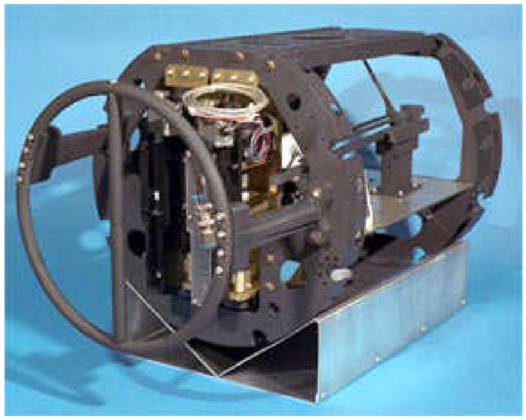
Multiuser Droplet Combustion Apparatus Developed to Conduct Combustion Experiments

A major portion of the energy produced in the world today comes from the combustion or burning of liquid hydrocarbon fuels in the form of droplets. However, despite vigorous scientific examinations for over a century, researchers still lack a full understanding of many fundamental combustion processes of liquid fuels. Understanding how these fuel droplets ignite, spread, and extinguish themselves will help us develop more efficient ways of energy production and propulsion, as well as help us deal better with the problems of combustion-generated pollution and fire hazards associated with liquid combustibles. The ability to conduct more controlled experiments in space, without the complication of gravity, provides scientists with an opportunity to examine these complicated processes closely.

The Multiuser Droplet Combustion Apparatus (MDCA) supports this continued research under microgravity conditions. The objectives are to improve understanding of fundamental droplet phenomena affected by gravity, to use research results to advance droplet combustion science and technology on Earth, and to address issues of fire hazards associated with liquid combustibles on Earth and in space.

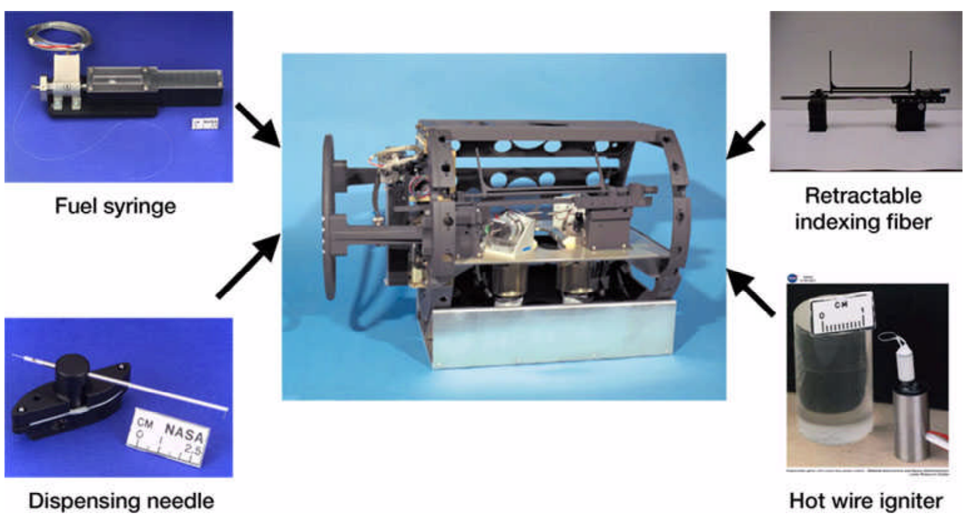
MDCA is a multiuser facility designed to accommodate different combustion science experiments. The modular approach permits the on-orbit replacement of droplet combustion principal investigator experiments such as different fuels, droplet-dispensing needles, and droplet-tethering mechanisms. Large components such as the avionics, diagnostics, and base-plate remain on the International Space Station to reduce the launch mass of new experiments. MDCA is also designed to operate in concert with ground systems on Earth to minimize the involvement of the crew during orbit.

The Combustion Integrated Rack (CIR) provides diagnostics, power, data storage and processing, fluid control, interconnection, and crew-ground interfaces. It also contains the principal-investigator-specific hardware.



MDCA chamber insert assembly--reusable hardware to accommodate different combustion experiments.

MDCA will conduct experiments using the Combustion Integrated Rack (CIR) of the NASA Glenn Research Center's Fluids and Combustion Facility onboard the space station. This facility is a multiuser, microgravity science laboratory with three individually powered space station racks that accommodate both combustion and fluid experiments. MDCA, in conjunction with CIR-provided common hardware, will allow for cost-effective extended access to the microgravity environment, not possible on previous space flights.



Principal investigator-specific hardware allows unique fuels as well as variable droplet diameters, deployment conditions, and diagnostics.

For the first phase, plans call for four principal investigators to study the combustion of small, spherical droplets of pure and bicomponent fuels. Isolated liquid fuel droplets remain the easiest to study because of their well-defined system. Three of the investigators will study the combustion of single droplets in a quiescent environment. The Droplet Combustion Experiment-2 reflight investigation will further explore droplet combustion behaviors, especially related to extinction phenomena. These were first observed during its first flight on the Microgravity Science Laboratory-1 flight in the Spacelab Module onboard space shuttle flights STS-83 and -94 in April and July 1997. The Bi-Component Droplet Combustion Experiment has its focus on the internal liquid fluid dynamics and combustion of bi-component fuel droplets. This experiment will be the first to study how each fuel species and their capillary forces drive the internal flow dynamics and combustion of a burning droplet. Sooting behaviors of droplets are the focus of the Sooting Effects in Droplet Combustion Investigation. The goal of this experiment is to measure and sample soot generated from a burning droplet. An understanding of the formation of soot and how it travels is important in fire safety. In contrast to the first three droplet investigations in a quiescent environment, the Dynamic Droplet Combustion Experiment plans to investigate the effects of small convective flows on the droplet during combustion such as may be found in the ventilation systems of space vehicles. This will improve the understanding of enhanced fire safety margins in spacecraft.

The MDCA hardware consists of the chamber insert assembly, avionics package, and a multiple array of diagnostics. The MDCA chamber insert assembly offers interchangeable fuel systems, igniter systems, droplet-tethering mechanisms, and droplet-dispensing systems. Additional diagnostics hardware will be provided by the CIR of the Fluids and Combustion Facility. The CIR will also provide the structural support for the chamber insert assembly and diagnostics, the utilities for the avionics and diagnostics, and the mixing capability for principal-investigator-specific combustion chamber environments. In concert with the CIR, the MDCA allows for interchangeability and reorientation of the chamber insert assembly and diagnostics to meet principal investigator needs. Different combustion chamber environments will be controlled by the Fluids and Combustion Facility fuel/oxidizer management assembly system.

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