USER MANUAL

FOR THE

TIPTILT INFRARED SECONDARY

ON THE 2.3m TELESCOPE

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Version 1-4

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1. **User Guide**
   1. *Introduction*

The essential hardware components of the 2.3m telescope, tiptilt secondary mirror and infrared system are shown in Figure 1.1. The aim of the tiptilt system is to counteract any motion of the star caused by translational seeing and guide errors. To do this, the tilt of the secondary mirror can be adjusted rapidly to move the image of a star in the focal plane by up to 10 arcseconds.

In order to know how to move the secondary mirror, it is necessary to detect a guide star in the focal plane and tilt the secondary mirror to correct any deviation of the guide star from a designated *reference position*. The detection of the guide star is done with the tiptilt CCD. It uses the light shortward of 0.85 microns which is split off from the CASPIR beam with a dichroic beam splitter. The IMB focus is used to make sure the CASPIR array and the CCD are simultaneously in focus. Since guide stars need to be obtained over a wide field, the tiptilt CCD is carried on an X-Y stage that can move up to +/- 2.5 arcminutes.

When set to *correct* mode, the system reads out a small portion of the CCD called the *subframe* at up to 110 times per second. The guide star will be close to the centre of the subframe. The centroid of the guide star image is calculated, compared with its *reference position* at the centre of the subframe, and the positional error is converted into drive voltages for the mirror actuators.
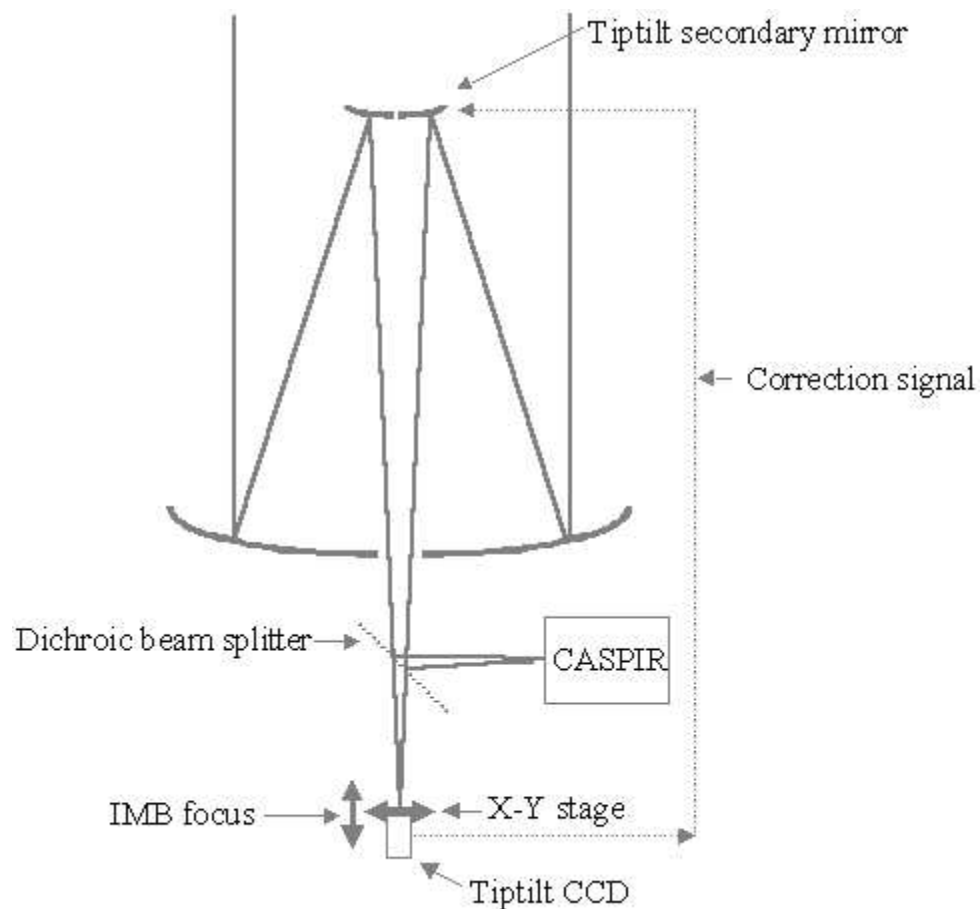
Figure 1.1: Hardware components of the 2.3m telescope, tiptilt secondary mirror and

infrared system

The computer interface of the tiptilt system runs on the Sun workstation "misty". A small Ximtool window shows the continually updating image taken by the tiptilt CCD (Figure 1.2). Also visible on this window is a small blue box (typically 8x8 pixels), the *subframe*. When operating in acquire mode, the whole CCD window of 64x64 pixels is continually updated. Each CCD pixel is 0.6 arcsec square and the visible CCD field is 38x38 arcsec. When operating in correct mode, the tiptilt system only displays the subframe: it is always at the centre of the window regardless of the position of the subframe (blue box) during acquire mode. (Note that the 64x64 pixel display is half of the 64x128 frame transfer CCD, the top 20% of whose store area is exposed to light during readout. This shows up as a semicircular bright patch on the top 20% of the image when the sky is bright, and as streaked star images if a star falls on this area during readout. Never try to guide on these streaked stars.)
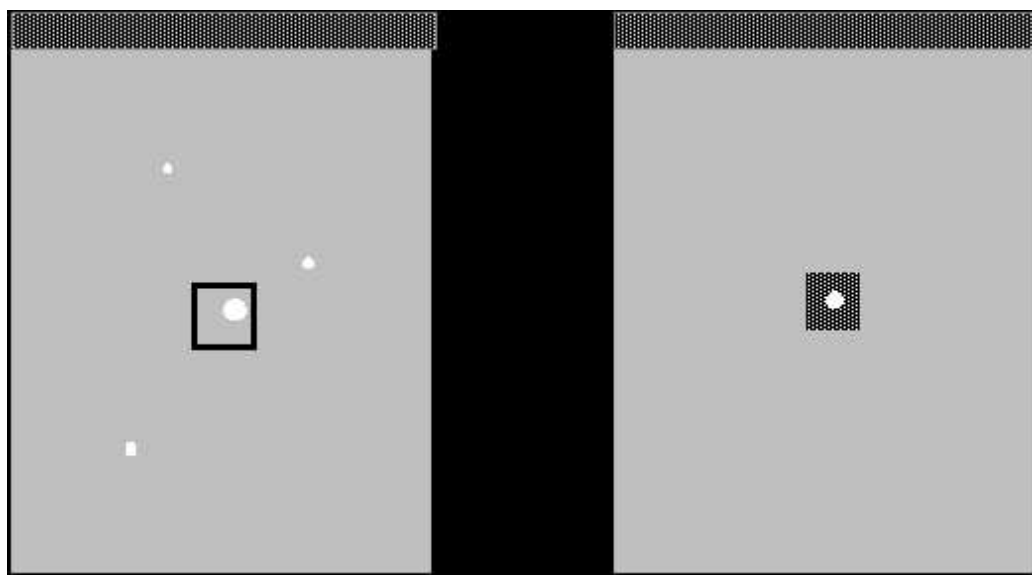

Figure 1.2: The Ximtool window during acquire mode (left), and during correct mode (right). Note that the image orientation is north up, east to the right. This is flipped left-right from the CASPIR display.

In a typical mode of operation, the user will specify a *tracking coordinate* for a science object which will cause the telescope to move and put the science object at the centre of the CASPIR array. The user will also specify a *guide coordinate* for the guide star which will cause the XY stage, or possibly the subframe, to move so that the guide star is near the centre of the subframe

There are a number ways in which tiptilt can be operated: from the GUI on misty, via commands at the telescope console, or via CASPIR DO files. In the latter case, which is undoubtedly the most efficient, the infrared computer MOPRA controls the telescope, CASPIR and tiptilt. Examples of DO files for typical observations are given in Section 1.4 below. It is recommended that these examples be modified for by the observer for his or her particular objects.

Sections 1.2 and 1.3 provide a brief guide on use of the tiptilt system. Section 1.4 gives DO file examples covering most types of observations. A summary is given in Section 1.5. The latter half of the manual, Section 2, is a Reference Guide giving details of all the possible commands associated with the tiptilt system.

2. *Starting up*

Make sure "Telescope Systems" power is on (top left of telescope console: automatically started if telescope startup sequence is run). Start the tiptilt system by typing

tiptilt &

in a window on the Sun workstation misty. Wait a minute or so for the various windows to appear. In particular, there should be an Ximtool window with a rapidly updating image from the CCD.

