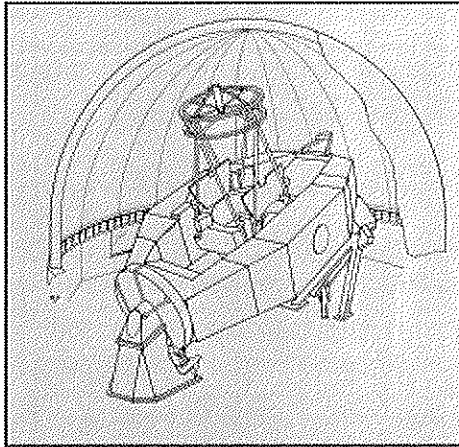


| REV | DESCRIPTION | DATE | BY |
|-----|-----------------|---------|-----|
| - | Initial Release | 4/17/08 | EAW |

T3-3003 Rev -

T3-3003
Safety Board Test Procedure
Revision: -

SERIAL NUMBER TESTED 003 Rev C



T3-3003 Rev -

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1 Test Overview

This test procedure is for validating and setting hardware limits on the TCS3 Safety Board. This procedure is primarily intended to be used for board level testing. However, since the TCS3 software and the lab setup are used during testing, some minor system level interface testing will also be included where it is convenient. Only after completing and passing this procedure is the Safety Board acceptable for operational use.

All fields with a **yellow background** are recordable data fields and must be completed.

Note: making a test procedure that is completely independent of the TCS3 lab setup was determined to be very cumbersome due to the number and types of interfaces. Therefore, it is important that the lab setup be maintained and functional for this test procedure.

2 Equipment and Tools Required

The table below lists the equipment and tools required to complete this test procedure.

| Item # | Qty | Model / Part Number | Description |
|--------|-----|---------------------------|----------------------------------|
| 1 | 2 | Fluke 179 (or equivalent) | Fluke Multimeter |
| 2 | 1 | - | TCS3 Lab System |
| 3 | 1 | - | Latest TCS3 Software |
| 4 | 1 | TDS2014B (or equivalent) | Oscilloscope, 100 MHz, 4 channel |
| 5 | REF | TCS-T3 | Safety Board Schematics |
| 6 | 1 | - | 14 pin DIP Test Clip |
| 7 | 1 | - | Safety Board (unit under test) |

Table 1 Required Test Equipment

3 Test Setup

Follow these steps to setup the lab system:

1. Power down the TCS3 motor amp supplies. This is the big supply at the bottom of the rack.
2. Power down the TCS3 rack box containing the Safety Board.
3. Disconnect all connectors from the Safety Board in the rack box and remove the Safety Board. Install Safety Board that is to be tested and connect all connectors to it.
4. Remove jumpers W1, W2, W3, and W4 from the Safety Board.
5. Power up the TCS3 rack box and motor amp power supply.
6. Turn on the "t9h" PC if it is not already running. This is the analog tachometer emulator.
7. Start up the latest version of the TCS3 software.
8. Bring up two mcc windows and display mcc1 and mcc2.
9. Press the "T3.Reset" button on mcc1.
10. Press the system power on button on mcc2.
11. Select the track button on mcc1.

The lab unit should be tracking. If it is not, look for any errors listed in the mcl1 window. Most likely the error will be related to the limit switches on the test panel. If not, refer to the TCS3 lab unit documentation.

