OSKAR Introduction

Version history:

Revision	Date	Modification
1	2012-04-23	Creation.
2	2012-04-27	Added reference to theory of operation document.
3	2012-11-23	Added reference to binary file format description.
4	2013-03-01	Added references to documents for pointing files and MATLAB interface for OSKAR 2.2.0.
5	2013-11-26	Added summary of OSKAR features (moved from the release notes document) and updated file names of settings and release notes documents.
6	2014-07-16	Updated feature summary and roadmap for OSKAR 2.5.0.

1 What is OSKAR 2?

The OSKAR package consists of a number of open source libraries and applications for the simulation of astronomical radio interferometers. OSKAR 2.x has been designed primarily to produce simulated data from large aperture arrays, such as those envisaged for the SKA.

2 Features

Below is a summary of the current features of the OSKAR package.

- **Simulation capability:**
  - Evaluation of a fully polarised Measurement Equation accelerated using NVIDIA GPU(s).
  - Extensible framework using Jones matrix formalism. The following terms are currently implemented (for baselines p, q and all visible sources, s):
    $\langle \mathbf{V}_{p,q} \rangle = \sum_s \mathbf{K}_{p,s}\mathbf{E}_{p,s}\mathbf{R}_{p,s}\langle \mathbf{B}_s \rangle \mathbf{R}^H_{q,s}\mathbf{E}^H_{q,s}\mathbf{K}^H_{q,s}$
    - **B** – Source brightness matrix.
    - **R** – Parallactic angle rotation.
    - **E** – Station beam, including antenna element response(s).
    - **K** – Interferometer phase.
    - **V** – Complex visibility.
  - Optimised for simulation using very large source catalogues.
  - Easily capable of simulating interferometers constructed from large aperture arrays.
  - Sky models:
    - Catalogues of point and/or elliptical Gaussian sources.
    - Imported from a number of data file formats:
      - Simple custom ASCII or binary tables.
      - HEALPix pixel grids, in ASCII list and/or FITS format.
      - FITS images.
    - Built-in sky model generators for random power-law, random broken-power-law and uniform HEALPix grid distributions.
  - Station beam response:
    - Direct evaluation of aperture array station beams (E Jones) from arbitrary telescope configurations (using either single level or hierarchical beam forming schemes). Options include:
      - Independent specification of pointing direction for each station or tile.
      - Apodisation weighting.
      - Antenna element position and dipole orientation errors.
      - Systematic and random element phase and gain errors.
    - Inclusion of (embedded) antenna element patterns specified by an analytical dipole response or a numerically defined pattern, as a function of element type and frequency.
  - Interferometric response allows for:
    - Analytical time and bandwidth smearing.
    - Uncorrelated system noise.
    - Filtering as a function of baseline UV distance.
- **An application to simulate interferometer data**

  - Configurable using INI format settings files.
  - Export to Measurement Set format.
  - Capability to produce raw images of simulated visibility data in FITS format.
- **An application to simulate aperture array beam patterns**
  - Configurable using INI format settings files.
  - Employs the same algorithms as those used to evaluate the beam response when simulating interferometric data.
  - Export to FITS image format.
- **A simple graphical user interface application for setting up and running simulations.**
- **A number of utility applications to provide support for scripting of simulations.**
- **Supported and tested on Linux and Apple Mac OS X.**

3 Getting Started

The following documents are available, and we suggest that you read them in the order listed below.

- Release Notes (www.oerc.ox.ac.uk/~ska/oskar/OSKAR-Release-Notes.pdf)
  - Describes the features in the current release of OSKAR.
- Installation Guide (www.oerc.ox.ac.uk/~ska/oskar/OSKAR-Install.pdf)
  - Describes how to build and install OSKAR.
- Example (www.oerc.ox.ac.uk/~ska/oskar/OSKAR-Example.pdf)
  - Describes how to run an example simulation and test that your version of OSKAR is working as intended.
- Theory of Operation (www.oerc.ox.ac.uk/~ska/oskar/OSKAR-Theory.pdf)
  - Describes the theory of operation of OSKAR, its implementation of the measurement equation and its treatment of polarisation. Please read this document to verify that OSKAR works as you expect.
- Apps (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Apps.pdf)
  - Describes the available OSKAR applications and the MATLAB interface.
- Sky Model (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Sky-Model.pdf)
  - Describes the format of the OSKAR sky model files.
- Telescope Model (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Telescope-Model.pdf)
  - Describes the format of the OSKAR telescope model files and directories.
- Pointing File (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Pointing-File.pdf)
  - Describes the format of OSKAR pointing files.
- Settings Files (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Settings.pdf)
  - Describes settings used by OSKAR and the format of the OSKAR settings files.
- MATLAB interface (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-MATLAB-Interface.pdf)
  - Describes an experimental interface for accessing OSKAR data types and making images of visibility data in MATLAB.
- Binary File Format (www.oerc.ox.ac.uk/~ska/oskar2/OSKAR-Binary-File-Format.pdf)
  - Describes the format of binary files written by OSKAR applications (for reference only).

4 FAQ

This section attempts to address some frequently asked questions about OSKAR. If you have a question that is not answered here, please send it to oskar@oerc.ox.ac.uk and we will do our best to respond.

4.1 Which operating systems/platforms are supported?

OSKAR has been tested on Ubuntu Linux 12.04 and 13.10, and we anticipate that it will work without problems with other recent Linux distributions. OSKAR has also been tested to compile and run correctly on Mac OS X 10.8 and 10.9. If you encounter a problem with OSKAR while trying to compile or run it on a Linux or Mac OS X system, please report it to oskar@oerc.ox.ac.uk.

Since there is no known platform-specific code in OSKAR, it is likely that it will work on Microsoft Windows, but this platform is currently unsupported. However, depending on demand, support for this platform could be added in a future release.

4.2 Does OSKAR require an NVIDIA GPU to work?

Yes. The core parts of the code are currently written using NVIDIA's CUDA language for general-purpose computing on GPUs, and this is only supported on NVIDIA hardware. Systems that do not have a CUDA-capable NVIDIA graphics processor will not be able to run the current version of OSKAR.

4.3 Is OpenCL supported?

No. However, depending on demand, support for OpenCL could potentially be added in a future release.

4.4 Are pre-built binary packages of OSKAR available?

No. Currently we don't have the resources to produce or support pre-built binaries. Please compile OSKAR for your target system using the available source code.

4.5 I found a bug!

Please let us know by sending an email to oskar@oerc.ox.ac.uk.

4.6 I found a bug, but I managed to fix it in my copy!

Wonderful! Please send us your patch by sending an email to oskar@oerc.ox.ac.uk. We'll test it and integrate it back into the main code base.

4.7 Please could you add feature/capability <X>?

Please check first to see if it's something that's already on the list in the planned roadmap. We will certainly consider new features but can't guarantee that we can implement them.

5 Roadmap

Releases in the immediate future will be mainly aimed at fixing bugs and adding missing features. The current items on the high-priority list include:

- Interferometry simulations using dishes.
- Inclusion of direction-independent gain and phase errors, to be corrected during calibration
- Inclusion of a simple ionosphere model.