DOCUMENT

Format for the prescription of the optics of EChO

Prepared by **Isabel Escudero Sanz**
Reference
Issue **draft**
Revision **2**
Date of Issue **12/09/2012**
Status
Document Type
Distribution

European Space Agency
Agence spatiale européenne

APPROVAL

Title	
Issue draft	**Revision** 2
Author	**Date** 12/09/2012
Approved by	**Date**

CHANGE LOG

Reason for change	**Issue**	**Revision**	**Date**

CHANGE RECORD

Issue draft	**Revision** 2		
Reason for change	**Date**	**Pages**	**Paragraph(s)**

Table of contents:

1 INTRODUCTION

This document establishes the way in which the optics of EChO instruments and telescope must be described and presented. The purpose of the document is to avoid mistakes arising from the translation of the representation of the optics with different optical design software tools by defining a format that is independent of them. Although a Zemax or a Code V file containing the optical data will be requested, the identification of the optical design will not be based on it but on an accompanying document containing the information and using the format described here.

2 DESCRIPTION OF THE REQUIRED DATA

The optics of the EChO instruments and telescope shall be described in a document that contains the optics data, a summary of the optics performance and an identification of the corresponding Zemax or Code V file (name and date).

The optics data shall include:

- Description of the optical components (identification label, shape, size and relevant data used to assess the nominal optical performance of the system).
- The location and orientation of all optical surfaces with respect to a global coordinate system.
- A description of the system configuration (entrance pupil diameter, effective focal length, field of view, wavelengths, etc.).
- A description of the optics performance.

It should be noted that image surface, entrance pupil, field and aperture stops and any other aperture introducing vignetting are optical components/surfaces.

The optics performance summary shall include ray trace data and spot diagrams for selected field objects and wavelengths.

The location and orientation of all the optical components shall be given with respect to a global coordinate system. This is a Cartesian coordinate system defined as follows:

- The origin is the centre of the entrance pupil of the telescope.
- The z-axis is parallel to the input light for an object at (0, 0) degrees in the field of view. It is positive in the direction of propagation of the light.
- The y-axis is orthogonal to the z-axis. It is positive in the direction of the off-axis objects that would appear above the field object at (0,0) degrees when looking towards the field of view.
- The x-axis completes a right handed coordinate system with the other two axes.

3 OPTICS DATA

3.1 Description of optical components

Each component shall be described individually. The minimum information required for this description is the identification of the component (which instrument, which band, which observing mode, etc.) with a unique label, the type of component, the material, the shape of its surface (or surfaces), the axial thickness, the aperture and other specific data (conic constant, aspheric coefficients, grating frequency, wedge, etc) required to describe it and assess the optical performance of the system. For non flat surfaces it shall be indicated if the surface is convex or concave.

For refractive components the material shall be clearly identified with the following information: chemical composition and/or name given by manufacturer and refractive index. The refractive index shall be given at 3 wavelengths at least: the minimum, maximum and mid wavelength of the spectral band in which is used. For those components which are used in more than one wavelength band, the data should be given for 3 wavelengths of each band. In the case of transmission gratings made of more than one material (e.g. replica ruled gratings), the refractive index data shall be given for each material.

3.2 Location and orientation of optical surfaces

A global coordinate system –as described above- shall be used to specify the location and orientation of an optical surface. The location of the surface shall be given by the coordinates of a reference point with respect to the global coordinate system. The orientation of the surface shall be indicated by the direction cosines of its reference vector in the global coordinate system.

The location reference point of a surface location shall be a point of the surface: its geometrical vertex (e.g. the centre of radial symmetry of the surface, or the intersection of two axes of mirror symmetry) or, in the case of flat surfaces, the intersection with the optical axis used in the ray tracing software. The orientation reference vector of a surface shall be a vector normal to the surface at the reference point of the surface and pointing towards the direction of propagation of the incident light.

