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## **C4Or1D-03: Characterization Testing of the Northrop Grumman MiniCoolerPlus (MCP)**

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Northrop Grumman Space Park (NGSP) introduced the MiniCoolerPlus (MCP) to its family of pulse tube cryocoolers in 2019 and presented the details of its TRL6 qualification testing in 2022. The thermal mechanical unit (TMU) of the MCP is an extension of space-qualified pulse tube coolers, all of which are designed to provide a long life (ten-plus years) of delivering low-mass, high-cooling capacity for hyperspectral and infrared imaging payloads in tactical airborne and space applications. The cooler is of modular split configuration allowing flexibility in the compressor (wave generator) and cold head placements in order to meet the available envelope of packaging constraints. The cold head assembly can be oriented at any position relative to the compressor assembly, and the transfer line (length and shape) can be customized to individual applications. The TMU weighs less than 3kg and can lift 1.5 W at 45 K or 11 W at 110K with 150 W electrical input at 300 K reject. The thermal performance has been characterized as a function of input voltage and as a function of cold tip load and temperature at a variety of heat sink temperatures of -20C, 0C, +20C and +40C. Functional testing of the MCP was performed to higher input powers and MCP impedance versus operating conditions were collected. An analytical expression for cold tip load ( $Q_c$ ) and impedance ( $Z$ ) as a function of reject temperature ( $T_{rej}$ ), cold tip temperature ( $T_c$ ), frequency ( $f$ ), and input power ( $P_{ac}$ ) were generated. These tests were conducted with third party control electronics and the results will be presented here.

**Author:** Dr AMOUZEGAR, Ladan (Northrop Grumman)

**Co-authors:** RICH, Nicholas (Northrop Grumman); PETACH, Michael (Northrop Grumman); COLBERT, Ralph (Northrop Grumman); DAIR, Edwin (NG); RUSSO, J (Northrop Grumman); DURAND, D (Northrop Grumman); HUA, J (Northrop Grumman)

**Presenter:** RICH, Nicholas (Northrop Grumman)

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