GMOS Mask Design Software SPE-PS-G0083

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1. Introduction

The following is both a description of the procedure for designing a mask for GMOS and a definition of the interface between the discrete processing steps. The description is in the form of user requirements for the software and a functional description of the process. The software is currently under development. Section 11 contains the Interface Control Documents (ICDs) for both the software and the interactions between the PI and Gemini (IGPO).

1.1 Abbreviations and definitions

ASCII	American Standard Code for Information Exchange
FITS	Flexible Image Transport System
GMOS	Gemini Multi-Object Spectrograph
ICD	Interface Control Document
IGPO	International Gemini Project Office
IRAF	Image Reduction and Analysis Facility
LCI	Laser Cutter Instructions
Master ODF	Master Object Definition File
MDF	Mask Definition File
ODF	Object Definition File
OT	Observing Tool
PI	Principal Investigator
STSDAS	Space Telescope Science Data Analysis System
WCS	World Coordinate System

2. Overview of the Process

Figure 1 gives an overview over the full procedure, from obtaining the imaging of the field to making the mask using the laser mask cutter.

The steps in the mask making process are the following:

IGPO staff or the PI:

1. Initial direct image acquisition. These will nominally be GMOS images. The images (and associated calibration frames) may be obtained in queue time by IGPO staff or in classical time by the PI. The PI may also use GMOS images from the Gemini Science Archive or GMOS images obtained by the PI during a previous observing run. The early use of GMOS will require that GMOS images are used for the mask making process. The GMOS Mask Making Software will be designed to handle object lists generated by other sources (e.g. other telescopes) once the necessary transformations have been determined.

PI:

2. Reduction of GMOS images. It is recommended to use the Gemini IRAF package for GMOS for the reductions of the images. The package will contain tasks for the basic reductions (bias and dark subtraction, flat field correction) and for mosaicing the images from the three GMOS CCDs. It will also contain tasks for co-adding multiple GMOS images. See Section 3 for details.

3. Generation of the Object Table. Produced by the PI, this is a list of the objects in the field that spectroscopy is desired for. These will nominally be the output of a photometry program

(see Section 4 for supported programs and formats).

4. Generation of the Master Object Definition File (Master ODF). Produced by the PI using the GMOS Mask Making Software, this produces a file that contains all of the objects in the Object Table, but with additional entries to describe the slit sizes and priorities for the objects.

5. Generation of the Object Definition Files (ODFs). The ODFs are produced using the GMOS Mask Making Software. The goal of this step is to design the mask layout and in the process to maximize the number of objects that may be placed covered by one mask. It may be necessary to produce multiple ODFs in order to cover all the objects in the Master ODF. It will also be necessary to permit the PI to limit the number of ODFs produced. The output of this step is a set of ODFs and a new 'residual' Master ODF that includes all of the objects that were not able to be placed on one of the masks (i.e. not included in one of the ODFs).

6. Interactive ODF editing. The PI uses the GMOS Mask Making Software to display the original image with an overlay of each ODF indicating the slit placement, spectral extent and zero-order image for each slit-let. Assorted editing functions will be provided to permit the PI to alter the ODF.

7. Creation of minimal ODF. The ODFs may contain proprietary information that was necessary for the mask design. The PI may choose to strip the ODFs of proprietary information before submitting the files to the IGPO. The GMOS Mask Making Software will allow the PI to create such minimal ODFs.

IGPO staff:

8. Generation of the Mask Definition File (MDF). IGPO staff derives the Mask Definition Files (MDFs) from the ODFs and the constraints on the planned observations (e.g. zenith distance). The MDFs contain all the information from the submitted ODFs necessary for the manufacturing of the mask and for archival use of the data. The MDFs will be archived with the obtained spectra. The MDFs describe the slit-let positions compensating for observing effects. As a different mask may be required for different conditions (such as zenith distance), each ODF may lead to multiple MDFs. The Gemini IRAF package for GMOS will be used for derivation of the MDFs from the ODFs.

9. Generation of the later cutter instructions (LCI). IGPO staff translates the MDF slit-let positions into the a file format that can be handled by mask cutting machine. The translation is handled by the MDF-to-LCI software, which is not distributed.

10. Mask cutting. IGPO staff takes care of cutting the mask using the laser mask cutter. Each mask will be outfitted with a barcode for tracking and then shipped to the location where it will be used for observations.

The Object Table, the Master Object Definition File (Master ODF), the Object Definition File(s)

(ODFs) and Mask Definition File (MDF) are binary FITS tables. The tables can be manipulated and viewed with tasks from the STSDAS tables package and with tasks in the Gemini IRAF package.