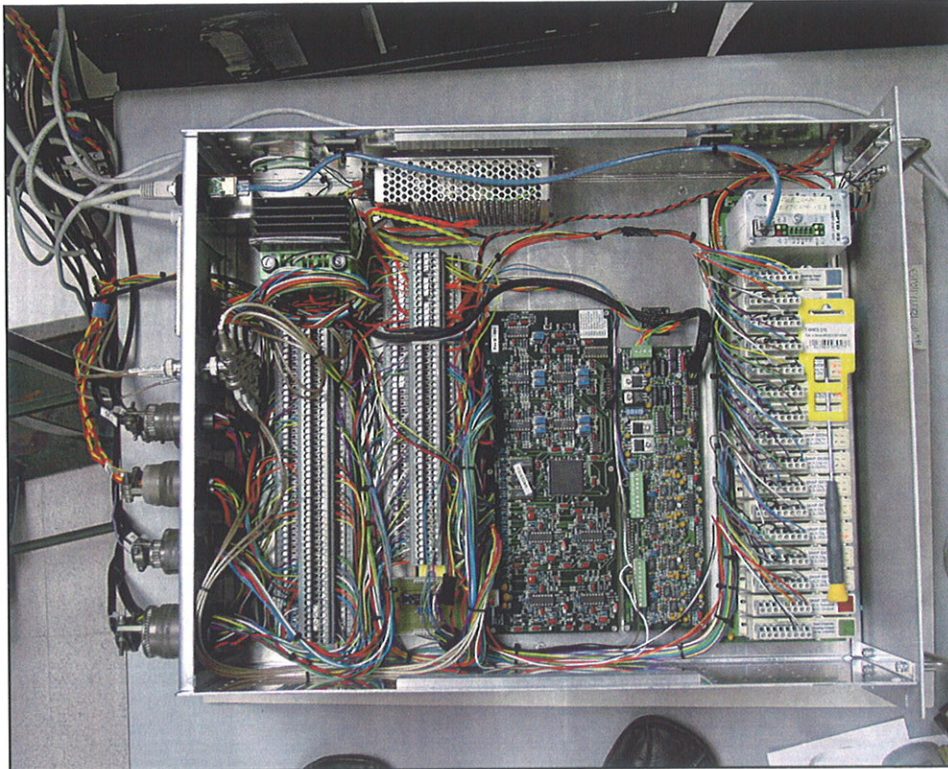


Figure 1 Safety Board Installed in Servo Box

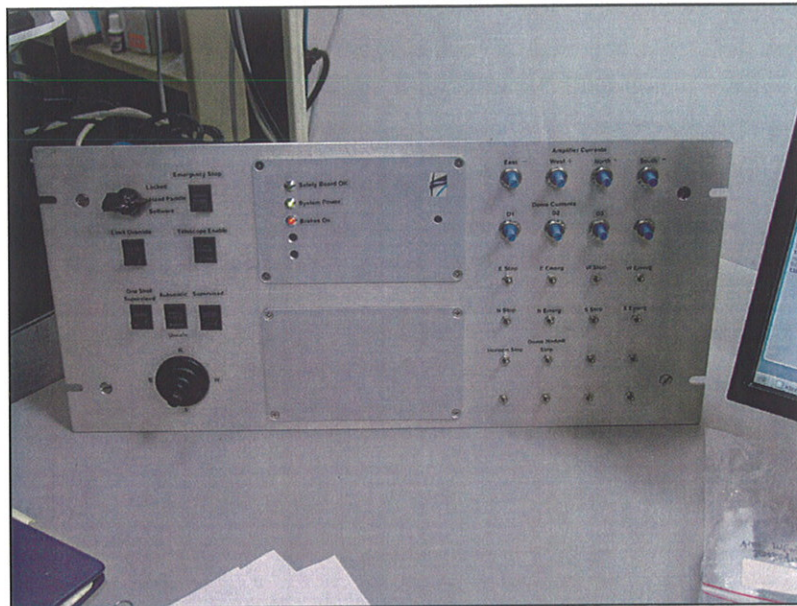


Figure 2 TCS3 Lab Setup TO Control Panel

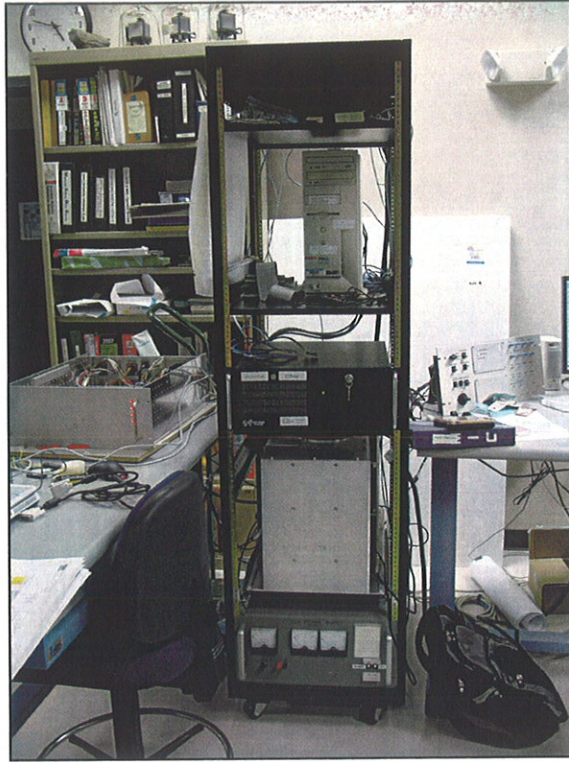


Figure 3 TCS3 Lab Rack

4 Testing

4.1 Limit & Stop Switches

Each switch in the table below will simulate a fault when it is switched. Start each test in tracking mode. After each fault, move the switch back to its non-fault position and push the "T3.Reset" (mcc1) button followed by the power on button (mcc2) and select racking again. Repeat this procedure for the next switch listed. In addition to testing the switches (simulated fault conditions), the testing below also tests the reset and brake signals by using these functions in the procedure.

