ISIS Planetary Geodesy Software

(formerly RAND/USGS Planetary Geodesy (RUPG) Software)

Narrative description of *Randlsq* Main printout Description (general file format)

File: ISIS-PG-FMT511.doc, .pdf, or .asc

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The following is a general guide to the solution "general printout" output that is generated by the *randlsq* program. The "Group" designations here are meant to be a general guide to the different sections of that output.

The examples below are taken from the file "ULCN2005-printout.dat", the main printout file of the Unified Lunar Control Network 2005.

Group 1 - Camera angle weighting.
=======

If camera angle weighting has been specified (iawt=1), the weighting for all camera angles is given here, including the one standard deviation (one sigma) weight in degrees, and the actual weight applied in 1/radians**2.

If not specified (iawt=0), this printout will not appear.

Example:

 Camera angle right ascension - uncertainty specified (deg), weight used
(1/rad**2):   1.00000000 3282.8064
 Camera angle declination   - uncertainty specified (deg), weight used
(1/rad**2):   1.00000000 3282.8064
 Camera angle twist   - uncertainty specified (deg), weight used
(1/rad**2):   1.00000000 3282.8064

Group 2 - General description of solution parameters.
=======

Number of images (NPIC), number of control points (NPOI), number of image measures (line and sample) (NMEA), and number of unknowns (NUNK). This is followed by a list of the types of parameters being solved for.

Example:

  INITIAL CONFIGURATION FOR THESE DATA

   NPIC = 43866   NPOI = 272931   NMEA = 546126   NUNK = 950391

 SOLVING FOR CORRECTIONS TO LATITUDES OF POINTS
 SOLVING FOR CORRECTIONS TO LONGITUDES OF POINTS
 SOLVING FOR CORRECTIONS TO RADII OF POINTS
 SOLVING FOR CORRECTIONS TO ALPHA C-MATRIX ANGLES

1

```
   SOLVING FOR CORRECTIONS TO DELTA C-MATRIX ANGLES
   SOLVING FOR CORRECTIONS TO KAPPA C-MATRIX ANGLES
```

Group 3 - Parameter Weights in RAND Scheme
=======

These are parameter weights, as used by the original RAND weighting scheme.
Numbers are simply listed in solved for order, from parameter number 1 to
parameter number NUNK. (The order is as specified in the list of types of
parameters in "group 2" above, i.e. latitude, longitude, radii of point 1, then
point 2, etc., then the three angles for image 1, then image 2, etc.) A "20"
here indicates the parameter is fixed (e.g. weighted with a value of 10^20). A
"-38" here indicates the parameter is free (weighted with a value of 10^-38).

(Note that a bug currently exists that when angle weighting is done (IAWT=1) or
control point weighting is done (from the a priori input file) this listing will
not show the correct weights for camera angle parameters or control point
parameters, respectively, as the printout is done before those weights have been
applied.)

Example:

The 66 "20" values reflect that the latitude, longitude, and radius coordinates
of the first 22 control points are to be fixed. (But note in this particular
case, these weights are ignored as they are later overridden by specific weights
from the a priori input file.)

```
                                 WEIGHTS
  20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20
  20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20
  20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20   20
  20   20   20   20   20   20  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38
 -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38
 -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38  -38
etc.
```


Group 4 - Iteration Output
=======

The output from each iteration of the program follows. For each iteration there
are two sub-groups of output, with one (Group 4A) being the measurement
residuals, and the other (Group 4B) being the solution statistics for the
current iteration.

Note that the first set of (Group 4A and 4B) output is actually from the
"zeroth" iteration of the program, i.e. it is a simple calculation of the
residuals (observed minus computed) values, but derived only from the a priori
values **before any solution is done**. The (4B) statistics are actually the
statistics for these residuals only and not a solution. In other words, this
set of residuals and the statistics only show how well the a priori information
actually matches the measurement data before a solution is done.

After that printout, an actual least squares solution is done, and the next and succeeding sets of output are all from actual solutions. Therefore, if "nit" iterations are specified in the program control file (see file ISIS-PG-FMT101.doc or .pdf for format), then the actual number of least squares solution iterations will be NIT-1.

Group 4A - Residual output from the current iteration
========

Shown for each line and sample measurement from the input mm measurement file, are the image number, the control point number, the X or SAMPLE residual (mm), and Y or LINE residual (mm).

Example:

PICTURE	POINT	XO-XC	YO-YC
5503559	1	-0.03959	-0.24139
16620062	10	-0.07242	-0.08646
16170025	100	-0.08233	0.06269
16140430	100	-0.13691	-0.27135
29111574	1000	0.09592	-0.43485
15831434	1000	0.06703	-0.21000
29320962	1001	-0.06119	-0.31545
29320929	1001	-0.09810	-0.11393
29020894	1003	0.16548	-0.06924

etc.

Group 4B - Residual or Solution Statistics.
========

Next is printed the residual (first iteration) or solution (later iterations) statistics.

If this solution is being done using the method of conjugate gradients, after the first (mathematically "zeroth") iteration only, the used normal matrix array (array "ltl") size, in number of elements, is printed.

For the second and later iterations, the previous iteration solution standard deviation (SIG1, see below) is printed for comparison with this iteration's standard deviation.

For the second and later iterations, if the solution standard deviation has changed by less than 10^-6, a message is also printed that says "Solution has CONVERGED."

Next, statistics are printed. For the first iteration these are actually just the statistics based on the residuals with no solution having been done. For later iterations they are the true solution statistics. These values are the standard deviations (in mm) for the line (or Y) measurements (SIGL), for the sample (or X) measurements (SIGM), for both (SIG1), and then as the a posteriori standard deviation of unit weight (SIG2), where:

```
SIGL = sqrt ( sum Y**2 ) / NMEA )

SIGM = sqrt ( sum X**2 ) / NMEA )

SIG1 = sqrt ( (sum X**2 + sum Y**2) / (NMEA*2) )

SIG2 = sqrt ( (sum X**2 + sum Y**2) / (NMEA*2 - NUNK) )
```

where X are the sample residuals, Y are the line residuals, and NMEA and NUNK are as in Group 1 above. Note that NMEA*2 - NUNK can be zero or negative and yet a solution can be obtained if a sufficient number of parameters are weighted. However, if this case occurs a warning is issued and SIG2 is set to 1.

Example 1:

Normal matrix array size is   6815871

 SIGL =   1.03999 SIGM =   0.71315 SIG1 =   0.89167 SIG2 =   2.47421

Example 2:

Previous SIG1 =   0.89167

 SIGL =   0.01939 SIGM =   0.01999 SIG1 =   0.01969 SIG2 =   0.05464

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Reference: Model, program, and format generally follow that specified in:

Colvin, Tim R. (1992). "Photogrammetric Algorithms and Software for Spacecraft Optical Imaging Systems," _ A RAND NOTE _, N-3330-JPL.

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Document History:

Begun 2006.08.10 by B. Archinal.

Modifications:

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(End of document.)