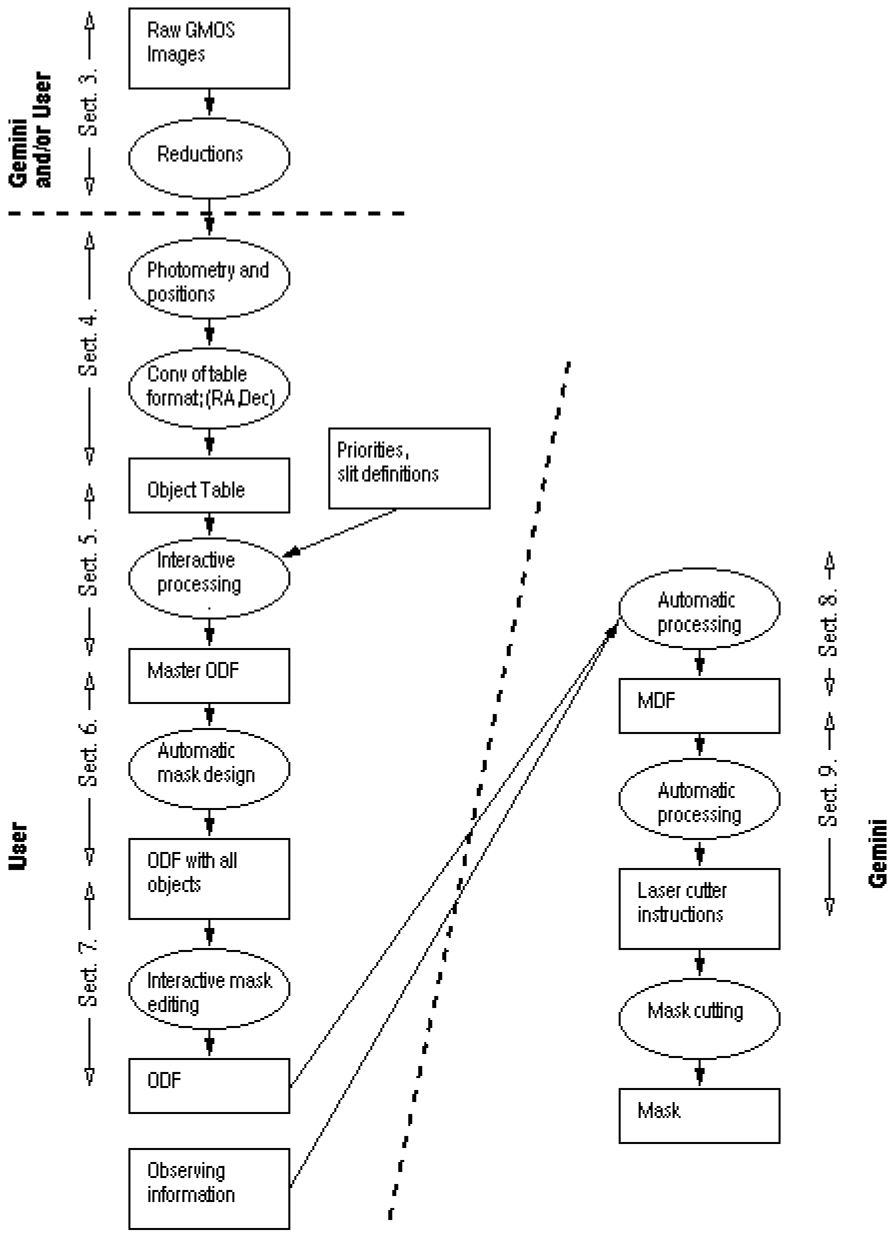

Figure 1: Overview over the procedure for the mask design, with references to the sections in this document covering each of the steps. The responsibilities for the different parts of the procedure (Gemini or User) are given in bold.

Summary of responsibilities and software

Step 1 is handled by IGPO staff or by the PI.

Step 2 is handled by the PI using the Gemini IRAF package for GMOS.

Step 3 is handled by the PI using the PI's preferred software.

Steps 4-7 are handled by the PI using the GMOS Mask Making Software, which will use Skycat for display and have a graphical user interface.

Step 8 is handled by IGPO staff using the Gemini IRAF package for GMOS.

Step 9 is handled by IGPO staff using the MDF-to-LCI software.

Step 10 is handled by IGPO staff.

3. Imaging and reductions

In order to design a mask for GMOS direct imaging of the field is needed. For the early use of GMOS it is a requirement that GMOS direct images are used for the mask design. However, the user may calibrate their positions from deep images obtained at other telescopes by means of shorter exposures obtained with GMOS.

It is the goal to be able to import data from other sources once the telescope/GMOS solution has been determined. However, for the highest velocity precision work it is likely that GMOS images will always be required.

Images from GMOS will have World Coordinate System (WCS) information included in their headers. It is recommended that the Gemini IRAF package for GMOS is used for the reductions of the GMOS. The package will contain tasks for the basic reductions (bias and dark subtraction, flat field correction) and for mosaicing the images from the three GMOS CCDs. The mosaicing task will apply the correct transformations to ensure that Object Tables derived from a mosaiced image will be handled correctly by the GMOS Mask Making Software. The output format of the mosaiced image will be a multi-extension FITS file with one image extension, see Section 11 for details.

The Gemini IRAF package will also contain tasks for co-adding multiple GMOS images, ensuring that the WCS in the co-added image is valid and correct and that the image will be handled correctly by the GMOS Mask Making Software.

The use of the WCS, RA and Dec by the GMOS Mask Making Software will ease the import of images from other sources. Note that this will not degrade the slit-let placement accuracy for the highest velocity precision work as the same WCS coefficients will be use by the process to go back into detector space when the prepared MDF files are used to cut the mask.

4. The Object Table

The Object Table is a binary FITS table. It is expected that the users may want to use their preferred photometry programs to derive photometry of the objects and positions in detector co-ordinates. These programs are expected to include (but not be limited to):

- IRAF's apphot
- IRAF's daophot
- SExtractor
- IRAF's focas
- dophot

As part of the Gemini IRAF package for GMOS, Gemini will provide software for converting output tables from these programs to binary FITS tables. Support may be added for other photometry programs. The user may also provide the required information as:

- a FITS table,
- as an ASCII table with a standard header defining the columns, or
- an STSDAS binary table.

Software will be provided to convert STSDAS and ASCII to FITS binary tables and to check that resulting FITS table contains the correct columns required for the Object Table. The user may wish to merge program specific (possibly proprietary) columns to the Object Table (these will be removed in the final stage, which produces the minimally acceptable tables). The user's column names should consist of letters, numbers and "_" (underscore), only. No other special characters may be used.

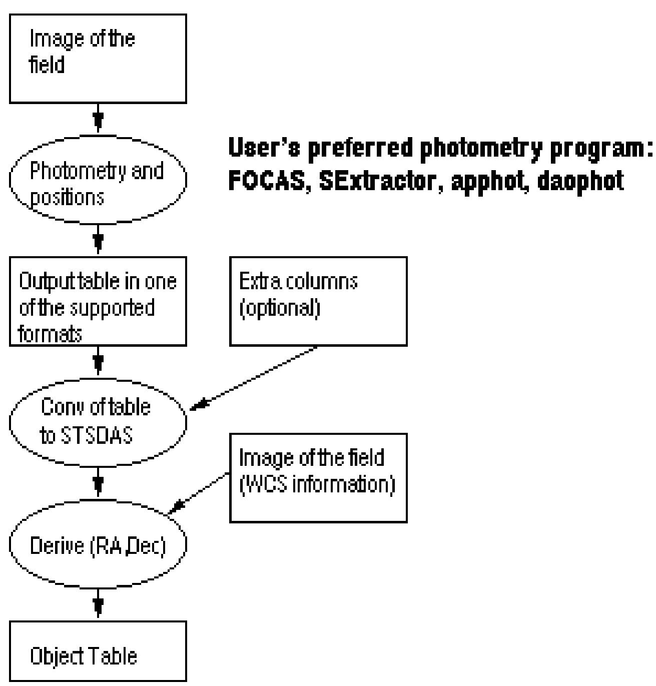

Figure 2: Deriving the positions and the photometry.

From the information about the positions in detector co-ordinates and the WCS defined in the header of the GMOS direct image, the positions will be converted to RA and Dec in J2000. The use of RA and Dec will make the system compatible (at least interface-wise) with data from sources other than GMOS. Figure 2 outlines the input and output of the steps covered in this section. Table 1 lists the typical columns defined in the Object Table. The magnitude column is required. However, it is sufficient to provide relative magnitudes in the user's preferred system. Table 2 lists the typical header information for the Object Table after this table has been created and processed to include the RA and Dec in J2000.

