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Orbit Targeting Specialist Function

Level C Formulation Requirements

Mission Planning and Analysis Division

August 1978

NASA
National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
SHUTTLE PROGRAM

ORBIT TARGETING SPECIALIST FUNCTION

LEVEL C FORMULATION REQUIREMENTS


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Mission Planning and Analysis Division
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas
August 1978
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>SUMMARY</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>INTRODUCTION</td>
<td>2</td>
</tr>
<tr>
<td>3.0</td>
<td>ACRONYMS</td>
<td>3</td>
</tr>
<tr>
<td>4.0</td>
<td>ORBIT TARGETING SPECIALIST FUNCTION</td>
<td>4</td>
</tr>
<tr>
<td>4.1</td>
<td>PROXIMITY OPERATIONS TARGETING EXECUTIVE TASK (PROX_EXEC)</td>
<td>6</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Detailed Requirements</td>
<td>7</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Interface Requirements</td>
<td>11</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Processing Requirements</td>
<td>11</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Initialization</td>
<td>11</td>
</tr>
<tr>
<td>4.1.5</td>
<td>Supplemental Information</td>
<td>11</td>
</tr>
<tr>
<td>4.2</td>
<td>PROXIMITY OPERATIONS TARGETING STATUS TASK (PROX_STAT)</td>
<td>12</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Detailed Requirements</td>
<td>12</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Interface Requirements</td>
<td>12</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Processing Requirements</td>
<td>12</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Initialization</td>
<td>12</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Supplemental Information</td>
<td>13</td>
</tr>
<tr>
<td>4.3</td>
<td>PROXIMITY OPERATIONS TARGETING TARGET SET SELECT TASK (PROX_TGT_SEL)</td>
<td>13</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Detailed Requirements</td>
<td>13</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Interface Requirements</td>
<td>14</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Processing Requirements</td>
<td>14</td>
</tr>
<tr>
<td>4.3.4</td>
<td>Initialization</td>
<td>15</td>
</tr>
<tr>
<td>4.3.5</td>
<td>Supplemental Information</td>
<td>15</td>
</tr>
<tr>
<td>4.4</td>
<td>PROXIMITY OPERATIONS TARGETING INITIALIZATION TASK (PROX_INIT)</td>
<td>15</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Detailed Requirements</td>
<td>15</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Interface Requirements</td>
<td>15</td>
</tr>
<tr>
<td>4.4.3</td>
<td>Processing Requirements</td>
<td>15</td>
</tr>
<tr>
<td>4.4.4</td>
<td>Initialization</td>
<td>15</td>
</tr>
<tr>
<td>4.4.5</td>
<td>Supplemental Information</td>
<td>15</td>
</tr>
<tr>
<td>4.5</td>
<td>PROXIMITY OPERATIONS TARGETING GUIDANCE QUANTITY TRANSFER TASK (PROX_TRANS)</td>
<td>18</td>
</tr>
<tr>
<td>4.5.1</td>
<td>Detailed Requirements</td>
<td>18</td>
</tr>
<tr>
<td>4.5.2</td>
<td>Interface Requirements</td>
<td>18</td>
</tr>
<tr>
<td>Section</td>
<td>Processing Requirements</td>
<td>Initialization</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>4.5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>PROXIMITY OPERATIONS TARGETING SUPERVISORY LOGIC TASK (PROX_TGT_SUP)</td>
<td></td>
</tr>
<tr>
<td>4.6.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>4.6.2</td>
<td>Interface Requirements</td>
<td></td>
</tr>
<tr>
<td>4.6.3</td>
<td>Processing Requirements</td>
<td></td>
</tr>
<tr>
<td>4.6.4</td>
<td>Initialization</td>
<td></td>
</tr>
<tr>
<td>4.6.5</td>
<td>Supplemental Information</td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>PROXIMITY OPERATIONS TARGETING SUPERVISORY LAMBERT LOGIC TASK (PROX_TGT_SUP_LAMB)</td>
<td></td>
</tr>
<tr>
<td>4.7.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>4.7.2</td>
<td>Interface Requirements</td>
<td></td>
</tr>
<tr>
<td>4.7.3</td>
<td>Processing Requirements</td>
<td></td>
</tr>
<tr>
<td>4.7.4</td>
<td>Initialization</td>
<td></td>
</tr>
<tr>
<td>4.7.5</td>
<td>Supplemental Information</td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>PROXIMITY OPERATIONS TARGETING START TIMER TASK (PROX_STIME)</td>
<td></td>
</tr>
<tr>
<td>4.8.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>4.8.2</td>
<td>Interface Requirements</td>
<td></td>
</tr>
<tr>
<td>4.8.3</td>
<td>Processing Requirements</td>
<td></td>
</tr>
<tr>
<td>4.8.4</td>
<td>Initialization</td>
<td></td>
</tr>
<tr>
<td>4.8.5</td>
<td>Supplemental Information</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>MANEUVER TO OFFSET TARGETING TASK (OFFSET_TGT)</td>
<td></td>
</tr>
<tr>
<td>4.9.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>4.9.2</td>
<td>Interface Requirements</td>
<td></td>
</tr>
<tr>
<td>4.9.3</td>
<td>Processing Requirements</td>
<td></td>
</tr>
<tr>
<td>4.9.4</td>
<td>Initialization</td>
<td></td>
</tr>
<tr>
<td>4.9.5</td>
<td>Supplemental Information</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>RELATIVE STATE PREDICTOR TASK (REL_PRED)</td>
<td></td>
</tr>
<tr>
<td>4.10.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>4.10.2</td>
<td>Interface Requirements</td>
<td></td>
</tr>
<tr>
<td>4.10.3</td>
<td>Processing Requirements</td>
<td></td>
</tr>
<tr>
<td>4.10.4</td>
<td>Initialization</td>
<td></td>
</tr>
<tr>
<td>4.10.5</td>
<td>Supplemental Information</td>
<td></td>
</tr>
<tr>
<td>4.11</td>
<td>RELATIVE STATE COMPUTE TASK (REL_COMP)</td>
<td></td>
</tr>
<tr>
<td>4.11.1</td>
<td>Detailed Requirements</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>4.11.2 Interface Requirements</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.11.3 Processing Requirements</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.11.4 Initialization</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.11.5 Supplemental Information</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.12 PROXIMITY OPERATIONS TARGETING OUTPUT DISPLAY LOAD TASK (PROX_DISP_LOAD)</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.12.1 Detailed Requirements</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>4.12.2 Interface Requirements</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.12.3 Processing Requirements</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.12.4 Initialization</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.12.5 Supplemental Information</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.13 TIME CONVERSION TASK (TIME_CONVRT)</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.13.1 Detailed Requirements</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.13.2 Interface Requirements</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4.13.3 Processing Requirements</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4.13.4 Initialization</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4.13.5 Supplemental Information</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>4.14 DELTA-T COMPUTE TASK (DT_COMP)</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.14.1 Detailed Requirements</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.14.2 Interface Requirements</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.14.3 Processing Requirements</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.14.4 Initialization</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.14.5 Supplemental Information</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.15 OMEGA-DT CALCULATION TASK (OMEGA_DT_COMP)</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>4.15.1 Detailed Requirements</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>4.15.2 Interface Requirements</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.15.3 Processing Requirements</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.15.4 Initialization</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.15.5 Supplemental Information</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.16 ELEVATION ANGLE SEARCH TASK (TELEV)</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.16.1 Detailed Requirements</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>4.16.2 Interface Requirements</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>4.16.3 Processing Requirements</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>4.16.4 Initialization</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>4.16.5 Supplemental Information</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>4.17 PRECISION-REQUIRED VELOCITY TASK (PREVR)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4.17.1 Detailed Requirements</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4.17.2 Interface Requirements</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>
4.17.3 Processing Requirements ................. 53
4.17.4 Initialization ............... 53
4.17.5 Supplemental Information .............. 53

4.18 ELEVATION ANGLE COMPUTATION TASK (COMELE) ................. 53
4.18.1 Detailed Requirements ................. 53
4.18.2 Interface Requirements ............... 54
4.18.3 Processing Requirements .............. 54
4.18.4 Initialization ............... 54
4.18.5 Supplemental Information .............. 54

4.19 ELEVATION ANGLE ITERATION TASK (ELITER) ................. 54
4.19.1 Detailed Requirements ................. 54
4.19.2 Interface Requirements ............... 56
4.19.3 Processing Requirements .............. 56
4.19.4 Initialization ............... 56
4.19.5 Supplemental Information .............. 56

4.20 LAMBERT CONIC-VELOCITY-REQUIRED TASK (LAMBERT) ................. 56
4.20.1 Detailed Requirements ................. 57
4.20.2 Interface Requirements ............... 60
4.20.3 Processing Requirements .............. 60
4.20.4 Initialization ............... 60
4.20.5 Supplemental Information .............. 60

4.21 STATE VECTOR UPDATE TASK (UPDATVP) ................. 60
4.21.1 Detailed Requirements ................. 60
4.21.2 Interface Requirements ............... 61
4.21.3 Processing Requirements .............. 61
4.21.4 Initialization ............... 61
4.21.5 Supplemental Information .............. 61

4.22 NEWTON-RAPHSON ITERATION TASK (ITERV) ................. 61
4.22.1 Detailed Requirements ................. 62
4.22.2 Interface Requirements ............... 63
4.22.3 Processing Requirements .............. 63
4.22.4 Initialization ............... 63
4.22.5 Supplemental Information .............. 63

4.23 ORBITER LVLH TRANSFORMATION TASK (ORBLV) ................. 63
4.23.1 Detailed Requirements ................. 63
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.23.2 Interface Requirements</td>
<td>64</td>
</tr>
<tr>
<td>4.23.3 Processing Requirements</td>
<td>64</td>
</tr>
<tr>
<td>4.23.4 Initialization</td>
<td>64</td>
</tr>
<tr>
<td>4.23.5 Supplemental Information</td>
<td>64</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>PROX_WORLD COMMON</td>
</tr>
<tr>
<td>2</td>
<td>PROX_DIP COMMON</td>
</tr>
<tr>
<td>3</td>
<td>PROX_ILOAD_COMMON</td>
</tr>
<tr>
<td>4</td>
<td>PROX_VARIABLES_COMMON</td>
</tr>
<tr>
<td>5</td>
<td>PROX_LAMVAR_COMMON</td>
</tr>
<tr>
<td>6</td>
<td>INPUT PARAMETERS FOR THE PROX_STAT MODULE</td>
</tr>
<tr>
<td>7</td>
<td>OUTPUT PARAMETERS FOR THE PROX_STAT MODULE</td>
</tr>
<tr>
<td>8</td>
<td>INPUT PARAMETERS FOR THE PROX_INIT MODULE</td>
</tr>
<tr>
<td>9</td>
<td>OUTPUT PARAMETERS FOR THE PROX_INIT MODULE</td>
</tr>
<tr>
<td>10</td>
<td>INPUT PARAMETERS FOR THE PROX_DISP_LOAD MODULE</td>
</tr>
<tr>
<td>11</td>
<td>OUTPUT PARAMETERS FOR THE PROX_DISP_LOAD MODULE</td>
</tr>
<tr>
<td>12</td>
<td>INPUT PARAMETERS FOR THE PROX_STIME MODULE</td>
</tr>
<tr>
<td>13</td>
<td>OUTPUT PARAMETERS FOR THE PROX_STIME MODULE</td>
</tr>
<tr>
<td>14</td>
<td>INPUT PARAMETERS FOR THE PROX_TRANS MODULE</td>
</tr>
<tr>
<td>15</td>
<td>OUTPUT PARAMETERS FOR THE PROX_TRANS MODULE</td>
</tr>
<tr>
<td>16</td>
<td>INPUT PARAMETERS FOR THE PROX_EXEC MODULE</td>
</tr>
<tr>
<td>17</td>
<td>OUTPUT PARAMETERS FOR THE PROX_EXEC MODULE</td>
</tr>
<tr>
<td>18</td>
<td>INPUT PARAMETERS FOR THE PROX_TGT_SEL MODULE</td>
</tr>
<tr>
<td>19</td>
<td>OUTPUT PARAMETERS FOR THE PROX_TGT_SEL MODULE</td>
</tr>
<tr>
<td>20</td>
<td>INPUT PARAMETERS FOR THE PROX_TGT_SUP MODULE</td>
</tr>
<tr>
<td>21</td>
<td>OUTPUT PARAMETERS FOR THE PROX_TGT_SUP MODULE</td>
</tr>
<tr>
<td>22</td>
<td>INPUT PARAMETERS FOR THE PROX_TGT_SUP_LAMB MODULE</td>
</tr>
<tr>
<td>23</td>
<td>OUTPUT PARAMETERS FOR THE PROX_TGT_SUP_LAMB MODULE</td>
</tr>
<tr>
<td>24</td>
<td>INPUT PARAMETERS FOR THE OFFSET_TGT MODULE</td>
</tr>
<tr>
<td>Table</td>
<td>OUTPUT PARAMETERS FOR THE OFFSET_TGT MODULE</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>25</td>
<td>INPUT PARAMETERS FOR THE REL_PRED MODULE</td>
</tr>
<tr>
<td>26</td>
<td>OUTPUT PARAMETERS FOR THE REL_PRED MODULE</td>
</tr>
<tr>
<td>27</td>
<td>INPUT PARAMETERS FOR THE REL_COMP MODULE</td>
</tr>
<tr>
<td>28</td>
<td>OUTPUT PARAMETERS FOR THE REL_COMP MODULE</td>
</tr>
<tr>
<td>29</td>
<td>INPUT PARAMETERS FOR THE TIME_CONVRT MODULE</td>
</tr>
<tr>
<td>30</td>
<td>OUTPUT PARAMETERS FOR THE TIME_CONVRT MODULE</td>
</tr>
<tr>
<td>31</td>
<td>INPUT PARAMETERS FOR THE DT_COMP MODULE</td>
</tr>
<tr>
<td>32</td>
<td>OUTPUT PARAMETERS FOR THE DT_COMP MODULE</td>
</tr>
<tr>
<td>33</td>
<td>INPUT PARAMETERS FOR THE OMEGA_DT_COMP MODULE</td>
</tr>
<tr>
<td>34</td>
<td>OUTPUT PARAMETERS FOR THE OMEGA_DT_COMP MODULE</td>
</tr>
<tr>
<td>35</td>
<td>INPUT PARAMETERS FOR THE TELEV MODULE</td>
</tr>
<tr>
<td>36</td>
<td>OUTPUT PARAMETERS FOR THE TELEV MODULE</td>
</tr>
<tr>
<td>37</td>
<td>INPUT PARAMETERS FOR THE PREVR MODULE</td>
</tr>
<tr>
<td>38</td>
<td>OUTPUT PARAMETERS FOR THE PREVR MODULE</td>
</tr>
<tr>
<td>39</td>
<td>INPUT PARAMETERS FOR THE COMELE MODULE</td>
</tr>
<tr>
<td>40</td>
<td>OUTPUT PARAMETERS FOR THE COMELE MODULE</td>
</tr>
<tr>
<td>41</td>
<td>INPUT PARAMETERS FOR THE ELITER MODULE</td>
</tr>
<tr>
<td>42</td>
<td>OUTPUT PARAMETERS FOR THE ELITER MODULE</td>
</tr>
<tr>
<td>43</td>
<td>INPUT PARAMETERS FOR THE LAMBERT MODULE</td>
</tr>
<tr>
<td>44</td>
<td>OUTPUT PARAMETERS FOR THE LAMBERT MODULE</td>
</tr>
<tr>
<td>45</td>
<td>INPUT PARAMETERS FOR THE UPDATVP MODULE</td>
</tr>
<tr>
<td>46</td>
<td>OUTPUT PARAMETERS FOR THE UPDATVP MODULE</td>
</tr>
<tr>
<td>47</td>
<td>INPUT PARAMETERS FOR THE ITERV MODULE</td>
</tr>
<tr>
<td>48</td>
<td>OUTPUT PARAMETERS FOR THE ITERV MODULE</td>
</tr>
<tr>
<td>49</td>
<td>OUTPUT PARAMETERS FOR THE ITERV MODULE</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>50</td>
<td>INPUT PARAMETERS FOR THE ORBLV TASK</td>
</tr>
<tr>
<td>51</td>
<td>OUTPUT PARAMETERS FOR THE ORBLV TASK</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Orbit targeting generic display</td>
</tr>
<tr>
<td>2</td>
<td>Orbit targeting specialist function task organization</td>
</tr>
<tr>
<td>3</td>
<td>Orbit targeting specialist function data flow</td>
</tr>
<tr>
<td>4</td>
<td>Common package allocations for function modules</td>
</tr>
<tr>
<td>5</td>
<td>Orbit targeting executive task functional flow</td>
</tr>
<tr>
<td>6</td>
<td>Proximity operations targeting supervisory logic task functional flow</td>
</tr>
<tr>
<td>7</td>
<td>Proximity operations targeting supervisory Lambert logic task functional flow</td>
</tr>
</tbody>
</table>
ORBIT TARGETING SPECIALIST FUNCTION

LEVEL C FORMULATION SPECIFICATION

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1.0 SUMMARY

This document contains a definition of the Mission Planning and Analysis Division (MPAD) level C requirements for onboard maneuver targeting software. Included are revisions of the level C software requirements delineated in JSC IN 78-FM-27, Proximity Operations Software; Level C Requirements, dated May 1978. The software will support the terminal phase midcourse (TPM) maneuver, braking and close-in operations as well as supporting computation of the rendezvous corrective combination maneuver (NCC) and the terminal phase initiation (TPI). The second corrective combination maneuver (NSR), which is designed to create an Orbiter orbit coelliptic with the target orbit, is not available. Another NCC to an offset will be used as a substitute. Specific formulation is contained here for the orbit targeting specialist function including the processing logic, linkage, and data base definitions for all modules. The crew interface with the software is through the keyboard and the ORBIT_TGT display.
2.0 INTRODUCTION

The requirements that are provided define software to support maneuver targeting for rendezvous and close-in operations. A primary input is an accurate navigated state vector. To maintain a relative navigation state for maneuver targeting and vehicle control, relative navigation and the processing of sensor tracking data from the star tracker, crew optical alignment sight, or the Ku-band rendezvous radar are required. Prior to the TPI maneuver, sensor updates are incorporated only during the coasting major mode. After TPI, the sensor update will be continuously processed except during periods of Orbiter accelerations above a TBD threshold. Access and control of the software will be through the keyboard and the ORBIT_TGT display. Definition is provided for input, output, and control. The maneuver targeting software consists of two-impulse Lambert software and two-impulse Clohessy-Wiltshire (CW) software, each capable of targeting to an offset position. The maneuvers are displayed to the crew and transferred to guidance for manual execution. Implementation of these requirements will provide the crew with software support to reduce crew workload, to reduce reaction control system (RCS) propellant usage, and to fly a special trajectory.
3.0 **ACRONYMS**

- CW: Clohessy-Wiltshire
- CRT: cathode-ray tube
- delta-t: delta-time
- delta-v: delta-velocity
- GN&C: guidance, navigation, and control
- I/O: input/output
- LV: local vertical
- LVC: local vertical rotating curvilinear
- LVLH: local vertical local horizontal
- LVIR: local vertical inertial rectangular
- NCC: corrective combination maneuvers
- RCS: reaction control system
- TBD: to be determined
- TPI: terminal phase initiation
- TPM: terminal phase midcourse
4.0 **Orbit Targeting Specialist Function**

The orbit targeting specialist function gives the Orbiter crew the capability to generate targeted maneuvers so as to generate vehicle motion from a given position to a desired target referenced relative position. Profile examples that could utilize this targeting function include NCC, TPI, TPM, terminal phase finalization (TPF), braking, stationkeeping, transition, approach, and separation. The targeted maneuver outputs of this specialist function will be available for display to the crew and as inputs to the maneuver execution software functions, including the maneuver guidance function.

The targeting algorithm computes either maneuver of a two-maneuver set. The initial maneuver of the set is targeted to achieve a given position relative to the target vehicle in a given delta-time (delta-t). The second maneuver is targeted to null the Orbiter's velocity relative to a target-centered rotating reference frame.

The targeting algorithm has as inputs a set of constraints (denoted as a target set) that are selected by crew action via the orbit targeting specialist function display (fig. 1). The selected target set can be one of 40 sets available in the I-load or from ground uplink. Lambert maneuvers will be computed for the first NLAMB target sets. Closed-form CW equations will be used to compute maneuvers for the rest of the target sets. The crew has the capability via display input to modify a selected target set and have the appropriate I-load changed accordingly.

In general, a sequence of rendezvous maneuvers, braking maneuvers, stationkeeping maneuvers, or transition maneuvers can be performed by selecting the appropriate target set, computing the solution, executing the indicated maneuver, and then repeating the process for each remaining maneuver in the sequence.

The following sections describe the detailed logic and equations necessary to support orbit operations targeting.

The specifications for the orbit targeting specialist function are presented as a set of modular tasks. These tasks are listed as follows and are numbered with corresponding section numbers of this document in which the detailed requirements are presented.

4.1 Proximity operations targeting executive task (PROX_EXEC)
4.2 Proximity operations targeting status task (PROX_STAT)
4.3 Proximity operations targeting target set select task (PROX_TGT_SEL)
4.4 Proximity operations targeting initialization task (PROX_INIT)
4.5 Proximity operations targeting guidance quantity transfer task (PROX_TRANS)
4.6 Proximity operations targeting supervisory logic task (PROX_TGT_SUP)
4.7 Proximity operations targeting supervisory-Lambert logic task (PROX_TGT_SUP_LAMB)
4.8 Proximity operations targeting start timer task (PROX_STIME)
4.9 Maneuver to offset targeting task (OFFSET_TGT)
4.10 Relative state predictor task (REL_PRED)
4.11 Relative state compute task (REL_COMP)
4.12 Proximity operations targeting output display load task (PROX_DISP_LOAD)
4.13 Time conversion task (TIME_CONVRT)
4.14 Delta-t compute task (DT_COMP)
4.15 Omega-dt compute task (OMEGA_DT_COMP)
4.16 Elevation angle search task (TELEV)
4.17 Precision velocity required task (PREVR)
4.18 Elevation angle computation task (COMELE)
4.19 Elevation angle iteration task (ELITER)
4.20 Lambert conic-velocity-required task (LAMBERT)
4.21 State vector update task (UPDATVP)
4.22 Newton-Raphson iteration task (ITERV)
4.23 Orbiter LVLH transformation task (ORBLV)

The organization of the tasks is shown in figure 2. The main control is in the executive task (PROX_EXEC). The executive calls other tasks that monitor the status and provide for display and guidance interfacing. It also calls one of two targeting supervisory tasks to compute either a maneuver using CW equations or a Lambert maneuver (PROX_TGT_SUP and PROX_TGT_SUP_LAMB, respectively). A general data flow of the orbit targeting specialist function is shown in figure 3.

