Exhibit A
Scope of Services

Near-Miss Traffic Incident Identification System at Signalized Intersections for Proactive Roadway Safety Analytics and Mobility Enhancement – A Pilot Study

University of Florida (hereafter, the University) and County agree that the University shall provide the following Services:

1. Services Summary

The project is to obtain and analyze data regarding traffic movement at intersections in Broward County with machine learning. The information will assist the County in planning improvements to the County's roadways and intersections to provide for greater safety and enhanced mobility. Through this pilot, Broward County will be able to assess the applicability and effectiveness in the County's unique conditions such as larger intersection geometry (i.e., larger number of lanes) and different mix of heterogeneous vehicles in traffic flow.

2. Services Description

This project will utilize the video image data captured by fisheye cameras installed at roadway intersections within Broward County to refine and enhance the existing algorithms and processes to identify near misses/crashes at a real-time manner without recording any image. A fisheye camera can capture large portions of an intersection. These camera(s) transmit video streams to a GPU (Graphics processing unit) processor at regular intervals (every few minutes) where image processing techniques convert the video to time-stamped 2D location coordinates of objects (e.g., vehicles, pedestrians, bicyclists). Currently, a total of eleven fisheye cameras have been installed by Florida Department of Transportation (FDOT) and maintained by Broward County's Traffic Engineering Division at six intersections on Stirling Road (SR 848) in Broward County. The University will work collaboratively with the Traffic Engineering Division, Senior Engineer in surtax-funded Mobility Planning Team, and any other County or Florida Department of Transportation (FDOT), District 4 representatives identified, in defining use cases that will provide useful data and benefits for broader deployment.

This project is staged into two phases. Phase 1 will consist of tasks that are needed to demonstrate accuracy of object detection using videos from multiple intersections. The processing of the video will be done on the University servers. Phase 2 will consist of tasks to demonstrate computational performance and latency testing towards developing a scalable system for video processing on the edge. In other words, Phase 2 will be built upon the software and hardware infrastructure developed in Phase 1 by adding additional features to evaluate the performance of the system created in Phase 1 as well as assessing its scalability. In addition, the University will perform a before-and-after analysis to compare pre-deployment and post-deployment near-miss conditions on improvement designs and strategies.

3. Technical Approach

A. **Phases**. The Services will be provided in the following Phases:

Phase 1: Develop a system compatible and capable of processing video captured from intersections on Stirling Road installed with fisheye cameras in streamed mode

In Phase 1, the University will develop a system for processing video from fisheye cameras at up to six intersections in a historical mode. A GPU based server will be used at the University to process recorded video provided by Broward County and send trajectories to a central server (or a cloud). Phase 1 consists of the tasks identified in the following sections.

Task 1: Historical Data Collection and Pre-processing for All Existing Transportation Modes

The University will engage and collaborate with the FDOT District 4, Traffic Operations Office, and other regional partner agencies throughout the project. If available, the University will collect detector data at the selected intersections, including:

- Geometry for the intersections of interest
- Detector Phase/Channel Mapping
- Demand profiles (volumes, turning movements, etc.) and signal timing parameters (phasing green times) for different "base conditions" (time of day periods, days of the week, and seasons/special events)
- Timing sheets
- ATSPM data, if available, for signal changes and detector activations. The signal changes are used for doing a phase-based analysis. Traffic signals divide a cycle into multiple phases (e.g. (2.6), (4,8), (3,7)). Traffic flow and interactions between objects, in general depend on these phases The detector activation in ATSPM logs (at a decisecond (ds) level granularity), allows for vehicle arrival information and is only useful as a secondary measure to derive vehicle counts, as part of the project delivery.

Along with data collection, the University will perform data normalization, outlier detection and cleaning, and other data pre-processing steps aimed at simplifying subsequent data analyses and machine learning solutions.

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum summarizing the data collected and preprocessing conducted. All material developed through this effort, including computer source codes, will be provided to Broward County.