Check the conditions that apply to each switch. If all boxes are checked, then the fault that the switch simulates passes.

| Switch | mcc1 display (✓) | | | | | Lab TO Panel LEDs (✓) | Final Result - All boxes checked (circle one) | Tester Initials | Date |
|------------------|------------------------------|--|-----------------------|--------------------|----------------|-----------------------|---|-----------------|---------|
| | Unique mcc1 Error Message | Unique Error "Safety Board Error Exist" | "System Power is off" | System Power = OFF | Brakes On = ON | | | | |
| E stop | SafetyBrd_HA_Stop_E_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | 2anw | 6/19/08 |
| E Emerg | SafetyBrd_HA_Emerg_E_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| W Stop | SafetyBrd_HA_Stop_W_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| W Emerg | SafetyBrd_HA_Emerg_W_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| N Stop | SafetyBrd_Dec_Stop_N_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| N Emerg | SafetyBrd_Dec_Emerg_N_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| S Stop | SafetyBrd_Dec_Stop_S_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| S Emerg | SafetyBrd_Dec_Emerg_S_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| Horizon Stop | SafetyBrd_Horizon_Stop_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| Hand Paddle Stop | SafetyBrd_DomeHP_Stop_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| Emergency Stop | Safety Brd_Emerg_Stop_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |

Table 2 Limit Switch Tests

4.2 Limit Override Switch

Start tracking mode. Move the "Limit Override" switch to the up position. With this switch in the up position, activate each switch and record the data in the table below until all switches are active.

| Switch | mcc1 display (✓) | | | | | Lab TO Panel LEDs (✓) | Final Result - All boxes checked (circle one) | Tester Initials | Date |
|--------------|------------------------------|--|-------------------|-------------|--------------------|-----------------------|---|-----------------|---------|
| | Unique mcc1 Error Message | Unique Error Hardware Limit Override On | System Power = ON | Brake = OFF | Safety Brd OK = ON | | | | |
| E stop | SafetyBrd_HA_Stop_E_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | 2anw | 6/19/08 |
| E Emerg | SafetyBrd_HA_Emerg_E_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| W Stop | SafetyBrd_HA_Stop_W_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| W Emerg | SafetyBrd_HA_Emerg_W_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| N Stop | SafetyBrd_Dec_Stop_N_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| N Emerg | SafetyBrd_Dec_Emerg_N_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| S Stop | SafetyBrd_Dec_Stop_S_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| S Emerg | SafetyBrd_Dec_Emerg_S_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |
| Horizon Stop | SafetyBrd_Horizon_Stop_Latch | ✓ | ✓ | ✓ | ✓ | ✓ | PASS / FAIL | | |

Table 3 Override Switch Tests #1

Deactivate all of the switches from the above table. Move the "Limit Override" switch to the up position. For each mode below, start in tracking mode. Unlike the test above, the tests in the table below should cause faults. Reset, turn on power, and start tracking after each fault. After the completion of the tests, move the Limit Override to the down position (off).

| Switch | mcc1 display (✓) | | Lab TO Panel LEDs (✓) | | | | Final Result - All boxes checked (circle one) | Tester Initials | Date |
|------------------|-----------------------------|---|-----------------------|------------|---------------------|---|---|-----------------|---------|
| | Unique mcc1 Error Message | Unique Error "Safety Board Error Exist" "System Power is off" | System Power = OFF | Brake = ON | Safety Brd OK = OFF | | | | |
| Hand Paddle Stop | SafetyBrd_DomeHP_Stop_Latch | X | X | X | X | X | PASS / FAIL | gan | 6/19/08 |
| Emergency Stop | SafetyBrd_Emerg_Stop_Latch | X | X | X | X | X | PASS / FAIL | ↓ | ↓ |

Table 4 Override Switch Tests #2

4.3 Telescope Enable Switch

The telescope enable switch will not cause the TCS3 to remove system power. It simply disables the telescope (and applies brakes) as its name implies. Begin in tracking mode, move the switch down to disable the telescope, and record the data. After completion of the tests, move the switch to the up position.

| Switch | mcc1 display (✓) | | Lab TO Panel LEDs (✓) | | | Final Result - All boxes checked (circle one) | Tester Initials | Date |
|------------------|------------------------|-------------------|-----------------------|--------------------|---|---|-----------------|---------|
| | Unique Error Message | System Power = ON | Brake = ON | Safety Brd OK = ON | | | | |
| Telescope Enable | TOP Tele Enable is OFF | X | X | X | X | PASS / FAIL | gan | 6/19/08 |

Table 5 Telescope Enable Switch Tests

4.4 Overcurrent

There are several overcurrent telemetry points used to protect the amplifiers and motors for both the dome and the telescope axes. To test these points, the lab TO Panel has potentiometers that can vary the voltage, emulating the current feedback in the actual system.

There are two steps to this testing section. The first step is to adjust the Safety Board potentiometer to the correct value. The second is to test the Safety Board and TCS3 software together. Repeat the steps for each point listed in the table.

NOTE: The current limits will be set fairly high relative to the average current usage. Based on the position of the telescope much higher current may be required during acceleration. If the dome "sticks" or binds at a certain point, maximum current may be required. Therefore,

the dome current limits are set very high and may only trip under a catastrophic condition such as a short or amplifier malfunction.

1. Adjusting the Safety Board Current Trip Point

Set TCS3 to idle mode. It is likely that the TCS will have overcurrent conditions when adjusting the potentiometers. These errors can be ignored. While monitoring the “current telemetry”, “comparator input”, and “Logic State”, adjust the TO Panel potentiometer until the “current telemetry” reaches the specified value. Adjust the Safety Board potentiometer until the overcurrent logic state changes from a logic “1” to a logic “0”. Record the requested values in the table. All measurements are referenced to “AGND”. There is no pass or fail in this subsection. This an adjustment section and the values must be within the setpoint. If the potentiometer is not adjusted correctly, the next subsection tests will not be passed.

