FUEL INJECTION AND MIXING
TWIN-FLUID JET IN CROSSFLOW

OVERVIEW
This research program focuses on developing an understanding of the atomization, evaporation, and mixing processes that occur in an airblast-atomized liquid jet injected into a crossflow (Figure 1). Insight gained into these processes will enable the design of fuel injectors that enhance fuel-air mixing and lower noxious pollutant emissions in future advanced gas turbine engines targeted for next generation high speed civilian aircraft.

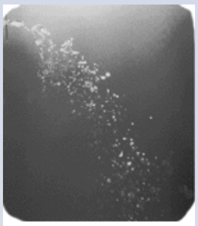

Figure 1: Atomized Liquid Jet of Methanol Injected into a High Velocity Crossflow of Air.

GOALS
- Optimize geometric and operational parameters for optimal fuel atomization, dispersal, and mixing with air.
- Correlate the non-reacting mixing results performed under atmospheric and elevated pressures and temperatures to emissions results from a model combustor.

RESULTS
Achieving uniform mixing of fuel and air via airblast spray injection into a crossflow requires knowledge of the interaction of many processes including primary atomization in the injection hole region provided by the airblast, secondary atomization due to the crossflow, mass dispersal due to jet-crossflow mixing, and evaporation. To study the physical processes in the spray field, the spray facility shown in Figure 2 is utilized.

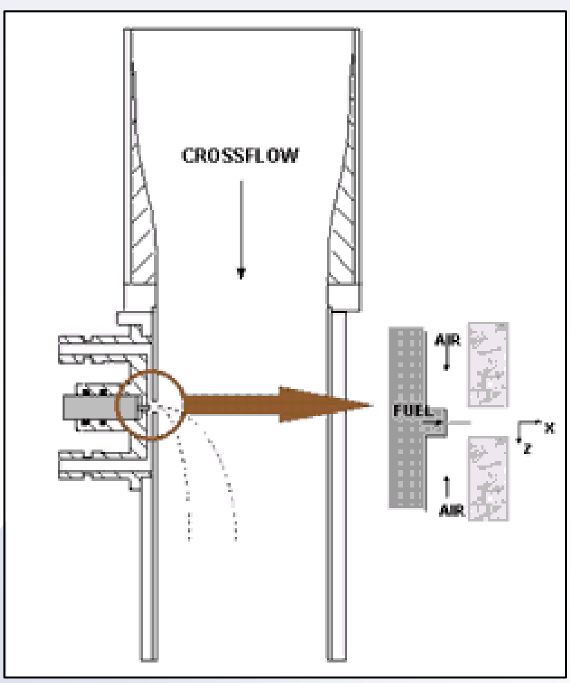

Figure 2: Experimental set-up for airblast spray injection into a crossflow

RESULTS (CONTINUED)
In order to obtain information on the spray mass distribution, Planar Liquid Laser Induced Fluorescence (PLLIF) is employed. Implementation of PLLIF requires the use of a fluorescein-laced liquid such as methanol fuel. An Argon-ion laser sheet passes through the spray to fluoresce the dye in the liquid mass. A CCD camera captures the fluorescence and a computer records the image. Figure 3 shows sample PLLIF images obtained for a methanol fuel spray flowing at a rate of 0.180 g/sec at various airblast Air to Liquid Ratios (ALR) injected into a crossflow of air flowing at 38 m/sec. The images in Figure 3 are taken at a plane 8 injection hole diameters downstream of the injection point. The PLLIF images show that the ALR 3 case shows a more even dispersal of mass across a larger spray area.

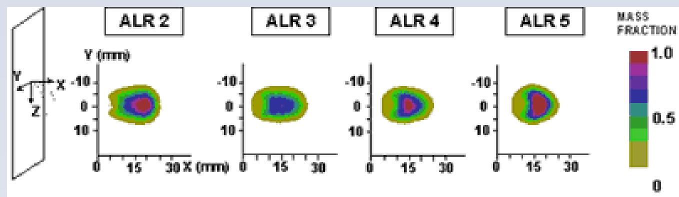

Figure 4: D32 (Sauter Mean Diameters) measured at various ALR conditions

Phase Doppler Interferometry (PDI) can also be used to obtain measurements of droplet size and velocity distributions. Droplet size distributions such as those shown in Figure 4 at the same downstream plane reflect the atomization quality of the spray at each ALR condition. The ALR 3 case, which showed the most diffuse distribution of mass in Figure 3, exhibits the widest range of D32 values (an average diameter based on a ratio of the total droplet volume to total droplet surface area) amongst the cases tested. This suggests that the flow conditions generating the most diffuse distribution of mass does not necessarily produce the smallest-sized spray of droplets.

PUBLICATIONS / PRESENTATIONS

VISUALIZATION OF AN AIRBLAST-ATOMIZED SPRAY JET USING LASER INDUCED FLUORESCENCE AND SCATTERING METHODS (2000). Proceedings of the Seventh International Congress on Atomization and Spray Systems (ICLASS2000) (M.Y. Leong, V. G. McDonell, and G.S. Samuelsen).

EFFECT OF AMBIENT PRESSURE ON AN AIRBLAST SPRAY INJECTED INTO A CROSSFLOW (2001). Journal of Propulsion and Power, Vol. 17, No. 5, pp. 1076-1084 (M.Y. Leong, V.G. McDonell, and G. S. Samuelsen)

PERSONNEL

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SPONSOR: NASA-Lewis Research Center