SPONSORED RESEARCH AGREEMENT

This Sponsored Research Agreement ("Agreement") is between THE UNIVERSITY OF PITTSBURGH under the laws of the State of Pennsylvania, doing business on its Pittsburgh campus through the Office of Sponsored Programs, 123 University Place ("UNIVERSITY"), and The COUNTY OF LAKE, Illinois, an Illinois body politic and corporate, acting by and through its Chair and County Board, organized and existing under the laws of the State of Illinois with its principal offices at 18 North County Street, Waukegan, Illinois 60085 ("SPONSOR"). The parties may be referred to individually as "Party" and collectively as the "Parties".

The Parties contemplate that the research to be performed under this Agreement will be of mutual interest and benefit; and

UNIVERSITY has determined that the research will further the instructional, research, public service or economic development objectives of UNIVERSITY consistent with its status as a public institution of higher education.

NOW, THEREFORE, the Parties agree:

1.0. THE RESEARCH

1.1. STATEMENT OF WORK. UNIVERSITY will use reasonable efforts to perform the research project titled "Traffic Signal Optimization based on Fuel-consumption and Pollutant Emissions" and more fully described in the statement of work attached to this Agreement as Exhibit A ("Research").

1.2. REPORTS. UNIVERSITY will furnish to SPONSOR written progress reports of the Research in such detail that SPONSOR reasonably requests according to the following schedule: technical report for Task 2 by April 30, 2020, technical report for Task 3 by July 2020, a Vissim simulation model for Task 4 by October 30, 2020, interim technical report for Task 5 by January 29, 2021, a brief technical memo for Task 6 by March 31, 2021, and the final report by June 30, 2021.

1.3. PRINCIPAL INVESTIGATOR. The Principal Investigator who will direct the Research for UNIVERSITY is Professor Aleksandar Stevanovic. If the Principal Investigator becomes unable to perform this Agreement for any reason, UNIVERSITY may appoint a successor Principal Investigator with SPONSOR's written approval. Either Party may terminate this Agreement in accordance with Section 3.5 if the Parties cannot agree on an acceptable successor within a reasonable time.

1.4. PERFORMANCE PERIOD. UNIVERSITY will perform the Research during the period December 2, 2019 through July 30, 2021 ("Performance Period"). The Parties may extend the Performance Period by written amendment.

1.5. EQUIPMENT/SUPPLIES. Title to all equipment and property purchased by UNIVERSITY under this Agreement will be in and remain with UNIVERSITY even after completion or termination of the Agreement.

2.0. RESEARCH COSTS

2.1. BUDGET. SPONSOR will pay to UNIVERSITY the direct and the facilities and administration ("F&A") costs (collectively "Research Costs") described in Exhibit B ("Budget") that UNIVERSITY incurs in performing the Research. The F&A cost rate set forth in the Budget will remain in effect during the

Performance Period. SPONSOR is not liable for costs other than the Research Costs described in the Budget, and UNIVERSITY is obligated to perform only the Research funded by SPONSOR.

2.2. PAYMENT SCHEDULE. SPONSOR will pay to UNIVERSITY the Research Costs in U.S. dollars as follows:

☐ This is a cost-reimbursement agreement. No more frequently than monthly, UNIVERSITY will submit invoices to SPONSOR evidencing the actual Research Costs incurred by UNIVERSITY in performing the Research. SPONSOR will pay the full amount due within 30 days from its receipt of an invoice.

☒ This is a fixed-price agreement. SPONSOR will pay UNIVERSITY as follows: $20,000 less 10% retained upon completion of Task 2 (April 30, 2020), $30,000 less 10% retained upon completion of Task 3 (July 30, 2020), $30,000 less 10% retained upon completion of Task 4 (October 30, 2020),$30,000 less 10% retained upon completion of Task 5 (January 29, 2021), $10,000 less 10% retained upon completion of Task 6 (March 31, 2021), and $29,492 plus retained to date upon completion of Task 8 (July 30, 2021) for total compensation of $149,492.