Table 1: Object Table Columns

Column	***Explanation***	***Required/Optional input or output***	***Type***	***Format***
id	User supplied object id number; must be unique	Required input	int	
id_txt	User supplied object id text string	Optional input	char	
x_ccd	Object position, x detector co-ordinate	Required input	real	
y_ccd	Object position, y detector co-ordinate	Required input	real	
mag	Magnitude (may be relative magnitudes)	Required input	real	
radius	Angular size	Optional input	real	
userprior	User priority	Optional input	int	
RA	Right Ascension, J2000	Output	real	hh:mm:ss.sss
DEC	Declination, J2000	Output	real	sdd:mm:ss.ss

Table 2: Object Table Header Information

Header Keyword	***Explanation***	***Source***	***Type***	***Format***
PID_IMAG	Program ID of GMOS image	Image	char	
PI_IMAG	PI of GMOS image	Image	char	
DATEIMAG	Date of observation of GMOS image	Image	char	yyyy-mm-dd
TIMEIMAG	Time of observation of GMOS image	Image	real	hh:mm:ss.s
RA_IMAG	RA center of GMOS image	Image	real	hh:mm:ss.sss
DEC_IMAG	DEC center of GMOS image	Image	real	sdd:mm:ss.ss
PA_IMAG	Position angle of GMOS image	Image	real	
FILTER	Filter of GMOS image	Image	char	
ADCMODE	ADC mode of GMOS image	Image	char	
PID_SPEC	Program ID of GMOS spectroscopic program	User/OT	char	

PI_SPEC	PI of GMOS spectroscopic program	User/OT	char	
DATE_OT	Date of creation of Object Table	Software	char	yyyy-mm-dd
TIME_OT	Time of creation of Object Table	Software	real	hh:mm:ss.s
PERS_OT	Person making Object Table	User	char	
EXTSOFT	External Software name and version	Software/User	char	
GEMSOFT	Gemini Software name and version	Software	char	

5. The Master Object Definition File (Master ODF)

In this step the user supplies the Object Table, the image of the field, the slit definitions and a set of statements to define the priorities of the objects. The user then interactively inspects and edits the priorities and the slit definitions. The Object Table can contain more objects than can be observed with one mask. The final product of this step is the Master ODF, which contains all the objects from the Object Table, with priority and slit definitions assigned. Figure 3 shows the interactive process. The Master ODF is a binary FITS table.

In order to define the slits, an x-y coordinate system for the mask design is defined as follows: The y-axis has a position angle on the sky equal to the position angle of the mask, *maskPA*, (North through East) which is the position angle of the instrument. The position angle of the mask is supplied in the next step, the automated mask design. The x-axis is perpendicular to the y-axis and 90 degrees CW. The dispersion is along the x-axis. The slits may be tilted an angle *slittilt* relative to the position angle of the mask. In this case the slit size still refers to the x-y coordinate system, e.g. the size in the x-direction is the slit size in the direction of the dispersion. The position angle of the slit is *maskPA+slittilt.* (This assumes that the GMOS image orientation is not mirrored relative to the sky.) The slit definitions can either be given as a global statement (see Table 3 and Figure 4) assuming that all the slits are the same size and shape, or the user may supply the information as part of the Object Table, see Table 4 for the column names to be used.

The x-y coordinate system for the mask design has axes aligned with the x-y coordinate system for the detectors. The unit for coordinates and lengths in the x-y coordinate system for the mask design is arcsec.

The priorities of the objects are given as a list of priority statements, see Table 5 for examples. In general, the priority statements may consist of logical statements using any of the columns in the Object Table.

Each mask requires 2-4 acquisition objects (normally stars) defined. These objects will have *priority=0* in the Master ODF. The user may either give these objects as part of the priority statements, or identify them as part of the interactive process. If they are not given as part of the priority statements, the software will assume that the user will start the interactive process by identifying the acquisition objects.

The user interacts with the display of the image, with overlays showing the slits and the priorities. The user has the possibility of interactively editing both the priorities and the slit definitions. The product of the interactive process is the Master ODF. Table 6 lists the columns in the Master ODF. Table 7 lists the header information in the Master ODF. Many of the columns and header keywords are naturally the same in the Object Table and the Master ODF, since all the information from the Object Table is included in the Master ODF. The Master ODF can be used to define several ODFs and MDFs. Therefore, the Master ODF may contain more objects than can possibly be observed with one mask.

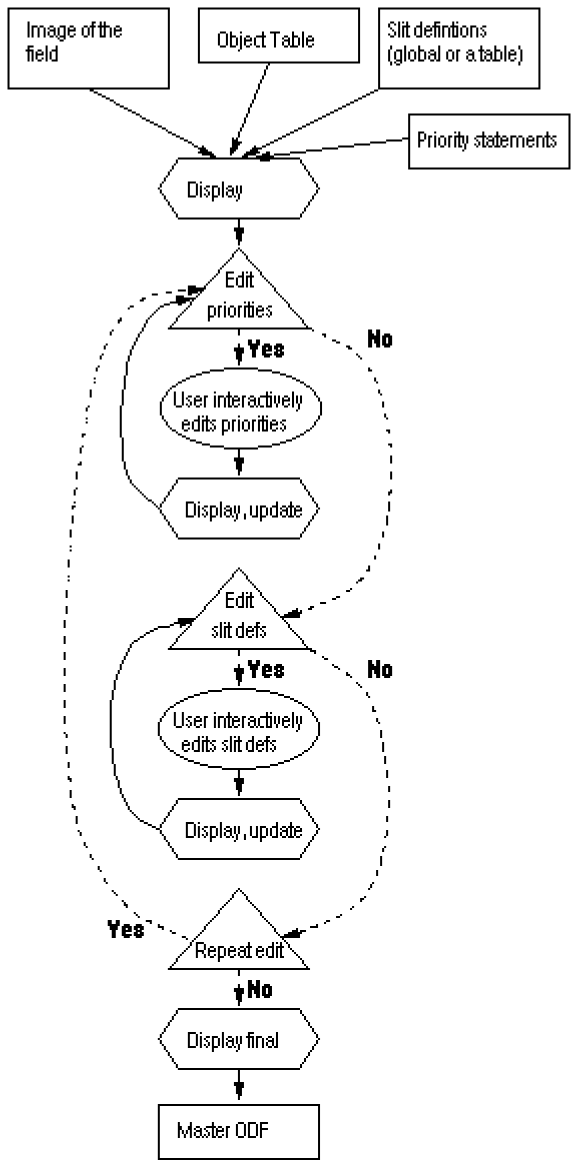

Figure 3: The interactive editing of the priorities and the slit definitions.