Make sure that you have entered the following on the telescope console:

enlist tt

enlist ir

configure effective_wavelength 1700 (a mean wavelength - the exact value is not critical)

configure guider_wavelength 700

On the CASPIR control console type the following:

caspir/tiptilt

caspir/stage_offset

3. *Calibration*
   1. **Initial calibration (only at the start of a run)**

Before doing any observing, you must properly calibrate the telescope and guider systems, in particular, the telescope apertures and pointing, and the guider stage. This is done with the following procedure:

- TRACK a bright object (say, a standard star) with a known coordinate.
- Focus the telescope on the CASPIR array.
- Centre the star on the CASPIR display, pixel (128,128). For fine adjustment, use the CASPIR ZOOM function.
- Use the CALIBRATE APERTURE command to define an aperture. Follow the steps of the calibration procedure as prompted. Remember on subsequent nights to select the aperture (eg. A) you want to use (by default, it is the previous aperture used).
- Centre the star in the aperture once more and issue the CALIBRATE POINTING command.
- If the guider stage is positioned too far from the field centre, the star may not appear on the Tiptilt CCD display. In this case, try issuing the command IMB/XY_HOME on the CASPIR command line. If the star still doesn't appear on the Tiptilt display, try the commands IMB/X_ABS =-548 and IMB/Y_ABS=-99.
- Focus the star in the Tiptilt display by using the IMB/FOCUS command on the Infrared system.
- Issue the CALIBRATE STAGE command on the telescope console and follow the steps of this procedure as prompted.
- If the subframe was positioned over the star and is now in an inconvenient position, it can be brought to the centre with the Telescope command: TIPTILT/TRACK/REF=(32,32). (Or any other values desired.)
- All the above can be achieved (in principle, more quickly and accurately) by the single command CALIBRATE TIPTILT/ALL on the telescope console. Have a star centred on the CASPIR array and visible on the tiptilt CCD before issuing the command: then follow the instructions.

   1. **Regular calibration**

The IMB focus and the aperture calibration should not need to be done more than once per run. On subsequent nights, make sure that the calibrated aperture is selected (with the command APERTURE/SHOW). CALIBRATE POINTING needs to be done on a regular basis, as for non-tiptilt observing. The stage should not normally require recalibration. However, if CALI STAGE/ADJUST is used during spectral observations (section 1.4.7.1), the stage centering may be significantly altered and a CALI STAGE should be done before recommencing imaging observations.

   1. *DO file examples*

The most efficient way to use Tiptilt is via CASPIR DO files. Some examples of DO files which cover common tasks are listed here. In all the examples, it is assumed the system has been properly calibrated with the CALIBRATE APERTURE, CALIBRATE POINTING and CALIBRATE STAGE commands. You should also have typed CAS/TIP and CAS/STAGE on MOPRA. Appropriate correct times for tiptilt (tt_ct) for guide stars of known magnitude can be obtained from the table near the end of this manual.

   1. **Standard or other bright stars**

RUN cy=100 tim=0.3 dec=+12 fil=K tt_mo=correct tt_ct=10 gra=0 gdec=0 stage

RUN dec=-12

This command sequence is for doing a bright standard star in K. The file is suitable for any object that is bright enough to act as the tiptilt guide star. It is assumed that a TRACK/COORD command has been issued

on the telescope console. The DO file first sets CASPIR to an exposure time of 0.3 seconds and 100 cycles. It sets the tiptilt correct mode exposure time to 10ms (tt_ct=10) and tells the system to use a guide coordinate with zero offsets from the tracking coordinates (ie. use the tracking object for correcting). It then offsets the telescope by 12 arcseconds in declination, starts tiptilt correcting and begins the CASPIR run. The second line does much the same thing but with the telescope offset by -12 arcseconds in declination. Note that in both cases the X-Y stage will be moved to keep the object in the tiptilt subframe. The parameter tt_ctime could be increased for less bright objects.

2. **Observing a list of objects**

   DARK tim=2 cy=30 rep=1 met=2 tiptilt stage acqx=2 acqy=2 acqdx=60 acqdy=60 -

   ttx=28 tty=28 ttdx=8 ttdy=8 tt_mod=acquire tt_at=100 gra=0 gdec=0 nott_find

   !

   RUN "STAR1",tra="18 00 33.8 -28 01 10 j2000" dec=+12 filt=k tt_m=correct -

   guide="18 00 37.0 -28 01 58 j2000" tt_ct=20

   RUN dec=-12

   RUN "STAR2",tra="18 29 02.1 -30 21 11 j2000" dec=+12 -

   guide="18 29 05.0 -30 21 59 j2000" tt_ct=10

   RUN dec=-12

   RUN "STAR3",tra="18 30 49.0 -30 24 10 j2000" dec=+12 tt_m=acquire

   RUN dec=-12

   RUN "STAR4",tra="18 29 12.9 -30 21 43 j2000" dec=+12 tt_m=correct-

   guide="18 29 05.0 -30 21 59 j2000" tt_ct=10

   RUN dec=-12

   The first DARK line is used to make sure the tiptilt parameters are set to suitable values. The tiptilt subframe is set to 8x8 pixels (ttdx=8, ttdy=8), and the acquire box is set to the entire CCD except for edge columns and rows (acqx=2 acqy=2 acqdx=60 acqdy=60). The *nott_err* flag is set so that the observation will continue if a suitable guide star is not found. Note that the DARK exposure will be done with the telescope pointing at the tracking coordinate in operation when the DO command is issued.

   For the first RUN on each tracking object, the object name and coordinates are defined, as are the guide coordinates if available (in this example, there is a guide star available within 2.5 arcmin of all tracking objects but the third). Note that the track and guide coordinates remain in operation on subsequent lines until explicitly changed (the dec=-12 exposure is done with the same guide star as the dec=+12 exposure in this example, the stage moving between exposures to keep the guide star in the tiptilt subframe). . For STAR3, no guide coordinate is specified, so the guide coordinates for the previous object will be assumed. The stage will not be able to move to this position with the telescope pointing at the tracking object, so a stage-out-of-range error will be printed on the telescope console. This does not stop operation, and the exposure will be done without tiptilt.

   The filter and tiptilt mode are defined by the first RUN command of the DO file and remain in operation for the remainder of the DO file. The tiptilt exposure time is specified for each guide object (see the Table at the end of the Manual for appropriate values). Any number of objects and filters could be added to the list, each object with or without a guide star .

3. **Mosaicing**

   DARK tim=2 cy=30 rep=1 met=2 tiptilt stage acqx=2 acqy=2 acqdx=60 acqdy=60 -

   ttx=28 tty=28 ttdx=8 ttdy=8 tt_mod=acquire tt_at=100 gra=0 gdec=0 nott_find nott_error

   !

RUN "GRB source", tra="1 18 45.0 -5 26 00 j2000" dec=+120 ra=120 tt_m=correct -

guide="1 18 38.6 -5 27 21 j2000" filt=k tt_ct=25

RUN dec=+120 ra=0

RUN dec=+120 ra=-120

RUN dec=+0 ra=+120

RUN dec=+0 ra=0

RUN dec=+0 ra=-120

RUN dec=-120 ra=+120 guide="1 18 54.6 -5 27 21 j2000" tt_ct=10

RUN dec=-120 ra=0

RUN dec=-120 ra=-120

In a mosaic, guide stars may only be available in some positions (a guide star must exist within 2.5 arcminutes of the position, in RA and Dec). If there is no accessible guide star, then the exposure will be done without tiptilt. In this sort of file, guide stars are added to appropriate lines if available (with either a *guide=* command, or *gra=* and *gdec=* commands, and a tt_ctime). The first DARK line sets appropriate tiptilt parameters while the first RUN line sets the filter and correct mode.

4. **Dithering**

DARK tim=2 cy=30 rep=1 met=2 tip stage acqx=2 acqy=2 acqdx=60 acqdy=60 -

ttx=28 tty=28 ttdx=8 ttdy=8 tt_mod=acquire tt_at=100 gra=0 gdec=0

!

RUN "Sgr_A*",tra="17 42 29.5 -28 59 18 b1950" ra=+4.75 dec=+4.75 -

guide="17 45 31.4 -28 59 53 j2000" tt_m=correct tt_ct=30 fi=k

RUN ra=+4.75 dec=-4.75

RUN ra=-4.75 dec=+4.75

RUN ra=-4.75 dec=-4.75

RUN "LWHM32",TRA="17 41 35.1 -29 05 00 B1950" RA=+4.75 DEC=+4.75 -

guide="17 44 46.6 -29 07 17 j2000" tt_ct=40

RUN ra=+4.75 dec=-4.75

RUN ra=-4.75 dec=+4.75

RUN ra=-4.75 dec=-4.75

The DARK is done first, setting all the relevant parameters. Then some dithered RUN lines follow, the first RUN on each object setting the filter as well as defining the tracking and guide coordinates and selecting correct mode.

5. **Using the FIND option**

DARK gra=0 gdec=0 ttx=28 tty=28 ttdx=8 ttdy=8 acqx=2 acqy=2 acqdx=60 acqdy=60 -

nott_err tt_mod=acquire tt_at=70 tt_ct=100 cy=100 ti=0.3 stage tip tt_find

DARK cy=60 ti=1

!

