Introduction:

Correlator version 1.4 can be used to measure pointing drifts between images within the same cycle (**intracycle**) or between cycles (**intercycle**). The key difference between these two modes of operation is the nature of the input into the program. Correlator will expect to read in quicklook files for intracycle drift measurements and sharpinteg files for intercycle drift measurements.

Correlator does not generate correlation maps in the true sense, but instead produces maps of correlation coefficients. It was found during development that the algorithm for producing correlation maps could introduce errors that would effect the pointing measurement. The correlation coefficient maps are generated by selecting the first file listed in the input as a reference and then comparing each of the remaining files with this reference. These maps are printed out as Correl.n.fits where n = 1 to total number of files. The correlation coefficient is given by:

$$C_{(\tau x)(\tau y)} = \frac{\sum_i (x_{1i} - m_1)(x_{2i} - m_2)}{(N-1)\sqrt{v_1 v_2}} \qquad (1)$$

where m_1, m_2, v_1, v_2 are the means and variances of images 1 and 2, x_{1i} and x_{2i} are the ith pixel values for images 1 and 2, and N is the total number of pixels in each of the images being compared. To produce a 2D map of correlation coefficients the reference image is superimposed on the image it is being compared with (herein called the "secondary image") and is "shifted" by τ_x and τ_y in the x and y directions respectively. Equation 1 is then used to calculate $C_{(\tau x)(\tau y)}$. In order to improve the accuracy of the correlation maps and to ensure there is no instance of the reference image being shifted off of the secondary image, a crop of the reference image is taken and is compared with its overlap projection on the secondary image. The user can set the size and position of the crop on the reference image at run time (see Arguments).

In general, Correlator is to be called within a shell script program; this enables the user to process large amounts of data at any given time. Two shell scripts have been written for this purpose: 'correl' and 'scorrel', that are to be used when dealing with intracycle or intercycle measurements respectively.

Note: a brief explanation of how to run Correlator will be printed out on the command line if one types in: "./correlator" at the UNIX prompt.

Arguments:

The arguments that can be used with Correlator include:

./correlator -hv <NAMES.LIST> -rgm <RGM.DAT> {-debug -cxy <Lx Ly> -pxy <Px Py> -p <PARAMETERS.LIST> -ic -si}

where arguments beginning with '-' are flags to signal a specific request to the program, arguments bracketed by '< >' are values to be read into the program, and arguments bracketed by '{ }' are non-essentials (Correlator does not require them in order to run). Below is a brief description for each of the flags and the commands they represent.

-hv: The flag '-hv' is one of two flags that must be present for proper use of this program. The '-hv' flag will force Correlator to read the next item in the command line, the string <NAMES.LIST>, and will open the file located in the working directory with this name. This file must contain the names of all the input source files that are to be read in. In general, the file <NAMES.LIST> is assembled by the shell script program at run-time. If Correlator is set to measure intracycle drifts the first pair of files for every four pairs listed in <NAMES.LIST> is used as the reference (quicklook outputs two files for one input sharc2 file, an h.fits and a v.fits). If Correlator is set to measure intercycle drifts only the very first file listed in <NAMES.LIST> will be used as the reference.

-rgm: The '-rgm' flag will signal the program to read in the following filename, <RGM.DAT>, from the command line. This argument is the second flag that must be present for proper use of this program. Correlator will open <RGM.DAT> and use it to identify bad pixels.

-debug: If the '-debug' is present, Correlator will print out intensity (I.n.fits), cropped intensity (Crop_Io.0.fits), and cropped overlap (Over_I.0.fits) images. Correlator will only print out a cropped intensity image for the reference I map and a cropped overlap image for the second file listed in <NAMES.LIST>. Intensity maps will be printed for all the files listed in <NAMES.LIST>. The cropped I reference map will be useful for correcting any pointing misalignments in the crop (see –cxy and –pxy flags plus the section on Usage).

-cxy: If the '-cxy' is present, Correlator will take a crop of the reference image Lx by Ly in size (units of pixels). The default is 6X6.

