Project 2
Non-Volatile PM Emissions Measurements

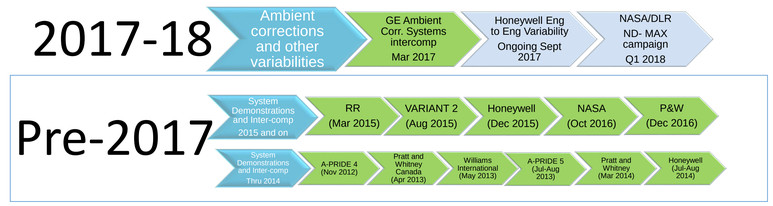
Motivation and Objectives

❑The FAA along with the EPA, NASA, Transport Canada, EASA, and FOCA has committed to underwrite studies, that address research needs that related to corrections for ambient conditions and fuel properties in order to establish a regulatory standard to nvPM number and mass-based emissions.

❑**This work is driven by the critical needs toward standardizing non-volatile PM measurement reporting for regulatory purposes.**

- **Long-term objectives**
  - Balloted SAE ARP specifying standardized nvPM measurement methodology.
  - Application of the standardized nvPM Measurement system to:
    - evaluate and characterize engine to engine variability
    - develop international standard atmosphere (ISA) corrections for NVPM measurements.
    - Assess fuel property correlations with nvPM emissions
  - Develop a line-loss correction methodology using measured mass and number concentrations
  - Inform ICAO CAEP WG3 on results of methodology development and measurements
- **Near term objectives**
  - Standardized sampling methodology performance evaluation:
    - Continue laboratory and field studies building upon SAMPLE III.2, and A-PRIDE** 2,4 and 5 studies and VARIANT 1 & 2 and MANTRA
  - Close coordination with and feedback from SAE E-31 committee
  - Common agreement on way forward
  - Demonstrations and Inter-comparisons of AIR6241/Annex 16 appendix 7 compliant systems
    - **Demonstrations and inter-comparisons of North American mobile reference system at OEM facilities and other test venues. From all of these studies data is shared with E31 committee for systems evaluation purposes.**

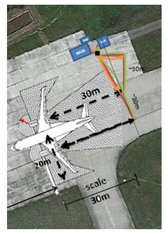
Schedule and Status



Task	Task Description	Status	Outcome
Task 1	Ambient conditions corrections for nvPM. Joint activity with GEAE	Completed April 2017	Results will be provided to ICAO CAEP WG3 by November 2017
Task 2	Engine to Engine Variability and Derivation of Characteristic nvPM Emissions. Joint activity with Honeywell Aerospace	Ongoing awarded Sept. 2016	Testing of 25 engines completed. Results will be provided to ICAO CAEP WG3 by November 2017
Task 3	Ground-based Emission Measurements in Support of the ND-MAX Campaign	Ongoing awarded August 2017	Testing scheduled for January 2018. The data will be used to inform an ongoing cruise nvPM modelling effort

Results and Discussion

ND-MAX Campaign
January 2018

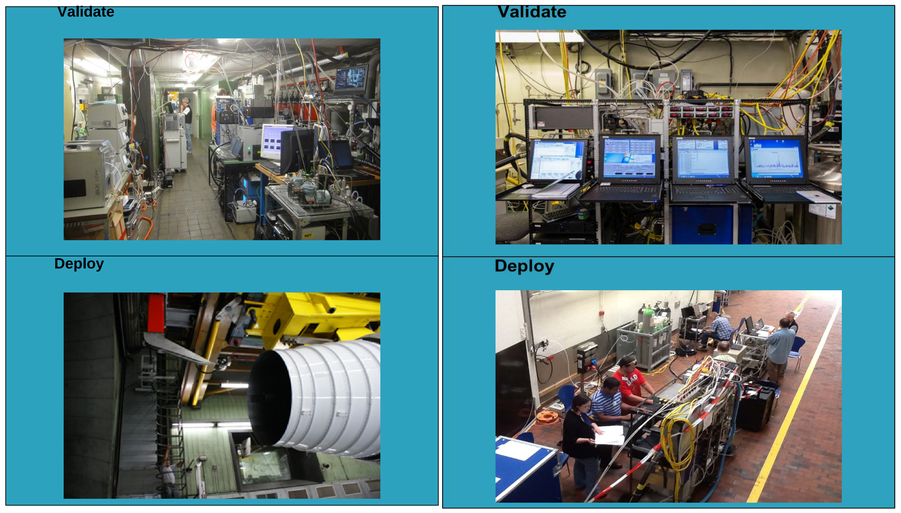


- 6 to 8 flights will be conducted from Ramstein to sample emissions and contrails created by the DLR A320 burning standard and alternative fuels. Flight hours will be added to sample emissions from Lufthansa B747 aircraft departing from Frankfurt. Measurements will include turbulence parameters, airframe stresses, ambient conditions and cirrus microphysical and optical properties.
- **Ground tests will be conducted in Germany to measure A320 emissions using the FAA's "North American Reference System" along with the NASA and DLR systems used to characterize emissions in previous tests.**

Anticipated Outcomes

- DLR-ATRA as source and NASA DC-8 as chaser will allow to reach true cruse speed conditions. This should enable the teams to answer the question: Are the previous findings (ACCESS & ECLIF) valid and of same order when flying under commercial aviation-relevant conditions?
- Use of Sustainable Alternative Jet Fuel (SAJF)
- Combined DLR-NASA instrumentation on the chaser (NASA DC-8) forms a comprehensive and systematic emissions and contrails characterization platform, which would not be possible alone.
- **Combined DLR-NASA-FAA instrumentation for ground tests**
- More data in the far-field with single fuels to improve statistics and reduce errors. Reliable data with SAJF are needed.
- Opportunity to compare engine technologies.
- Measure contrails optical depth.

Methods and Materials



Interfaces and Communications

- External
  - Briefings to SAE E-31 PM sub-committee at SAE E31 Annual Meeting in Halifax July 2017
  - Briefings at the AEC roadmap Meeting May 2017
  - Paper presented at 21st ETH-conference on combustion generated nanoparticles
  - Working with OEMs
  - Working with NASA
  - Working with regulators (FAA, EPA, TC, EASA and FOCA)
- Within ASCENT
  - None to report at this time but expect significant interactions with other ASCENT projects and CLEEN based on the data collected to date and in the future.

References and Presentations

Publications:

No publications during this reporting period

Presentations at international meetings:

Three presentations were given based on the work funded through this project.

Authors: Whitefield, Hagen, and Lobo

Conclusions and Next Steps

Summary

Demonstrations, inter-comparisons and methodology validation for finalizing an Aerospace Recommended Practice (ARP) that is used for determining compliance with a new regulatory standard for aircraft engine nvPM. In total 12 campaigns have been completed and data gathered on at least 6 representative engine types. The data from these studies have been made available to ICAO CAEP WG3

- Next steps?
  - Continue close coordination with SAE E31
  - Review data, correlate, and build upon current knowledge with other programs i.e. SAMPLE III, A-PRIDE, VARIANT and MANTRA
  - Continue to Plan, prepare and execute engine demonstrations with OEMs
- Key challenges/barriers
  - Engine testing schedule slippage
  - Complex interaction with multiple stakeholders

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