RUN "D18465" ,TRA="18 46 34.6 -7 17 18 B1950" FIL=K TI=0.3 CY=100 DEC=-10 -

tt_fi gra=0 gdec=0

RUN FIL=H

RUN FIL=J TI=1 CY=60

RUN "D17208" ,TRA="17 20 53.6 -37 2 47 B1950" FIL=K TI=0.3 CY=100 DEC=+10 -

tt_fi gra=0 gdec=0

RUN FIL=H

RUN FIL=J TI=1 CY=60

RUN "D17223" ,TRA="17 22 23.6 -37 41 44 B1950" FIL=K TI=0.3 CY=100 DEC=-10 -

tt_fi gra=0 gdec=0

RUN FIL=H

RUN FIL=J TI=1 CY=60

The DO file in this example does sequential observations of a series of objects using tiptilt if a guide star turns up on the tiptilt CCD. A large tt_ct is used to increase the chance of a guide star being found, at the expense of image size reduction. If no suitable guide star appears, the observation is done without tiptilt operating. The important distinction between tt_find and nott_find is described below.

Tiptilt is normally run with nott_find in operation (this is the default). With nott_find, the *telescope moves* to bring the brightest star in the acquire box (assumed to be the guide star) to the centre of the tiptilt subframe: consequently, the tracking object is put on an exactly defined part of the CASPIR array. However, when tt_find is used, tiptilt *moves the subframe* onto the brightest star in the acquire box (normally the full CCD) and starts correcting there, leaving the tracking object on the part of the CASPIR array that it was put by the telescope in response to the TRACK command issued by the DO file. Generally, nott_find is not terribly useful because the chance of having a bright guide star in the small CCD frame is small.

6. **Not bothering to use tiptilt**

Any of the files above could be used without tiptilt if the *notiptilt* keyword is added to the first line instead of the *tiptilt* keyword. For example:

DARK gra=0 gdec=0 ttx=28 tty=28 ttdx=8 ttdy=8 acqx=2 acqy=2 acqdx=60 acqdy=60 -

nott_err tt_mod=acquire tt_find tt_at=70 tt_ct=100 cy=100 ti=0.3 stage notip

DARK cy=60 ti=1

!

RUN "D18465" ,TRA="18 46 34.6 -7 17 18 B1950" FIL=K TI=0.3 CY=100 DEC=-10 -

tt_fi gra=0 gdec=0

RUN FIL=H

RUN FIL=J TI=1 CY=60

7. **Spectroscopy**
    1. *Short-slit grism spectroscopy*

        RUN ra=+4 dec=0 tt_mode=correct tip nostage

RUN ra=-4 dec=0 tt_mode=correct

RUN ra=-4 dec=0 tt_mode=correct

RUN ra=+4 dec=0 tt_mode=correct

Tiptilt can greatly increase the photon flux passing through a narrow slit in spectroscopic mode. It is important that the science object falls in exactly the central position of the slit with tiptilt running but before any offsetting is done. This position is close to pixel (128,128) - see the CASPIR manual for

determining its position. Two methods for getting the science object into the centre of the slit are given below. The first is probably more simple. (CASPIR will need to be in an imaging mode in order that the user can see the position of the science object: switch back to spectroscopic mode when positioning is completed. If the object being observed is bright enough that the spectrum can be seen on the CASPIR idle display, then the intensity of the spectrum can be peaked up in the procedures below, while CASPIR remains in spectroscopic mode).

Method 1

1. Specify the guide and track coordinates and put tiptilt in correct mode *by using telescope commands*. This would be done by (for example):

TRACK HD38150 (or TRACK/COORD 17 23 …)

TIP/TRACK (or TIP/COORD 17 24 …)

TIP/CORRECT

2. Issue the command CALI STAGE/ADJUST on the telescope console, and follow the instructions. Note that one click of the arrow keys for IMB/XY_INC is approximately 0.5 arcsec.

3. The object should now be at the centre of the slit. Now run the DO file above as many times as desired. It assumes the slit is aligned E-W. The science object is exposed at positions +/- 4 arcsec from the central slit position.

Method 2

This method relies on making small corrections to the guide coordinate in order to exactly position the science object at slit centre.

Firstly, on the telescope console, define the tracking and guide coordinates and start tiptilt with:

TRACK/COORD "Tracking Object" 12... (usual format) (or TRACK Object-name)

TIP/COORD "Guide Object" 12... (usual format) (or TIP/TRACK)

TIP/CORRECT

Note the position of the science object on the CASPIR array and the offset from the desired position.

The **guide coordinates** are now adjusted by the (small) amount needed to put the science object in exactly the correct place on the CASPIR array. This is done with a repeat of the commands:

TIP/COORD "Guide Object" 12... (changed value)

TIP/CORRECT

Check again, and repeat until satisfied. For narrow (1 arcsec) slits, the guide star declination can be set to 0.25 arcsec to advantage (for an E-W slit orientation).

When the science object position has been correctly set and the CASPIR parameters set, run the DO file above (as many times as required). It assumes the slit is aligned E-W. The science object is exposed at positions +/- 4 arcsec from the central slit position.

2. *Long-slit grism spectroscopy*

The procedure here is similar to that for short-slit spectroscopy except that larger offsets are possible. If the offsets are >15 arcsec, then omit the "nostage" keyword. NOD mode can also be used (see the CASPIR manual for details).

2. *Summary: Quick guide to using tiptilt*

1. Make sure that you have entered the following on the telescope console:
   1. **enlist tt**
   2. **enlist ir**
   3. **configure effective_wavelength 1700**
   4. **configure guider_wavelength 700**
2. On the CASPIR control console type the following:
   1. **caspir/tiptilt**
   2. **caspir/stage_offset**
3. Track a (bright) calibration object
4. On the telescope, calibrate as usual by
   1. **calibrate aperture**
   2. **calibrate pointing**
   3. **calibrate stage**

   or **cali tip/all** to do all 3 together
5. For efficient use of the telescope, use a DO file based on one of the examples above, or one made to your own prescriptions.

For exploratory purposes, you can always get tiptilt operating on guide stars visible on the tiptilt CCD by using the GUI on misty, or by issuing telescope commands.

2.
Known Bugs

Bug	Workaround
1. Some tiptilt parameters are not restored after do file completion on CASPIR	There is no workaround for this. Refer to the user manual as to which parameters are affected.
2. Deletion of acquire frame on ximtool should reset acquire frame size to default	Deleting the acquire frame makes it disappear from the screen, but it is not actually reset. There is no workaround.
3. Queue manager on MAIA does not work	Means that you cannot print to laser from MAIA. Copy file to MOPRA and print from there
4. Moriarty-sso hangs if Astromed controller is powered off while tiptilt in operation	Don't turn Astromed off
5. On SUN: Run-time exception error; current exception: IPC_Error During stack unwinding a destructor must handle its own exception	Only occurs during shutdown. Creates a core file which should be deleted; there is no workaround.
6. Describing an acquire frame when not in acquire mode gives "ignoring region marked outside CCD" error	No workaround: only draw acquire frames when in acquire mode.
7. May drop into Idle state during Acquire mode.	Once or twice a night, the remote tiptilt process on moriarty will be reset. This used to require a power cycle on moriarty, but now it will just drop to the Idle state. Normal operation should be possible from then on.

8. Killing ximtool from window button causes hang	Don't shut down the ximtool your self. Let tiptilt do it when you do a normal shutdown.

1.
2. Reference
1. *The Solaris Interface*
1. **Starting up Tiptilt**

1. Log onto misty and make sure that OpenWindows starts up
1. In a window type "tiptilt &"
1. The tiptilt control and status windows should appear. Wait for about 30 seconds while the Astromed controller is initialised.
1. A modified Ximtool window will also appear. Note that the user can start another ximtool (or saoimage) from a window on misty and use it for data reduction while tiptilt is running.

1. **The Control Window**

The tiptilt control window is shown in Figure 2.1.
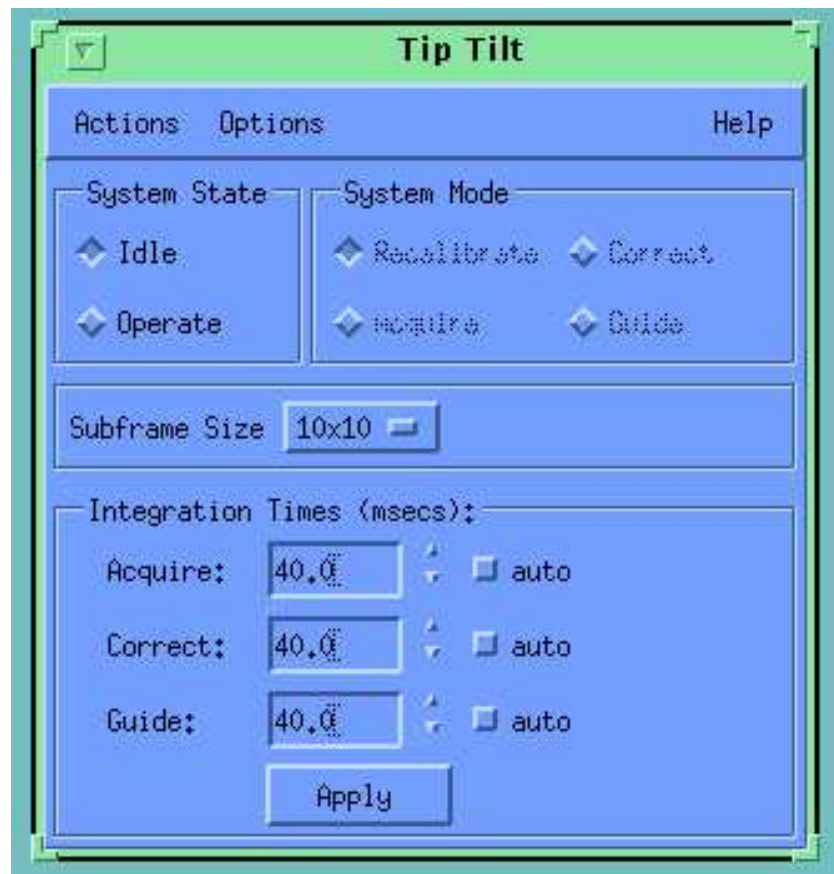
Figure 2.1: The Tiptilt control window

This window is used to control the actions of the tiptilt system and also to set some of the more commonly used parameters associated with the system's use. The window has three sections, each described below.

