VERY LARGE TELESCOPE INTERFEROMETER

Statement of Work and Software Specifications For an upgrade of the ASPRO package

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Prepared: A.Richichi, P. Ballester

Name Date Signature

Approved: M. Peron

Name Date Signature

Released: J. Melnick

Name Date Signature

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1 INTRODUCTION

1.1 SCOPE

This document lists and describes the main specifications of a proposed update to the ASPRO software that ESO would require in order to satisfy a number of needs currently not fulfilled by other existing tools.

The JMMC coordinates the efforts of several Laboratories in France to offer all the potential users of interferometric facilities the best operational environment. The main activity of JMMC, besides prospective and training, is software oriented system analysis and software development. Among several other SW tools, JMMC has developed and actively supports ASPRO, an Astronomical Software to PRepare Observations. ASPRO has several features, which are specific for preparing and simulating observations at the VLTI.

ESO supports the preparation of observations at the VLTI through tools available from its ETC web page http://www.eso.org/observing/etc/. In particular, it offers VISCALC and CALVIN. VISCALC allows the user to compute visibilities and other observation-related quantities for a number of model sources or free-input images, while CALVIN allows the selection of suitable calibrators. The ESO tools, although general in their intrinsic design, are in fact normally offered at each period with specifically selected features adapted to the actual current observational settings.

The VLTI is a complex facility, and it is in constant evolution. Thus, some of the newest instrumental modes may produce observables, which are not always fully represented in the standard versions of VISCALC and CALVIN. Given the high degree of development of ASPRO, and its broad support provided by JMMC, ESO considers that an efficient approach is to complement the capabilities of VISCALC and CALVIN with those offered by ASPRO. However, given the specific needs of the ESO users, it is necessary to outline some changes and improvements to ASPRO. These are described in the present document. For convenience, the resulting new ASPRO subset to be provided to and used by ESO will be called ASPRO-ESO hereafter.

1.2 DOCUMENT ORGANIZATION

This document is organized as follows. The user requirements for observation preparation at the VLTI are outlined in Sect. 2. The specifications for ASPRO-ESO are outlined in Sect. 3 and Sect. 4. The procedures and conditions for the development and support of ASPRO-ESO are described in Sect. 5.

1.3 APPLICABLE DOCUMENTS AND REFERENCES

[1] Proposals for Phase A studies of 2nd Generation VLTI Instruments, ESO-STC/402, April 6, 2006

[2] Phase A proposal for GRAVITY, ESO-STC/402A, April 6, 2006

[3] ICD between VLTI and Instruments VLT-ICD-ESO-15000-1826 v.4.0 11/08/2005

[4] Interface Control Document between VLTI Supervisor Software and VLTI Instrumentation Software, VLTI-ICD-ESO-15410-2117, issue 3, 17/11/2006

[5] Data Flow for VLT/VLTI Instruments Deliverables Specification VLT-SPE-ESO-19000-1618 v2.0 2004/05/22

[6] Proposed FITS File Formats for Optical/IR Interferometry Data, v1.2.4 October 2, 2000

1.4 ACRONYMS FREQUENTLY USED AT ESO/VLTI

AMBER	Astronomical Multi-BEam Recombiner
ASPRO	Astronomical Software to PRepare Observations
AO	Adaptive Optics
ASTO	Archive Storage System
AT	Auxiliary Telescope (1.8m)
CALVIN	VLTI Calibrator Selector
CCC	Closed-Cycle Cooler
CNRS	Centre National de la Recherche Scientifique (France)
DFS	Data Flow System
DHS	Data Handling System
DICB	Data Interface Control Board
DID	Data Interface Dictionary
DAS	Data Analysis Software
DRS	Data Reduction Software
ETC	Exposure Time Calculator
FITS	Flexible Image Transport System
FLUOR	Fiber Linked Unit for Optical Recombination
FSU	Fringe Sensor Unit
GENIE	The ground-based nulling demonstrator of DARWIN (ESA)
GTO	Guaranteed Time Observations
ICD	Interface Control Document
ITF	Interferometric Task Force
JMMC	Jean-Marie Mariotti Center
MIDI	Mid-Infrared interferometric instrument
OB	Observation Block
OPC	Observing Program Committee
OPD	Optical Path Difference
OS	Observation Software
P2PP	Phase 2 Proposal Preparation
PAOS	Prima Astrometric Observation Software
PRIMA	Phase-Referenced Imaging and Microarcsecond Astrometry
PT	Pulse-Tube
QC	Quality Control
QC1	Quality Control Level 1
STC	ESO Science and Technology Committee
SW	Software

