Chapter 1

Test Procedures

1.1 Spacecraft Orbit Tab

Name	STC-3 Orbit GUI Behavior for Disallowed Conversion
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to a Keplerian state when the coordinate system does not have a celestial body (i.e. mu value) at the origin.
PreConditions	BS-2
Steps	1. Load BS-2. 2. Open the dialog box for DefaultSC. 3. Change the StateType to Keplerian. 4. Click on the down arrow on the Coordinate System drop-down menu and inspect the available Coordinate Systems. 5. Change the StateType to Modified Keplerian. 6. Click on the down arrow on the Coordinate System drop-down menu and inspect the available Coordinate Systems. 7. Change the StateType to Equinoctial. 8. Click on the down arrow on the Coordinate System drop-down menu and inspect the available Coordinate Systems.
Expected Results	The only coordinate systems available in the inspection steps above should be EarthMJ2000Eq, EarthMJ2000Ec, and Earth Fixed. Coordinate Systems CS_ESL2 and CS_SSBary are NOT available because these orbit state representations are only valid for coordinate systems with a central body at the origin.

Table 1.1: STC-3 Orbit GUI Behavior for Disallowed Conversion

Name	STC-4 Orbit GUI Behavior for Disallowed Conversions
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to a new coordinate system that does not have a celestial body at the center.
PreConditions	BS-2
Data	1. Load BS-2. 2. Open the dialog box for DefaultSC. 3. Change the Coordinate System to CS_ESL2. 4. Click on the down arrow on the State Type drop-down menu and inspect the available State Types. 5. Change the Coordinate System to CS_SSBary. 6. Click on the down arrow on the State Type drop-down menu and inspect the available State Types.
Expected Results	The only State Types available are Cartesian, SphericalRADEC, and SphericalAZFPA. State Types Keplerian, Modified Keplerian, and Equinoctial are NOT available because these orbit state representations are only valid for coordinate systems with a central body at the origin.

Table 1.2: STC-4 Orbit GUI Behavior for Disallowed Conversions

Name	STC-5 GUI Epoch and State Independence for Time Dependent Coordinate System
Requirements	FR-1.3
Summary	This test is to verify that changing the epoch of the spacecraft, does not effect the orbit state, even when the coordinate system is, for example, a libration point coordinate system that has a time varying origin and axis system.
PreConditions	BS-2
Steps	1. Load BS-2 2. Open the dialog box for DefaultSC 3. Change the CoordinateSystem to CS_ESL2 4. Change the Epoch Format to UTCGregorian 5. Change the Epoch value to 01 Jan 2010 12:00:00.000 6. Hit Ok to close the dialog box 7. Reopen the dialog box for DefaultSC.
Expected Results	The data in the GUI should agree with the data below to at least 12 significant figures. • DefaultSC.X = 273083.6097699367 ; • DefaultSC.Y = -1332500.504835084; • DefaultSC.Z = -576402.9744365886 ; • DefaultSC.VX = 0.2990482122160891; • DefaultSC.VY = 7.400368588891073; • DefaultSC.VZ = 1.021835464804587 ;

Table 1.3: STC-5 GUI Epoch and State Independence for Time Dependent Coordinate System

Name	STC-6 Orbit GUI Behavior for Singular Conic Section
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations with a cartesian state that results in a singular conic section.
PreConditions	BS-2 and TD-4
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the Cartesian state data from TD-5. 4. Hit Apply. 5. Change the State Type to Keplerian and verify the following error message is thrown: "GMAT does not support parabolic orbits in conversion from Cartesian to Keplerian state". 6. Change the State Type to Modified Keplerian and verify the following error message is thrown: "GMAT does not support parabolic orbits in conversion from Cartesian to Keplerian state". 7. Change the state to SphericalRADEC and verify the numeric data with TD-5. 8. Change the state to SphericalAZEL and verify the numeric data with TD-5. 9. Change the State Type to Equinoctial and verify the following error message is thrown: "GMAT does not support parabolic orbits in conversion from Cartesian to Equinoctial state".
Expected Results	The only State Types available are Cartesian, SphericalRADEC, and SphericalAZFPA. State Types Keplerian, Modified Keplerian, and Equinoctial are NOT available because they are undefined.

Table 1.4: STC-6 Orbit GUI Behavior for Disallowed Conversions

Name	STC-7 Orbit GUI Behavior for Circular, Equatorial Orbit
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1 and TD-5
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the Cartesian state data from TD-5. 4. Hit Apply. 5. Change the state to Keplerian and verify the numeric data with TD-5. 6. Change the state to Modified Keplerian and verify the numeric data with TD-5. 7. Change the state to SphericalRADEC and verify the numeric data with TD-5. 8. Change the state to SphericalAZEL and verify the numeric data with TD-5. 9. Change the state to Equinoctial and verify the numeric data with TD-5.
Expected Results	The truth data is contained in TD-5.

