Combustion Experiments on STS-83 and STS-94: The Crew's Perspective

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Despite years of planning and hundreds of drop-tower tests in preparation, the combustion experiments aboard STS-83 and STS-94 were full of surprises. Fortunately, these surprises were related to physical phenomena rather than the hardware's performance. The combustion experiments were successful for one main reason: they were ready to fly. From our perspective, there was no more important factor affecting how productive and enjoyable the missions were for us than the talent and dedication of the science team members who had conceived of and built the experiments and with whom we trained and worked. Because of their work, the experiments were clearly defined and elegant, the hardware well-designed and built, and the software simple to use and thoroughly tested. During the flights, knowing that dozens of individuals were working night and day to keep us as productive as possible and to solve problems as they arose allowed us to work expediently.

Space-based combustion experiments are different from typical earth-based ones. The hardware is designed and built long before its use, and change becomes difficult or impossible as the flight nears. The experimental procedures are exactly specified in a flight document, and are practiced by the crew for a year prior to the flight. These factors make the experiments more constrained than the principal investigators would prefer, yet considerable flexibility is achieved through clever experiment design and by having trained scientist-astronauts on board to conduct the experiments. When confronted by phenomena never observed or predicted by ground experiments, the ground-based science teams could call upon the crew to change the procedure, swap experiment components, or modify the hardware to accommodate newly-planned tests.

Our role on orbit varied from the assembly of the experiments to the application of our scientific judgment at crucial points in the operations. Usually, our first jobs were to assemble, activate, and test the hardware. Some tasks were routine, but our care and thoroughness affected the quality and quantity of data. Even more important, at key moments, our scientific understanding of the experiment was essential for successful operation. For example, the Laminar Soot Processes (LSP) experiment could not be conducted by remote ground command because the phenomena occurred too fast for the video downlink and command uplink to respond adequately making astronaut participation crucial. Other times, we were conducting experiments while video downlink was unavailable, and the only information provided to the scientists on the ground for real-time decision-making was our verbal description. Finally, most of the glovebox experiments required manual operation by a crew member, many required considerable skill and dexterity, and all required assembly.

The combustion experiments had video displays and view ports for real-time observation. The flames were fascinating to observe, and a challenge to describe accurately in the short time available. Often, we on board and the science team on the ground observed the first flames of their type ever burned in the history of humankind. For some of the burns, we had four or five crew members floating around the rack,

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in all orientations, with eyes fixed on the monitor.

The psychological aspects of spaceflight have as much to do with success as the technical ones, and on our flights, it was easy to maintain enthusiasm. Through a circuitous electronic and human path, we on board and the scientists on the ground shared various emotions. Sometimes our satisfaction came merely from performing the procedures carefully and expeditiously; other times it was from seeing the data. We knew the experimental challenges the scientists faced, and sensed their anxiety. Consistently deploying droplets with small residual velocity is difficult on the ground. When the Droplet Combustion Experiment team achieved it on orbit despite setbacks, we were thrilled; when they were given permission to burn heptane with cabin air (for comparison with the glove-box experiments), we shared their pleasure. We knew how difficult it was for the LSP scientists to identify the smoke point of a flame which had a structure unlike anything ever burned before, but shared their relief when we explored the domain of conditions. When the "Structure of Flame Balls at Low Lewis Number" experiment achieved steady flame balls that burned for as long as the experiment was set to run, we knew the experiment was a success.

One of the strongest impressions upon arriving in μg is that some of our most common experiences on earth such as standing, sitting, and walking, are useless in μg and must be re-learned. Similarly, in their interpretation of the μg combustion data in the coming years, the ground-based scientists will also have to adopt new approaches, and our understanding of combustion phenomena will advance commensurately.

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