NASA FLIGHT EXPERIMENTS PROGRAM

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Abstract

The NASA Office of Advanced Concepts and Technology's space flight experiments program is conducted to obtain research data, evaluate the performance and/or operation of experimental hardware in the space environment, or validate components, subsystems, or systems prior to application in future spacecraft or missions. "The high cost of space access mandates that only those technology experiments with a significant need for exposure to the space environment arc selected for flight. In addition, the requirements for different types of technology experiments and their priority vary significantly depending on the. maturity of the technology in question,

The new OACT and NASA mission includes a new emphasis on industrial commercialization of technology developed for and by the Agency. With this emphasis the role of flight testing may best be modified to address more mature technologies even to the point of including system demonstration experiments, not traditionally supported by NASA's flight programs. The question that this paper will attempt to answer is: At what point in the technology development cycle is space flight testing necessary and most cost-effective (compared to equivalent ground testing), from both the industry's (developer) and the Agency's (sponsor) perspective?

This paper reviews briefly the development and history of the space flight experiment program and reports in some detail on four existing or recently flown experiments sponsored by the in-Space Technology Experiments Program (IN-STEP), ranging from a engineering research experiment (low technology maturity) to a system validation experiment (high maturity), all flown on the Space Shuttle:

- The Experimental Investigation of Spacecraft Glow (EISG) is a research experiment developed by Lockheed Corporation to determine the intensity and causes of spacecraft glow at various attitudes and altitudes. Results from this experiment will be used to develop coatings and other means to reduce the effect of surface/plasma glows on optical instruments flown in low earth orbit.

- The Tank Pressure Control Experiment (TPCE) is a Boeing Aerospace Company experiment, first flown in 1991, to test the effect of jet mixing of cryogenic fluids to help control pressure in cryogenic tanks. Results from this experiment will be used to design lighter cyrogenic tanks for future space flights.

- The Heat Pipe Performance (HPP) experiment, designed by Hughes Aircraft Company, was flown in 1993 to test the microgravity performance of various types of heat pipes to be used on spinning spacecraft.

- The Cryo System Experiment (CSE), also developed by Hughes Aircraft Company, is a system-level experiment designed to validate the operation and performance. of a 65 K cryogenic cooler and oxygen heat pipe in the space environment.

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The examples above will be discussed with reference to the level of technology maturity and the specific driving requirements for space flight experimentat ion for each. 1 n addition, the nature and benefits of the results will be described for the type of customer in each case. Results of the experiments will be discussed in the context of their impact on technology (and product) development at their organi zat ion. The CSE experiment will be detailed as a case study to describe the role of in-flight testing in the development of a technology for commercial sale, from the industry perspective.

The Technology **Readiness** Level (“l’RI,), a nine-point scale used as a measure of the maturity of a particular technology or system, will be used to illustrate the differences and anticipated returns of various experiments. Anecdotal evidence will be cited (primarily using the above examples) to examine the most effective approach to in-flight testing and the most cost-effective timing for introduction of the technology in the relevant environment. A relative measure of experiment cost vs. TRL will be demonstrated and shown that, especially when launch costs arc taken into consideration, the highest benefit/cost from the. industry perspective may be achieved when flying higher TRL experiments.

Alternatives to in-flight testing will be discussed for different types of experiments and compared with the equivalent space test in terms of cost vs. return. In addition, the paper will address the validation requirements from the spacecraft and mission designer’s perspective to assess the results necessary from an in-flight experiment to justify incorporation of the technology into future systems, and the effect of mission classification on the degree of validation required.

in addition, the paper will address the cost-effectiveness to both the Agency sponsor and the private contractor of true demonstration flights (TRL 8), which have not traditionally been supported by the NASA flight programs. Also, the role and likelihood of sponsor/contractor cost-sharing and the relationship of this requirement vs. TRL will be discussed, with the hypothesis that cost-sharing is both more effective and more likely when flying high TRL experiments. And final] y, the question of how these results can be used to develop and maintain an appropriate balance between engineering research (low TRL) and advanced development (high TRL) experiments will be addressed,

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