Table 1.5: STC-7 Orbit GUI Behavior for Circular, Equatorial Orbit

Name	STC-8 Orbit GUI Behavior for Circular, Inclined Orbit
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1 and TD-6
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the Cartesian state data from TD-6. 4. Hit Apply. 5. Change the state to Keplerian and verify the numeric data with TD-6. 6. Change the state to Modified Keplerian and verify the numeric data with TD-6. 7. Change the state to SphericalRADEC and verify the numeric data with TD-6. 8. Change the state to SphericalAZEL and verify the numeric data with TD-6. 9. Change the state to Equinoctial and verify the numeric data with TD-6.
Expected Results	The truth data is contained in TD-6.

Table 1.6: STC-8 Orbit GUI Behavior for Circular, Inclined Orbit

Name	STC-9 Orbit GUI Behavior for orbit with zero velocity
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the following Cartesian State data: (a) X = 7000 (b) Y = 7000 (c) Z = 7000 (d) VX = 0; (e) VY = 0; (f) VZ = 0; 4. Hit Apply. 5. Change the state to Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Keplerian elements are undefined. 6. Change the state to Modified Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Modified Keplerian elements are undefined. 7. Change the state to SphericalRADEC and verify that the following error message is returned: The orbit is a singular conic section and the SphericalRADEC elements are undefined. 8. Change the state to SphericalAZEL and verify that the following error message is returned: The orbit is a singular conic section and the SphericalAZEL elements are undefined. 9. Change the state to Equinoctial and verify that the following error message is returned: The orbit is a singular conic section and the Equinoctial elements are undefined.
Expected Results	The truth data is described above.

Table 1.7: STC-9 Orbit GUI Behavior for orbit with zero velocity

Name	STC-10 Orbit GUI Behavior for orbit with zero position
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the following Cartesian State data: (a) X = 0.0 (b) Y = 0.0 (c) Z = 0.0 (d) VX = 7.0; (e) VY = 7.0; (f) VZ = 7.0; 4. Hit Apply. 5. Change the state to Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Keplerian elements are undefined. 6. Change the state to Modified Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Modified Keplerian elements are undefined. 7. Change the state to SphericalRADEC and verify that the following error message is returned: The orbit is a singular conic section and the SphericalRADEC elements are undefined. 8. Change the state to SphericalAZEL and verify that the following error message is returned: The orbit is a singular conic section and the SphericalAZEL elements are undefined. 9. Change the state to Equinoctial and verify that the following error message is returned: The orbit is a singular conic section and the Equinoctial elements are undefined.
Expected Results	The truth data is described above.

Table 1.8: STC-10 Orbit GUI Behavior for orbit with zero position

Name	STC-11 Orbit GUI Behavior for orbit with zero state
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Enter the following Cartesian State data: (a) X = 0.0 (b) Y = 0.0 (c) Z = 0.0 (d) VX = 0.0; (e) VY = 0.0; (f) VZ = 0.0; 4. Hit Apply. 5. Change the state to Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Keplerian elements are undefined. 6. Change the state to Modified Keplerian and verify that the following error message is returned: The orbit is a singular conic section and the Modified Keplerian elements are undefined. 7. Change the state to SphericalRADEC and verify that the following error message is returned: The orbit is a singular conic section and the SphericalRADEC elements are undefined. 8. Change the state to SphericalAZEL and verify that the following error message is returned: The orbit is a singular conic section and the SphericalAZEL elements are undefined. 9. Change the state to Equinoctial and verify that the following error message is returned: The orbit is a singular conic section and the Equinoctial elements are undefined.
Expected Results	The truth data is described above.

Table 1.9: STC-11 Orbit GUI Behavior for orbit with zero state

Name	STC-12 Orbit GUI behavior when performing Modulo on Keplerian Angular Elements
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Change the State Type to Keplerian 4. Change INC to 370.0 degrees. 5. Change RAAN to 380.0 degrees. 6. Change AOP to 390.0 degrees. 7. Change TA t0 400.0 degrees. 8. Change the State Type to Cartesian. 9. Change the State Type to Keplerian.
Expected Results	INC = 10.0 degrees, RAAN = 20 degrees, AOP = 30.0 degrees, and TA = 40.0 degrees. (All values match to 14 sig. figs.)

Table 1.10: STC-12 Orbit GUI behavior when performing Modulo on Keplerian Angular Elements

Name	STC-13 Orbit GUI behavior when performing Modulo on Modified Keplerian Angular Elements
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Change the State Type to Modified Keplerian 4. Change INC to 370.0 degrees. 5. Change RAAN to 380.0 degrees. 6. Change AOP to 390.0 degrees. 7. Change TA t0 400.0 degrees. 8. Change the State Type to Cartesian. 9. Change the State Type to Keplerian.
Expected Results	INC = 10.0 degrees, RAAN = 20 degrees, AOP = 30.0 degrees, and TA = 40.0 degrees. (All values match to 14 sig. figs.)

