Appendix TAC
Three Axis Compass Option

Date: 14 December 2011
Software: 1.60

1.0 INTRODUCTION

The Three Axis Compass (TAC) is a smaller and less expensive heading sensor option compared to the Fluxgate Compass. The TAC is more expensive than the Single Axis Compass but is packaged in the same enclosure. Compared to the Single Axis Compass, the TAC allows heading determination without time-consuming mount movements.

The Three Axis Compass also offers potential for shorter satellite acquisition times since it is capable of determining platform tilt without performing mount movements.

1.1 Appendix Organization

This appendix is provided as a supplement to the baseline RC3000 manual. The unique items relating to the Three Axis Compass option are described following a paragraph numbering scheme corresponding to the baseline RC3000 manual's paragraph numbering.

1.2 Software Configuration.

The TAC is designated as one of the Navigation options of the RC3000.

Navigation Option Designation	Description
N	No Navigation Sensors
G	GPS / Fluxgate
C	CSI GPS derived heading
O	GPS only
S	GPS / Single Axis Compass
T	**GPS / Three Axis Compass**

The software containing the Three Axis Compass option would therefore be designated as RC3K-ab-**T**xyz.

1.3 Theory of Operation

This compass module contains 3 axis magnetic sensors and accelerometers that mechanize an electronically gimbaled digital compass. These sensors also provide the capability to determine the instantaneous tilt of the antenna system.

1.4 Specifications

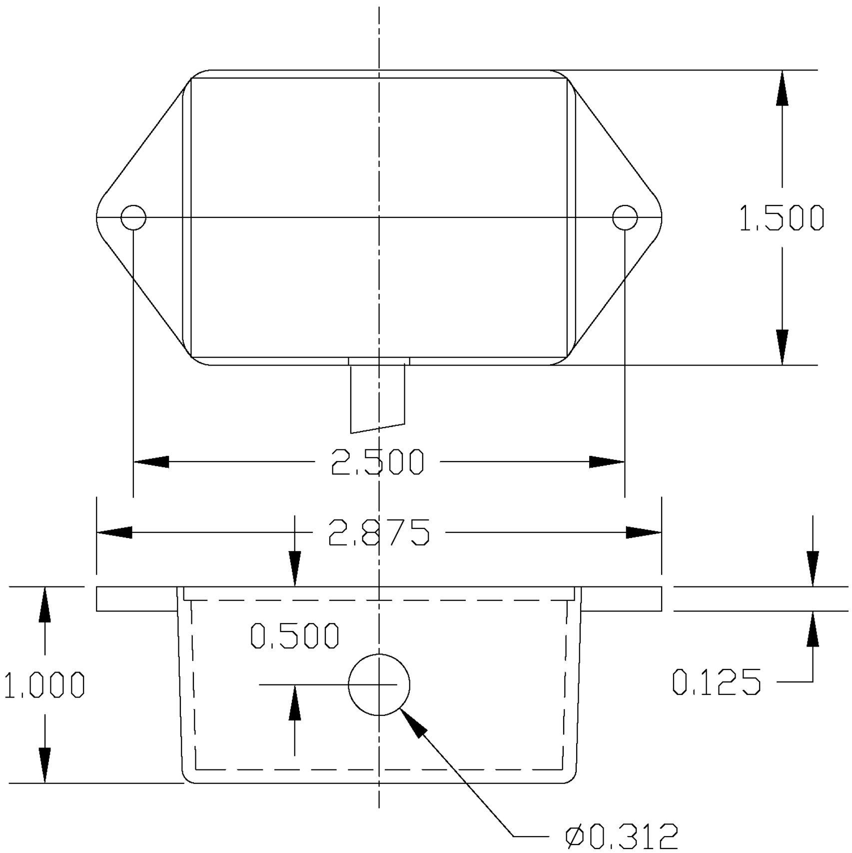
Compass Accuracy:	1 degree RMS while level (undisturbed field) 0.1 deg. resolution
Operating Temperature:	-40 deg. C. to 80 deg. C.
Tilt Sensing:	Pitch +/- 90 deg., Roll +/- 180 deg.

