineering, research and enforcement operations. He has extensive experience in traffic safety analysis and the development of law enforcement countermeasures. In addition to his professional accomplishments, Dr. Carrick holds a Ph.D. in Transportation Engineering from the University of Florida. He has published and presented at numerous state, national, and international conferences on traffic safety and operations.

Roles and Responsibilities of Project Team

The roles and responsibilities of the project team are listed below. Additional information on the team can be found in the qualifications of the UCF research team section in this proposal.

Professor Haitham Al-Deek, Ph.D., P.E., *UCF Principal Investigator*. He will be responsible for the entire project management and coordination with CFX, budget control, submitting the

final report, conducting progress and final presentations to CFX, and attending project meetings with CFX.

Adrian Sandt, *Graduate Research Assistant and UCF Ph.D. Student.* He will be responsible for editing of reports, presentations, as well as other products submitted to CFX during the course of this study. He will also help with methodology development and data analysis, including development of the optimization model, as well as work on the literature reviews, final report, final presentation, and progress presentations and will attend the project meetings with CFX.

Md. Imrul Kayes, *Graduate Research Assistant and UCF Ph.D. Student.* He will be responsible for collecting and analyzing WWD events, including all WWD acts and false activations/false alerts generated by the RRFB devices. He will also help with the literature reviews, FHWA progress reports, monthly detection and false alerts reports, final report, final presentation, and progress presentations and will attend the project meetings with CFX.

Omar Al-Sahili, *Graduate Research Assistant and UCF MS Student.* He will be responsible for analyzing WWD median crossover citations and determining the appropriate countermeasures to use at medians. He will also help with the editing of progress presentations and attend project meetings with CFX.

Md. Omar Faruk, *Graduate Research Assistant and UCF MS Student.* He will help with the analysis of the WWD median crossover citations, as well as the investigation of using automated

and connected vehicle technologies for WWD prevention. He will also attend project meetings with CFX.

Sara Wertanen, *UCF Undergraduate Student Researcher*. She will help with the examination of WWD countermeasures and notification methods, including design and analysis of the customer survey results. She will also edit progress reports, presentations, literature reviews, final report, and final presentation, and will attend project meetings with CFX. She will attend field trips and technology testing.

Antony Shamma, *UCF Undergraduate Student Researcher*. He will help identify potential WWD countermeasures and notification methods, including automated and connected vehicle technologies. He will attend field trips and technology testing. He will also work on literature reviews and progress presentations and attend project meetings with CFX.

Corin Staves, *UCF Undergraduate Student Researcher*. He will help analyze and monitor WWD events, as well as identify potential WWD countermeasures and notification methods. He will also work on progress reports and presentations and attend project meetings with CFX.

Abigail VanLuven, *UCF Undergraduate Student Researcher*. She will help analyze and monitor WWD events, as well as examine potential WWD countermeasures and notification methods. She will also work on progress presentations and reports and attend project meetings with CFX.

Grady Carrick, Ph.D., *Enforcement Engineering Inc.* He will provide the research team with vital WWD CAD/911 call and citation data in a timely fashion to evaluate the implemented WWD countermeasures (RRFBs and median treatments) and meet the project deadlines on time. He will also provide the perspective of law enforcement and input on the median treatments and the feasibility of innovative technologies to stop intentional wrong-way drivers. (Formal commitment will be provided by the consultant when funding is established).

8. PROJECT EXTENSION DELIVERABLES

a. **Progress Presentations.** A progress presentation will be made to CFX approximately **once every four months** during the extension period of the project. These progress presentations are deliverables by themselves.

b. **Final Report.** A final report will be submitted to CFX in MS Word or PDF format. The final report will be provided in electronic format only. As agreed with CFX, only one final report will be delivered for the entire project (including the original contract and this extension of the original contract).

c. **Project Final Presentation to CFX.** The UCF research team will make a final presentation at CFX's Headquarters (HQ) with conclusions and recommendations. The final presentation represents the last progress presentation in this project. As agreed with CFX, only one final presentation will be delivered for the entire project (including the original contract and its current proposed extension). The original contract final presentation will be substituted by a regular progress presentation due on the last day of the current contract ending date (August 12, 2017).