Task 2: Enhance and train the existing near-miss algorithms

Task 2 consists of the following subtasks:

- Offline Video Analysis: Coordinate with the County's Traffic Engineering Division to stream video images from six intersections on Stirling Road (SR 848) in Broward County for several hours (up to eight) and then perform offline video processing for each intersection. The video will be processed by the University servers in conjunction with Broward County based on Broward County System and security requirements for a combined total of 40 hours across all intersection. Video data are used for training and fine-tuning object detection, classification and tracking at an intersection. The video collected for training is also used for validating the accuracy of trajectories generated for that intersection. After the training period, the learnt models will be used to convert the video into trajectories and derive relevant statistics such as near misses and turn movement counts. Once, the video frames are converted into trajectories the historical video data are removed from the system.
- Apply a deep learning system based on YOLO[1] ("You Only Look Once") object detection and tracking module to detect, track, and convert vehicles, and pedestrians into trajectories for each object. The trajectories will be used to compute and report various performance measures such as:

  - Time to collision (TTC): the time remaining to avoid a collision, from the time the road user takes an action to the point where the collision can occur. When the time is less than a certain threshold such as 2.0 seconds, the record is flagged as a severe event.
  - Post Encroachment Time (PET): the time difference between the time at which the first road user leaves one point and the time at which the second road user arrives at that same point. When the time is less than a certain threshold such as 3.0 seconds, the record is flagged as a severe event.
  - CPI Crash Potential Index: the number of seconds a following object would be unable to stop in time to avoid collision with the leading object divided by total number of seconds of following.
  - Deceleration: the rate of change of speed when a vehicle is slowing down. When the deceleration is above a given threshold, a warning will be prompted.
  - Vehicle Speed Distribution: Feature computed and used for computing TTC.
  - Severe Event: a new surrogate safety measure, defined by the University, that includes all near-miss events as well as unsafe behavior exhibited by road users and uses a combination of phase information, TTC, PET, CPI and Deceleration.

[1] YOLO is an object detector that uses features learned by a deep convolutional neural network to detect an object.

- In coordination with the cross-functional team consisting of staff members from Broward County, FDOT, and other regional partner agencies as applicable, the University will derive turning movement counts, which represent the various approach movements (left, thru, right) that pass through an intersection over a given period, for all modes, in 15-minute intervals. Turning movement counts will be verified with visual counts or any available data.

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum describing the methods and summarizing the findings as stated above. All material developed through this effort, including computer source codes, will be provided to Broward County.

Task 3: Stream video images from multiple intersections and demonstrate the use of video processing for multimodal safety

The University will stream video images from the chosen fisheye cameras in Broward County and implement the video processing system developed in this study to convert the video into trajectory representations that remove vehicle identification information. The video stream in this Task 3 will only be buffered in memory and will not be stored on disk or any other storage media. In addition, due to bandwidth and resource constraints, the system established in Phase 1 will be limited to support streamed on only one intersection at a time (and not concurrently). It will be possible to manually switch processing from one intersection to the next. The following tasks will be performed:

- Stream video images from fisheye cameras at intersections identified in Task 1 and run video processing.
- Assess latency of the streamed data, including time for data transmission from Broward County to the University servers, buffering of the data over multiple frames that is required for video processing (for object tracking and improving accuracy) and fusing the signal timing data with the video data.
- Provide a visualization system to Broward County for data and traffic statistics at the central server.

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum summarizing the findings as described above. In addition, the University will deliver an in-person presentation to the Transportation Surtax Oversight Board summarizing Year 1 activities, including relevant performance information, findings, and recommendations, as well as the introduction of the related products and findings in Phase 2. All material developed through this effort, including computer source codes, will be provided to Broward County.

Phase 2: Enhance and advance the process established in Phase 1. Estimate the required resources for countywide deployment of the enhanced near-miss detection technology. Conduct before and after assessment on approaches adopted to address near misses at intersections.

This phase will consist of the following parts:

- Enhance the process established in Phase 1 and assess the required resources for countywide deployment, including edge computing and other distributed computing technologies.
- Build a solution for processing data from multiple intersections on a corridor.
- Conduct before-and-after-analysis to compare pre-deployment and post-deployment crash conditions on improvement designs and strategies adopted to address near misses identified at intersection in Phase 1.

