AAFEX Status Report #9 – 28 January 2009

Primary Activities: Cold-phase JP-8 exhaust characterization run; warm phase FT1 run; data analysis

Weather: 28 F at 7 am, dry with clear skies and slight westerly winds. Temperatures warmed to near 60 F in the afternoon. Perfect weather for the intended test runs.

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

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

Summary: Participants were on site at 4 am to begin what turned out to be a 12 hour day with over 6 hours of engine runs. Two separate tests were conducted: a JP-8 characterization under cold conditions and a FT1 test during warmer conditions. The JP-8 test started at 6 am and extended until 9:30; the FT test ran from 12:40 (only 10 minutes late) to around 3:30 pm. All groups successfully recorded measurements during both runs. Some highlights of the day are described below.

- The DAOF group changed out N2 cylinders and added a second port-a-potty to our comfort facilities (Figure 1); shortages in both areas were starting to affect our test schedule and length of engine runs.

- With the first test run of the day, we finished characterizing standard JP-8 fuel. Previous measurements had shown that the fuel contained 1200 ppm S contaminant and we noted that sulfate particles nucleated very quickly within the exhaust plume as it cooled. By adding dry N2 dilution gas at the 30-m inlet tip to suppress line chemistry, we also gained further evidence that the sulfate particles most likely form in the plume during the few milliseconds of transport time between the engine exit plane and 30-m inlet. Downwind measurements continued to show relative high concentrations of sulfate aerosols. Winds picked up toward the end of the run, which caused the plume to miss the 200-m inlet at low power settings. Turbulent exhaust flow at high thrust levels caused the ¼" bolts holding down the 30-m instrument box lid to loosen and many backed out completely (Figure 2); the box lid began to flap up and down during the first 100% run. The test was halted and the box lid was re-secured with new bolts and lock washers.

- After the JP-8 run, fuel was transferred out of the #3 main tank and replaced with a Fischer Tropsch fuel produced by Shell from natural gas (FT1); JP-8 fuel remained on board to fuel the #2 engine. The #3 engine was started and operated at 30% thrust to burn out the remaining JP-8. Over a 10 minute period, SO2 levels measured at 1 m gradually decreased from 16 ppm to below 0.5 ppm and 30-m particle number densities decreased by a factor of 10 and shifted to smaller diameters. Measurements were recorded from the 1- and 30-m inlets behind the #2 and #3 engines at thrust levels of 4, 7, 15, 30, 45, 65, 85% and 100%.

Figure 3 shows plots of particle number emission indices for the engines as a function of power—note that the engine burning FT fuel emits 1 to 2 orders of magnitude fewer particles that its counterpart burning JP-8 at all points of comparison. Similar differences were seen in mass emissions. We must emphasize, however, that there were some differences seen between the two engines during the JP-8 tests and these must be taken into consideration during the final analysis.

- By translating the #3 engine 1-m rake further off the centerline of the engine, we determined that the fluctuating particle concentrations seen at the 30 and 45% power settings were related to engine oil being vented through the center vent tube. Afterward, the rake was set at a -8" position, instead of -4", for collecting samples at these two powers.

- Apparently lacking a need for sleep, Scott (ARI) continued analyzing data from the downstream sampling area and has produce some interesting results. Figure 4 shows the high correlation between CO2 and CO measurements recorded at 200-m during Monday afternoon's 1-m mapping test. Emission indices calculated from the regression slope between the two species compare fairly well with CO EIs measured during APEX-1 (Figure 5). Using this approach and the 200-m data, Scott has also extended the APEX-1 HCHO EI vs. temperature curve to much lower temperatures.

Figure 1. Ron oversees the much needed cleaning and augmentation of the Portalets.

Figure 2. The UTRC "Death-Box" after the morning's first 100% run. Note the missing and loose bolts. We were able to resume engine runs after these were quickly replaced with new bolts and lock washers, which were torqued-down tightly with a long-handled socket wrench.

