



Project 069 Transitioning a Research nvPM Mass Calibration Procedure to Operations

Missouri University of Science and Technology and Aerodyne Research Inc.

Project Lead Investigator

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University Participants

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- PI: Philip D. Whitefield, Chancellor's Professor of Chemistry
- FAA Award Number: 13-C-AJFE-MST Amendments: 014
- Period of Performance: June 5, 2020 to June 4, 2021
- Task:
 - Investigate the validity of the centrifugal particle mass analyzer (CPMA) mass calibration research approach for non-volatile particulate matter (nvPM) certification measurement systems. The assessment will extend across all nvPM mass ranges encountered during certification tests. The primary goal will be the successful transitioning of the research methodology to operations

Project Funding Level

The total amount of funding from FAA is \$846,707. The matching funding of \$846,707 is from the Swiss Federal Laboratories for Materials Science and Technology (EMPA).

Investigation Team

- Professor Philip Whitefield, Missouri University of Science and Technology
- Steven Achterberg, research technician, Missouri University of Science and Technology
- Max Trueblood, research technician, Missouri University of Science and Technology
- Dr. Richard Miake-Lye, subcontractor, Aerodyne Research Inc.
- Dr. Robert Howard, sub-contractor, Arnold Engineering Development Center (AEDC), USAF

Project Overview

This project is designed to investigate the validity of the CPMA mass calibration research approach. The assessment will extend across all nvPM mass ranges encountered during certification tests. The primary goal will be the successful transitioning of the research methodology to operations. The project will begin with a laboratory assessment leading to a dedicated small engine as the test source at the USAF Arnold Engineering Development Complex.

The challenge mass devices for calibration (micro-soot sensor (MSS), laser-induced incandescence (LII), and cavity attenuated phase shift (CAPS)) will be provided by the North American Reference nvPM Measurement System and ancillary equipment along with the CPMA and other needed instruments such as a DMS500, and an aerosol mass spectrometer (AMS) and CAPS.

Task 1 – Investigate the Validity of the Centrifugal Particle Mass Analyzer (CPMA) Mass Calibration Research Approach for nvPM Certification Measurement Systems

Missouri University of Science and Technology

Objective

Acquire the components of a CPMA-based mass calibration system similar to that described in SAE E31 discussion paper DP-32 (presented by Dr. G. Smallwood) from the annual committee meeting June 17-21, 2019, Saclay, France. Assemble system and evaluate its performance.

Research Approach

Subtask 1

Acquire the components of a CPMA-based mass calibration system similar to that described in SAE E31 discussion paper DP-32 (presented by Dr. G. Smallwood) from the annual committee meeting June 17-21, 2019, Saclay, France.

Subtask 2

Assemble and test the CPMA-based mass calibration system performance, at Missouri University of Science and Technology’s laboratories using a miniature combustion aerosol standard (mini-CAST) as the nvPM generation source (Figure 1).

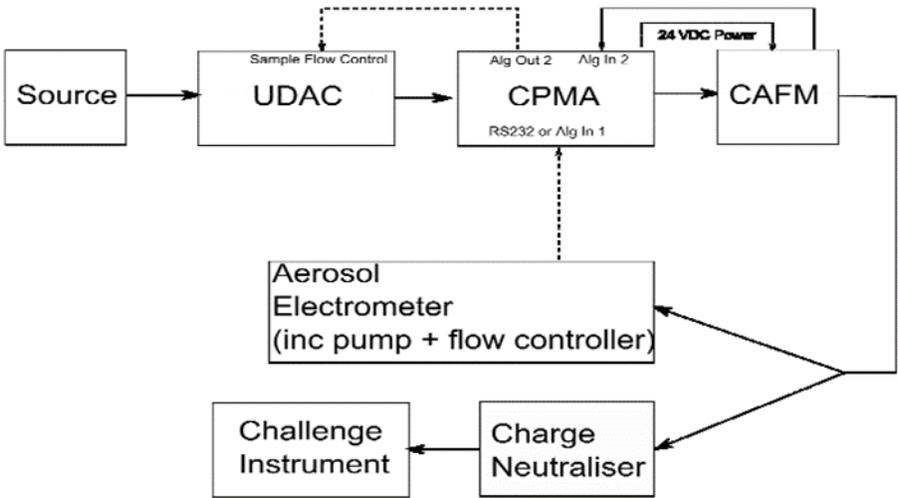


Figure 1. Schematic diagram of the CPMA-based mass calibration system.

Subtask 3

Investigate the validity of the CPMA mass calibration research approach across all nvPM mass ranges encountered during certification tests to successfully transition the methodology to operations.

Subtask 3a

Deploy (transport and install) the North American Reference System (NARS), including the CPMA-based mass calibration system and ancillary diagnostic suite, including the Air Force AVL nvPM measurement system, to engine testing facilities at Arnold Air Force Base, TN. Specifically, these engine testing facilities will include the J85 turbojet and a gas-turbine-based “start cart” as nvPM sources.



