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ATLANTA, GA 30328
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WWW.CRCAO.ORG

November 11, 2025
In reply, refer to:
CRC Project No. CM-137-25a/ E-147a

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "AKI Study at Altitude with Modern Vehicles Statistical Analysis" (CRC Project No. CM-137-25a/ E-147a). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate your intention to bid at this link on or before **December 3, 2025** if you or your organization intends to submit a written proposal for this research program. 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 Link. CRC will then return written answers to all of the bidders, along with a copy of the original questions. Questions submitted within a week of the deadline may not be answered before the proposal submission deadline.

A CRC technical group composed of industry representatives will evaluate your proposal. CRC reserves the right to accept or reject any or all proposals.

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).

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. 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.

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. After developing a recommendation based on technical considerations, the costs are revealed and the recommendation is modified as needed.

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

Amber Leland
Coordinating Research Council
1 Concourse Parkway, Suite 800
Atlanta, GA 30328

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

The deadline for receipt of your proposal is **December 19, 2025**.

Yours truly,

Amber B. Leland
Deputy Director

EXHIBIT A

CM-137-25a/ E-147a STATEMENT OF WORK
"AKI Study at Altitude with Modern Vehicles Statistical Analysis"

1. Background

The specifications for gasoline used in spark-ignition automobile engines in the United States are detailed in ASTM International's, "Standard Specification for Automotive Spark-Ignition Engine Fuel", commonly referred to as ASTM D4814. Although ASTM D4814 does not explicitly list mandatory minimum specifications for antiknock/octane number ratings, it does provide non-mandatory information in its Appendix describing the effects of altitude on vehicle antiknock requirements for pre-1984 vehicles. These older vehicles lack sophisticated closed-loop computerized engine control module controls and are predominantly large cylinder bored, carbureted, naturally aspirated designs having emissions certifications much less stringent than today's vehicles. Additionally, the D4814 Appendix shows areas in the western United States where reduced antiknock requirements for pre-1984 vehicles are applicable based on the altitude of the area. Therefore, ASTM D02, Sub-committee A is seeking to update D4814 based on controlled vehicle performance studies and data. The importance of fuel antiknock quality is highlighted by its impact on vehicle design and performance. Modern day automobile engines are calibrated for maximum fuel economy and performance, while minimizing emissions using the octane grade of gasoline that the manufacturer recommends or requires for use in the vehicle's owner's manual. However, to avoid engine damage in case a lower fuel octane than specified in the owner's manual is used, the engine must be "protected" for the minimum octane fuel available in the market of sale. Consequently, engine design and calibration are constrained by the lowest anti-knock index fuel commercially available.

In recent years, with more sophisticated engine design and calibration, new vehicles may be able to take advantage of higher AKI fuels. This allows the vehicle to optimize vehicle power, performance and emissions to the fuel in the tank. On the horizon, the use of drop-in lower carbon intensity gasoline blends could be used in conjunction with these sophisticated vehicles. Does higher octane with lower carbon intensity deliver real world benefits?

2. Objective

Evaluate the latest **vehicle technology sets** with current range of market fuel comparing 85 AKI to higher octane fuel (87, 91 AKI) at altitude (>5000') and sea-level (<1000') conditions to provide data showing effects on vehicle power and performance. Full load operation for sustained periods of time is one of the most challenging operating conditions for an engine under knock-limited operation. This is typical for a vehicle fully loaded and/or towing a load.

3. **Project Testing - Overview**

Phase 1 (altitude):

Vehicles

- 6-10 cars, MY15+
    - Include Light Duty (LD) vehicles commonly used for towing, including SUVs and LD trucks.
    - Include small LD (SUV or passenger car).
    - Option for contractor procurement and/or OEM supplied

Fuels

- 3 fuels (85, and 87, and 91 AKI with typical octane sensitivity)
    - Contractor to provide fuel procurement estimates. It is possible that a member partner company could provide in-kind. Fuels should have similar octane number sensitivity (Sensitivity = RON - MON) and ethanol content (E10) to control these factors.
    - It can be estimated that each vehicle will need x2 tanks of fuel per fuel to conduct the testing. Assume x1 55gal drum of fuel per car per fuel. Total amount of fuel will be determined by the number of cars which will be finalized by the committee after contractor selection.
    - Each drum of fuel to have an aliquot of fuel collected for analysis.
    - Contractor to provide fuel analysis estimates. It is possible that a member partner company could provide in-kind.
    - Fuel prep procedure (Reference SAE 2017-01-0801)
    - Option to run 2-3 lower carbon intensity gasoline blends with varying AKI.

