Liquid Motion Experiment Flown on STS-84

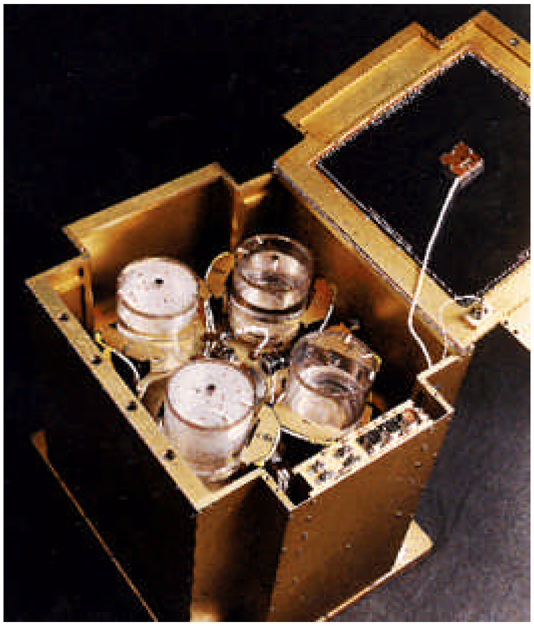
During some part or all of each mission, about half of all scientific and commercial spacecraft will spin. For example, commercial spacecraft are made to spin during the transfer maneuver from low Earth orbit to the mission orbit to obtain gyroscopic stiffness. Many spacecraft spin continuously in orbit for the same reason. Other reasons for spinning include controlling the location of liquid propellants within their tanks and distributing solar heat loads.

Although spinning has many benefits, it also creates problems because of the unavoidable wobble motion that accompanies spinning. Wobbling makes the spacecraft's flexible components oscillate. The energy dissipated by the internal friction of these components causes the wobbling amplitude to increase continually until, at some point, the attitude control thrusters must be fired to bring the spacecraft's amplitude back to an acceptable level.

For modern spacecraft, by far the most massive flexible component and the largest source of energy dissipation is a mobile liquid propellant in a partially filled spinning tank. The liquid's energy dissipation cannot, however, be quantified adequately by any ground test, and current analytical models are also inadequate. Consequently, spacecraft attitude control systems are designed and operated very conservatively. Nonetheless, spacecraft often perform poorly in orbit and some have even been lost by a rapid and unanticipated increase of the wobbling amplitude.

NASA Lewis Research Center's Liquid Motion Experiment (LME) was designed to study these energy dissipation effects for liquids in rotating tanks. Data generated on LME will be used to validate and provide guidance for improved analytical models of liquid motions in the tanks of spinning spacecraft. Such improved models will lead to less conservative attitude control system designs, which will reduce the mass and increase the life of spacecraft.

LME was successfully integrated into the SpaceHab and launched as a secondary payload on the STS-84 Phase I Mir flight in May 1997. Astronauts Carlos Noriega and Dr. Ed Lu operated the LME following undocking with Mir. The experiment performed nominally throughout the flight, generating both energy dissipation data and video of the actual liquid motions inside the tanks.



Interior view of LME prior to installation in the Space Shuttle Atlantis.

Data analysis is ongoing. Current plans call for a final data review, a meeting of an industry-led users' panel for data dissemination, and publication of the results. Lewis is pursuing the possibility of a reflight of LME, primarily to investigate the use of various proprietary propellant management devices within the tanks.

LME was built under contract to Lewis by the Southwest Research Institute of San Antonio, Texas. Their principal LME investigator is Dr. Franklin Dodge, and their LME project manager is Danny Deffenbaugh. From NASA Lewis, the LME project manager is Penni Dalton and the project scientist is David Chato.

Astronaut Carlos Noriega videotapes LME in operation.

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