for rigid metallic bodies becomes quite large. Small penetrations of surface boundaries can produce large contact forces.

The Method of Soft Constraints is a contact dynamic modeling technique in which surface boundary constraints of contacting bodies are enforced through application of restoring forces to the bodies when contact is detected. This technique allows small violations of the constraints. The advantages of the method are that it is relatively easy to implement and the number of constraints is unlimited.

A disadvantage of the method is that simulation run times are relatively long on most affordable computers. Usually, results are saved from a simulation and then processed by a graphics program to generate an animation. What makes the simulation take a long time? When this type of contact model is used for "force" with the system equations of motion run in a time domain simulation, the integration step must be chosen carefully. Often a very small integration time step is selected to avoid numerical instability even though this makes the simulation run time longer.

Contact force models using the Method of Soft Constraints can help evaluate capture mechanism performance, both before and after hardware production. Engineers can use simulation results in examining loads, and dynamic response characteristics as well as in stress analysis. Data can help determine size and shape of capture envelopes and can evaluate mechanisms and their controllers.

Contact force models were used to validate hardware-in-the-loop tests at MSFC's 6-DOF motion facility. Models included were: OMV, SSF docking, SSF berthing, and Apollo/Skylab. These models were incorporated in time-domain contact dynamics simulations. They were used to generate contact loads and dynamic response data.

The contact force model for Space Station Freedom contains component models for all parts of the berthing system, thus facilitating accurate simulations. Mass properties and initial conditions are given to the contact force models and the hardware in-the-loop simulation. Computer dynamic responses and contact characteristics closely match the actual results. In 1992, this model will support hardware in the loop berthing tests.

After the presentation, two questions were asked. Does the model deal with compliance between the payload and the Remote Manipulator System (RMS)? Flexibility terms were incorporated. Could berthing or docking with Space Station Freedom be accomplished without force feedback? The force feedback discussed in the presentation was only for simulation implementation and the actual docking does not require force feedback.

S28-18
ABS **N93 - 21435** A Phase One AR&C System Design
146 69 p By Peter Kachmar, Robert Polutchko, Marty Matusky, and William Chu/C.S. Draper Laboratory
William Jackson and Moises Montez/JSC

The Phase One AR&C System Design integrates an evolutionary design based on the legacy of previous mission successes, flight tested components from manned Rendezvous and Proximity Operations (RPO) space programs and additional AR&C components validated using proven methods.

The Phase One system has a modular, open architecture with the standardized interfaces proposed for Space Station Freedom system architecture.

As of today, the "Phase One" AR&C integrated GN&C system design is complete. The new subsystems are an integrated system executive; laser sensor and laser navigation capability for relative position, velocity, and attitude; auto maneuver execution; and trajectory controller. The

hardware requirements are specified, and essential components were validated with proven tools which were themselves proven through flight design support.

The next step is to define and execute flight demonstrations of the Phase One system and its components.

After the presentation, concerns were addressed: What are the additional laser requirements? The response: A report to NASA is planned in about 4 weeks. The plan is to look at expanding the envelope to include manned and unmanned operations and to look at performance degradation. A trade comparing the Phase One system with respect to laser accuracy specifications will be done.