Table 1.11: STC-13 Orbit GUI behavior when performing Modulo on Modified Keplerian Angular Elements

Name	STC-14 Orbit GUI behavior when performing Modulo on SphericalRADEC Angular Elements
Requirements	FR-1.3
Summary	This case tests GUI behavior when attempting to convert to element representations when the cartesian state results in a circular, equatorial orbit.
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Change the State Type to Spherical 4. Change RA to 370.0 degrees. 5. Change DEC to 380.0 degrees. 6. Change RAV to 390.0 degrees. 7. Change DECV t0 400.0 degrees. 8. Change the State Type to Cartesian. 9. Change the State Type to Keplerian.
Expected Results	RA = 10.0 degrees, DEC = 20 degrees, RAV = 30.0 degrees, and DECV = 40.0 degrees. (All values match to 14 sig. figs.)

Table 1.12: STC-14 Orbit GUI behavior when performing Modulo on SphericalRADEC Angular Elements

Name	STC-18 Orbit GUI behavior when Orbit is near parabolic
Requirements	FR-1.1
Summary	SMA is undefined for parabolic orbits. This test check behavior as orbit approaches parabolic from ECC ¡ 1 side for Keplerian state type.
PreConditions	BS-1
Steps	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Change the State Type to Keplerian 4. Change ECC to 0.99999999 5. Hit Apply.
Expected Results	The following error message should be displayed: The value of ”0.99999999” for field ”ECC” is not an allowed value. The allowed values are: [0.0 *leq* Real Number $\leq$ 0.9999999, or Real Number $\geq$ 1.0000001].)

Table 1.13: STC-18 Orbit GUI behavior when performing Modulo on Equinoctial Angular Elements

Name	STC-19 Orbit GUI behavior when Cartesian state results in nearly singular conic section
Requirements	FR-1.1
Summary	This test checks that conversion to other state representations is disallowed when the cartesian state is nearly singular.
PreConditions	BS-1
Steps	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Set the Cartesian state to the following values (a) X = 6999.998216286026 (b) Y = 0 (c) Z = -5.002359263770285 (d) VX = 10.63431352889248 (e) VY = 0 (f) VZ = -0.003772975815698364 4. Hit Apply. 5. Change state type to Keplerian and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.” 6. Change state type to Modified Keplerian and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.” 7. Change state type to Equinoctial and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.”
Expected Results	Test results are described above.

Table 1.14: STC-19 Orbit GUI behavior when performing Modulo on Equinoctial Angular Elements

Name	STC-19 Orbit GUI behavior when Cartesian state results in nearly singular conic section
Requirements	FR-1.1
Summary	This test checks that conversion to other state representations is disallowed when the cartesian state is nearly singular.
PreConditions	BS-1
Steps	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Set the Cartesian state to the following values (a) RMAG = 7000.00000 (b) RA = 0 (c) DEC = -0.04094487109516581 (d) VMAG = 10.63431419820442 (e) AZI = 0 (f) FPA = 0.02061675296478873 4. Hit Apply. 5. Change state type to Keplerian and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.” 6. Change state type to Modified Keplerian and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.” 7. Change state type to Equinoctial and ensure that the following error is thrown: “Error: The state results in a singular conic section with radius of periapsis less than 1 m.”
Expected Results	Test results are described above.

Table 1.15: STC-20 STC-20 Orbit GUI behavior when SphericalAZFPA state results in nearly singular conic section

<table>
<tr><th>Name</th><th>STC-23 Epoch conversion in the spacecraft orbit dialog box</th></tr>
<tr><td>Requirements</td><td>FRR-2.3</td></tr>
<tr><td>Summary</td><td>This test case represents $n(n-1)$ tests where n is the number of epoch formats supported as input types in GMAT. Each test case is designated a unique number. For example, STC-23.32 test GUI conversion from A1Gregorian to TAIModJulian. The procedures described below must be performed for each test case in the table below.</td></tr>
<tr><td>PreConditions</td><td>To run this test you need to load BS-1 and have data defined in TD-2 available.</td></tr>
<tr><td>Steps</td><td>

Select subtest number. (STC-23.32, for example)
Create a new spacecraft.
Change the Epoch Format to the format defined in the first column of the row containing the test case ID. (A1Gregorian, for STC-23.32)
Enter the epoch in the Define Format from TD-2.
Change the Epoch Format to the format defined in the first row of the column containing the test case Id. (TAIModJulian for STC-23.32)
Verify that the new epoch exactly matches the value for that format given in TD-2.