To facilitate understanding of the data flow interfaces, all orbit targeting specialist function variables are placed in one of the five common packages:

a. PROX_WORLD_COMMON contains all variables that are passed between the specialist function and other guidance, navigation, and control (GN&C) functions.

b. PROX_DIP_COMMON contains all variables that are passed between the specialist function and the ORBIT_TGT_DIP.
c. **PROX_LOAD_COMMON** contains all variables that are input data to the specialist function.

d. **PROX_VARIABLES_COMMON** contains all variables internal to the specialist function.

e. **PROX_LAMVAR_COMMON** contains variables internal to the Lambert routines of the specialist function.

The specific contents of each of these common packages are listed in tables 1 through 5. The common packages available to each of the orbit targeting specialist function modules are shown in figure 4.

In the following sections each function module is explained, and specific input/output (I/O) variables for each module are listed.

### 4.1 PROXIMITY OPERATIONS TARGETING EXECUTIVE TASK (PROX_EXEC)

This cyclically executed module (fig. 5) is the top-level module of the orbit targeting specialist function. A functional flow of the executive task is shown in figure 5. It performs as follows.

a. Initializes data

b. Responds to the crew changes in the display area

c. Sets status discretes for display items to be flashed and for display items to carry stars

d. Transfers target set data between the I-load buffers and the display and computational buffers

e. Calls the task to compute the relative state

f. Calls the appropriate targeting supervisory logic task

g. Calls the task to load the output display data buffers

h. Calls the task to load the guidance buffers with data for the upcoming maneuver

i. Calls the task to load the time management buffer with the time to be counted down to the next maneuver.

This module design assumes that a higher-level software calls or schedules **PROX_EXEC** whenever the specialist function is called by a crew request. It is assumed that the higher-level software will cycle **PROX_EXEC** at a TBD frequency until the crew terminates the specialist function.
4.1.1 Detailed Requirements

The following steps are required to perform the orbit targeting function.

a. Perform a logic test to determine if this is the first pass through the executive.

If first pass (PROX_FIRST_PASS_STATUS = ON)

(1) Set the prox base time to the ILOAD values by setting up the inputs and calling the time conversion task (TIME_CONVRT). The TIME_CONVRT detailed requirements are presented in section 4.13.

TIME_CONVRT_FLAG = 1
DAY = BASE_START_DAY
HR = BASE_START_HOUR
MIN = BASE_START_MIN
SEC = BASE_START_SEC

Call TIME_CONVRT; inputs: TIME_CONVRT_FLAG, DAY, HR, MIN, SEC
output: TIME_SEC

PROX_BASE_TIME = TIME_SEC

(2) Put the base time into the display.

PROX_BASE_DAY = BASE_START_DAY
PROX_BASE_HR = BASE_START_HOUR
PROX_BASE_MIN = BASE_START_MIN
PROX_BASE_SEC = BASE_START_SEC

(3) Initialize T1_TIG and T2_TIG.

T1_TIG = 0
T2_TIG = 0

(4) Initialize the compute in progress status flags.

PROX_T1_STAR_STATUS = OFF
PROX_T2_STAR_STATUS = OFF
(5) Set the first pass status off.

\texttt{PROX\_FIRST\_PASS\_STATUS = OFF}

\textbf{b.} Perform a logic test to determine if the crew made an entry to items 21, 22, 23, or 24.

If an entry was made \texttt{(PROX\_ITEM\_21TO24\_STATUS = ON)}, set the LOAD to flash \texttt{(PROX\_LOAD\_FLASH = ON)}.

\textbf{c.} Call the proximity operations targeting status task (sec. 4.1) to set the maneuver status flag to on or off position if the maneuver TIG time is prior to or past current time. The inputs and outputs are listed in tables 6 and 7.

d. Perform a logic test to determine if the crew has made an entry to item 1. If so \texttt{(PROX\_ITEM\_1\_STATUS = ON)}:

\begin{enumerate}
  \item Call the proximity operations target set select task (sec. 4.3) to load input display buffer and computation buffer from the ILOAD buffer.
  \item Set \texttt{PROX\_ITEM\_1\_STATUS = OFF}.
\end{enumerate}

e. Perform a logic test to determine if the crew executed item 25. If an execution was made \texttt{(PROX\_ITEM\_25\_STATUS = ON)}:

\begin{enumerate}
  \item Transfer the T2 maneuver time data in the computation buffer to the T1 maneuver time computational buffer slots.
    \begin{equation*}
    T1\_TIG = T2\_TIG
    \end{equation*}
  \item Transfer the T2 maneuver time data in the computation buffer to the T1 maneuver time display buffer slots.
    \begin{equation*}
    TIME\_CONVERT\_FLAG = 0
    TIME\_SEC = T1\_TIG
    \end{equation*}
    Call \texttt{TIME\_CONVRT}; inputs: \texttt{TIME\_CONVERT\_FLAG, TIME\_SEC} \\
    \text{outputs:} \texttt{DAY, HR, MIN, SEC} \\
    \texttt{DISP\_T1\_DAY = DAY} \\
    \texttt{DISP\_T1\_HR = HR} \\
    \texttt{DISP\_T1\_MIN = MIN} \\
    \texttt{DISP\_T1\_SEC = SEC}
\end{enumerate}
(3) Set the status flag to off.

\[ \text{PROX\_ITEM\_25\_STATUS} = \text{OFF} \]

f. Perform a logic test to determine if the crew made any entries to items 2 through 20.

(1) If entry was made (\[ \text{PROX\_ITEM\_2T020\_STATUS} = \text{ON} \]), set flag to flash "LOAD".

\[ \text{PROX\_LOAD\_FLASH} = \text{ON} \]

g. Perform a logic test to determine if the crew executed item 26. If execution was made (\[ \text{PROX\_ITEM\_26\_STATUS} = \text{ON} \]):

(1) Convert the input data display buffer items and store in the computational data buffers and the I-load data buffers. The conversion is performed by the proximity operations targeting initialization task (sec. 4.4). The inputs and outputs are presented in tables 8 and 9.

(2) Set status flags to the off condition.

\[ \text{PROX\_ITEM\_2T020\_STATUS} = \text{OFF} \]
\[ \text{PROX\_ITEM\_21T024\_STATUS} = \text{OFF} \]
\[ \text{PROX\_LOAD\_FLASH} = \text{OFF} \]
\[ \text{PROX\_ITEM\_26\_STATUS} = \text{OFF} \]

h. Perform a logic test to determine if the crew executed item 27. If so (\[ \text{PROX\_ITEM\_27\_STATUS} = \text{ON} \]):

(1) Set the compute T1 star status flag to on.

\[ \text{PROX\_T1\_STAR\_STATUS} = \text{ON} \]

(2) Perform a logic test to see if any of the display buffers for T1 relative state are blank (items 7, 8, 9, 10, 11, 12), or if the T1 maneuver time is in the past (\[ \text{T1\_TIG < PROX\_T\_CURRENT} \]).

(a) If so, set USE\_DISP\_REL\_STATE = OFF

(b) If not, set USE\_DISP\_REL\_STATE = ON

i. Perform a logical test to determine if the crew executed item 28. If so (\[ \text{PROX\_ITEM\_28\_STATUS} = \text{ON} \]):
(1) Set the compute T2 star status flag to on.
    PROX_T2_STAR_STATUS = ON
(2) Set the use relative display to off.
    USE_DISP_REL_STATE = OFF
(3) Set the item 28 status to off.
    PROX_ITEM_28_STATUS = OFF

j. Perform a logic test to determine if the compute T1 or compute T2 solutions were requested.

If a request was made (PROX_T1_STAR_STATUS = ON or PROX_T2_STAR_STATUS = ON):

(1) Retrieve the current Orbiter and target state vectors from ON_ORB_UPP.
    RS_M50_PROX = R_AVGG
    VS_M50_PROX = V_AVGG
    RT_M50_PROX = R_TARGET
    VT_M50_PROX = V_TARGET
(2) Retrieve the ON_ORB_UPP nav state time tag (T_STATE), assumed GMT, if the use display flag is off or a Lambert solution is requested.
    If USE_DISP_REL_STATE = OFF or PROX_TGT_SET_NO < NLAMB,
    set TIME_PROX = T_STATE-BASE_MST
(3) Convert the orbital angular rate from the target inertial vector.
    RT_MAG = MAG(RT_M50_PROX)
    VTAN = VT_M50_PROX - UNIT(RT_M50_PROX)(RT_M50_PROX·VT_M50_PROX)/RT_MAG
    OMEGA_PROX = MAG(VTAN)/RT_MAG
(4) Determine whether a Lambert or a CW calculation will be performed and call the appropriate targeting supervisory logic.
    If PROX_TGT_SET_NO < NLAMB, call PROX_TGT_SUP_LAMB.
    Otherwise, call PROX_TGT_SUP
(5) Call the prox ops targeting output display load (sec. 4.12) to transfer the computed output data to the display buffers. The inputs and outputs are listed in tables 10 and 11.

(6) Set the status flags to off.

PROX_Ti_STAR_STATUS = OFF
PROX_T2_STAR_STATUS = OFF

(7) Call the prox ops targeting start timer task (sec. 4.8) and compute the time to the upcoming maneuver and place it in the time management buffer. The inputs and outputs are listed in tables 12 and 13.

(8) Transfer the maneuver execution data to the guidance buffer or array. This transfer is performed by the proximity operations guidance quantity transfer task (sec. 4.5). The inputs and outputs for the task are listed in tables 14 and 15.

4.1.2 Interface Requirements

The input and output requirements for the proximity operations targeting executive task are given in tables 16 and 17.

4.1.3 Processing Requirements

The specialist function will be called on crew demand and will be cycled thereafter at a TBD rate until the crew terminates the specialist function. The display data will be in the main memory so that when the specialist function is recalled the display will contain the data present when the display was last deactivated.

4.1.4 Initialization

The keyboard status flags will be initially set by the orbit targeting DIP I-load values. The output data in the upper portion of the display will be blank until an initial compute is performed. The input data (items 2 through 20) will be blank initially. Initialization of items 2 through 20 will occur from execution of items 26 and 27 or 28. The initialization of items 21 through 24 will be by I-load values.

4.1.5 Supplemental Information

None.
4.2 PROXIMITY OPERATIONS TARGETING STATUS TASK (PROX_STAT)

This task sets the maneuver status flag if the maneuver ignition time is prior to current time.

4.2.1 Detailed Requirements

The following steps are required to perform the proximity operations targeting status task.

a. Perform a logic test to see if current time (T_CURRENT) from FCOS is GMT or MET.

   (1) If GMT (TM_IND = OFF), compute a MET current time.
       \[ \text{PROX_T_CURRENT} = T_{\text{CURRENT}} - \text{BASEMET} \]

   (2) If \( T_{\text{CURRENT}} \) is MET (TM_IND = ON), compute a MET current time.
       \[ \text{PROX_T_CURRENT} = T_{\text{CURRENT}} \]

b. Perform a logical test to determine if the maneuver exists and if it is in the past.

   If it exists and if it is in the past (T_MAN > 0 and PROX_T_CURRENT > T_MAN), set the past status flag to on.
   \[ \text{PROX_PAST_STATUS} = \text{ON} \]
   Otherwise, set it to off.
   \[ \text{PROX_PAST_STATUS} = \text{OFF} \]

4.2.2 Interface Requirements

The input and output parameters for this task are listed in tables 6 and 7.

4.2.3 Processing Requirements

Perform once on call.

4.2.4 Initialization

None.
4.2.5 Supplemental Information
None.

4.3 PROXIMITY OPERATIONS TARGETING TARGET SET SELECT TASK (PROX_TGT_SEL)

This task loads the inputs into the display and computational buffers from the selected set of I-load values.

4.3.1 Detailed Requirements

The following steps are required to perform the proximity operations targeting target set select task. Perform a logic test to retrieve the selected target set data from the I-load arrays.

If the array index equals the target set number (I_INDEX = PROX_TGT_SET_NO), load that value of the array to define the desired set.

\[
\begin{align*}
&\text{T1_ILOAD_ARRAY (I_INDEX)} \\
&\text{DT_ILOAD_ARRAY (I_INDEX)} \\
&\text{EL_ILOAD_ARRAY (I_INDEX)} \\
&\text{XOFF_ILOAD_ARRAY (I_INDEX)} \\
&\text{YOFF_ILOAD_ARRAY (I_INDEX)} \\
&\text{ZOFF_ILOAD_ARRAY (I_INDEX)} \\
\end{align*}
\]

= the desired set in the I-load arrays

a. Load the computational data buffers where:

\[
\begin{align*}
&\text{I_INDEX} = \text{PROX_TGT_SET_NO} \\
&\text{T1_TIG} = \text{PROX_BASE_TIME} + 60 \times \text{T1_ILOAD_ARRAY (I_INDEX)} \\
&\text{COMP_PROX_DT} = \text{DT_ILOAD_ARRAY (I_INDEX)} \\
&\text{EL_ang} = \text{EL_ILOAD_ARRAY (I_INDEX)} \\
&\text{COMP_T2_XOFF} = \text{XOFF_ILOAD_ARRAY (I_INDEX)} \\
&\text{COMP_T2_YOFF} = \text{YOFF_ILOAD_ARRAY (I_INDEX)} \\
&\text{COMP_T2_ZOFF} = \text{ZOFF_ILOAD_ARRAY (I_INDEX)} \\
\end{align*}
\]

b. Load the display buffers for T1 relative position and T2 time with blanks.

\[
\begin{align*}
&\text{DISP_T2_DAY} = \text{blank}
\end{align*}
\]
d. Convert the computational T1 maneuver time (which is in MET) to days, hours, minutes, and seconds by calling the time conversion task (TIME_CONVRT). TIME_CONVRT detailed requirements are presented in section 13.

```plaintext
TIME_CONVERT_FLAG = 0
TIME_SEC = T1_T1G
Call TIME_CONVRT; inputs: TIME_CONVERT_FLAG, TIME_SEC
outputs: DAY, HR, MIN, SEC
```

d. Load the display data buffers where I_INDEX = PROX_TGT_SET_NO.

```plaintext
DISP_T1_DAY = DAY
DISP_T1_HR = HR
DISP_T1_MIN = MIN
DISP_T1_SEC = SEC
DISP_PROX_DT = DT_ILOAD_ARRAY (I_INDEX)
DISP_EL_ANG = (180/PI) * EL_ILOAD_ARRAY (I_INDEX)
DISP_T2_XOFF = XOFF_ILOAD_ARRAY (I_INDEX)
DISP_T2_YOFF = YOFF_ILOAD_ARRAY (I_INDEX)
DISP_T2_ZOFF = ZOFF_ILOAD_ARRAY (I_INDEX)
```

4.3.2 Interface Requirements

The input and output parameters for the proximity operations targeting target set select task are listed in tables 18 and 19.

4.3.3 Processing Requirements

Perform once on call.
4.3.4 Initialization
None.

4.3.5 Supplemental Information
None.

4.4 PROXIMITY OPERATIONS TARGETING INITIALIZATION TASK (PROX_INIT)
This task performs conversions on the input data display buffer items and stores the results in computational data buffers and I-load data buffers.

4.4.1 Detailed Requirements
The following steps are required to perform the proximity operations targeting initialization tasks.

a. Did crew request a change to the base time (PROX_ITEM_21T024_STATUS = ON)? If so, put the displayed base time into the computational buffer:

IF PROX_ITEM_21T024_STATUS = ON and PROX_ITEM_2TO20_STATUS = OFF, then set:
TIME_CONVERT_FLAG = 1
DAY = PROX_BASE_DAY
HR = PROX_BASE_HR
MIN = PROX_BASE_MIN
SEC = PROX_BASE_SEC

Call TIME_CONVRT; inputs: TIME_CONVERT_FLAG
DAY, HR, MIN, SEC
output: TIME_SEC
PROX_BASE_TIME = TIME_SEC.

b. If PROX_ITEM_2TO20_STATUS is ON and PROX_ITEM_21T024_STATUS is OFF:

(1) Load the offset position and delta-Δ computation buffers and I-load buffers. The I-load buffers index value is determined by the selected target set (I_INDEX = PROX_TGT_SET_NO).
\[
\text{COMP\_T2\_XOFF} = \text{DISP\_T2\_XOFF} \\
\text{COMP\_T2\_YOFF} = \text{DISP\_T2\_YOFF} \\
\text{COMP\_T2\_ZOFF} = \text{DISP\_T2\_ZOFF} \\
\text{COMP\_PROX\_DT} = \text{DISP\_PROX\_DT} \\
\text{EL\_ANG} = \text{DISP\_EL\_ANG} \cdot \frac{\pi}{180} \\
\text{XOFF\_ILOAD\_ARRAY (I\_INDEX)} = \text{DISP\_T2\_XOFF} \\
\text{YOFF\_ILOAD\_ARRAY (I\_INDEX)} = \text{DISP\_T2\_YOFF} \\
\text{ZOFF\_ILOAD\_ARRAY (I\_INDEX)} = \text{DISP\_T2\_ZOFF} \\
\text{DT\_ILOAD\_ARRAY (I\_INDEX)} = \text{DISP\_PROX\_DT} \\
\text{EL\_ILOAD\_ARRAY (I\_INDEX)} = \text{EL\_ANG}
\]

(2) Load the computation relative position and velocity buffers.

\[
\text{COMP\_X} = \text{DISP\_T1\_X} \\
\text{COMP\_XD} = \text{DISP\_T1\_XD}
\]

(3) Convert the display T1 time and display T2 time and load the computation and I-load buffers.

(a) Call the time conversion task \(\text{TIME\_CONVRT}\) to convert display T1 time to total seconds. \(\text{TIME\_CONVRT}\) detailed requirements are presented in section 4.13.

\[
\text{TIME\_CONVRT\_FLAG} = 1 \\
\text{DAY} = \text{DISP\_T1\_DAY} \\
\text{HR} = \text{DISP\_T1\_HR} \\
\text{MIN} = \text{DISP\_T1\_MIN} \\
\text{SEC} = \text{DISP\_T1\_SEC}
\]

Call \(\text{TIME\_CONVRT}\); inputs: \(\text{TIME\_CONVRT\_FLAG}, \text{DAY}, \text{HR}, \text{MIN}, \text{SEC}\)

output: \(\text{TIME\_SEC}\)

(b) Load the T1 time in the computation and I-load buffers. Set \(\text{TIME\_PROX}\).
\[ T_{1\_TIG} = \text{TIME\_SEC} \]
\[ T_{1\_LOAD\_ARRAY\,(I\_INDEX)} = (\text{TIME\_SEC}\,-\text{PROX\_BASE\_TIME})/60. \]
\[ \text{TIME\_PROX} = T_{1\_TIG} \]
\[ I\_INDEX = \text{PROX\_TGT\_SET\_NO} \]

(c) Call the time conversion task (TIME\_CONVRT) to convert display T2 time to total seconds.

\[ \text{DAY} = \text{DISP\_T2\_DAY} \]
\[ \text{HR} = \text{DISP\_T2\_HR} \]
\[ \text{MIN} = \text{DISP\_T2\_MIN} \]
\[ \text{SEC} = \text{DISP\_T2\_SEC} \]

Call TIME\_CONVRT; inputs: TIME\_CONVERT\_FLAG, DAY, HR, MIN, SEC

output: TIME\_SEC

(d) Load the T2 time in the computation array.

\[ T_{2\_TIG} = \text{TIME\_SEC} \]

4.4.2 Interface Requirements

The input and output parameters for the proximity operations targeting initialization tasks are listed in tables 8 and 9.

4.4.3 Processing Requirements

Perform once on call.

4.4.4 Initialization

None.

4.4.5 Supplemental Information

None.
4.5 PROXIMITY OPERATIONS TARGETING GUIDANCE QUANTITY TRANSFER TASK
(PROX_TRANS)

This task sets the quantities required to perform the maneuver.

The delta-v maneuver (called DELTA_V_LVLH_GUID) is defined in terms of the
Orbiter-centered local vertical local horizontal (LVLH) coordinate system for
Lambert maneuvers (which have GUID_FLAG = 1) and is defined in terms of the tar-
get-centered LVLH curvilinear coordinate system, otherwise.

4.5.1 Detailed Requirements

The following steps are required to perform the proximity operations targeting
guidance quantity transfer task.

a. Perform a logical test to see if the maneuver has been executed. If it has
not been executed (PROX_FAST_STATUS = OFF), then:

(1) Set TIG_GUID_DAY = DISP_TMAN_DAY
    TIG_GUID_HR = DISP_TMAN_HR
    TIG_GUID_MIN = DISP_TMAN_MIN
    TIG_GUID_SEC = DISP_TMAN_SEC

(2) Set DELTA_V_LVLH_GUID = DV_LVLH

(3) Test to see if the maneuver is a Lambert maneuver. If so
    (GUID_FLAG = 1), set:
    S_ROTATE_GUID = S_ROTATE
    R_OFFSET_GUID = R_OFFSET
    T_OFFSET_GUID = T_OFFSET

4.5.2 Interface Requirements

The input and output parameters for the proximity operations targeting guidance
quantity transfer task are given in tables 14 and 15.

4.5.3 Processing Requirements

Perform once on call.
4.5.4 **Initialization**

None.

4.5.5 **Supplemental Information**

None.

4.6 **PROXIMITY OPERATIONS TARGETING SUPERVISORY LOGIC TASK (PROX_TGT_SUP)**

This task is scheduled and executed following a crew execution of item 27 or item 28 for a non-Lambert targeted maneuver. This task is the top-level supervisory module for performing the subtask required to compute the maneuver delta-velocity (delta-v) vector using closed form CW equations. A functional flow of PROX_TGT_SUP is shown in figure 6.

4.6.1 **Detailed Requirements**

The following steps are required to perform the targeting supervisory logic.

a. Is the USE_DISP_REL_STATE flag off? If so, use navigated target and Orbiter states and compute the LVLH curvilinear relative state:

\[
\begin{align*}
\mathbf{R}_{\text{T INER}} &= \mathbf{R}_{\text{T M50 PROX}} \\
\mathbf{V}_{\text{T INER}} &= \mathbf{V}_{\text{T M50 PROX}} \\
\mathbf{R}_{\text{S INER}} &= \mathbf{R}_{\text{S M50 PROX}} \\
\mathbf{V}_{\text{S INER}} &= \mathbf{V}_{\text{S M50 PROX}} \\
\text{INER_TO_LVC} &= \text{ON} \\
\text{Call REL_COMP; inputs: } \mathbf{R}_{\text{T INER}}, \mathbf{V}_{\text{T INER}} \\
& \hspace{1cm} \mathbf{R}_{\text{S INER}}, \mathbf{V}_{\text{S INER}} \\
& \hspace{1cm} \text{INER_TO_LVC, OMEGA_PROX} \\
& \hspace{1cm} \text{outputs: } \mathbf{R}_{\text{REL}}, \mathbf{V}_{\text{REL}} \\
\end{align*}
\]

\[
\begin{align*}
\text{COMP}_{\mathbf{X}} &= \mathbf{R}_{\text{REL}} \\
\text{COMP}_{\mathbf{XD}} &= \mathbf{V}_{\text{REL}}
\end{align*}
\]

b. Compute the minimum time to ignition:

\[
\text{TIG_MIN} = \text{PROX_T_Current} + \text{PROX_DTM_MIN}
\]
c. Did the crew request the compute T1 function (PROX_T1_STAR_STATUS = ON)?