2.3. REMITTANCE. SPONSOR will pay UNIVERSITY through one of the following two payment options:

(a) By check made payable to the "University of Pittsburgh" and mailed to:

University of Pittsburgh
Sponsored Projects Accounting
3100 Cathedral of Learning
Pittsburgh, PA 15260
U.S.A

(b) By Automated Clearinghouse ("ACH") sent to UNIVERSITY's bank account:

Financial Institution	BNY Mellon
Address	500 Ross Street Pittsburgh, PA 15219
Nine-Digit Routing Transit Number	043000261
Depositor Account Title	University of Pittsburgh General Fund
Depositor Account Number	001-5510
Type of Account	Checking

3.0. EFFECTIVE DATE AND TERMINATION

3.1. EFFECTIVE DATE. This Agreement is effective on the date signed by the last of the Parties to sign this Agreement unless otherwise provided in this section as follows: _____ ("Effective Date").

3.2. EXPIRATION. This Agreement will expire on the end date of the Performance Period, unless sooner terminated in accordance with this Section 3.

3.3. TERMINATION FOR CONVENIENCE. Either Party may terminate this Agreement for convenience by providing 60 days' advance written notice to the other Party.

3.4. TERMINATION FOR BREACH. Upon material breach, the aggrieved Party may terminate this Agreement provided that the breaching Party fails to cure the breach within 30 days after receipt of written notice. This remedy is in addition to any other remedies available at law.

3.5. IMMEDIATE TERMINATION. Either Party may terminate this Agreement effective immediately upon notice to the other if: (a) the Parties cannot agree on an acceptable successor Principal Investigator; (b) SPONSOR has been declared insolvent, ceases (or threatens to cease) to carry on its business; or an administrator or receiver has been appointed over all or part of its assets; (c) SPONSOR's failure to pay promptly; or (d) either Party is debarred or excluded from participating in any government program.

3.6. EFFECT OF TERMINATION. If SPONSOR terminates this Agreement or convenience, SPONSOR will pay for all Research Costs incurred through the date of termination, including all non-cancelable obligations, even though the obligations may extend beyond the termination date. For any other termination, SPONSOR will pay UNIVERSITY for all Research Costs incurred through the termination date. Termination will not affect the Parties' rights and obligations accrued prior to termination.

4.0. CONFIDENTIAL INFORMATION

4.1. CONFIDENTIALITY OBLIGATION. Each Party will advise its employees to use reasonable efforts to hold in confidence all proprietary information received from the other Party in connection with the Research ("Confidential Information"); provided, however, that each Party may share Confidential Information with third parties to the extent necessary to perform the Research under terms consistent with this Agreement. For written disclosures, the Party disclosing Confidential Information will mark the information "Confidential" at the time of disclosure. For oral or visual disclosures, the Party disclosing Confidential Information will designate the information "Confidential" at the time of disclosure and confirm such designation in writing to the other Party no later than 30 days after disclosure. Except as provided in Section 6.2, each Party's obligation of confidentiality shall extend for three years from disclosure and shall not apply to information that: (a) was in recipient's possession on a non-confidential basis prior to receipt from disclosing Party; (b) is in the public domain or is general or public knowledge prior to disclosure, or after disclosure, enters the public domain or becomes general or public knowledge through no fault of recipient; (c) is properly obtained by recipient from a third party not under a confidentiality obligation to disclosing Party; (d) is explicitly approved for release by written authorization of disclosing Party; (e) is or has been developed by recipient independent of recipient's access to disclosing Party's Confidential Information; or (f) is required by law or court order to be disclosed.

4.2. RESPONSE TO INFORMATION REQUESTS. If UNIVERSITY receives a request under the Illinois Freedom of Information Act or a request by legal process to disclose Confidential Information, UNIVERSITY will use reasonable efforts to provide prompt notice to SPONSOR and will reasonably cooperate with SPONSOR to protect any SPONSOR Confidential Information.

5.0. PUBLICATION/PUBLIC PRESENTATIONS

5.1. REVIEW PERIOD. UNIVERSITY researchers may publish or publicly disclose non-confidential Research results without SPONSOR interference after providing SPONSOR a 30-day period for review and comment. Upon written notice by SPONSOR that the proposed publication contains SPONSOR Confidential Information or enabling disclosures of Inventions (as defined below). UNIVERSITY will either revise the publication to eliminate such disclosures, or will delay publication for a limited period in its discretion to allow for preparation and filing of U.S. patent applications. The Parties will cooperate so that student theses or dissertations are not adversely affected by any delay.