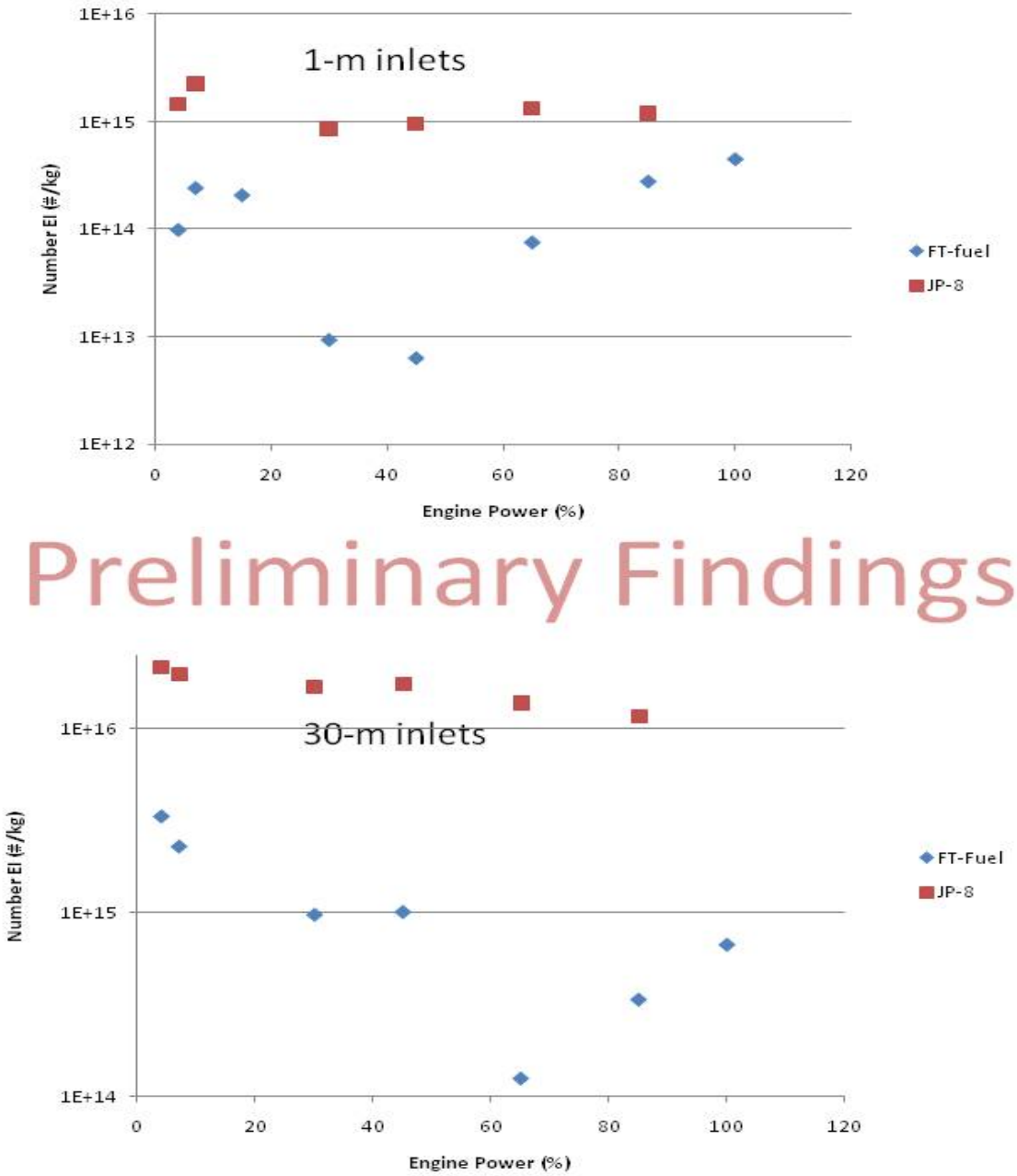

Figure 3. Number-based particle emission indices for the #2 engine burning JP-8 (red) and #3 burning FT1 for samples drawn from the 1-m rakes (top) and 30-m inlets. Values calculated from hand notes and are not corrected for sample pressure. **Not for public release.**