1. *Menu Bar*

At the top of the window is a menu bar with three pull down menus, the Actions menu, the Options menu and the Help menu.

The Actions menu allows the user to quit the system if necessary. The other two actions allow the

user to save and read in files containing parameter settings. The best policy is to save the current settings to a file (the default is .tiptilt) and edit this file to effect the desired changes. Note that this reading and writing of parameter files is optional. All of the parameters may be altered through the GUI at any time.

The Options menu contains three options, the Show Status Window option, the Show Centroid Statistics option and the Advanced Settings option. The status window is displayed by default. If the status window is dismissed, then the first option will redisplay it. The Centroid statistics window is explained in section 2.1.4 and the Advanced Settings dialogue in section 2.1.5.

The help menu is currently inactive.

2. *System State Controls*

The next panel in this window is used to both set and display the current system state. By clicking on the Operate radio button, the tiptilt system will check and initialise the hardware systems, and begin reading out the CCD in the Acquire mode. By pressing the Idle button, the system is made inactive.

3. *System Mode Controls*

The System Mode radio buttons are used to select system behaviour whilst in the Operational state. Recalibrate mode checks the hardware, recalibrates bias and display settings and then automatically enters the Acquire mode. Recalibrate mode can be used to force an initialisation of the CCD controller by setting the "Initialise CCD Controller in Recalibrate mode" check box in the advanced settings dialogue. See section 2.1.5 below.

In the Acquire mode, the entire CCD is continuously read out and displayed in the Ximtool window to allow a guide object to be positioned on the CCD. There are two areas of the Ximtool window which are of special importance - the **subframe** and the **acquire frame**.

During Acquire mode, the subframe is shown as a yellow box on the Ximtool. The subframe may be moved by holding down the shift key and clicking the left mouse button on the pixel where the subframe should be centred. The subframe will now be redisplayed.

The acquire frame is not initially visible, and occupies the entire CCD. It is used in the automatic acquisition methods on the telescope to find the brightest object. If a crowded field is present on the CCD and the user wishes to limit the acquisition area to a portion of the CCD, a new acquire frame may be drawn on the CCD by holding down the left mouse button and dragging to describe the frame. The image of the acquire frame may be deleted from the Ximtool by using the right mouse button within the frame area and selecting the destroy option from the menu which appears. Please note that this removes the acquire frame image from the Ximtool but does not reset the definition of the acquire frame within the tiptilt system. The acquire frame may be reset by drawing a new frame, as described above, or by reading a parameter file containing the desired acquire frame dimensions. Note that drawing an acquire frame when the system is not in acquire mode results in an error. It is best not to include the edge columns (1 and 64) and rows (1 and 64) in the acquire box as these sometimes have high counts.

By selecting the Correct radio button the tiptilt system enters the Correct mode. In this mode, the subframe specified in Acquire mode is read out rapidly. The image is centroided, and the tiptilt mirror is moved to correct for the difference between the centroid position and the centre of the subframe. The long term mirror deflection (caused by telescope tracking inaccuracy) is applied to the telescope system as in an ordinary auto-guider. The subframe is displayed on the Ximtool, but is shown in the centre of the display, not at its relative position on the CCD; that is, although the image has moved in the display, the telescope has not moved. When the system returns to Acquire mode, the mirror is reset to the no-deflection position.

In Guide mode, the system will not correct the centroid using the mirror, but will average the errors over a 1 second period and transmit the resulting corrections to the telescope system to adjust the tracking. Telescope corrections are averaged (and not transmitted at the Guide exposure rate) to "filter" the correction signal and because the telescope tracking will not respond in less than a second.

4. *Other Control Window Parameters*

The bottom half of the window is devoted to some of the more commonly changed parameters. The first is a list selection of subframe sizes. Possible values are 8x8, 10x10, 12x12 and 16x16. The default size is 10x10. For integration times less than 10ms, the 8x8 subframe is required. The selected subframe is displayed on the Ximtool.

The next three fields control the CCD integration times in milliseconds for the various Operational modes. A check box next to each field instructs the system to calculate an integration time itself. It does this in Acquire mode by starting at a minimum integration time of 10 ms and increasing the time by 5 ms until a centroid is found. In Correct and Guide modes, the integration time is scaled from the peak counts found in Acquire mode and the Acquisition integration time.

Note that these parameters will not take effect until the Apply button is pressed.

2.
3. **The Status Window**

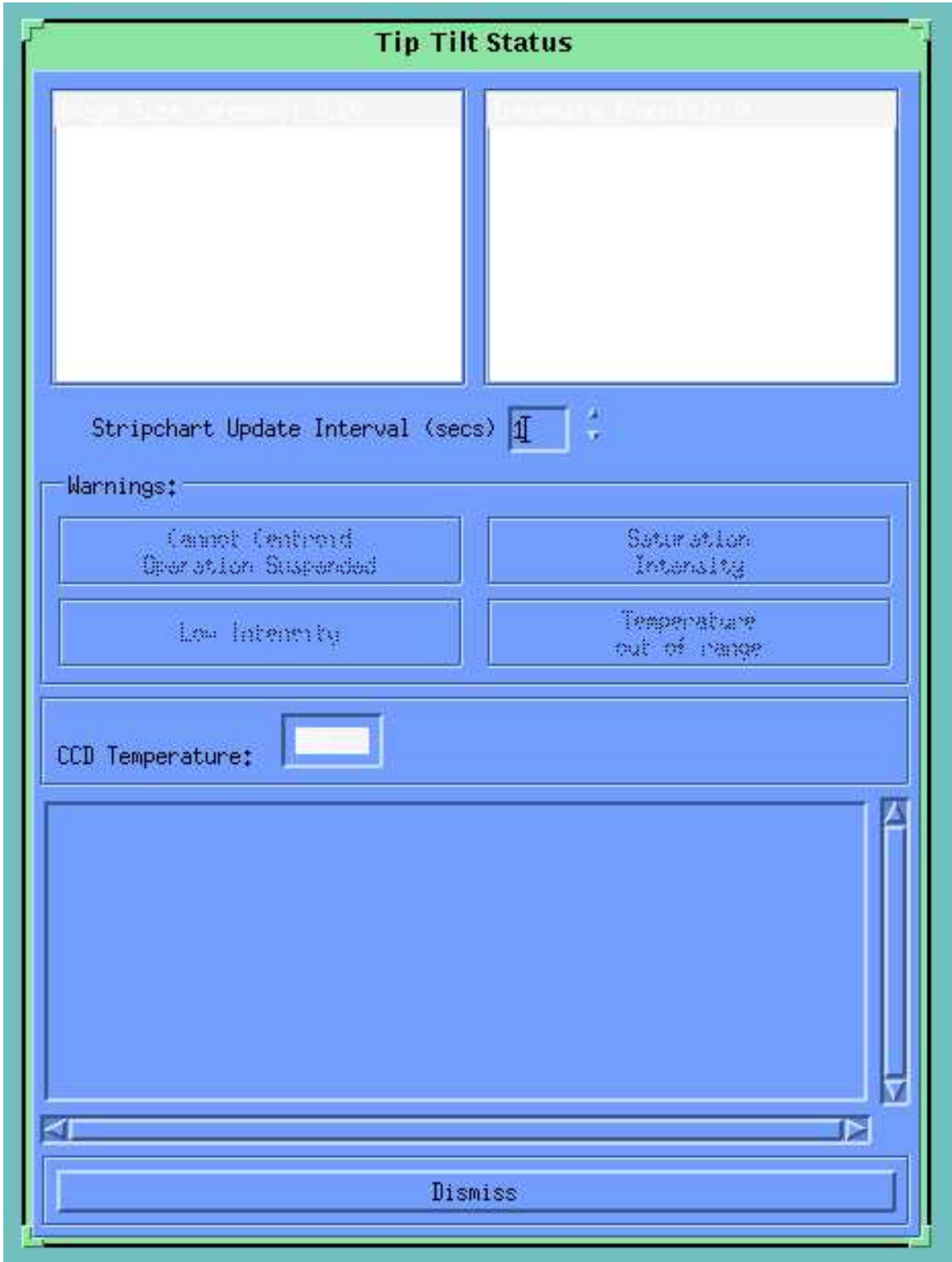The tiptilt status window is shown in Figure 2.2.

