# Abstract 論文の内容の要旨

論文題目 Self-Pressurised Cold Gas Satellite Propulsion System using Phase Transition through Supercriticality
(超臨界遷移による相変化を用いた衛星搭載の自己加圧推進機関に関する研究)

氏 名 Boden Ralf Christian ﾎﾞｰﾃﾞﾝ ﾗﾙﾌ ｸﾘｽﾁｱﾝ

The increase in missions utilizing small spacecraft below 100 kg, such as nano and cube satellites, is a continuously increasing trend in the satellite market. Use of small spacecraft in more complex missions requires new system capabilities. One of the most critical capabilities is propulsion, as small spacecraft place a number of restrictions on propulsion systems due to their small volume, as well as safety, and health concerns.

One potential propulsion system is presented and investigated in detail here – the High Density Cold Gas Jet (HDCGJ). This new concept, developed by the Japan Aerospace Exploration Agency (JAXA), is based on previous experiences with a vapor-liquid green propulsion system used on board of the IKAROS solar sail demonstrator mission, which was limited to short, impulsive thrusts ($\leq 1$ s).

The main advantage of the HDCGJ system is its potential to provide continuous thrust. This is achieved by storing the liquid propellant within a newly developed, self-pressurizing tank – the charger device. The propellant is stored above critical pressure and heated up to supercritical state before being expanded into gas state. A fraction of the generated gas is used in the piston-like charger device, allowing the system to maintain pressure. This self-pressurization is hereby controlled by a solenoid valve.

As part of the research conducted in this thesis, the HDCGJ concept with its linked liquid and gas sides is investigated in detail. The system behavior is modeled and a number of performance parameters are identified, characterizing the system. Based on the established theory, a promising propellant options are identified by trading propellant mass, volume, and power requirements. This is necessary, as simply choosing the highest specific impulse propellant is not possible, due to the complex behavior of the HDCGJ system. HDCGJ performance is based on the fraction of propellant needed to keep the system pressurized, and its storage volume needs to consider both the liquid and gas sides of the charger device.

As a result of this system trade, and considering safety, health, and environmental aspects, the refrigerant Hexafluoroethane (R116) is selected as propellant for a first HDCGJ based flight demonstration system, to be used in a 50 kg small satellite. The development and testing of this system includes design and manufacture of breadboard and engineering models, as well as preparation of JAXA's test facilities. The system makes use of COTS components where available, to keep costs low. Newly developed components are manufactured and tested.

Experiments have been performed with a breadboard model system. Continuous thrusting capabilities are confirmed, with the R116 propellant undergoing the required state transition via supercritical phase. Measured performance such as operating efficiency matches the expected performance within a few percent, confirming the validity of the models. Problem with system design have been identified, based on initial test results, and changes implemented into the design of the engineering and flight demonstration hardware, which has been recently completed and successfully undergone initial testing.