**Mount Model Update Program**

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This software was written around 1990 by Jan McGarry for the NASA SLR Network to provide a single program for generating mount model coefficients for all of the various NASA SLR stations. The program will handle mounts that are Azimuth/Elevation, X/Y, or any two-angle defined coordinate system.

The current version, as delivered, has been modified for NASA’s Next Generation SLR station (NGSLR) but can be easily changed to work on any SLR system.

1. Source files and compiling

The source code is written in FORTRAN. There are four source files and one include file:

mmupds2k.f, staranal.f, matsolv.f, hmodel22.f and starfile.inc.

The program was compiled and linked on CDDIS using the following:

f95 –o mmupds2k mmupds2k.f staranal.f hmodel22.f matsolv.f

The file “makemmupd” is included with the source which duplicates the above line.

1. mmupds2k.f

This is the main calling program. It reads the input files and sets up the data for calls to the subroutines in the staranal file. There are two types of input formats possible: a MOBLAS system format, and an NGSLR/S2K format (see Appendices A and B for formats). In addition to being prompted for the type of input data format, the user is prompted for other inputs. The suggested options are preceded with an “\*”. See the example in Appendix E for the prompts.

1. staranal.f

These subroutines perform the mount model solution. The mmupds2k calling routine only uses the Least Squares Batch solution in this version of the software. Calls to the Kalman solution are not shown here. As given in the comments at the start of the file, the following subroutines are in this file:

1. RECURSIVE Kalman filter.

2. BATCH Least squares batch process: calling routine.

UPDATE Perform the least squares solution.

CHKERR Check the error in the least squares fit.

3. SUMMARY Summary computations and file write.

4. COVINI Initialize the covariance matrix (and coeffs).

5. COEWRT Write out the coefficients to file.

6. COVWRT Write out the covariance matrix to file.

7. DEF\_READ Read the [STAR\_DEFAULT.DAT] file.

8. MMODEL Compute the mount model correction.

1. matsolv.f

This file contains matrix manipulation routines.

1. hmodel22.f

This subroutine contains the current NGSLR mount model. Replace this subroutine with your mount model. In addition, replace the value NMMC in the starfile.inc with the number of mount model coefficients for your system.

1. STARFILE.INC

Include file containing the various structures needed along with the number of mount model coefficients (NMMC) used in the system. This include file was written by Jack Cheek (John.W.Cheek@nasa.gov). This filename must be in all caps in order for it to be correctly included in the program build.

1. Input data files

The program reads a file called star\_default.dat. The format of this file is given in Appendix C. This file holds the default settings for generating mount model coefficients from the star data for the given system.

The main input data for the program is in the star data file which contains a single line of information for each star in the star calibration. Required data fields include the azimuth and elevation of the star (or the X and Y angles of the star) , the input biases needed to center the star, and the total mount model offset in each axis for each star which should include the biases used to center the star. All of these fields are in degrees.

There are two possible input formats: (1) NGSLR star data file format (Appendix B), and (2) the MOBLAS star data file format (Appendix A). Modify the main calling routine to change the format to your star data file format.

1. Output files

The program outputs an analysis summary (“anal”) file whose format is given in Appendix D. The program also outputs a COEFS.NEW file which contains the updated mount model coefficients, a COVARS.NEW file which contains the updated covariance matrix that is a product of the solution, and an OLDNEW.SUM file which has a side by side listing of the old and new coefficients. The information that is in these files is also in the analysis summary file.

1. Sample input and output

Included in this package is an NGLSR (S2K) “star\_default.dat” file, along with an NGSLR star data input file, and an analysis summary file.

1. Modifying the software for your system
2. Change the name of the calling program to something more representative of your system.
3. Change the reads on line 111 and 217 to your star data format (or convert your star data format to match the read).
4. Change the parameter NMMC to the number of mount model coefficients that are in your system.
5. Replace the hmodel22.f with a subroutine of your mount model.
6. Change the values in the star\_default.dat file to reflect your system.
7. Compile and run.

**Appendix A: MOBLAS Star Data Format**

The first line of file is temperature (deg.C), barometric pressure (mbars), and humidity.