Surfaces with structure (e.g. diffraction gratings) required additional information to describe the orientation of the structure. For them, an axis of symmetry of the structure shall be defined and the orientation of this axis shall be given with respect to the global coordinate system.

3.3 System configuration

The system configuration shall be described by the following parameters:

- The dimensions of the entrance pupil and the shape if is not circular.

- The effective focal length or the dimensions of the exit pupil if it is afocal.
- The field of view.
- The wavelengths used.

3.4 Format of the data

The optical data of each instrument and telescope shall be presented in at least three separate tables containing the components description, the layout description and the system configuration description. Length units shall be mm, angular units shall be degrees and wavelength units shall be nm. Drawings of each instrument shall be included in which optical components or surfaces are clearly identified with labels. Labels used in drawings and tables should be the same for the same component or surface.

The table with the component description shall combine information of component and individual surface data. It shall include a component or surface label, the kind of component (mirror, lens, aperture, etc.), the axial thickness, the material, a number indicating the order of the surface in the optical path from entrance pupil to detector, the surface curvature and orientation (convex/concave), the conic constant, a box indicating that extra data –if any- exists and a reference to where in the document can be found. The extra data could be aspheric coefficients, grating frequency, refractive index, etc. This extra data will be given separately. No format is specified for it other than for aspheric coefficient and conic constant data which shall follow ISO 10110 standards. There shall be at least one component description table per instrument. If there are variations in the components within the same instrument (e.g. zoom configurations with different data for different bands) additional tables shall be given with the details of the different components. There shall be at least one additional table for each band/observing mode with a clear identification of the band/observing mode.

Part of the surface description information is the aperture data. These data could be included in the above table or in a separate table. In this case, there will be an aperture data table for each component description table. The aperture data shall include a component/ surface label, a number indicating the order of the surface in the optical path from entrance pupil to detector, the type of aperture (clear aperture, hole, etc.) shape and dimensions (semi-diameters) and aperture decentre data for non flat surfaces with respect local surface coordinates in the ray tracing software.

The table with the layout description shall include a number indicating the order of the surface in the optical path from entrance pupil to detector, a component/surface labels, the three coordinates and the three direction cosines of the surface in the global coordinate system. There shall be at least one layout description table per instrument. If there are variations within the same instrument (e.g. zoom configurations with different data for different bands), one complete table for each band/observing mode shall be given with a clear identification of the band/observing mode.

The system configuration description shall include:

- the dimensions of the entrance pupil: defined by the diameter if it is circular and by the coordinates of the four corners if it is rectangular.
- the effective focal length of the system at the mid wave length of the spectral band.
- the field of view: defined by the diameter (in degrees) if it is circular and by the angular coordinates of the field objects at four corners if it is rectangular. If the field of view is off-axis, the angular coordinates of the geometrical centre shall be given.
- there shall be at least one system configuration table per instrument. If there are variations in the system configuration within the same instrument (e.g. zoom configurations with different data for different bands/observing modes), additional tables can be given with the details of the differences.

4 OPTICS PERFORMANCE

The performance of the optics shall be described by trace data and spot diagrams.

The ray trace data shall correspond to the principal ray of the object in the centre of the field of view for the mid wavelength of the spectral band of each instrument and observing mode. These data will be given in tables with the following information: identification of the instrument, spectral band and observing mode, a number indicating the order of the surface in the optical path from entrance pupil to detector, a surface label, coordinates of the intersection of the principal ray with the surface in the surface coordinate system and the wavelength used in the ray tracing calculation. The ray trace data shall be given in tables. There will be at least one table per instrument/band/observing mode.

Spot diagrams for each instrument band and observing mode shall be given at least for three field objects –centre, outermost and 0.7 of the outermost field- if the field is circular and five –centre and corners- if the field is rectangular. They should be given for at least three wavelengths (maximum, minimum and middle wavelengths of the band). The scale of the diagrams shall be 50 µm. A square grid containing 20 rays across the entrance pupil diameter shall be used to generate the spots.