5.2. COPIES OF PUBLICATIONS. UNIVERSITY will furnish SPONSOR with an electronic copy of any publications resulting from the Research.

5.3. ACKNOWLEDGMENT. Each Party will acknowledge the contributions of the other Party in publications or public presentations as scientifically appropriate.

6.0. INTELLECTUAL PROPERTY

6.1. INVENTIONS. "Inventions" means those potentially patentable discoveries, including pending patent applications and issued patents, first conceived and actually reduced to practice in performance of the Research. UNIVERSITY shall own all Inventions first conceived and actually reduced to practice solely by UNIVERSITY employees or solely by SPONSOR employees through significant use of UNIVERSITY resources ("UNIVERSITY Inventions"). SPONSOR shall own all Inventions otherwise first conceived and actually reduced to practice solely by SPONSOR employees ("SPONSOR Inventions"). The Parties shall jointly own all Inventions first conceived and actually reduced to practice by both UNIVERSITY and SPONSOR employees ("Joint Inventions").

6.2. CONFIDENTIALITY OF INVENTION DISCLOSURES. UNIVERSITY will promptly notify SPONSOR of any Invention disclosure received by its Office of Technology Management ("OTM"). SPONSOR shall treat all UNIVERSITY Invention disclosures as Confidential Information. Notwithstanding Section 4.1, SPONSOR's obligation of confidentiality for Invention disclosures shall continue until the Confidential Information becomes publicly available through no fault of SPONSOR. Each Party will promptly notify the other of any Joint Inventions.

6.3. PATENTS

6.3.1. PATENT FILING. UNIVERSITY may, at its discretion and at its expense, file patent applications in the United States and in foreign countries for any UNIVERSITY or Joint Invention. UNIVERSITY also will, at SPONSOR's request and expense, file patent applications in the United States for UNIVERSITY or Joint Inventions. SPONSOR will make any such request to UNIVERSITY in writing and within 60 days of UNIVERSITY's notice of Invention disclosure. UNIVERSITY will keep SPONSOR promptly informed regarding the status of any patent application filed at SPONSOR's expense and will give SPONSOR reasonable opportunity to comment.

6.3.2. FOREIGN FILING ELECTION. SPONSOR will notify UNIVERSITY of any foreign countries in which SPONSOR desires a license at least 60 days prior to the respective foreign filing due date.

6.3.3. COSTS. If SPONSOR requests UNIVERSITY to file a patent application or if SPONSOR elects to license UNIVERSITY Inventions, SPONSOR will pay UNIVERSITY, within 30 days of invoice date, all documented costs to secure and maintain the patents.

6.4. LICENSING. For any patent application on a UNIVERSITY Invention or Joint Invention, UNIVERSITY grants to SPONSOR (a) a non-exclusive, non-transferable, royalty-free license to practice the Invention for non-commercial purposes; and (b) the option to negotiate a royalty-bearing commercial license in a designated field of use and territory, which SPONSOR may elect by written notice to UNIVERSITY no later than six months after UNIVERSITY's notice of Invention disclosure. The negotiation period for the license shall be three months from the date of notice of election. If the parties have not entered into a license before the end of the negotiation period, then UNIVERSITY may license the Invention and its interest in the Joint Invention to third parties without further obligation to SPONSOR.

6.5. BACKGROUND INTELLECTUAL PROPERTY. Nothing in this Agreement grants to either Party any rights or interest in the other Party's Background Intellectual Property. "Background Intellectual Property" means (a) all works of authorship created outside the scope of this Agreement and (b) potentially patentable discoveries, including pending patent applications and issued patents, conceived or first reduced to practice outside the scope of this Agreement.

6.6. CREATE ACT. The Parties agree by marking this box ☒ that this Agreement constitutes a "joint research agreement" as that term is defined by the Cooperative Research and Technology Enhancement Act of 2004, 35 U.S.C. § 103(c)(3). In the event of any Inventions, the Parties will reasonably cooperate in invoking the CREATE Act and its companion regulations to overcome an obviousness rejection of a patent application.

