

ASCENT Project 69



Transitioning a Research nvPM Mass Calibration Procedure to Operations

Missouri University of Science and Technology

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Cost Share Partner: EASA and EMPA

Objective:

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 Benefits:

- This project will validate an advanced calibration method that reduces the current time constraints imposed for annual nvPM mass instrument calibration.
- The method will reduce measurement uncertainty during certification.
- Once successfully demonstrated, the method can be implemented in ICAO Annex 16 Vol. II.
- Currently each engine emissions certification test costs approximately \$500k, the implementation of this new method will reduce (~50%) instrument calibration costs.
- This approach will provide in-the-field real-time performance check of the nvPM mass instrument during certification testing, improving confidence in the PM mass concentration measurements.

Research Approach:

- Acquire instruments for use with the CPMA calibration system
- Develop a suitable sampling and test configuration for evaluating the CPMA-based nvPM mass calibration using laboratory aerosol sources at MS&T
- 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
 - Deploy the measurement system, to engine testing facilities at Arnold AFB, TN. Specifically, these engine testing facilities will include the J85 turbojet and a gas-turbine-based “start cart” as nvPM sources.
 - Evaluate the performance 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.
 - Undertake performance demonstration by performing a mock-certification test on the J85 engine where the calibration will include the standard EC/OC analysis, as well as the CPMA-based calibration system.
- Analyze and interpret the data gathered and deliver a final report that can be used by SAE E31 to update ARP 6320 and by ICAO to update Annex 16 Vol.II.

Major Accomplishments (to date):

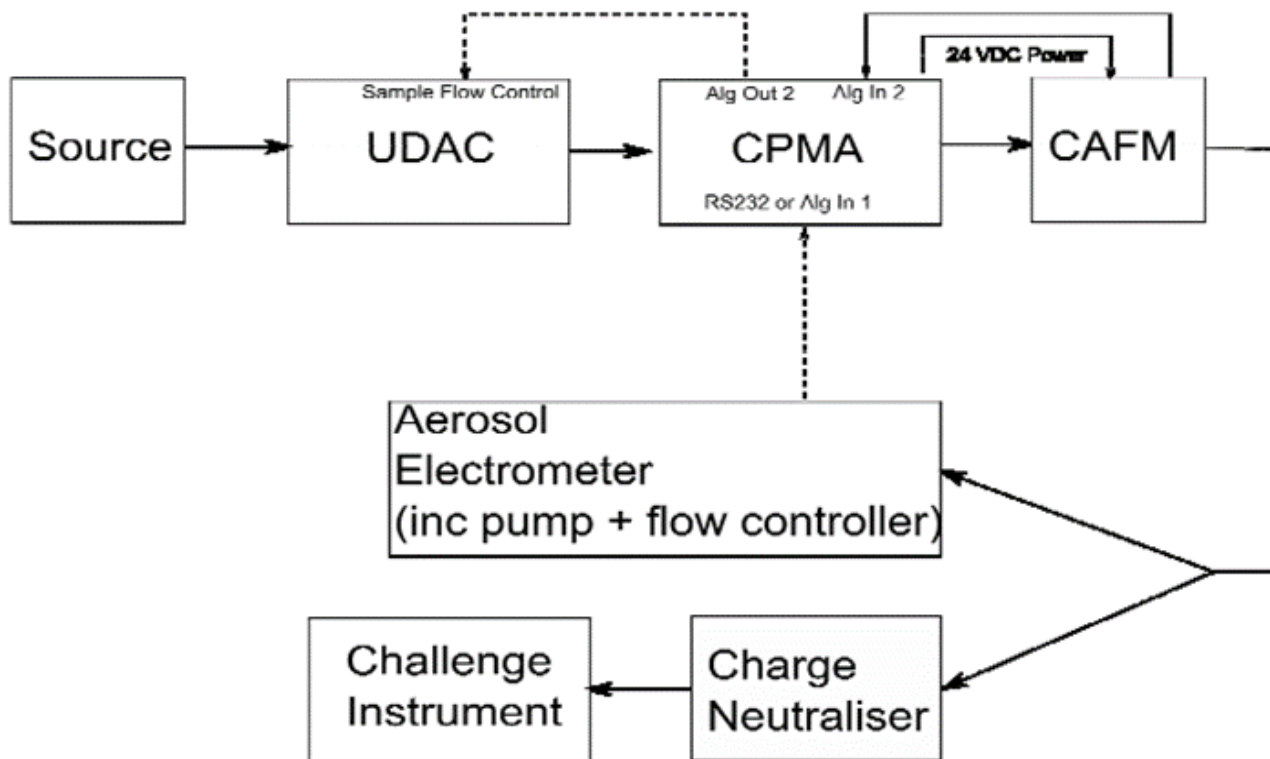
- CPMA Calibration System Assembled
- A sampling and test protocol has been proposed and is under evaluation
- Laboratory-based performance assessment experiments are underway
 - Preliminary results are encouraging