9. TRAVEL

Travel during the extension period includes **6 meetings (3 per year) including the final presentation** with CFX, the project sponsor, in their Orlando HQ office. This also includes a potential of 4 field (and/or CFX HQ) visits. Estimate of local travel cost is based on travel history to CFX HQ (and previous field trips/field visits) and is included in the budget where only mileage and tolls will be charged.

10. PROJECT SCHEDULE

Central Florida Expressway Authority
CFX
PROJECT SCHEDULE

Project Title	EXTENSION TO "WRONG-WAY DRIVING PHASE-3 STUDY: ALLOCATING COUNTERMEASURES ON CFX ROADWAY NETWORK"
Start - Finish	August 13, 2017 to August 12, 2019
Research Agency	University of Central Florida
Principal Investigator	Professor Haitham Al-Deek, Ph.D., P.E., University of Central Florida

RESEARCH TASK	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1. Phase-3 kick-off meeting																								
2. Methodology development and extension (expansion to 34 sites + additional sites)													■	■	■	■	■							
3. Collection and analysis of WWD data + Extension to Task#3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
4. Literature review on median WWD countermeasures																								
4. Extension to Task #4. Investigation of new WWD countermeasures	■	■	■	■	■	■	■	■	■	■	■	■												
5. Examination of right-way driver notification systems																								
5.1 Literature review on WWD notifications																								
5.2 Customer survey on WWD notifications																								
5.3 Determination of notification methods													■	■	■	■	■	■	■	■	■			
5. Extension to Task #5. Research on V2V and V2I WWD notification	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
6. Literature review of technologies to stop intentional WW drivers																								
6. Extension to Task #6. Investigation of automated and connected vehicle WWD prevention	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
7. Determination of appropriate median crossover countermeasures																								
8. Progress reports for FHWA RTE (Extension to Task#8)						■						■						■						■
9. New Extension Task: WWD countermeasure optimization model for CFX network	■	■	■	■	■	■	■	■	■	■	■	■												
10. New Extension Task: Evaluation of current RRFB deployment sites										■	■	■	■	■	■	■	■	■	■	■	■			
11. New Extension Task: Analysis of CFX network for mainline WWD detection deployment	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
12. Recommendations for CFX							■	■	■													■	■	■
12. Extension to Task #12. Recommendations on application of connected vehicles							■	■	■													■	■	■
13. Final report and presentation of results to CFX																								■
14. Progress Presentations				■				■				■				■				■				

11. BUDGET SHEET

EXTENSION TO PROJECT TITLED "WRONG-WAY DRIVING PHASE-3: ALLOCATING COUNTERMEASURES ON CFX ROADWAY NETWORK"
PROJECT PERIOD (AUGUST 13, 2017- AUGUST 12, 2019)

	PROJECT DURATION IS 24 MONTHS			TOTAL
PERSONNEL	Hours	Rate	Subtotal	
P.I. (Professor Al-Deek, Ph.D., P.E.)	509.60	$104.314	$53,158	$53,158
Graduate Research Assistant (1 student)	2080	$21.32	$44,335	$44,335
OPS	2080	$21.32	$44,335	$44,335
Undergraduate students	2000	$10.15	$20,300	$20,300
PERSONNEL BENEFITS				
P.I. (Professor Al-Deek, Ph.D., P.E.)		28.95%	$15,389	$15,389
Students		0.65%	$420	$420
OPS		2.25%	$998	$998
EXPENSES				
Local travel for CFX project meetings +	Trips	Each Trip		
field visits	10	$60.0	$600	$600
Enforcement Engineering, Inc., Consultant			$5,000	$5,000
	Months	Cost/Month		
Supplies	24	$38.08	$914	$914
Student tuition (1 student)			$19,096	$19,096
DIRECT COST PER TIME PERIOD			$204,545	$204,545
INDIRECT COST (10%)				$20,455
TOTAL COST				$225,000

*Hours and hourly rates are included in this budget for estimating purposes only. Faculty and Administrative and Professional personnel of the University of Central Florida are salaried employees that do not complete time cards. Invoicing for services rendered will be based on percentage of total professional effort, in amounts not to exceed the total budgeted salary.

**PI rate incluldes anticipated incease in connection with internal awards. This increase has been included in the above proposed budget.