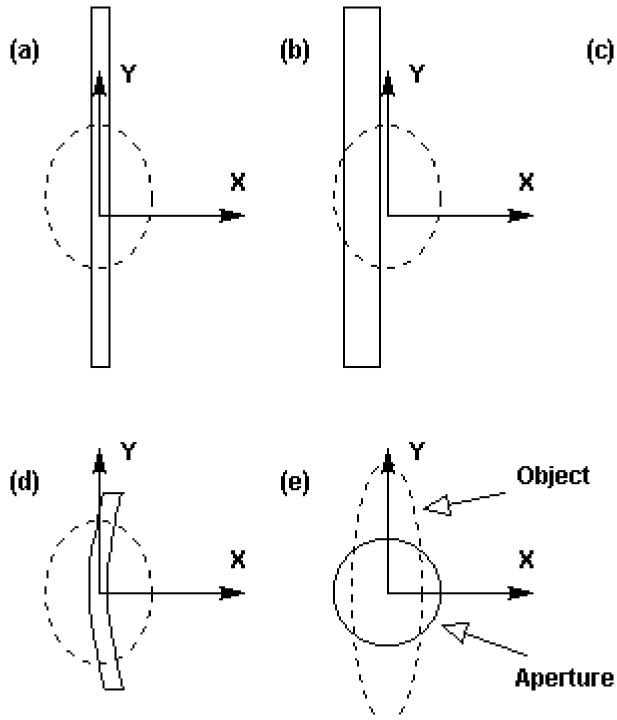

Figure 4: The slit examples described in Table 3.

Table 3: Global slit definitions - five unrelated examples

Slit definition	***Notes***	***Figure***
slittype=rectangle	Rectangular slits	Fig 4a
slitpos=(0,0)	Slits have the same position as the objects	
slitsize=(0.25,5)	Slit length =5 arcsec; slit width = 0.25 arcsec	
slittilt=0	Slit tilt relative to the *maskPA*. In this example the slits are not tilted	
slittype=rectangle	Rectangular slits	Fig 4b
slitpos=(-0.5,0)	Slits are positioned -0.5 arcsec offset from objects in the direction of the x-axis	
slitsize=(0.5,5)	Slit length = 5 arcsec; slit width = 0.5 arcsec	
slittilt=0	Slits are not tilted	
slittype=rectangle	Rectangular slits	Fig 4c
slitpos=(0,0)	Slits have the same position as the objects	

slitsize=(0.25,5)	Slit length = 5 arcsec (in the y-direction); slit width = 0.25 arcsec (in the x-direction)	
slittilt=15	Slits tilted 15 deg CCW relative to *maskPA*. The resulting position angle of the slit is *maskPA+slittilt*	
slittype=arc	The slits are arcs	Fig 4d
slitpos=(0,0)	Slits have same positions as the objects. The position of an arc is the position of the peripheral point in the direction of the y-axis (arc angle 0 deg).	
slitsize= (-15,15,5,0.25)	Slit size is given as the angle range in degrees covered by the arc measured relative to the direction of the x-axis (here from -15 deg to +15 deg). The angle is measured CCW. Then the radius of the arc (5 arcsec) is given, and finally the width in the x-direction is given (0.25 arcsec). A positive radius produces a "right"-turned arc as shown on the figure. To produce a "left"-turned arc, give a negative radius.	
slittilt=0	Slits are not tilted	
slittype=circle	Circular slits (apertures)	Fig 4e
slitpos=(0,0)	Slits have same positions as the objects	
slitsize=(0.75)	Aperture radius is 0.75 arcsec	
slittilt=0	Slit tilt is not relevant for this type of slits, assumed to be zero	

Table 4: Slit definition columns in the Object Table

Column	***Explanation***	***Required/ Optional***	***Type***
id	User supplied object id number. Must be unique. (Repeated here for clarity.)	Required	int
slittype	Slit type (rectangle, arc, circle)	Required	char
slitpos_x slitpos_y	Slit position in arcsec relative to object position. The position is given as (*x,y*) relative to the object position. The position of a rectangle and circle is the position of the center. The position of an arc is the position of the peripheral point on the arc in the direction of the x-axis.	Required	real
slitsize_x slitsize_y slitsize_r	Slit size. If *slittype=rectangle,* then *slitsize_x* defines the slit width, and *slitsize_y* defines the slit length (*slitsize_r* and *slitsize_w* are not used). If *slittype=arc*, then *slitsize_x* and *slitsize_y* define the angle range in	Required	real

slitsize_w	degrees covered by the arc measured relative to the x-axis (the angle is measured CCW), *slitsize_r* defines the arc radius, and *slitsize_w* defines the width in the x-direction. If *slittype=circle*, then *slitsize_x* is the radius of the aperture (*slitsize_y*, *slitsize_r* and *slitsize_w* are not used). Slit length, slit width, arc radius and aperture radius are in arcsec.		
slittilt	Slit position angle relative to *maskPA*, measured CCW. If not defined, *slittilt* is assumed to be zero.	Optional	real

Table 5: Priority statements - three unrelated examples

Priority statements	***Notes***
priority=0: "userprior==0"	Acquisition objects
priority=1: "mag<=16"	Bright objects - highest priority
priority=2: "mag16"	Faint objects - lowest priority
priority=0: "userprior==0"	Acquisition objects
priority=1: "B_V<1.5 && B_V>0.8 && mag<=17 && type=='E'"	Objects of certain color, magnitude and type
priority=2: "B_V<=0.8 && type=='S'"	Objects of another color and type
priority=3: "B_V1.5"	Objects of yet another color
	Objects not included in statements will be given next higher value of priority, e.g. priority=4
	In this example the acquisition objects are selected interactively
priority=1: "type=='star'"	Objects of type "star"
priority=2: "type=='galaxy'"	Objects of type "galaxy"

Table 6: Master Object Definition File - Columns

Column	***Explanation***	***Required/Optional input or output***	***Type***	***Format***
id	User supplied object id number; must be unique	Required input	int	
id_txt	User supplied object id text string	Optional input	char	
x_ccd	Object position, x detector co-ordinate	Required input	real	

y_ccd	Object position, y detector co-ordinate	Required input	real	
mag	Magnitude (may be relative magnitudes)	Required input	real	
radius	Angular size	Optional input	real	
userprior	User priority	Optional input	int	
RA	Right Ascension, J2000	Required input	real	hh:mm:ss.sss
DEC	Declination, J2000	Required input	real	sdd:mm:ss.ss
slittype	Slit type: rectangle, arc, circle	Output (from slit definitions)	real	
slitpos_x	Slit position relative to object position, arcsec in x-direction	Output (from slit definitions)	real	
slitpos_y	Slit position relative to object position, arcsec in y-direction	Output (from slit definitions)	real	
slitsize_x slitsize_y slitsize_r slitsize_w	Slit size. If *slittype=rectangle,* then *slitsize_x* defines the slit width, and *slitsize_y* defines the slit length (*slitsize_r* and *slitsize_w* are not used). If *slittype=arc*, then *slitsize_x* and *slitsize_y* define the angle range in degrees covered by the arc measured relative to the x-axis (the angle is measured CCW), *slitsize_r* defines the arc radius, and *slitsize_w* defines the width in the x-direction. If *slittype=circle*, then *slitsize_x* is the radius of the aperture (*slitsize_y*, *slitsize_r* and *slitsize_w* are not used). Slit length, slit width, arc radius and aperture radius are in arcsec.	Output (from slit definitions)	real	
slittilt	Slit position angle relative to *maskPA*, measured CCW.	Output (from slit definitions)	real	
priority	Priority of object	Output (from priority statements)	int	