Figure 2.2: The Tiptilt status window

This window has three sections: at the top are two strip charts which display the (approximate) instantaneous full width at half maximum in arcseconds and the peak intensity in ADU counts. The update rate for the two charts may be set in the field immediately below them.

The next area in this window will display current system warnings and the temperature of the CCD. The warnings which may appear are:

- Cannot Centroid - Operation Suspended: this means that a centroid was found in less than a percentage threshold (default 95%) of the last M images (M is 100 by default). In the Acquire mode this means very little. In Correct or Guide mode, it means that corrections are not being made. The mirror is left in the last position determined before corrections stopped. The percentage threshold and the number of frames used are both set in the Advanced Settings dialogue - see section 2.1.5 below.
- Saturation Intensity: this means that a frame or frames contained pixels above the saturation threshold (set at 20000 counts). If this warning is persistent, check that the CCD is still cold (<240K) or try reducing the integration time.
- Low Intensity: this means that a frame or frames did not contain enough pixels of sufficient intensity to centroid. See the Advanced Settings dialogue for more information on setting the low intensity limit.
- Temperature out of Range: this warning lights up if the temperature of the CCD drifts more than 15 degrees from the set point. (the set point is currently 220K but is not adjustable by the user).

The temperature of the CCD is displayed in Kelvin below the warning lights.

The final area in the Status window is a scrolling text area where messages will appear during the course of operation. During system startup, messages pertaining to the hardware initialisation of the Astromed controller will appear here. Some error messages will appear here as well, particularly regarding errors in network communications, hardware errors from the tiptilt corrector assembly and software error conditions. Please note down the messages displayed here in cases of catastrophic failure. In most cases, shutting down the software and restarting should clear the error.

1. **Centroid Statistics**

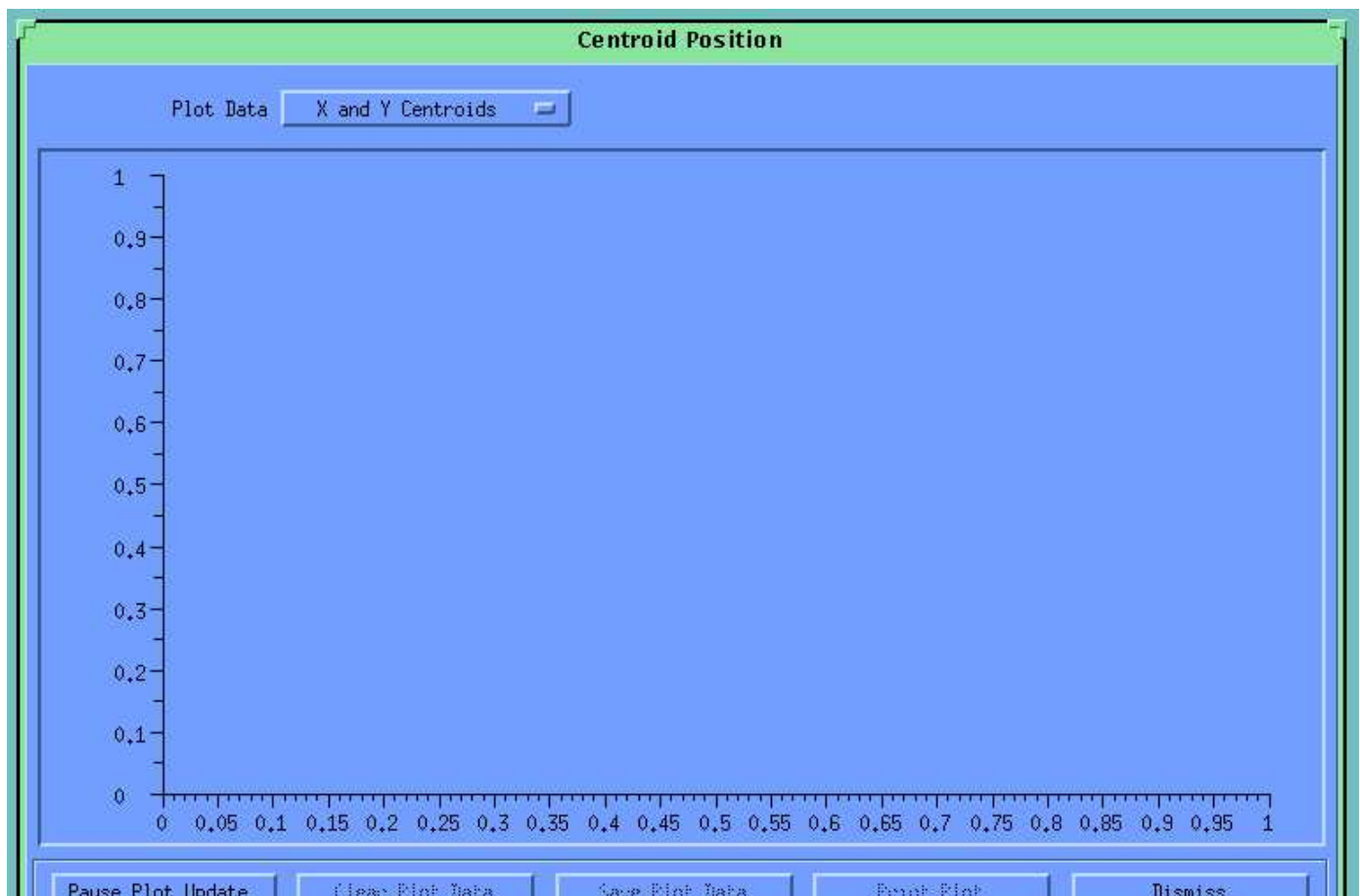The tiptilt centroid position window is shown in Figure 2.3.

Figure 2.3: The centroid position window

This window displays the position of the current centroid on an XY plot with pixels on the Y axis and time on the X axis. The list selector at the top of the window allows the user to display the centroid either in absolute pixels or as an error from the current reference position. The reference position is usually the centre of the subframe. The RMS error over the last second is displayed near the top of the plot.

The update of the plot window may be paused at any time by pressing the Pause Plot Update button in the lower left of the window; this makes the following functions available:

- Clear Plot Data - this deletes the currently displayed data and starts afresh when the window is unpaused
- Save Plot Data - the data displayed in the window may be saved to an ASCII file for later processing and display.
- Print Plot - this button will attempt to print the current plot on the default printer.
- Scrolling and zooming the Plot - these functions are available by using the mouse in the plot itself. The plot may be zoomed by dragging on the axis markers in the direction of interest. The plot may then be scrolled by dragging in the plot area. When the plot window is unpaused, the zooming will reset.

The window may be dismissed at any time.

1. **Advanced Settings**

    The tiptilt advanced settings dialogue is shown in Figure 2.4.
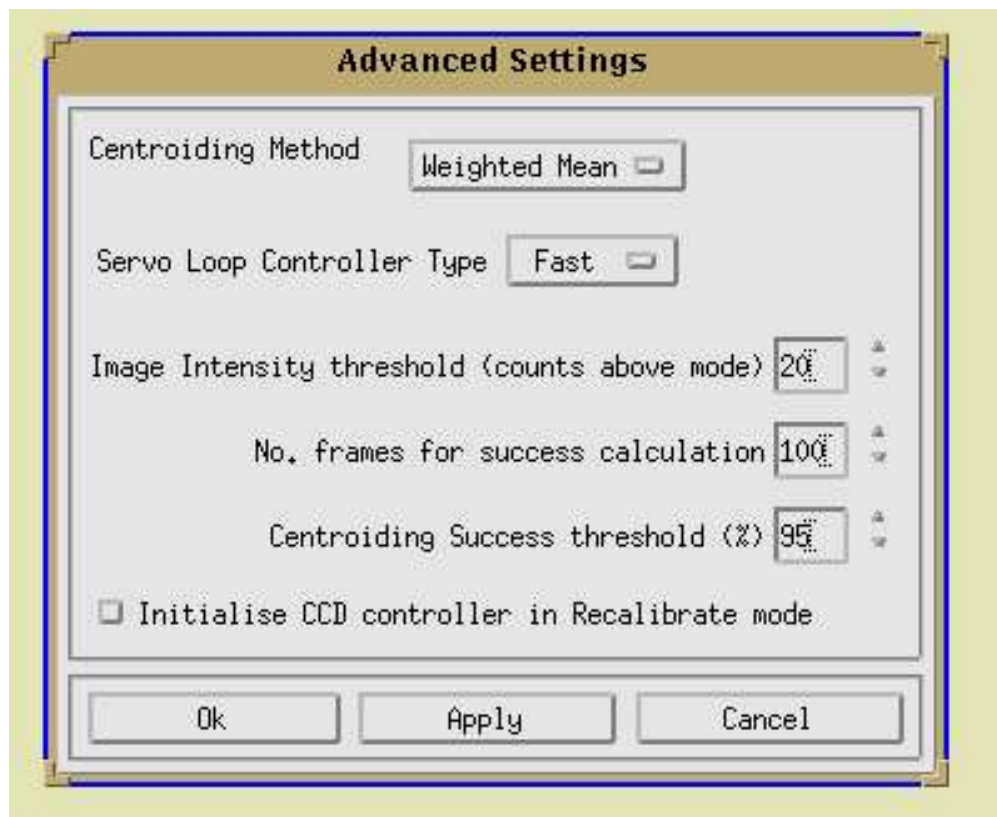
Figure 2.4: The advanced settings dialogue

    This dialogue allows the user to interactively change system settings. The new value entered will become active within the tiptilt system when the apply or OK buttons are pressed. If OK is pressed, the dialogue will disappear; if apply is pressed, the dialogue will remain on the screen.

