AAFEX Status Report #10 – 29 January 2009

Primary Activities: Cold-phase FT fuel exhaust characterization; Anticipation of blend characterization run; APU exhaust characterization

Weather: 34 F at 7 am, dry with clear skies and slight northeasterly winds early, increasing to 10 to 15 knots after lunch.

********* See AAFEXers in action on the Dryden Photo website **************

ftp://ftp.dfrc.nasa.gov/incoming/photolab/DC-8/

Summary: Sleep-deprived participants were on site at 4 am for the second consecutive day of early morning testing. Today's schedule called for a cold-phase, FT fuel test early, then a 50/50 FT/JP-8 blend test to ensue at 11:00 am. Here's how it went.

- The FT test was a repeat of the previous afternoon's experiment at 20 F colder temperatures to assess the impact of ambient conditions on plume chemistry. For the first time, a full test matrix was completed without having to power or idle down the engines to repair or adjust sampling equipment. Results were similar to the earlier test in that the engine burning FT full produced lower emissions of black carbon and volatile aerosols than the engine burning JP-8. SO2 measurements provided by GRC suggested the FT fuel contained ~25 ppm S contaminants, which were probably introduced during shipping, handling, or by the failure to completely drain the aircraft tank of residual JP-8. In any case, nucleation mode particles were observed in the FT fuel exhaust at 30-m, which suggests that the particles were either composed of organic carbon or that even minor amounts of fuel sulfur can promote new formation under relatively cold conditions.

- To explore the effects of lube oil venting on engine particle emissions, the #3 inlet rake was translated in 2" intervals from 2" left to 8" right of the engine center line. AMS measurements indicated significant levels of oil at the +2", 0, -2", -4", and -6" positions, but relative clean samples at -8". Particle concentrations varied significantly at the oil contaminated positions, but were steady and much lower at -8". Further analysis is required to establish the implications of these observations.

- A blended fuel test was scheduled for 11:00 am, but NE winds picked up and became relatively strong before this hour. To prevent possible compressor stalls, the engines can't be run at high powers in cross- or tail-wind conditions situations. Because even higher NE winds were forecasted, we decided to conduct the first of two scheduled APU emission characterization runs. As shown in Figure 1, the group quickly cobbled together a sample inlets for the EPA trailer, GRC gas bench and common aerosol sampling groups and erected them just below the DC-8 APU exhaust, which is located on the aircraft's starboard side, just ahead of the wing root. Flow from the common inlet was diluted with dry N2 near the tip

and routed through the right 1-m aerosol valve box to the MST trailer and common sample distribution manifold (Figure 2). Gas samples were transferred undiluted through heated tubing to the GRC instruments for certification gas analysis, smoke number determination, and black carbon assay. EPA inlet air was diluted with dry N2 introduced through a Swagelok "T" about 3' below in the inlet tip then drawn through about 150' of ½" stainless tubing to instruments located in the EPA trailer. After a few adjustments to center the inlets within the core exhaust flow, about an hour's worth of data was recorded as the APU was run at minimum power (EGT=350 C) or was used to motor the #2 engine (EGT=610 C). Preliminary results indicate that the APU produces 5 to 10 times more black carbon mass per unit of fuel burned than the aircraft's CFM-56 engines do at take-off thrust (Figure 3).

- A meeting was scheduled to be held at 7:30 pm at the Residence Inn to decide whether weather predictions would be compatible with our sampling plans. Bruce obtained an early forecast from Scott (DFRC) that indicated winds would be relatively calm in the early morning; acting on this advice he informed the science team that the 5:30 am engine runs were a go and that there was no need for an evening confab. Several participants showed up anyway, and spent the early evening hours in serious debate over a range of scientific topics (Figure 4).

Figure 1. Reminiscent of our forefather's efforts to plant a flag on Iwo Jima, AAFEX participants struggle to erect a sampling stand beneath the DC-8 APU exhaust vent.