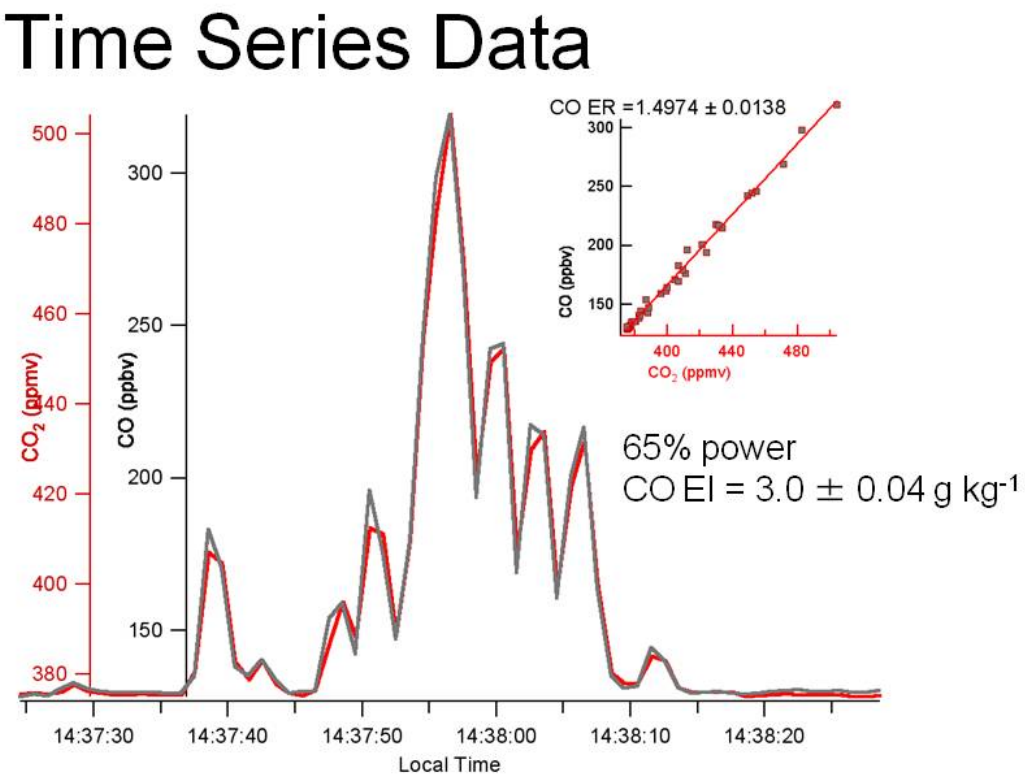

Figure 4. Time series of CO and CO2 recorded in the ARI van parked about 200-m downwind of the aircraft.