    1. *Centroiding Method*

        The first item is a list box which allows the method by which centroids are calculated to be changed. The default method is the weighted mean method most commonly used. The sky background is first

calculated by taking a whole frame exposure and finding the mode. The image intensity threshold specified in the third field is then added to the mode to give a bias level that is subtracted from the image. The centroid is then calculated as an intensity-weighted pixel position, using only pixels with positive counts; that is, pixels above the bias level. The subtracted bias is fixed until the operational mode changes.

The second centroiding option is Adaptive Bias. This method initially calculates the bias as in the Weighted Mean method, but if too few pixels are available for centroiding the bias is decremented. Similarly if too many pixels are above the bias, then the bias is incremented. Too few is less than 15% of the pixels being read out, too many is more than 65% of the pixels being read out and the increment/decrement amount is one count. The actual method used to calculate the centroid is the Weighted Mean method. This method is useful at dawn and dusk when the (visible) sky level is changing rapidly. Do not use it in cloudy conditions as, when cloud comes over, the bias level will drop until the system sees noise, giving excessive mirror movements which will cause tiptilt to drop into Idle State.

The third centroiding method is a peak centring algorithm. This algorithm finds the brightest pixel in the frame and computes the marginal distributions about this pixel in each of the X and Y directions. The distributions are computed for one pixel to each side of the peak pixel, so that a total of three rows (or columns) are used. A quadratic is then fitted to the distributions in the X and Y directions to give a centroid with sub-pixel resolution. This method should not be affected by changes in background sky brightness.

2. *Servo Loop Controller Type*

The second field determines the closed loop response of the system to movements in the guide image centroid. In a system such as Tiptilt, where there is a delay between sampling the centroid position and applying the correction and where the dynamics of the mirror assembly are not perfect, it becomes necessary to filter the error signal applied to the mirror to avoid instability. The three available controller types are Fast, Slow and Bright. At present, the Fast controller is the most robust and best performing under a variety of conditions. The Bright controller requires an integration time of 20ms or greater.

In principle, this field allows the user to select a filter strategy to suit the seeing conditions. It is hoped that as the system is used more, better strategies will be made available and guidance on the conditions appropriate for each strategy will be made available.

3. *Image Intensity Threshold*

As described in section 2.1.5.1, this field determines the level of the bias subtracted by specifying a value to add to the sky background.

4. *Centroiding Success Fields*

The next two fields are used in calculating the Cannot Centroid warning. The No. of frames (M) for success calculation determines the "memory" of the system. The percentage of frames in the memory for which a centroid was found is calculated during operation and if this percentage is below the threshold specified in the next field, mirror movement stops. A warning is also triggered on the status window. When the percentage of frames with valid centroids has been exceeded, mirror movement resumes. Note that telescope pointing correction also ceases when this warning is in effect.

5. *Initialise CCD Controller in Recalibrate Mode*

This check box determines the behaviour of recalibrate mode. Normally, the only time that the CCD controller is initialised is at system startup or if the CCD temperature changes by more than 5 degrees. You can force the system to initialise the Astromed controller if you check this box and then enter Recalibrate mode. There should rarely be any need for users to do this.

1.
2. *The Telescope Control System*

It is possible to control tiptilt by typing in commands at the telescope console, as well as by issuing commands from the Solaris interface on misty or by running CASPIR do files. The telescope commands are useful mostly for manually setting track and guide star coordinates, and for initial calibration.

1. **Tiptilt Commands**

As preparation of the telescope system for future use with any autoguider system, the Tiptilt system is considered a super-guider which can *correct* as well as *guide*. Because of this, two telescope commands have been implemented: GUIDE and TIPTILT.

These commands are equivalent, apart from the state and mode change operations. In this manual only the TIPTILT command will be explained.

TIPTILT related commands can be split into the following groups:

1. **Tiptilt preparation commands:**
   selecting guide coordinates and setting the Tiptilt reference position.
2. **Tiptilt operation commands:**
   to turn the system on and off etc.
3. **Miscellaneous tiptilt commands.**
4. **Additional qualifiers:**
   these apply to pre-existing telescope motion commands. They indicate that tiptilt action is to continue after moving the telescope, using the previously used guide star. For example: TRACK/TIPTILT, OFFSET/TIPTILT.

These commands are now described in detail.

1. **Command Reference Guide**
   1. *Tiptilt Preparation*

      The commands below set the coordinates of the guide star and/or where it will appear on the tiptilt CCD. When the command is issued, the stage will move and you should see the guide star appear in the tiptilt subframe.

      TIPTILT objectname searches the currently selected coordinate file (refer TRACK/FILE command) for the supplied object name and sets the coordinates of the selected object as guide coordinates.

      TIPTILT/NEXT [n] selects the entry (or the *n-th* entry) after the current tracking object in the currently selected coordinate file as guide coordinates; this does not update the index pointer into the file.

      TIPTILT /PREVIOUS [n] selects the entry (or the *n-th* entry) before the current tracking object in the currently selected coordinate file as guide coordinates; this does not update the index pointer into the file.

      TIPTILT /TRACK sets the guide coordinates equal to the current tracking coordinates (not the base coordinates)

      TIPTILT /COORDINATES ["name"] RA Dec [equinox[(epoch)]] [Mu_ra Mu_dec [Pi [Vr]]] [!comment] sets the guide coordinates to the values supplied, any valid coordinate string (refer to the Telescope User's Manual) will be accepted. Guide coordinates further than ~2.5 arcminutes from the tracking coordinate are not accessible as the X-Y stage can not move further.

      TIPTILT /OFFSET   accepts guide coordinates as offsets from the current tracking coordinates.

      By default   are in arcseconds on the sky.

      TIPTILT /OFFSET/BASE   accepts guide coordinates as offsets from the base coordinates.

      Base coordinates are the original coordinates specified to the TRACK command, and not including any subsequent OFFSET commands or telescope movement using the console pushbuttons. By default   are in arcseconds on the sky.

      TIPTILT/OFFSET[/BASE]/RA_TIME   As above, but the RA offset is to be entered in seconds of time.

      TIPTILT/OFFSET[/BASE]/NOSCALE/RA_TIME   As above, but the RA offset is not to be scaled by cos   to allow use of polar axis rotation offsets, and is to be entered in seconds of time.

      The /NOSCALE and /RA_TIME qualifiers may also be used separately.

      Any of the above commands can be combined with one only of the following qualifiers:

      /REF=(x, y) defines the position on the Tiptilt display on which the guide object is to be centred.

      /NOREF *{default}??* specifies that the position on the Tiptilt display on which the guide object is to

be centred is to be maintained

/NOSTAGE specifies that the X-Y stage is not to be moved.

Any of the above commands can be combined with the /WAIT qualifier:

/WAIT specifies that, after preparation has been done, the system waits till telescope and X-Y stage have arrived at the desired positions and then turns the tiptilt system on in the last used mode (*correct* or *guide*). If used immediately after startup, this will select *correct* mode.

2. *Tiptilt Operation*

When the system is activated by a TIPTILT, TIPTILT/CORRECT or TIPTILT/GUIDE command, the action taken depends on whether a preceding Tiptilt preparation command was executed:

- **a previous preparation command was executed:**

  the system waits till telescope and X-Y stage have arrived at the desired positions, corrects the reference position for any inaccuracies in X-Y stage setting and then sets the tiptilt system to the specified mode.

- **no previous preparation command:**

  the system accepts the current reference and X-Y stage positions as the position of the guide object in the focal plane and from that determines the coordinates of the object, assuming that the tracking object is in the currently selected aperture, and then sets the tiptilt system to the specified mode. This is equivalent to TIPTILT/HERE.

Just prior to entering guide or correct modes, the brightest object found within the acquire frame is assumed to be the desired guide star. The telescope position is adjusted to bring this object to the reference image position: it is assumed that positional errors result from incorrect telescope pointing. The effects of differential atmospheric refraction and diffraction are taken into account. During guiding and correcting, the telescope tracking coordinates stay constant, as guiding signals are considered to be corrections to the telescope pointing, needed to keep the selected aperture in the correct position on the sky.