INTERLOCAL AGREEMENT BETWEEN
CENTRAL FLORIDA EXPRESSWAY AUTHORITY
AND
UNIVERSITY OF CENTRAL FLORIDA

THIS AGREEMENT is made and entered into as of the 13th day of August, 2015 ("Effective Date"), by and between the CENTRAL FLORIDA EXPRESSWAY AUTHORITY, a body and corporate politic and agency of the State of Florida, hereinafter referred to as "AUTHORITY" and the UNIVERSITY OF CENTRAL FLORIDA BOARD OF TRUSTEES, a public body corporate of the State of Florida, hereinafter referred to as "UNIVERSITY."

WHEREAS, the UNIVERSITY is authorized by Section 1004.22, Florida Statutes, to enter into interlocal agreements providing for the performance by one governmental unit on behalf of another of any function which either agency is authorized to perform; and

WHEREAS, the AUTHORITY was created and established to acquire, hold, construct, improve, maintain and operate the Central Florida Expressway Authority System, pursuant to Part III, Chapter 348, Florida Statutes; and

WHEREAS, pursuant to Section 348.754, Florida Statutes, the AUTHORITY has been granted the power to make and enter into contracts or other transactions and to do all acts and things necessary or convenient for the conduct of its business and for carrying out the purposes of the AUTHORITY; and

WHEREAS, the AUTHORITY desires that the UNIVERSITY perform a study entitled "Wrong-Way Driving Study Phase III: Allocating and Evaluating Countermeasures on CFX Roadway Network".

NOW, THEREFORE, in consideration of the promises herein made and the benefits to accrue to the parties, and for good and valuable consideration, the parties agree as follows:

1. Term. Services to be provided by the UNIVERSITY shall begin upon the Effective Date and shall be completed no later than two (2) years from the Effective Date, unless extended by written modification and signed by the parties.

2. Services. The UNIVERSITY shall provide the services outlined in the attached **Exhibit A**. Any changes must be approved in writing by the authorized representatives of the parties.

3. Anything contained herein to the contrary notwithstanding, the AUTHORITY shall have final approval of the study product as it relates to its implementation on the AUTHORITY system.

4. Payment. The AUTHORITY shall pay the UNIVERSITY for services rendered as outlined in the budget included in **Exhibit A,** which states that payment will be billed in eight (8) equal invoices of $25,000 each every three months. All deliverables/invoices submitted by the UNIVERSITY must be approved in writing by Authority prior to payment by the AUTHORITY to the UNIVERSITY. The payment for all work shall not exceed $200,000.00. Invoices shall be submitted in a format acceptable to the AUTHORITY with detail sufficient for a proper pre-audit and post-audit thereof. Invoices submitted for pre-authorized travel expenses shall be paid in accordance with the rates specified in Section 112.061, Florida Statutes. Payment will be remitted to:

University of Central Florida
Contracts & Grants
PO Box 160118
Orlando, FL 32816

5. Administrative Personnel. The UNIVERSITY shall perform the activities described in **Exhibit A** and will comply with all statutory requirements and applicable regulations in the conduct of the project. The UNIVERSITY agrees that such activities will be directed by:

AUTHORITY:

Technical and Contractual:
Corey Quinn, P.E.
Central Florida Expressway Authority
4974 ORL Tower Road
Orlando, FL 32807
Phone: (407) 690-5000
Fax: (407) 690-5011
E-mail: Corey.Quinn@CFXway.com

UNIVERSITY:

Project Director/Technical:
Dr. Haitham Al-Deek, Ph.D., P.E.
University of Central Florida/CECE
4000 Central Florida Boulevard
Orlando, FL 32816-2450
Phone: (407) 823-2988
Fax: (407) 823-3315
e-mail: Haitham.Al-Deek@ucf.edu

Contractual:
Jessica Maass

University of Central Florida
Office of Research and Commercialization
12201Research Parkway, Suite 501
Orlando, FL 32826-3252
Phone: (407) 882-1187
Fax: (407) 823-1379
e-mail: Jessica.Maass@ucf.edu

6. Records and Audit. The UNIVERSITY agrees to keep and maintain accounts for a period of at least three (3) years from the end of the contract, or longer if required by the State of Florida's retention schedules, in order to record complete and correct entries as to all costs and expenditures. No funds provided by the AUTHORITY shall be expended for expenses other than for the study. Such books and records shall be available at all reasonable times during normal business hours for examination and audit by the AUTHORITY. Incomplete or incorrect entries in such books and records will be grounds for disallowance by the AUTHORITY of any fees, expenses or costs based upon such entries.

