DESIGN AND SIMULATION OF EVA TOOLS AND ROBOT END EFFECTORS FOR SERVICING MISSIONS OF THE HST

By

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ABSTRACT

The Hubble Space Telescope (HST) was launched into near-earth orbit by the Space Shuttle Discovery on April 24, 1990. The payload of two cameras, two spectrographs, and a high-speed photometer is supplemented by three fine-guidance sensors that can be used for astronomy as well as for star tracking. A widely reported spherical aberration in the primary mirror causes HST to produce images of much lower quality than intended. A Space Shuttle repair mission in January 1994 installed small corrective mirrors that restored the full intended optical capability of the HST.

A Second Servicing Mission (SM2) scheduled in 1997 will involve considerable Extra Vehicular Activity (EVA). To reduce EVA time, the addition of robotic capability in the remaining servicing missions has been proposed. Toward that end, two concept designs for a general purpose end effector for robots are presented in this report.
## CONTENTS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ABSTRACT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LIST OF FIGURES</td>
<td>(ii)</td>
</tr>
<tr>
<td>1</td>
<td>Background</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Requirements</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>General Purpose End Effector</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>REFERENCES</td>
<td>7</td>
</tr>
<tr>
<td>Fig. No.</td>
<td>Title</td>
<td>Page No.</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1</td>
<td>H-Plate Interface</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Alpha Interface Attachment</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>General Purpose End Effector (Concept - 1)</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>General Purpose End Effector (Concept - 2)</td>
<td>6</td>
</tr>
</tbody>
</table>
Design and Simulation of EVA Tools 
and Robot End Effectors for 
Servicing Missions of the HST

1. Background:
The Hubble Space Telescope (HST) was launched into near-earth orbit by 
the Space Shuttle Discovery on April 24, 1990. The HST's components and 
science instruments are modular to facilitate in-orbit servicing during its expected 
15 year operational time span. A widely reported spherical aberration in the 
primary mirror caused HST to produce images of much lower quality than 
intended. A Space Shuttle repair mission in January 1994 installed small 
corrective mirrors that restored the full intended optical capability of the HST. Four 
additional servicing missions are planned in the future. The Second Servicing 
Mission (SM2) is expected to take place in February 1997 and the remaining 

The First Servicing Mission (FSM) involved five days of Extra Vehicular 
Activity (EVA). On the basis of the experience gained during the FSM, the addition 
of robotic capability on the remaining service missions has been proposed. The 
primary purpose of the robotic systems would be to relieve the astronauts of some 
of the laborious and repetitive tasks of the earlier mission.

Tasks that could be done robotically to assist the astronauts are presented 
in Reference 1. A general purpose end effector (GPEE) will be required for the 
servicing missions and for space station applications. Such devices will have 
advantages where tasks are repetitive, time consuming, and laborious. A concept 
design for a GPEE is presented in this report.

2. Requirements:
The requirements for a GPEE are derived from the end effector 
requirements for the Servicing Aid Tool (SAT) and are listed as follows:
1. The ability to grasp a payload interface plate (Fig. 1) and Micro interface 
   (Fig 2).
2. The ability to grasp a ORU handrail.
4. Mechanically robust to react to 110% of SAT maximum forces and 
   moments in the power-off mode.
5. Integral vision and lighting capability.
3. General Purpose End Effector:

The outline of the concept designs of the proposed general purpose end effector is shown in Figs. 3 and 4. The design is based on an acme screw drive which is inherently non backdrivable when in the power-off mode. Each jaw is independently driven by a separate drive composed of a DC brushless motor and an epicenter gear train. The option of separate drives for each jaw is attractive since it allows for independent control of each finger. This arrangement simplifies motion control of each finger in difficult-to-reach workspace environments. In addition, it facilitates emergency decoupling of the payload with a single jaw. Each drive shaft has been provided with a 3/8-inch socket for EVA override in case of failure. The gripper jaws have been designed to grasp the standard H-plate (payload interface plate) and ORU handrails. A gripper with jaws designed for the micro interface and H-plate interface is shown in Fig. 3 while a second concept with rollers included to reduce friction while gripping the H-plate is shown in Fig. 4. Detailed calculations were made to size acme screws, select various transmission components, and select the brushless motors. Since the design is still in the concept stage, these calculations have not been included.
Fig. 1 H-Plate Interface
INTEGRATING THE DEXTEROUS HANDLING TARGET WITH A MICRO INTERFACE

INTegrating the dexterous handling target with an h-handle

Fig. 2 Alpha Interface Attachment
Fig. 3 General Purpose End Effector (Concept - 1)
Fig. 4 General Purpose End Effector (Concept - 2)
REFERENCES: