Queue Planning Software Requirements

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2005 April 11
V1.1

Revision History
V0.1 – 2004 Nov 28 – Bryan Miller
V1.0 – 2005 Mar 08 – Bryan Miller
V1.1 – 2005 Apr 01 – Bryan Miller

Document Purpose
This document presents requirement needed for implementing automated queue planning and tracking in the Observing Tool and OCS.

Intended Audience
The intended audience for this document is the scientific and software staff responsible for the development and testing of the OT and the OCS.

Acknowledgment
This document is based in part on Gemini preprints 13 and 19 by Phil Puxley.

Table of Contents

1 Introduction

1.1 Abbreviations

CS – contact scientist
CCD – charge coupled device optical solid-state photon detector
DA – data analyst
DHS – data handling system
IFU – integral field unit
IS – instrument scientist
FITS – flexible image transport system (astronomical image file format)
GCAL – Gemini calibration unit
GQPT -- Gemini Queue Planning Tool
IRAF – image reduction and analysis facility
MEF – multi-extension FITS
MOS – multi-object spectroscopy
NGO – national Gemini office
OCS – observatory control system
OLDP – on-line data processing system for real-time data reduction
OT – observing tool
PI – principal investigator
PIT – phase I tool
ROI – region of interest or a sub-section of a detector
SSA – system support associate
ToO – target of opportunity

1.2 Rationale

The Gemini telescopes were designed to be run in queue-scheduled mode in which observations are done in the conditions that are appropriate for them rather than giving each program fixed dates on which they can be executed. With Gemini staff that are familiar with the instruments and telescope systems executing the observations rather than inexperience visitors, this is the most efficient use of the telescope time. For example, highly ranked programs that need the best conditions will get data when the conditions are superb while programs that can tolerate poor conditions can be done during times of poor image quality or clouds. The Gemini user community has now embraced this mode and more than 90% of proposals are for queue mode even when classical time is available. In an acknowledgement of the community's choice, the Gemini board has recently dictated that the observatory should change its staffing model to support 100% queue observing.

Queue observing is most efficient when the number of available options is maximized. A small number of programs usually cannot fill all combinations of RA and observing conditions constraints, often leaving the observer with the choice of either doing nothing or taking data in inappropriate conditions. One way to maximize the available options is to allow the use of more than one instrument on a given night. The Gemini telescopes were also designed with this in mind; two or three instruments are usually mounted at the same time. At this time the telescope systems are being completed and automated in order to simplify switching between instruments.

Large numbers of programs and multiple instruments do complicate the process of planning, management, and execution of the queue. Each observer cannot be familiar with all of the programs and planning the observations and their calibrations can quickly become overwhelming. Therefore, software tools are needed for queue planning and management. This document defines the requirements for new queue planning tools and associated changes to program organization in the OT and the seqexec.

2 Operations model

Efficient running of a full multi-instrument queue requires the coordinated work of a team consisting of a queue coordinator, the contact scientists (CSs), the instrument scientists (ISs), the observers (SSAs and astronomers), and data analysts (DAs). The following gives the duties for each of these roles.

2.1 Queue coordinator

A queue coordinator (QC) at each site is responsible for running and coordinating the queue. The role of the QC will rotate among the staff on a timescale to be determined. The responsibilities of the queue coordinator are:

1. Final PhaseII checks
    a. Enforce consistency between instruments where possible
    b. Work with CSs, and DAs to ensure that OLDP recipies are defined in advance
    c. Coordinate MOS mask checking
2. Queue planning
    a. Setting priorities and developing the queue plan
    b. Working with ISs to ensure that the instruments are ready and maintained
    c. Coordinating needed instrument configuration changes (gratings, masks, etc.)
    d. Handling target-of-opportunity (ToO) triggers
3. Coordinating daytime calibration
4. Coordinating data backups, packaging, and data deletion with the DAs
5. Time accounting

2.2 Contact scientist

This person is the liaison between the PI and NGO contact and Gemini for a given program. They are responsible for:

1. Checking of observations set to ‘For Activation’ by the NGO contact
2. Responding to questions escalated to them by the NGO contact or PI.
3. Final assessment and approval of data before packaging

2.3 Instrument scientist

The instrument scientist is in charge of the instrument and is responsible or making sure that the instrument delivers the required performance. Their responsibilities include:

1. Commissioning modes
2. Developing operations procedures
3. Defining the necessary calibration
4. Monitoring the instrument performance.