7. Public Records Act. Both parties and any subconsultants to this Agreement shall comply with the provisions of Chapter 119, Florida Statutes, and shall permit public access to all documents, papers, letters or other material subject to the provisions of Chapter 119, Florida Statutes, and made or received in conjunction with this Agreement.

8. Extensions. The AUTHORITY and the UNIVERSITY agree that at future dates this Agreement may be extended or supplemented for future services, as mutually agreed to and signed by the authorized representatives of the parties.

9. Assumption of Risk. Each party assumes any and all risks of personal injury and property damage attributable to the negligent acts or omissions of that party and its officers, agents or employees while acting within the scope of their employment. Neither party, nor any of its agents or employees will be liable under this section for damages arising out of injury or damage to persons or property directly caused or resulting from the negligence of the other party or any of its officers, agents or employees. In no event will either party be responsible for any incidental damages, consequential damages, exemplary damages of any kind, lost goodwill, lost profits, lost business and/or any indirect economic damages whatsoever regardless of whether such damages arise from claims based upon contract, negligence, tort (including strict liability or other legal theory), a breach of any warranty or term of this agreement, and regardless of whether it was advised or had reason to know of the possibility of incurring such damages in advance.

10. No Contingency Fee. The UNIVERSITY represents that it has not employed or obtained any company or person, other than bona fide employees or consultants of the UNIVERSITY to solicit or to secure this Agreement, and it has not paid or agreed to pay any company, corporation, individual or firm, other than

bona fide employees employed by the UNIVERSITY. For the breach or violation of this provision, the AUTHORITY shall have the right to terminate the Agreement at its discretion.

11. No Assignments without Written Consent. This Agreement or any interest herein shall not be assigned, transferred or otherwise encumbered under any circumstances by either party without the prior written consent of the other party. However, the Agreement shall run to the AUTHORITY and its successors.

12. Termination. This Agreement may be terminated by either party upon 30 days written notice to the other with or without cause. In the event of termination by the parties the AUTHORITY will pay the UNIVERSITY for all costs incurred and any non-cancellable obligations properly incurred through the date of termination. In the event that UNIVERSITY'S project director becomes unable or unwilling to continue the project activities hereunder, and a mutually acceptable substitute is not available, the AUTHORITY shall have the option to cancel this Agreement.

13. Publication. The parties agree that UNIVERSITY may publish the results of the work in its own form. AUTHORITY shall be furnished with copies of any proposed publication, to review for confidential information only, thirty (30) days in advance of the intended publication date. AUTHORITY will complete its review and provide UNIVERSITY with any objections within thirty (30) days of receipt. In the absence of timely objection, UNIVERSITY shall be free to proceed without restriction, subject to compliance with the exemptions and provisions set forth in the Florida Statutes and law. In the event of an objection, the parties will negotiate in good faith the removal of the confidential material.

14. Ownership. Except for ownership of Intellectual Property pursuant to Section 15, and publications pursuant to Section 13, AUTHORITY is and shall be and remain the sole owner of all deliverable documents, software, data and items developed with respect to and in connection with the performance of this Agreement. Subject to UNIVERSITY's right to publish in Section 13 above, UNIVERSITY may not use such materials in any way, other than in performance of its services under the terms of this Agreement, without the prior written consent of AUTHORITY, which may be granted or denied in the AUTHORITY's sole discretion. Deliverable information and work product generated in connection with this Agreement shall be the property of AUTHORITY. Subject to UNIVERSITY's right to publish in Section 13 above, UNIVERSITY shall not transfer, disclose or otherwise use such information or work product for any purpose other than in performance of its duties hereunder, without AUTHORITY's prior written consent, which may be withheld or granted in the sole discretion of AUTHORITY. Information and materials with respect to the AUTHORITY and this Agreement obtained by UNIVERSITY from AUTHORITY during the Term of this Agreement shall remain confidential for a period of three (3) years from the Effective Date. Notwithstanding the foregoing, both parties will be subject to the requirements of the Florida Public Records law and other law, including requirements pertaining to confidential information, and any valid court order.