Table 7: Master Object Definition File - Header Information

Header Keyword	***Explanation***	***Source***	***Type***	***Format***
PID_IMAG	Program ID of GMOS image	Object Table	char	
PI_IMAG	PI of GMOS image	Object Table	char	
DATEIMAG	Date of observation of GMOS image	Object Table	char	yyyy-mm-dd

TIMEIMAG	Time of observation of GMOS image	Object Table	real	hh:mm:ss.s
RA_IMAG	RA center of GMOS image	Object Table	real	hh:mm:ss.sss
DEC_IMAG	DEC center of GMOS image	Object Table	real	sdd:mm:ss.ss
PA_IMAGE	Position angle of GMOS image	Object Table	real	
FILTER	Filter of GMOS image	Object Table	char	
ADCMODE	ADC mode of GMOS image	Object Table	char	
PID_SPEC	Program ID of GMOS spectroscopic program	Object Table	char	
PI_SPEC	PI of GMOS spectroscopic program	Object Table	char	
DATE_OT	Date of creation of Object Table	Object Table	char	yyyy-mm-dd
TIME_OT	Time of creation of Object Table	Object Table	real	hh:mm:ss.s
PERS_OT	Person making Object Table	Object Table	char	
EXTSOFT	External Software name and version	Object Table	char	
FILE_OT	Originating Object Table	Object Table	char	
DATEMODF	Date of creation of Master ODF	Software	char	yyyy-mm-dd
TIMEMODF	Time of creation of Master ODF	Software	real	hh:mm:ss.s
PERSMODF	Person making Master ODF	User	char	
GEMSOFT	Gemini Software name and version	Software	char	

6. Automated mask design

The user provides the Master ODF and constraints for the observations. The software will then attempt to design the minimum number of masks that contain all of the highest priority objects, and then fill any additional space with lower priority objects. The constraints supplied by the user must contain the following information:

1. Position angle of the masks or allowed interval [*maskPA=(PA1:PA2)*]. The position angle is fixed if *PA1=PA2*. If an interval is given (*PA1<PA2)*, the software will search for the best position angle, *PA*, using steps of *dPA*, where *dPA* defaults to one degree if not specified by the user. Variable *maskPA* may not be supported by the first version of the GMOS Mask Making Software, in which case the mask is assumed to be aligned with the orientation of the image used for the mask design.
2. Minimum blank space between the slits (in arcsec).
3. Grating (also available from the Observing Tool).
4. Filter (also available from the Observing Tool).
5. Minimum wavelength range inside the detectors. This can either be given as start and end wavelength or as a fraction of the wavelength range resulting from the combination of the grating and the filter.
6. The maximum number of masks to produce. Should this be less than required by the

software to include all of the highest priority objects, the number of included highest priority objects will be maximized.

A flow diagram of the software is given in Figure 5. The products of this stage are:

- a set of ODFs, each of which contains all of the objects from the Master ODF. A column *slitid* indicates if an object is included in the current design. Objects not included will have *slitid=0*, while objects that are included will have a unique *slitid*. The columns and header keywords of the resulting ODF are given in Tables 8 and 9, respectively.
- a 'residual' Master ODF. This will contain all of the objects from the original Master ODF that did not make it into one of the ODFs, plus all of the priority=0 objects (i.e. the alignment objects).

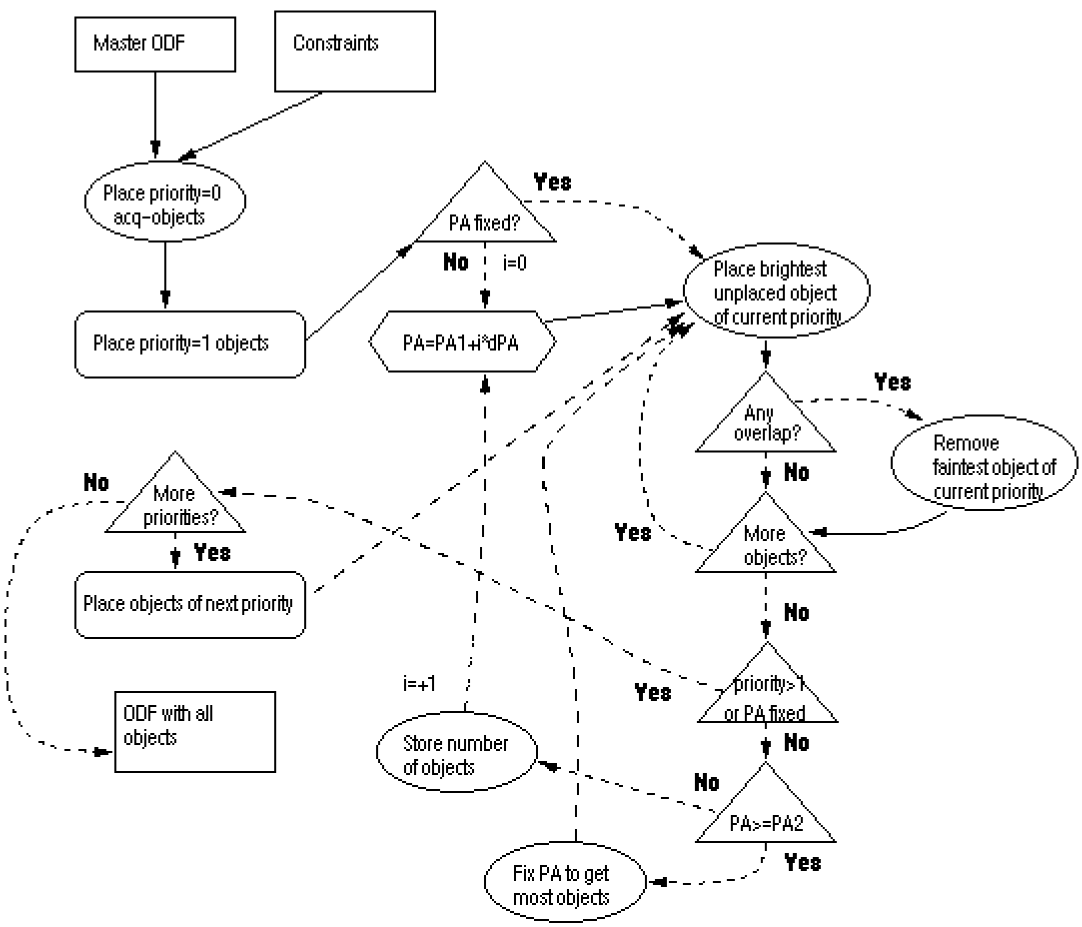

Figure 5: The automated mask design.

