To: Haystack SKA Group

From: Lynn D. Matthews

Subject: Limitations and Bugs in the MAPS Software

Date: October 10, 2009 Updated: March 3, 2010

1   Background

Below is a compilation of known bugs, limitations, and other issues in the MAPS Software package as of March 2010. All tests were performed with a version of MAPS installed in November 2008. Problems are listed in no particular order.

2   Limitations and Annoyances

Problem 1: No comprehensive user manual exists for MAPS.
Solution/Comments: Create our own?

Problem 2: When running MAPS_im2uv, one must manually enter a scaling factor via the "- n" switch in order that the output data set will have units of "Jy steradian^{-1}". It is easy to make a mistake in this step, and sometimes difficult to test if the scaling was correct.
Solution: Modify MAPS_im2uv to perform this scaling automatically.

Problem 3: MAPS_im2uv does not retain or pass along any information from the header of an input FITS image after it FFTs it. Consequently, when the data are passed to visgen, visgen does not have any *a priori* information about the coordinates of the field center or the field-of-view, and these values must be explicitly passed to visgen through the obs spec file. If the field-of-view (FOV) that the user specifies in the "obs spec" file does not match that of the original input image (including any zero padding that has been added to its periphery), visgen will *not* select a sub-region of the input image; it will assume that whatever the user has specified is the intrinsic FOV of the input model and rescale the spatial coordinates accordingly.
Solution/Comments: Coordinate information should somehow be retained and passed between MAPS modules. In case a user wishes to adopt arbitrary coordinates or rescale an input image, an option to ignore or override this coordinate information might be desirable.

Problem 4: LOsim creates images with epoch 1950.0 coordinates. If one runs such an image through MAPS, the output epoch of the newly generated data will be J2000.0, but the coordinates will not be precessed.
Solution/Comments: Tried adding an "EPOCH" keyword to the header of a LOsim-generated image, but this did not remedy the problem. MAPS modules need to be

smarter in reading and passing along coordinate information directly from input images. This will be a non-issue of LOsim is retired.

Problem 5: Images generated by LOsim have RA increasing to the right; this is non-standard and can create later hassles and confusion.
Solution/Comments: Either retire LOsim or modify it to output images that are transposed east-west.

Problem 6: If one attempts to "observe" a source from a particular observatory site at a time when it is not visible, visgen will produce an output of all zeros, without any warning messages.
Solution/Comments: visgen should warn the user if a source is not visible. maps2uvfits should also issue a warning if the input file is all zeros. A tool for computing source elevation as a function of time from an arbitrary observatory site would be valuable.

Problem 7: Often an externally-generated 2-D FITS image will have additional axes that convey e.g., STOKES and FREQUENCY information. MAPS_im2uv chokes on these extra axes and will report the error message: "input image is NOT 2 dimensional. wrong wrong wrong."
Solution/Comments: Allow MAPS_im2uv to ignore all non-coordinate axes provided that they are one-dimensional. Allowing MAPS_im2uv to operate on data cubes might also be useful for some applications.

Problem 8: Aliasing will occur when imaging model visibility data created by visgen in cases where a user-generated sky model (FFTed via MAPS_im2uv) is not padded with zeros first. Adding the padding requires extra steps each time a model sky is created.
Solution/Comments: Add the capability to pad an input image to MAPS?

Problem 9: visgen will fail if one attempts to "observe" too large a field-of-view with too long a baseline; e.g.,:
ERROR: get_patch() failed with code 2. u,v: -42840.4,-1.62819e+06. udim,vdim: 2163.81,2093.3
The user needs some straightforward way of determining *a priori* what is the maximum FOV observable via MAPS with a given antenna array.
Solution/Comments: This problem may have been discussed by Shep and Steven Tingay years ago. Unknown whether they thought about fixes.

Problem 10: Because one can only "observe" a small FOV when the baselines become long, simulations involving realistic sky models are not possible in the VLBI regime. (Simulated sky patches are so small that they contain few or no sources at realistic flux density limits).
Solution/Comments: Intrinsic limitation?

Problem 11: The program add_noise.c uses a system efficiency, η, to compute the theoretical noise for each baseline. However, in line 630 of visgen.c, η is hardwired to be 1.0.

Solution/Comments: The user should be able to specify η. This would likely need to be included in the "array" file. For VLBI, an extra switch to provide a choice between 1 and 2 bit sampling may also be desirable.

Problem 12: The program add_noise.c does not include the noise contribution from the total power received at the antenna.
Solution/Comments: This part of the code needs completing.

Problem 13: obs_.html quotes the specification for the declination part of the pointing center as PNT_center_DEC, as do the error messages reported by read_obs_spec.c; however, read_obs_spec.c actually expects this field to be PNT_center_Dec.
Solution/Comments: Edit obs_.html and fix messages outputted by read_obs_spec.c so that the cases match those needed in the obs_ file. It would be better if the obs_spec file avoided mixed cases entirely, but attempting to fix this would probably cause additional problems. A better solution would be that *visgen* halts if it does not recognize a field in the obs spec file instead of surreptitiously writing this information to the log file and continuing.

Problem 14: Coordinates of out-of-beam sources written to the log file by oob.c do not carry enough significant digits.
Solution/Comments: It appears that sufficient significant digits are carried along in the computations. Simply replace "%g" format statements with "%f" in line 72 of oob.c?

Problem 15: MAPS is supposed to accept absolute Cartesian coordinates (X,Y,Z) for station positions, but it is unclear that this is being handled correctly. The "array center" concept is still used even in this case, and results will change depending on which array center is selected.
Solution/Comments: Check this implementation. If absolute (X,Y,Z) coordinates are specified, the program should ignore the specified array center.

Problem 16: Conversions between geodetic and Cartesian coordinates assume a spherical Earth.
Solution/Comments: Use a more realistic Earth model.

Problem 17: Segmentation faults occur when there are too many stations and/or too large a range in baselines.
Solution/Comments: Identify the location and cause of this failure.

Problem 18: The recipe for creating new stn_layout files is undocumented.
Solution/Comments: The relevant information should be extracted from the code and complied into a help file.

Problem 19: The elimination of LOsim would leave MAPS without a means of introducing non-point sources (e.g., elliptical Gaussians) into model data.
Solution/Comments: Introduce this functionality into MAPS_im2uv via an optional input source list. Could be done in the u-v plane. A flag could be implemented to allow

use of this feature even in cases where the user is not starting with a pre-fabricated sky image.

Problem 20: If one uses an externally-generated image as a sky model for a MAPS simulation and then images the resulting model visibilities, the coordinates in the resulting image will be mirror-reversed (i.e., the sign of CDELT1 in the FITS header will be incorrect, hence the coordinates of sources in the field will no longer be correct). This does not occur if the sky model was generated by LOsim.
Solution/Comments: According to Randall Wayth, this will require retrofitting two core MAPS modules.

Problem 21: visgen crashes and burns without any warning messages if there are more than ∼1405 antennas in the array. Examination of the log file shows errors like the following after successfully reading the first 1405 antennas:

mpivisgen: Could not open station layout directory '/hom'
mpivisgen: Cannot find station layout 'dish_12m_unpol'
mpivisgen: Failure reading array specification from file
Solution/Comments: Need to identify trigger of this problem. Unclear if it always occurs after a fixed number of antennas.