The lines that follow all have the following information on each line:

Star Number (integer)

Day of year (integer)

Hour (integer)

Minute (integer)

Second (integer)

Angle #1 (azimuth or X) in degrees (float)

Angle #2 (elevation or Y) in degrees (float)

Total Angle 1 mount model correction at this location in degrees (float): previous correction + added bias

Total Angle 2 mount model correction at this location in degrees (float): previous correction + added bias

Angle 1 bias added to center star in degrees (float)

Angle 2 bias added to center star in degrees (float)

Star catalog number (integer)

Star magnitude (float)

**Appendix B: NGSLR (SLR2000) Star Data Format**

Line 1: filename

Line 2: blank

Line 3: header for coefficients

Lines 4-25: starting mount model coefficients

Line 26: blank

Line 27: header for covariance matrix

Lines 28-49: covariance matrix elements to the diagonal (this is a symmetric matrix)

Line 50: UT1-UTC in seconds

Line 51: Temperature (deg C)

Line 52: Barometric pressure (mbars)

Line 53: Humidity (percent)

Line 54: Measurement Error (deg)

Line 55: Sigma scale for star rejection

Line 56: Scaling for initialization of the covariance matrix

Lines 57 to end: star calibration information – one line per star

Definitions of the columns in each line:

Column Definition

1 Catalog Number

2 Star Number in software table

3 Star magnitude

4 Sky section (1-16)

5 RAS - deg

6 RAS - min

7 RAS - sec

8 DEC - deg

9 DEC - min

10 DEC – sec

11 Year (4 digits)

12 Month

13 Day of month

14 Day of year

15 Hour (UTC)

16 Minute

17 Second

18 Mount Angle #1 (azimuth or X) in degrees for this star

19 Mount Angle #2 (elevation or Y) in degrees for this star

20 Angle #1 total mount model offset (== old mount model offset + input bias to center this star) in deg

21 Angle #2 total mount model offset (== old mount model offset + input bias to center this star) in deg

22 Angle #1 bias entered to center this star (deg)

23 Angle #2 bias entered to center this star (deg)

**Appendix C: Star Defaults File (from NGSLR Programmer’s Reference Manual)**

The star.defaults file is used to differentiate independent system information for the star calibration and star assessment threads. Information such as magnitude limits, star table size, acceptable RMS’s and other star related information. Some of the information is not used in the NGSLR system. This file was created manually and is rarely updated. The file format consists of one piece of information per line with an explanation of that piece of information. A sample file follows:

/\* Star Calibration Default for S2K : 02/05/09 Vers 5.00 \*/

/\* S2K \*/ # system name

200 # maximum number of star to compare for star map

GRID # type of star calibration solution

3.0 # bright star magnitude for highest magnitude stars, not used in s2k

7.0 # bright star magnitude for lowest magnitude stars, not used in s2k

3.0 # grid star magnitude for highest magnitude stars

4.0 # grid star magnitude for lowest magnitude stars

907 # alignment star

20 # number of table stars, not used in s2k

2 # number of stars preferred per sky section per revolution

2 # number of star required for even distribution per sky section

0.0003 # estimate of measurement error (degrees)

20 # maximum number of iterations for solution

3.0 # multiplier for Standard deviation in star error to reject stars

200.0 # scale factor to roundup an existing P at start

2 # initial IOPT value for COVINI routine

5.0 # RMS comparator for starcal, RMS < this value

0.010 # Angular step size for star search

2.0 # Star Assessment night upper magnitude limit

4.0 # Star Assessment night lower magnitude limit

-2.0 # Star Assessment day upper magnitude limit

2.0 # Star Assessment day lower magnitude limit

-2.0 # Star Assessment twilight upper magnitude limit

2.5 # Star Assessment twilight lower magnitude limit

100.0 # maximum distance from the object daylight

20.0 # maximum distance from the object twilight

10.0 # maximum distance from the object night

# initial covariance matrix (diagonal only)

0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1

# covariance matrix MASK, IOPT=1 for COVINI routine, if any

Note: The covariance matrix mask (the last line in the file) may not appear for some systems.