Table 8: Object Definition File with all objects - Columns				
Column	***Explanation***	***Required/Optional input or output***	***Type***	***Format***
id	User supplied object id number; must be unique	Required input	int	
id_txt	User supplied object id text string	Optional input	char	
x_ccd	Object position, x detector co-ordinate	Required input	real	
y_ccd	Object position, y detector co-ordinate	Required input	real	
mag	Magnitude (may be relative magnitudes)	Required input	real	
radius	Angular size	Optional input	real	
userprior	User priority	Optional input	int	
RA	Right Ascension, J2000	Required input	real	hh:mm:ss.sss
DEC	Declination, J2000	Required input	real	sdd:mm:ss.ss
slittype	Slit type: rectangle, arc, circle	Required input	real	
slitpos_x	Slit position relative to object position, arcsec in x-direction	Required input	real	
slitpos_y	Slit position relative to object position, arcsec in y-direction	Required input	real	
slitsize_x slitsize_y slitsize_r slitsize_w	Slit size. If *slittype=rectangle,* then *slitsize_x* defines the slit width, and *slitsize_y* defines the slit length (*slitsize_r* and *slitsize_w* are not used). If *slittype=arc*, then *slitsize_x* and *slitsize_y* define the angle range in degrees covered by the arc measured relative to the x-axis (the angle is measured CCW), *slitsize_r* defines the arc radius, and *slitsize_w* defines the width in the x-direction. If *slittype=circle*, then *slitsize_x* is the radius of the aperture (*slitsize_y*, *slitsize_r* and *slitsize_w* are not used). Slit length, slit width, arc radius and aperture radius are in arcsec.	Required input	real	
slittilt	Slit position angle relative to *maskPA*, measured CCW.	Required input	real	
priority	Priority of object	Required input	int	
slitid	Slit number, *slitid=0* if object not included in current design	Output	int	

Table 9: Object Definition File with all objects - Header Information				
Header Keyword	***Explanation***	***Source***	***Type***	***Format***
PID_IMAG	Program ID of GMOS image	Master ODF	char	
PI_IMAG	PI of GMOS image	Master ODF	char	
DATEIMAG	Date of observation of GMOS image	Master ODF	char	yyyy-mm-dd
TIMEIMAG	Time of observation of GMOS image	Master ODF	real	hh:mm:ss.s
RA_IMAG	RA center of GMOS image	Master ODF	real	hh:mm:ss.sss
DEC_IMAG	DEC center of GMOS image	Master ODF	real	sdd:mm:ss.ss
PA_IMAGE	Position angle of GMOS image	Master ODF	real	
FILTER	Filter of GMOS image	Master ODF	char	
ADCMODE	ADC mode of GMOS image	Master ODF	char	
PID_SPEC	Program ID of GMOS spectroscopic program	Master ODF	char	
PI_SPEC	PI of GMOS spectroscopic program	Master ODF	char	
DATE_OT	Date of creation of Object Table	Master ODF	char	yyyy-mm-dd
TIME_OT	Time of creation of Object Table	Master ODF	real	hh:mm:ss.s
PERS_OT	Person making Object Table	Master ODF	char	
EXTSOFT	External Software name and version	Master ODF	char	
FILE_OT	Originating Object Table	Master ODF	char	
DATEMODF	Date of creation of Master ODF	Master ODF	char	yyyy-mm-dd
TIMEMODF	Time of creation of Master ODF	Master ODF	real	hh:mm:ss.s
PERSMODF	Person making Master ODF	Master ODF	char	
FILEMODF	Originating Master ODF	Master ODF	char	
DATE_ODF	Date of creation of ODF	Software	char	yyyy-mm-dd
TIME _ODF	Time of creation of ODF	Software	real	hh:mm:ss.s
PERS_ODF	Person making ODF	User	char	
MASK_PA	Position angle of the mask	User/Software	real	
GRATING	GMOS grating	User/OT	char	
FILTSPEC	GMOS filter for spectroscopic observation	User/OT	char	
GEMSOFT	Gemini Software name and version	Software	char	

7. Interactive editing of the ODF

The purpose of this step is to evaluate the result of the automatic mask design, and if needed make changes in the design. Although possible, it is not expected that major changes would be made to the mask design here. If major changes are required at this point it would be better to backtrack and provide a different input to the step generating the Master ODF.

The GMOS image of the field and all the ODFs, as produced by the automatic mask design, are used as input. The user interacts with the image display to evaluate and edit the mask design. The procedure is outlined in Figure 6. The image display will indicate which ODF is active by presenting the apertures for this mask in red. The apertures defined by the remaining ODFs will be presented in a different colour (e.g. light grey).

The products of this stage are:

- A new Master ODF (if changes made)
- A new set of ODFs (if changes made)
- A set of 'minimal' ODFs suitable for submission to IGPO for mask cutting (if desired).
- A new 'residual' Master ODF (if any changes in object inclusion/exclusion occurred).

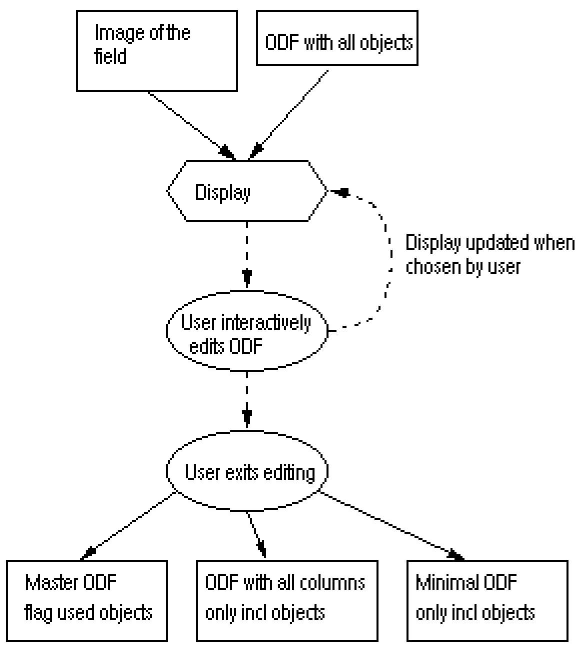

Figure 6: Interactive editing of the mask design.

