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April 12, 2022
In reply, refer to:
CRC Project No. E-140

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "Low NO_x and NMOG - Modeling," (CRC Project No. E-140). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate by **April 28, 2022** if you or your organization intends to submit a written proposal for this research program by submitting an intent to bid using THIS LINK. CRC will answer technical questions regarding the Request for Proposal if they are submitted in writing at least one week before the proposal submission deadline here: Q & A Submission Link. CRC will compile all questions, and return a copy of written responses to all intended bidders. Questions submitted within a week of the deadline may not be answered before the proposal submission deadline.

The reporting requirements will be monthly progress reports and a summary technical report at the end of the contractual period. The reporting requirements are described in more detail in the attachment entitled "Reports" (Exhibit B). Status updates may be requested for committee meetings, which occur three times per year.

The proposal must be submitted as two separate documents. The technical approach to the problem will be described in part one, and a cost breakdown that is priced by task will be described in part two. **Bidders may choose to bid on all or part of the project described.** Please clearly indicate which components of the project you intend to bid.

Important selection factors to be taken into account are listed in Exhibit E. CRC evaluation procedures require the technical group to complete a thorough technical evaluation before considering costs. Please ensure that any details relevant to Criteria one (1) through four (4) are provided in the technical proposal. After developing a recommendation based on technical considerations, the costs are revealed and the recommendation is modified as needed. CRC reserves the right to accept or reject any or all proposals.

In this case, we request the quotation be provided on a per-vehicle/ per-fuel basis as the CRC panel may request that additional vehicles or fuels may be added to the program. The cost proposal document should include all costs associated with conducting the proposed program. The technical proposal shall not be longer than 10 pages in length.

CRC expects to negotiate a cost-plus fixed fee or cost reimbursement contract for the research program.

Contract language for intellectual property and liability clauses is presented in Exhibit C and in Exhibit D, respectively.

Electronic copies of the technical and cost proposals should be submitted to:

Amber B. Leland
Coordinating Research Council
5755 North Point Parkway, Suite 265
Alpharetta, GA 30022

Phone: 678-795-0506
Fax: 678-795-0509
E-mail: aleland@crcao.org

The deadline for receipt of your proposal is **May 16, 2022.**

Yours truly,

Amber B. Leland
Deputy Director

EXHIBIT A

Statement of Work
Low NOX and NMOG - Modeling

Background
Current emissions measurement capabilities may not be sensitive enough to measure very low NOx and NMOG (HC, CH4) emissions that will be required for future Light-Duty (LD) and Medium-Duty (MD) vehicles for certification at Super Ultra-Low Emission Vehicle (SULEV) levels. One potential area of concern is the impact of test weight. With traditional Constant Volume Sampler (CVS) technology dilute volume increases as test mass increases requiring the instrumentation to measure lower concentrations. The uncertainty and limitations of the current sampling and analytical systems technology over the range of test weights need to be understood in order to identify potential areas for improvement.

Objectives
The objective of this project is to develop a model to demonstrate and identify opportunities to reduce the uncertainty of the current technology used for chassis dyno LD and MD certification testing. The model developed shall incorporate the many variables which contribute to the measurement uncertainty. Analysis of the modeling results shall provide a sensitivity analysis identifying the contribution of each factor to the overall uncertainty. Based on the results, recommendations for areas of improvement and future study shall be included.

Scope of Work

Project Management

Coordinating Research Council (CRC) and its project technical panel will provide management and oversight for this project. These entities are hereafter referred to collectively as the project sponsor.

Technology Assumptions/Scope:

While there are many different technologies allowed for LD chassis dyno certification testing, the following are representative of the 'typical' methods used for chassis emission dyno testing according to US EPA 1066 test procedures and shall be reflected in the model.