-pxy: If the '-pxy' flag is present, Correlator will crop the reference image centered on the point [Px,Py] (units of pixels). The default is the center of the image (5.5,5.5). NOTE: for fractional values of Px & Py, Lx & Ly must be even #'s. By fractional values, only x.5 is an acceptable entry (values like 2.3, 4.6, 1.2 will not be properly processed). Whole # values of Px & Py require odd Lx & Ly values. The difference between whole and fractional values for the pointing is as follows: whole values refer to points at the center of pixels while fractional values refer to points at the edges of pixels. For example, the point [Px,Py] = [1,1] refers to the center of the pixel located in the lower left hand corner (the pixel labeled 1,1 in fv) and the point [Px,Py] = [1.5,1.5] refers to the upper right-hand corner of the same pixel.

-p: If the '-p' flag is present, Correlator will print out the x and y offsets to the file <PARAMETERS.LIST>. This is to be used in conjunction with GAP and hence is only applicable with intracycle analysis.

-ic: If the '-ic' flag is present Correlator will print out an average I map (called Iave.0.fits). Like the previous flag, this is to be used in conjunction with GAP.

-si : If the '-si' flag is present Correlator will treat the input data as coming from sharpinteg and will hence measure intercycle pointing drifts. Correlator will also print out measurement data to the file "dither_positions.txt" for easy viewing with a program such as xemacs. Correlator will also print out rotation and correlation data to "xsheet_dither_data.txt" in a format that allows for rapid transfer onto an excel spreadsheet. If this flag is not present Correlator will treat the input data as coming from quicklook and thus will measure intracycle pointing drifts.

Usage:

As stated in the introduction, this program is to be executed by calling a shell script program that will assemble all the input data files (by either calling quicklook or sharpinteg) plus the <NAMES.LIST> file. The shell script should be reviewed and catered to the specific needs of the user. This not only includes entering the specific flags a user requires but also to specify the sharc2 files to be used in the analysis. This involves changing the 'while' loops in the shell script that have the following syntax:

```
@ i = First File Num
While ( $i <= Final File Num )
.
.
.
@ i++
end
```

Where "First File Num" is the first file number in the following sequence:
"First File Num", "First File Num"+1, "First File Num"+2, ……. "Final File Num"
If some files in this sequence need to be removed from the analysis an "if" statement can be included into the 'while' loop as follows:

```
@ i = First File Num
While ( $i <= Final File Num )

if ( $i <= First File Num + 2 && $i >= First File Num + 1 ) then
else
.
.
.
endif
```

@ i++
end

In the above code the files “First File Num”+1, “First File Num”+2 are removed from the analysis. Please see the copy of “scorrel” included with this document for an example of the “while” loop and “if” statements. Note: if a user wants to disable an “if” statement all one needs to do is type a “#” character in front of the lines to be commented out. An example of this is the “if” statement in “scorrel”, which is already commented out.

Optimal use of this program is achieved when the crop of the reference image is centered on the source peak; the more symmetric the cropped reference image is the more accurate the correlation map. Centering the cropped image is thus the first step any user should make when using this program. Thus the first runs of Correlator on any analysis should include the ‘-debug’ flag in order to view the cropped reference image. Subsequent runs will likely include the ‘-cxy’ and ‘-pxy’ flags as adjustments to the pointing are made. Once the cropped image is adequately centered, the ‘-debug’ flag can be removed from the shell script.

For the case of running an intercycle analysis, care should be taken when choosing a reference file, as only one is used for the entire analysis. A user should ensure that the reference file has a high SNR and a generally good appearance.

When using Correlator to measure intracycle drifts, the output will be printed to the <PARAMETERS.LIST> file (if the ‘-p’ flag is present). When measuring the intercycle drifts, the correction terms are printed to the headers of the input source files under the keywords CAZO & CZAO and also to the file ‘dither_positions.txt’.

Note: when running Correlator to measure intracycle drifts a minimum of one cycle’s worth of data must be entered into <NAMES.LIST>. When measuring intercycle drifts at least two files need to be listed in <NAMES.LIST>.