15. Intellectual Property. The term "Intellectual Property" means individually and collectively all inventions, improvements and/or discoveries, patentable or unpatentable, copyrightable or uncopyrightable, including but not limited to mask works, computer software, both object and source code, data bases and works of authorship.

Intellectual Property developed solely by UNIVERSITY shall be solely and exclusively owned by UNIVERSITY. Intellectual Property developed solely by AUTHORITY shall be solely and exclusively owned by AUTHORITY. "Joint Intellectual Property" means any Intellectual Property developed jointly by the AUTHORITY and UNIVERSITY under this Agreement. Joint Intellectual Property will be owned jointly by AUTHORITY and UNIVERSITY, who agree to jointly determine proper inventorship, authorship, and ownership subject to Title 35 of the United States Code for inventions and Title 17 of the United States Code for works of authorship, and to jointly determine filing and licensing.

"Background Intellectual Property" means Intellectual Property which was in existence, prior to the Effective Date of this Agreement, or which is subsequently created or developed by a party so long as such creation or development was not in the course of this project. The parties agree that Background Intellectual Property of AUTHORITY and UNIVERSITY is their separate property, respectively, and are not affected by this Agreement. Neither party shall acquire any claims to or rights in the Background Intellectual Property of the other party.

Nothing in the Agreement shall circumvent or restrict either party's pre-existing obligations with the U.S. government pertaining to any kind of intellectual property or any copyrightable material or other Intellectual Property, including but not limited to such pre-existing obligations contained in grants, contracts and other types of agreements or arrangements between either parties, and the U.S. government. These obligations may include granting licenses to the U.S. government for certain Intellectual Property or any copyrightable material or other intellectual property which is being developed.

Notwithstanding any provision to the contrary in the Agreement, UNIVERSITY shall retain the right to practice any invention, discovery and copyright developed hereunder for its own academic, non-commercial research and teaching purposes.

16. Dispute Resolution. The parties will attempt in good faith to resolve any controversy or claim arising out of or relating to this Agreement promptly by negotiations between a senior executive of the UNIVERSITY who has the authority to settle the controversy and a designated representative from the AUTHORITY who has the authority to recommend a settlement to the Board.

The disputing party shall give the other party written notice of the dispute. Within twenty days after receipt of said notice or longer with the prior written approval from the disputing party, the receiving party shall submit to the other a written response. The

notice and response shall include (a) a statement of each party's position and a summary of the evidence and arguments supporting its position, and (b) the name and title of the executive who will represent that party. The executives shall meet at a mutually acceptable time and place within thirty days of the date of the disputing party's notice and thereafter as often as they reasonably deem necessary to exchange relevant information and to attempt to resolve the dispute.

In the event a dispute arising out of or related to this Agreement (on the Services performed thereunder) has not been resolved pursuant to the aforesaid mediation procedure within sixty days of the initiation of such procedures, the parties shall be free to pursue any available legal remedies.

17. Governing Law; Venue. This Agreement and the rights of the parties will be governed and construed in accordance with the laws of the State of Florida and the United States, without regard to its choice of law principles. The parties agree that jurisdiction and venue for any action arising under this Agreement shall lie exclusively within either the state courts of Florida located in Orange County, Florida or the United States District Court for the Middle District of Florida, Orlando Division. The parties specifically waive the right to any other jurisdiction and venue, and the defense based on inconvenient forum.

18. Time is of the Essence. The AUTHORITY and the UNIVERSITY recognize that time is of the essence with respect to the Agreement and UNIVERSITY shall meet the date specified in Exhibit A attached hereto.

19. Waiver. No failure or delay by a party hereto to insist on the strict performance of any term of this Agreement, or to exercise any right or remedy consequent to a breach thereof, shall constitute a waiver of any breach or any subsequent breach of such term. No waiver of any breach hereunder shall affect or alter the remaining terms of this Agreement, but each and every term of this Agreement shall continue in full force and effect with respect to any other then existing or subsequent breach thereof.

20. Force Majeure. Neither party shall be liable in damages or have the right to terminate this Agreement for the delay or default in performing hereunder if such delay or default is caused by conditions beyond its control including, but not limited to, Acts of God, government restrictions, wars, insurrections and/or any other cause beyond the reasonable control of the party whose performance is affected.