Note: For the the West, East, North, and South overcurrent circuits, only one direction (voltage polarity) will actually need to be tested. TCS3 has opposing motors with each motor driving in only one direction. Therefore, the opposite polarity will never trip outside of an unexpected catastrophic type of failure.

The dome amplifiers may be expected to put out maximum current for a significant amount of time due to the dome “sticking” at certain points. Therefore the current limits are set above the amplifier limit and would only be tripped during a catastrophic type of event.

The nominal current telemetry factor is 11.66 A/V.

| Current Point | Monitor Overcurrent Logic State At | Current Telemetry (Vdc) (Using TO Panel) | | | | Comparator Input (Vdc) (Using Safety Board Pot) | | | | Tester Initials | Date |
|-----------------|------------------------------------|---|------------|----------------|--------|--|------------|-----------------|--------|-----------------|---------|
| | | Approx. Current Trip Point | Measure At | Setpoint (Vdc) | Actual | Pot | Measure At | Expected (Vdc) | Actual | | |
| West Current | U10-1 | 35 A | TB1-B1 | 3.0 +/- 10mV | 3.00 | R128 | TP5 | 0.42 to 0.50V | .474 | Eaon | 6/19/08 |
| East Current | U10-14 | 35 A | TB1-B2 | -3.0 +/- 10mV | -3.00 | R130 | TP8 | -0.42 to -0.50V | -.496 | | |
| North Current | U7-1 | 35 A | TB1-B3 | 3.0 +/- 10mV | 3.00 | R99 | TP2 | 0.42 to 0.50V | .452 | | |
| South Current | U7-14 | 35 A | TB1-B4 | -3.0 +/- 10mV | -2.99 | R101 | TP3 | -0.42 to -0.50V | -.488 | | |
| DOME #1 Current | U9-1 | 47 A | TB1-B5 | 4.0 +/- 100mV | 3.99 | R127 | TP6 | 0.42 to 0.50V | .472 | | |
| DOME #2 Current | U9-14 | 47 A | TB1-B6 | 4.0 +/- 100mV | 4.00 | R129 | TP7 | 0.42 to 0.50V | .474 | | |
| DOME #3 Current | U13-1 | 47 A | TB1-B7 | 4.0 +/- 100mV | 4.01 | R152 | TP9 | 0.42 to 0.50V | .473 | | |

Table 6 Overcurrent Trip Point Adjustment

2. Testing the Overcurrent Telemetry

Reset by pushing the "T3.Reset" (mcc1) button followed by the power on button (mcc2). While monitoring the "current telemetry" and the "overcurrent" telemetry, adjust the TO Panel potentiometer until the "overcurrent" telemetry changes states from a logic "1" to a logic "0". Record the requested values in the table. All measurements are referenced to "AGND".

NOTE: *The overcurrent trip points are not symmetrical due to the design and current build of all of the Safety Boards. It was decided not to modify the built boards to be symmetrical since the TCS operation isn't affected by it. Motors are driven in one direction only, so having unsymmetrical trip points in the other direction doesn't matter. A shorted, catastrophic condition would still be detected. The Dome motor overcurrents are set high, above the maximum continuous current available by the amps, so their function is only to detect high current, catastrophic conditions.