Hard Iron Calibration available

2.0 INSTALLATION

2.1.3 Compass Mounting

The Three Axis Compass consists of a 2.875" x 1.500" x 1.000" plastic box with an attached cable.



Three Axis Compass Box

The TAC box provides 2 mounting holes on end mounting flanges.
The standard part number for the compass is: FP_CMPOS01 which includes a 42 ft. unterminated cable. Contact RCI for other cable length or connectorization options.

MOUNTING CONSIDERATIONS

Because the TAC may also sense tilt, additional considerations need to be made with respect to how the TAC is properly mounted on the antenna system. When deciding on where to mount the compass box on the antenna structure, the following factors should be considered:

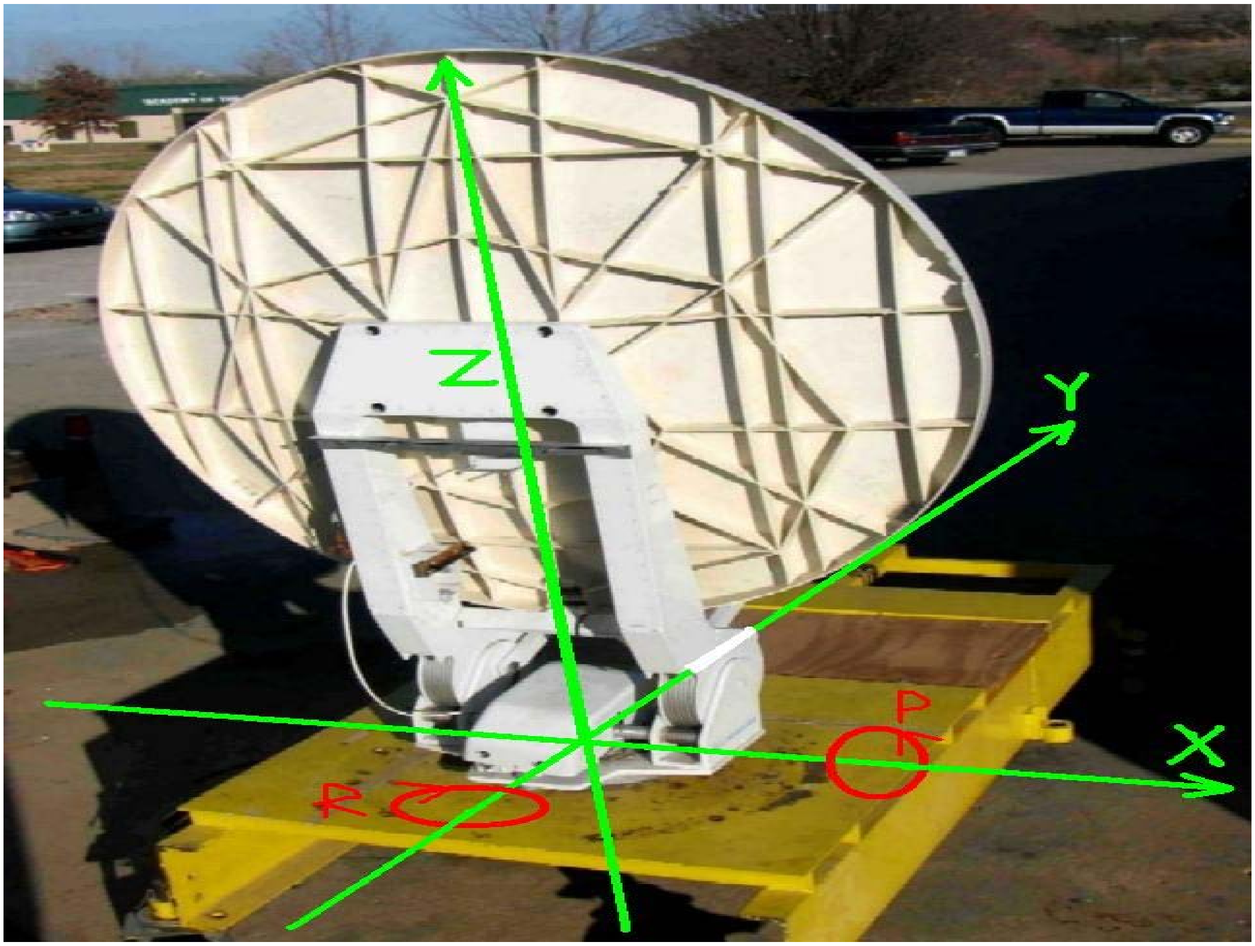
1) The box should be mounted as high on the antenna structure as feasible. When the antenna is deployed, the higher the compass can be mounted the "cleaner" the sensed earth's magnetic field will be.