Testing

- Chassis dyno testing: (Reference SAE 2017-01-0801)
    - Replicate chassis dyno testing of FTP75, HWFET, US06 with certification fuel pre and post test program To be performed pre and post Performance Testing to bookend the AKI study (WOT steady-state and dyno acceleration runs). Report FE, CO_2, CO, THC, NMHC, CH_4, NO_x, N_2O, and PM. Ensure vehicle is not reporting a MIL.
- Performance Testing:
    - WOT at various steady-state engine operating conditions to evaluate vehicle power curve (Reference SAE 2017-01-0801)
    - Simulated loaded condition (up to vehicle GVWR) dyno acceleration evaluation
        - ♣ Contractor to show proof of repeatability for the test cycle chosen
            - Ex: 0-60, 20-60, 30-70, or other acceleration run agreed upon by the committee.
        - ♣ This is typically performed in a fixed transmission gear.

- Record ECU and chassis data
    - Accelerator Pedal Position, Throttle Position, Manifold Pressure, Intake Air Temperature, Spark Timing, Knock Value, Calculated Load, Equivalence Ratio, etc.
    - Option: External instrumentation for EGT and lambda sensor(s)
    - Option for external knock sensor and/or spark plug pressure transducer

Phase 2 (sea-level):

- Repeat of Phase 1 at an altitude <1000'

4. **Scope of Work: Overview**

The Contractor selected under **CM-137-25 a** will support the design of experiments of the above-described project and will participate throughout the duration of the **CM-137-25** project to conduct statistical analysis on all test data. At the halfway point of the **CM-137-25** test program, some statistical analysis will be conducted to determine how the program is going. Complete statistical analysis will be conducted on completion of the test program.

5. **Scope of Work: Design of Experiments**

- Develop a design of experiments to maximize the vehicle power and performance data which provides a 95% confidence level
- Determine how many tests on each fuel-vehicle-altitude combination should be run
- Determine how many repeats on each fuel day after day should be conducted
- If fuel changes should be made to acquire an informative new data point that elucidates the relationship between fuel octane, altitude, and vehicle performance.
- Validate that 6-10 vehicles and 3 fuels will generate an appropriate model as described in section 7c.
    a. Recommend additional fuel parameters that may be required to support modeling. E.g. fuel octane rating sensitivity, fuel distillation profile.

6. **Scope of Work: General Analysis**

a. Identification of any outlier or potentially invalid data points not previously flagged by the test laboratory, using statistical analysis or best industry practices. Contractor to identify possible outliers only using established statistical methods; All data is expected to be compliant with procedures specified in 40 CFR 1065 and 1066. No data is expected to be excluded, and the decision to exclude any data points from the analysis must be reviewed and approved by CRC.
b. Analysis and comparison of any redundant measurements to ensure data quality, such as emissions tests used as bookends pre and post performance testing, repeat transient runs, and repeat steady state runs, etc.
c. Analysis of acceleration time, transient power, and steady state power evaluating the effects of fuel AKI should be included.
d. Assess if test-to-test variability meets acceptable industry standards.
e. Examine potential sources of variability, including repeat tests, driver, vehicle, fuel, temperature, altitude, and test cycle.

f. Analysis of existing contractor data that may demonstrate if long-term drift / repeatability and driver variation is observed in the emissions measurements based on repeat measurements from the same vehicle (the so-called "golden bee" vehicle) over a 6-12 month or longer period, compare with fuel and vehicle testing results from this program. Determine if long-term, repeat emissions measurements are in statistical control and calculate repeatability for key emissions metrics.
g. Compilation of all predictors and results into a unified table in XLS format.

7. **Scope of Work: Statistical Analysis**

a. Identification of any co-linearities and property groupings in fuel properties, altitude, or vehicle features, for example using Pearson correlation coefficient, principal component analysis (PCA), or other appropriate methodology proposed by contractor.

b. Use of regularization with cross validation to perform feature selection (e.g. fuel property, altitude, vehicle technology, temperatures, test cycle, driver) or other appropriate statistical or machine learning method – to identify and down-select features to be used for prediction of vehicle power and acceleration from fuel properties and detailed composition (e.g., LASSO regularization).
    i. An appropriate regularization technique should be used to select the fuel/vehicle/test conditions which best correlate with measured power, among many features with multiple collinearities.
    ii. The method should also be able to identify if no specific fuel, altitude, or vehicle effects are observed among properties considered, or if the predictive power of one feature is indistinguishable from another due to collinearity and test-test variability.

c. Construction of a global model to describe vehicle acceleration or power as a function of vehicle type, fuel properties, altitude, test cycle, temperature, driver, OBD parameter, or other information provided to contractors.
    i. If possible, the contractor may use features selected in Section 5b to inform the model construction.
    ii. If any input data is to be normalized or processed prior to correlation/modelling the reason for pre-processing must be well-explained and justified, as well as identify how different pre-processing methodologies could change the results or conclusions.
    iii. Contractor may consider selecting an appropriate model which allows for quantification of factor effects (importance) and provides quantitative information which can be used to interpret the data and answer the questions in Paragraph 6. For example, a linear model or tree model may be suitable for this purpose. The model may include interaction terms if deemed appropriate, but care should be taken not to overfit the data.