- CVS sampling system
  - Multiple critical flow venturis which support total dilution tunnel flow rates from 6 m3/min to 40 m3/min in increments of 3 m3/min.
  - Dilution Air with HEPA filtration and heated over a range between 15 to 52 deg C
  - Sample bags for both Ambient/Background air and Diluted Exhaust Samples
  - 1066 Dilution Factor requirements of 7:1 to 20:1
- Bag Analysis
  - NOX Analyzer
    - Chemiluminescent detector (CLD) technology
  - Total HC Analyzer - Gasoline
    - Flame Ionization Detector (FID) technology
    - FID Fuel: Either H2/He or H2/N2
  - CH4 Analyzer
    - Gas Chromatography (GC) technology with FID
    - FID Fuel: Either H2/He or H2/N2
- Continuous dilute tunnel analysis
  - Total Heated HC Analyzer - Diesel
    - Flame Ionization Detector technology
    - FID Fuel: Either H2/He or H2/N2
- Span Gas and Zero Gas as defined by 40 CFR 1065.750
  - Include uncertainty of the reference standard
  - Include the Zero gas contamination limits and their impact on the overall uncertainty. Evaluate worst case specification as well as the limit required to improve the measurements.
  - Identify the uncertainty associated with using gas dividers to support 1065 linearizations extending below the 1 ppm level.
- Dilution Air Concentrations
  - Identify the range of ambient concentrations expected
  - Identify the stability of ambient concentrations expected during the test
- Test Fuels:
  - E10: US EPA Tier 3 (or) CARB LEVIII
  - Diesel B7: US EPA Tier 3 (or) CARB LEVIII
- NMOG
  - Determination based on calculations defined by US EPA 40 CFR 1066.635
  - HC and Ethanol Speciation is out of scope for this project

- Test Types:
    - FTP (3 & 4 Phase)
    - HWFE
    - US06

NOX Modeling

- Identify expected NOX concentrations required to meet the standard at different CVS flow rates
    - Estimate the fractions by phase of NMOG vs NOX @ 15 mg/mi NMOG + NOX Standard (or lower)
    - Note: Assume engineering margin and actual vehicle emissions @ 50% of the standard.
- Identify range of ambient bag concentrations expected
- Identify range of sample bag concentrations expected by phase as a function of vehicle mass / exhaust volume / CVS tunnel flow rate
    - Note: Higher CVS flow rates are required for higher mass vehicles which result in a decrease in the expected NOX concentrations.
    - Determine the ratio of sample bag concentration to ambient bag concentration needed to obtain an accurate and reliable measurement of the net sample concentration after subtracting the ambient from the sample concentration.
- Identify a range or limits of that ratio that would result in an accurate reliable measurement of the net NOx concentration NOX Analyzer
    - Include analyzer accuracy/uncertainty at the expected NOX concentrations (ambient and sample bags)
    - Include the effects of H2O and CO2 quench at the expected low NOX concentrations
    - Include the effects of NOX converter conversion efficiency
- Include other factors which may influence the uncertainty of the NOX mass determination
    - Estimate the overall uncertainty in the NOX mass results at the expected levels as a function of vehicle mass / exhaust volume
    - Identify recommended analyzer ranges and calibration methodology
    - Identify potential methods to improve NOX mass accuracy and reduce uncertainty

NMOG Modeling

- Hydrocarbons:
    - Identify expected THC and CH4 concentrations required to meet the standard at different CVS flow rates
        - Estimate the fractions by phase of NMOG vs NOX @ 15 mg/mi NMOG + NOX Standard (or lower)
        - Note: Assume engineering margin and actual vehicle emissions @ 50% of the standard.
- Identify ambient bag concentrations expected
- Identify sample bag concentrations expected by phase as a function of vehicle mass / exhaust volume / CVS tunnel flow rate
    - Higher CVS flow rates required for higher mass vehicles. Expected HC concentrations decrease as exhaust volume increases
    - Identify integrated HC dynamic range required as a function of vehicle mass / exhaust volume / CVS tunnel flow rate
    - Determine the ratio of sample bag concentration to ambient bag concentration needed to obtain an accurate and reliable measurement of the net sample concentration after subtracting the ambient from the sample concentrations.
    - Identify a range and recommended limits of that ratio that would result in an accurate reliable measurement of the net HC and CH4 concentrations
- HC Analyzer (Gasoline) - Bag Readings
    - Include the analyzer accuracy / uncertainty at the expected HC concentrations (sample and ambient bags)
    - Include the effects of Oxygen on the HC readings over the range of dilution factors from 7:1 to 20:1. (Approximately 18 to 21% O2)
    - Include the impact of FID fuel between 40% H2/ 60% N2 (+/-1% abs) and 40% H2/ 60% He (+/-1% abs)
    - Include any additional factors which may impact the uncertainty of the HC readings
- HC Analyzer (Diesel) - Integrated HC readings from CVS Tunnel
    - Include the analyzer accuracy / uncertainty over the range of expected HC concentrations
    - Include the effects of Oxygen on the HC readings
    - Include the impact of FID fuel between 40% H2/ 60% N2 (+/-1% abs) and 40% H2/ 60% He (+/-1% abs)
    - Include any additional factors which may impact the uncertainty of the HC readings
- CH4 Analyzer - Bag Readings
    - Include the analyzer accuracy / uncertainty at the expected CH4 concentrations (sample and ambient bags)
    - Include the impact of FID fuel between 40% H2/ 60% N2 (+/-1% abs) and 40% H2/ 60% He (+/-1% abs)