TIPTILT without further qualifiers or parameters this command is equivalent to TIPTILT/CORRECT

TIPTILT /IDLE set the Tiptilt system to the Idle mode

TIPTILT /RECALIBRATE set the Tiptilt system to the Recalibrate mode

TIPTILT /STOP

TIPTILT /ACQUIRE set the Tiptilt system to the Acquire mode

TIPTILT /CORRECT wait till telescope and X-Y stage have arrived at the desired positions, correct the reference position for any inaccuracies in X-Y stage setting and then set the tiptilt system to the *correct* mode (i.e. move the tiptilt secondary to correct image wander). If no Tiptilt preparation command preceded this command, it will act as if TIP/HERE was entered.

TIPTILT /GUIDE wait till telescope and X-Y stage have arrived at the desired positions, correct the reference position for any inaccuracies in X-Y stage setting and then set the tiptilt system to the *guide* mode (i.e. drive the telescope once per second to correct image wander) . If no tiptilt preparation command preceded this command, it will act as if TIP/HERE was entered.

TIPTILT /RESUME set the Tiptilt system to the last used mode (guide or correct; if used immediately after startup, will select *correct* mode), assuming that nothing has changed since the Tiptilt was last turned off (does not wait for cessation of motion, does not calculate guide coordinates or aperture).

TIPTILT /FIND

TIPTILT/CORRECT/FIND

TIPTILT/GUIDE/FIND set the reference position to the centroid of the brightest object in the acquire frame, from that determine the coordinates of the object, assuming that the tracking object is in the currently selected aperture

and then set the Tiptilt system to the desired mode (*correct* if not specified).

TIPTILT /HERE

TIPTILT/CORRECT/HERE

TIPTILT/GUIDE/HERE take the current reference and X-Y stage positions and from those determine the guide coordinates, assuming that the tracking object is in the currently selected aperture. Then move the brightest object in the acquire frame to the reference position by autoguiding the telescope, and then set the Tiptilt system to the desired mode (*correct* if not specified).

1. *Miscellaneous*

TIPTILT /SHOW

TIPTILT /SHOW/BRIEF Shows details of tracking and guiding coordinates and apertures

TIPTILT /SHOW/FULL as /BRIEF, also shows Tiptilt and guider stage settings.

TIPTILT /PRINT prints the information shown on the screen with /SHOW (VMS V5.5-2 on MAIA has an unexplained problem with the queue manager which does not allow any printing, this may be corrected later)

TIPTILT /SAVE saves guide coordinates to the currently selected coordinate file.

1. **Changes to Existing Commands**
   1. *ENLIST/IGNORE*

   ENLIST TT Starts the processes for communication with Tiptilt. This command needs to be issued once after telescope startup if tiptilt is to be used.

   IGNORE TT Removes the processes for communication with Tiptilt. Issue this command if it is desired to stop using tiptilt.

   2. *Modification to all motion commands:*

   Any motion command (including HALT) issues an implicit TIPTILT/ACQUIRE.

   3. *Additions to the TRACK, OFFSET, APERTURE and ROTATOR commands:*

   TRACK/TIPTILT ....

   OFFSET/TIPTILT ....

   APERTURE/TIPTILT........

   ROTATOR/TIPTILT .... When the telescope arrives at the desired position, Tiptilt operation is resumed with the same guide star.

   /NOSTAGE

   /NOREFERENCE

   /REFERENCE=(x,y) The default behaviour for determining X-Y stage and reference positioning can be modified by the use of one only of these qualifiers as described for the TIPTILT command.

   4. *Additions to the CONFIGURE command and to CFILEs*

The CFILE command can be used to save and restore the parameters associated with tiptilt operation (see the 2.3m telescope manual for details of the CFILE command). The addition of the keyword TIPTILT causes the saving of Tiptilt system configuration variables i.e. to save the tiptilt parameters, issue the command CFILE /SAVE=TIPTILT[,keywordlist]

Parameters associated with tiptilt operation that can be set with the CONFIGURE command are listed below (see the 2.3m telescope manual for details of the CONFIGURE command).

SUBFRAME_X_POS

SUBFRAME_Y_POS This pair of integer parameters alters the position of the subframe in pixels on the tiptilt CCD for use during subsequent Guide or Correct mode operations. The parameters set the bottom left corner of the subframe.

SUBFRAME_SIZE This parameter alters the subframe size in pixels on the tiptilt CCD for use during subsequent Guide or Correct mode operations. The size may be set to any of 8x8, 10x10, 12x12 or 16x16.

ACQFRAME_X_SIZE

ACQFRAME_Y_SIZE

ACQFRAME_X_POS

ACQFRAME_Y_POS This group of integer parameters alters the size and position of the acquisition frame in pixels on the tiptilt CCD for use during subsequent automatic acquisition operations. The ACQFRAME_X_POS and ACQFRAME_Y_POS parameters set the bottom left corner of the acquisition frame. The ACQFRAME_X_SIZE and ACQFRAME_Y_SIZE parameters select the width and height of the acquisition frame. The acquisition frame need not be square, so all parameters are independent of each other. Omitted parameters remain unchanged.

CENTROID_TYPE This parameter sets the centroiding algorithm used by the system. It may be any of the following: WEIGHTED_MEAN, ADAPTIVE_BIAS or PEAK. The meaning of these centroid algorithms is described in section 2.1.5.1.

SERVO_LOOP_TYPE This parameter changes the servo loop controller filter used by the Tiptilt system. It may be any of FAST, SLOW or BRIGHT. The meaning of these controllers is described in section 2.1.5.2.

IM_INTENSITY_THRESHOLD

This parameter sets the number of counts added to the sky background when calculating a bias level. It sets the field described in sections 2.1.5.3.

NUM_SAMPLES

THRESHOLD These two parameters control the centroiding success calculations described in section 2.1.5.4.

ACQ_EXP

CORRECT_EXP

GUIDE_EXP This group of REAL parameters control the exposure times (in milliseconds??) for the acuter guide and correct modes.

ACQ_EXP_AUTO

CORRECT_EXP_AUTO

GUIDE_EXP_AUTO This group of BOOLEAN parameters control the automatic calculation of tiptilt exposure times by the system, as described in section 2.1.2.4.

5. *Additions to the CALIBRATE command*

Before the TipTilt system can be used, the stage position needs to be calibrated. This only needs to be done at the start of an observing run.

CALIBRATE STAGE

Follow the instructions on the telescope control terminal to set the zero point of the stage motion so that with the stage at 0,0 the (imaginary) TipTilt CCD pixel 0,0 is aligned with Aperture 0 (the rotator centre) of the telescope system. This procedure assumes that the current telescope aperture has been properly calibrated using the CALIBRATE APERTURE command.

CALIBRATE STAGE/ADJUST

Especially when using an offset guide star while the science object has to fall on a CASPIR slit, minor calibration errors need to be rectified. The CALI STAGE/ADJUST procedure allows the stage position to be adjusted with TipTilt running to obtain maximum throughput through the slit. Follow the instructions on the telescope control terminal. This procedure assumes that the current telescope aperture and stage position have been properly calibrated, and that the current tracking and guide coordinates are correct.

CALIBRATE TIPTILT/ALL

Inaccuracies in execution of the CALIBRATE APERTURE and CALIBRATE STAGE commands can result in less than optimal performance of the TipTilt system. To reduce these effects, a combined automated sequence has been developed. CALIBRATE TIPTILT/ALL requires the observer to only once centre the object on CASPIR. The procedure then rotates the rotator and uses the TipTilt autoguiding information to determine the telescope aperture, the pointing offsets and the stage zero point, so combining the usual CALI APERTURE, CALI POINTING, CALI STAGE sequence in one command.

1.
2. *Using Tiptilt with CASPIR*
1. **New Commands**

CASPIR/TIPTILT

This command tells CASPIR whether the tiptilt system will be used or not. The current status of this flag is shown on the CASPIR miscellaneous status screen. The negation, CASPIR/NOTIPTILT, turns the flag off.

If the flag is set, then do files will issue commands to control the tiptilt system according to tiptilt parameters in the do file. If the flag is not set, then tiptilt parameters in the do file will be ignored and no attempt will be made to control the tiptilt system when telescope motion commands are encountered. Note that the tiptilt flag can be set within a do file, temporarily overriding the external setting (see section 2.3.3).

If the flag is set, then the CASPIR observing mode NOD will issue tiptilt commands to place the system in Acquire mode before each new aperture is selected, and into Correct mode after the telescope has arrived at each new aperture.

2. **Changes to Existing Commands**

CASPIR/MODE=NOD

This command still requires the user to define apertures N1 and N2 for the NOD sequence. However, it is no longer necessary to enter the aperture coordinates into CASPIR. As described above, the TIPTILT flag determines whether the state of the tiptilt system is changed as the telescope moves between apertures.

CASPIR/STAGE_OFFSET

This command determines whether the system attempts to move the X-Y stage in order to maintain the guide aperture on the tiptilt CCD when the telescope moves during a do file or in the NOD mode. The current status of this flag is shown on the CASPIR miscellaneous status screen. The negation, CASPIR/NOSTAGE_OFFSET clears the flag.