21. Export Control. Both parties are subject to United States laws and regulations controlling the export of technical data, computer software, laboratory prototypes and other commodities, and that its obligations hereunder are contingent on compliance with applicable U.S. export laws and regulations (including the Arms Export Control Act, as amended, and the Export Administration Act of 1979). The transfer of certain technical data and commodities may require a license from the cognizant agency of the United States Government and/or written assurances by the parties that they will

not re-export data or commodities to certain foreign countries without prior approval of the cognizant government agency. While UNIVERSITY agrees to cooperate in securing any license which the cognizant agency deems necessary in connection with this Agreement, UNIVERSITY cannot and does not guarantee that such licenses will be granted.

22. No Warranties. UNIVERSITY is a NON-PROFIT EDUCATIONAL INSTITUTION. UNIVERSITY MAKES NO REPRESENTATIONS AND EXTENDS NO WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED WITH REGARD TO THE RESEARCH AND WORK PERFORMED UNDER THIS AGREEMENT. THERE ARE NO EXPRESS OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR THAT ANY RESEARCH DELIVERABLES OR INTELLECTUAL PROPERTY DEVELOPED BY UNIVERSITY UNDER THIS AGREEMENT WILL NOT INFRINGE ANY THIRD PARTY PATENT, COPYRIGHT, TRADEMARK, OR OTHER THIRD PARTY RIGHTS. UNIVERSITY MAKES NO REPRESENTATION AS TO THE USEFULNESS OF RESEARCH DELIVERABLES OR INTELLECTUAL PROPERTY. IF THE AUTHORITY CHOOSES TO EXPLOIT RESEARCH DELIVERABLES OR INTELLECTUAL PROPERTY IN ANY MANNER WHATSOEVER, IT DOES SO AT ITS OWN RISK.

23. Non-Use of Name. UNIVERSITY and the AUTHORITY may not use each other's name or trademarks in any promotion, statement, advertisement, press release or communications to the general public or any third party without each other's express written consent. Any proposed public statement, advertisement, press release or communications by either party shall be submitted to the other party for its review and written approval at least thirty (30) days prior to the planned dissemination or publication. However, neither party shall be prohibited from complying with Section 1004.22(2) regarding sponsored research activities.

24. Independent Contractor. UNIVERSITY shall provide services under this Agreement as an independent contractor and as such shall maintain complete control over and be responsible for all of its operations and personnel. This Agreement shall not be deemed to create any other form of employment relationship or business organization between the parties.

25. Severability. If any one or more of the provisions of this Agreement shall be held to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions of this Agreement shall not be in any way affected or impaired thereby and shall remain in full force and effect.

26. Counterparts. This Agreement may be executed in counterparts, each of which shall be considered an original, but which together shall constitute but one and the same Agreement.

27. Entire Agreement. This Agreement and its Exhibit(s) constitute the entire

agreement of the parties and supersedes all prior communications, understandings and agreements relating to the subject matter hereof, whether oral or written.

28. No Third Party Beneficiaries. This Agreement shall not be construed to inure to the benefit of or to invest rights in any third parties and shall inure only to the benefit of the parties hereto.

29. Unauthorized Aliens. The AUTHORITY shall consider the employment by the UNIVERSITY of unauthorized aliens a violation of Section 274A(e) of the Immigration and Nationality Act. If the UNIVERSITY knowingly employs unauthorized aliens, such violation shall be cause for unilateral cancellation of the contract.

IN WITNESS WHEREOF, the parties hereto set their hands and seals the day and year set forth below. This Agreement was approved by the AUTHORITY'S Board of Directors at its meeting on August 13, 2015.

UNIVERSITY OF CENTRAL FLORIDA BOARD OF TRUSTEES

BY: _____
Authorized Signature

Courtney Bensen
Print Name

Title: Contract Manager

Date: 7/30/2015

CENTRAL FLORIDA EXPRESSWAY AUTHORITY

BY: _____
Director of Procurement

Date: 8/19/15

4 AUG '15 AM 8:43

Legal Content Approved for the University:

_____
Name:

Date: 7-30-15

Approved as to form and execution, only.

Linda S. B. Lanosa
General Counsel, Deputy