(1) If not, compute the T2 maneuver:
   
   (a) If TIG_MIN > T2_TIG, set T2_TIG = TIG_MIN

   (b) Update the present relative state to T2_TIG:
       \[
       \begin{align*}
       \bar{X} &= \text{COMP}_\bar{X} \\
       \bar{XD} &= \text{COMP}_\bar{XD} \\
       DTIME &= T2_TIG - \text{TIME_PROX}
       \end{align*}
       \]
       Call REL_PRED; inputs: \(\bar{X}, \bar{XD}, DTIME\)
       outputs: \(\bar{X}_2, \bar{XD}_2\)
       \[
       \begin{align*}
       \text{COMP}_\bar{X} &= \bar{X}_2 \\
       \text{COMP}_\bar{XD} &= \bar{XD}_2
       \end{align*}
       \]
       \[
       \text{TIME_PROX} = \text{TIME_PROX} + DTIME
       \]

   (c) Null the relative rate.
       \[
       \bar{DV}_LVLH = -\text{COMP}_\bar{XD}
       \]
       T_MAN = T2_TIG

(2) Otherwise, compute the T1 maneuver:

   (a) Compute the transfer time and T2_TIG.
       Call DT_COMP; inputs: T1_TIG, T2_TIG, COMP_PROX_DT
       outputs: T2_TIG, COMP_PROX_DT
       \[
       \text{USE}_\Omega DT
       \]

   (b) If TIG_MIN > T1_TIG, then:
       (i) Set T1_TIG = TIG_MIN
       (ii) If USE_\Omega DT is off, set
            \[
            \text{COMP_PROX_DT} = (T2_TIG - T1_TIG)/60.
            \]
       (iii) Set USE_DISP_REL_STATE = OFF
(c) If USE_DISP_REL_STATE is off, then:

(i) Update the present relative state to T1_TIG:

\[ \bar{X} = \text{COMP}_{\bar{X}} \]
\[ \bar{XD} = \text{COMP}_{\bar{XD}} \]
\[ \text{DTIME} = \text{T1_TIG\_TIME\_PROX} \]
Call REL_PRED; inputs: \( \bar{X}, \bar{XD}, \text{DTIME} \)
output: \( \bar{X} = X2 \)
\[ \text{COMP}_{\bar{X}} = X2 \]
\[ \text{COMP}_{\bar{XD}} = XD2 \]

(ii) Display the expected state at T1_TIG.

\[ \text{DISP}\_T1\_\bar{X} = \text{COMP}_{\bar{X}} \]
\[ \text{DISP}\_T1\_\bar{XD} = \text{COMP}_{\bar{XD}} \]

(d) If USE_OMEGA_DT is on:

(i) Use the OMEGA_DT_COMP routine to compute the transfer time.

Call OMEGA_DT_COMP;

\[ \text{COMP}\_X \]
\[ \text{COMP}\_T2\_XOFF \]
\[ \text{COMP}\_T2\_YOFF \]
\[ \text{COMP}\_T2\_ZOFF \]
inputs: \( \text{XOFF}\_\text{ILOAD\_ARRAY} \)
\( \text{YOFF}\_\text{ILOAD\_ARRAY} \)
\( \text{ZOFF}\_\text{ILOAD\_ARRAY} \)
\( \text{DT}\_\text{ILOAD\_ARRAY} \)
\( \text{OMEGA\_PROX} \)
output: \( \text{COMP}\_\text{PROX\_DT} \)
(ii) Compute $T_2\_TIG$.

$$T_2\_TIG = T1\_TIG + 60 \text{ COMP\_PROX\_DT}$$

(e) Compute the $T1$ maneuver.

$$DT\_OFFTGT = \text{COMP\_PROX\_DT}$$
$$\bar{X}\_OFFTGT = \text{COMP\_X}$$
$$\bar{XD}\_OFFTGT = \text{COMP\_XD}$$

$$\begin{cases} \text{COMP\_T2\_XOFF} \\
\text{COMP\_T2\_YOFF} \\
\text{COMP\_T2\_ZOFF}
\end{cases}$$

$\bar{X2}\_OFFTGT$

Call OFFSET_TGT inputs: $DT\_OFFTGT$

$$\bar{X}\_OFFTGT$$

$$\bar{XD}\_OFFTGT$$

$$\bar{X2}\_OFFTGT$$

output: $\bar{DV}$

$$\bar{DV}\_LVLH = \bar{DV}$$

$T\_MAN = T1\_TIG$

d. Set the guidance flag (GUID\_FLAG) to zero.

4.6.2 Interface Requirements

The input and output parameters for the proximity operations targeting supervisory logic task are listed in tables 20 and 21.

4.6.3 Processing Requirements

Perform once on call.

4.6.4 Initialization

None.

4.6.5 Supplemental Information

None.
4.7 PROXIMITY OPERATIONS TARGETING SUPERVISORY LAMBERT LOGIC TASK
(PROX_TGT_SUP_LAMB)

This task is scheduled and executed following a crew execution of item 27 or item 28 if Lambert targeting is requested (PROX_TGT_SET_NO < NLAMB). This task is the top level supervisory module for performing the subtask required to compute the maneuver delta-v vector with Lambert equations. A functional flow of PROX_TGT_SUP_LAMB is shown in figure 7.

4.7.1 Detailed Requirements

The following steps are required to compute maneuvers.

a. Compute minimum time to ignition.

\[ T_{IG\_MIN} = PROX\_T\_CURRENT + PROX\_DTMIN\_LAMB \]

b. Check compute T1 flag:

(1) If PROX_T1\_STAR\_STATUS = OFF, compute the T2 maneuver.

   (a) If T2\_TIG < TIG\_MIN, set T2\_TIG = TIG\_MIN

   (b) Update Shuttle and target inertial states from the present time to T2\_TIG.

\[ S\_OPTION = 1 \]
\[ \bar{R}_{IN} = \bar{R}_{S\_M50\_PROX} \]
\[ \bar{V}_{IN} = \bar{V}_{S\_M50\_PROX} \]
\[ T_{IN} = TIME\_PROX + BASE\_MET \]
\[ T_{OUT} = T2\_TIG + BASE\_MET \]

Call UPDATVP; inputs: S\_OPTION, \( \bar{R}_{IN} \), \( \bar{V}_{IN} \), T\_IN, T\_OUT

outputs: \( \bar{R}_{OUT} \), \( \bar{V}_{OUT} \)

\[ \bar{R}_{S\_INNER} = \bar{R}_{OUT}; \bar{V}_{S\_INNER} = \bar{V}_{OUT} \]
\[ S\_OPTION = 2 \]
\[ \bar{R}_{IN} = \bar{R}_{T\_M50\_PROX} \]
\[ \bar{V}_{IN} = \bar{V}_{T\_M50\_PROX} \]
Call UPDATVP:
\[ \mathbf{R}_{T, \text{INER}} = \mathbf{R}_{OUT} \]
\[ \mathbf{V}_{T, \text{INER}} = \mathbf{V}_{OUT} \]

(c) Convert to a target-centered curvilinear state.
\[ \text{INER}_\text{TO}_LVC = \text{ON} \]
Call REL_COMP; inputs: \[ \mathbf{R}_{T, \text{INER}}, \mathbf{V}_{T, \text{INER}} \]
\[ \mathbf{R}_{S, \text{INER}}, \mathbf{V}_{S, \text{INER}} \]
\[ \text{INER}_\text{TO}_LVC \]
outputs: \[ \mathbf{R}_{REL}, \mathbf{V}_{REL} \]

(d) Null relative velocity. Determine maneuver time. Set guidance flag for external DV.
\[ \mathbf{DV}_{LVLH} = -\mathbf{V}_{REL} \]
\[ \text{T}_\text{MAN} = T2_{TIG} \]
\[ \text{GUID}_\text{FLAG} = 0. \]

(2) If \( \text{PROX}_T\text{i}_{\text{STAR}}\text{_STATUS} = \text{ON} \), compute the T1 maneuver.

(a) If elevation angle \( (\text{EL}_\text{ANG}) \) is \( \neq 0 \), then determine T1 time from elevation angle search:

(1) Compute time of elevation angle.
Call TELEV; inputs: \[ \mathbf{R}_S_{M50}\text{PROX} \]
\[ \mathbf{V}_S_{M50}\text{PROX} \]
\[ \mathbf{R}_T_{M50}\text{PROX} \]
\[ \mathbf{V}_T_{M50}\text{PROX} \]
\[ \text{TIME}_\text{PROX}, \]
\[ \text{EL}_\text{ANG}, \]
\[ \text{PI} \]
\[ \text{EL}_\text{TOL}, \text{EL}_\text{DH}_\text{TOL} \]
outputs: TTPI, RS_OUT, VS_OUT
          RT_OUT, VT_OUT
          TS_OUT, TT_OUT

T1_TIG = TTPI

(ii) Find relative state.
    R_S_INER = RS_OUT
    V_S_INER = VS_OUT
    R_T_INER = RT_OUT
    V_T_INER = VT_OUT
    INER_TO_LVC = ON
    Call REL_COMP;
    COMP_X = R_REL
    COMP_XD = V_REL

(iii) Display relative state.
    DISP_T1_X = R_REL
    DISP_T1_XD = V_REL

(iv) Change base time in display and computational buffer; change I-load.
    T1_ILOAD_ARRAY (PROX_TGT_SET_NO) = 0.
    PROX_BASE_TIME = T1_TIG
    TIME_CONVERT_FLAG = 0
    TIME_SEC = T1_TIG
    Call TIME_CONVRT; inputs: TIME_CONVERT_FLAG
                        TIME_SEC
    outputs: DAY, HR, MIN, SEC
PROX_BASE_DAY = DAY
PROX_BASE_HR = HR
PROX_BASE_MIN = MIN
PROX_BASE_SEC = SEC

(b) If elevation angle (EL_ANG) = 0, use the T1 time given for the maneuver time.

(i) Given T1_TIG, compute T2_TIG and/or COMP_PROX_DT.
Call DT_COMP; inputs: T1_TIG, T2_TIG, COMP_PROX_DT
outputs: T2_TIG, COMP_PROX_DT

USE_OMEGA_DT

(ii) Compare to the minimum time of ignition (TIG_MIN).
If T1_TIG < TIG_MIN:

(aa) Set T1_TIG = TIG_MIN.

(bb) Check the USE_OMEGA_DT. If it is off, then the maneuver transfer time will be adjusted so that the next maneuver will be on time.

COMP_PROX_DT = (T2_TIG-T1_TIG)/60

(cc) Set the USE_DISP_REL_STATE flag to off.

(iii) Update the target state to T1_TIG:
S_OPTION = 2
\( \bar{R}_{IN} = RT_{M50_PROX} \)
\( \bar{V}_{IN} = VT_{M50_PROX} \)
\( T_{IN} = TIME_PROX + BASE_MET \)
\( T_{OUT} = T1_TIG + BASE_MET \)
Call UPDATVP; inputs: \( \bar{R}_{IN}, \bar{V}_{IN}, T_{IN}, T_{OUT}, S_{OPTION} \)
outputs: \( \bar{R}_{OUT}, \bar{V}_{OUT} \)
R_T_INER = R_OUT
V_T_INER = V_OUT
RT_T1TIG = R_OUT
VT_T1TIG = V_OUT

(iv) Check the USE_DISP_REL_STATE flag.

(aa) If USE_DISP_REL_STATE is on, compute the Shuttle inertial state at T1.

INER_TO_LVC = OFF
R_REL = COMP_X
V_REL = COMP_XD

Call REL_COMP inputs: R_REL, V_REL, INER_TO_LVC

outputs: R_S_INER
V_S_INER

RS_T1TIG = R_S_INER
VS_T1TIG = V_S_INER

(bb) If USE_DISP_REL_STATE is off, update the present Shuttle states to T1_TIG, convert to curvilinear coordinates and display:

(aaa) Update the Shuttle inertial state.

S_OPTION = 1
R_IN = RS_M50_PROX
V_IN = VS_M50_PROX

Call UPDATVP

RS_T1TIG = R_OUT
VS_T1TIG = V_OUT
(bbb) Convert to LVLH curvilinear coordinates.

\[ \text{INER}_\text{TO}_LVC = \text{ON} \]

Call REL\_COMP;

inputs: \( \text{R}_T \_\text{INER}, \text{V}_T \_\text{INER} \)
\[ \text{R}_S \_\text{INER}, \text{V}_S \_\text{INER} \]
\[ \text{INER}_\text{TO}_LVC \]

outputs: \( \text{R}_\text{REL}, \text{V}_\text{REL} \)

(ccc) Load the computation buffers at T1\_TIG for possible use in OMEGA\_DT\_COMP later.

\[ \text{COMP}_X = \text{R}_\text{REL} \]
\[ \text{COMP}_XD = \text{V}_\text{REL} \]

(ddd) Load the display buffers at T1\_TIG.

\[ \text{DISP}_T1_\text{X} = \text{R}_\text{REL} \]
\[ \text{DISP}_T1_\text{XD} = \text{V}_\text{REL} \]

(c) Compute T2\_TIG and COMP\_PROX\_DT from the T1\_TIG being used.

Call DT\_COMP; inputs: T1\_TIG, T2\_TIG, COMP\_PROX\_DT

outputs: T2\_TIG, COMP\_PROX\_DT,
\[ \text{USE}_\text{OMEGA}_\text{DT} \]

(d) Check the USE\_OMEGA\_DT flag. If it is on, there is insufficient information to determine T2\_TIG and COMP\_PROX\_DT. Compute this information instead by use of the "t-calculation."

(i) Compute the transfer time.

Call OMEGA\_DT\_COMP.

inputs: COMP\_X

\[ \text{COMP}_T2\_XOFF \]
\[ \text{COMP}_T2\_YOFF \]
\[ \text{COMP}_T2\_ZOFF \]

ORIGINAL PAGE IS OF POOR QUALITY
XOFF_ILOAD_ARRAY (PROX_TGT_SET_NO + 1)
YOFF_ILOAD_ARRAY (PROX_TGT_SET_NO + 1)
ZOFF_ILOAD_ARRAY (PROX_TGT_SET_NO + 1)
DT_ILOAD_ARRAY (PROX_TGT_SET_NO + 1)

OMEGA_PROX

output: COMP_PROX_DT

(ii) Compute T2_T1G:

T2_T1G = T1_T1G + 60 COMP_PROX_DT

(e) Update the target inertial state from T1_T1G.

S_OPTION = 2

\( \overline{R}_{IN} = \overline{R}_{T\_INER} \)

\( \overline{V}_{IN} = \overline{V}_{T\_INER} \)

\( T_{IN} = T1\_T1G + BASE\_MET \)

\( T\_OUT = T2\_T1G + BASE\_MET \)

Call UPDATVP; inputs: \( \overline{R}_{IN}, \overline{V}_{IN}, T\_IN, T\_OUT \)

outputs: \( \overline{R}_{OUT}, \overline{V}_{OUT} \)

\( \overline{R}_{T\_INER} = \overline{R}_{OUT} \)

\( \overline{V}_{T\_INER} = \overline{V}_{OUT} \)

(f) Compute the Shuttle inertial state at T2.

\[
\overline{R}_{REL} = \begin{cases} 
\text{COMP\_T2\_XOFF} \\
\text{COMP\_T2\_YOFF} \\
\text{COMP\_T2\_ZOFF}
\end{cases}
\]

\( \overline{R}_{\_INER\_TO\_LVC} = \text{OFF} \)

Call REL\_COMP; inputs: \( \overline{R}_{T\_INER}, \overline{V}_{T\_INER}, \overline{R}_{REL} \)

outputs: \( \overline{R}_{S\_INER} \)
(g) Do the Lambert problem using the precision velocity required routine.

Call PREVR; inputs: T1_TIG, T2_TIG, RS_T1TIG, VS_T1TIG, RS_T2TIG

output: VS_REQUIRED
RS_IPO
R_OFFSET, T_OFFSET
S_ROTATE

(h) Compute the LVLH Shuttle-centered relative state at T1 before the maneuver.

RS = RS_T1TIG
VS = VS_T1TIG
RT = RT_T1TIG
VT = VT_T1TIG

Call ORBLV; inputs: RS, VS, RT, VT
output: VSLV
V_LVLH = VSLV

(i) Compute the LVLH Shuttle-centered relative state at T1 after the impulsive maneuver.

VS = VS_REQUIRED

Call ORBLV; inputs: RS, VS, RT, VT
output: VSLV

(j) Compute the LVLH Shuttle-centered maneuver required at T1.

DV_LVLH = VSLV-V_LVLH

T_MAN = T1_TIG
GUID_FLAG = 1
4.7.2 Interface Requirements

The input and output parameters for the proximity operations targeting supervisory Lambert logic task are listed in tables 22 and 23.

4.7.3 Processing Requirements

Perform once per call.

4.7.4 Initialization

None.

4.7.5 Supplemental Information

None.

4.8 PROXIMITY OPERATIONS TARGETING START TIMER TASK (PROX_STIME)

This task sets the display time to count down to.

4.8.1 Detailed Requirements

The following steps are required to perform this task.

a. Perform a test to see if the maneuver has been executed (PROX_PAST_STATUS = ON).

(1) If PROX_PAST_STATUS = ON, set CRT_TIME = OFF.

(2) If PROX_PAST_STATUS = OFF, calculate the delta-t between the current time and the maneuver time and set the cathode-ray tube (CRT) timer status flags:

(a) If current time is GMT (TM_IND = OFF), set

\[ DT_{ST\_TIMER} = T_{MAN} + BASE_{MET} - T_{CURRENT} \]

(b) If current time is MET (TM_IND = ON), set

\[ DT_{ST\_TIMER} = T_{MAN} - T_{CURRENT} \]

(c) Set the CRT timer status flags:

\[ CRT\_TIME = ON \]
\[ CRT\_UPDWN = ON \]
4.8.2 Interface Requirements

The input and output parameters for the proximity operations targeting start time task are listed in tables 12 and 13.

4.8.3 Processing Requirements

Perform once on call.

4.8.4 Initialization

None.

4.8.5 Supplemental Information

None.

4.9 MANEUVER TO OFFSET TARGETING TASK (OFFSET_TGT)

This task computes a LVLH maneuver delta-v vector to achieve the desired offset position in the specified delta-t.

4.9.1 Detailed Requirements

The following steps are required to perform the maneuver to offset targeting task.

a. Compute the T1 maneuver delta-v vector:

\[ W = \text{OMEGA}_\text{PROX} \]
\[ T = 60 \ DT_\text{OFFTGT} \]
\[ S = \sin (W \ T) \]
\[ C = \cos (W \ T) \]
\[ C_1 = 1 - C \]
\[ K = W/(8 - 8C - 3S \ W \ T) \]

\[
\text{MAT} = \begin{bmatrix}
-KS & 0 & K(14C1-6WTS) & KS & 0 & -2KC1 \\
0 & -CW/S & 0 & 0 & W/S & 0 \\
-2KC1 & 0 & K(3CWT-4S) & 2KC1 & 0 & K(4S-3WT)
\end{bmatrix}
\]
\[ \text{STATE}_{1,2,3} = \bar{x}_{\text{OFFTGT}} \]
\[ \text{STATE}_{4,5,6} = \bar{x}_{2_{\text{OFFTGT}}} \]
\[ \bar{v}_{\text{T1\_NEED}} = \text{MAT \ STATE} \]
\[ \bar{d}v = \bar{v}_{\text{T1\_NEED}} - \bar{x}_{\text{D\_OFFTGT}} \]

4.9.2 Interface Requirements

The input and output parameters for the maneuver to offset targeting task are listed in tables 24 and 25.

4.9.3 Processing Requirements

Perform once on call.

4.9.4 Initialization

None.

4.9.5 Supplemental Information

None.

4.10 RELATIVE STATE PREDICTOR TASK (REL_PRED)

This task propagates a target-centered LVLH relative rotating curvilinear vector. The algorithm is closed form and utilizes several simplifying assumptions.

4.10.1 Detailed Requirements

The following are the steps required to perform the relative state predictor tasks.

a. Find transformation matrix to predict the new state at time \( t_2 \) from the state at \( t_1 \).

\[ W = \text{OMEGA\_PROX} \]
\[ T = \text{D\_TIME} \]
\[ S = \text{SIN} (W \cdot T) \]
C = \cos (W T)

C1 = 1 - C

\text{MAT\_PRED} = \begin{bmatrix}
1 & 0 & 6W - 6S & 4S/W - 3T & 0 & 2 C1/W \\
0 & C & 0 & 0 & S/W & 0 \\
0 & 0 & 4 - 3C & -2 C1/W & 0 & 2/W \\
0 & 0 & 6W C1 & 4C - 3 & 0 & 2S \\
0 & -WS & 0 & 0 & C & 0 \\
0 & 0 & 3 WS & -2S & 0 & C
\end{bmatrix}

b. Use predictor matrix to get new relative state at T2.

\overline{\text{STATE}1_{1,2,3}} = \overline{X}

\overline{\text{STATE}1_{4,5,6}} = \overline{XD}

\overline{\text{STATE}2} = \text{MAT\_PRED} \overline{\text{STATE}1}

\overline{X2} = \overline{\text{STATE}2_{1,2,3}}

\overline{XD2} = \overline{\text{STATE}2_{4,5,6}}

4.10.2 Interface Requirements

The input and output parameters for the relative state predictor task are listed in tables 26 and 27.

4.10.3 Processing Requirements

Perform once on call.

4.10.4 Initialization

None.

4.10.5 Supplemental Information

None.

4.11 RELATIVE STATE COMPUTE TASK (REL\_COMP)

This task computes the state of the Orbiter in a target-centered local vertical rotating curvilinear (LVC) coordinate system using the Earth-centered inertial (M50) states of the Orbiter and the target, or performs the reverse transformation, depending on an input flag.
4.11.1 Detailed Requirements

The following steps are required to perform this task.

a. Find RT_MAG: \( RT\_MAG = \text{mag}(\vec{R}T\_INER) \)

b. Compute the transformation matrix from M50 inertial frame to the local vertical inertial rectangular (LVIR) coordinate frame:
\[
\text{MAT}_{M50\_LVIR} = \begin{bmatrix}
\text{unit}\left( (\vec{R}T\_INER \times \vec{V}T\_INER) \times \vec{R}T\_INER \right)^T \\
-\text{unit}\left( \vec{R}T\_INER \times \vec{V}T\_INER \right)^T \\
-\text{unit}\left( \vec{R}T\_INER \right)^T
\end{bmatrix}
\]

c. Determine the orbital angular rate vector in LVLH coordinates:
\[
\vec{\text{OMEGA\_LV\_PROX}} = \text{OMEGA\_PROX} \begin{pmatrix} 0 \\ -1 \\ 0 \end{pmatrix}
\]

d. Determine if the transformation to be done is from inertial M50 coordinates to the LV curvilinear target-centered coordinates (LVC), i.e. INER\_TO\_LVC = ON.