2) The box should be mounted as close to the azimuth axis' center of rotation as possible. This means that preferably the box would rotate about a point when the antenna is rotated in azimuth (while at the elevation deploy position). If this is not achievable, minimize the distance from the center of rotation as much as possible.

3) The TAC may be placed in 1 of 6 orientations orthogonal to the antenna platform. The TAC installer should choose a mounting location that offers sturdy attachment to the antenna and convenient routing of the cable.

Antenna Platform

Proper placement and calibration of the TAC requires reference to the "antenna platform." The azimuth axis of an antenna rotates in an X/Y plane about the Z axis. The elevation axis rotates about the X axis. Heading is defined in the positive Y direction when the antenna is at the azimuth reference position. With respect to platform "tilt", pitch is rotation about the X axis and roll is rotation about the Y axis.



To correctly estimate antenna heading and to properly sense platform tilt, the TAC must be placed orthogonal to the antenna platform and must be calibrated while the platform is level.

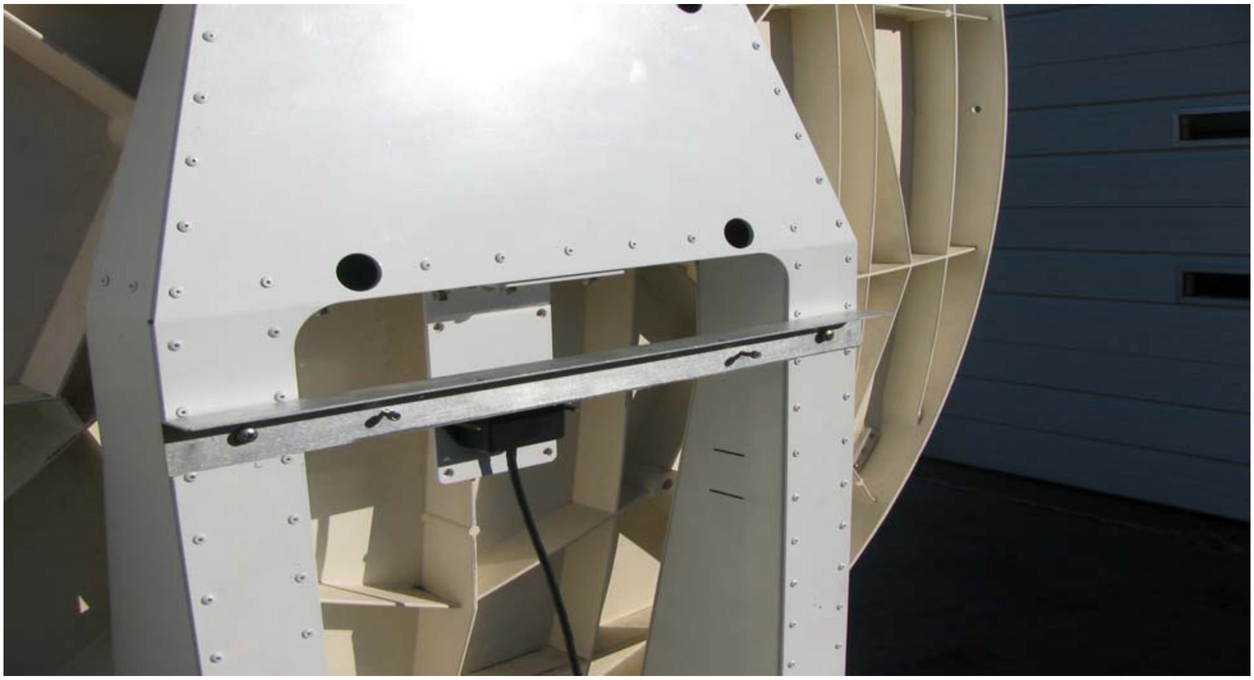
Mounting Orientations

The following pictures show the six different orientations that the TAC may be mounted with respect to the antenna platform's frame of reference. In all orientations the reported heading and tilt will be as defined above. Defining the orientation allows the TAC to translate the sensed gravitational field (from its 3 accelerometers) into a pitch and roll wrt the antenna platform. The orientation is also required by the TAC to "electronically gimbal" the magnetic sensors. Having chosen 1 of the orientations, it will be programmed into the TAC as described in the calibration section.

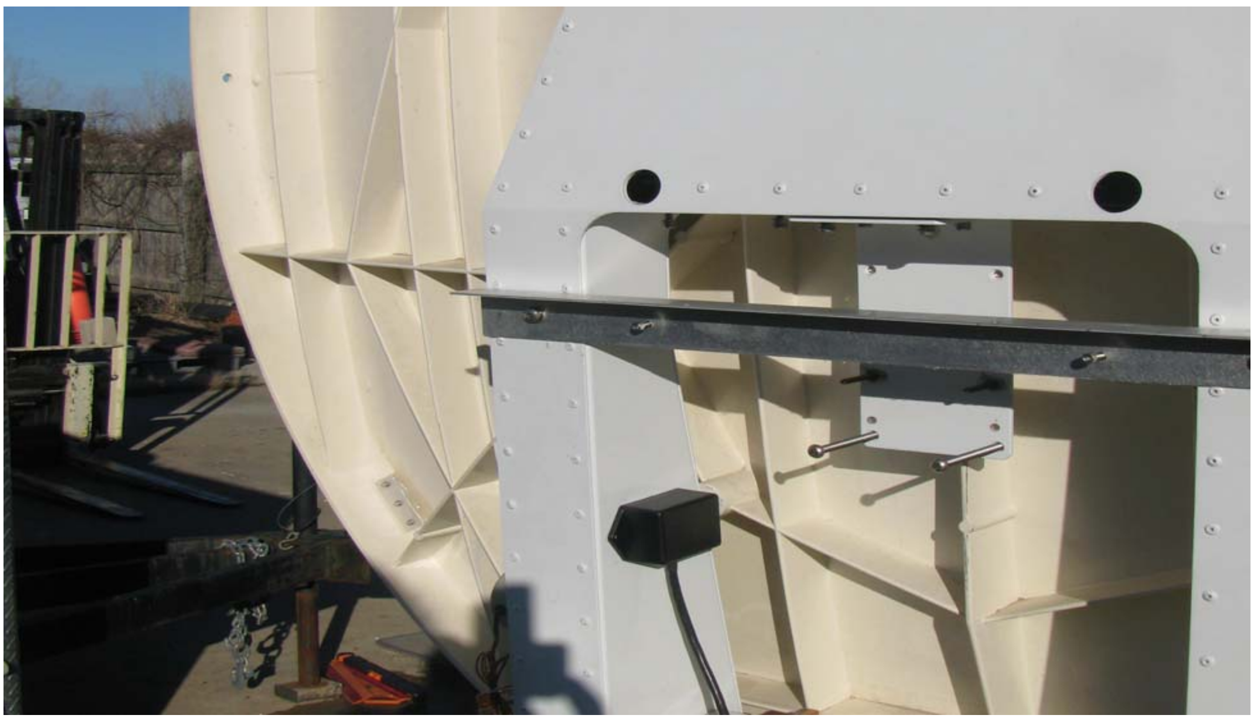
The six orientations may be thought of as the six sides of a cube that is in the antenna platform's reference axis. A description (top, front, etc.) is given to each orientation as a way to help describe it.