<table>
<tr><th></th><th>UTCGregorian</th><th>UTCModJulian</th><th>TAIGregorian</th><th>TAIModJulian</th><th>A1Gregorian</th><th>A1ModJulian</th><th>TTGregorian</th><th>TTModJulian</th></tr>
<tr><td>UTCGregorian</td><td>N/A</td><td>23.1</td><td>23.2</td><td>23.3</td><td>23.4</td><td>23.5</td><td>23.6</td><td>23.7</td></tr>
<tr><td>UTCModJulian</td><td>23.8</td><td>N/A</td><td>23.9</td><td>23.10</td><td>23.11</td><td>23.12</td><td>23.13</td><td>23.14</td></tr>
<tr><td>TAIGregorian</td><td>23.15</td><td>23.16</td><td>N/A</td><td>23.17</td><td>23.18</td><td>23.19</td><td>23.20</td><td>23.21</td></tr>
<tr><td>TAIModJulian</td><td>23.22</td><td>23.23</td><td>23.24</td><td>N/A</td><td>23.25</td><td>23.26</td><td>23.27</td><td>23.28</td></tr>
<tr><td>A1Gregorian</td><td>23.29</td><td>23.30</td><td>23.31</td><td>23.32</td><td>N/A</td><td>23.33</td><td>23.34</td><td>23.35</td></tr>
<tr><td>A1ModJulian</td><td>23.36</td><td>23.37</td><td>23.38</td><td>23.39</td><td>23.40</td><td>N/A</td><td>23.41</td><td>23.42</td></tr>
<tr><td>TTGregorian</td><td>23.43</td><td>23.44</td><td>23.44</td><td>23.45</td><td>23.46</td><td>23.47</td><td>N/A</td><td>23.48</td></tr>
<tr><td>TTModJulian</td><td>23.49</td><td>23.50</td><td>23.51</td><td>23.52</td><td>23.53</td><td>23.54</td><td>23.55</td><td>N/A</td></tr>
</table>
</td></tr>
<tr><td>Expected Results</td><td>The expected numeric results are described above and in TD-2.</td></tr>
</table>

Table 1.16: STC-23 Epoch conversion in the spacecraft orbit dialog box

<table>
<tr><th>Name</th><th>STC-24 State conversion in the spacecraft orbit dialog box</th></tr>
<tr><td>Requirements</td><td>FRR-2.3</td></tr>
<tr><td>Summary</td><td>This test case represents $n(n-1)$ tests where n is the number of state representations supported as input types in GMAT. Each test case is designated a unique number. For example, STC-24.17 tests GUI conversion from SphericalRADEC to Keplerian elements. The procedures described below must be performed for each test case in the table below.</td></tr>
<tr><td>PreConditions</td><td>To run this test you need to load BS-1 and have data defined in TD-1 available.</td></tr>
<tr><td>Steps</td><td>

Select subtest number. (STC-24.17, for example)
Create a new spacecraft.
Change the Epoch Format to the format defined in the first column of the row containing the test case ID. (SphericalRADEC, for STC-24.17)
Enter the epoch in the Define Format from TD-1.
Change the Epoch Format to the format defined in the first row of the column containing the test case Id. (Keplerian for STC-24.17)
Verify that the new state matches the value for that format given in TD-1 to 14 significant figures.

<table>
<tr><th></th><th>Cartesian</th><th>Keplerian</th><th>Mod. Keplerian</th><th>SphericalRADEC</th><th>SphericalAZFPA</th><th>Equinoctial</th></tr>
<tr><td>Cartesian</td><td>N/A</td><td>24.1</td><td>24.2</td><td>24.3</td><td>24.4</td><td>24.5</td></tr>
<tr><td>Keplerian</td><td>24.6</td><td>N/A</td><td>24.7</td><td>24.8</td><td>24.9</td><td>24.10</td></tr>
<tr><td>TAIGregorian</td><td>25.11</td><td>24.12</td><td>N/A</td><td>24.13</td><td>24.14</td><td>24.15</td></tr>
<tr><td>SphericalRADEC</td><td>24.16</td><td>24.17</td><td>24.18</td><td>N/A</td><td>24.19</td><td>24.20</td></tr>
<tr><td>SphericalAZFPA</td><td>24.21</td><td>24.22</td><td>24.23</td><td>24.24</td><td>N/A</td><td>24.25</td></tr>
<tr><td>Equinoctial</td><td>24.26</td><td>24.27</td><td>24.28</td><td>24.29</td><td>24.30</td><td>N/A</td></tr>
</table>
</td></tr>
<tr><td>Expected Results</td><td>The expected numeric results are described above and in TD-1.</td></tr>
</table>

Table 1.17: STC-24 State Representation conversion in the spacecraft orbit dialog box

