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EXPERIMENT RESULTS AND POST-FLIGHT ANALYSIS OF THE ISS STUDENT EXPERIMENT PAPELL

Abstract

Pump Application using Pulsed Electromagnets for Liquid reLocation (PAPELL) was a fast-paced student experiment conducted on the International Space Station (ISS). The 1.5 U flight hardware was housed internally in a rack of the educational company DreamUp and was executed for over 60 days in total during a half-year stay on the ISS. A multidisciplinary team of more than 30 students of the University of Stuttgart has developed PAPELL within less than a year to flight readiness status. The students have organised themselves within the Small Satellite Student Society of the University of Stuttgart (KSat e.V.) and were supported by the Institute of Space Systems. The technology demonstration experiment aimed to show that a mechanic-free actuation method can be produced by utilizing a magnetisable liquid, a ferrofluid, and localised magnetic fields. Such a mechanic-free device is likely to be highly reliable and to have long lifetime. The absence of mechanical moving parts corresponds to minimal wear and tear and vibration generation. Lessened qualification requirements reduce development time and overall costs. The PAPELL experiment demonstrated successfully that ferrofluid manipulation through the utilization of localised magnetic fields generated by electromagnets is possible in a repeatable and reliable way in the microgravity environment of the ISS. The basic functions of a digital microfluidic circuit i.e. droplet generation, movement, splitting and merging have been shown during the operation phase. These results allow for a wide variety of application development based on the observed fluid dynamic behaviour of PAPELL. The experiment has been equipped with a sensor suite to ascertain secondary effects of experiment operation (i.e. magnetic fields, temperature, vibrations, power consumption). The produced data shows promising results as disadvantageous effects are minimal. Further, it can be determined that ferrofluid actuation in microgravity requires less power compared to Earth based tests, while viscosity and surface tension effects become significant. Sensor data and analysis of ferrofluid dynamic influenced by

magnetic fields in a micro-gravity environment and corresponding behaviour in a ground test environment yields critical information for modelling the corresponding physics and informing future designs. As PAPELL was returned to Earth after mission conclusion subsequent follow-up tests and hardware analysis is conducted for in-depth assessment of the potential of this mechanic-free actuation technology and will be presented as part of this paper. The flight hardware and ferrofluid is examined for degradation effects occurring from launch, re-entry loads and ISS stay.