If this flag is set and the TIPTILT flag is set then the X-Y stage will move to counter the movement of the telescope in the following cases:

* Nod mode
* TRACK_COORD in a do file
* GUIDE_COORD in a do file
* RA_OFFSET and/or DEC_OFFSET in a do file
* GRA_OFFSET and/or GDEC_OFFSET in a do file

If this flag is not set but the TIPTILT flag is set, then in the cases above, the tiptilt system will attempt to move the subframe but not the X-Y stage to counter the telescope movement.

If the TIPTILT flag is not set, then the STAGE_OFFSET flag is ignored in all cases.

1. New DO File Parameters

TIPTILT/NOTIPTILT

This keyword sets the TIPTILT flag from within a do file. If the NOTIPTILT keyword is encountered, tiptilt parameters are ignored until the TIPTILT key word is read. If the TIPTILT keyword is encountered, then tiptilt parameters and commands are executed until a NOTIPTILT keyword is read. This keyword overrides the flag set externally by a CASPIR/[NO]TIPTILT command. The flag is reset to its original state at the end of the do file.

STAGE_OFFSET/NOSTAGE_OFFSET

This keyword sets the STAGE_OFFSET flag from within a do file. It overrides the flag set externally by a CASPIR/[NO]STAGE command. The flag is reset to its original state at the end of the do file. The stage will not move if nostage is chosen.

TRACK_COORD

This parameter requires a text string delimited by double quotes and sends a new TRACK/COORD command to the telescope. The format of the string inside the quotes is the same as that for the telescope command TRACK/COORD, except that no object name should be present. Instead, the object name should be set using the OBJECT parameter.

At the end of the do file, the telescope remains at the tracking coordinates last set.

Example use:

RUN TRACK_COORD="5 23 42.0 -69 46 00 J2000"

GUIDE_COORD

This parameter requires a text string delimited by double quotes and sends a new TIPTILT/COORD command to the telescope. The format of the string inside the quotes is the same as that for the telescope command TRACK/COORD, except that no object name should be present i.e. guide object names are not supported.

At the end of the do file, the guide coordinates remain at the values last set.

GRA_OFFSET and GDEC_OFFSET

These parameters take floating point arguments and issue the equivalent of a TIPTILT/OFFSET/BASE command to the telescope system. The effect is to set the guide coordinate relative to the telescope base coordinates in arcseconds on the sky. Note that these parameters do not remain in effect on subsequent lines of a do file. It is the guide coordinate set by them that remains in use.

As a general rule, if a TRACK_COORD command is used on a do file line, either a GUIDE_COORD, or a GRA_OFFSET and a GDEC_OFFSET, or a TT_FIND command (see below) needs to be specified (unless the same guide star is indeed required).

At the end of the do file, the guide coordinates remain at the values last set.

TTX, TTY, TTDX and TTDY

This group of integer parameters alters the size and position of the subframe in pixels on the tiptilt CCD for use during subsequent Guide or Correct mode operations. The TTX and TTY parameters set the *bottom left corner* of the subframe. The TTDX and TTDY parameters select the width and height of the subframe. It is only necessary to set the X or Y size, as the other axis will be set to the same value (the tiptilt subframe is always square). If the size parameter is less than or equal to 8 then the subframe size is set to 8x8. If the size parameter is less than or equal to 10 but greater than 8 then the subframe size is set to 10x10. If the size parameter is less than or equal to 12 but greater than 10 then the subframe size is set to 12x12. If the size parameter is greater than 12 then the subframe size is set to 16x16. Valid TTX values are 1 to 65-TTDX (although recommended values are 2 to 64-TTDX). Similarly for TTY.

The new subframe position and size remains in effect after the do file finishes execution.

ACQX, ACQY, ACQDX and ACQDY

This group of integer parameters alters the size and position of the acquisition frame in pixels on the tiptilt CCD for use during subsequent automatic acquisition operations. The ACQX and ACQY parameters set the *bottom left corner* of the acquisition frame. The ACQDX and ACQDY parameters select the width and height of the acquisition frame. The acquisition frame need not be square, so all parameters are independent of each other. Omitted parameters remain unchanged. Valid values of ACQDX are 1 to 64. ACQX can have values 1 to 65-ACQDX. (Recommended values for ACQDX are 8 to 62 and for ACQX are 63-ACQDX). Similarly for ACQDY and ACQY.

The new acquisition frame position and size remains in effect after the do file finishes execution.

Note: The top ~20% of the tiptilt CCD (as displayed on misty) is exposed directly to sky. If the sky is bright (as at dawn and dusk, or in bright moon with cloud), then there will be a significant sky signal here and tiptilt may find the brightest pixel in this region as the guide star if that pixel is brighter than the brightest pixel at the true guide star position, and provided the top 20% of the CCD is in the acquire box. To stop this happening, use ACQY=48.

TT_MODE

This text parameter expects one of the following strings which specifies which mode the tiptilt system should be placed in while data taking is in progress. The string may be GUIDE, RECALIBRATE, CORRECT or ACQUIRE.

If unspecified, the tiptilt system will remain in the Acquire mode. After a TT_MODE parameter has been set, all subsequent do file runs will use this setting until it is changed.

At the end of a do file, the tiptilt system will be left in the Acquire mode. New do files always default to using Acquire mode.

Example of use:

RUN RA_OFFSET=10 DEC_OFFSET=-5 TT_MODE=CORRECT

TT_FIND/NOTT_FIND

This negatable keyword enables or disables the tiptilt system's automatic guide star finding feature.

If this keyword is not specified, the tiptilt system will adjust the pointing of the telescope prior to entering Correct or Guide mode to bring the brightest object in the acquisition frame to the centre of the subframe. If the TT_FIND keyword is set, then prior to entering Correct or Guide mode, the system will adjust the central position of the subframe to the centre of the brightest object found in the acquire frame. The telescope pointing will not change and the system will go into correct or guide mode at the current telescope position. After the TT_FIND or NOTT_FIND keyword has been set, all subsequent do file lines will use this keyword setting until it is changed. The position of the subframe remains at its adopted position until moved with another TT_FIND or with TTX, TTY (or at the end of the do file with the GUI or a telescope command).

You should use NOTT_FIND when you know that the guide object you are using has coordinates that are definitely correct and any misalignment with the tiptilt sensor can be blamed on telescope pointing. You should use TT_FIND if you are not sure about the presence or suitability of a guide object in the vicinity.

At the end of a do file, the tiptilt system will be left in the NOTT_FIND state. New do files always default to NOTT_FIND.

TT_ERROR/NOTT_ERROR

This negatable keyword determines how CASPIR will handle tiptilt errors if they arise during a do file execution. If NOTT_ERROR is set, then CASPIR will ignore error codes returned from the tiptilt system and continue on processing the do file. If TT_ERROR is set, then tiptilt errors will cause the do file to abort processing. Failure to find a suitable guide star is considered an error. Cloud coming over after a run is successfully started is not considered an error.

If this keyword is not specified, tiptilt errors will be ignored. After the TT_ERROR or NOTT_ERROR keyword has been set, all subsequent runs in the do file will use this setting until it is changed.

New do files always default to NOTT_ERROR.

TT_ATIME

This floating point parameter sets the Acquire mode integration time in milliseconds. Note that if the "auto" switch for acquire time is set on the Tiptilt window of the GUI, this parameter is ignored.

The new Acquire mode integration time remains in effect after the do file finishes execution.

TT_GTIME

This floating point parameter sets the Guide mode integration time in milliseconds. Note that if the "auto" switch for guide time is set on the Tiptilt window of the GUI, this parameter is ignored.

The new Guide mode integration time remains in effect after the do file finishes execution.

TT_CTIME

This floating point parameter sets the Correct mode integration time in milliseconds. Note that if the "auto" switch for correct time is set on the Tiptilt window of the GUI, this parameter is ignored. The shortest possible integration time is 9.4 ms, which can only be achieved in a subframe of size 8x8. The minimum integration times for each subframe size is given in the following table:

Subframe size	Minimum tt_ctime(ms)
8x8	9.4
10x10	13.0
12x12	17.2

The following table gives the minimum recommended integration time (ms) as a function of seeing and guide star R magnitude (since most catalogues give V magnitudes, V-R = 0.5 is a medium value which might be used to derive R from V in the absence of any other information). The seeing is R-band seeing, an approximate estimate of which is given in the Tiptilt status window when tiptilt is running. The corresponding K-band seeing, measurable on a CASPIR frame without tiptilt running is given in parentheses. Note that exposures shorter than 13ms need an 8x8 subframe.

	Seeing=1.0 (0.8)	Seeing=1.5 (1.2)	Seeing=2.0 (1.6)
R=10	9.4	9.4	9.4
R=11	9.4	9.4	9.4
R=12	9.4	10	17
R=13	10	25	40
R=14	25	60	100
R=15	60	150	250

The new Correct mode integration time remains in effect after the do file finishes execution.

A convenient web site for obtaining guide stars (HST Guide Star Catalog) is:

http://arch-http.hq.eso.org/cgi-bin/gsc