    iv. In general, in modelling the data, contractor should use established methodologies to construct a parsimonious model and determine if the data is being over-fitted. Contractors should evaluate the precision and predictive capability of the model and assess if different modelling approaches or assumptions result in

different conclusions regarding the impact of various vehicle or fuel characteristics.

d. Identification of any physical causes of aberrant (extremely high or low) test results for repeat measurements, for example dynamometer metric, vehicle energy metric, or OBD parameter.

e. Identification of the need for additional testing (additional repeats, vehicles, or fuels)

8. **Scope of Work: Data Interpretation and Reporting**

Contractor to use modelling and analysis from (section 5) appropriate statistical methods to answer the following questions based on the data collected in this project:

a. What percentage of acceleration time or measured power variability can be attributed to each of the following:
   i. Random test to test variation
   ii. Driver
   iii. Vehicle characteristics
   iv. Fuel characteristics
   v. Altitude
   v. Test cycle
   vi. Temperature

b. Do the test results demonstrate that any single fuel property can consistently predict acceleration and power across all vehicles, test cycles, drivers, altitude, and temperatures?

c. Do the test results demonstrate that any single vehicle or measured OBD parameter can consistently be correlated to higher or lower acceleration and power across all test fuels, test cycles, drivers, altitude, and temperatures?

d. Considering variability in testing and co-linearities in properties, can any of the fuel properties considered in this work be said to consistently have a greater impact acceleration and power than the other properties at a statistically significant level?

e. To what extent can acceleration and vehicle power be reduced or increased with each of the following:
   i. Fuel selection in general
   ii. Fuel characteristic, to the extent possible given data size and collinearities
   iii. Vehicle selection in general
   iv. Vehicle characteristic, to the extent possible given data size and collinearities
   v. Measured parameter (e.g. from OBD)
   vi. Test cycle
   vii. Altitude
   vii. Temperature
   viii. Driver

f. The objective of the analysis is not to "find" significance where none exists. A negative result in which no significant effects are observed, in which multiple co-linear effects cannot be deconvoluted, or in which the data is poorly modeled, are all perfectly acceptable--so long as the analysis is comprehensive and the results can be clearly explained.

g. The analysis should seek to be introspective, reflective, and skeptical. It should aim to understand and communicate the confidence with which any conclusions can be made, and the extent to which different statistical models, approaches, or assumptions could skew the overall conclusions.

Reporting

a. The final report should thoroughly document the analysis conducted and described in Paragraphs 4-6 above, including assumptions, sources of error, or selection of methods which could alter the findings significantly. Include a brief definition/description of all statistical terms used so the report may be understood by those with a scientific/technical background but not familiar with statistical terminology/lingo. Contractor performing vehicle testing will provide sections for the final report detailing findings from vehicle check-in/check-out, test facility setup, and technical findings.

b. The final report should be a stand-alone document, not referring to any monthly or interim reports. The final report should be in CRC standard report format, not presentation format.

c. Depending on the final program schedule, the contractor may be requested to issue an interim report. This interim report would be structured in the format of a final report and would address all vehicles that had completed testing to that point.

d. A robust analysis of all test results is a key deliverable from this project. The contractor will update CRC with any changes to its approach to analyzing results based on initial findings.

e. Further, an "easy to digest" executive summary no more than two pages long is another key deliverable of the final report. Key figures should be included in the executive summary highlighting key findings.

f. The final report should include an attached excel worksheet with the results compiled for each vehicle, fuel, and each valid test cycle. If any invalid tests are identified in the analysis these should be mentioned in the final report.

Project Management

CRC and its project technical panel will provide management and oversight for this project. These entities are here after referred to collectively as the project sponsor.

Deliverables

The statistician will deliver an interim report detailing the design of experiments for work to be conducted as CRC Project **CM-137-25**. After initiation of Project **CM-137-25**, the statistician will be required to call in on all the project calls to help make decisions as the project progresses as well as make sure they understand all the data as it is being taken. As outlined in the subsequent "Exhibit" section, the contractor should submit monthly reports in addition to the draft and final reports. Monthly reports should contain all data acquired during the report month using the scan tool shown in MS Excel chart format when appropriate. Check-in/checkout emissions test results and notes should also be included. Depending on the final program schedule, the contractor may be requested to issue an interim report. This interim report would be structured in a format like the final report and would address all vehicles that had completed testing to that point.

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 five (5) 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.