TBD	To Be Defined
UT	Unit Telescope of VLT
VCM	Variable Curvature Mirror
VINCI	VLT INterferometer Commissionning Instrument
VISCALC	VLTI Visibility Calculator
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer

2 OBSERVATION PREPARATION AT THE VLTI

2.1 CURRENT TOOLS AND CAPABILITIES

In order to plan an interferometric observation with MIDI and AMBER, and to assess its feasibility, it is necessary to estimate the visibility values for the expected intensity distribution of the science target and the chosen VLTI configuration. In addition, appropriate calibration stars to derive the interferometric transfer must be selected. Two interactive tools are provided by ESO for these purposes, the visibility calculator VisCalc and the calibrator selection tool CalVin.

VisCalc provides calculations of synthetic dispersed visibilities based on software models of the VLTI instruments. The declination and spectral energy distribution, as well as the source geometry, are parameters used to specify the scientific target. Visibilities are calculated analytically for uniform discs, Gaussian discs, and binaries, and numerically for a user-provided brightness distribution, which is uploaded as a FITS file. The user-specified observation parameters include the starting hour angle and the duration of the observation, as well as the instrument and array configuration. Different results can be displayed including observability as a function of local sidereal time, shadowing effects on the VLTI platform, limitations by the stroke of the delay lines, the *uv*-tracks, the input image and its Fourier transform, and plots of visibility versus time.

CalVin suggests suitable calibrators from an underlying list of stars based on different user-defined criteria such as magnitude, spectral type, and distance on sky. The strategy to preferably select calibration stars from the limited underlying lists of calibration stars preserves objects, which have already been studied. Hence, more and more detailed knowledge of these calibration sources will be rapidly acquired. Currently, the underlying CalVin list of calibration stars for MIDI is based on the catalogue of calibration stars that has been developed by the MIDI instrument consortium by spectro-photometric observations of candidate stars fitting the data to atmosphere models (B. Stecklum, ESO calibrator workshop 2003). The underlying list of CalVin calibration stars for AMBER is currently based on the catalogues of Borde et al. (2002) and Merand et al. (2006).

The most recent versions of both tools released in December 2006 include in addition calculations of the visibility at the wavelength of FINITO in order to assess the feasibility of a MIDI or AMBER target/calibrator to be used as guide star for FINITO.

Both tools can be accessed from the VLT Exposure Time Calculators page on http://www.eso.org/observing/etc. The standard version shows only the configurations that are offered for the current Call for Proposals. It is updated for each new Call for Proposals in order to reflect the offered VLTI baseline configurations and instrument modes. An “expert” version, accessible from the ETC preview page (http://www.eso.org/observing/etc/preview.html) offers an extended interface with many more choices. It supports the modes and configurations that are currently not offered.