Subtask 3b

Undertake performance evaluations of the CPMA-based mass calibration system, surveying across all mass ranges using the start cart as the nvPM source and compare these results with concomitant mass calibration data acquired using the SAE E-31 OCEC-based mass calibration methodology.

Subtask 3c

Undertake performance demonstration by performing a mock-certification test on the J85 engine where the calibration will include the standard elemental carbon/organic carbon (EC/OC) analysis, as well as the CPMA-based calibration system described in document DP-32.

Subtask 3d

De-couple the diagnostic suites from the Arnold AFB engine facilities and transport them back to Missouri and Massachusetts.

Subtask 4

Analyze and interpret the data gathered in Tasks 2 and 3.

Subtask 5

Prepare and deliver a final report.

Milestones

- Components have been purchased and delivered.
- A straw man test protocol has been proposed and is under evaluation.
- An advisory team has been assembled to help with the evaluation of the various stages of this project. The team includes advisors from the Environmental Protection Agency (EPA) and the National Research Council (NRC) Canada. It meets virtually on a bi-weekly basis.

Major Accomplishments

Having acquired the components, work on Tasks 2 and 3 is being pursued. Figure 2 is a schematic diagram of the source evaluation system exploring the dynamic range in nvPM mass concentration that can be employed in the laboratory-based studies in Task 2

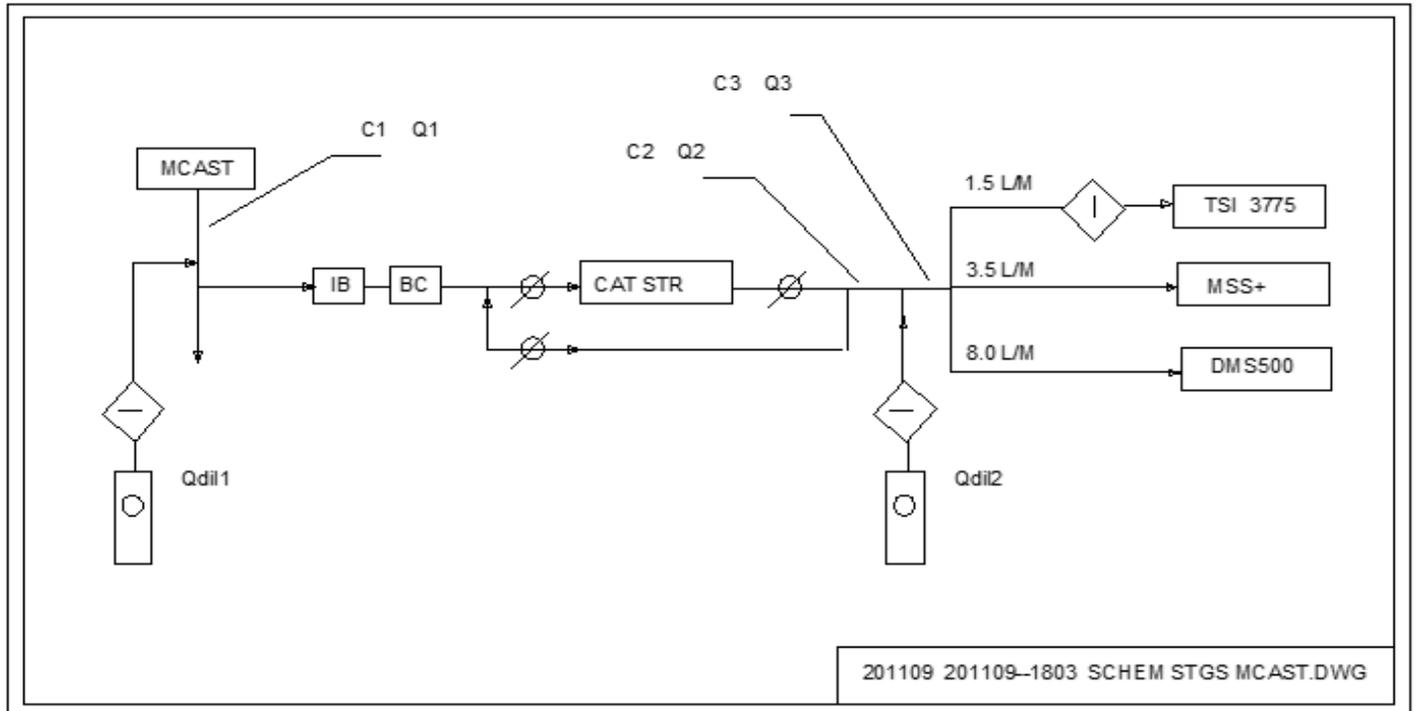


Figure 2. Schematic diagram of source evaluation studies in Task 2.

Publications

None

Outreach Efforts

Project 069 plan and progress was delivered as a recorded presentation at the virtual ASCENT advisory board meeting in April 2020.

Awards

None

Student Involvement

There are no graduate students currently assigned to this project. The restrictions imposed by the COVID-19 pandemic have prohibited the participation of undergraduate students.

Plans for Next Period

Continue to pursue the statement of work from Subtask 2 to Subtask 5 as described above.