- A final such "go/no-go" briefing was given 2 hours prior to scheduled takeoff.
- After takeoff, periodic updates based of weather-balloon and satellite data were provided to the pilot and mission planner.
- Approximately 2 hours before landing, a final weather forecast was issued to enable estimation of the earliest possible landing time and selection of a runway.
- After landing, surface conditions were monitored until the airplane was safely in the hangar.

The first successful flight took place on July 14, 2001. The takeoff was delayed for 20 minutes because of clouds. Convection over the runway generated moderate turbulence during takeoff. The airplane climbed to a maximum altitude of 76,500 ft (≈23.3 km). The airplane landed in stable conditions after more than 15 hours of flight.

The second successful flight took place on August 13, 2001. This time, the takeoff was delayed 45 minutes because of clouds. Strong wind shear due to strong trade winds and island wake was observed at an altitude of 2,000 ft (≈600 m). The airplane then climbed until it reached a world-record altitude for a non-rocket-powered aircraft — 96,863 ft (29,524 m). This altitude is more than 11,000 ft (≈3.35 km) higher than the record set in a flight of the SR-71 airplane. The airplane landed safely after a last-minute change in runway because of winds.

This work was done by Casey Donohue of AS&M, Inc., for **Dryden Flight Research Center**. *For further information, contact the Dryden Commercial Technology Office at (661) 276-3689.*
DRC-02-25

Model of Mixing Layer With Multicomponent Evaporating Drops

Effects of multiple chemical components are represented with computational efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mathematical model of a three-dimensional mixing layer laden with evaporating fuel drops composed of many chemical species has been derived. The study is motivated by the fact that typical real petroleum fuels contain hundreds of chemical species. Previously, for the sake of computational efficiency, spray studies were performed using either models based on a single representative species or models based on surrogate fuels of at most 15 species. The present multicomponent model makes it possible to perform more realistic simulations by accounting for hundreds of chemical species in a computationally efficient manner.

The model is used to perform Direct Numerical Simulations in continuing studies directed toward understanding the behavior of liquid petroleum fuel sprays. The model includes governing equations formulated in an Eulerian and a Lagrangian reference frame for the gas and the drops, respectively. This representation is consistent with the expected volumetrically small loading of the drops in gas (of the order of 10^{-3}), although the mass loading can be substantial because of the high ratio (of the order of 10^{3}) between the densities of liquid and gas. The drops are treated as point sources of mass, momentum, and energy; this representation is consistent with the drop size being smaller than the Kolmogorov scale. Unsteady drag, added-mass effects, Basset history forces, and collisions between the drops are neglected, and the gas is assumed calorically perfect.

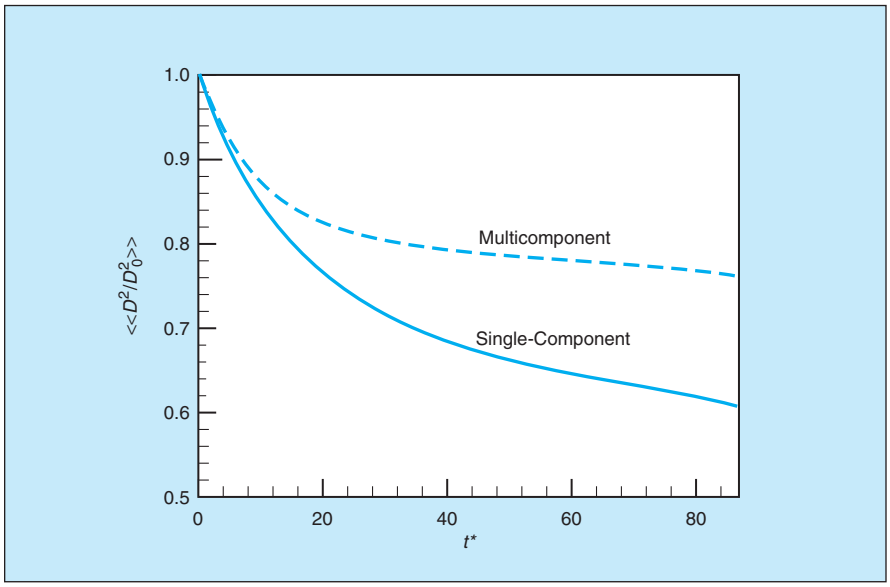

Figure 1. The **Evolution of Residual Droplet Areas** was computed for the single-component and multicomponent cases. Here t* is time in units of a characteristic time calculated from initial parameters of the mixing layer, D_o is the initial drop diameter, D is the drop diameter as a function of time, and << >> denotes an ensemble average.

The model incorporates the concept of continuous thermodynamics, according to which the chemical composition of a fuel is described probabilistically, by use of a distribution function. Distribution functions generally depend on many parameters. However, for mixtures of homologous species, the distribution can be approximated with acceptable accuracy as a sole function of the molecular weight. The mixing layer is initially laden with drops in its lower stream, and the drops are colder than the gas. Drop evaporation leads to a change in the gas-phase composition, which, like the composition of the drops, is described in a probabilistic manner.