<table>
<tr><th>Name</th><th>STC-25 Epoch conversion in the spacecraft orbit dialog box</th></tr>
<tr><td>Requirements</td><td>FRR-2.3</td></tr>
<tr><td>Summary</td><td>This test case represents $n(n-1)$ tests where n is the number of epoch formats supported as input types in GMAT. Each test case is designated a unique number. For example, STC-25.32 test GUI conversion from A1Gregorian to TAIModJulian. The procedures described below must be performed for each test case in the table below.</td></tr>
<tr><td>PreConditions</td><td>To run this test you need to load BS-1 and have data defined in TD-2 available.</td></tr>
<tr><td>Steps</td><td>
1. Select subtest number. (STC-25.32, for example)
2. Create a new spacecraft.
3. Change the Epoch Format to the format defined in the first column of the row containing the test case ID. (A1Gregorian, for STC-25.32)
4. Enter the epoch in the Define Format from TD-2.
5. Change the Epoch Format to the format defined in the first row of the column containing the test case Id. (TAIModJulian for STC-25.32)
6. Verify that the new epoch exactly matches the value for that format given in TD-2.
<table>
<tr><th></th><th>EarthMJ2000Eq</th><th>EarthMJ2000Ec</th><th>EarthFixed</th><th>LunaFixed</th><th>EarthMoonRot</th><th>SunMJ2000Ec</th><th>CS_ESL2</th><th>CSSSBary</th><th>PhobosFixed</th></tr>
<tr><td>EarthMJ2000Eq</td><td>N/A</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td></td></tr>
<tr><td>EarthMJ2000Ec</td><td>8</td><td>N/A</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td></td></tr>
<tr><td>EarthFixed</td><td>15</td><td>16</td><td>N/A</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td></td></tr>
<tr><td>LunaFixed</td><td>22</td><td>23</td><td>24</td><td>N/A</td><td>25</td><td>26</td><td>27</td><td>28</td><td></td></tr>
<tr><td>EarthMoonRot</td><td>29</td><td>30</td><td>31</td><td>32</td><td>N/A</td><td>33</td><td>34</td><td>35</td><td></td></tr>
<tr><td>SunMJ2000Ec</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>N/A</td><td>41</td><td>42</td><td></td></tr>
<tr><td>CS_ESL2</td><td>43</td><td>44</td><td>44</td><td>45</td><td>46</td><td>47</td><td>N/A</td><td>48</td><td></td></tr>
<tr><td>CS_SSBary</td><td>49</td><td>50</td><td>51</td><td>52</td><td>53</td><td>54</td><td>55</td><td>N/A</td><td></td></tr>
<tr><td>PhobosFixed</td><td>49</td><td>50</td><td>51</td><td>52</td><td>53</td><td>54</td><td>55</td><td>N/A</td><td></td></tr>
</table>
</td></tr>
<tr><td>Expected Results</td><td>The expected numeric results are described above and in TD-2.</td></tr>
</table>

Table 1.18: STC-25 Coordiate system conversion in the spacecraft orbit dialog box

1.2 Spacecraft Attitude Tab

<table>
<tr><th>Name</th><th>STC-26 Attitude conversion in the spacecraft attitude dialog box</th></tr>
<tr><td>Requirements</td><td>FRR-3.3</td></tr>
<tr><td>Summary</td><td>This test case represents $n(n-1)$ tests where n is the number of attitude representations supported as input types in GMAT. Each test case is designated a unique number. For example, STC-26.32 tests conversion from a 231 to a 232 Euler angle sequence. The procedures described below must be performed for each test case in the table below.</td></tr>
<tr><td>PreConditions</td><td>To run this test you need to load BS-1 and have data defined in TD-8 available.</td></tr>
<tr><td>Steps</td><td>

Select subtest number. (STC-26.32, for example)
Create a new spacecraft.
Open the dialog box for the new spacecraft.
Click on the Attitude tab.
Change the AttitudeStateType to the format defined in the first column of the row containing the test case ID. (Euler Angles, for STC-26.32)
If the AttitudeStateType is EulerAngles, change the EulerAngleSequence to the sequence defined in the first column of the row containing the test case ID. (231, for STC-26.32)
Enter the attitude state for the test ID using the data from TD-8.
Hit Apply.
Change the AttitudeStateType to the format defined in the first row of the column containing the test case Id. (Euler Angles, for STC-26.32)
If the AttitudeStateType is EulerAngles, Change the EulerAngleSequence to the format defined in the first row of the column containing the test case Id. (232, for STC-26.32)
Verify that the new epoch exactly matches the value for that format given in TD-8.
Compare the new Euler Angles to those in TD-8 for the new attitude representation. The values should agree to at least 13 significant figures.

<table>
<tr><th></th><th>q</th><th>123</th><th>231</th><th>312</th><th>132</th><th>321</th><th>213</th><th>121</th><th>232</th><th>313</th><th>131</th><th>323</th><th>212</th></tr>
<tr><td>q</td><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>123</td><td>13</td><td>X</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr>
<tr><td>231</td><td>25</td><td>26</td><td>X</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td></tr>
<tr><td>312</td><td>37</td><td>38</td><td>39</td><td>X</td><td>40</td><td>41</td><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td></tr>
<tr><td>132</td><td>49</td><td>50</td><td>51</td><td>52</td><td>X</td><td>53</td><td>54</td><td>55</td><td>56</td><td>57</td><td>58</td><td>59</td><td>60</td></tr>
<tr><td>321</td><td>61</td><td>62</td><td>63</td><td>64</td><td>65</td><td>X</td><td>66</td><td>67</td><td>68</td><td>69</td><td>70</td><td>71</td><td>72</td></tr>
<tr><td>213</td><td>73</td><td>74</td><td>75</td><td>76</td><td>77</td><td>78</td><td>X</td><td>79</td><td>80</td><td>81</td><td>82</td><td>83</td><td>84</td></tr>
<tr><td>121</td><td>85</td><td>86</td><td>87</td><td>88</td><td>89</td><td>90</td><td>91</td><td>X</td><td>92</td><td>93</td><td>94</td><td>95</td><td>96</td></tr>
<tr><td>232</td><td>97</td><td>98</td><td>99</td><td>100</td><td>101</td><td>102</td><td>103</td><td>104</td><td>X</td><td>105</td><td>106</td><td>107</td><td>108</td></tr>
<tr><td>313</td><td>109</td><td>110</td><td>111</td><td>112</td><td>113</td><td>114</td><td>115</td><td>116</td><td>X</td><td>117</td><td>118</td><td>119</td><td>120</td></tr>
<tr><td>131</td><td>121</td><td>122</td><td>123</td><td>124</td><td>125</td><td>126</td><td>127</td><td>128</td><td>129</td><td>X</td><td>130</td><td>131</td><td>132</td></tr>
<tr><td>323</td><td>133</td><td>134</td><td>135</td><td>136</td><td>137</td><td>138</td><td>139</td><td>140</td><td>141</td><td>142</td><td>143</td><td>X</td><td>144</td></tr>
<tr><td>212</td><td>145</td><td>146</td><td>146</td><td>148</td><td></td><td>149</td><td>150</td><td>151</td><td>152</td><td>153</td><td>154</td><td>155</td><td>X</td></tr>
</table>
</td></tr>
<tr><td>Expected Results</td><td>The expected numeric results are described above and in TD-8.</td></tr>
</table>