The following options are available to the user while the interactive editing is active:

1. Update image display
2. Toggle over plot of objects not included in the current mask design
3. Toggle over plot of objects included in the current mask design
4. Show object and slit properties for one object
5. Delete object from current mask design
6. Include object in current mask design - warning if it causes overlaps

7. Change slit position (for one or all objects)
8. Change slit size (for one or all objects)
9. Change slit tilt (for one or all objects)
10. Change priority of object
11. Extend slit to fill empty space between slits (for one or all objects)
12. Save intermediate ODF with all columns
13. Save final ODF with all columns
14. Save intermediate minimal ODF
15. Save final minimal ODF
16. Save intermediate Master ODF, with used objects flagged
17. Save new Master ODF, with used objects flagged
18. Save PostScript file of display with current overplots
19. Save PostScript file of display with current overplots plus the object ids and slit ids
20. Graphics of how the spectra will populate the CCDs (for some average HA)
21. Save PostScript file of how the spectra will populate the CCDs (for some average HA)

When the user exits the interactive editing stage, possible items saved are:

1. A new copy of the Master ODF. By default if any editing has occurred, by request if not. This file contains the same columns and entries as the original Master ODF plus a column *usedmask*. The column *usedmask* will indicate the number of ODFs that contain this object (i.e. "0" to the number of ODFs defined from this Master ODF). If the column *usedmask* already exists, then for objects included in the current mask design the value with be incremented by one, for all other objects the value will be left unchanged. This new Master ODF can be used as input for additional mask designs. The column *usermask* can be used to exclude objects already included in other mask designs if this is desired.

2. A set of ODFs with all the columns and only the objects included in the current mask design. These files contain the same columns as the input ODFs with all the objects. The header keywords are the same as for the ODF with all objects, except the values of DATE_ODF, TIME_ODF and PERS_ODF are updated. This output is optional unless editing changes have been made.

3. Optionally, a set of minimal ODFs that contains only the objects included in the current mask design and only the columns and header keywords needed for the processing from ODF to MDF by IGPO staff (Section 7). The columns and header keywords that are required in the minimal ODF are given in Tables 10 and 11, respectively.

The ODFs with all the columns are likely to contain data that the user does not wish to make public, e.g., redshifts, morphological types, spectral types and detailed photometric information. Therefore, the user may choose to submit the minimal ODF to the Gemini Observatory. The minimal ODF should not contain any information that the user does not wish to make public once the proprietary period for the data has passed. If the ODF with all the columns is submitted to the IGPO, the columns not needed for the minimal ODF will be ignored when the MDF is created. These columns will not become part of the MDF.

Table 10: Minimal Object Definition File - Columns

Column	***Explanation***	***Type***	***Format***
id	User supplied object id number; must be unique	int	
x_ccd	Object position, x detector co-ordinate	real	
y_ccd	Object position, y detector co-ordinate	real	
mag	Magnitude (may be relative magnitudes)	real	
RA	Right Ascension, J2000	real	hh:mm:ss.sss
DEC	Declination, J2000	real	sdd:mm:ss.ss
slittype	Slit type: rectangle, arc, circle	real	
slitpos_x	Slit position relative to object position, arcsec in x-direction	real	
slitpos_y	Slit position relative to object position, arcsec in y-direction	real	
slitsize_x	Slit size. If *slittype=rectangle,* then *slitsize_x* defines the slit width, and *slitsize_y* defines the slit length (*slitsize_r* and *slitsize_w* are not used). If *slittype=arc*, then *slitsize_x* and *slitsize_y* define the angle range in degrees covered by the arc measured relative to the x-axis (the angle is measured CCW), *slitsize_r* defines the arc radius, and *slitsize_w* defines the width in the x-direction. If *slittype=circle*, then *slitsize_x* is the radius of the aperture (*slitsize_y*, *slitsize_r* and *slitsize_w* are not used). Slit length, slit width, arc radius and aperture radius are in arcsec.	real	
slitsize_y			
slitsize_r			
slitsize_w			
slittilt	Slit position angle relative to *maskPA*, measured CCW.	real	
slitid	Slit number, *slitid=0* if object not included in current design	int	

Table 11: Minimal Object Definition File - Header Information

Header Keyword	***Explanation***	***Source***	***Type***	***Format***
PID_IMAG	Program ID of GMOS image	ODF	char	
PI_IMAG	PI of GMOS image	ODF	char	

DATEIMAG	Date of observation of GMOS image	ODF	char	yyyy-mm-dd
TIMEIMAG	Time of observation of GMOS image	ODF	real	hh:mm:ss.s
RA_IMAG	RA center of GMOS image	ODF	real	hh:mm:ss.sss
DEC_IMAG	DEC center of GMOS image	ODF	real	sdd:mm:ss.ss
PA_IMAGE	Position angle of GMOS image	ODF	real	
FILTER	Filter of GMOS image	ODF	char	
ADCMODE	ADC mode of GMOS image	ODF	char	
PID_SPEC	Program ID of GMOS spectroscopic program	ODF	char	
PI_SPEC	PI of GMOS spectroscopic program	ODF	char	
DATE_ODF	Date of creation of ODF	Software	char	yyyy-mm-dd
TIME _ODF	Time of creation of ODF	Software	real	hh:mm:ss.s
MASK_PA	Position angle of the mask	ODF	real	
GRATING	GMOS grating	ODF	char	
SPECFILT	GMOS filter for spectroscopic observation	ODF	char	
GEMSOFT	Gemini Software name and version	Software	char	

8. Mask Definition File (MDF)

The minimal ODFs and the constraints for the planned observation are used by Gemini Staff to transform the slit definitions in the minimal ODF to the mask co-ordinate system. The result is stored in the Mask Definition file (MDF). The transformation software also produces predicted locations on the CCDs for the obtained spectra. Though this step is performed by Gemini Staff, the user may find it valuable to run the software in order to get these predicted locations on the CCDs for the obtained spectra. Hence this software will be made available as part of the Gemini IRAF package for GMOS.

The input for this step (per MDF) is:

- A (possibly “minimal”) ODF.
- A mean observing zenith distance

The MDF contains all information from the minimal ODF, plus the slit definitions in the mask co-ordinate system. The columns and header keywords are listed in Tables 12 and 13, respectively. The MDF will be archived together with the obtained spectra. The MDF contains all necessary information for the data to be useful for later archive users. A minimal ODF could be used to produce several MDFs, e.g. for different hour angles. Thus, the minimal ODF is not linked to a specific observation and is therefore not archived. The minimal ODF will be kept until the observing program with which it is associated is completed or until the end of the observing semester, whichever occurs first.