(1) If INER\_TO\_LVC = ON:

(a) Compute the relative M50 state of the Orbiter with respect to the target.
\[
\vec{\text{RTS\_M50}} = \vec{R}S\_INER - \vec{R}T\_INER \\
\vec{\text{VTS\_M50}} = \vec{V}S\_INER - \vec{V}T\_INER
\]

(b) Convert these states to a target-centered LVIR coordinate frame:
\[
\vec{\text{RTS\_LVIR}} = \text{MAT}_{M50\_LVIR} \vec{\text{RTS\_M50}} \\
\vec{\text{VTS\_LVIR}} = \text{MAT}_{M50\_LVIR} \vec{\text{VTS\_M50}}
\]

(c) Convert the LVIR relative states to a target-centered LV rotating rectangular coordinate frame.
\[
\vec{\text{RTS\_LVL}} = \vec{\text{RTS\_LVIR}} \\
\vec{\text{VTS\_LVL}} = \vec{\text{VTS\_LVIR}} - (\vec{\text{OMEGA\_LV\_PROX}} \times \vec{\text{RTS\_LVIR}})
\]

(d) Convert the LV relative states to a target-centered local vertical rotating curvilinear coordinate frame.
\[
\text{ZCON} = \vec{\text{RT\_MAG}} - \vec{\text{RTS\_LVL}}
\]
\[
\begin{align*}
\theta &= \text{atan} \left( \frac{\text{RTS}_{LV1} / \text{ZCON}}{\text{RT}_\text{MAG} \text{ THETA}} \right) \\
\overline{R}_{\text{REL}} &= \begin{bmatrix} \text{RT}_\text{MAG} \text{ THETA} \\
\text{RTS}_{LV2} \\
\text{RT}_\text{MAG} - \text{ZCON} / \text{COS(THETA)} \end{bmatrix} \\
\overline{\text{THETA}}_{\text{DOT}} &= \text{COS}^2(\text{THETA})(\text{VTS}_{LV1} \text{ ZCON} + \text{RTS}_{LV1} \text{ VTS}_{LV3}) / (\text{ZCON})^2 \\
\overline{V}_{\text{REL}} &= \begin{bmatrix} \text{RT}_\text{MAG} \text{ THETA}_{\text{DOT}} \\
\text{VTS}_{LV2} \\
(\text{VTS}_{LV3} - \text{ZCON} \text{ THETA}_{\text{DOT}} \text{TAN(THETA)}) / \text{COS(THETA)} \end{bmatrix}
\end{align*}
\]

(2) If INER_TO_LVC = OFF, convert from target-centered curvilinear coordinates to M50 inertial coordinates.

(a) Compute internal variables.

\[
\begin{align*}
\theta &= \overline{R}_{\text{REL1}} / \text{RT}_\text{MAG} \\
\theta_{\text{DOT}} &= \overline{V}_{\text{REL1}} / \text{RT}_\text{MAG} \\
\text{ZCON} &= \text{RT}_\text{MAG} - \overline{R}_{\text{REL3}}
\end{align*}
\]

(b) Convert to LV target-centered rotating rectangular coordinates.

\[
\begin{align*}
\overline{\text{RTS}}_{LV} &= \begin{bmatrix} \text{ZCON} \text{ SIN(THETA)} \\
\overline{R}_{\text{REL2}} \\
\text{RT}_\text{MAG} - \text{ZCON} \text{ COS(THETA)} \end{bmatrix} \\
\overline{\text{VTS}}_{LV} &= \begin{bmatrix} \overline{\text{ZCON}} \text{ THETA}_{\text{DOT}} \text{ COS(THETA)} \\
\overline{V}_{\text{REL3}} \text{ SIN(THETA)} \\
\text{RTS}_{LV1} \text{ THETA}_{\text{DOT}} + \overline{R}_{\text{REL3}} \text{ COS(THETA)} \end{bmatrix}
\end{align*}
\]

(c) Convert from the LV frame to a target-centered LVIR frame.

\[
\begin{align*}
\overline{\text{RTS}}_{LVIR} &= \overline{\text{RTS}}_{LV} \\
\overline{\text{VTS}}_{LVIR} &= \overline{\text{VTS}}_{LV} + \omega_{\text{LV}} \text{PROX} \times \overline{\text{RTS}}_{LVIR}
\end{align*}
\]

(d) Convert from LVIR coordinates to an inertial frame relative to the target.
\[
\begin{align*}
\tilde{\text{RTS}}_{M50} &= [\text{MAT}_{M50}, \text{LVIR}]^T \tilde{\text{RTS}}_{LVIR} \\
\tilde{\text{VTS}}_{M50} &= [\text{MAT}_{M50}, \text{LVIR}]^T \tilde{\text{VTS}}_{LVIR}
\end{align*}
\]

(e) Compute the Shuttle inertial M50 coordinate.
\[
\begin{align*}
\tilde{R}_{S\_\text{INER}} &= \tilde{R}_{T\_\text{INER}} + \tilde{\text{RTS}}_{M50} \\
\tilde{V}_{S\_\text{INER}} &= \tilde{V}_{T\_\text{INER}} + \tilde{\text{VTS}}_{M50}
\end{align*}
\]

4.11.2 **Interface Requirements**

The input and output parameters for the relative state compute task are given in tables 28 and 29.

4.11.3 **Processing Requirements**

Perform once on call.

4.11.4 **Initialization**

None.

4.11.5 **Supplemental Information**

None.

4.12 **PROXIMITY OPERATIONS TARGETING OUTPUT DISPLAY LOAD TASK (PROX\_DISP\_LOAD)**

This task loads the output display buffers with data from the computational buffers once a compute item 27 or item 28 is complete.

4.12.1 **Detailed Requirements**

The following steps are required to perform the proximity operations targeting output display load task.

a. Display the maneuver.

\[
\begin{align*}
\text{MAN\_TGT} &= \text{PROX\_TGT\_SET\_NO} \\
\text{DISP\_DV} &= \tilde{\text{DV}}_{LVLH} \\
\text{DISP\_DV\_MAG} &= \text{MAG} (\tilde{\text{DV}}_{LVLH})
\end{align*}
\]
b. Convert the T1_TIG and T2_TIG times to days, hours, minutes, and seconds using the time conversion task.

(1) TIME_SEC = T1_TIG
    TIME_CONVERT_FLAG = 0
    Call TIME_CONVERT; inputs: TIME_CONVERT_FLAG, TIME_SEC
    outputs: DAY, HR, MIN, SEC
    DISP_T1_DAY = DAY
    DISP_T1_HR = HR
    DISP_T1_MIN = MIN
    DISP_T1_SEC = SEC

(2) TIME_SEC = T2_TIG
    Call TIME_CONVERT; inputs: TIME_CONVERT_FLAG, TIME_SEC
    outputs: DAY, HR, MIN, SEC
    DISP_T2_DAY = DAY
    DISP_T2_HR = HR
    DISP_T2_MIN = MIN
    DISP_T2_SEC = SEC

c. Display the transfer time.
    DISP_PROX_DT = COMP_PROX_DT.

d. Display the maneuver time.

(1) If T_MAN = T1_TIG, set:
    DISP_TMAN_TIME = T1_TIG
    DISP_TMAN_DAY = DISP_T1_DAY
    DISP_TMAN_HR = DISP_T1_HR
    DISP_TMAN_MIN = DISP_T1_MIN
    DISP_TMAN_SEC = DISP_T1_SEC
(2) If T\_MAN = T2\_TIG, set:
   \[ \text{DISP\_TMAN\_TIME} = \text{TMAN} \]
   \[ \text{DISP\_TMAN\_DAY} = \text{DISP\_T2\_DAY} \]
   \[ \text{DISP\_TMAN\_HR} = \text{DISP\_T2\_HR} \]
   \[ \text{DISP\_TMAN\_MIN} = \text{DISP\_T2\_MIN} \]
   \[ \text{DISP\_TMAN\_SEC} = \text{DISP\_T2\_SEC} \]

4.12.2 Interface Requirements

The input and output parameters for the proximity operations targeting output display load task are listed in tables 10 and 11.

4.12.3 Processing Requirements

Perform once on call.

4.12.4 Initialization

None.

4.12.5 Supplemental Information

4.13 TIME CONVERSION TASK (TIME\_CONVRT)

This task computes total time in seconds (given days, hours, minutes, and seconds) and computes days, hours, minutes, and seconds (given total time in seconds).

4.13.1 Detailed Requirements

The following steps are required to perform the time conversion tasks.

a. Perform a logical test to determine if the time is to be computed in seconds or days, hours, minutes, and seconds.

(1) If total time is to be computed in seconds

\[ \text{TIME\_SEC} = 86400 \ \text{DAY} + 3600 \ \text{HR} + 60 \ \text{MIN} + \text{SEC} \]
(2) If time is to be computed in days, hours, minutes, and seconds
(TIME_CONVERT_FLAG = 0), set

\[
\text{DAY} = \text{truncate} \left( \frac{\text{TIME_SEC}}{86400} \right) \\
\text{HR} = \text{truncate} \left( \frac{\text{TIME_SEC} - 86400 \ \text{DAY}}{3600} \right) \\
\text{MIN} = \text{truncate} \left( \frac{\text{TIME_SEC} - 86400 \ \text{DAY} - 3600 \ \text{HR}}{60} \right) \\
\text{SEC} = \text{TIME_SEC} - 86400 \ \text{DAY} - 3600 \ \text{HR} - 60 \ \text{MIN}
\]

4.13.2 Interface Requirements

The input and output parameters for the time conversion task are listed in tables 30 and 31.

4.13.3 Processing Requirements

Perform once per call.

4.13.4 Initialization

None.

4.13.5 Supplemental Information

None.
4.14 DELTA-T COMPUTE TASK (DT_COMP)

The delta-t compute task is called to determine the transfer time and/or the maneuver time of the second of two impulse maneuvers.

4.14.1 Detailed Requirements

The following steps are required to perform this task.

a. Set the USE_OMEGA_DT flag to off.

b. Check the transfer time (COMP_PROX_DT):

\[
\begin{align*}
\text{If } \text{COMP_PROX_DT} < 0, & \text{ set USE_OMEGA_DT = ON} \\
\text{set } \text{COMP_PROX_DT} = \frac{(\text{T2_TIG} - \text{T1_TIG})}{60}
\end{align*}
\]

4.14.2 Interface Requirements

The input and output parameters for the delta-t compute task are given in tables 32 and 33.

4.14.3 Processing Requirements

Perform once on call.

4.14.4 Initialization

None.

4.14.5 Supplemental Information

None.

4.15 OMEGA-DT CALCULATION TASK (OMEGA_DT_COMP)

This task is called when the given transfer time and T2 TIG are zero. This task calculates the transfer time needed to go from the T1_TIG state to the T2_TIG state such that the T2_TIG maneuver is perpendicular to the line of sight and intercepts the next target point at the appropriate time.
4.15.1 *Detailed Requirements*

The following steps are required to perform the omega-dt calculation task.

a. Find the velocity required at the displayed T2 time to intercept the next target set.

\[
\text{DT\_OFFTGT} = \text{DT\_ILOAD\_ARRAY (PROX\_TGT\_SET\_NO + 1)}
\]

\[
\bar{X}\_OFFTGT = \begin{pmatrix}
\text{COMP\_T2\_XOFF} \\
\text{COMP\_T2\_YOFF} \\
\text{COMP\_T2\_ZOFF}
\end{pmatrix}
\]

\[
\bar{X}D\_OFFTGT = (0, 0, 0)
\]

\[
\bar{X}2\_OFFTGT = \begin{pmatrix}
\text{XOFF\_ILOAD\_ARRAY (PROX\_TGT\_SET\_NO + 1)} \\
\text{YOFF\_ILOAD\_ARRAY (PROX\_TGT\_SET\_NO + 1)} \\
\text{ZOFF\_ILOAD\_ARRAY (PROX\_TGT\_SET\_NO + 1)}
\end{pmatrix}
\]

Call OFFSET\_TGT; inputs: OMEGA\_PROX, DT\_OFFTGT, \bar{X}\_OFFTGT,
\bar{X}D\_OFFTGT, \bar{X}2\_OFFTGT

output: \bar{DV}

b. Define internal variables.

\[
\bar{X}D1 = \bar{DV}_1
\]

\[
\bar{Y}D1 = \bar{DV}_2
\]

\[
\bar{Z}D1 = \bar{DV}_3
\]

\[
W = \text{OMEGA\_PROX}
\]

\[
\bar{X}0 = \text{COMP\_X1}
\]

\[
\bar{Y}0 = \text{COMP\_X2}
\]

\[
\bar{Z}0 = \text{COMP\_X3}
\]

\[
X1 = \text{COMP\_T2\_XOFF}
\]

\[
Y1 = \text{COMP\_T2\_YOFF}
\]

\[
Z1 = \text{COMP\_T2\_ZOFF}
\]

\[
X2 = \bar{X}2\_OFFTGT_1
\]
\[ \begin{align*}
  y_2 &= x_{2\_OFFTGT}^2 \\
  z_2 &= x_{2\_OFFTGT}^3 \\
  \alpha &= \frac{(x_1 x_{D1} + y_1 y_{D1} + z_1 z_{D1})}{w} \\
  a &= 8\alpha - 12x_1z_1 - 2x_0z_1 + 2x_1z_0 \\
  b &= -a \\
  c &= x_0x_1 - x_1x_1 + 4z_0z_1 - 4z_1z_1 + 8y_0y_1 \\
  d &= 3(y_1^{**2} + z_1^{**2}) \\
  e &= -3\alpha + 6x_1z_1 \\
  f &= 8y_1(y_0 + y_1) \\
  g &= -8y_0y_1 \\
  h &= -3y_0y_1 \\
  i &= -3y_1y_1 \\
  j &= -8y_1y_1 \\
  l &= -3z_0z_1 \\
  m &= -8y_0y_1
\end{align*} \]

c. Set up Newton-Raphson iteration.

\[ \begin{align*}
  i_c &= 0 \\
  i_{cmax} &= 10 \\
  \text{del}_x_t&= 0 \\
  x_{\_IND} &= -60 \text{COMP\_PROX\_DT} \\
  \text{del}_x_{\text{GUESS}} &= 100
\end{align*} \]

d. Do until \( i_c > i_{cmax} \) or \(|x_{\_IND} - x_{\_IND\_PRIME}| < 0.5\):

\[ \begin{align*}
  t &= \text{w}x_{\_IND} \\
  \cos &= \cos(t) \\
  \sin &= \sin(t) \\
  \tan &= \sin/\cos
\end{align*} \]
\[ X_{\text{DEP}} = A + B \cos + C \sin + DT \cos + ET \sin + F \cos/TAN + G \cos \cos/TAN + HT \cos \cos + IT \sin \sin + J/TAN + LT + M \cos \sin \]

Call ITERV; inputs: IC, X_{\text{DEP}}, X_{\text{IND}}
\[ X_{\text{DEP.PRIME}}, X_{\text{IND.PRIME}} \]
\[ \Delta X_{\text{GUESS}}, I_{\text{CMAX}}, \Delta X_{\text{TOL}} \]
outputs: IC, X_{\text{IND}}, X_{\text{DEP.PRIME}}
\[ X_{\text{IND.PRIME}}, \text{SPAIL} \]

e. Compute the transfer time (COMP_PROX_DT)
\[ \text{COMP_PROX_DT} = X_{\text{IND}}/60 \]

4.15.2 Interface Requirements
The input and output parameters for the omega--dt calculation task are given in tables 34 and 35.

4.15.3 Processing Requirements
Perform once on call.

4.15.4 Initialization
None.

4.15.5 Supplemental Information
None.

4.16 ELEVATION ANGLE SEARCH TASK (TELEV)
The elevation angle search task determines the time a desired elevation angle exists between the Shuttle and the target.

4.16.1 Detailed Requirements
The following steps are required in the iteration logic to determine the time a desired elevation angle exists between the Shuttle and the target.
a. Set the iteration counter to zero, and initialize the previous pass differential altitude indicator to indicate inconsistency:

\[ IC = 0 \]
\[ NN = 0 \]

b. Advance both the Shuttle and the target to first-guess time where the desired elevation angle should exist. The advancement is performed in two calls to the state vector update task (sec. 4.21), with inputs of vehicle position and velocity vectors, first-guess time. The outputs are the vehicle position and velocity vectors, and time at the first-guess time.

Update Shuttle state:

\[ S_{\text{OPTION}} = 1 \]
\[ \bar{\mathbf{R}}_{\text{IN}} = \bar{\mathbf{R}}_{\text{S}_50}\_\text{PROX} \]
\[ \bar{\mathbf{V}}_{\text{IN}} = \bar{\mathbf{V}}_{\text{S}_50}\_\text{PROX} \]
\[ T_{\text{IN}} = \text{TIME}\_\text{PROX} + \text{BASE}\_\text{MET} \]
\[ T_{\text{OUT}} = 60. \ \text{T}_1\_\text{LOAD}\_\text{ARRAY} (\text{PROX}\_\text{TGT}\_\text{SET}\_\text{NO}) + \text{BASE}\_\text{MET} \]

Call UPDATVP; inputs: \( \bar{\mathbf{R}}_{\text{IN}}, \bar{\mathbf{V}}_{\text{IN}}, T_{\text{IN}}, T_{\text{OUT}} \)

outputs: \( \bar{\mathbf{R}}_{\text{OUT}}, \bar{\mathbf{V}}_{\text{OUT}} \)

\[ \bar{\mathbf{R}}_{\text{S}}\_\text{OUT} = \bar{\mathbf{R}}_{\text{OUT}} \]
\[ \bar{\mathbf{V}}_{\text{S}}\_\text{OUT} = \bar{\mathbf{V}}_{\text{OUT}} \]
\[ T_{\text{S}}\_\text{OUT} = T_{\text{OUT}} \]

Update target state:

\[ S_{\text{OPTION}} = 2 \]
\[ \bar{\mathbf{R}}_{\text{IN}} = \bar{\mathbf{R}}_{\text{T}_50}\_\text{PROX} \]
\[ \bar{\mathbf{V}}_{\text{IN}} = \bar{\mathbf{V}}_{\text{T}_50}\_\text{PROX} \]

Call UPDATVP; inputs: \( \bar{\mathbf{R}}_{\text{IN}}, \bar{\mathbf{V}}_{\text{IN}}, T_{\text{IN}}, T_{\text{OUT}} \)

outputs: \( \bar{\mathbf{R}}_{\text{OUT}}, \bar{\mathbf{V}}_{\text{OUT}} \)

\[ \bar{\mathbf{R}}_{\text{T}}\_\text{OUT} = \bar{\mathbf{R}}_{\text{OUT}} \]
\[ \bar{\mathbf{V}}_{\text{T}}\_\text{OUT} = \bar{\mathbf{V}}_{\text{OUT}} \]
\[ T_{\text{T}}\_\text{OUT} = T_{\text{OUT}} \]
a. Perform an iteration to find a time for which the desired elevation angle and the delta-h at that line are consistent (-DELTA_H*(ELANG-PI) ≥ 0). Execute the following code while the maximum number of iterations has not been reached (IC ≤ ICMPAX) and while the delta-h and elevation angle are inconsistent (NN = 0). (NOTE: Initially NN = 0, thus the loop will be entered at least once.)

(1) Calculate the differential altitude:

\[ \text{DELTA}_H = |\vec{RT}_{OUT}| - |\vec{RS}_{OUT}| \]

(2) Test for consistency between the calculated delta-h and the desired elevation angle.

(a) If the elevation angle and differential altitude are consistent, set the differential altitude consistency indicator to indicate consistency.

\[ \text{IF } -\text{DELTA}_H (\text{EL}_\text{ANG} - \pi) \geq 0, \text{ then} \]

\[ \text{NN} = 1 \]

(b) If they are not consistent, compute a dependent variable (ERR_DH) with the differential altitude and incompatibility tolerance (EL_DH_TOL).

\[ \text{IF } -\text{DELTA}_H (\text{EL}_\text{ANG} - \pi) < 0, \text{ then} \]

\[ \text{ERR}_DH = \text{DELTA}_H + \text{EL}_DH_TOL \cdot \text{SIGN}(\text{DELTA}_H) \]

Calculate the new guess at the time of consistency and advance the Shuttle and target to the time. This is performed in the elevation angle iterator task (see 4.19), with inputs of Shuttle position and velocity vectors, iteration counter, error in the elevation angle, current TPI time, previous error, and previous time. The outputs are the Shuttle and target position and velocity vectors, time, iteration counter, the new time, the new values of the previous error and time, and an error flag.

\[ \text{ERR} = \text{ERR}_DH \]

\[ \text{ERR}_\text{PRIME} = \text{ERR}_DH_\text{PRIME} \]

Inputs/outputs for the elevation angle iteration (ELITER) task are:

Inputs: \(\vec{RS}_{OUT}, \vec{VS}_{OUT}, \vec{RT}_{OUT}, \vec{VT}_{OUT},\)

\(\text{IC, ERR, TTPI, ERR}_\text{PRIME,}\)

\(\text{TTPI}_\text{PRIME}\)
Outputs: $\overline{RS}_{OUT}, \overline{VS}_{OUT}, \overline{TS}_{OUT}, \overline{RT}_{OUT}, \overline{VT}_{OUT}$

$\overline{TT}_{OUT}, IC, TT_PI, ERR\_PRIME, TT_PI\_PRIME$

ALARM

$ERR\_DH\_PRIME = ERR\_PRIME$

d. Determine the time that the desired elevation angle exists. Test to see if the delta-$h$ iteration has failed (i.e., the consistency flag, NN, is still set to zero).

1. If the delta-$h$ iteration has failed (i.e., the consistency flag is set to OFF, $NN = 0$), then exit the routine, since there will be no time for which the desired elevation angle will exist.

2. If the consistency flag is set to ON ($NN = 1$), then find the time of elevation angle.

(a) If iterations have occurred ($IC \neq 0$), compute a TPI time in the direction of the direction of difference between the current and previous TPI time and set iteration counter ($IC$) to zero. This is done to ensure that the first two iterations are consistent.

$$TTPI = TTPI + 10 \text{SIGN} (TTPI - TTPI\_PRIME)$$

$$IC = 0$$

Advance both the Shuttle and target to the time of TPI. This is performed by two calls to the state vector update task, with inputs of Shuttle and target positions and velocity vectors, time, and TPI time. The outputs are position and velocity vectors, and time.