Table 1.19: STC-26 Attitude conversion in the spacecraft attitude dialog box

Name	Attitude GUI behavior when entering zero quaternion
Requirements	FR-3.1
PreConditions	BS-1
Data	1. Load BS-1. 2. Open the dialog box for DefaultSC. 3. Click on the attitude tab. 4. Set all values of the quaternion to zero. 5. Click Ok.
Expected Results	The following warning is displayed: The magnitude of a quaternion must be greater than 1e-10.

Table 1.20: STC-17 Attitude GUI behavior when entering zero quaternion

1.3 Differential Corrector

Name	TC-1 Differential Corrector Dialog Box Range Tests - Disallowed Values
Requirements	FR-19
Summary	This case verifies the Differential Corrector dialog box rejects disallowed data.
PreConditions	BS-1
Data	1. Load BS-1. 2. In the solvers folder in the mission tree, right-click on the Boundary Value Solvers folder and add a Differential Corrector. 3. Open the dialog box for the new Differential Corrector. 4. In the Max Iterations field, enter -2, and hit Apply. Ensure the following error message is provided: The value of "-2" for field "Maximum Iterations" is not an allowed value. The allowed values are: [Integer Number > 0]. 5. In the Max Iterations field, enter DNE, and hit Apply. Ensure the following error message is provided: The value of "DNE" for field "Maximum Iterations" is not an allowed value. The allowed values are: [Integer Number > 0]. 6. In the Max Iterations field, enter 23.6, and hit Apply. Ensure the following error message is provided: The value of "23.6" for field "Maximum Iterations" is not an allowed value. The allowed values are: [Integer Number > 0].
Expected Results	Test results are described above.

Table 1.21: TC-1 Differential Corrector Dialog Box Range Tests - Disallowed Values

Name	TC-2 Differential Corrector Dialog Box Range Tests- Allowed Values
Requirements	FR-19
Summary	This case verifies the Differential Corrector accepts allowed data.
PreConditions	BS-1
Data	1. Load BS-1. 2. In the solvers folder in the mission tree, right-click on the Boundary Value Solvers folder and add a Differential Corrector. 3. Open the dialog box for the new Differential Corrector. 4. Set the Max Iterations to 56. 5. In the ReportFile field type `.\output\DCReport.txt` 6. Uncheck the ShowProgress box. 7. Set the DerivativeMethod drop-down menu to CentralDifference. 8. Set the ReportStyle drop-down menu to Verbose. 9. Click the Apply button. 10. Click the Show Script button.

Expected Results	`Create DifferentialCorrector DC1;`
	`GMAT DC1.ShowProgress = false;`
	`GMAT DC1.ReportStyle = 'Verbose';`
	`GMAT DC1.ReportFile = '.\output\DCData.txt';`
	`GMAT DC1.MaximumIterations = 56;`
	`GMAT DC1.DerivativeMethod = CentralDifference;`