| Current Point and Polarity | Monitor Overcurrent Logic State At | Current Telemetry (V) | | | | Trip Point SPEC | Unique mcc1 Error Message | Unique mcc1 Error Present | Tester Initials | Date |
|----------------------------|------------------------------------|----------------------------|------------|-------------------------|---------------------------------|-----------------|---------------------------|---------------------------|-----------------|---------|
| | | Approx. Current Trip Point | Measure At | Actual Trip Point (V) | Trip Point SPEC (Vdc) | | | | | |
| West+ | U10-1 | 35 A | TB1-B1 | 2.93 3.00 | 2.9 to 3.1 | PASS/ FAIL | SafetyBrd_OC_West_Latch | PASS/ FAIL | ECPN | 6/19/08 |
| West- | U10-1 | *-42 A | TB1-B1 | -3.57 | -3.5 to -3.7 -3.4 | PASS/ FAIL | SafetyBrd_OC_West_Latch | PASS/ FAIL | | |
| East+ | U10-14 | *28 A | TB1-B2 | 2.47 | 2.4 to 2.6 | PASS/ FAIL | SafetyBrd_OC_East_Latch | PASS/ FAIL | | |
| East- | U10-14 | -35 A | TB1-B2 | -3.00 | -2.9 to -3.1 | PASS/ FAIL | SafetyBrd_OC_East_Latch | PASS/ FAIL | | |
| North+ | U7-1 | 35 A | TB1-B3 | 2.94 | 2.9 to 3.1 | PASS/ FAIL | SafetyBrd_OC_North_Latch | PASS/ FAIL | | |
| North- | U7-1 | *42 A | TB1-B3 | -3.41 | -3.5 to -3.7 -3.4 | PASS/ FAIL | SafetyBrd_OC_North_Latch | PASS/ FAIL | | |
| South+ | U7-14 | *28 A | TB1-B4 | 2.43 | 2.4 to 2.6 | PASS/ FAIL | SafetyBrd_OC_South_Latch | PASS/ FAIL | | |
| South- | U7-14 | -35 A | TB1-B4 | -2.98 | -2.9 to -3.1 | PASS/ FAIL | SafetyBrd_OC_South_Latch | PASS/ FAIL | | |
| DOME 1+ | U9-1 | 47 A | TB1-B5 | 3.94 | 3.9 to 4.1 | PASS/ FAIL | SafetyBrd_OC_Dome1_Latch | PASS/ FAIL | | |
| DOME 1- | U9-1 | -54 A | TB1-B5 | -4.53 | -4.5 to -4.7 | PASS/ FAIL | SafetyBrd_OC_Dome1_Latch | PASS/ FAIL | | |
| DOME 2+ | U9-14 | 47A | TB1-B6 | 3.94 | 3.9 to 4.1 | PASS/ FAIL | SafetyBrd_OC_Dome2_Latch | PASS/ FAIL | | |
| DOME 2- | U9-14 | -54 A | TB1-B6 | -4.54 | -4.5 to -4.7 | PASS/ FAIL | SafetyBrd_OC_Dome2_Latch | PASS/ FAIL | | |
| DOME 3+ | U13-1 | 47 A | TB1-B7 | 3.94 | 3.9 to 4.1 | PASS/ FAIL | SafetyBrd_OC_Dome3_Latch | PASS/ FAIL | | |
| DOME 3- | U13-1 | -54 A | TB1-B7 | -4.53 | -4.5 to -4.7 | PASS/ FAIL | SafetyBrd_OC_Dome3_Latch | PASS/ FAIL | | |

Table 7 Overcurrent Testing

4.5 Overspeed

There are two overspeed circuits that prevent the HA or DEC axis from exceeding a set, maximum speed

Two steps must be completed in this testing section. The first step is to adjust the Safety Board overspeed potentiometers to the correct values. The second is to test the Safety Board and TCS3 software together.

1. Adjusting the Safety Board Overspeed Trip Point

Turn pots R100 and R102 clockwise to lower the potentiometer resistances. This will effectively disable the overspeed circuit and prevent the board from reporting an overcurrent condition that would shutdown the TCS3 system, preventing this test from being completed.

OPTIONAL: To verify that the potentiometers are low enough, measure TP1 (for R100) and TP4 (for R102) to AGND with TCS3 powered down. Adjust the potentiometers until the resistance is less than 100Ω.

While monitoring the “velocity telemetry” and “comparator input”, set and execute an “MV” command at 2000 arcsec/sec on mcc1. This command should produce a voltage that falls within the desired velocity telemetry range. If not, there is an issue. Adjust the Safety Board potentiometer until the overspeed logic state changes from a logic “1” to a logic “0”. This will cause a fault and the TCS3 will have to be reset and the MV command will have to be reissued. Record the requested values in the table. All measurements are referenced to “AGND”.

Note: The scale factor for velocity is approximately 596 (arcsec/s)/V.

| Overspeed Axis | Monitor Overspeed Logic State At | Velocity Telemetry (V) | | | Comparator Input (V) | | | | Tester Initials | Date |
|----------------|----------------------------------|------------------------|----------------|--------|----------------------|------------|-----------------|--------|-----------------|---------|
| | | Measure At | Setpoint (Vdc) | Actual | Pot | Measure At | Desired (mV dc) | Actual | | |
| HA Axis | U8-1 | U1-1 | 3.4 +/- 100mV | 3.48 | R100 | TP1 | 0.41 to 0.49V | 0.489 | gaw | 6/20/08 |
| DEC Axis | U8-14 | U3-1 | 3.4 +/- 100mV | 3.46 | R102 | TP4 | 0.41 to 0.49V | 0.488 | k | k |

Table 8 Overspeed Trip Point Adjustment

2. Testing the Overspeed Telemetry

Reset by pushing the “T3.Reset” (mcc1) button followed by the power on button (mcc2). While monitoring the “velocity telemetry” and the “overspeed” telemetry, increment and execute the MV command until the “overspeed” telemetry changes states from logic “1” to logic “0”. The overspeed circuit will be tested with both positive and negative velocities. Start the MV command at +1900 arcsec/s (-1900 arcsec/s) and increase magnitude in increments of 10 arcsec/s. Record the requested values in the table below. All measurements are referenced to “AGND”.

* Velocity is very unstable (spikes appear).
 This is due to velocity feedback lag issue.
 and/or gears.