At the beginning of Task 2 in this phase, the Broward County Traffic Engineering Division will stream live videos to the University for process enhancements, effective testing, and latency measurements. The tasks included in Phase 2 of this study are described in the following sections.

Task 1: Performance Testing for estimating equipment and installation costs

The University will conduct the subtasks described as follows:

- Conduct performance testing to determine the resolution and number of video frames that should be processed every minute on a typical GPU.
- Study the impact on this performance based on video resolution, framerate, and other variables. Measure the CPU, GPU and RAM, disk space and other requirements.
- Quantify one-time and recurring costs of hardware layout (video cameras, data, and power transmissions, etc.) and maintenance for the cameras and perform an equipment life-cycle cost analysis per intersection for the County to acquire and install the identified hardware. This process will be built and tested based on existing fisheye cameras installed along Stirling Rd.
- Estimate respective recurring costs of software maintenance needed in the event the County wants to purchase a scalable solution from another vendor.

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum summarizing the equipment and installation costs for the camera system. All material developed through this effort, including computer source codes, will be provided to Broward County.

Task 2: Build a solution for processing data from multiple intersections on a corridor

The University will conduct the subtasks described as follows:

- Run video analysis software to demonstrate the implementation on Broward County's (or at University of Florida's) computing infrastructure (consisting of a GPU) on one or two cameras for a single intersection; the purpose of which is to measure the latency in communication and processing of the video and signal timing data, and then send it to the cloud (or central server). Configure the system to provide vehicle trajectory information to the cloud (or a central server).
- Evaluate GPU based servers in terms of performance and cost and other hardware specifications. The multiple GPU server will be installed at Broward County (or University of Florida).

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum summarizing the work as described above.

Task 3: Conduct before and after analysis to compare pre-deployment and post-deployment near-miss conditions on improvement designs and strategies adopted to address near misses identified at intersection in Phase 1.

The University will conduct the subtasks described as follows:

- Analyze video stream data that is recorded from all six intersections (for at least two weeks) to determine areas and times of conflict, potential near misses, and other anomalous traffic behaviors (as done is phase 1 but with focus on new time periods).
- In conjunction with Traffic Engineering Division personnel at Broward County, derive mitigations that are feasible for deployment and evaluation within the project timeframe to address high areas, or time periods, of conflict. In general, this would depend on the type of controller and corresponding flexibility, but some examples of these include:

    - Advance Walk (Leading Pedestrian Interval (LPI)) - A Leading Pedestrian Interval (LPI) typically gives pedestrians a 3–7 second head start when entering an intersection with a corresponding green signal in the same direction of travel. LPIs enhance the visibility of pedestrians in the intersection and reinforce their right-of-way overturning vehicles, especially in locations with a history of conflict. Some controllers will also allow LPI by time of day -- thus, it can be programmed selectively based on data learned from fisheye and computer vision.
    - FYA (Flashing yellow arrow) -- FYA allows a driver to make a left turn if there is no oncoming traffic and there are no pedestrians crossing the street. At high pedestrian volume locations, FYA can be managed to enhance safety:

- In some modern controllers, if the programmed FYA is in service, the FYA will be terminated before the pedestrian phase (walk signal at crossing) can begin service, i.e., No FYA during "Walk" and "Flashing Don't Walk" (FDW) to the associated left turning movements.
- FYA pedestrian delay can also be offered (like an advance walk/LPI) prior to the onset of FYA in appropriate conditions.

- Analyze video data after the changes to determine changes in patterns, behavior, actual conflict, near misses for two weeks
- Provide a comparative before-and-after analysis report based on the above tasks.

Deliverable: Upon completion of this task, the University will submit a written Technical Memorandum summarizing the equipment and installation costs for the camera system. All material developed through this effort, including computer source codes, will be provided to Broward County. In addition, the University will deliver an in-person presentation to the Transportation Surtax Oversight Board (and County Commission, if requested) summarizing Year 2 activities, including relevant performance information, findings, and recommendations. The University will also provide a summary report consisting of all technical memorandums submitted during Years one and two to the County for final contract closeout. All materials developed through this effort, including computer source codes, will be provided to Broward County.