Update Shuttle state:

$S\_OPTION = 1$

$\overline{R\_IN} = \overline{RS\_OUT}$

$\overline{V\_IN} = \overline{VS\_OUT}$

$T\_IN = TTPI\_PRIME + BASE\_MET$

$T\_OUT = TTPI + BASE\_MET$

Call $UPDATVP$; inputs: $\overline{R\_IN}, \overline{V\_IN}, T\_IN, T\_OUT$

outputs: $\overline{R\_OUT}, \overline{V\_OUT}$

$\overline{RS\_OUT} = \overline{R\_OUT}$
\[
\begin{align*}
\overline{V_{\text{OUT}}} &= \overline{V_{\text{OUT}}} \\
TS_{\text{OUT}} &= T_{\text{OUT}}
\end{align*}
\]
Update target state:
\[S_{\text{OPTION}} = 2\]
\[\overline{R_{\text{IN}}} = \overline{R_{\text{OUT}}}\]
\[\overline{V_{\text{IN}}} = \overline{V_{\text{OUT}}}\]
Call \text{UPDATVP}; inputs: \(\overline{R_{\text{IN}}}, \overline{V_{\text{IN}}}, T_{\text{IN}}, T_{\text{OUT}}\)
 outputs: \(\overline{R_{\text{OUT}}}, \overline{V_{\text{OUT}}}\)
\[\overline{R_{\text{OUT}}} = \overline{R_{\text{OUT}}}\]
\[\overline{V_{\text{OUT}}} = \overline{V_{\text{OUT}}}\]
\[TT_{\text{OUT}} = T_{\text{OUT}}\]

(b) Perform an iteration to find the time of elevation angle. Execute the following code as long as the maximum number of iterations has not been reached and the current error is larger than the tolerance, or while the number of iterations is equal to zero. (This condition forces at least one iteration.) The condition for iteration is
\[
[(\text{ERR}_{\text{EL}} \geq \text{EL}_{\text{TOL}}) \text{ and } (IC \leq I_{\text{CMAX}})] \text{ or } (IC = 0)
\]

(i) Calculate the elevation angle that currently exists between the two vehicles. The calculations are performed in the elevation angle computation task (sec. 4.18), with inputs of the Shuttle position and velocity vectors, and target position vector. The output is the elevation angle.
\[
\begin{align*}
\overline{RS_{\text{COM}}} &= \overline{RS_{\text{OUT}}} \\
\overline{VS_{\text{COM}}} &= \overline{VS_{\text{OUT}}} \\
\overline{RT_{\text{COM}}} &= \overline{RT_{\text{OUT}}} \\
\end{align*}
\]
Call \text{COMBLE}; inputs: \(\overline{RS_{\text{COM}}}, \overline{VS_{\text{COM}}}, \overline{RT_{\text{COM}}}\)
 outputs: \(\text{EL}_{\text{ANG}_{\text{COM}}}\)

(ii) Calculate the difference between the desired and computed elevation angles:
\[\text{ERR}_{\text{EL}} = \text{EL}_{\text{ANG}} - \text{EL}_{\text{ANG}_{\text{COM}}}\]
Calculate the new guess at the time of TPI and advance the Shuttle and target to the time. This is performed in the elevation angle iterator task (sec. 4.19), with inputs of Shuttle position and velocity vectors, iteration counter, error in the elevation angle, current TPI time, previous error, and TPI time. The outputs are the Shuttle and target positions and velocity vectors, time, iteration counter, new TPI time, new values of the previous error and TPI time, and an error flag.

\[
\text{ERR} = \text{ERR\_EL}
\]

\[
\text{ERR\_PRIME} = \text{ERR\_EL\_PRIME}
\]

Inputs/outputs for the elevation angle iteration task (ELITER) are:

Inputs: \(\overline{\text{RS\_OUT}}, \overline{\text{VS\_OUT}}, \overline{\text{RT\_OUT}}, \overline{\text{VT\_OUT}}, \text{IC}, \text{ERR}, \text{TTP}\)I, \text{ERR\_PRIME}, \text{TTP}\_PRIME

Outputs: \(\overline{\text{RS\_OUT}}, \overline{\text{VS\_OUT}}, \overline{\text{TS\_OUT}}, \overline{\text{RT\_OUT}}, \overline{\text{VT\_OUT}}, \text{TT\_OUT}, \text{IC}, \text{TTP}\), \text{ERR\_PRIME}, \text{TTP\_PRIME}, \text{ALARM}

\[
\text{ERR\_EL\_PRIME} = \text{ERR\_PRIME}
\]

4.16.2 Interface Requirements

The input and output parameters for the elevation angle search task are given in tables 36 and 37.

4.16.3 Processing Requirements

Perform once on call.

4.16.4 Initialization

None.

4.16.5 Supplemental Information

None.
4.17 PRECISION-REQUIRED VELOCITY TASK (PREVR)

The precision-required velocity task computes the precision velocity-required to satisfy both terminal position and time of flight constraints (Lambert problem).

4.17.1 Detailed Requirements

The following steps are required to compute the velocity that satisfies the Lambert problem constraints.

a. Set or initialize variables that are used in the iteration to find the required velocity:

\[
\begin{align*}
\text{DELT}_T\text{TRAN} & = T_{2TIG} - T_{1TIG} \\
\bar{R}_{OFFSET} & = \bar{R}_{S2TIG} \\
T_{OFFSET} & = T_{2TIG} \\
N & = 0 \\
\bar{V}_G & = \bar{0} \\
\bar{V}_G\_MAG & = 0 \\
\text{ALPHA} & = 2/|\bar{R}_{S1T1G}| - (\bar{V}_{S1T1G} \cdot \bar{V}_{S1T1G})/\text{EARTH}_\text{MU} \\
\text{ORB}\_R\_ RATE & = \text{ALPHA} (\text{ALPHA} \times \text{EARTH}_\text{MU})^{\frac{1}{5}} \\
S\_\text{ROTATE} & = 1 \\
\bar{UN}\_\text{REF} & = \text{UNIT} (\bar{R}_{S1T1G} \times \bar{V}_{S1T1G}) \\
\bar{R}\_\text{REF} & = \bar{R}_{S1T1G} \\
\text{ACC} & = \text{THRUST G/WS}
\end{align*}
\]

b. Perform the iteration to compute the required velocity. Continue until the miss distance between the Shuttle position vector at the terminal time is within a tolerance (\(|\text{R}\_\text{MISS}| \leq \text{R}_\text{TOL}\)), and a minimum number of iterations are achieved (\(N > N\_\text{MIN}\)), or the alarm flag is set (\(\text{ALARM} > 0\)).

1. Increase the iteration counter by one and set the initial position offset vector to the Shuttle position vector:

\[
\begin{align*}
N & = N + 1 \\
\bar{R}\_\text{IPO} & = \bar{R}\_\text{REF}
\end{align*}
\]

2. Perform a logical test to determine if the transfer angle is near 180°.
(a) If the transfer angle is not near 180° (S_ROTATE ≠ 0), calculate the transfer plane vector and the transfer angle before and after the burn:

\[ \overline{UN} = \overline{RS}_{IPO} \times \overline{R}_{OFFSET} \]

\[ S_{\text{ROTATE}} = \text{SIGN} (\overline{UN} \cdot \overline{UN}_{\text{REF}}) \]

\[ SBETA = S_{\text{ROTATE}} |\overline{UN}| \]

\[ CBETA = \overline{RS}_{IPO} \cdot \overline{R}_{OFFSET} \]

\[ BBEF = \pi + \arctan2 (-SBETA, -CBETA) \]

\[ BAFT = BBEF - \text{ORB RATE VG_MAG/ACC} \]

(b) Perform a logical test to determine if the transfer angle (before and after the burn) is not near 180°.

(i) If the transfer angle is not near 180° (BBEF < \pi - \text{CONE} or BAFT > \pi + \text{CONE}), calculate the transfer plane:

\[ \overline{UN} = \overline{UN} / SBETA \]

(ii) If the transfer angle is near 180° (BBEF > \pi - \text{CONE} and BAFT < \pi + \text{CONE}), set the iteration counter to zero, set the transfer plane equal to the Shuttle orbital plane, set the projection flag to zero, and project the offset position vector into the transfer plane:

\[ N = 0 \]

\[ S_{\text{ROTATE}} = 0 \]

\[ \overline{UN} = \overline{UN}_{\text{REF}} \]

\[ \overline{R}_{OFFSET} = \overline{R}_{OFFSET} - (\overline{R}_{OFFSET} \cdot \overline{UN}) \overline{UN} \]

(3) Calculate the required velocity vector, which with the position vector will pass through the desired target vector at the desired time. The calculations for the required velocity vector are in the Lambert conic velocity-required task (sec. 4.20) with inputs of the initial position offset vector, the desired target offset vector, the transfer plane vector, and the transfer time. The outputs are the required velocity vector and an alarm or error flag.

Inputs/outputs for the Lambert conic-velocity-required task (LAMBERT) are:

Inputs: \( \overline{RS}_{IPO}, \overline{R}_{OFFSET}, \overline{UN}, \text{DEL}_T \_\text{TRAN} \)

Outputs: \( \overline{VS}_{\text{REQUIRED}}, \text{ALARM} \)
(4) Calculate the velocity-to-be-gained vector and magnitude:
\[ \vec{V}_G = \vec{V}_{\text{REQUIRED}} - \vec{V}_{T1TIG} \]
\[ \vec{V}_G\text{ MAG} = |\vec{V}_G| \]

(5) Advance the Shuttle state vector to the terminal point by a call to the state vector update task (sec. 4.21), with inputs of the state vector time, update option flag, terminal point time. The output is the state vector at terminal point time.
\[ S_{\text{OPTION}} = 1 \]
\[ \vec{R}_{\text{IN}} = \vec{R}_{\text{IPO}} \]
\[ \vec{V}_{\text{IN}} = \vec{V}_{\text{REQUIRED}} \]
\[ T_{\text{IN}} = T_{1TIG} + \text{BASE}_M \]
\[ T_{\text{OUT}} = T_{2TIG} + \text{BASE}_M \]
Call UPDATVP; inputs: \( \vec{R}_{\text{IN}}, \vec{V}_{\text{IN}}, T_{\text{IN}}, T_{\text{OUT}}, S_{\text{OPTION}} \)
outputs: \( \vec{R}_{\text{OUT}}, \vec{V}_{\text{OUT}} \)
\[ \vec{R}_{\text{TERMINAL}} = \vec{R}_{\text{OUT}} \]
\[ \vec{V}_{\text{TERMINAL}} = \vec{V}_{\text{OUT}} \]

(6) Compute the miss-distance vector between the Shuttle position vector and the desired position vector at the terminal point:
\[ \vec{R}_{\text{MISS}} = \vec{R}_{\text{TERMINAL}} - \vec{R}_{S2TIG} \]

(7) Perform a logic test to determine if the transfer angle is near 180°. If it is (\( S_{\text{ROTATE}} = 0 \)), compute the miss as a projection into the actual transfer plane:
\[ \vec{R}_{\text{MISS}} = \vec{R}_{\text{MISS}} - (\vec{R}_{\text{MISS}} \cdot \vec{U}_N) \vec{U}_N \]

(8) Calculate the offset position vector that the required velocity calculations are based on. Increment the iteration counter:
\[ \vec{R}_{\text{OFFSET}} = \vec{R}_{\text{OFFSET}} - \vec{R}_{\text{MISS}} \]

(9) Perform a logic test to determine if the maximum number of iterations were exceeded.
If \( N > N\text{MAX} \), then \( \text{ALARM} = 6 \)
4.17.2 Interface Requirements

The input and output parameters for the precision-required velocity task are given in tables 38 and 39.

4.17.3 Processing Requirements

Perform once on call.

4.17.4 Initialization

None.

4.17.5 Supplemental Information

None.

4.18 ELEVATION ANGLE COMPUTATION TASK (COMELE)

The elevation angle computation task computes the elevation angle between one vehicle position vector and another vehicle position vector. The elevation is defined as the angle measured from the local horizontal plane of the Shuttle to the line of sight of the target.

4.18.1 Detailed Requirements

The following steps are required to calculate the elevation angle between one vehicle position vector and another vehicle position vector.

a. Calculate intermediate variables used in the elevation angle computation:

\[ A = \overline{RS\_COM} \cdot \overline{RS\_COM} \]
\[ B = \overline{RS\_COM} \cdot \overline{RT\_COM} \]
\[ C = \overline{RT\_COM} \cdot \overline{RT\_COM} \]
\[ D = \overline{RS\_COM} \cdot \overline{VS\_COM} \]
\[ E = \overline{RT\_COM} \cdot \overline{VS\_COM} \]

b. Calculate the elevation angle between two position vectors (\(\overline{RS\_COM}\) AND \(\overline{RT\_COM}\)):

If \((A \cdot C - B^2) < 0\), then \(EL\_ANG\_COM = \pi + [SIGN (A-C)] \pi/2\), otherwise
EL_ANG_COM = PI + ARCTAN2 (A - B, SIGN (B D - A E))(A C - B^2)^{1/2}

If EL_ANG_COM = 2·PI, reset EL_ANG_COM = 0

4.18.2 Interface Requirements

The input and output parameters for the elevation angle computation task are given in tables 40 and 41.

4.18.3 Processing Requirements

Perform once on call.

4.18.4 Initialization

None.

4.18.5 Supplemental Information

None.

4.19 ELEVATION ANGLE ITERATION TASK (ELITER)

The elevation angle iterator task computes the time of TPI and updates the Shuttle and target to this time.

4.19.1 Detailed Requirements

The following steps are required in the computation and the advancement of the Shuttle and target to the time of the TPI maneuver.

a. Calculate the new guess at the time of TPI. This is performed in the Newton-Raphson iteration task (sec. 4.22), with inputs of iteration counter, current error in the elevation angle, current TPI time, previous error, and TPI time. The outputs are the new TPI time, new previous error and TPI time, and an error flag that is set if the maximum number of iterations is exceeded.

X_SEP = ERR
X_IND = TTP1
X_SEP_PRIME = ERR_PRIME
X_IND_PRIME = TTPI_PRIME

Call ITERV; inputs: IC, X_DEP, X_IND, X_DEP_PRIME, X_IND_PRIME

outputs: IC, X_IND, X_DEP_PRIME, X_IND_PRIME, SFAIL

TTPI = X_IND

ERR_PRIME = X_DEP_PRIME

TTPI_PRIME = X_IND_PRIME

b. Perform a logic test to determine if the maximum number of iterations has been exceeded.

(1) If the iteration maximum has been exceeded (SFAIL ≠ 0), set an ALARM flag and terminate the elevation angle iterator task:

If SFAIL ≠ 0, then ALARM = 7

(2) If the maximum number of iterations has not been exceeded (SFAIL = 0), perform a logic test to determine if the current TPI time is greater than some delta-t from the previous TPI time. If it is, set the current TPI time to the previous time plus the delta-t:

If |TTPI - TTPI_PRIME| > DEL_T_MAX,

then TTPI = TTPI_PRIME + DEL_T_MAX sign (TTPI - TTPI_PRIME)

(3) Advance both Shuttle and target to the current TPI time. The state vector update task performs the advancement with two calls, one for the Shuttle and the other for the target. The inputs are position and velocity vectors and TPI time. The outputs are position and velocity vectors and time of TPI.

Update Shuttle state:

S_OPTION = 1

\vec{R}_{IN} = \vec{R}_{OUT}

\vec{V}_{IN} = \vec{V}_{OUT}

T_{IN} = TTPI_PRIME + BASE_MET

T_{OUT} = TTPI + BASE_MET

Call UPDATVP; inputs: \vec{R}_{IN}, \vec{V}_{IN}, T_{IN}, T_{OUT}

outputs: \vec{R}_{OUT}, \vec{V}_{OUT}

\vec{R}_{OUT} = \vec{R}_{OUT}
\[ \vec{V}_{\text{OUT}} = \vec{V}_{\text{OUT}} \]
\[ T_{\text{OUT}} = T_{\text{OUT}} \]

Update target state:
\[ S_{\text{OPTION}} = 2 \]
\[ \vec{R}_{\text{IN}} = \vec{R}_{\text{OUT}} \]
\[ \vec{V}_{\text{IN}} = \vec{V}_{\text{OUT}} \]

Call UPDATVP; inputs: \( \vec{R}_{\text{IN}}, \vec{V}_{\text{IN}}, T_{\text{IN}}, T_{\text{OUT}} \)

outputs: \( \vec{R}_{\text{OUT}}, \vec{V}_{\text{OUT}} \)
\[ \vec{R}_{\text{OUT}} = \vec{R}_{\text{OUT}} \]
\[ \vec{V}_{\text{OUT}} = \vec{V}_{\text{OUT}} \]
\[ T_{\text{OUT}} = T_{\text{OUT}} \]

4.19.2 Interface Requirements

The input and output parameters for the elevation angle iteration task are given in table 42 and 43.

4.19.3 Processing Requirements

Perform once on call.

4.19.4 Initialization

None.

4.19.5 Supplemental Information

None.

4.20 LAMBERT CONIC-VELOCITY-REQUIRED TASK (LAMBERT)

The Lambert conic-velocity-required task calculates the required orbital velocity vector that satisfies the following Lambert problem: given an initial position vector, a terminal position vector, and a specified transfer time between the initial and final vector, determine the initial velocity required to transfer from the initial vector to the final vector with the required transfer time,
assuming two-body conic orbital motion. The equations hold only for the elliptical case, and the task does not have multirevolution capability. This task is used both in targeting and in the execution of a Lambert-guided maneuver.

4.20.1 Detailed Requirements

The following steps are required to calculate the initial velocity vector to transfer from an initial position vector to a final position vector with a specified transfer time.

a. The alarm flag is set to the off position. The alarm flag is used to indicate when problems occur from input or from calculations:

```
ALARM = 0
```

b. Calculate the magnitude of the initial vector and the final vector:

```
RO = R_S IPO
R1 = R_OFFSET
RO_MAG = |RO|
R1_MAG = |R1|
```

c. Calculate the semiperimeter of the transfer triangle to be used as a normalizing constant:

```
R_PARABOLA = (RO_MAG + R1_MAG + |R1 - RO|)/2
```

d. Calculate the parabolic velocity at perigee for R_PARABOLA for use as a normalizing factor.

```
V_PARABOLA = 2 EARTH_MU/R_PARABOLA
```

e. Calculate the parameter Z, where Z = RO_MAG R1_MAG - RO · R1. Z is equal to RO_MAG R1_MAG(1-COSθ), where θ is the transfer angle. Test to determine if θ is close to 0 or 360°. If Z ≤ EP_TRANSFER RO_MAG R1_MAG, set the alarm flag and exit:

```
ALARM = 2
```

f. Calculate the cotangent of θ/2 (also to be designated by the parameter Z). RO and R1 are assumed to be in the plane defined by UN:

```
Z = (RO x R1) · UN/Z
```

g. Calculate the parameter VH:

```
VH = √[RO_MAG R1_MAG/(1 + Z²)]
```
h. Set the initial value on the counter to count the number of iterations:

\[ N = 0 \]

i. Set the upper and lower limits of the independent variable:

\[ U_{\text{MAX}} = 1 - DU/2 \]
\[ U_{\text{MIN}} = -1.0 \]

DU is an I-load parameter to prevent the orbit from becoming close to parabolic.

j. Calculate the constant parameter, LAMBDA:

\[ \text{LAMBDA} = (VH/R_{\text{PARABOLA}}) Z \]

k. Calculate the first guess for the independent variable. This first guess assumes a circular orbit:

\[ U = \text{LAMBDA}/\sqrt{1 + \text{LAMBDA}^2} \]

l. Calculate the normalized transfer time:

\[ T_{\text{TILDA \_ DESIRED}} = (V_{\text{PARABOLA}}/R_{\text{PARABOLA}}) \text{DEL \_ T \_ TRAN} \]

m. Determine a transfer time that is slightly greater than the parabolic transfer time:

\[ T_{\text{MIN}} = (2/3) (1 - \text{LAMBDA}^3) + (0.4) (1 - \text{LAMBDA}^5) \text{ DU} \]

If the input transfer time is negative or is less than or equal to \( T_{\text{MIN}} \), set the alarm flag and exit:

\[ \text{ALARM} = 1 \]

n. The initialization procedure has been completed. The iteration steps to determine the value of \( U \) to yield the desired transfer time from Kepler's equation follows. This iteration continues until the time error is within a given tolerance or until the number of iterations, \( N \), is equal to the maximum number of iterations, \( N_{\text{MAX}} \). Set \( \text{ALARM} = 5 \) and exit if \( N = N_{\text{MAX}} \).

1. Increase the counter on the number of iterations by one:

\[ N = N + 1 \]

2. The following parameters are calculated to obtain the transfer time corresponding to the current value of \( U \):

\[ W = \sqrt{1 - U^2} \]
\[ X = \text{LAMBDA} \cdot W \]
The current value of the transfer time is given by

\[ T_{\text{TILDA}} = \left[ \text{ARCTAN2} \left( F, G \right) - \left( U W X Y \right) \right] / \sqrt{3} \]

The ARCTAN2 function should produce angles between 0 degree and 2 \( \pi \) radians.

(4) Determine the slope of \( T_{\text{TILDA}} \) with respect to the independent variable \( U \) for use with the Newton-Raphson iteration:

\[ S_{\text{TILDA}} = (3 U T_{\text{TILDA}} - 2(1 - (U/Y) \Lambda^3))/\sqrt{2} \]

(5) Determine the error in the current value of \( T_{\text{TILDA}} \) and the desired value \( T_{\text{TILDA DESIRED}} \):

\[ T_{\text{TILDA ERROR}} = T_{\text{TILDA DESIRED}} - T_{\text{TILDA}} \]

(6) Determine if the error in \( T_{\text{TILDA DESIRED}} \) is small enough to consider the current value of \( U \) as the correct answer. If the absolute value of \( T_{\text{TILDA ERROR}} \) is less than \( T_{\text{TILDA DESIRED}} \) times \( \text{EPS}_U \), then the Newton-Raphson iteration is considered converged, and the required initial velocity can be determined in step o. Otherwise, continue calculations.

(7) Calculate a change in the current value of \( U \):

\[ U_{\text{STEP}} = T_{\text{TILDA ERROR}} / S_{\text{TILDA}} \]

If \( U_{\text{STEP}} \) is positive, then set \( U_{\text{MIN}} \) equal to \( U \). Set the new value of \( U \) equal to \( U \) plus \( U_{\text{STEP}} \). However, if the value of \( U \) is greater than \( U_{\text{MAX}} \), set \( U \) equal to \( (U_{\text{MIN}} + U_{\text{MAX}})/2 \).