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| Overspeed Axis | Monitor Overspeed Logic State At | Velocity Telemetry (V) | | | Overspeed Trip Point SPEC | Last MV CMD @ Trip Point (arcsec/s) | Unique mcc1 Error Message | Unique mcc1 Error Present | Tester Initials | Date |
|---------------------|----------------------------------|------------------------|-----------------------|---------------------|---------------------------|-------------------------------------|---------------------------|---------------------------|-----------------|---------|
| | | Measure At | Actual Trip Point (V) | Trip Point SPEC (V) | | | | | | |
| HA Axis (positive) | U8-1 | U1-1 | 3.5 | 3.3 to 3.5 | PASS/FAIL | 1990 | SafetyBrd_OS_Ha_Latch | PASS/FAIL | gan | 6/20/08 |
| HA Axis (negative) | U8-1 | U1-1 | -3.4 | -3.3 to -3.5 | PASS/FAIL | -1980 | SafetyBrd_OS_Ha_Latch | PASS/FAIL | | |
| DEC Axis (positive) | U8-14 | U3-1 | 3.5 3.4 | 3.3 to 3.5 | PASS/FAIL | 2000 1900 | SafetyBrd_OS_De_Latch | PASS/FAIL | | |
| DEC Axis (negative) | U8-14 | U3-1 | -3.5 | -3.3 to -3.5 | PASS/FAIL | 1920 -2020 | SafetyBrd_OS_De_Latch | PASS/FAIL | | |

Table 9 Overspeed Testing Tests

4.6 Velocity Loop Testing

The velocity loop is an analog loop on the Safety Board. This section will test the DC gain of the circuit. Using two multimeters, measure and record the values listed in the table below while using the MV command to move at the specified rate (use mcc1). All measurements are referenced to "AGND". There are not any convenient test points or pins for the "Vel In" values, so resistors will have to be probed. The side of the resistor to measure is the side that connects to P1 and is a nonzero value when the axis is moving. The other side is a virtual ground on the input of an op-amp and will read very close to zero.

| Motor Under Test | MV CMD Velocity | Measure At | "Vel In" Value (mV) | Measure At | "Vel Out" (mV) | Gain= | GAIN SPEC | GAIN PASS / FAIL | Tester Initials | Date |
|------------------|-----------------|------------|---------------------|------------|----------------|--|--------------|------------------|-----------------|---------|
| | | | | | | $\frac{\text{"Vel_Out"}}{\text{"Vel_In"}}$ | | | | |
| WEST | 500 | R5 | -0.7v | TB1-T9 | -0.7v | 1 | 0.95 to 1.05 | PASS/FAIL | gan | 6/19/08 |
| WEST | 1500 | R5 | -0.75v | TB1-T9 | -0.75v | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| EAST | -500 | R8 | 0.6v | TB1-T7 | 0.6v | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| EAST | -1500 | R8 | 0.8v | TB1-T7 | 0.8v | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| NORTH | 500 | R46 | -550 | TB1-T13 | -550 | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| NORTH | 1500 | R46 | -740 | TB1-T13 | -740 | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| SOUTH | -500 | R45 | 750 | TB1-T11 | 750 | 1 | 0.95 to 1.05 | PASS/FAIL | | |
| SOUTH | -1500 | R45 | 0.8v | TB1-T11 | 0.8v | 1 | 0.95 to 1.05 | PASS/FAIL | | |

Table 10 Velocity Loop DC Gain Tests

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4.7 Tachometer Gain

TCS3 uses a filtered, average velocity from the two opposing motor tachometers. To verify that the velocity gain is correct, several points will be measured and the corresponding data will be used to calculate the gain. Use the MV command to set the velocity as indicated in the table. Record the required data. All measurements are referenced to "AGND" with the exception of "measure from" values. Measure from red (+) to black (-).

4.7.1 HA Axis

| MV CMD Velocity | East Tach (V) (measure from TB1-T20 to TB1-T21) | West Tach (V) (measure from TB1-T23 to TB1-T24) | "HA Vel Feedback" (V) (measure at U1-1) | Tach_Gain= "HVel" $(East + West) / 2$ | GAIN SPEC | GAIN PASS / FAIL | Tester Initials | Date |
|-----------------|--|--|--|---|--------------|---------------------|-----------------|---------|
| 100 | 0.80 | 0.80 | 0.17 | 0.2125 | 0.20 to 0.22 | PASS / FAIL | Ear | 6/19/08 |
| 1000 | 8.2 | 8.2 | 1.7 | 0.207 | 0.20 to 0.22 | PASS / FAIL | L | L |
| 1800 | 15 | 15 | 3.1 | 0.206 | 0.20 to 0.22 | PASS / FAIL | L | L |

Table 11 HA Axis Tachometer Gain Tests

4.7.2 DEC Axis

| MV CMD Velocity | North Tach (V) (measure from TB1-T29 to TB1-T30) | South Tach (V) (measure from TB1-T26 to TB1-T27) | "HA Vel Feedback" (V) (measure at U3-1) | Tach_Gain= "HVel" $(East + West) / 2$ | GAIN SPEC | GAIN PASS / FAIL | Tester Initials | Date |
|-----------------|---|---|--|---|--------------|---------------------|-----------------|---------|
| 100 | 0.81 | 0.81 | 0.17 | 0.210 | 0.20 to 0.22 | PASS / FAIL | Ear | 6/19/08 |
| 1000 | 8.3 | 8.3 | 1.70 | 0.205 | 0.20 to 0.22 | PASS / FAIL | L | L |
| 1800 | 15 | 15 | 3.1 | 0.207 | 0.20 to 0.22 | PASS / FAIL | L | L |

