State of California
AIR RESOURCES BOARD

RESEARCH PROPOSAL

Resolution 09-17

February 26, 2009

Agenda Item No.: 09-2-2

WHEREAS, the Air Resources Board has been directed to carry out an effective research program in conjunction with its efforts to combat air pollution, pursuant to Health and Safety Code sections 39700 through 39705;

WHEREAS, a research proposal, number 2673-263, entitled “Integrated Physical, Chemical and Optical Measurements of Heavy-duty Diesel Emissions at NASA AMES Full Scale Wind Tunnel,” has been submitted by the University of California, Davis;

WHEREAS, the Research Division staff has reviewed and recommended this proposal for approval; and

WHEREAS, the Research Screening Committee has reviewed and recommends for funding:

> Proposal Number 2673-263 entitled “Integrated Physical, Chemical and Optical Measurements of Heavy-duty Diesel Emissions at NASA AMES Full Scale Wind Tunnel,” submitted by the University of California, Davis, for a total amount not to exceed $419,917.

NOW, THEREFORE BE IT RESOLVED that the Air Resources Board, pursuant to the authority granted by Health and Safety Code section 39703, hereby accepts the recommendation of the Research Screening Committee and approves the following:

> Proposal Number 2673-263 entitled “Integrated Physical, Chemical and Optical Measurements of Heavy-duty Diesel Emissions at NASA AMES Full Scale Wind Tunnel,” submitted by the University of California, Davis, for a total amount not to exceed $419,917.

BE IT FURTHER RESOLVED that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and contracts for the research effort proposed herein, and as described in Attachment A, in an amount not to exceed $419,917.

I hereby certify that the above is a true and correct copy of Resolution 09-17, as adopted by the Air Resources Board.

/s/

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Monica Vejar, Clerk of the Board

## ATTACHMENT A

### "Integrated Physical, Chemical and Optical Measurements of Heavy-duty Diesel Emissions at NASA AMES Full Scale Wind Tunnel"

**Background**

Understanding the health and climate impacts of mobile sources and developing the corresponding control technologies requires that laboratory measurements of vehicle emissions represent conditions of actual use. However, there exists a disconnect between particulate emissions measured on-road and in the laboratory. This discrepancy is particularly pronounced for ultrafine particles (<100 nanometers). The introduction of after-treatment devices to comply with the stringent new PM and $NO_X$ emissions standards for heavy duty diesel vehicles in California adds complexity to the process of ultrafine particle formation. Optical properties, and hence the climate impact, of diesel exhaust are likely to change as well.

**Objective**

This study will quantify ultrafine particle formation/growth potentials, the aging process of exhaust plumes, and the optical properties of exhaust in a NASA full-scale wind tunnel, which is a controlled laboratory setting with realistic atmospheric dilution conditions. This study also provides a platform for evaluation of real-time PM measurement instruments, and potentially a platform for toxicity studies.

**Methods**

Comprehensive emission tests for diesel vehicles, representative of the current and future California fleet, will be conducted in the largest wind tunnel in the world, located at NASA Ames Research Center in Moffett Field, California. The wind tunnel has a test cross section of 80 x 120 ft and can provide a testing length of over 180 ft without side wall interference. This wind tunnel emission test marries the advantages of both the laboratory (repeatable driving cycles and well-characterized diluent properties) and on-road (natural dilution) emission tests, while avoiding the main shortcomings in either method. Plume dilution rates will be determined by using $CO_2$ or CO as an inert tracer, which also allows a mapping of the plume trajectories. The physical, chemical and optical characteristics of plumes will be measured at 8 sampling points between the exhaust pipe and 180 ft downwind under different dilution ratios, temperature and relative humidity. The analytical instruments will be housed in two electric lift platforms, which move along the plume under control by the staff. The data collected under different conditions, i.e., vehicle types, cycles, dilution ratios, dilution rates, temperature, and relative humidity, will be stored in a relational database to permit rapid and easy retrieval for researchers participating in this project.

**Expected Results**
Results will be summarized in three forms, plume dispersion profiles, nanoparticle formation potentials, and plume evolution profiles. A final report consists of detailed description of the experimental procedures, all relevant test data, description of the statistical and other analytical tools used in the assessment, and detailed analysis. All data (raw and analyzed) will be made available to ARB investigators in an appropriate format in addition to the database. Findings from this project will be jointly published in peer-reviewed journals and presented in national and international conferences.

**Significance to the Board**
This study will address specific processes of ultrafine particle formation and growth under real world dilution conditions, leading to improved understanding of mechanisms, and improved inputs for models that evaluate the impact of diesel emissions on air quality and public health.

**Contractor:**
University of California, Davis (UCD)

**Contract Period:**
24 Months

**Principal Investigators (PIs):**
Dr. Anthony Wexler (PI), Drs. K. Max Zhang and Anthony Strawa (Co-PIs)

**Contract Amount:**
$419,917

**Cofunding:**

**Basis for Indirect Cost Rate:**
UCD is applying the standard 10% indirect cost rate applicable to interagency agreements. Cornell University has agreed to the same ten percent indirect cost rate. This is a much lower rate than can normally be obtained from private entities, NASA Ames Research Center has also agreed to the ten percent indirect cost rate.

**Past Experience with this Principal Investigator:**
Dr. Wexler and Dr. Zhang have been PIs and/or co-PIs for several Air Resources Board funded projects. Their performance on those projects has been excellent and results from those projects have led to many highly impacted publications. Dr. Strawa, research scientist at NASA Ames, is a well-known expert in aerosol and cloud processes and their effects on climate.

