

**A Berthing and Fastening Strategy for  
Orbital Replacement Units**

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Research in the area of berthing of Orbital Replacement Units (ORUs) at the Goddard Space Flight Center consists of two major parts. First, we concentrate on the development of a comprehensive fastening strategy that can provide both mechanical as well as electrical connection to the ORU. Second, our efforts in robot collision avoidance and motion planning has led to the development of a state-of-the-art capacitive proximity sensor with associated motion control algorithms. These efforts combine to produce a system that allows safe and reliable machine assisted berthing. Although our main emphasis has been on berthing of ORUs, we believe that some of our results can also be applied to docking.

The Work Attachment Fixture/Work Attachment Mechanism (WAM/WAF) allows the fail-safe mating and demating of the ORU with the robot arm. Sensors that are placed onto the ORU box can be connected through the WAM/WAF and used for collision avoidance due to the built in electrical connectors. The WAM/WAF also enables the robot arm to derive power and data from the spacecraft, and can therefore be used as the primary attachment point or "foot" for the robot.

The "Capaciflector" (capacitive reflector) uses a simple extension of an instrumentation technique for controlling stray capacitances. In this instance a capacitive sensing element, backed by a reflector driven at the same voltage as the sensor, is used to reflect the field lines away from the grounded robot arm towards the intruding object, thus dramatically increasing range (greater than 12 inches with the reflector - one inch without) and resolution.

In addition to the ORU, the sensor has also been placed on the body of robot arm manipulators, allowing them to avoid collisions with unknown objects. In addition, due to the excellent resolution at close range, the sensor has shown to be useful in applications as an imaging sensor to locate reference points.

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