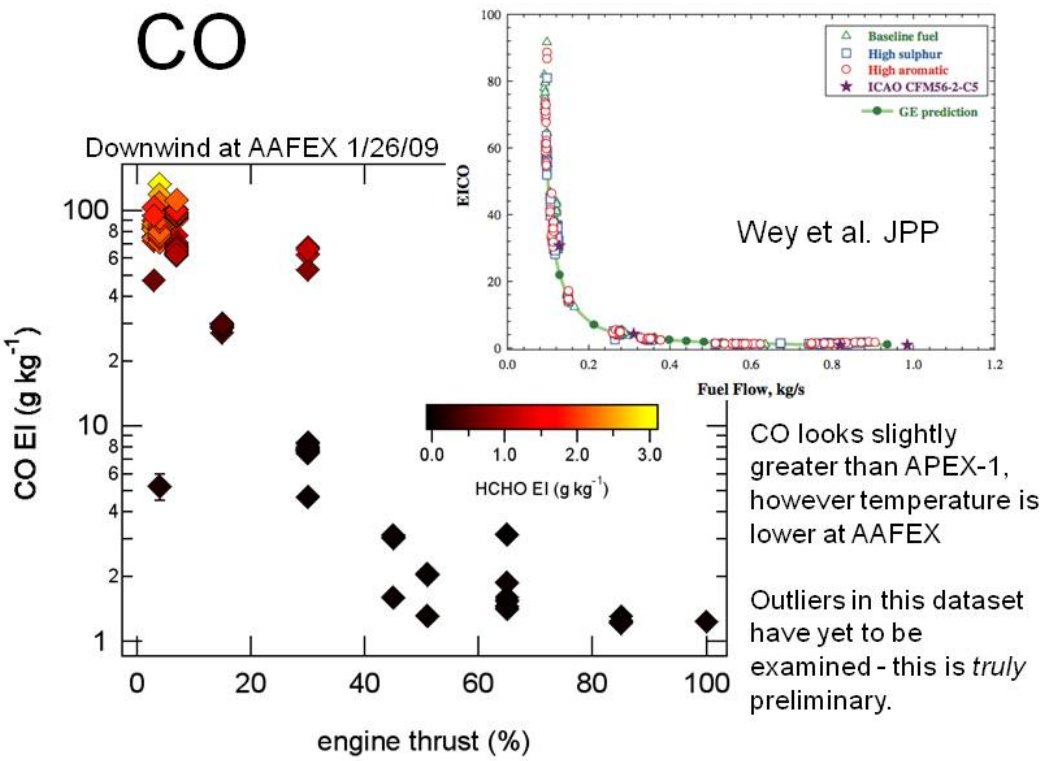

Figure 5. Comparison of AAFEX and APEX-1 CO emission indices. **Data not for public release.**

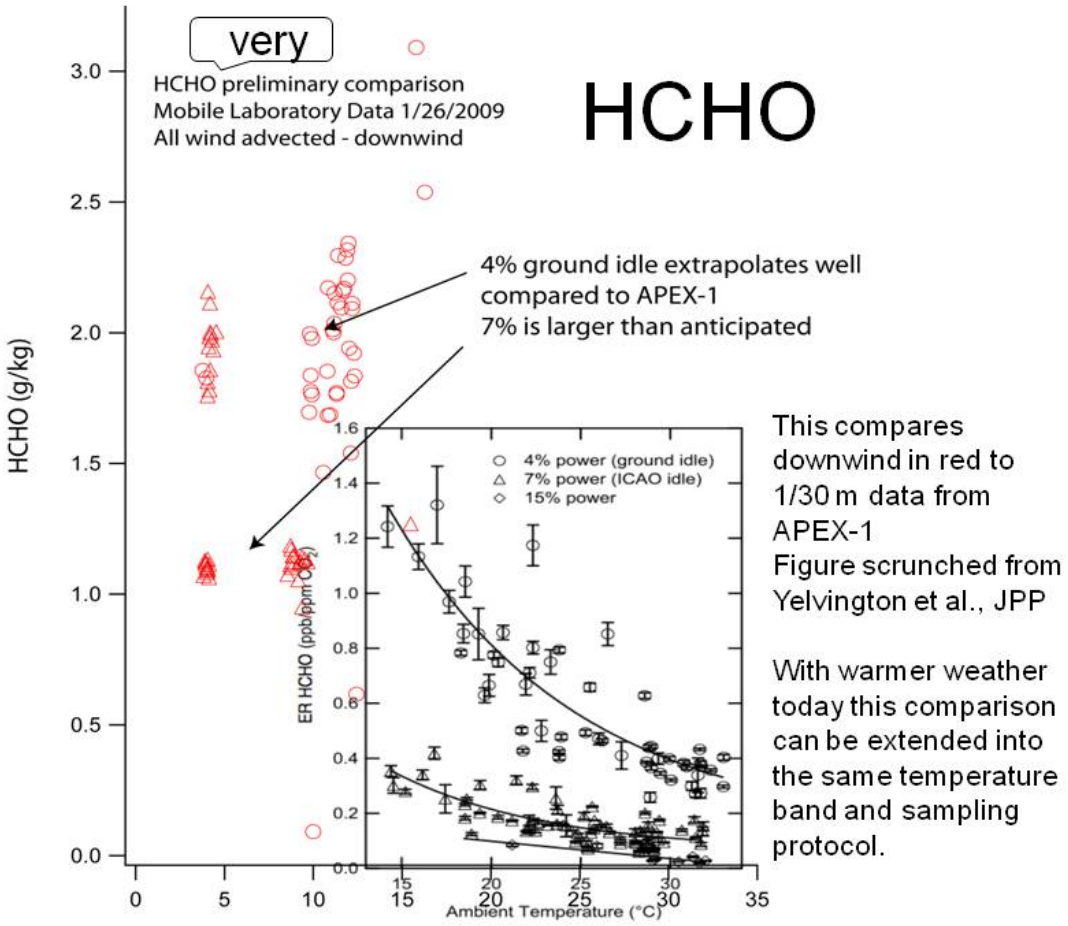

Figure 6. Combined data from AAFEX and APEX-1 showing the effects of temperature on formaldehyde emissions. **Data not for public release.**