6.7. COPYRIGHTS

6.7.1. OWNERSHIP. Title to all original works of authorship created in performance of the Research and in which copyright may be claimed ("Copyrightable Works") shall vest initially in the author, subject to the policies of the Party that employs the author. Any joint work, as that term is defined by the U.S. Copyright Act of 1976, 17 U.S.C. § 101, as amended, shall be jointly owned, but co-owners shall have no duty of accounting for any profits.

6.7.2. INTERNAL USE LICENSE. UNIVERSITY grants to SPONSOR a non-exclusive, royalty-free license to use, reproduce, prepare derivative works, display, distribute and perform all UNIVERSITY-owned Copyrightable Works other than computer software and its documentation and informational databases for SPONSOR's internal research purposes, provided that SPONSOR shall not have the right to distribute copies or derivative works to third parties. For UNIVERSITY-owned Copyrightable Works that are identified as a deliverable under the Statement of Work and in the nature of computer software (and its documentation) or informational databases, UNIVERSITY grants to SPONSOR for SPONSOR's internal research purposes a royalty-free, non-transferable, non-exclusive license to use, reproduce, prepare derivative works, display and perform such Copyrightable Works.

7.0. TANGIBLE RESEARCH PROPERTY. "Tangible Research Property" ("TRP") means those tangible (corporeal) items, as distinguished from intangible (intellectual) property, produced in performance of the Research. For purposes of illustration, TRP may include items such as: biological materials, computer media, drawings and diagrams, integrated circuit chips, prototype devices, and equipment. UNIVERSITY shall hold title to all TRP produced by UNIVERSITY with UNIVERSITY resources; provided, however, that title to TRP identified as a deliverable under the statement of work will vest in SPONSOR upon delivery by UNIVERSITY.

8.0. DISCLAIMER OF WARRANTIES. UNIVERSITY MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, REGARDING ITS PERFORMANCE UNDER THIS AGREEMENT. UNIVERSITY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY, USE OR FITNESS FOR A PARTICULAR PURPOSE AND NON-INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO DATA, INVENTIONS, COPYRIGHTABLE WORKS, TRP, OR OTHER RESEARCH RESULTS PROVIDED BY UNIVERSITY.

9.0. LIMITATION OF/RELEASE FROM LIABILITY

9.1. LIMITATION OF LIABILITY. UNIVERSITY SHALL NOT BE LIABLE TO SPONSOR FOR INDIRECT, SPECIAL, CONSEQUENTIAL, PUNITIVE, INCIDENTAL OR OTHER DAMAGES (INCLUDING LOST REVENUE, PROFITS, USE, DATA OR OTHER ECONOMIC LOSS OR DAMAGE) HOWEVER CAUSED AND REGARDLESS OF THEORY OF LIABILITY (WHETHER

FOR BREACH OR IN TORT, INCLUDING NEGLIGENCE) ARISING FROM, RELATED TO, OR CONNECTED WITH SPONSOR'S USE OF DATA, INVENTIONS, COPYRIGHTABLE WORKS, TRP, OR ANY OTHER RESEARCH RESULTS PROVIDED BY UNIVERSITY, EVEN IF UNIVERSITY WAS ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

9.2. RELEASE FROM LIABILITY. SPONSOR releases UNIVERSITY and its Trustees, officers, employees, and agents from all liability, and shall be responsible, for any and all costs, damages, and expenses, including attorney fees, arising from any claims, damages, and liabilities asserted by third parties in connection with or arising from SPONSOR's use of data, Inventions, Copyrightable Works, TRP, or any other Research results provided by UNIVERSITY.

10.0. GENERAL PROVISIONS

10.1. FISCAL MANAGEMENT. UNIVERSITY will maintain complete and accurate accounting records in accordance with accepted accounting practices for institutions of higher education. UNIVERSITY will make the accounting records available for inspection and audit by SPONSOR or its authorized agent, at reasonable times upon reasonable notice at SPONSOR's expense for three years following the end of UNIVERSITY's fiscal year (July 1 - June 30) in which Research Costs are incurred.

10.2. USE OF NAMES. Neither Party will use the name of the other in any form of advertising or publicity without the express written permission of the other Party. SPONSOR shall seek permission from UNIVERSITY by submitting the proposed use, well in advance of any deadline to the University of Pittsburgh Office of Sponsored Programs.

10.3. RELATIONSHIP OF THE PARTIES. Neither Party is agent, employee, legal representative, partner or joint venturer of the other. Neither Party has the power or right to bind or commit the other.