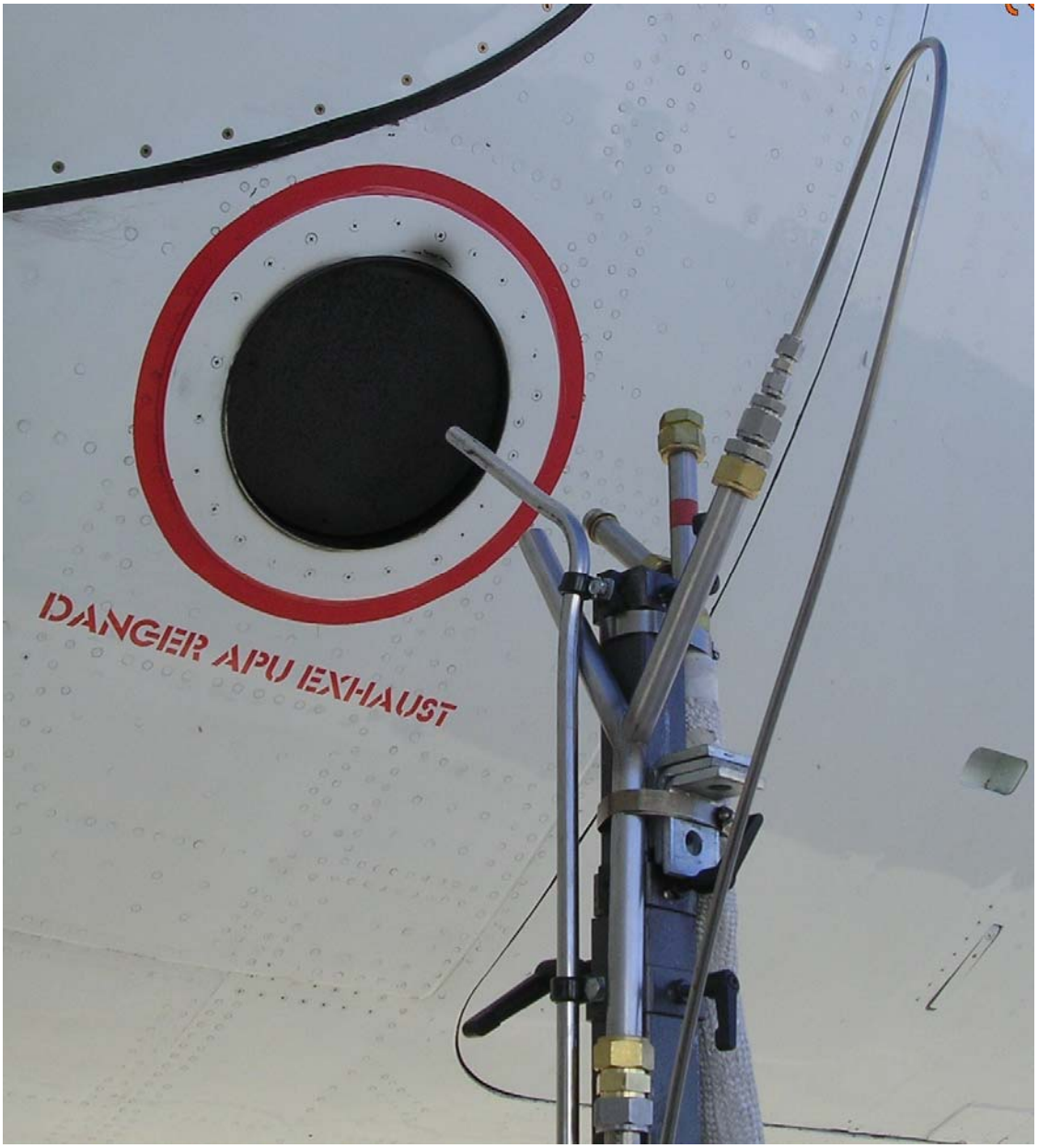

Figure 2. An elegant piece of engineering, the APU community inlet supports the EPA ½” probe, the common probe (3/4” stainless steel “Y” with dilution air injected down the rear fork) and the GRC gas probe (3/4” stainless “Y” with vertical leg capped).

Figure 3. Terry and Subrata (UCSD) are all smiles in anticipation of collecting milligram quantities of black carbon crud on the large quartz filters in their high-volume sampling box during the APU exhaust runs.

Figure 4. For some unknown reason, Robert loses focus after a very long day of work and an evening spent pouring over data…and other things.