**Prior Research Division Funding to UCD:**

| Year | 2008 | 2007 | 2006 |
|---|---|---|---|
| Funding | $894,566 | $1,002,293 | $1,891,281 |

# B U D G E T S U M M A R Y

Contractor: University of California, Davis

Integrated Physical, Chemical and Optical Measurements of Heavy-duty Diesel Emissions at NASA AMES Full Scale Wind Tunnel

| **DIRECT COSTS AND BENEFITS** | | | |
|---|---|---|---|
| 1. | Labor and Employee Fringe Benefits | $ 18,748 | |
| 2. | Subcontractors | $ 393,917[1] | |
| 3. | Equipment | $ 0 | |
| 4. | Travel and Subsistence | $ 0 | |
| 5. | Electronic Data Processing | $ 0 | |
| 6. | Reproduction/Publication | $ 0 | |
| 7. | Mail and Phone | $ 0 | |
| 8. | Supplies | $ 343 | |
| 9. | Analyses | $ 0 | |
| 10. | Miscellaneous | $ 0 | |
| | Total Direct Costs | | $413,008 |
| **INDIRECT COSTS** | | | |
| 1. | Overhead | $ 6,909 | |
| 2. | General and Administrative Expenses | $ 0 | |
| 3. | Other Indirect Costs | $ 0 | |
| 4. | Fee or Profit | $ 0 | |
| | Total Indirect Costs | | $6,909 |
| **TOTAL PROJECT COSTS** | | | **$419,917** |

[1] Dr. K. Max Zhang from Cornell University requests $210,000 for this project. The subcontract will cover the mobile dynamometer service from West Virginia University; support a full-time post-doctoral researcher for Year 1, a half-time graduate research assistant for Year 2, travel expenses to NASA Ames, and a fraction of Dr. Zhang's academic year efforts.

Dr. Strawa requests $183,917 for this project. The subcontract will cover the cost of operating the wind tunnel, integration costs, and 0.1 FTE of Dr. Strawa's efforts.

**Attachment 1**

# S U B C O N T R A C T O R S' B U D G E T S U M M A R Y

Subcontractor: K. Max Zhang-Cornell University

Description of subcontractor's responsibility: Cornell University will be responsible for conducting dynamometer experiments to measure the physical and chemical characteristics of PM from heavy–duty diesel vehicles, conducting data analysis, and preparing quality progress reports, final report as well as manuscripts to be submitted for publication in peer-reviewed journals.

| **DIRECT COSTS AND BENEFITS** | | | |
|---|---|---|---|
| 1. | Labor and Employee Fringe Benefits | $ 88,493 | |
| 2. | Subcontractors | $ 0 | |
| 3. | Equipment | $ 0 | |
| 4. | Travel and Subsistence | $ 2,416 | |
| 5. | Electronic Data Processing | $ 0 | |
| 6. | Reproduction/Publication | $ 0 | |
| 7. | Mail and Phone | $ 0 | |
| 8. | Supplies | $ 0 | |
| 9. | Analyses | $ 0 | |
| 10. | Miscellaneous | $ 100,000[1] | |
| | Total Direct Costs | | $190,909 |
| **INDIRECT COSTS** | | | |
| 1. | Overhead | $ 19,091 | |
| 2. | General and Administrative Expenses | $ 0 | |
| 3. | Other Indirect Costs | $ 0 | |
| 4. | Fee or Profit | $ 0 | |
| | Total Indirect Costs | | $19,091 |
| **TOTAL PROJECT COSTS** | | | **$210,000** |

**Attachment 2**

[1] Includes the cost for transportation, rental and operation of the mobile heavy-duty dynamometer from West Virginia University to NASA Ames wind tunnel during the course of testing. The personnel from West Virginia University will be recruited for maintaining, operating the mobile heavy-duty dynamometer.

# S U B C O N T R A C T O R S' B U D G E T S U M M A R Y

Subcontractor: A. W. Strawa-NASA Ames Research Center

Description of subcontractor's responsibility: NASA Ames Research Center will lead the effort to construct a sampling platform for the heavy-duty vehicle and conduct dynamometer experiments to measure the physical, chemical and optical characteristics of PM. Dr. Strawa will coordinate with the National Full-Scale Aerodynamics Complex (NFAC) staff on integrating the test equipment into the wind tunnel and will assist in the oversight of the entire program, and assist in the preparation of a report/manuscript documenting the results. NASA will also be responsible for the optical and physical measurement in the tunnel.

| **DIRECT COSTS AND BENEFITS** | | | |
|---|---|---|---|
| 1. | Labor and Employee Fringe Benefits | $ 17,596 | |
| 2. | Subcontractors | $ 0 | |
| 3. | Equipment | $ 0 | |
| 4. | Travel and Subsistence | $ 721 | |
| 5. | Electronic Data Processing | $ 0 | |
| 6. | Reproduction/Publication | $ 0 | |
| 7. | Mail and Phone | $ 0 | |
| 8. | Supplies | $ 14,000 | |
| 9. | Analyses | $ 0 | |
| 10. | Miscellaneous | $ 133,200[1] | |
| | Total Direct Costs | | $165,517 |
| **INDIRECT COSTS** | | | |
| 1. | Overhead | $ 0 | |
| 2. | General and Administrative Expenses | $ 16,552 | |
| 3. | Other Indirect Costs | $ 1,848 | |
| 4. | Fee or Profit | $ 0 | |
| | Total Indirect Costs | | $18,400 |
| **TOTAL PROJECT COSTS** | | | **$183,917** |

[1] Includes the cost for rental and operation of the NASA Full-scale Aerodynamic Facility (NFAC) during the course of testing.