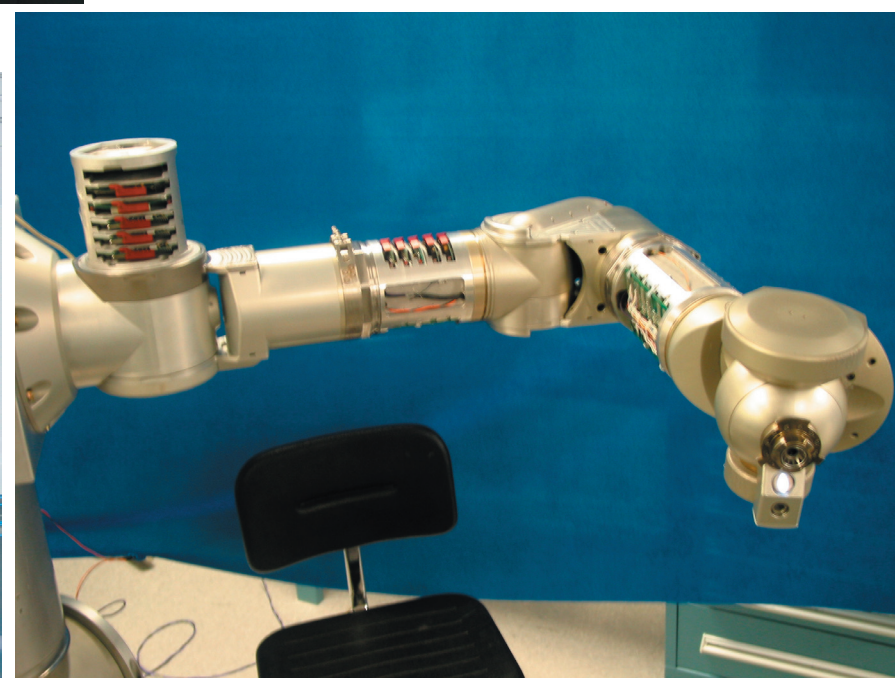
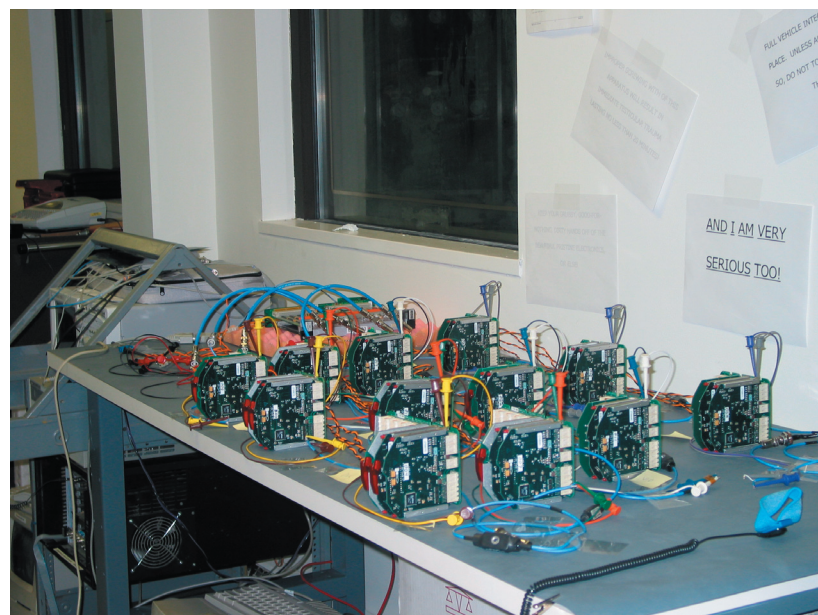
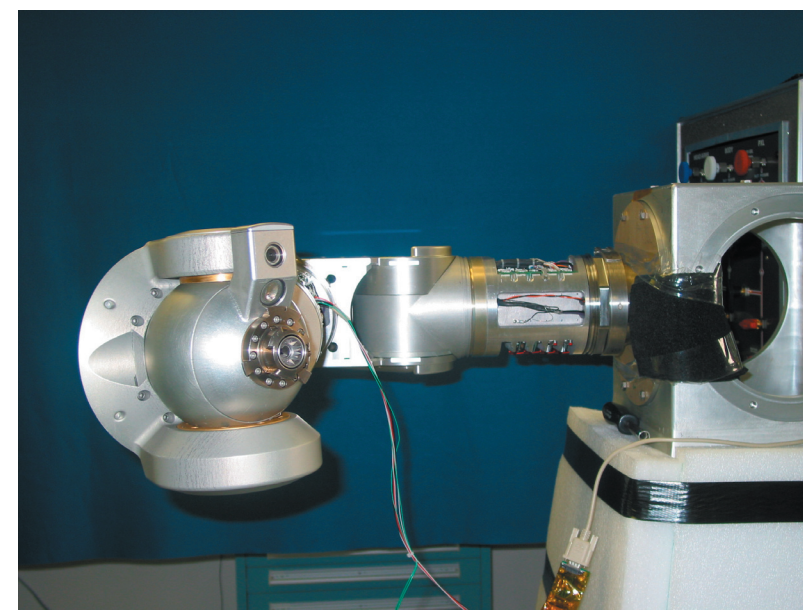
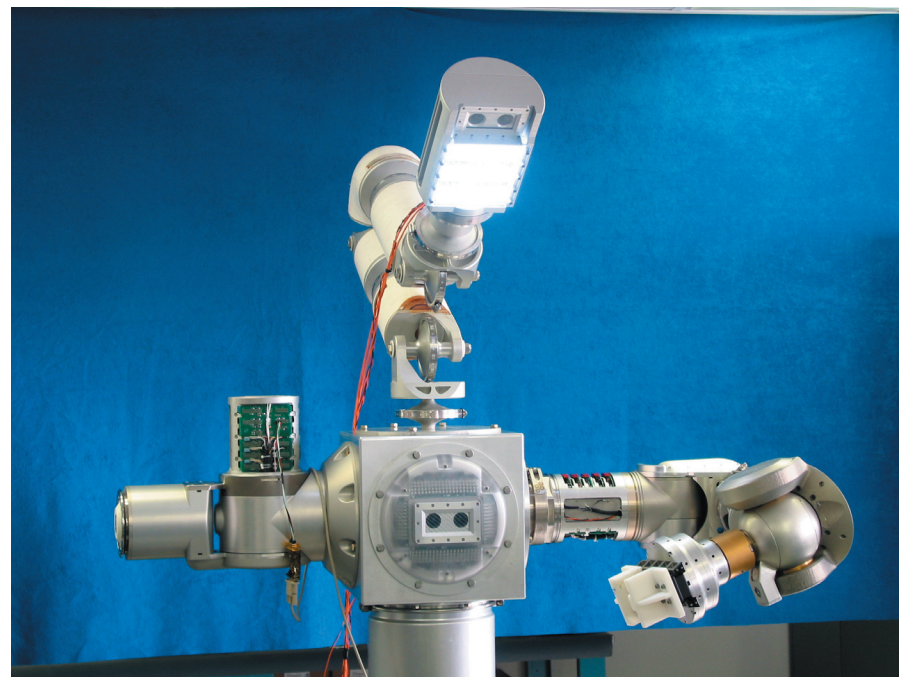
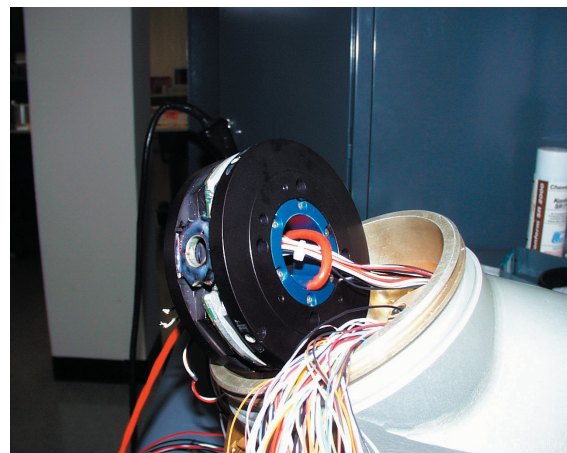
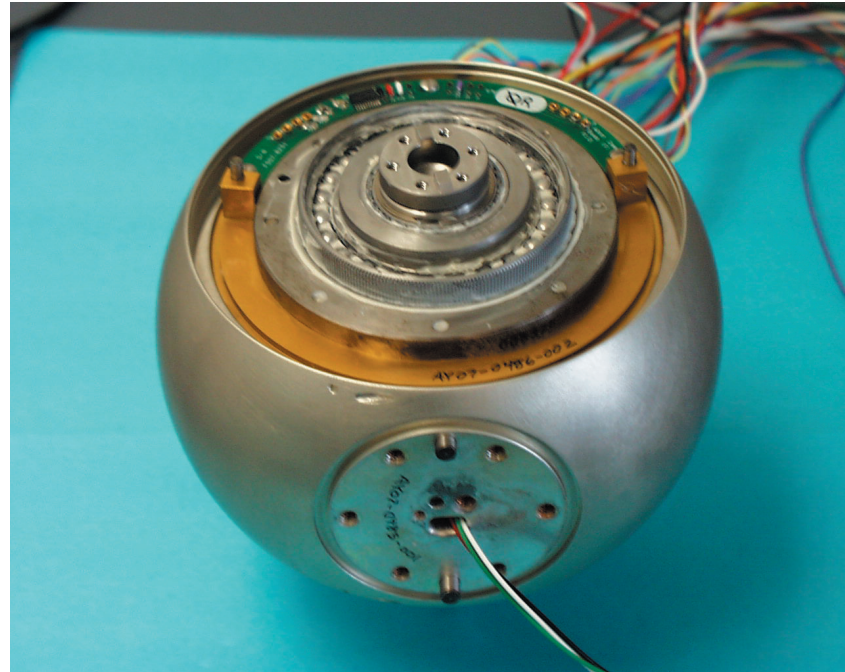


# Ranger Flight Development Arm



The Ranger TSX manipulators are quite possibly the most sophisticated and capable manipulators ever designed for space flight. The dexterous manipulators each have ten actuators for eight degrees of freedom, plus two actuation motions for the interchangeable end effectors. Six different end effectors are planned for use on the flight experiment; the interchangeable end effector mechanism (IEEM) provides a fault-tolerant mechanism for locking the tool to a mounting post before releasing it from the robot arm, and vice versa. The manipulators are designed with only one offset in the entire arm, providing a dexterous work envelope almost entirely devoid of singularities.

Perhaps equally impressive is the computer architecture which drives the Ranger manipulators. All arm joints are controlled at co-located processors, which communicate via a redundant 1553 bus to a pair of R4700 RISC processors, acting as the high-level computation nodes. All actuators are two-failure tolerant to electronic, mechanical, or software failures. Any discrepancy between redundant sensor readings results in the automatic safing of the system. Ranger TSX was selected as the first shuttle payload to be certified for computer control of hazards. The engineering development arm is the pathfinder for the build-up of arms for the Neutral Buoyancy Vehicle II.