    - Include any additional factors which may impact the uncertainty of the CH4 readings
- NMOG mass uncertainty
    - Estimate overall uncertainty of NMOG mass results at expected levels as a function of vehicle mass / exhaust volume
- Identify recommended analyzer ranges and calibration methodology
- Identify potential methods to improve NMOG mass accuracy and reduce uncertainty

Uncertainty Determination

Measurement uncertainty determined by the model shall be consistent with "GUM, Guide to the Expression of Uncertainty in Measurement, issued by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML"

Model Variables

Model developed and provided shall include variables to allow the uncertainties of the various instruments and measurements to be entered. The analysis shall include uncertainties of the instruments listed in Appendix A/ Attachment I. In addition, the contractor shall also include other available instruments which may potentially improve the overall measurement uncertainty.

Deliverables

The contractor shall provide status presentations to the committee and project panel meetings. The contractor shall submit monthly reports in addition to the draft and final reports with the modeling analysis. The contractor shall deliver a model to CRC for future use by CRC members which can be used to identify the uncertainties and allows for the user to input uncertainties for individual measurements.
The reports shall identify all the variables incorporated in the model as well as all assumptions. The final results shall identify the overall uncertainty and sensitivity analysis of each variable. The report shall also identify the factors with the most significant impact and provide recommendations for potential areas for improvement. Depending on the final program schedule, the contractor may be requested to issue an interim report. This interim report would be structured in format of a final report.

Attachment I (4/7/2022)
Instrumentation to be included in the NMOG, NOX Measurement Uncertainty Model

Instrument Type	Technology	Manufacturer	Series	Model #	Sample Ranges
Total Hydrocarbon Analyzer	Flame Ionization Detector (FID)	Horiba	Mexa One	FIA-01SL	5,15,125 ppmC3
Methane Analyzer	Gas Chromatograph (GC)	Horiba	Mexa One	GFA-01SL	25 ppm CH4
NOX Analyzer	Chemilumensence Detector (CLD)	Horiba	Mexa One	CLA-01SL	20, 50 ppm Nox
Tunnel Heated Hydrocarbon Analyzer	Flame Ionization Detector (FID)	Horiba	Mexa One	FIA-01O	125 (or) 500 ppmC3
Total Hydrocarbon Analyzer	Flame Ionization Detector (FID)	AVL	AMA i60	AVL Cutter FID i60 LHD	25, 100 & 500ppmC3
Methane Analyzer	Gas Chromatograph (GC)	AVL	AMA i60	AVL GC i60 LC	25ppm
NOX Analyzer	Chemilumensence Detector (CLD)	AVL	AMA i60	AVL CLD i60 LH SLQ	25 & 100ppm
Tunnel Heated Hydrocarbon Analyzer	Flame Ionization Detector (FID)	AVL	AMA i60		
Total Hydrocarbon Analyzer	Flame Ionization Detector (FID)	Horiba	7000 Series		
Methane Analyzer	Gas Chromatograph (GC)	Horiba	7000 Series		
NOX Analyzer	Chemilumensence Detector (CLD)	Horiba	7000 Series		
Tunnel Heated Hydrocarbon Analyzer	Flame Ionization Detector (FID)	Horiba	7000 Series		

EXHIBIT B

REPORTS

MONTHLY TECHNICAL PROGRESS REPORTS

The contractor shall submit a monthly technical progress report covering work accomplished during each calendar month of the contract performance. An electronic Microsoft® Word compatible file (<1 MB) of the monthly technical progress report shall be distributed by the contractor within ten (10) calendar days after the end of each reporting period. The report shall contain a description of overall progress, plus a separate description for each task or other logical segment of work on which effort was expended during the reporting period.