10.4. GOVERNING LAW. Remain Silent

10.5. THIRD PARTY BENEFICIARIES. This Agreement does not create any rights, or rights of enforcement, in third parties.

10.6. SEVERABILITY. If a court of competent jurisdiction finds any provision of this Agreement legally invalid or unenforceable, such finding will not affect the validity or enforceability of any other provision of this Agreement and the Parties will continue to perform. If the Agreement cannot be performed in the absence of the provision, this Agreement will terminate upon 30 days' written notice by one Party to the other Party.

10.7. MERGER. This Agreement and all attachments embody the entire understanding of the Parties and will supersede all previous or contemporaneous communications, either verbal or written, between the Parties relating to this Agreement. All terms and conditions of any instruments, including purchase orders, issued by SPONSOR to facilitate payment under this Agreement are void, even though they may be issued after the signing of this Agreement.

10.8. AMENDMENTS. No modification to this Agreement will be effective unless confirmed in a written amendment signed by each Party's authorized representative.

10.9. COUNTERPARTS. The Parties may sign this Agreement in one or more counterparts, each of which constitutes an original and all of which together constitute the Agreement. The Parties agree that a facsimile or PDF copy of a signature shall have the same effect and validity as an original signature.

10.10. ASSIGNMENTS. This Agreement shall bind, and inure to the benefit of, the Parties and any successors to substantially the entire assets of the respective Party. Neither Party may assign this Agreement without first obtaining the prior written consent of the other Party, and any attempted assignment is void.

10.11. FORCE MAJEURE. Each Party will be excused from performance of the Agreement only to the extent that performance is prevented by conditions beyond the reasonable control of the affected Party. The Party claiming excuse for delayed performance will promptly notify the other Party and will resume its performance as soon as performance is possible.

10.12. EXPORT CONTROL. Each Party acknowledges that performance of all obligations under this Agreement is contingent on compliance with applicable United States laws and regulations controlling the export of technical data, computer software, laboratory prototypes and other commodities. 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 SPONSOR that SPONSOR will not re-export data or commodities to certain foreign countries or nationals thereof without prior approval of the cognizant government agency.

10.13. RESOLUTION OF DISPUTES. The Parties will enter into good faith negotiations to resolve any disputes arising from this Agreement. Resolution will be confirmed by written amendment to this Agreement. If the Parties cannot resolve any dispute amicably through negotiation, either Party may terminate this Agreement in accordance with Article 3.0.

10.14. SURVIVAL. All terms of this Agreement that are intended to survive termination or expiration in order to be effective shall survive such termination or expiration.

10.15. WAIVER. No waiver of any right, remedy, power or privilege by any Party under this Agreement shall be effective unless made in writing. No waiver of any breach of any provision of this Agreement shall constitute a waiver of any subsequent breach of the same or of any other provision of this Agreement.

10.16. NOTICES. Any notice given under this Agreement will be in writing and will be effective upon receipt evidenced by: (a) personal delivery; (b) confirmed facsimile transmission; (c) return receipt of postage prepaid registered or certified mail; or (d) delivery confirmation by commercial overnight carrier. All communications will be sent to the addresses set forth below or to such other address designated by a Party by written notice to the other Party in accordance with this section:

UNIVERSITY: *For matters related to the Sponsored Research Agreement and Intellectual property and licensing:*

University of Pittsburgh
Office of Sponsored Programs
123 University Place
Pittsburgh, PA 15213-2302
Telephone: (412) 624-7400
Fax: (412) 624-7409

SPONSOR: Lake County Division of Transportation
600 West Winchester Road
Libertyville, IL 60048-1381
Telephone: (847) 377-7400
Fax: (847) 984-5888

10.17. AUTHORIZED SIGNATORIES. Each Party represents that the individuals signing this Agreement on its behalf are authorized, and intend, to bind the organization in contract.