B. **Services Schedule.** The University shall comply with the following Services Schedule, unless otherwise approved in advance by Contract Administrator:

Deliverable # / Description as provided in the scope (included associated task #)	Anticipated Date of Deliverable Submittal (from NTP)
Kickoff Meeting	Upon execution of contract
Project Management Plan (Draft and Final)	1 month
Phase 1 Task 1 Technical Memorandum	4 months
Phase 1 Task 2 Technical Memorandum	7 months
Year 1 Summary Presentation to Oversight Board	12 months
Phase 1 Task 3 Technical Memorandum	13 months
Phase 2 Task 1 Technical Memorandum	15 months
Phase 2 Task 2 Technical Memorandum	18 months
Phase 2 Task 3 Technical Memorandum	21 months
Year 2 Summary Presentation to Oversight Board	24 months
Final Summary/Closeout Report	24 months

Notes: The table will be used by the Broward County to monitor principal investigator (PI) performance and activity on the project. The PI should consider the time needed to complete a task(s) and deliverable(s) against current workload. Failure to submit deliverables in a timely manner may result in delayed payment and possible cancelation of the project.

4. Managerial Approach

The University will ensure that the persons responsible for the University's performance of the Services and, to the extent applicable, identified below (collectively "Key Personnel") are appropriately trained and experienced and have adequate time and resources to perform in accordance with the terms of this Agreement. If the University seeks or is required to make any change to the composition of the Key Personnel, the University will provide County with thirty (30) days' advance written notice (or as much advance notice as is possible if thirty (30) days' notice is not possible) regarding such changes and the management plan associated with such changes. County shall not be responsible for any additional costs associated with a change in Key Personnel.

The Key Personnel shall be as follows:

Prof. SANJAY RANKA, PH.D.
Telephone: 352-514-4213
Fax: 352-392-1220
Email: ranka@cise.ufl.edu
Website(s): https://sanjayranka.com/
Office: E532 CSE

Mailing Address:
432 Newell Drive
PO Box 116120, CSE Building
Gainesville, FL 32611
United States

5. Communication & Reports

Hold bi-weekly meetings with County staff (Public Works Traffic Engineering Division representative(s) and Mobility Advancement Program Administration's (MAP Admin) Senior Engineer, at a minimum) to review project statuses and assess communications. Additional meetings may be arranged as needed upon concurrence by both parties.

6. Deliverable Products and Services

The University shall provide the deliverables defined above in Section 3 – Technical Approach, which shall be considered accepted by County only upon written notice by Contract Administrator that the Deliverable meets the applicable Acceptance Criteria.

Exhibit B
Payment Schedule

The rates specified below shall be in effect for the entire Term, unless otherwise expressly stated below. Any goods or services required under this Agreement for which no specific fee or cost is expressly stated in this Payment Schedule shall be deemed to be included, at no extra cost, within the costs and fees expressly provided for in this Exhibit B.

For the satisfactory performance of services details in Exhibit A, the University shall be paid a Maximum Amount of $204,491 for Year 1 and $210,509 for Year 2 of the contract. Deliverables shall only be invoiced upon satisfactory completion of the applicable Deliverable as evidenced by written approval by the Contract Administrator. The invoice amount shall be the Total Deliverable Amount minus the applicable Retainage. The University should submit back-up documents verifying the payroll/salary costs, payroll records, travel documentation/receipts, etc., accordingly. Lump sum payments shall be made to the University for the satisfactory completion of each task and approval by Broward County of each task deliverable. The Maximum Amount consists of the amounts listed in the following table:

Table A: Deliverables/Phases Payment

Description	Retainage	Total Deliverable Amount (including retainage)
Deliverable 1: Year 1, Task 1	__%	$40,733.22
Deliverable 2: Year 1, Task 2	__%	$85,539.76
Deliverable 3: Year 1, Task 3	__%	$78,218.02
Deliverable 4: Year 2, Task 1	__%	$62,905.30
Deliverable 5: Year 2, Task 2	__%	$77,582.77
Deliverable 6: Year 2, Task 3	__%	$70,020.93