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The Space Shuttle's manipulator arm — at the edge of technology

The Space Shuttle, a squat rocket-cum-glider capable of shuttling to and from near-earth orbit, is being developed by the U.S. National Aeronautics and Space Administration (NASA) with help from other nations. Canada is contributing the remote manipulator system — an arm which will be attached to the craft, enabling its crew to manipulate objects out in space. The challenging job of designing and building the arm is being carried out by a team led by Spar Aerospace Products Ltd. of Toronto, and directed by the National Research Council. It has now reached the stage at which hardware can be tested.

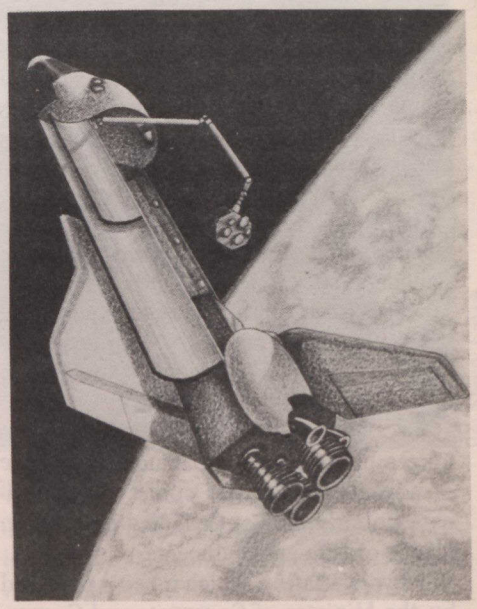
Science fiction becomes fact. In 1979, high above the earth's atmosphere, an astronaut will, for the first time, use a remote manipulator in space. From the flight deck of the Space Shuttle he will control the stately movement of an arm more than 15 m long, adroitly grasping and jockeying satellites as big and heavy as a bus.

This futuristic device, now being built in Canada, will resemble the human arm and hand in form as well as in function. It will be hinged inside the spacecraft's cargo bay at a shoulder joint, divided into two sections at an elbow joint, each about the length of a telephone pole, and terminated by a "hand" moving in a wrist joint and capable of grasping.

Dissecting the arm to expose its components would reveal more of its analogy to the human body. The arm will have a skin — a coat of metal and plastic films to protect it from the temperature extremes of space; muscles — sophisticated electric motors and gear trains; and an eye — a television camera mounted on its wrist. Like nerves, a network of wires will spread through the arm, and like the brain, a computer will process the signals pulsing through the network, translating the commands of the operator into coordinated movements of the whole system.

After surviving the severe buffeting of a rocket launch, the arm has to work reliably and accurately in an extremely hostile environment — an almost total vacuum, bathed in intense radiation, with temperatures that alternately plummet and soar. Designing within these constraints has severely taxed the collective ingenuity of hundreds of engineers and technicians.

In a carefully orchestrated process, they have refined their design from its starting point, NASA's requirements. Options have been selected following trade-off studies and computer simulations, electronic circuits spread out in so-called "breadboard" models to check their feasibility, components built, critically examined and modified, the evolving configuration of the arm constantly monitored, and its performance as an integrated system compatible with the Space Shuttle's even more complex system constantly improved.



An artist's impression of the Space Shuttle using its Canadian-built manipulator arm.

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