Orientation #1 "TOP"

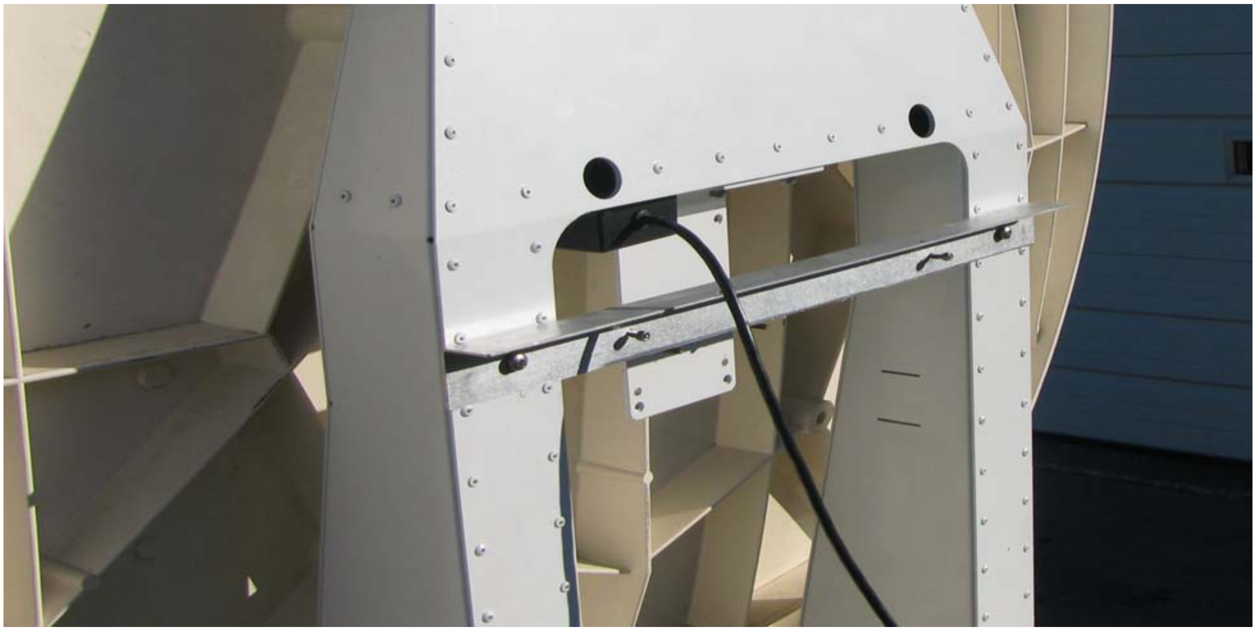
Orientation #2 "FRONT"