The advantage of the probabilistic description is that while a wide range of individual species can be accommodated in the mixture, the number of governing equations is increased minimally over that necessary for a single species because the composition is represented only by the parameter(s) necessary to construct the distribution function. Here the distribution function is entirely defined by the mean and variance. For this choice of distribution function, the model accounts for evaporation-induced changes in the composition of fuel drops and the surrounding gas, yet involves only two more conservation equations (one for the mean and one for the

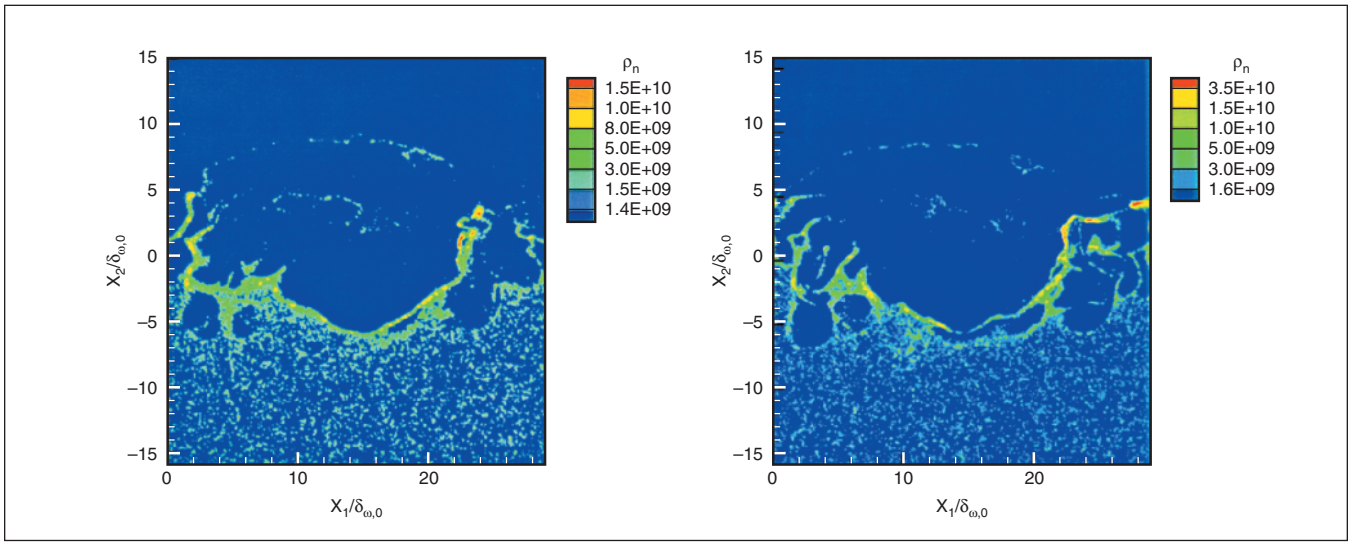

Figure 2. **Drop Number Density** is shown in a representative plane at the final computation time: (a) single-component drop layer and (b) multicomponent drop layer.

variance) than does an equivalent model for a single-component fuel. The initial mathematical form of the distribution function is postulated to be retained during the drop lifetime, but with evolving mean and variance as the drops evaporate.

In a test, a mixing-layer simulation was performed for drops of single-component-fuel and another such simulation for drops of a multicomponent fuel. Analysis of the results revealed that although the global layer characteristics were similar in the single-component and multicomponent cases, the drops evaporated more slowly in the multicomponent than in the single-component case (see Figure 1). The slower evaporation of the multicomponent drops was primarily attributed to the lower volatility of higher molar-weight species and to condensation of these species on drops transported in regions of different gas composition. The more volatile species released in the gas phase earlier during the drop lifetime were found to be entrained in the mixing layer, whereas the heavier species that evaporated later during the drop lifetime tended to reside in regions of high drop-number density. This behavior was found to lead to segregation of species in the gas phase on the basis of the relative evaporation time from the drops. The slower evaporation of multicomponent fuel drops was found to lead to regions of higher drop-number density in the drop-laden layer and to permit greater interaction of the drops with the flow, resulting in a more developed small-scale structure (see Figure 2).

This work was done by Josette Bellan and Patrick Le Clercq of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30505

Solution-Assisted Optical Contacting

Components in optical contact can be adjusted for about a minute.

NASA's Jet Propulsion Laboratory, Pasadena, California

A modified version of a conventional optical-contact procedure has been found to facilitate alignment of optical components. The optical-contact procedure (called simply "optical contacting" in the art) is a standard means of bonding two highly polished and cleaned glass optical components without using epoxies or other adhesives. In its unmodified form, the procedure does not involve the use of any foreign substances at all: components to be optically contacted are dry. The main disadvantage of conventional optical contacting is that it is difficult or impossible to adjust the alignment of the components once they have become bonded.

In the modified version of the procedure, a drop of an alcohol-based optical cleaning solution (isopropyl alcohol or similar) is placed at the interface between two components immediately before putting the components together. The solution forms a weak bond that gradually strengthens during a time interval of the order of tens of seconds as the alcohol evaporates. While the solution is present, the components can be slid, without loss of contact, to perform fine adjustments of their relative positions.

After about a minute, most of the alcohol has evaporated and the optical components are rigidly attached to each other. If necessary, more solution can be added to enable resumption or repetition of the adjustment until the components are aligned to the required precision.

This work was done by Daniel Shaddock and Alexander Abramovici of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30731