THE UNIVERSITY OF PITTSBURGH

_____
Laura Kingsley, Senior Associate Director

Date _____

UNDERSTOOD AND AGREED

_____
Principal Investigator: Aleksandar Stevanovic, Ph.D., P.E.

RECOMMENDED FOR EXECUTION

_____
Shane E. Schneider
Director of Transportation/County Engineer
Lake County

COUNTY OF LAKE

By: _____
Chair, Lake County Board

Date _____

ATTEST:

_____
County Clerk, Lake County

Exhibit A – Scope of Service

Project Title: **Traffic Signal Optimization based on Fuel-consumption and Pollutant Emissions**

Principal Investigator: Aleksandar Stevanovic, PhD, PE
Department of Civil & Environmental Engineering
Swanson School of Engineering
University of Pittsburgh
218D Benedum Hall
3700 O'Hara Street
Pittsburgh, PA 15261
Tel: (412) 383-3766
Email: stevanovic@pitt.edu

Pitt's DOR Contact: TBD

Project Manager: Justin R. Effinger, P.E.
Traffic Signal Engineer
Lake County Division of Transportation
600 W Winchester Road,
Libertyville, IL 60048
Tel: (847) 377-7474
Fax: (847) 984-5606
Email: JEffinger@lakecountyil.gov

Background Statement

Optimization of traffic signal timings has been a subject of numerous academic research efforts and field technician endeavors (*1-9*). However, from its early beginnings the signal operations have been predominantly observed through the prism of resulting delays to traveling public (*10*). Early models of signals' impact on drivers have been based on a simplistic queueing theory models with a single-channel queue and deterministic arrivals and departures (e.g. D/D/1), where a primary focus was on vehicular delay (*11, 12*), which then propagated into a full-blown theory that we know as a series of deterministic delay models (e.g. uniform, random, overflow) as presented in the series of relevant engineering literature (*13, 14*). Since the early beginnings of the traffic signal models and optimizations, we have covered a long way to identify right methods to characterize performance of traffic signals (*15, 16*). Along that way, impact of signal's operations (its timings) on fuel consumption, and resulting pollutant emissions, has not been given a continuous and due attention. The first efforts to investigate impacts of signals on fuel consumption were done in 1970's during the first World's oil crisis (*1-4*). Significant research efforts of '70s, conducted by several traffic engineering research groups around the world (*1, 2*), led into development of some of the well-known traffic signal performance measures (PMs) which have stood the test of time. Many traffic signal engineers today take those PMs for granted not understanding that their development was driven by the need to save fuel consumption (and consequently reduce polluting emissions) from traffic predominantly driven by the engines with internal combustion. In meanwhile, after the first World oil crisis of '70s had passed, emphasis on impact of signal operations on the fuel consumption, and emissions, has diminished. Revival of the research efforts to include fuel consumption and pollutant emissions into signal optimization occurred, approximately, after the start of the new millennium (e.g. 2000-2010) when advancements in computational hardware and methods made possible to use computationally demanding models for accurate fuel-consumption and emission estimations (*5-9*). However, it seems that in the process of using the cutting-edge computational methods the new cohort of the researchers has forgotten what was done in the previous research efforts (from 70's) and has therefore missed some important lessons learned and opportunities for true advancements in this field. Finally, the latest advancements in retrieval and processing of high-resolution (a tenth of a second) signal timing and detection data have put even more emphasis on data collection and visualization without a proper follow-up on the data-interpretation side, especially from the view of minimizing fuel consumption and polluting emissions (*17, 18*). To clarify, and provide an example, while increasing a percentage of vehicles arriving on green certainly helps (through a better coordination) to reduce unnecessary stops and consequent fuel consumption; when such percentages need to be considered for multiple conflicting traffic movements, it is not neither intuitive nor easy to find a right balance or trade-off between such traffic movements.

Purpose of this project is to develop a methodology to reduce fuel consumption and vehicular emissions by utilizing common traffic engineering data and methods and disseminate results in the forms applicable to both static (pre-timed signal plans) and dynamic (adaptive or real-time control) traffic signal operations and both data-poor and data-rich traffic signals.

Project Objective(s)

The goal of this research is to redefine methodology for use of the fundamental performance measures to adjust signal timing parameters in order to minimize fuel consumption and pollutant emissions. This goal is achieved through a few research objectives, which are executed through a relevant administrative project tasks which are given below. The basic objectives are: 1) Justify the need for this research and explain basic relationship between fuel consumption/emissions and traffic operations (paradoxically, if one wants to reduce fuel consumption/emissions by using measured fuel consumption or emissions as an optimization's objective function, this may neither be theoretically-sound nor practically-useful approach); 2) Apply proposed methodology in a relevant simulation environment and document its performance and success in virtual traffic conditions; and 3) Apply the proposed methods in the field operations by incorporating required findings and parameters in the relevant ATSPM tools.