Table 12 DEC Axis Tachometer Gain Tests

4.8 Power & Miscellaneous Board Signals

Power and board level signals that do not fit into any specific category and are tested in this section. All measurements are referenced to "AGND".

| Signal Name | Measure At | Value | Units | SPEC | PASS / FAIL | Tester Initials | Date |
|-------------------|------------------|--------|-------|------------------|-------------|-----------------|---------|
| -0.44 V Reference | R154 / R153 Node | -436 | mVdc | -400 to -480 mV | PASS / FAIL | eanw | 6/19/08 |
| +0.44 V Reference | R150 / R143 Node | 440 | mVdc | 400 to 480 mV | PASS / FAIL | | |
| CLK OUT Frequency | U13 pin 14 | 7.04 | Hz | 7.0 to 8.0 Hz | PASS / FAIL | | |
| CLK OUT Vmax | U13 pin 14 | 5.1 | Vdc | 4.5 to 5.1 | PASS / FAIL | | |
| CLK OUT Vmin | U13 pin 14 | -520 | mVdc | -400 to -530 mV | PASS / FAIL | | |
| +15V Power | U7-3 | 15.27 | Vdc | 14.5 to 15.5 V | PASS / FAIL | | |
| -15V Power | U1-11 | -15.37 | Vdc | -14.5 to -15.5 V | PASS / FAIL | | |
| VCC Power | U11-16 | 5.04 | Vdc | 4.75 to 5.25 V | PASS / FAIL | | |
| TCS Lockout | TB1-T36 | 87 | mVdc | < 100 mV | PASS / FAIL | | |
| Mtr Cntr Err | TB1-T35 | 85 | mVdc | < 100 mV | PASS / FAIL | | |

Table 13 Miscellaneous Board Signal Testing

4.9 Watch Dog Timer

The Safety Board has two watch dog timers. The watchdog timer reset signal is sent from the TCS3 Control PC to the Safety Board. With the TCS3 software running and Safety Board powered, push and hold the momentary contact switch located at TB1-T38 for about 1-2 seconds. This disconnects the watchdog timer connection. Record the results. Depending on the timing, it may take a few attempts to get both errors to appear at the same time on the mcl screen.

| Condition | mcl Error Message | PASS / FAIL | Tester Initials | Date |
|----------------|--------------------------------|-------------|-----------------|---------|
| Normal | No Errors | PASS / FAIL | eanw | 6/19/08 |
| Switch Pressed | SafetyBrd_Watchdog_Tmr_Latch | PASS / FAIL | | |
| Switch Pressed | SafetyBrd_Clocking_Error_Latch | PASS / FAIL | | |

Table 14 Watchdog Timer Test

4.10 Brake & Telescope Relays

To test these relays, start tracking (turns off brakes) and measure between the specified points in the table. Then enter idle mode (turns brakes on) and measure the specified points again.

NOTE: In the lab system, the outputs of the relays do not ultimately connect to anything.

| Condition | Relay Under Test | Measure Between | Value | Units | SPEC | PASS / FAIL | Tester Initials | Date |
|-----------------------|------------------|--------------------|-----------|----------|---------------------------|-------------|-----------------|---------|
| Tracking (brakes OFF) | Brake Enable | TB1-B49 to TB2-B33 | 24.00 | V | 23V to 25V | PASS / FAIL | Eaon | 6/19/08 |
| Tracking (brakes OFF) | Telescope Amp | TB1-T1 to TB1-T2 | 0.4 | Ω | Less than 1 Ω | PASS / FAIL | | |
| Idle (brakes ON) | Brake Enable | TB1-B49 to TB2-B33 | 0.0 | V | Less than 100 mV | PASS / FAIL | | |
| Idle (brakes ON) | Telescope Amp | TB1-T1 to TB1-T2 | off scale | Ω | Greater than 1 M Ω | PASS / FAIL | | |

Table 15 Brake & Telescope Relay Tests

4.11 Dome Switch & Relay

The dome switch on the TO panel selects what controls the dome. Move the switch to the desired position and measure across the specified points.