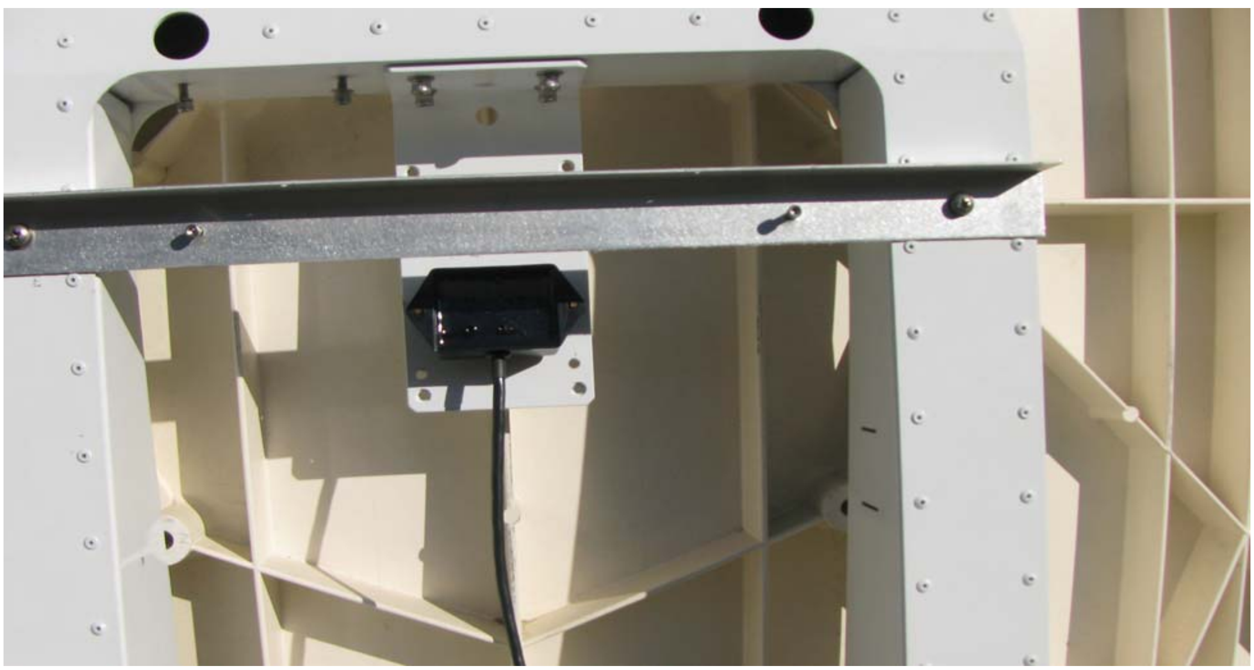
Orientation #3 "LEFT"



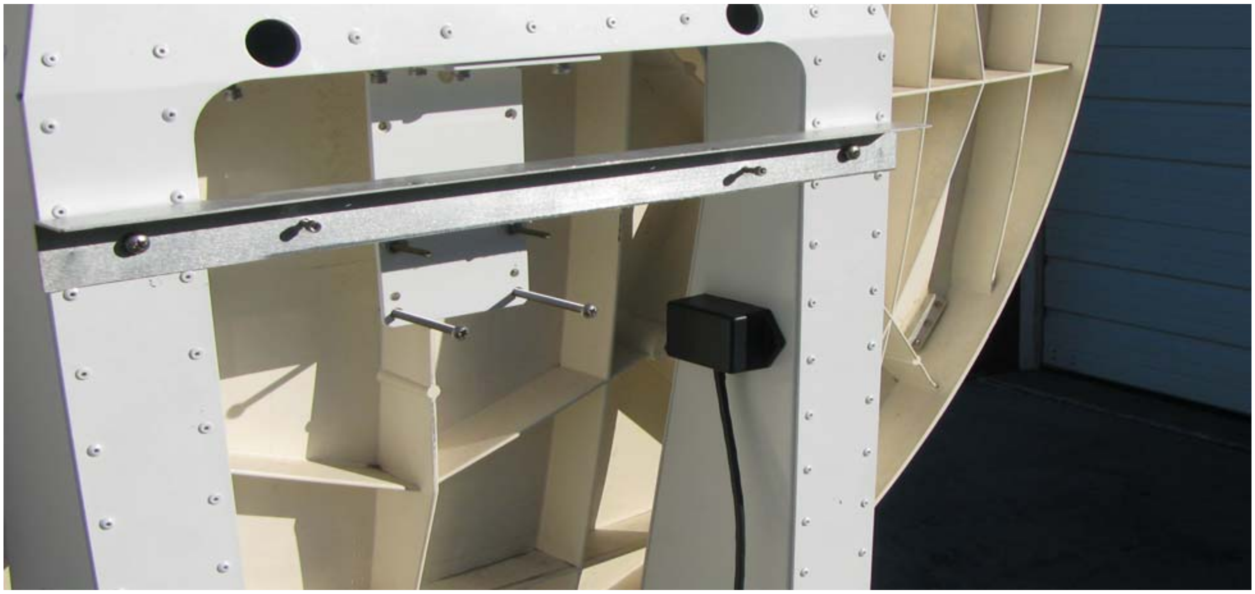
Orientation #4 "BOTTOM"