If \( U_{\text{STEP}} \) is negative, set \( U_{\text{MAX}} \) equal to the current value of \( U \). Set the new value of \( U \) equal to \( U \) plus \( U_{\text{STEP}} \). However, if the new value of \( U \) is less than \( U_{\text{MIN}} \), set \( U \) equal to \( (U_{\text{MIN}} + U_{\text{MAX}})/2 \).

The required initial velocity can now be obtained by the following relationships:

\[ VH = VH/RO \_MAG \]

\[ VR = \left( R_{\text{PARABOLA}}/RO \_MAG \right) \Lambda - G \]

\[ CŒF = V_{\text{PARABOLA}}/(Y - \Lambda U) \]
\[ \text{VS}_\text{REQUIRED} = (\text{COEF/R0}_\text{MAG})(VR \text{ R0} + VH (\text{UN} \times \text{R0})) \]

where UN is a unit vector in the direction of the angular momentum vector.

4.20.2 Interface Requirements

The input and output parameters for the Lambert conic-velocity-required task are given in tables 44 and 45.

4.20.3 Processing Requirements

Perform once on call.

4.20.4 Initialization

None.

4.20.5 Supplemental Information

If the transfer angle is near 180°, the parameter LAMBDA will be near zero. When this occurs, raising LAMBDA to a power in the code may result in an underflow. This situation must be covered in the code.

4.21 STATE VECTOR UPDATE TASK (UPDATVP)

The state vector update task calls for the precision onorbit predictor to update a state vector to a time.

4.21.1 Detailed Requirements

The following steps are required to update a state vector to a specific point of interest.

a. Determine if the Shuttle state or the target state, is to be updated. (S_OPTION = 1, 2, respectively). Also set the onorbit predictor parameters: gravity model degree and order flag, drag model, vent model, altitude mode flag, and minimum integration step size.

Set \[ \text{GMD}_\text{PRED} = \text{GMD}_I \]
\[ \text{GMO}_\text{PRED} = \text{GMO}_I \]
\[ \text{ATM} = \text{ATM}_I \]
Set \( \text{DMP} = \text{DMP}_I \) (S_OPTION)

\( \text{VMP} = \text{VMP}_I \) (S_OPTION)

\( \text{PRED\_ORB\_MASS} = \text{PRED\_ORB\_MASS}_I \) (S_OPTION)

\( \text{PRED\_ORB\_CD} = \text{PRED\_ORB\_CD}_I \) (S_OPTION)

\( \text{PRED\_ORB\_AREA} = \text{PRED\_ORB\_AREA}_I \) (S_OPTION)

b. Call the onorbit predictor to update the state vector to the final time.

Call ON\_ORB\_PRED; inputs: GMD\_PRED, GMO\_PRED, DMP, VMP, ATM,

\( \text{PRED\_ORB\_MASS}, \text{PRED\_ORB\_CD}, \text{PRED\_ORB\_AREA}, \text{R}\_IN, \text{V}\_IN, \text{T}\_IN, \text{T}\_OUT \)

outputs: \( \text{R}\_OUT, \text{V}\_OUT \)

4.21.2 Interface Requirements

The input and output parameters for the state vector update task are given in tables 46 and 47.

4.21.3 Processing Requirements

Perform once per call.

4.21.4 Initialization

None.

4.21.5 Supplemental Information

None.

4.22 NEWTON-RAPHSON ITERATION TASK (ITERV)

The Newton-Raphson task performs an iteration with a secant numerical derivative to drive the differences between two successive values of a dependent variable to zero.
4.22.1 **Detailed Requirements**

The following are the steps required to drive the successive difference of the dependent variable to zero.

a. Perform a logic test to determine if it is the first pass through the function.

   (1) If it is the first pass (IC = 0), set the delta independent variable to a constant first guess:
   
   \[
   \text{DEL}_X = \text{DEL}_X \text{GUESS}
   \]

   (2) If it is not the first pass (IC ≠ 0), calculate the delta dependent variable from the current and previous values of the dependent variable.
   
   \[
   \text{DEL}_X = \text{X}\text{DEP} - \text{X}\text{DEP PRIME}
   \]

   Perform a logic test of \(\text{DEL}_X\) to see if it is less than a small tolerance:

   If it is (\(\text{DEL}_X < \text{TOL}\)), then
   
   \[
   \text{DEL}_X = \text{DEL}_X \text{GUESS}
   \]

   If \(\text{DEL}_X\) is not less than \(\text{DEL}_X \text{TOL}\), then
   
   \[
   \text{SLOPE} = \frac{\text{DEL}_X}{(\text{X}\text{IND} - \text{X}\text{IND PRIME})}
   \]

   \[
   \text{DEL}_X = \frac{\text{X}\text{DEP}}{\text{SLOPE}}
   \]

b. Set the previous values of the dependent and independent variable to the current values. Calculate the new current values of the independent variable. Add one to the iteration counter, and set an iteration failure flag to zero:

   \[
   \text{SFAIL} = 0
   \]

   IC = IC + 1

   X\_DEP PRIME = X\_DEP

   X\_IND PRIME = X\_IND

   X\_IND = X\_IND - DEL\_X\_IND

c. Perform a logic test to determine if the maximum number of iterations has been exceeded. If the iteration exceeds the maximum (IC > ICMAX), set the failure flag:

   \[
   \text{SFAIL} = 1
   \]
4.22.2 Interface Requirements

The input and output parameters for the Newton-Raphson iteration task are given in tables 48 and 49.

4.22.3 Processing Requirements

Perform once on call.

4.22.4 Initialization

None.

4.22.5 Supplemental Information

None.

4.23 ORBITER LVLH TRANSFORMATION TASK (ORBLV)

The Orbiter LVLH transformation tasks determine the position and velocity of the target as seen from an Orbiter-centered LVLH frame starting with Orbiter and target M50 inertial vectors.

4.23.1 Detailed Requirements

The following steps are required to perform this task.

a. Find the magnitude of the Shuttle inertial vector.

\[ RS_{\text{MAG}} = \text{MAG}(\bar{RS}) \]

b. Compute the transformation matrix from M50 inertial frame to the local vertical inertial Shuttle-centered rectangular coordinate frame:

\[
\text{MAT}_{\text{M50-LVIR}} = \begin{bmatrix}
\text{unit}\left((\bar{RS} \times \bar{VS}) \times \bar{RS}\right)^T \\
-\text{unit}\left(\bar{RS} \times \bar{VS}\right)^T \\
-\text{unit}\left(\bar{RS}\right)^T
\end{bmatrix}
\]

c. Determine the orbital angular rate vector.

\[ \bar{VTAN} = \bar{VS} - \text{UNIT}(\bar{RS}) (\bar{RS} \cdot \bar{VS})/RS_{\text{MAG}} \]

\[ \bar{\Omega}_{\text{LV-PROX}} = \left(\bar{VTAN}/RS_{\text{MAG}}\right) \begin{pmatrix} 0 \\ 1 \end{pmatrix} \]
d. Compute the relative M50 state of the target with respect to the Shuttle.
\[ \vec{RST}_{M50} = \vec{RT} - \vec{RS} \]
\[ \vec{VST}_{M50} = \vec{VT} - \vec{VS} \]

e. Convert to a Shuttle-centered LV inertial rectangular frame.
\[ \vec{RST}_{LVIR} = \begin{bmatrix} \text{MAT}_{M50, LVIR} \end{bmatrix} \vec{RST}_{M50} \]
\[ \vec{VST}_{LVIR} = \begin{bmatrix} \text{MAT}_{M50, LVIR} \end{bmatrix} \vec{VST}_{M50} \]

f. Convert to a Shuttle-centered LVLH frame.
\[ \vec{RSLV} = \vec{RST}_{LVIR} \]
\[ \vec{VSLV} = \vec{VST}_{LVIR} - (\Omega_{LV, PROX} \times \vec{RST}_{LVIR}) \]

4.23.2 Interface Requirements
The input and output parameters for the Orbiter LVLH transformation task are given in table 50 and 51.

4.23.3 Processing Requirements
Perform once on call.

4.23.4 Initialization
None.

4.23.5 Supplemental Information
None.
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<td>ft</td>
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<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>( \vec{V} )</td>
<td>TBD</td>
<td>Delta-v vector from OFFSET_TGT</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>DT_OFFTGT</td>
<td>TBD</td>
<td>Transfer time for OFFSET_TGT</td>
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<td>( \vec{X}_OFFTGT )</td>
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<td>T1 relative position vector for OFFSET_TGT</td>
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<td>( \vec{V}_OFFTGT )</td>
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<td>ft/sec</td>
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<td>( \vec{X}_2_OFFTGT )</td>
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<td>T2 relative position vector for OFFSET_TGT</td>
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<td>( \vec{R}_S_INER )</td>
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<td>Input Shuttle inertial position for REL_COMP</td>
<td>F(3)</td>
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<td>PRECISION</td>
<td>DEFINITION</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>F(3)</td>
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<td>F(3)</td>
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<td>$\vec{v}_{T_INER}$</td>
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<td>$\mathbf{\bar{r}}<em>{S</em>{T1TIG}}$</td>
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<td>Inertial position vector of Shuttle at T1_TIG for PREVR</td>
<td>F(3)</td>
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<tr>
<td>$\mathbf{\bar{v}}<em>{S</em>{T1TIG}}$</td>
<td>TBD</td>
<td>Inertial velocity vector of Shuttle at T1_TIG for PREVR</td>
<td>F(3)</td>
<td>ft/sec</td>
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<td>$\mathbf{\bar{r}}<em>{S</em>{T2TIG}}$</td>
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<td>Inertial position vector of Shuttle at T2_TIG for PREVR</td>
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<td>Predicted time of TPI (MET)</td>
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<td>$\mathbf{\bar{r}}<em>{S</em>{OUT}}$</td>
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<td>Shuttle position vector</td>
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<td>Shuttle velocity vector</td>
<td>F(3)</td>
<td>ft/sec</td>
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<td>$\mathbf{\bar{r}}<em>{T</em>{OUT}}$</td>
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<td>Target position vector</td>
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<td>Target velocity vector</td>
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<td>Time of the target position vector (GMT)</td>
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<td>sec</td>
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<td>$\mathbf{\bar{v}}<em>{S</em>{REQUIRED}}$</td>
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<td>Velocity required at the maneuver time</td>
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<td>ft/sec</td>
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<td>$\mathbf{\bar{r}}<em>{S</em>{IPO}}$</td>
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<td>Initial position offset of Shuttle from PREVR</td>
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<td>$\mathbf{\bar{r}}<em>{S</em>{COM}}$</td>
<td>TBD</td>
<td>Shuttle inertial position for COMELE</td>
<td>F(3)</td>
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<td>$\mathbf{\bar{v}}<em>{S</em>{COM}}$</td>
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<td>Shuttle inertial velocity for COMELE</td>
<td>F(3)</td>
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<td>TBD</td>
<td>Target inertial position for COMELE</td>
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<td>ft</td>
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<td>DEFINITION</td>
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<td>Computed elevation angle from COMELE</td>
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<td>UN</td>
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<td>Unit normal along the Shuttle angular momentum vector</td>
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<td>F</td>
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<td>IC</td>
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<td>Iteration counter to ITERV</td>
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<td>Flag set if maximum number of iterations have occurred</td>
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<td>Dependent variable in search for elevation angle</td>
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<td>Previous value of the dependent variable in search for elevation angle</td>
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<td>Input inertial position of Shuttle to ORBLV</td>
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<td>TBD</td>
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<td>F(3)</td>
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<td>Shuttle-centered LVLH relative velocity of target</td>
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<td>PROX_EXEC</td>
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<td>Delta-t's from T1 maneuver to T2 maneuver for target sets</td>
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<td>I</td>
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<td>Converted time for TIMECV</td>
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<td>F</td>
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TABLE 9. - Concluded

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<tr>
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<th>TYPE</th>
<th>UNITS</th>
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<td>Delta-t in the computation buffer</td>
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<td>PROX_TGT_SUP</td>
<td>F</td>
<td>ft</td>
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<td>COMP_T2_ZOFF</td>
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<td>Computational desired position at T2</td>
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<td></td>
<td></td>
<td>PROX_TGT_SUP_LAMB</td>
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<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>sec</td>
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<td>I</td>
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<td>PROX_EXEC</td>
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<td>F</td>
<td>sec</td>
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<td>DV_LVLH</td>
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<td>Impulsive maneuver in LVLH reference frame</td>
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<td>F(3)</td>
<td>ft/sec</td>
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<td></td>
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<td>PROX_TGT_SUP_LAMB</td>
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<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>F</td>
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<td>I</td>
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<td>DISP_T1_HR</td>
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<td>Displayed T1 time</td>
<td></td>
<td>I</td>
<td>hr</td>
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<td>DISP_T1_MIN</td>
<td>TBD</td>
<td>Displayed T1 time</td>
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<td>I</td>
<td>min</td>
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<tr>
<td>DISP_T1_SEC</td>
<td>TBD</td>
<td>Displayed T1 time</td>
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<td>F</td>
<td>sec</td>
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<td>DISP_T2_HR</td>
<td>TBD</td>
<td>Displayed T2 time</td>
<td></td>
<td>I</td>
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<td>DISP_T2_SEC</td>
<td>TBD</td>
<td>Displayed T2 time</td>
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<td>F</td>
<td>sec</td>
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<td>DISP_DV</td>
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<td>Maneuver LVLH velocity vector</td>
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<td>F(3)</td>
<td>ft/sec</td>
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<td>DISP_DV_MAG</td>
<td>TBD</td>
<td>Maneuver velocity magnitude</td>
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<td>F</td>
<td>ft/sec</td>
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<tr>
<td>DISP_TMAN_TIME</td>
<td>TBD</td>
<td>Maneuver time (MET)</td>
<td></td>
<td>F</td>
<td>sec</td>
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<td>DISP_TMAN_DAY</td>
<td>TBD</td>
<td>Displayed maneuver time</td>
<td></td>
<td>I</td>
<td>day</td>
</tr>
<tr>
<td>DISP_TMAN_HR</td>
<td>TBD</td>
<td>Displayed maneuver time</td>
<td></td>
<td>I</td>
<td>hr</td>
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<tr>
<td>DISP_TMAN_MIN</td>
<td>TBD</td>
<td>Displayed maneuver time</td>
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<td>I</td>
<td>min</td>
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<td>DISP_TMAN_SEC</td>
<td>TBD</td>
<td>Displayed maneuver time</td>
<td></td>
<td>F</td>
<td>sec</td>
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<td>I</td>
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</tr>
<tr>
<td>TIME_SEC</td>
<td>TBD</td>
<td>Converted time</td>
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<td>F</td>
<td>sec</td>
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</table>

**TABLE 11.- OUTPUT PARAMETERS FOR THE PROX_DISP_LOAD MODULE**
### TABLE 12.- INPUT PARAMETERS FOR THE PROX_STIME MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
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<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM_IND</td>
<td>TBD</td>
<td>Time GMT/MET select indicator</td>
<td>FCOS</td>
<td>D</td>
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<tr>
<td>BASE_MET</td>
<td>TBD</td>
<td>GMT/MET reference time</td>
<td>FCOS</td>
<td>F</td>
<td>sec</td>
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<tr>
<td>T_MAN</td>
<td>TBD</td>
<td>Time of the computed maneuver (MET)</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>sec</td>
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<tr>
<td>PROX_PAST_STATUS</td>
<td>TBD</td>
<td>Maneuver past time status flag</td>
<td>PROX_STAT</td>
<td>D</td>
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</table>
### TABLE 13.- OUTPUT PARAMETERS FOR THE PROX_TIME MODULE

<table>
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<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT_ST_TIMER</td>
<td>TBD</td>
<td>Time to be counted down</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>CRT_TIME</td>
<td>TBD</td>
<td>CRT timer start/stop discrete</td>
<td>ORBIT_TGT_DIP (6.14)</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>CRT_UPDOWN</td>
<td>TBD</td>
<td>CRT timer up/down discrete</td>
<td></td>
<td>D</td>
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### TABLE 14 - INPUT PARAMETERS FOR THE PROX_TRANS MODULE

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<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
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<td>PROX_TGT_SUP</td>
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<td></td>
<td></td>
<td>PROX_TGT_SUP_LAMB</td>
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</tr>
<tr>
<td>PROX_PAST_STATUS</td>
<td>TBD</td>
<td>Maneuver past time status flag</td>
<td>PROX_STAT</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>DV_LVLH</td>
<td>TBD</td>
<td>Impulsive maneuver in L^L reference frame</td>
<td>PROX_TGT_SUP</td>
<td>F(3)</td>
<td>ft/sec</td>
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<td></td>
<td>PROX_TGT SUP LAMB</td>
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<tr>
<td>S_ROTATE</td>
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<td>Rotation flag for near 180° transfers</td>
<td></td>
<td>D</td>
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</tr>
<tr>
<td>N_OFFSET</td>
<td>TBD</td>
<td>Offset position vector</td>
<td>PREVR</td>
<td>F(3)</td>
<td>ft</td>
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<td>TBD</td>
<td>Time of offset position vector (MET)</td>
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<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>DISP_TMAN_DAY</td>
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<td>I</td>
<td>day</td>
</tr>
<tr>
<td>DISP_TMAN_HR</td>
<td>TBD</td>
<td>Maneuver time for display</td>
<td>PROX_DISP_LOAD</td>
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<td>hr</td>
</tr>
<tr>
<td>DISP_TMAN_MIN</td>
<td>TBD</td>
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<td></td>
<td>I</td>
<td>min</td>
</tr>
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<td>TBD</td>
<td></td>
<td></td>
<td>F</td>
<td>sec</td>
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<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>-----------</td>
<td>----------------------------------------------------</td>
<td>---------------------------</td>
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<tr>
<td>( \Delta v ) _LVLH_GUID</td>
<td>TBD</td>
<td>Delta-v vector of current maneuver</td>
<td>ORBIT_MNVR_DISP (6.35)</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>S_ROTATE_GUID</td>
<td>TBD</td>
<td>Rotation flag for near-180° transfers</td>
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<td>D</td>
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</tr>
<tr>
<td>( \vec{R} ) _OFFSET_GUID</td>
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<td>Offset position vector</td>
<td>ORBIT_MNVR_DIP (4.158)</td>
<td>F(3)</td>
<td>ft</td>
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<tr>
<td>T_OFFSET_GUID</td>
<td>TBD</td>
<td>Time of offset position vector (MET)</td>
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<td>sec</td>
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<td>TBD</td>
<td>Ignition time of current maneuver</td>
<td>ORBIT_MNVR_DISP (6.35)</td>
<td>I</td>
<td>day</td>
</tr>
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<td>TIG_GUID_HR</td>
<td>TBD</td>
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<td></td>
<td>I</td>
<td>nr</td>
</tr>
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<td>TIG_GUID_MIN</td>
<td>TBD</td>
<td></td>
<td></td>
<td>I</td>
<td>min</td>
</tr>
<tr>
<td>TIG_GUID_SEC</td>
<td>TBD</td>
<td></td>
<td></td>
<td>F</td>
<td>sec</td>
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### TABLE 16: INPUT PARAMETERS FOR THE PROX_EXEC MODULE

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<th>TYPE</th>
<th>UNITS</th>
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</thead>
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<td>BASE_MERET</td>
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<td>GMT/MET reference time</td>
<td>FCOS</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T_STATE</td>
<td>TBD</td>
<td>Time tag for M50 vectors</td>
<td>ON_ORB_UPP (4.22)</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>R_AVGG</td>
<td>TBD</td>
<td>Orbiter position M50 vectors</td>
<td>ON_ORB_UPP (4.22)</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_AVGG</td>
<td>TBD</td>
<td>Orbiter velocity M50 vectors</td>
<td>ON_ORB_UPP (4.22)</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>R_TARGET</td>
<td>TBD</td>
<td>Target position M50 vectors</td>
<td>ON_ORB_UPP (4.22)</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_TARGET</td>
<td>TBD</td>
<td>Target velocity M50 vectors</td>
<td>ON_ORB_UPP (4.22)</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>PROX_TGT_SET_NO</td>
<td>TBD</td>
<td>ILÔAD set number selected for trajectory</td>
<td>ORBIT_TGT_DIP (6.14)</td>
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<td>Items 21 through 24 data entry status flag</td>
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<td>Items 2 through 20 data entry status flag</td>
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<td>PROX_FIRST_PASS_STATUS</td>
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<td>I</td>
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<td>Conversion time</td>
<td>TIME_CONVRT</td>
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TABLE 17.- OUTPUT PARAMETERS FOR THE PROX_EXEC MODULE

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<td>DEFINITION</td>
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<td>Prox ops base time</td>
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<td>Orbital angular rate of target</td>
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<td>Prox ops target M50 velocity vector</td>
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<td>ft/sec</td>
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### TABLE 18 - INPUT PARAMETERS FOR THE PROXTGT_SEL MODULE

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<th>TYPE</th>
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<td>DT_ILOAD_ARRAY</td>
<td>TBD</td>
<td>Delta-t from T1 maneuver to T2 maneuver for target sets</td>
<td>F(40)</td>
<td>min</td>
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<td>Maneuver elevation angle</td>
<td>PROX_INIT ILOAD</td>
<td>F(40)</td>
<td>rad</td>
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<tr>
<td>XOFF_ILOAD_ARRAY</td>
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<td>ILOAD LVLH offset position for target sets</td>
<td>F(40)</td>
<td>ft</td>
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<td>YOFF_ILOAD_ARRAY</td>
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<td>ILOAD LVLH offset position for target sets</td>
<td>F(40)</td>
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<td>ILOAD LVLH offset position for target sets</td>
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<td>ft</td>
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<td>I</td>
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<td>TIME_CONVRT</td>
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<td>min</td>
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<td>SEC</td>
<td>TBD</td>
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<td>TYPE</td>
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**TABLE 19.--- Concluded**