Table 1.22: TC-2 Differential Corrector Dialog Box Range Tests- Allowed Values

Chapter 2

Test Data

Name	TD-1 Equivalent State Representations in EarthMJ2000Eq
Description	This table contains equivalent states in all GMAT state representations that have a central body at the origin.
Source	This is data comes from GMAT and allows testing consistency between state conversions. We have numerical tests that verify that GMAT is correctly performing conversions correctly via the script when compared to truth data from STK. The data below is to ensure that the GUI state conversions agree with conversions in the script. (The test data assumes $\mu = 398600.4415$)
Data	1. Cartesian State (a) X = -2011.554639349956 (b) Y = 7587.193672855249 (c) Z = 1362.382029017782 (d) VX = -7.694247416401868 (e) VY = -0.9065479140190984 (f) VZ = 0.4284953758282981 2. Keplerian State (a) SMA = 10000 (b) ECC = 0.25 (c) INC = 10.0 (d) RAAN = 25.0 (e) AOP = 35.0 (f) TA = 45.0 (g) MA = 27.24378911263291; (h) EA = 35.57751520702131; 3. Modified Keplerian (a) RadPer = 7500 (b) RadApo = 12500 (c) INC = 10.0 (d) RAAN = 25.0 (e) AOP = 35.0 (f) TA = 45.0 4. Spherical RADec (a) RMAG = 7966.67714229061 (b) RA = 104.8489182889519 (c) DEC = 9.846551939834079 (d) VMAG = 7.759309293508375 (e) AZI = 88.24621654190652 (f) FPA = 81.45684518510772 5. Spherical RADec (a) RMAG = 7966.67714229061 (b) RA = 104.8489182889519 (c) DEC = 9.846551939834079 (d) VMAG = 7.759309293508375 (e) AZI = -173.2803040524276 (f) FPA = 3.165677683357204 6. Equinoctial (a) SMA = 10000 (b) h = 0.2165063509461095 (c) k = 0.125 (d) p = 0.03697430690134294 (e) q = 0.07929165703097431 (f) MLONG = 87.2437891126329

Table 2.1: TD-1 Equivalent State Representations

Name	TD-2 Equivalent Epoch Representations
Description	This table contains equivalent epoch representations in all formats and systems supported as input types.
Source	Need to verify source.
Data	1. 04 Jul 2004 12:34:56.789 UTC 2. 23191.0242683912 UTC 3. 04 Jul 2004 12:35:28.789 TAI 4. 23191.02463876157 TAI 5. 04 Jul 2004 12:35:28.823 A1 6. 23191.02463915951 A1 7. 04 Jul 2004 12:36:00.973 TT 8. 23191.0250112616 TT

Table 2.2: TD-2 Equivalent Epoch Representations

Name	TD-3 Equivalent States in Different Coordinate Systems
Description	This table contains equivalent states in various coordinate systems. The epoch is 04 Feb 2001 11:59:28.000 UTC.
Source	This is data comes from GMAT and allows testing consistency between state conversions. We have numerical tests that verify that GMAT is correctly performing conversions correctly via the script when compared to truth data from STK. The data below is to ensure that the GUI state conversions agree with conversions in the script.
Data	1. EarthMJ2000Eq (a) 5071.298226925739 (b) 7611.115643763225 (c) 3591.57811088299 (d) -5.443963856628132 (e) 2.768170139549618 (f) 1.993434604659487 2. EarthMJ2000Eq (a) 5071.298226925739 (b) 8411.709801736053 (c) 267.6805571735547 (d) -5.443963856628132 (e) 3.332689195355913 (f) 0.7278256465019841 3. EarthFixed System —- (a) -1863.0575794316 (b) 8953.983671172193 (c) 3591.903847242492 (d) -5.139752276668541 (e) -1.799622038729856 (f) 1.992983974458626 4. LunaFixed System —- (a) 356291.5164882602 (b) -33974.36961780395 (c) 16667.54936624816 (d) -3.267914664134139 (e) -5.374404304814976 (f) 0.7247736501205496 5. EarthMoonRot System (a) 8968.872502970022 (b) -3907.723350348471 (c) 914.1141166948707 (d) 2.581713440043834 (e) 5.842794343296872 (f) 0.3253861743578399 6. SunMJ2000Ec System (a) 125912803.1220472 (b) 163450023.4650465 (c) 66337826.42493016 (d) -33.57498440092737 (e) 0.0008503562866066794 (f) 1.493151380860197 7. CS_ESL2 System (a) -560121.5615799141 (b) 284125.8138175178 (c) 13140.72166463266 (d) 5.466911578720965 (e) 0.7694483179080936 (f) 0.6355953786263187 8. CS_SSBary System (a) 147428584.0468952 (b) -9578.340467568873 (c) 266.8937442606475 (d) 6.68279484246637 (e) 1.370672075811688 (f) 0.726953785084683

Name	TD-4 Equivalent State Representations for a Singular Conic Section
Description	This table contains equivalent states in all GMAT state representations that have a central body at the origin.
Source	STK. The data below is to ensure that the GUI state conversions agree with conversions in the script. (The test data assumes $\mu = 398600.4415$)
Data	1. Cartesian State (a) X = 7000 (b) Y = 7000 (c) Z = 7000 (d) VX = -4.04145188432738 (e) VY = -4.04145188432738 (f) VZ = -4.04145188432738 2. Keplerian State: Undefined (e = 1); 3. Modified Keplerian: Undefined (e = 1); 4. Spherical RADec (a) RMAG = 12124.355652982142 (b) RA = 45 (c) DEC = 35.2643896827546470 (d) VMAG = 6.999999999999998 (e) AZI = 0 (f) FPA = 180 5. Spherical RADec (a) RMAG = 12124.355652982142 (b) RA = 45 (c) DEC = 35.2643896827546470 (d) VMAG = 6.999999999999998 (e) DECV = 225 (f) RAV = 35.264389682754661 6. Equinoctial: Undefined (e = 1);