Orientation #5 "BACK"



Orientation #6 "RIGHT"



2.2 Electrical Connections

The "Compass" J9 (DB-9 Female) connector on the RC3000 backpanel is used to interface to the TAC. The following table describes the signals on the provided cable.

J9 (DB9)	COLOR	SIGNAL DESCRIPTION
2	Green	Serial Data to ACU
3	Orange	Serial Data from ACU
4	Yellow	+ 12 VDC
5	White	Ground
8	Clear	Drain Shield

A schematic of the cable connected to a DB9 connector is attached to the end of this document.

2.4.1 Compass Calibration

NOTE: All compass calibration actions must take place with the antenna platform level.

DEPLOY Position. The elevation deploy position should describe the elevation angle that places the TAC box level. If the default value is not correct, enter this value in the EL_DEP configuration item in the Stow & Deploy Positions configuration screen (see 3.3.1.3.10 of the baseline manual.)

Given a level platform, the following calibration actions can be accomplished from the TAC maintenance screen described in 3.3.2.9 below:

1) Orientation.

Confirm that the orientation shown in the "MNT" field is correct for the way the TAC is installed on the antenna. If not, program the correct orientation.

2) Center Tilt Sensors.

From the calibration position , press the +/- key to zero the pitch and roll values.
NOTE: The pitch and roll offset values determined in this step will be applied to all future reported pitch and roll values (until the calibration action is performed again.) It is therefore critical that the TAC box be perfectly level at this point.

3) Hard Iron Calibration.

If the antenna is to be placed on a vehicle, this step does not need to be accomplished until the antenna is in place and the calibration may be performed correctly. Refer to section 2.4.1 of the baseline RC3000 manual for guidance in picking a proper calibration sight.

The hard iron calibration function is initiated by pressing the ENTER key in the TAC maintenance screen. After initiating the function, rotate the vehicle/platform slowly in a circle. For best results, take at least 30 seconds to rotate. After turning a complete circle, signal the TAC that the turn has been completed by pressing the STOP key.

NOTE: for the TAC, the requirement of a level surface to perform the Hard Iron Calibration maneuver is critical.

3.0 Operation Overview

3.2.2.3 LOCATE

The LOCATE mode will sequence through operations described in the baseline manual in a similar fashion as when a fluxgate compass is installed. The LOCATE function initially gets lat/lon from the GPS, synchronizes time and calculates a local magnetic variation value. Finally the magnetic heading reading is obtained from the Three Axis Compass and an estimated true heading is calculated.

3.2.2.3.6 Polarization Tilt Compensation

Rather than performing antenna movements to characterize the platform tilt (via inclinometer readings), the TAC has the ability to determine polarization tilt compensation instantaneously after the LOCATE movement has arrived at the Target location. This ability would shorten total time to acquisition of the satellite.

In order to enable this instantaneous tilt sensing, the TILT field in the AUTOPEAK configuration screen should be set to 2 (COMPASS) as described in the calibration section.