Supporting Tasks and Deliverables

Task 1: Project kickoff teleconference

The Principal Investigator (PI) will schedule a kickoff teleconference that shall be held within the first 30 days of execution of the contract. The Project Manager (PM) and Principal Investigator shall attend the meeting. Other parties may be invited as appropriate. The purpose of the meeting is to review the tasks, deliverables, and deployment plan. Teleconference/web meeting should be used if possible.

Task 2: Literature review

The PI and PITTS (Pittsburgh Intelligent Transportation Systems) Lab's team will conduct a literature review to document and describe history of the research on traffic signal optimization to reduce fuel consumption and vehicular emissions. This task will also identify studies which help to understand interdependencies between these non-traditional traffic signal objective functions and common signal performance measures such as delays, stops, throughput, etc. Finally, the literature review will identify studies where interdependencies between fuel consumptions and various pollutant emissions have been described.

Deliverable 1: Upon completion of Task 2, the PI will submit (electronically) to the LC DOT a technical report which contains the entire literature review, along with the introduction/background of this research project.

Task 3: Development of methodology

The PI and PITTS Lab's team will develop and present a methodology that explains which performance measures should be used when optimizing traffic signals for minimal fuel consumption and pollutant emissions. The methodology will also explain how such performance measures should be defined and combined in various operational conditions; those which have significant impact on the presented methodology. The methodology will be accompanied with a short field data collection plan, that will show which data PITTS Lab's researchers will collect to support development and application of the proposed methodology.

Deliverable 2: Upon completion of Task 3, the PI will submit (electronically) to the LC DOT a technical report which documents the proposed methodology and a brief field data collection plan.

Task 4: Field data collection and model building

The PITTS Lab's team will collect necessary data from the field in order to support development and application of the proposed methodology. Such data may include traffic signal timing sheets, turning movement counts, intersection delays, GPS trajectory data etc. When possible, the data will be collected through remote access to LC DOT cameras and other infrastructure available through relevant LC DOT software platforms. However, it is also envisioned that the PITTS Lab researchers may make one or more field visits to LC DOT signals and collect the data in the field. Also, when needed and applicable, the PITTS researchers may need to collect field data from local traffic conditions in Pittsburgh metro area.

The field data will be mainly collected for following reasons: 1. To support development and calibration of the relationships between fuel consumption and pollutant emission on one side and other, more common, signal performance metrics on the other side; 2. To support building, calibration and validation of a relevant Vissim microscopic model (of a 12-intersection system) to prove the benefits of utilizing the newly proposed methodology versus the old (traditional) methods; 3. To validate proposed methodology through either the field data directly or field-like simulation data (indirectly).

The Vissim microsimulation model developed under this task will resemble field traffic conditions from Washington Street in Lake County, including the intersections from Almond Rd (western end) to Teske Blvd (eastern end). This is a 12-intersection system consisting of either ASC/3 or cobalt controllers. Annual Daily Traffic (ADT) along this roadway ranges from 21,000 to 27,900 vehicles.

Deliverable 3: Upon completion of Task 4, the PI will submit to LC DOT a working microsimulation model, which will be used to optimize signal timings on a small network under LC DOT jurisdiction. Field data usages for calibration and validation of the proposed methodology will be reflected in consecutive technical reports.

Task 5: Signal timing optimization

The PI and PITTS Lab's team will integrate the proposed methodology into a stochastic optimization framework which will enable optimization of signal timings (on a small network under LC DOT jurisdiction) to reduce fuel consumption and pollutant emissions. It is envisioned that major polluting trends will be covered with this optimization but not every single polluting criterion may be covered. E.g. if reduction of a particular pollutant criterion (e.g. PM10) does not follow the same general trend of the other pollutant criteria, which are linearly correlated with fuel consumption, such a criterion will not be separately addressed in this study. Once the signal optimization is performed for several scenarios (e.g. delay, traditional performance index, and a PM developed in this research) results should show benefits of the proposed methodology. Such benefits should validate previously estimated benefits from proposed methodology.