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<tr>
<td>PROX_T1_STAR_STATUS</td>
<td>TBD</td>
<td>T1 maneuver compute star flag</td>
<td>PROX_EXEC</td>
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</tr>
<tr>
<td>PROX_DTMIN</td>
<td>TBD</td>
<td>Tolerance on minimum time in the future to compute a prox ops maneuver solution</td>
<td>ILOAD</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>PROX_DIMIN_LAMB</td>
<td>TBD</td>
<td>Tolerance on minimum time in the future to compute a Lambert maneuver solution</td>
<td>ILOAD</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T1_TIG</td>
<td>TBD</td>
<td>T1 maneuver time (MET)</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>TR_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>PROX_T_CURRENT</td>
<td>TBD</td>
<td>Current MET time</td>
<td>PROX_STAT</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>COMP_PROX_DT</td>
<td>TBD</td>
<td>Delta-t in the computation buffer</td>
<td>PROX_TGT_SEL</td>
<td>F</td>
<td>min</td>
</tr>
<tr>
<td>COMP_PROX_DX</td>
<td>TBD</td>
<td>Computational desired position at T2</td>
<td>PROX_TGT_SEL</td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_PROX_DY</td>
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<td>Computational desired position at T2</td>
<td>PROX_TGT_SEL</td>
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<td>PROX_TGT_SEL</td>
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<td>ft</td>
</tr>
<tr>
<td>TIME_PROX</td>
<td>TBD</td>
<td>Time tag for M50 state (assume MET)</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>-----------</td>
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<td>-----------------------------</td>
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</tr>
<tr>
<td>$X_2$</td>
<td>TBD</td>
<td>Predicted Orbiter relative state position</td>
<td>REL_PRED</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>$\dot{X}_2$</td>
<td>TBD</td>
<td>Predicted Orbiter relative state velocity</td>
<td>REL_PRED</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>USE_OMEGA_DT</td>
<td>TBD</td>
<td>Use the WT calculation flag</td>
<td>PROX TGT SUP LAMB</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>USE_DISP_REL_STATE</td>
<td>TBD</td>
<td>Use displayed relative state flag</td>
<td>PROX EXEC</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>COMP_\dot{X}</td>
<td>TBD</td>
<td>Computation relative position</td>
<td>PROX INIT</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_\ddot{X}</td>
<td>TBD</td>
<td>Computation relative velocity</td>
<td>PROX_TGT_SUP LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>\text{\textasciitilde}R_{S-M50_PROX}</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>\text{\textasciitilde}R_{T-M50_PROX}</td>
<td>TBD</td>
<td>Prox ops target M50 position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>\text{\textasciitilde}V_{S-M50_PROX}</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 velocity vector</td>
<td>PROX_EXEC</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>\text{\textasciitilde}V_{T-M50_PROX}</td>
<td>TBD</td>
<td>Prox ops target M50 velocity vector</td>
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<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>\text{\textasciitilde}R_{REL}</td>
<td>TBD</td>
<td>LVLH curvilinear position vector from REL_COMP</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>\text{\textasciitilde}V_{REL}</td>
<td>TBD</td>
<td>LVLH curvilinear velocity vector from REL_COMP</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>\text{\textasciitilde}\Delta v</td>
<td>TBD</td>
<td>Delta-v vector from OFFSET_TGT</td>
<td>OFFSET_TGT</td>
<td>F(3)</td>
<td>ft/sec</td>
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### Table 21: Output Parameters for the PROX_TGT_SUP Module

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
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<tr>
<td>GUID_FLAG</td>
<td>TBD</td>
<td>Current maneuver guidance option flag</td>
<td>ORBIT_MNVR_DIP (4.158)</td>
<td>D</td>
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</tr>
<tr>
<td>T_MAN</td>
<td>TBD</td>
<td>Time of the computed maneuver (MET)</td>
<td>PROX_STAT</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>DISP_T1_X</td>
<td>TBD</td>
<td>Orbiter relative position at T1</td>
<td>PROX_INIT</td>
<td>F(3)</td>
<td>ft</td>
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<tr>
<td>DISP_T1_XD</td>
<td>TBD</td>
<td>Orbiter relative velocity at T1</td>
<td>ORB_TGT_DIP (6.14)</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>T1_TIG</td>
<td>TBD</td>
<td>T1 maneuver time (MET)</td>
<td>PROX_DISP_LOAD</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T2_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td>DT_COMP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>COMP_PROX_DT</td>
<td>TBD</td>
<td>Delta-t in the computation buffer</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F</td>
<td>min</td>
</tr>
<tr>
<td>COMP_T2_XOFF</td>
<td>TBD</td>
<td>Computational desired position at T2</td>
<td>PROX_DISP_LOAD</td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_T2_YOFF</td>
<td>TBD</td>
<td>Computational desired position at T2</td>
<td>OMEGA_DT_COMP</td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_T2_ZOFF</td>
<td>TBD</td>
<td>Computational desired position at T2</td>
<td></td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>DV_LVLH</td>
<td>TBD</td>
<td>Impulsive maneuver in LVLH reference frame</td>
<td>PROX_TRANS</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>USE_DISP_REL_STATE</td>
<td>TBD</td>
<td>Use displayed relative state flag</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>COMP_X</td>
<td>TBD</td>
<td>Computation relative position</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>-----------------------------------------------------</td>
<td>------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>COMP_XD</td>
<td>TBD</td>
<td>Computation relative velocity</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>DTIME</td>
<td>TBD</td>
<td>Time internal for prediction computation</td>
<td>REL_PRED</td>
<td>F</td>
<td>min</td>
</tr>
<tr>
<td>X</td>
<td>TBD</td>
<td>Input relative position for the relative predict task</td>
<td>REL_PRED</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>XD</td>
<td>TBD</td>
<td>Input relative velocity for the relative predict task</td>
<td>REL_PRED</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>INER_TO_LVC</td>
<td>TBD</td>
<td>Inertial to curvilinear conversion flag</td>
<td>REL_COMP</td>
<td>D</td>
<td>---</td>
</tr>
<tr>
<td>DT_OFFTGT</td>
<td>TBD</td>
<td>Transfer time for OFFSET_TGT</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>X_OFFTGT</td>
<td>TBD</td>
<td>T1 relative position vector for OFFSET_TGT</td>
<td>OFFSET_TGT</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>XD_OFFTGT</td>
<td>TBD</td>
<td>T1 relative velocity vector for OFFSET_TGT</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>X2_OFFTGT</td>
<td>TBD</td>
<td>T2 relative position vector for OFFSET_TGT</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
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<tr>
<td>R_S_INER</td>
<td>TBD</td>
<td>Input Shuttle inertial position for REL_COMP</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_S_INER</td>
<td>TBD</td>
<td>Input Shuttle inertial velocity for REL_COMP</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>R_T_INER</td>
<td>TBD</td>
<td>Input target inertial position for REL_COMP</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_T_INER</td>
<td>TBD</td>
<td>Input target inertial velocity for REL_COMP</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft/sec</td>
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</table>
### TABLE 22. - INPUT PARAMETERS FOR THE PROX_TGT_SUP_LAMB MODULE

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<tr>
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<th>PRECISION</th>
<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
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<tr>
<td>BASE_MET</td>
<td>TBD</td>
<td>GMT/MET reference time</td>
<td>FCOS</td>
<td>F</td>
<td>sec</td>
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<tr>
<td>PROX_T1_STAR_STATUS</td>
<td>TBD</td>
<td>T1 maneuver compute star flag</td>
<td>PROX_EXEC</td>
<td>D</td>
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<tr>
<td>PROX_TGT_SET_NO</td>
<td>TBD</td>
<td>ILOAD set number selected for targeting</td>
<td>ORBIT_TGT_DIP (6.14)</td>
<td>I</td>
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<tr>
<td>T1_TIG</td>
<td>TBD</td>
<td>T1 maneuver time (MET)</td>
<td>PROX_EXEC PROX_TGT_SEL PROX_INIT PROX_TGT_SUP</td>
<td>F</td>
<td>sec</td>
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<td>T2_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td>PROX_EXEC PROX_INIT PROX_TGT_SUP DT_COMP</td>
<td>F</td>
<td>sec</td>
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<tr>
<td>PROX_T_CURRENT</td>
<td>TBD</td>
<td>Current MET time</td>
<td>PROX_STAT</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>DAY</td>
<td>TBD</td>
<td>Converted time for TIMECV</td>
<td>TIME_CONVRT</td>
<td>I</td>
<td>day</td>
</tr>
<tr>
<td>HR</td>
<td>TBD</td>
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<td>TIME_CONVRT</td>
<td>I</td>
<td>hr</td>
</tr>
<tr>
<td>MIN</td>
<td>TBD</td>
<td>Converted time for TIMECV</td>
<td>TIME_CONVRT</td>
<td>I</td>
<td>min</td>
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<tr>
<td>SEC</td>
<td>TBD</td>
<td>Converted time for TIMECV</td>
<td>TIME_CONVRT</td>
<td>I</td>
<td>sec</td>
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<td>COMP_PROX_DT</td>
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<td>PROX_TGT_SEL PROX_INIT PROX_TGT_SUP DT_COMP OMEGA_DT_COMP</td>
<td>F</td>
<td>min</td>
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<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>-----------</td>
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<td>COMP_T2_XOFF</td>
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<td>PROX_TGT_SEL, PROX_INIT</td>
<td>F</td>
<td>ft</td>
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<tr>
<td>COMP_T2_YOFF</td>
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<td>Computational desired position at T2</td>
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<td>F</td>
<td>ft</td>
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<tr>
<td>COMP_T2_ZOFF</td>
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<td>Computational desired position at T2</td>
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<td>ft</td>
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<td>Time tag for the M50 state (assumed MET)</td>
<td>PROX_EXEC, PROX_INIT</td>
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<td>sec</td>
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<td>EL_Ang</td>
<td>TBD</td>
<td>Desired elevation angle at TP1</td>
<td>PROX_TGT_SEL, PROX_INIT</td>
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<td>D</td>
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</tr>
<tr>
<td>USE_DISP_REL_STATE</td>
<td>TBD</td>
<td>Use displayed relative flag</td>
<td>PROX_EXEC, PROX_TGT_SUP</td>
<td>D</td>
<td>--</td>
</tr>
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<td>COMP_X</td>
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<td>PROX_INIT, PROX_TGT_SUP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_XD</td>
<td>TBD</td>
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<td>PROX_INIT, PROX_TGT_SUP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>(\bar{\mathbf{r}})_{M50_PROX}</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
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<tr>
<td>(\bar{\mathbf{v}})_{M50_PROX}</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 velocity vector</td>
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<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>(\bar{\mathbf{r}})_{T_M50_PROX}</td>
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<td>Prox ops target M50 position vector</td>
<td>PROX_EXEC</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>(\bar{\mathbf{v}})_{T_M50_PROX}</td>
<td>TBD</td>
<td>Prox ops target M50 velocity vector</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
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<tr>
<td>R_OUT</td>
<td>TBD</td>
<td>Output inertial position vector</td>
<td>UPDATVP</td>
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<td>TBD</td>
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<td>F(3)</td>
<td>ft/sec</td>
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<tr>
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<td>TBD</td>
<td>Predicted time of TPI (MET)</td>
<td>TELEV</td>
<td>F</td>
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<tr>
<td>R_S_OUT</td>
<td>TBD</td>
<td>Shuttle position vector</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>V_S_OUT</td>
<td>TBD</td>
<td>Shuttle velocity vector</td>
<td>F(3)</td>
<td>ft/sec</td>
<td></td>
</tr>
<tr>
<td>T_T_OUT</td>
<td>TBD</td>
<td>Target position vector</td>
<td>F(3)</td>
<td>ft</td>
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</tr>
<tr>
<td>T_T_OUT</td>
<td>TBD</td>
<td>Target velocity vector</td>
<td>F(3)</td>
<td>ft/sec</td>
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<tr>
<td>TS_OUT</td>
<td>TBD</td>
<td>Time of the Shuttle position vector (GMT)</td>
<td>F</td>
<td>sec</td>
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<td>TT_OUT</td>
<td>TBD</td>
<td>Time of the target position vector (GMT)</td>
<td>F</td>
<td>sec</td>
<td></td>
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<td>V_S_REQUIRED</td>
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<td>Velocity required at the maneuver time</td>
<td>PREVR</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>R_S_IPO</td>
<td>TBD</td>
<td>Initial position offset of Shuttle</td>
<td>PREVR</td>
<td>F(3)</td>
<td>ft</td>
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<tr>
<td>R_REL</td>
<td>TBD</td>
<td>LVLH curvilinear position vector</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_REL</td>
<td>TBD</td>
<td>LVLH curvilinear velocity vector</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>R_S_INER</td>
<td>TBD</td>
<td>Input Shuttle inertial position vector</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_S_INER</td>
<td>TBD</td>
<td>Input Shuttle inertial velocity vector</td>
<td>REL_COMP</td>
<td>F(3)</td>
<td>ft/sec</td>
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<tr>
<td>V_SLV</td>
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<td>Shuttle-centered LVLH relative velocity of the target</td>
<td>ORBLV</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
</tbody>
</table>
### TABLE 23: OUTPUT PARAMETERS FOR THE PROX_TGT_SUP_LAMB MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
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<tbody>
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<td>GUID_FLAG</td>
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<td>Current maneuver guidance option flag</td>
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<tr>
<td></td>
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<td></td>
<td>ORBIT_MNVR_DIP</td>
<td>(4.158)</td>
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<tr>
<td>T_MAN</td>
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<td>Ignition time of maneuver (MET)</td>
<td>PROX_STAT</td>
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<td>sec</td>
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<tr>
<td></td>
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<td>PROX_STIME</td>
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<tr>
<td>DISP_T1_X</td>
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<td>Orbiter relative position at T1</td>
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<td>T2 maneuver time (MET)</td>
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<td>Prox ops base time</td>
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### TABLE 23.- Concluded

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<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
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<td>Inertial velocity vector of Shuttle at $T_1$</td>
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<td>Input inertial velocity</td>
<td>UPDATVP</td>
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<td>sec</td>
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<td>$\mathbf{V}_{\mathbf{T}}$</td>
<td>TBD</td>
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<td>ft/sec</td>
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<td>ft/sec</td>
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<td>DEFINITION</td>
<td>SOURCE</td>
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<td>UNITS</td>
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<td>Orbital angular rate of target</td>
<td>PROX_EXEC</td>
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<td>PROX_TGT_SUP</td>
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<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
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<td>OMEGA_DT_COMP</td>
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<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
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<td>TBD</td>
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<td>PROX_TGT_SUP</td>
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</tr>
<tr>
<td>OMEGA PROX</td>
<td>TBD</td>
<td>Orbital angular rate of target</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>rad/sec</td>
</tr>
<tr>
<td>$\bar{x}$</td>
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<td>ft/sec</td>
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### TABLE 27.- OUTPUT PARAMETERS FOR THE REL_PRED MODULE

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<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
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<tr>
<td>$\bar{x}_2$</td>
<td>TBD</td>
<td>Predicted Orbiter relative state position</td>
<td>PROX_TGT_SUP</td>
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Type: $^\prime$ (3)

Units: ft
## TABLE 28.- INPUT PARAMETERS FOR THE REL_COMP MODULE

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<td>Conversion time</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PROX_INIT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------</td>
<td>-------------------------------------------------</td>
<td>-----------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>T1_TIG</td>
<td>TBD</td>
<td>T1 maneuver time (MET)</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T2_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>COMP_PROX_DT</td>
<td>TBD</td>
<td>Delta-(t) in the computation buffer</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F</td>
<td>min</td>
</tr>
</tbody>
</table>
### TABLE 33. OUTPUT PARAMETERS FOR THE DT_COMP MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>COMP_PROX_DT</td>
<td>TBD</td>
<td>Delta-t in the computation buffer</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F</td>
<td>min</td>
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### Table 34.- Input Parameters for the Omega_DT_Comp Module

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROX_TGT_SEP_NO</td>
<td>TBD</td>
<td>ILOAD set number selected for targeting</td>
<td>ORBIT_TGT_DIP (6.14)</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>DT_ILOAD_ARRAY</td>
<td>TBD</td>
<td>Delta-t's from T1 to T2 for target sets</td>
<td></td>
<td>F(40)</td>
<td>min</td>
</tr>
<tr>
<td>EL_ILOAD_ARRAY</td>
<td>TBD</td>
<td>Maneuver elevation angle</td>
<td></td>
<td>F(40)</td>
<td>rad</td>
</tr>
<tr>
<td>XOFF_ILOAD_ARRAY</td>
<td>TBD</td>
<td>ILOAD LVLH offset position for target sets</td>
<td>PROX_INIT ILOAD</td>
<td>F(40)</td>
<td>ft</td>
</tr>
<tr>
<td>YOFF_ILOAD_ARRAY</td>
<td>TBD</td>
<td>ILOAD LVLH offset position for target sets</td>
<td></td>
<td>F(40)</td>
<td>ft</td>
</tr>
<tr>
<td>ZOFF_ILOAD_ARRAY</td>
<td>TBD</td>
<td>ILOAD LVLH offset position for target sets</td>
<td></td>
<td>F(40)</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_T2_XOFF</td>
<td>TBD</td>
<td>Computational desired at T2</td>
<td></td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_T2_YOFF</td>
<td>TBD</td>
<td>Computational desired at T2</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_T2_ZOFF</td>
<td>TBD</td>
<td>Computational desired at T2</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>COMP_X</td>
<td>TBD</td>
<td>Computation relative position</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>OMEGA_PROX</td>
<td>TBD</td>
<td>Orbital angular rate of target</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>rad/sec</td>
</tr>
<tr>
<td>DV</td>
<td>TBD</td>
<td>Delta-v vector</td>
<td>OFFSET_TGT</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>------------------------------</td>
<td>---------------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>COMP_PROX_DT</td>
<td>TBD</td>
<td>Delta-(t) in the</td>
<td>PROX_TGT_SUP</td>
<td>F</td>
<td>min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>computation buffer</td>
<td>PROX_TGT_SUP_LAMB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DT_OFFTGT</td>
<td>TBD</td>
<td>Transfer time</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>X_OFFTGT</td>
<td>TBD</td>
<td>T1 relative position vector</td>
<td>OFFSET_TGT</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>XD_OFFTGT</td>
<td>TBD</td>
<td>T1 relative position vector</td>
<td></td>
<td>F(3)</td>
<td>ft/see</td>
</tr>
<tr>
<td>X2_OFFTGT</td>
<td>TBD</td>
<td>T2 relative position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
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</table>
TABLE 36– INPUT PARAMETERS FOR THE TELEV MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE MET</td>
<td>TBD</td>
<td>GMT/MET reference time</td>
<td>FOOS</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>PI</td>
<td>TBD</td>
<td>Mathematical constant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1_ILOAD_ARRAY</td>
<td>TBD</td>
<td>Nominal time of maneuver for targets</td>
<td>F(40)</td>
<td>min</td>
<td></td>
</tr>
<tr>
<td>EL_TOL</td>
<td>TBD</td>
<td>Tolerance between computed and desired elevation angles</td>
<td>ILOAD</td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>EL_DH_TOL</td>
<td>TBD</td>
<td>Elevation angle-differential altitude incompatibility tolerance</td>
<td></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>TIME_PROX</td>
<td>TBD</td>
<td>Time tag for M50 state (assumed MET)</td>
<td>PROX_TGT_SUP_LARGE</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>EL_Ang</td>
<td>TBD</td>
<td>Desired elevation angle at TPI</td>
<td>PROX_EXEC</td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>iRS_M50_PROX</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>iRT_M50_PROX</td>
<td>TBD</td>
<td>Prox ops target M50 position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VS_M50_PROX</td>
<td>TBD</td>
<td>Prox ops Orbiter M50 velocity vector</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>VT_M50_PROX</td>
<td>TBD</td>
<td>Prox ops target M50 velocity vector</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>R_OUT</td>
<td>TBD</td>
<td>Output inertial position vector</td>
<td>UPDATYP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_OUT</td>
<td>TBD</td>
<td>Output inertial velocity vector</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
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### TABLE 36. - Concluded

