**Development of an Interchangeable End Effector Mechanism**

**1 inch**

**Note this is bold 12 point text for the Ranger Telerobotic Vehicle**

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*(NOTE there are two single spaced lines between authors and “Abstract”)*

**1 inch**

Abstract

This is 10 point Arial text with line spacing set to at least 12 point. The Ranger program at the Space Systems Laboratory (SSL) at the University of Maryland is a demonstration of an extremely low cost space flight experiment. The Ranger vehicle is designed to perform teleoperated spacecraft maintenance. Completing the various tasks included in spacecraft maintenance requires several specific tools. This paper describes the Ranger interchangeable end effector mechanism (IEEM). Its design allows Ranger to change end effectors to utilize the appropriate tool for the various tasks.

**1 inch**

Introduction

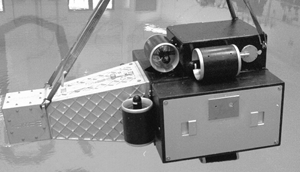
For many years, the Space Systems Laboratory has studied how to do useful work in space with a particular emphasis on neutral buoyancy simulation of the microgravity environment. The primary approaches are to understand how a person performs useful work in weightlessness, how machines operate in weightlessness, and how the two can work together. Neutral buoyancy was chosen as the weightless environment simulation for the Ranger program. This environment allows motion in all 6 DOF, but also introduces some new challenges.

Subheadings are Underlined

The SSL has developed several telerobotic systems for operations in the neutral buoyancy environment. The Ranger neutral buoyancy vehicle (Ranger NBV) is the newest system to come on-line in the SSL. Ranger NBV, shown in Figure 1, is the development unit for the Ranger telerobotic flight experiment.

Ranger Background

Ranger is a telerobot designed to perform complete, end-to-end spacecraft maintenance operations. These include rendezvous and docking with a target vehicle, performing a specified task set and departing



**Figure 1. Ranger NBV shown being lowered into tank**

**1 inch**



**Figure 2. Latching Mechanism shown in latched position**

**References**

1. Kingsbury, Edward P. "Torque Variations in Instrument Ball Bearings." *ASLE Transactions*, 8 (1965), 435-441.

2. Stevens, K. T. "Experimental Observations on Torque Variation Caused by Bearing Cage Instabilities." *Proceedings of the Second Space Tribology Workshop*, (October 1980), pp. 101-110.

3. Gupta, Pradeep K., J. F. Dill and H. E. Bandow. "Dynamics of Rolling Element Bearings - Experimental Validation of the DREB and RAPIDREB Computer Programs." *ASME Journal of Tribology*, 107 (January 1985), 132-137.

4. Kannel, J. W. and D. Snediker. "Hidden Cause of Bearing Failure." *Machine Design* (7 April 1977), pp. 78-82.

5. Kannel, J. W. "A Simplified Model of Cage Motion in Angular Contact Bearings Operating in the EHD Lubrication Regime." *ASME Journal of Lubrication Technology*, 100, no. 3 (July 1978), 395-403.

6. Gupta, Pradeep K. *Advanced Dynamics of Rolling Elements*. Berlin: Springer-Verlag, ©1984.

7. Meeks, Crawford R. and Karen O. Ng. "The Dynamics of Ball Separators in Ball Bearings - Part 1: Analysis." *ASLE Transactions*, 28, no. 3, 277-287.

8. Boesiger, Edward A. "Planar Analysis of a Dynamic Retainer in a Ball Bearing." Stanford University thesis, September, 1990.

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2. \*\* Note that this is 10 point Arial text

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