**Appendix D: Analysis Summary Format (from NGSLR Programmer’s Refererence Manual)**

The star summary file is created by the star calibration process whenever a star calibration is performed. It contains the results of the star calibration. It contains information such as weather parameters, rejection scale factors, estimated measurement errors, and the name of the star data file used. It then lists the mount modeling coefficients and standard deviations prior to the calibration, then the stars used along with the biases entered. Following that is the actual summary information including the RMS. Finally the new mount modeling coefficients and the standard deviations are listed. A sample file follows:



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**Appendix E: Sample Data Run**

Compile the software as delivered. Use the as delivered star\_default.dat file, along with the star\_s01y2012d242t0106 star data input file, and respond to the prompts as shown below. The output “anal” file should correspond to the one delivered with this package.

\* STAR CALIBRATION ANALYSIS PROGRAM \*

ENTER THE STAR DATA FILE NAME:

star\_s01y2012d242t0106

Enter (0) if this is MFT format,

or (1) if this is operational format:

1

Operational data format

INPUT COEF/COVAR SET-UP SELECTION:

(0)==>set coeffs to zero, set covars to default

(1)==>set coeffs & covars from star\_data\_file

\*(2)==>set coeffs from star\_data\_file and covars to default

Enter selection [0/1/2]:

2

Read the star default file

/\* NGSLR - GGAO \*/

Alignment Star: 907

Initial covariances read.

PMASK read.

Set initial coefficients and covariances

Read the beginning of the star\_data\_file...

Read the coefficients

Read the covariances

Set up of covariance matrix

Read the rest of the initial info from star data

The following are values from the star\_data\_file:

Meas. error (deg): SIGR= 3.000000000000000E-004

STD scale factor: SIGSCL= 3.00000000000000

Covar.scale factor: PSCALE= 200.000000000000

The following are values from the star\_def file:

Meas. error (deg): SIGR= 3.000000000000000E-003

STD scale factor: SIGSCL= 2.50000000000000

Covar.scale factor: PSCALE= 25.0000000000000

Do you want to use the values from:

\*(1) the star\_data\_file,

(2) the star\_default file,

(3) enter your own values?

1

Getting star data

2 336.3555 31.2847 433 3.8

3 314.7761 21.4653 441 3.7

4 278.9833 40.9997 534 3.6

5 243.3350 20.9966 545 3.9

6 248.6761 26.7966 547 3.7

7 223.0095 36.4376 605 3.2

8 197.3723 23.8548 644 3.3

9 173.2422 29.5432 710 3.5

10 144.5341 44.1897 756 3.2

11 122.0212 40.1702 800 3.9

12 132.4904 19.3619 812 3.7

13 55.6511 19.4638 33 3.9

14 90.7710 43.8024 831 3.8

15 43.0261 30.3669 17 3.7

16 42.4906 19.5973 52 3.6

17 338.8289 49.1308 569 3.0

18 319.4423 53.7347 571 3.3

19 278.1093 49.2481 563 3.5

20 297.4586 63.6662 608 3.9

21 250.2647 45.4662 583 3.7

22 248.2551 47.4163 591 3.8

23 224.3387 52.5400 633 3.2

24 228.8033 74.0370 667 3.4

25 161.4756 83.9792 705 3.3

26 171.0704 45.6675 717 3.4

27 150.5783 82.7373 713 3.2

28 140.9541 65.1013 743 3.8

29 57.5953 71.7097 757 3.8

30 74.3657 64.4256 788 3.9

31 23.0488 84.5480 711 3.9

32 5.5311 61.0169 723 3.1

33 322.1316 28.2433 456 3.3

34 290.2873 41.5270 535 3.0

35 240.3214 37.4015 588 3.7

36 199.8840 33.2018 658 3.5

37 152.7083 34.1737 761 3.6

38 112.0115 33.7914 834 3.5

39 88.5366 37.6308 859 4.0

40 28.6653 27.7553 63 3.4

41 356.2426 56.0379 695 3.6

42 279.9191 65.4119 626 3.5

43 264.9731 79.1739 672 3.9

44 201.2213 58.9078 680 3.7

45 165.6420 53.2124 730 3.4

46 138.7122 65.6506 752 3.5

47 67.9449 64.8119 792 3.7

48 14.1936 74.9863 726 3.8

49 335.2383 34.4908 472 3.9

50 231.1665 18.9459 577 3.9

51 190.9286 29.1117 682 3.9

There are 50 stars.

Updating the mount model coefficients...

Write out results to files...

The RMS(asec) of the calibration was 1.28711493095811

The RMS(deg) of the calibration was 3.575319252661408E-004

There were 50 stars used, and 0 rejected.