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
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</thead>
<tbody>
<tr>
<td>TTPi</td>
<td>TBD</td>
<td>Predicted time of TPI in MET</td>
<td>ELITER</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>EL_ANG_COM</td>
<td>TBD</td>
<td>Computed elevation angle</td>
<td>COMELE</td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>ERR PRIME</td>
<td>TBD</td>
<td>Previous value of the elevation angle guess</td>
<td></td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>TTPi PRIME</td>
<td>TBD</td>
<td>Previous value of the TPI time guess</td>
<td>ELITER</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>N</td>
<td>TBD</td>
<td>Iteration counter</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
</tbody>
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### TABLE 37: OUTPUT PARAMETERS FOR THE TELEV MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_OPTION</td>
<td>TBD</td>
<td>Spacecraft flag for UPDATVP</td>
<td></td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>N_IN</td>
<td>TBD</td>
<td>Input inertial position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_IN</td>
<td>TBD</td>
<td>Input inertial velocity vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>T_IN</td>
<td>TBD</td>
<td>Input time in GMT</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T_OUT</td>
<td>TBD</td>
<td>Output time in GMT</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>RS_OUT</td>
<td>TBD</td>
<td>Shuttle position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VS_OUT</td>
<td>TBD</td>
<td>Shuttle velocity vector</td>
<td>ELITER</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>RT_OUT</td>
<td>TBD</td>
<td>Target position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VT_OUT</td>
<td>TBD</td>
<td>Target velocity vector</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>RS_COM</td>
<td>TBD</td>
<td>Shuttle inertial position</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VS_COM</td>
<td>TBD</td>
<td>Shuttle inertial velocity</td>
<td>COMELT</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>RT_COM</td>
<td>TBD</td>
<td>Target inertial position</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>ERR_PRIME</td>
<td>TBD</td>
<td>Previous value of the dependent variable in</td>
<td>ELITER</td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>TIP1_PRIME</td>
<td>TBD</td>
<td>Previous value of the independent variable in</td>
<td>ELITER</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>TPI</td>
<td>TBD</td>
<td>Predicted time of TPI (MET)</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>-----------------------------------------------</td>
<td>-----------------------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>BASE_MET</td>
<td>TBD</td>
<td>GMT/MET reference time</td>
<td>FOOS</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>PI</td>
<td>TBD</td>
<td>Mathematical constant</td>
<td>ILOAD</td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>WS</td>
<td>TBD</td>
<td>Weight of the Orbiter</td>
<td>ON ORB UPP (4.22)</td>
<td>F</td>
<td>ft/sec²</td>
</tr>
<tr>
<td>R_TOL</td>
<td>TBD</td>
<td>Convergence tolerance in the terminal point offset iteration</td>
<td></td>
<td>F</td>
<td>ft</td>
</tr>
<tr>
<td>EARTH_MU</td>
<td>TBD</td>
<td>Earth gravitational constant</td>
<td>ILOAD</td>
<td>F</td>
<td>ft³/sec²</td>
</tr>
<tr>
<td>N_MAX</td>
<td>TBD</td>
<td>Maximum allowed number of iterations</td>
<td>ILOAD</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>CONE</td>
<td>TBD</td>
<td>Angular tolerance used to determine if the transfer angle $\sim 180^\circ$</td>
<td></td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>N_MIN</td>
<td>TBD</td>
<td>Minimum allowed number of iterations</td>
<td>ILOAD</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>T1_TIG</td>
<td>TBD</td>
<td>T1 maneuver time (MET)</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T2_TIG</td>
<td>TBD</td>
<td>T2 maneuver time (MET)</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>$\bar{R}<em>{S</em>{T1TIG}}$</td>
<td>TBD</td>
<td>Inertial position vector of Shuttle at $T_1$ TIG</td>
<td>PROX_TGT SUP LAMB</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>$\bar{V}<em>{S</em>{T1TIG}}$</td>
<td>TBD</td>
<td>Inertial velocity vector of Shuttle at $T_1$ TIG</td>
<td>PROX_TGT SUP LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>$\bar{R}<em>{S</em>{T2TIG}}$</td>
<td>TBD</td>
<td>Inertial position vector of Shuttle at $T_2$ TIG</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>$\bar{R}_{OUT}$</td>
<td>TBD</td>
<td>Output inertial position vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>$\bar{V}_{OUT}$</td>
<td>TBD</td>
<td>Output inertial velocity vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>$\bar{V}<em>{S</em>{REQUIRED}}$</td>
<td>TBD</td>
<td>Velocity required at the maneuver time</td>
<td>LAMBERT</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>-------------</td>
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<td>--------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>G</td>
<td>TBD</td>
<td>Gravitational constant</td>
<td>ILOAD</td>
<td>F</td>
<td>ft/sec²</td>
</tr>
<tr>
<td>THRUST</td>
<td>TBD</td>
<td>Thrust of the propulsion system</td>
<td></td>
<td>F</td>
<td>lbs</td>
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</table>
### TABLE 39 - OUTPUT PARAMETERS FOR THE PREVR MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
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<tr>
<td>S_ROTATE</td>
<td>TBD</td>
<td>Rotation flag for near-180° transfers</td>
<td></td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>OFFSET</td>
<td>TBD</td>
<td>Offset position vector (inertial)</td>
<td>PROX_TRANS</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>T_OFFSET</td>
<td>TBD</td>
<td>Time of offset position vector in MET</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>R_IN</td>
<td>TBD</td>
<td>Input inertial position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_IN</td>
<td>TBD</td>
<td>Input inertial velocity vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>T_IN</td>
<td>TBD</td>
<td>Time of input state in GMT</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T_OUT</td>
<td>TBD</td>
<td>Time of output state in GMT</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>ALARM</td>
<td>TBD</td>
<td>Alarm flag indicating error</td>
<td></td>
<td>I</td>
<td>--</td>
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<tr>
<td>R5 IPO</td>
<td>TBD</td>
<td>Initial position offset in GMT</td>
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<td>F(3)</td>
<td>ft</td>
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<tr>
<td>UN</td>
<td>TBD</td>
<td>Unit normal along the Shuttle angular momentum vector</td>
<td></td>
<td>F(3)</td>
<td>--</td>
</tr>
<tr>
<td>DEL_T_TRAN</td>
<td>TBD</td>
<td>Transfer time</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>VS_REQUIRED</td>
<td>TBD</td>
<td>Velocity required at the maneuver time</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>-----------------------------------</td>
<td>--------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>PI</td>
<td>TBD</td>
<td>Mathematical constant</td>
<td>ILOAD</td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>VS_COMM</td>
<td>TBD</td>
<td>Shuttle inertial position</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>RS_COMM</td>
<td>TBD</td>
<td>Shuttle inertial velocity</td>
<td>F(3)</td>
<td>ft/sec</td>
<td></td>
</tr>
<tr>
<td>FT_COMM</td>
<td>TBD</td>
<td>Target inertial position</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------</td>
<td>-----------------------------</td>
<td>-------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>EL_ANG_COM</td>
<td>TBD</td>
<td>Computed elevation angle</td>
<td>TELEV</td>
<td>F</td>
<td>rad</td>
</tr>
</tbody>
</table>
### TABLE 42. INPUT PARAMETERS FOR THE ELITER MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>PRECISION DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASE_MET</td>
<td>TBD</td>
<td>GMT/MET reference time</td>
<td>FCOS</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>DEL_T_MAX</td>
<td>TBD</td>
<td>Maximum step size used during an iteration</td>
<td>ILOAD</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>R_OUT</td>
<td>TBD</td>
<td>Output inertial position vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_OUT</td>
<td>TBD</td>
<td>Output inertial velocity vector</td>
<td>UPDATVP</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>TTPI</td>
<td>TBD</td>
<td>Predicted time of TPI (MET)</td>
<td>TELEV</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>RS_OUT</td>
<td>TBD</td>
<td>Shuttle position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VS_OUT</td>
<td>TBD</td>
<td>Shuttle velocity vector</td>
<td>TELEV</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>RT_OUT</td>
<td>TBD</td>
<td>Target position vector</td>
<td>TELEV</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VT_OUT</td>
<td>TBD</td>
<td>Target velocity vector</td>
<td>TELEV</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>X_IND</td>
<td>TBD</td>
<td>Independent variable</td>
<td>IERV</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>X_DEP_PRIME</td>
<td>TBD</td>
<td>Previous value of the dependent variable</td>
<td>IERV</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>X_IND_PRIME</td>
<td>TBD</td>
<td>Previous value of the independent variable</td>
<td>IERV</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>ERR</td>
<td>TBD</td>
<td>Guess of the elevation angle</td>
<td></td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>ERR_PRIME</td>
<td>TBD</td>
<td>Previous guess of the elevation angle</td>
<td>TELEV</td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>TTP1 PRIME</td>
<td>TBD</td>
<td>Previous guess of the TPI time</td>
<td>TELEV</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>N</td>
<td>TBD</td>
<td>Iteration counter</td>
<td></td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 43. OUTPUT PARAMETERS FOR THE ELTER MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_OPTION</td>
<td>TBD</td>
<td>Spacecraft flag for UPDATEVP</td>
<td>I</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>R_IN</td>
<td>TBD</td>
<td>Input inertial position vector for UPDATEVP</td>
<td>UPDATEVP</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>V_IN</td>
<td>TBD</td>
<td>Input inertial velocity for UPDATEVP</td>
<td></td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>TTPI</td>
<td>TBD</td>
<td>Predicted time of TPI (MET)</td>
<td>TELEV</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T_IN</td>
<td>TBD</td>
<td>Time of input state to UPDATEVP in GMT</td>
<td>UPDATEVP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>T_OUT</td>
<td>TBD</td>
<td>Time of output state to UPDATEVP in GMT</td>
<td>UPDATEVP</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>RS_OUT</td>
<td>TBD</td>
<td>Shuttle position vector</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>VS_OUT</td>
<td>TBD</td>
<td>Shuttle velocity vector</td>
<td>F(3)</td>
<td>ft/sec</td>
<td></td>
</tr>
<tr>
<td>RT_OUT</td>
<td>TBD</td>
<td>Target position vector</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>VT_OUT</td>
<td>TBD</td>
<td>Target velocity vector</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>TS_OUT</td>
<td>TBD</td>
<td>Time of the Shuttle position vector (GMT)</td>
<td>F</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td>TT_OUT</td>
<td>TBD</td>
<td>Time of the Target position vector (GMT)</td>
<td>F</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>TBD</td>
<td>Iteration counter to IERV</td>
<td>I</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>X_DEP</td>
<td>TBD</td>
<td>Dependent variable to IERV</td>
<td>F</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>X_IND</td>
<td>TBD</td>
<td>Independent variable to IERV</td>
<td>IERV</td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_DEP_PRIME</td>
<td>TBD</td>
<td>Previous value of the dependent variable to IERV</td>
<td>F</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>X_IND_PRIME</td>
<td>TBD</td>
<td>Previous value of the independent variable to IERV</td>
<td>F</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>------------------------------------------------</td>
<td>-------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>ERR_PRIME</td>
<td>TBD</td>
<td>Previous guess of the elevation angle</td>
<td></td>
<td>F</td>
<td>rad</td>
</tr>
<tr>
<td>TTPI_PRIME</td>
<td>TBD</td>
<td>Previous guess of TPI in MET</td>
<td>TELEV</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>N</td>
<td>TBD</td>
<td>Iteration counter for ELITER</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>EARTH_MU</td>
<td>TBD</td>
<td>Earth gravitational constant</td>
<td></td>
<td>F</td>
<td>ft³/sec²</td>
</tr>
<tr>
<td>N_MAX</td>
<td>TBD</td>
<td>Maximum allowed number of iterations</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>DU</td>
<td>TBD</td>
<td>Small deviation to prevent orbit from being almost parabolic</td>
<td>ELOAD</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>EP_TRANSFER</td>
<td>TBD</td>
<td>Parameter to test if transfer angle is close to 0°</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>EPS_U</td>
<td>TBD</td>
<td>Parameter to test convergence of the Newton-Raphson iteration</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>R_OFFSET</td>
<td>TBD</td>
<td>Offset position vector</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>RS_IPO</td>
<td>TBD</td>
<td>Initial position offset of Shuttle</td>
<td></td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>UN</td>
<td>TBD</td>
<td>Unit normal along the Shuttle angular momentum vector</td>
<td>PREVR</td>
<td>F(3)</td>
<td>--</td>
</tr>
<tr>
<td>DEL_T_TRAN</td>
<td>TBD</td>
<td>Transfer time</td>
<td></td>
<td>F</td>
<td>sec</td>
</tr>
</tbody>
</table>
### TABLE 45: OUTPUT PARAMETERS FOR THE LAMBERT MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM</td>
<td>TBD</td>
<td>Alarm flag to show error</td>
<td>--</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>$\bar{V}_S$ REQUIRED</td>
<td>TBD</td>
<td>Velocity required at the maneuver time</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>SOURCE</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------</td>
<td>-----------------------------------------</td>
<td>--------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>GMD_PRED_I</td>
<td>TBD</td>
<td>Gravity Model Degree Flag</td>
<td></td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>GMO_PRED_I</td>
<td>TBD</td>
<td>Gravity Model Order Flag</td>
<td></td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>ATM_I</td>
<td>TBD</td>
<td>Attitude Mode Flag</td>
<td>ILOAD</td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>DMP_I</td>
<td>TBD</td>
<td>Drag Model Flag</td>
<td>ILOAD</td>
<td>D (2)</td>
<td>--</td>
</tr>
<tr>
<td>VMP_I</td>
<td>TBD</td>
<td>Vent Model Flag</td>
<td>ILOAD</td>
<td>D (2)</td>
<td>--</td>
</tr>
<tr>
<td>PRED_ORB_MASS_I</td>
<td>TBD</td>
<td>Onorbit Predictor Drag</td>
<td></td>
<td>F</td>
<td>(2)</td>
</tr>
<tr>
<td>PRED_ORB_CD_I</td>
<td>TBD</td>
<td>Onorbit Predictor Drag</td>
<td></td>
<td>F</td>
<td>(2)</td>
</tr>
<tr>
<td>PRED_ORB_AREA_I</td>
<td>TBD</td>
<td>Spacecraft Flag for UPDATVP</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>S_OPTION</td>
<td>TBD</td>
<td>Spacecraft Flag for UPDATVP</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>( \mathbf{\mathbf{\bar{r}}}_\text{IN} )</td>
<td>TBD</td>
<td>Input Inertial Position for Vector for UPDATVP</td>
<td>PROX_TOT_SUP_LAMB</td>
<td>F (3)</td>
<td>ft</td>
</tr>
<tr>
<td>( \mathbf{\mathbf{\bar{v}}}_\text{IN} )</td>
<td>TBD</td>
<td>Input Inertial Velocity</td>
<td>TELEV</td>
<td>F</td>
<td>(3)</td>
</tr>
<tr>
<td>( T_\text{IN} )</td>
<td>TBD</td>
<td>Time of the Input State to UPDATVP in GMT</td>
<td>PREVR</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>( T_\text{OUT} )</td>
<td>TBD</td>
<td>Time of the Output State to UPDATVP in GMT</td>
<td>ELITER</td>
<td>F</td>
<td>sec</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>-------------------------------------------------</td>
<td>----------------------------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>$\vec{a}_{\text{OUT}}$</td>
<td>TBD</td>
<td>Output inertial position vector</td>
<td>PROX, TGT, SUP, LAMB</td>
<td>F(3)</td>
<td>ft</td>
</tr>
<tr>
<td>$\vec{v}_{\text{OUT}}$</td>
<td>TBD</td>
<td>Output inertial velocity vector</td>
<td>TELEV, PREVR, ELITER</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
</tbody>
</table>
TABLE 48.- INPUT PARAMETERS FOR THE IERTV MODULE

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>SOURCE</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEL_X_GUESS</td>
<td>TBD</td>
<td>ΔX guess for iterator if no prediction is possible</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>IC_MAX</td>
<td>TBD</td>
<td>Maximum allowed number of iterations</td>
<td>ILOAD</td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>DEL_X_TOL</td>
<td>TBD</td>
<td>Tolerance of dependent variable to ensure that a slope exists</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>IC</td>
<td>TBD</td>
<td>Iteration counter in IERTV</td>
<td></td>
<td>I</td>
<td>--</td>
</tr>
<tr>
<td>X_DEP</td>
<td>TBD</td>
<td>Dependent variable to IERTV</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_IND</td>
<td>TBD</td>
<td>Independent variable to IERTV</td>
<td>IERTV</td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_DEP_PRIME</td>
<td>TBD</td>
<td>Previous value of the dependent variable to IERTV</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_IND_PRIME</td>
<td>TBD</td>
<td>Previous value of the independent variable to IERTV</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
</tbody>
</table>
# Table 49: Output Parameters for the ITERS Module

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>X_IND</td>
<td>TBD</td>
<td>Independent variable to ITERS</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_DEP_PRIME</td>
<td>TBD</td>
<td>Previous value of the dependent variable</td>
<td>ELITER</td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>X_IND_PRIME</td>
<td>TBD</td>
<td>Previous value of the independent variable</td>
<td></td>
<td>F</td>
<td>--</td>
</tr>
<tr>
<td>SFAIL</td>
<td>TBD</td>
<td>Flag set if maximum number of iterations occurred</td>
<td></td>
<td>D</td>
<td>--</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>PRECISION</td>
<td>DEFINITION</td>
<td>DESTINATION</td>
<td>TYPE</td>
<td>UNITS</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>------------</td>
<td>-------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>ŃS</td>
<td>TBD</td>
<td>Input inertial position of Shuttle</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>̈VS</td>
<td>TBD</td>
<td>Input inertial velocity of Shuttle</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
<tr>
<td>̈̈T</td>
<td>TBD</td>
<td>Input inertial position of target</td>
<td>F(3)</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>̈VT</td>
<td>TBD</td>
<td>Input inertial velocity of target</td>
<td>F(3)</td>
<td>ft/sec</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 51: OUTPUT PARAMETERS FOR THE ORBLV TASK

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PRECISION</th>
<th>DEFINITION</th>
<th>DESTINATION</th>
<th>TYPE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{u}_{SLV}$</td>
<td>TBD</td>
<td>Shuttle-centered LVLH relative velocity of target</td>
<td>PROX_TGT_SUP_LAMB</td>
<td>F(3)</td>
<td>ft/sec</td>
</tr>
</tbody>
</table>

---

*Original page 136*
<table>
<thead>
<tr>
<th>INPUTS</th>
<th>CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGT NO</td>
<td>T2 T0 T1 25</td>
</tr>
<tr>
<td>TIG X/XX:XX:XX</td>
<td>XXXX 26</td>
</tr>
<tr>
<td>EL ±XX:XX:XX</td>
<td>COMPUTE T1 27X</td>
</tr>
<tr>
<td>ΔX/DNRNG ±XX:XX:XX</td>
<td>COMPUTE T2 28X</td>
</tr>
<tr>
<td>ΔY ±XX:XX:XX</td>
<td></td>
</tr>
<tr>
<td>ΔZ/ΔH ±XX:XX:XX</td>
<td></td>
</tr>
<tr>
<td>ΔX/ΔH ±XX:XX:XX</td>
<td></td>
</tr>
<tr>
<td>ΔY/ΔH ±XX:XX:XX</td>
<td></td>
</tr>
<tr>
<td>ΔZ/ΔH ±XX:XX:XX</td>
<td></td>
</tr>
<tr>
<td>T2 TIG X/XX:XX:XX</td>
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Figure 1.- Orbit targeting generic display.
Figure 2.— Orbit targeting specialist function task organization.
Figure 3.— Orbit targeting specialist function data flow.
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Figure 4.— Common package allocations for function modules.
**Figure 5.** Orbit targeting executive task functional flow.
PROX item 21 to 24 status = ON?

PROX status
Set maneuver status flags

Select target no.?

PROX item 1 status = ON?

PROX item 25 status = ON?

PROX first pass status = OFF

Change base time?

PROX item 21 to 24 status = ON?

PROX load flash = ON

Check to see if maneuvers are in the past

Select target no.?

PROX item 1 status = ON?

PROX item 1 status = OFF

T1 T2

PROX item 25 status = ON?

T1_TIG = T2_TIG?

Change computational buffer.

Figure 5.— Continued.
Figure 5—Continued

TIME_CONVERT_FLAG = 0
TIME_SEC = T1_TIG

TIME_CONVERT
   Convert to days, hr, min, sec.

DISP_T1_DAY = DAY.
DISP_T1_HOUR = HR.
DISP_T1_MIN = MIN.
DISP_T1_SEC = SEC.

PROX_ITEM_25_STATUS = OFF.

Change displayed T1 state?

PROX_ITEM_27020_STATUS = ON?

PROX_LOAD_FLASH = ON.

Change displayed time.
Figure 5 - Continued
Compute T2 only?

PROX_ITEM_28_STATUS = ON?

- PROX_T2_STAR_STATUS = ON
  - USE_DISP_REL_STATE = OFF
  - PROX_ITEM_28_STATUS = OFF

PROX_T2_STAR_STATUS = ON?

- or

PROX_T2_STAR_STATUS = ON?

Get M50 inertial states and time tag.

\[ \mathbf{R}_{\text{M50 PROX}} = \mathbf{R}_{\text{AVGG}} \]
\[ \mathbf{V}_{\text{M50 PROX}} = \mathbf{V}_{\text{AVGG}} \]
\[ \mathbf{RT}_{\text{M50 PROX}} = \mathbf{R}_{\text{TARGET}} \]
\[ \mathbf{VT}_{\text{M50 PROX}} = \mathbf{V}_{\text{TARGET}} \]

- IF USE_DISP_REL_STATE = OFF, or PROX_TGT_SET_NO ≤ NLAMB

- \[ \mathbf{RT}_{\text{MAG}} = \text{MAG} (\mathbf{RT}_{\text{M50 PROX}}) \]
  \[ \mathbf{VTAN} = \mathbf{VT}_{\text{M50 PROX UNIT}} (\mathbf{RT}_{\text{M50 PROX}}) \]
  \[ (\mathbf{RT}_{\text{M50 PROX}} \cdot \mathbf{VT}_{\text{M50 PROX}}) \]
  \[ \mathbf{OMEGA}_{\text{PROX}} = \text{MAG} (\mathbf{VTAN} / \mathbf{RT}_{\text{MAG}}) \]

- \[ \text{TIME}_{\text{PROX}} = T_{\text{STATE}} - \text{BASE\_MET} \]

Compute orbital angular rate.

\[ \text{OMEGA}_{\text{PROX}} = \text{MAG} (\mathbf{VTAN} / \mathbf{RT}_{\text{MAG}}) \]

\[ \text{PROX\_TGT\_SUP\_LAMB} \]

\[ \text{PROX\_TGT\_SET\_NO} ≤ \text{NLAMB} \]

\[ \text{PROX\_TGT\_SUP} \]
**Figure 7 -- Concluded.**
Figure 6.-- Proximity operations targeting supervisory logic task functional flow.
X = COMP_X
XD = COMP_XD
DTIME = T2_TIG - TIME_PROX

REL_PRED
Predict state at T2_TIG

COMP_X = X2
COMP_XD = XD2
TIME_PROX = TIME_PROX + DTIME

DV_LVLH = -COMP_XD
T_MAN = T2_TIG

Compute T2 maneuver.

Figure 6... Continued.
Figure 6. Continued

- If $\text{USE}_\text{OMEGA}_\text{DT} = \text{OFF}$
  - $\text{COMP}_\text{PROX}_\text{DT} = \frac{(T2_\text{TIG} - T1_\text{TIG})}{60}$
  - $\text{USE}_\text{DISP}_\text{REL}_\text{STATE} = \text{OFF}$

- $X = \text{COMP}_X$
- $XD = \text{COMP}_XD$
- $\text{DTIME} = T1_\text{TIG} - \text{TIME}_\text{PROX}$

**Predict state at $T1_\text{TIG}$**

- $\text{COMP}_X = X2$
- $\text{COMP}_XD = XD2$

**Update state from present to $T1_\text{TIG}$**

- $\text{DISP}_T1_X = \text{COMP}_X$
- $\text{DISP}_T1_XD = \text{COMP}_XD$

**Display expected state for $T1_\text{TIG}$**
Figure 6 — Concluded

\[ T_2 \text{_TIG} = T_1 \text{_TIG} + 60 \text{ COMP_PROX_DT} \]

\[ \text{DT_Offset} = \text{COMP_PROX_DT} \]
\[ x \_\text{Offset} = \text{COMP}_x \]
\[ x_2 \_\text{Offset} = \text{COMP}_x \]
\[ x_2 \_\text{Offset} = \text{COMP}_x \]
\[ x_2 \_\text{Offset} = \text{COMP}_x \]

Compute T1 maneuver.

\[ DV \_\text{LEVEL} = DV \]
\[ T \_\text{MAN} = T_1 \_\text{TIG} \]

Figure 6 — Concluded
Figure 7.- Proximity operations targeting supervisory Lambert logic task functional flow.
Figure 7.- Continued.

The T1_TIG time and the Shuttle and target states at T1_TIG have now been determined.
If USE_ÔMEGA_DT = OFF

USE_DISP_REL_STATE = OFF

ON
- T inertial state
- Displayed T1
- Relative state
- T1 state
- REL_COMP

REL_COMP
- Compute S inertial state at T1_TIG
- T1_TIG

OFF
- Present S inertial state
- Update S state to T1_TIG
- STATE
- UPDATE
- T1_TIG time
- S inertial state of T1_TIG
- T1_TIG

- S & T inertial state at T1_TIG
- Convert to curvilinear state at T1
- REL COMP
- Relative

COMP_X = relative position
COMP_XD = relative velocity

Display predicted relative states at T1_TIG

Figure 7.- Continued.
Figure 7.— Continued.
Figure 7.- Concluded.

\[ DLW_H = L_{LW_H} - L_{WHH} \]
\[ T_{MIN} = T_{LIG} \]
\[ ODD_{FLAG} = 1 \]

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<th>Shuttle and target inertial states after the TI maneuver</th>
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<td>Compute Shuttle-LVLH states before centered LVLH problem</td>
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\[ DV_{LVLH} = V_{LVLH} - V_{LVLIH} \]
\[ F_{MAN} = T_{LIG} \]
\[ GUTA_{FLAG} = 1 \]

Determine TI maneuver
in LVLH coordinates.