Table 2.4: TD-4 Equivalent State Representations for a Singular Conic Section

Name	TD-5 Equivalent State Representations for a Circular, Equatorial Orbit
Description	This table contains equivalent states in all GMAT state representations that have a central body at the origin.
Source	Hand calculations based on Math spec for all except Equinoctial which is from STK. (The test data assumes $\mu = 398600.4415$)
Data	1. Cartesian State (a) X = 4949.747468305833 (b) Y = 4949.747468305833 (c) Z = 0.0 (d) VX = -5.335865450622125 (e) VY = 5.335865450622125 (f) VZ = 0 2. Keplerian State (a) SMA = 7000 (b) ECC = 0.0 (c) INC = 0.0 (d) RAAN = 0.0 (e) AOP = 0.0 (f) TA = 45.0 3. Modified Keplerian (a) RadPer = 7000 (b) RadApo = 7000 (c) INC = 0.0 (d) RAAN = 0.0 (e) AOP = 0.0 (f) TA = 45.0 4. Spherical RADec (a) RMAG = 7000 (b) RA = 45.0 (c) DEC = 0.0 (d) VMAG = 7.5460532872678359 (e) RAV = 135.00000000000000 (f) DECV= 0.0 5. Spherical RADec (a) RMAG = 7000 (b) RA = 45.0 (c) DEC = 0.0 (d) VMAG = 7.5460532872678359 (e) AZI = 90 (f) FPA = 90 6. Equinoctial (a) SMA = 7000 (b) h = 0.0 (c) k = 0.0 (d) p = 0.0 (e) q = 0.0 (f) MLONG = 45.0

Table 2.5: TD-5 Equivalent State Representations for a Circular, Equatorial Orbit

Name	TD-6 Equivalent State Representations for a Circular, Inclined (retrograde) Orbit
Description	This table contains equivalent states in all GMAT state representations that have a central body at the origin.
Source	Hand calculations based on Math spec for all except Equinoctial which is from STK. (The test data assumes $\mu = 398600.4415$)
Data	1. Cartesian State (a) X = -5975.5752861126311 (b) Y = 480.14719831222595 (c) Z = -3416.4248371584213 (d) VX = 3.8002690670377621 (e) VY = 0.9160734111800478 (f) VZ = -6.5182010133917370 2. Keplerian State (a) SMA = 6900 (b) ECC = 0.0 (c) INC = 98 (d) RAAN = 0.0 (e) AOP = 0.0 (f) TA = 210.0 3. Modified Keplerian (a) RadPer = 6900 (b) RadApo = 6900 (c) INC = 98 (d) RAAN = 0.0 (e) AOP = 0.0 (f) TA = 210.0 4. Spherical RADec (a) RMAG = 6900 (b) RA = 175.4060606593105 (c) DEC = -29.67858910292156 (d) VMAG = 7.6005381340755180 (e) RAV = 13.55286811093926 (f) DECV= -59.04786932043024 5. Spherical RADec (a) RMAG = 6900 (b) RA = 175.4060606593105 (c) DEC = -29.67858910292156 (d) VMAG = 7.6005381340755180 (e) AZI = 189.2177489242794 (f) FPA = 90 6. Equinoctial (a) SMA = 6900 (b) h = 0.0 (c) k = 0.0 (d) p = 0.0 (e) q = 1.1503684072210094 (f) MLONG = 210.0

Table 2.6: TD-6 Equivalent State Representations for a Circular, Inclined (retrograde) Orbit

Name	Equivalent Attitude Representations
Description	This table contains equivalent states in various coordinate systems. The epoch is 04 Feb 2001 11:59:28.000 UTC.
Source	This is data comes from GMAT and allows testing consistency between state conversions. We have numerical tests that verify that GMAT is correctly performing conversions correctly via the script when compared to truth data from STK. The data below is to ensure that the GUI state conversions agree with conversions in the script.
Data	(see below)

- Quaternion
  1. 0.05431254465935684
  2. 0.1536190745285137
  3. 0.6870053865727263
  4. 0.7081489435519108
- Euler Angles

Sequence	θ_1 (deg.)	θ_2 (deg.)	θ_3 (deg.)
123	-8.063660107792256	16.98949666527142	89.46981218935655
231	86.45739059790678	81.76589766113709	-69.50363702414091
312	86.99826598215141	16.73807760458099	8.584547140308942
132	80.12240308416057	73.0024763951768	88.26525116243468
321	89.48768989493576	8.21825906808993	16.91694843278077
213	17.14924429081384	-7.709559339371771	87.09931277680732
121	81.78141688239583	89.49295108504926	-73.00981782084581
232	16.7597858904212	87.12555469792072	7.719330705131926
313	114.6605285775403	18.75489666719195	-26.39703015347826
131	-8.218583117604172	89.49295108504926	16.99018217915419
323	24.66052857754036	18.75489666719195	63.60296984652174
212	-73.2402141095788	87.12555469792072	97.71933070513192

- Direction Cosine Matrix

0.008849557522123823	0.9896911631236142	-0.1429443491946786
-0.9563173917401783	0.05014749262536867	0.2879970056070911
0.2921963921524783	0.134151521118533	0.9469026548672567

Table 2.7: TD-8 Equivalent Attitude Representations