Deliverable 4: Upon completion of Task 5, the PI will submit (electronically) to LC DOT a final interim technical report, which includes all the previously submitted reports description of field data collection, model building and validation, and optimization results.

Task 6: Integration of the methodology in LC DOT's ATSPM field operations

Once the LC DOT comments on the final interim technical report and provides a 'green light' for the implementation of the methodology in their ATSPM platform, the PITTS Lab's team will propose a method to implement proposed methodology in the ATSPM tool of LC DOT's choice. It is expected that the selected tool is based on the major principles of the freeware ATSPM system developed by Utah Department of Transportation.

Deliverable 5: Upon completion of Task 6, the PI will submit (electronically) to LC DOT a brief memo with instructions how to modify the elements of the ATSPM structure to achieve variables and parameters needed to implement the proposed methodology for fuel/emission minimization in the field ATSPM operations.

Task 7: Final Report

Sixty (60) days prior to the end date of the agreement, the university will submit a draft final report to LC DOT. The draft final report will contain all the elements from the previous final interim technical report and brief instructions for methodology implementation in an ATSPM platform, as an appendix. The LC DOT will review the draft final report and send their comments, and requests for revision, to the university not later than thirty (30) days prior to the end date of the agreement. Then the PI and the PITTS Lab's team will address the comments and suggestions and deliver the final report before the last date of the agreement. The draft final and final reports will follow technical and formatting guidelines set by LC DOT, if any. The reports will be well-written and edited for technical accuracy, grammar, clarity, organization, and format.

Deliverable 6: Upon LC DOT approval of the draft final report, the PI will submit (electronically) the Final Report to LC DOT.

Task 8: Project closeout meeting

If advised by the LC DOT Project Manager, the PI will schedule a closeout teleconference that shall be held during the final 15 days of the agreement. The PI and PM shall attend the project closeout meeting. Other parties may be invited, if appropriate. The purpose of the meeting is to summarize findings, review project performance, and consider future steps (if applicable).

Project Milestones

Task description	Anticipated timeframe for completion (in months)	Completed by beginning of
Task 1 - Project kickoff teleconference	1	January 2020
Task 2 - Technical report - literature review	4	April 2020
Task 3 - Technical report - methodology & data collection plan	6	July 2020
Task 4 - A calibrated Vissim microsimulation model of the 12-intersection system on Washington Street	10	October 2020
Task 5 - Technical report - including field data collection, model building and validation, and optimization results	6	January 2021
Task 6 - Technical memo - with instructions how to modify elements of the ATSPM to implement proposed methodology	2	March 2021
Task 7 - Draft Final/ Final Reports	6	April/June 2021
Task 8 - Project closeout meeting	1	July 2021
Total duration of the project	**19**	**July 2021**

References

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Exhibit B (Budget)

A budget of $149,492 is proposed. Two graduate students will be working with the PI to cover the outlined tasks. The detailed budget breakdown is listed below. In addition to the Lake County expenses, the University of Pittsburgh will provide a funding match of around 54% of those expenses (exactly $80,580) to cover a month and a half of PI's time and remission of the graduate students' tuitions.

Sponsor: Lake County, Illinois
Principal Investigator: Aleksandar Stevanovic
Title: Traffic Signal Optimization based on Fuel-consumption and Pollutant Emissions
Project Period: December 2, 2019 - July 30, 2021

Budget

A. Senior Personnel		$		UP Match
Prof. Stevanovic	1.5 mos.		22,420	22,420
B. Other Personnel				
Research Assistant – Post MS	18.0 mos.		40,128	
Total Salary and Wages			62,548	
C. Fringe				
Academic 31.9%, GRA 50%			27,217	7,152
Total Personnel			89,765	
D. Equipment				
E. Travel				
Domestic			4,000	
Foreign			4,000	
F. Other Direct Costs				
Materials and Supplies			4,000	
Travel			500	
Publications			200	
CS Service			-	
Services			300	
Tuition – N/A			-	51,008
Total Other Direct Costs			5,000	
Total Direct Costs Indirect Cost Base			102,765 82,701	
G. Indirect Costs				
Facilities and Admin. 56.5% of TDC			46,727	
Total Project Cost		$	**149,492**	**80,580**