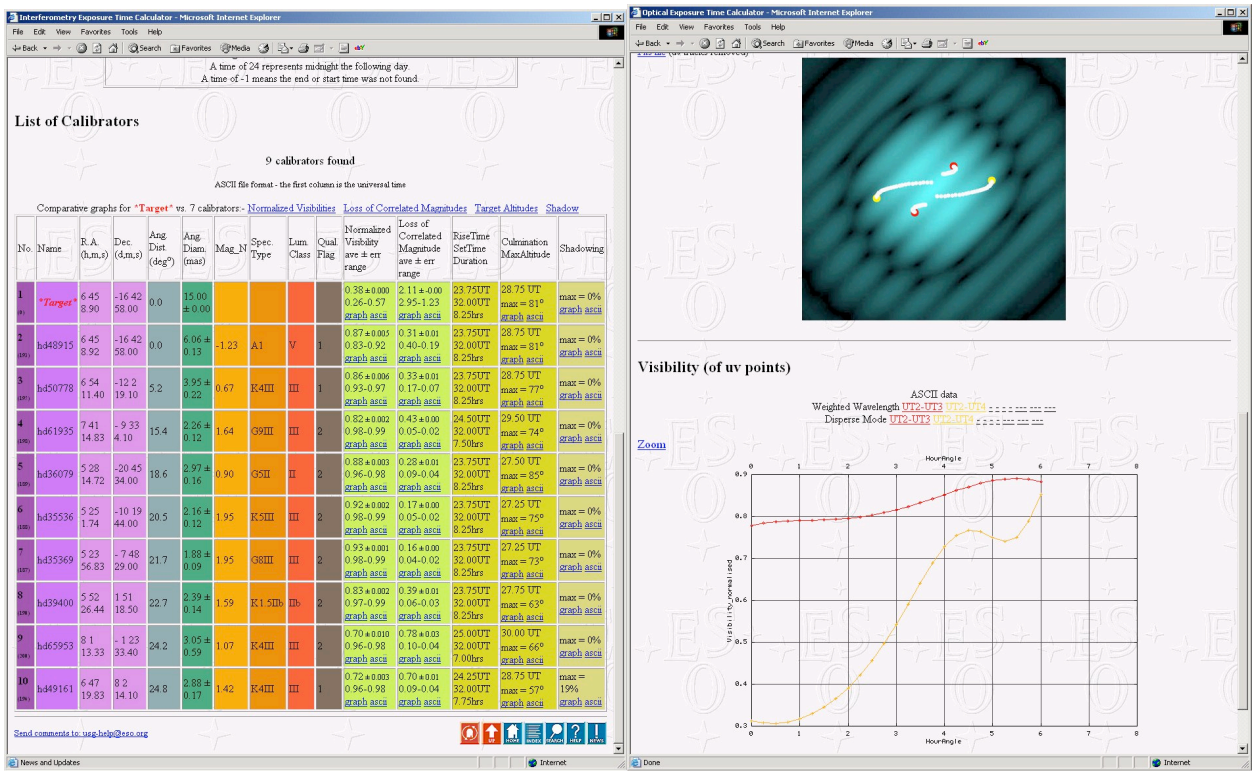

Fig. 1: Sample results from the calibrator selection tool CalVin (left) and from the visibility calculator VisCalc (right).

2.2 FURTHER DEVELOPMENTS

Further planned developments for VisCalc and CalVin (implementation presumably in 2007) include support for 3-telescope observations with AMBER by calculation of synthetic triple amplitudes, closure phases, and differential phases; improved support for the different instrument modes (synthetic visibility and phase calculations for medium and high resolution modes); and extended target definitions. The latter consist of elliptical uniform and Gaussian discs, as well as definitions of target geometry as a function of wavelength by uploading user-provided stacks of target geometry at different wavelengths in one fits file.

The main addition to the VLTI in the short-term (2007-2009) will be the PRIMA facility. ESO observers will have the possibility to use PRIMA as a stand-alone differential delay instrument (for astrometry programs), or as a front-end to the MIDI or AMBER instruments. The PRIMA astrometry observation preparation tool is being prepared by the PRIMA consortium as part of the PAOS software development program. The support for PRIMA when used with MIDI or AMBER will need to be provided. The latter includes calculations of visibility values at wavelength and fringe detection mode of PRIMA in order to assess whether a target is feasible as PRIMA guide star, as well as a selection option in CalVin to return calibrators that can be used as phase references.

On a longer time-scale, one or more VLTI 2nd generation instruments may be selected and developed (current proposal include VSI, MATISSE, GRAVITY). The initial studies indicate that these instruments will involve a 4-telescope beam combination, and possibly up to 6-beams. The

tools developed under the terms of the present document should allow supporting these coming instruments as well.

The support for calibrators needs to be extended: Phase calibrators for PRIMA (see above), choice of selecting a calibrator from a well known underlying list (fixed approach), or by selecting any suitable calibrator from an analysis of large databases and from estimates of the physical properties (dynamic approach).

Future versions of these tools shall have the option to create OBs based on the selected target, instrument mode, and array configuration.

In summary, with regard to the current capabilities of VisCalc, CalVin, the following additional features are required:

- Spatial-Spectral Distribution of the source (the geometry of the source can vary with the wavelength).
- Support for 3-4-6 beam operations including calculations of triple amplitudes, closure phases, and differential phases.
- Dynamic selection of calibrators up to magnitude H or K=12
- Separate visibility modelling for the on-axis and the off-axis sources (PRIMA)
- Separate visibility modelling at different wavelengths (FINITO, FSU)
- Output of OBs for the selected target and instrument mode, and array configuration.