Future Work / Schedule:

- Complete Laboratory Tests and develop a Robust Calibration System Configuration
- Tests using gas turbine start cart and parallel reference measurements
- Tests using J85 gas turbine engine
- Based on the results, develop a standardized in situ CPMA calibration protocol for nvPM mass

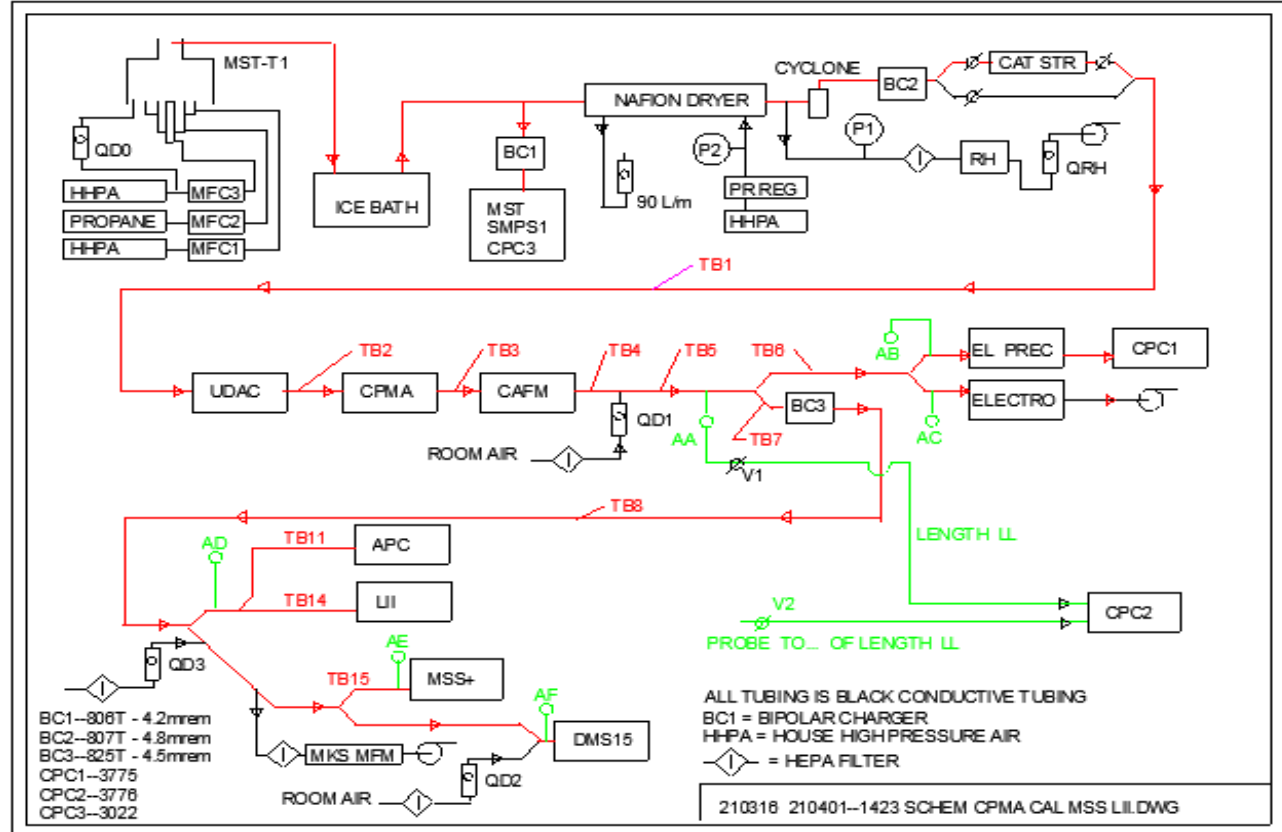
Schedule Proj 69	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q4 2022
Subtask 2					
Subtask 3					
Subtask 4					
Subtask 5					