Table 12: Mask Definition File - Columns

Column	***Explanation***	***Type***	***Format***
id	User supplied object id number; must be unique	int	
x_ccd	Object position, x detector co-ordinate	real	
y_ccd	Object position, y detector co-ordinate	real	
mag	Magnitude (may be relative magnitudes)	real	
RA	Right Ascension, J2000	real	hh:mm:ss.sss
DEC	Declination, J2000	real	sdd:mm:ss.ss
slittype	Slit type: rectangle, arc, circle	real	
slitpos_x	Slit position relative to object position, arcsec in x-direction	real	
slitpos_y	Slit position relative to object position, arcsec in y-direction	real	
slitsize_x slitsize_y slitsize_r slitsize_w	Slit size. If *slittype=rectangle,* then *slitsize_x* defines the slit width, and *slitsize_y* defines the slit length (*slitsize_r* and *slitsize_w* are not used). If *slittype=arc*, then *slitsize_x* and *slitsize_y* define the angle range in degrees covered by the arc measured relative to the x-axis (the angle is measured CCW), *slitsize_r* defines the arc radius, and *slitsize_w* defines the width in the x-direction. If *slittype=circle*, then *slitsize_x* is the radius of the aperture (*slitsize_y*, *slitsize_r* and *slitsize_w* are not used). Slit length, slit width, arc radius and aperture radius are in arcsec.	real	
slittilt	Slit position angle relative to *maskPA*, measured CCW	real	
slitid	Slit number, *slitid=0* if object not included in current design	int	
slitpos_mx	Slit position, mask co-ordinate system x-axis	real	
slitpos_my	Slit position, mask co-ordinate system y-axis	real	
slitsize_mx slitsize_my slitsize_mr slitsize_mw	Slit size in mask co-ordinate system. Definitions of the four columns as for *slitsize_x, slitsize_y, slitsize_r* and *slitsize_w.*	real	
slittilt_m	Slit position angle in mask co-ordinate system	real	

Table 13: Mask Definition File - Header Information

Header Keyword	***Explanation***	***Source***	***Type***	***Format***
PID_IMAG	Program ID of GMOS image	ODF	char	
PI_IMAG	PI of GMOS image	ODF	char	
DATEIMAG	Date of observation of GMOS image	ODF	char	yyyy-mm-dd
TIMEIMAG	Time of observation of GMOS image	ODF	real	hh:mm:ss.s
RA_IMAG	RA center of GMOS image	ODF	real	hh:mm:ss.sss
DEC_IMAG	DEC center of GMOS image	ODF	real	sdd:mm:ss.ss
PA_IMAGE	Position angle of GMOS image	ODF	real	
FILTER	Filter of GMOS image	ODF	char	
ADCMODE	ADC mode of GMOS image	ODF	char	
PID_SPEC	Program ID of GMOS spectroscopic program	ODF	char	
PI_SPEC	PI of GMOS spectroscopic program	ODF	char	
DATE_ODF	Date of creation of ODF	Software	char	yyyy-mm-dd
TIME _ODF	Time of creation of ODF	Software	real	hh:mm:ss.s
MASK_PA	Position angle of the mask	ODF	real	
GRATING	GMOS grating	ODF	char	
SPECFILT	GMOS filter for spectroscopic observation	ODF	char	
FILE_ODF	Originating ODF	ODF	char	
DATE_MDF	Date of creation of MDF	Software	char	yyyy-mm-dd
TIME_MDF	Time of creation of MDF	Software	real	hh:mm:ss.s
PERS_MDF	Person creating the MDF	User	char	
GEMSOFT	Gemini Software name and version	Software	char	

9. Laser cutter instructions

The MDF is translated to instructions to the laser cutter. This is performed by IGPO staff using the MDF-to-LCI software. This software is not distributed.

10. Tracking the masks

Once the user has supplied the ODFs to the Gemini Observatory, the status of the mask can be tracked by means of the mask database maintained on a dedicated host PC computer, see Mask Tracking Overview (http://www.gemini.edu/instruments/gmos/gmosMaskTracking.html) for details.

11. ICDs

This section describes the format of the data exchanged between the different parts of the software used for the mask design and production. It also briefly outlines the process by which the ODF is submitted to the IGPO.

11.1 ICD: Gemini IRAF package / GMOS Mask Making Software

11.1.2: Mosaiced image

Raw data from GMOS are multi-extension FITS files with three image extensions, one for each of the CCDs. The Gemini IRAF package for GMOS will contain a task for mosaicing of the three image extensions into one image, taking into account the gaps between the CCDs and the relative orientation of the CCDs. The format of such a mosaiced image will be a multi-extension FITS file with a primary header unit (PHU) and one image extension.

The transformation applied by the mosaicing tasks will correct for any distortion over the field of view. The transformation will also correct for any misalignment of the CCDs, and for their relative rotation. The transformation will be based on imaging through a pinhole mask with the apertures spaced in right-angle grid with equal grid size of the full field of view.

The mosaicing task will have the option of maintaining the full frames making the output image 4608 pixels by 6144 pixels. It is required that the full frames are maintained if the image is to be used with the GMOS Mask Making Software.

The Gemini IRAF package will also have a task for co-adding multiple dithered images, maintaining the format required for the GMOS Mask Making Software. The output image from the co-addition will be a multi-extension FITS file with a primary header unit (PHU) and one image extension. If full size GMOS images, 4608 pixels by 6144 pixels, are given as input, the size of the image extension of the output image will be 4608 pixels by 6144 pixels. To save disk space and CPU time, the co-addition may be done on just the imaging field of view (4608 pixels by 4608 pixels) and the result copied into a fill size image using a dedicated task provided in the Gemini IRAF package for GMOS.

11.1.3: Object Table

The Object Table is a binary FITS table. The columns are listed in Table 1. If slit definitions are provided as part of the Object Table their column names will be as listed in Table 4. The header information of the Object Table is described in Table 2.

The Gemini IRAF package for GMOS will contain task(s) for translating various other formats (see Section 4) into the correct format for the Object Table. The Gemini IRAF package for GMOS will also contain a task for checking that the Object Table has the correct format.

The GMOS Mask Making Software will be able to read the Object Table as a binary FITS table with the above described header information and columns.

11.1.4: (Minimal) Object Definition File

The main output file from the GMOS Mask Making Software is the ODF. The ODF is a binary FITS table. The PI may submit a minimal ODF with only the required columns. The required columns for the minimal ODF are listed in Table 10. The header information of the minimal ODF is listed in Table 11.

If the PI submits an ODF that contains additional columns, those columns will be ignored by the IGPO. Additional header information will also be ignored.

11.2 ICD: Gemini IRAF package / MDF-to-LCI software

The minimal ODF is converted to the MDF by a task in the Gemini IRAF package for GMOS. The MDF is a binary FITS table. The columns are listed in Table 12, the header information is listed in Table 13.

11.3 ICD: MDF-to-LCI software / Laser mask cutter

The MDF is converted to a format compatible with the laser mask cutter. The format may either be the native language for the laser mask cutter or it may be the Drawing eXchange Format.

The Drawing eXchange Format has the advantage of being understood by most CAD software packages and therefore offers a convenient method for the IGPO staff to check the final mask design.

11.4 ICD: PI / IGPO

The PI submits the (minimal) ODF to the IGPO. The submission may be handled by a web interface, which allow the PI to upload the ODF to a read protected Gemini ftp site, and to provide the observing constraints, e.g. zenith distance limits.

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