3 SOFTWARE REQUIREMENTS

The ASPRO update to be developed for ESO (ASPRO-ESO) will be a web tool. The tool can in fact be provided to ESO as two separate tools, one for visibilities and one for calibrators. We refer below to one single tool for convenience only. The tool shall comply with the following characteristics:

1. Public access without registration. ESO will have the possibility to log the usage.

2. The tool shall be distributed as Java Applications (not Java Applets).

3. The user interfaces, as well as the results and any data/plots, will be in English language. A comprehensive help will be included.

4. The tool shall provide all the functionality that is currently provided by VisCalc and CalVin (Sect. 2.1), as well as the outlined additional functionalities (Sect. 2.2). More detailed technical specifications can be discussed in the context of the ESO/JMMC MOU and added to this document during revisions and version control.

5. The Graphical User Interface will be innovative and build upon the current concepts of ASPRO, VisCalc, and CalVin. The user interface will be in the style of a flight-simulator where inputs and outputs are presented in one single page, and where the user can see the results of making even small changes to the input parameters in near real time, so as to be able to compare with the previous setting The ability of the user to change parameters should be supplemented by the use of pull-down menus, slide-bars, analog renditions, etc.

6. The application shall provide a safe mechanism for late-minute updates, configuration updates, new versions of software, and clearly notify the user when the configurations offered or the software itself have changed.

7. Design specific for the current Call for Proposal (alternative designs, such as for historical Periods or generic, may also be available on user's request). The Call for Proposal version will provide two sub-modes for Visitor and Service usage.

8. It shall be possible to update in the Call for Proposal version the list of offered baselines, and instrument filters by means of configuration files. The application will always query the latest configuration version without the need for a reinstallation.

9. An Expert version will give access to all possible VLTI configurations, as well as a broader choice of dates of observation and observation modes than possible in the version tailored to the current Call for Proposals.

10. For the calibrators, the fixed approach will include a mechanism that will permit ESO to provide lists other than those included in the tools.

4 DEVELOPMENT, DELIVERY AND SUPPORT

The development of ASPRO-ESO will be monitored through written reports as well as progress meetings. At least one written report each three months will be sent from JMMC to ESO, describing the differential between the current status of the SW and the status at the previous report, the actions foreseen until the next report, and including an account of the resources used (number of persons and amount of working time). At least one progress meeting will be held per year between JMMC and ESO representatives, and more frequently if deemed necessary by ESO or JMMC. Scope of the progress meeting is to monitor the progress of the software development, to demonstrate what is already available, and to discuss problems and management issues.

The ASPRO-ESO delivery will include the source codes and sufficient documentation to enable ESO to run and support it if needed (see Table 1). The delivery will be based on extensive testing of the Java code to be carried out on several of configurations, as will be specified by ESO.

Software Component	**Including**
Source Code	Java source files
Configuration Data	Data files
Software Design Document	Java classes design, mathematical methods description, structure of configuration files, installation procedure on ESO servers
User Manual	Step-by-step functions description and usage
Verification Document	Standard test cases with documented results

Table 1: List of software components (draft definition)

Starting with the first delivery of ASPRO-ESO, JMMC will support it for the duration of the corresponding Memorandum of Understanding between ESO and CNRS. In particular:

- It is foreseen to have a new ASPRO-ESO version at each ESO Call for Proposals, which are normally issued on March 1st and September 1st of each year. The new version may consist of updates of the configuration files and/or updates of the software code. Ideally the package should evolve such that unless a new facility is added to the VLTI (e.g. a new instrument), period-to-period updates are fully captured by the configurations files. ESO will be provided with the tools and documentation necessary to update the configuration files.
- Two (2) to four (4) months prior to the CfP, ESO will notify JMMC of a list of changes needed for the next version (such as changes of instrument, instrument modes, available baselines and including improvements over the previous version).
- No later than 6 weeks prior to the CfP, JMMC will make available to ESO the new version for testing.
- The new version will have to be completed, including testing and installation at ESO, at least one week prior to the CfP
- During the validity of the Call for Proposals, normally one month, a dedicated support will be provided by JMMC either in the form of a person based in Garching or through a rapid-response line. It is expected that problems, which arise during the time of the Call for Proposals, be dealt with immediately with the highest priority.

5 CONDITIONS GOVERNING THE ASPRO-ESO

The development of ASPRO-ESO will be completed within 18 months, with a goal of meeting the Call for Proposals for Period 83 (October 2008). As ESO has to plan ahead as part of its commitments and services to the community, significant delays will have a very negative impact. Should a delay in the delivery be foreseen by JMMC, it should be announced as early as possible to allow for alternative plans.

TBC