FINAL REPORT

The contractor shall submit to or distribute for CRC an electronic (Microsoft Word) copy transmittable via email) of a rough draft of a final report within thirty (30) days after completion of the technical effort specified in the contract. The report shall document, in detail, the test program and all of the work performed under the contract. The report shall include tables, graphs, diagrams, curves, sketches, photographs and drawings in sufficient detail to comprehensively explain the test program and results achieved under the contract. The report shall be complete in itself and contain no reference, directly or indirectly, to the monthly report(s).

The draft report must have appropriate editorial review corrections made by the contractor prior to submission to CRC to avoid obvious formatting, grammar, and spelling errors. The report should be written in a formal technical style employing a format that best communicates the work conducted, results observed, and conclusions derived. Standard practice typically calls for a CRC Title Page, Disclaimer Statement, Foreword/Preface, Table of Contents, List of Figures, List of Tables, List of Acronyms and Abbreviations, Executive Summary, Background, Approach (including a full description of all experimental materials and methods), Results, Conclusions, List of References, and Appendices as appropriate for the scope of the study. Reports submitted to CRC shall be written with a degree of skill and care customarily required by professionals engaged in the same trade and /or profession.

Within thirty (30) days after receipt of the approved draft copy of the final report, the contractor shall make the requested changes and deliver to CRC ten (10) hardcopies including a reproducible master copy of the final report. The final report shall also be submitted as electronic copies in a pdf and Microsoft Word file format. The final report may be prepared using the contractor's standard format, acknowledging author and sponsors. An outside CRC cover page will be provided by CRC. The electronic copy will be made available for posting on the CRC website.

EXHIBIT C

INTELLECTUAL PROPERTY RIGHTS

Title to all inventions, improvements, and data, hereinafter, collectively referred to as ("Inventions"), whether or not patentable, resulting from the performance of work under this Agreement shall be assigned to CRC. Contractor X shall promptly disclose to CRC any Invention which is made or conceived by Contractor X, its employees, agents, or representatives, either alone or jointly with others, during the term of this agreement, which result from the performance of work under this agreement, or are a result of confidential information provided to Contractor X by CRC or its Participants. Contractor X agrees to assign to CRC the entire right, title, and interest in and to any and all such Inventions, and to execute and cause its employees or representatives to execute such documents as may be required to file applications and to obtain patents covering such Inventions in CRC's name or in the name of CRC's Participants or nominees. At CRC's expense, Contractor X shall provide reasonable assistance to CRC or its designee in obtaining patents on such Inventions.

To the extent that a CRC member makes available any of its intellectual property (including but not limited to patents, patent applications, copyrighted material, trade secrets, or trademarks) to Contractor X, Contractor X shall have only a limited license to such intellectual property for the sole purpose of performing work pursuant to this Agreement and shall have no other right or license, express or implied, or by estoppel. To the extent a CRC member contributes materials, tangible items, or information for use in the project, Contractor X acknowledges that it obtains only the right to use the materials, items, or information supplied for the purposes of performing the work provided for in this Agreement, and obtains no rights to copy, distribute, disclose, make, use, sell or offer to sell such materials or items outside of the performance of this Agreement.

EXHIBIT D

LIABILITY

It is agreed and understood that _____ is acting as an independent contractor in the performance of any and all work hereunder and, as such, has control over the performance of such work. _____ agrees to indemnify and defend CRC from and against any and all liabilities, claims, and expenses incident thereto (including, for example, reasonable attorneys' fees) which CRC may hereafter incur, become responsible for or pay out as a result of death or bodily injury to any person or destruction or damage to any property, caused, in whole or in part, by _____'s performance of, or failure to perform, the work hereunder or any other act of omission in connection therewith.

EXHIBIT E

PROPOSAL EVALUATION CRITERIA

1) Merits of proposed technical approach.
2) Previous performance on related research studies.
3) Personnel available for proposed study – related experience.
4) Timeliness of study completion.
5) Cost.