3.2.2.7.2 Heading

In the POSTION/HEADING screen only the manual entry of true heading should be attempted.

```
    HDG:180.0    HEADING
    SRC:MANUAL
       <2>TRU
SELECT SOURCE <MODE>EXIT
```

3.3.3.2 Maintenance Items

When the three axis compass option is present, the choices "7-COMPAS" and "9-CMP CAL" are presented on the maintenance menu screen.

```
1-VOLTS   2-DRIVE   3-TIME   4-SIG MAINT
5-LIMITS  6-GPS COM 7-COMPAS 8-MOVETO
9-CMP CAL 0-SHAKE            .-CI RECORD
                             Z1-STRN1.59
```

3.3.2.7 Three Axis Compass Serial Port Diagnostics

Pressing the "7" key will select the Three Axis Compass Communications screen. This screen allows the user to ascertain if the Three Axis Compass is communicating correctly with the RC3000.

```
                              3 AXIS COM
$OHPR,266.1,0.8,0.1*2A==$OHPR,266.1,0.8,
0.1*2A==$OHPR,266.1,0.8,0.1*2A==$OHPR,26
6.1,0.8,-0.1*2A==$OHPR,266.1,0.8,-.1*2A=
```

The screen shows the raw ASCII data coming from the Three Axis Compass. If there is correct communication established with the compass, somewhere in the lines of displayed characters the string “$OHPR” should be recognizable. Following the “$OHPR” should be a number indicating the current magnetic heading (266.1 in example) the compass is reading. Following the magnetic heading, the current value of pitch (0.8 in example) and roll (0.1 in example) are displayed.

The $OHPR string of data should be updating at approximately four times a second.

3.3.2.9 Three Axis Compass Maintenance

Pressing the "9" key will select the Three Axis Maintenance screen. A reminder cautioning the user that any calibration actions require a level platform is initially displayed for several seconds while communication with the compass is being initialized.

```
                                                 3AXIS
*  CAUTION - ANY CALIBRATION ACTIONS   *
  MUST BE PERFORMED WITH PLATFORM LEVEL
INITIALIZING COMPASS
```

The maintenance screen allows the user to initiate antenna movements and compass calibration actions. The screen also displays the heading, pitch and roll currently being reported by the TAC.

```
-146.4        HDG:  26.5  MNT:1    3AXIS
  26.7      PITCH:  -2.1  SPD:SLOW
 -33.0       ROLL:  -2.0  CNT:     12345
<>X/Y CAL  <+/->ZERO P/R  <.>ORIENTATION
```

CNT:
This field shows the total number of correctly parsed data strings for heading, pitch and roll. This number should be increasing at a rate of approximately 4 Hz.

HDG:
This field shows the instantaneous magnetic heading reported by the TAC. After calibration, a sanity check of the heading may be performed by moving the azimuth and confirming that the reported magnetic heading moves in the correct direction.

PITCH: **<+/->ZERO P/R**
ROLL:
With the platform level, Pitch and Roll should show 0.0 +/- 0.1 degrees. A sanity check of pitch may be performed by moving the elevation axis UP. When moving up, the PITCH should increase.

MNT: <.>ORIENTATION

This field shows the currently programmed compass orientation.

Pressing the STOP/. key will cause the value in the MNT field to flash and the prompt "**<.> ENTER ORIENTATION 1-6**" to appear on line 4. Enter the correct compass orientation # (1 to 6) and press ENTER.
Following the entering a compass orientation, the reminder "**! IF ORIENTATION CHANGED, PERFORM X/Y CAL**" will appear on line 4 for several seconds.

<> X/Y CAL
Pressing the ENTER key triggers the TAC to begin collecting data for a hard iron calibration. The prompt "SLOWLY ROTATE PLATFORM <.> WHEN FINISHED" will appear on line 4 until the STOP/. key has been pressed.

SPD: FAST/SLOW
Toggles the speed of antenna movements.

4.0 Schematics