Schematic of CPMA Mass Standard System



Laboratory-based Performance Assessment

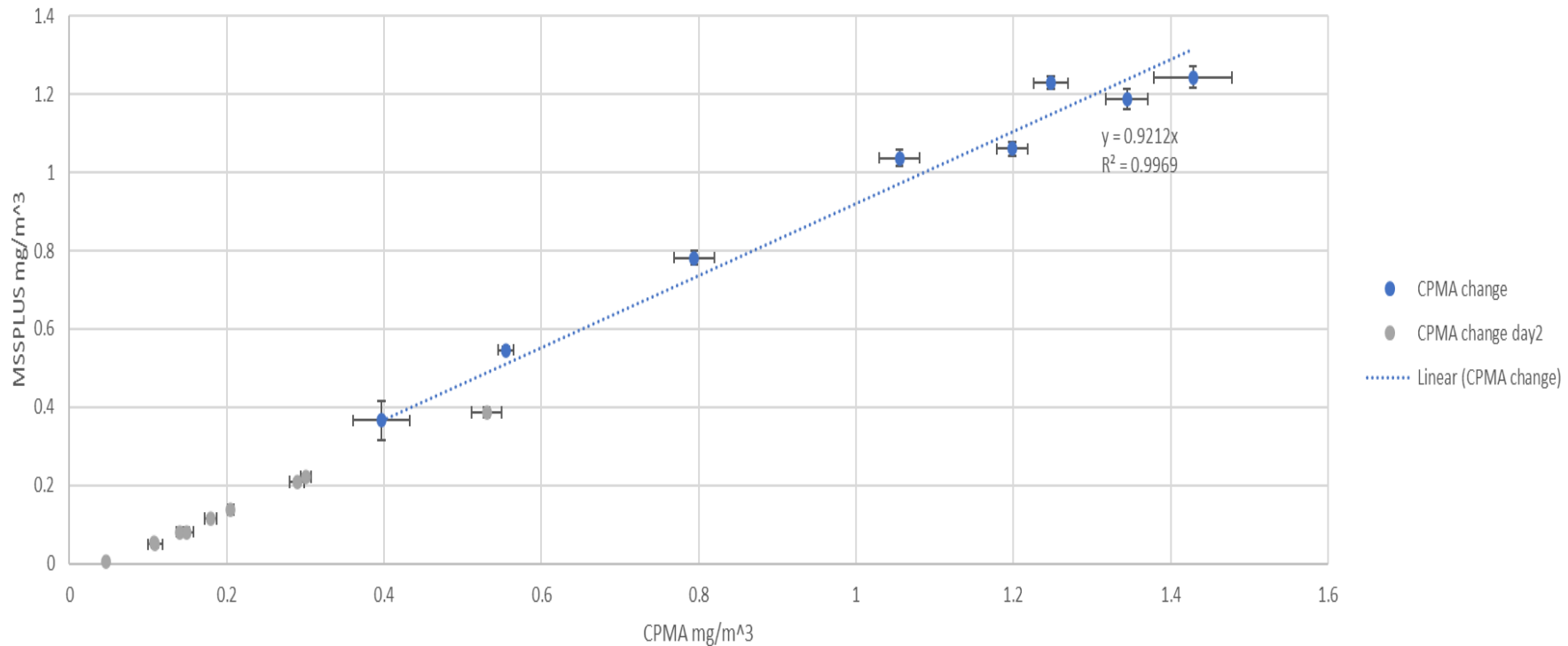
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TB2	165	3/16	~4
TB3	22	3/8	~4
TB4	4	3/8	~4
TB5	8	3/8	15 - 17
TB6	2	3/8	~1.3
TB7	2	3/8	13.7 - 15.7
TB8	77	3/8	13.7 - 15.7
TB9	9	3/8	~10
TB10	144	3/8	~8
TB11	45	3/8	~4.8
TB12	7	3/8	~4
TB13	128	3/8	~4
TB14	2	3/8	5
TB15	4	3/8	4



Calibration of MSS+ Mass Conc. Diagnostic for NVPM



MSSPLUS vs CPMA



Projected Benefits



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- The method will reduce measurement uncertainty during certification.
- Once successfully demonstrated, the method can be implemented in ICAO Annex 16 Vol. II.
- Currently each engine emissions certification test costs approximately \$500k, the implementation of this new method will significantly reduce instrument calibration costs.
- This approach will provide in-the-field real-time performance check of the nvPM mass instrument during certification testing, improving confidence in the PM mass concentration measurements.

Investigative and Advisory Teams



Investigation Team

- Philip Whitefield, Principal Investigator, 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
- Richard Miake-Lye, Subcontractor, Aerodyne Research Inc.
- Robert Howard, Subcontractor, Arnold Engineering Development Center (AEDC), USAF

Advisory Team

- EPA – Bob Gianelli, Jeff Stevens, John Kinsey
- NRC – Greg Smallwood, Joel Corbin, Prem Lobo

Other Collaborators

- U of Minnesota David Kittelson
- John Kinsey
- U of Alberta Jason Olfert
- Cambustion – John Symmonds