NOTE: On the lab system, the output of this relay is not ultimately connected to anything.

| Dome Switch Position | mcc1 message | mcc1 message present? | Measure Between | Value (Ω) | SPEC | PASS / FAIL | Tester Initials | Date |
|----------------------|------------------------------------|-----------------------|-------------------|--------------------|--------------------------|-------------|-----------------|---------|
| Locked | "TO Panel has locked Dome Control" | PASS / FAIL | TB1-T4 and TB1-T5 | off scale | Greater than 1M Ω | PASS / FAIL | Eaon | 6/19/08 |
| Hand Paddle | "Dome Control Hand Paddle Mode" | PASS / FAIL | TB1-T4 and TB1-T5 | 0.4 | Less than 1 Ω | PASS / FAIL | | |
| Software | "Software Mode Is Locked" | PASS / FAIL | TB1-T4 and TB1-T5 | 0.4 | Less than 1 Ω | PASS / FAIL | | |

Table 16 Dome Switch & Relay Tests

4.12 Overall Servo

The overall servo testing will consist of tracking, offsets, and slewing. Use the specified PID and velocity feed forward values with the appropriate command. When performing these tests, look for any abnormal signs, specifically large oscillations. A basic knowledge of using the TCS3 control software is assumed. If more information on using it is required, please contact someone who is familiar with it (software programmer, TO, etc).

The measurements required for all the tables below come from the sub-tab "Perf-G" in the "Details" tab.

Basic commands used in command line prompt:

pg.ferr 2 Zooms in on following error window.

beam.set 30 30 Sets beam switch to 30 arcsec for both HA and DEC.

next.hadec 1 40 Sets slew position to 1hr (HA) and 40 degrees (DEC).

NOTE: As of 6/19/08, the lab system has some known stability issues believed to be primarily caused by the velocity feedback lag. Therefore, this section's spec values should be used as more of a guide than anything else. The whole point of this section is to see if the Safety Board tracks, slews, and offsets normally.

| Operation | HA Axis | | | | DEC Axis | | | |
|-----------|---------|-----|----|------|----------|-----|----|------|
| | P | I | D | Vff | P | I | D | Vff |
| Tracking | 60k | 15k | 3k | 10k | 50k | 15k | 5k | 10k |
| SLEW | 40k | 100 | 3k | 1280 | 60k | 100 | 3k | 1280 |

Table 17 Servo PID Settings for mcc3 window.

| Operation | Axis | Following Error - "pmac" plot | | | | SPECS PASS / FAIL | Tester Initials | Date |
|-----------|------|------------------------------------|--|-------------------|------------------------|----------------------|--------------------|---------|
| | | "range" arcsec peak- peak | SPEC "range" arcsec peak-peak | std dev arcsec | SPEC std dev arcsec | | | |
| Tracking | HA | 0.368 | 0.5 | 0.1 | 0.1 | PASS / FAIL | ganw | 6/20/08 |
| Tracking | DEC | 0.05 | 0.1 | 0.025 | 0.03 | PASS / FAIL | L | k |

Table 18 Tracking Tests

* There are issues with the lab system, but results look "typical".

| Operation | Axis | Offset (arcsec) | Settling Time "pmac" plot (yellow) | SPEC Settling Time (back to within 0.2 arcsec p-p band) | SPECS PASS / FAIL | Tester Initials | Date |
|-----------|------|-----------------|------------------------------------|---|-------------------|-----------------|---------|
| Tracking | HA | +30 | 1.7 | < 2 seconds | PASS / FAIL | zan | 6/20/08 |
| Tracking | HA | -30 | 2.2 | < 2 seconds | PASS / FAIL | | |
| Tracking | HA | +100 | 1.5 | < 2.5 seconds | PASS / FAIL | | |
| Tracking | HA | -100 | 2.5 | < 2.5 seconds | PASS / FAIL | | |
| Tracking | DEC | +30 | 1.5 | < 2 seconds | PASS / FAIL | | |
| Tracking | DEC | -30 | 1.5 | < 2 seconds | PASS / FAIL | | |
| Tracking | DEC | +100 | 1.5 | < 2.5 seconds | PASS / FAIL | | |
| Tracking | DEC | -100 | 1.5 | < 2.5 seconds | PASS / FAIL | | |

Table 19 Offset Tests

| Operation | Axis | Movement | Velocity Error - "pmac" plot (yellow) (during constant velocity portion of SLEW) | | | | SPECS PASS / FAIL | Tester Initials | Date |
|-----------|------|----------|---|---------------------------------|--------------------|-------------------------|-------------------|-----------------|---------|
| | | | "range" arcsec/s peak-peak | SPEC "range" arcsec/s peak-peak | "std dev" arcsec/s | SPEC "std dev" arcsec/s | | | |
| SLEW | HA | - | 492 | 150 | 55 | 20 | PASS / FAIL | zan | 6/20/08 |
| SLEW | HA | + | 230 | 150 | 34 | 20 | PASS / FAIL | | |
| SLEW | DEC | - | 23 | 15 | 4 | 3 | PASS / FAIL | | |
| SLEW | DEC | + | 24 | 15 | 5 | 3 | PASS / FAIL | | |

Table 20 Slew Tests

5 Completion

- 1) Power down the TCS3 lab setup.
- 2) Remove the safety board.
- 3) Verify that the correct build revision sticker is on the Safety Board.
- 4) Insert jumpers W1, W2, W3, and W4 back into the Safety Board.
- 5) Place "tested (date)" sticker on Safety Board.
- 5) Testing for the Safety Board is now complete and is acceptable for use in TCS3.