The goal is to make the procedures for all instruments as similar as possible.

2.4 Observers

1. Execute the queue plan
2. Provide the first level of quality assessment

2.5 Data analysts

1. Header and obslog checks
2. Data processing recipes
3. Final data processing
4. Quality assessment
5. Prepare data for packing

3 Queue planning concepts

3.1 Time allocation and program preparation

- PIs submit the PhaseI proposal using the Phase I tool (PIT)
- Time allocation committees (TACs) for each partner rank the proposals
- The international TAC (ITAC) merges the ranked proposals into the semester’s queue of accepted programs.
- Successful PIs produce their detailed PhaseII observation plan using the OT and store their observations to the database after setting the observations status to ‘For Review’.

- The NGO contact checks the PhaseII and works with the PI to finalize the plan. Once ready for Gemini the observations are stored with the statuses set to 'For Activation'
- Gemini CS makes the final checks and iterates with the PI and NGO contact on any final changes. The statuses are then set to 'Ready' and the observation is now included in the active queue.

3.2 Observation weighting algorithms

There are many factors that might be incorporated into a decision of the best observation to execute at a given time. These include the scientific ranking of the program, the match between the requested and current site conditions, the position of the target in the sky, the amount of time remaining in the semester when target can be acquired, the status of other observations in the program, the relative usage of time amongst the partners. In this section we describe the baseline properties adopted for each of these factors and how they might be combined in an overall weighting function. These weighting algorithms are being tested in a proto-type Gemini queue planning tool (hereafter pGQPT) that will also be described (see Appendix A).

3.2.1 Scientific ranking bands

As outlined above, the programs recommended for time by the partner TACs are merged into a single list ranked on the basis of scientific quality. The queue is divided into three or four "scientific ranking bands" which contain programs of (assumed) equal scientific quality. (This also helps negate the difficulty that TACs might experience of distinguishing uniquely between different scientific programs). In this scheme, observations are drawn from the top ranking band provided that current conditions are at least good enough. Only if no observation meets this constraint does the search proceed down to the next band. Thus the bands effectively have infinite weight.

In addition to matching site conditions, there is also a trade-off between the number of programs in a band and the number of completed programs at the end of the semester. Results from simulations indicate that the optimum number of programs per band is 15-20, for the average of 6 observations/program and with 3 out of 4 instruments generally available. This band length has the additional benefit of typically enclosing at least one program from each partner in each band.

In the pGQPT the contribution to the weight due to the band is (4-band)*1000. This stratifies the bands sufficiently that other weighting factors should not cause programs to jump bands.

3.2.2 Match to conditions

Matching the requested observing constraints to the current conditions is not limited solely to the basic site properties of image quality, water vapor, cloud cover and sky brightness (i.e. lunar phase and distance). Observations may have a temporal constraint (e.g. occultations, periodic monitoring, or target-of-opportunity targets like supernovae or gamma-ray bursts) or some other limitation. One specific example is multi-object spectroscopy with GMOS in which differential atmospheric refraction and instrumental flexure impose restrictions on the zenith distance over which a particular slit mask may be used.

Extensive site monitoring equipment is being installed to provide the input data against which requests are tested. Current environment monitoring sensors include anemometers outside the dome as well as inside near both M1 and M2, temperature sensors outside the dome and on the telescope struts, pressure and humidity sensors, IQ estimates from P2 and GMOS OIWFS wavefront sensors, all sky cameras (CONCAM), water vapor tau meters (active on MK, being installed at CP), and a MASS DIMM at Gemini South. In combination with satellite images and weather forecasts (for MK), the observer now has a nearly complete view of the current conditions and can make queue selections accordingly.

In general the weight adopted for the match to conditions is an inverse proportionality to their frequency of occurrence, squared. This ensures that observations requiring the best image quality or IR background, conditions for which the telescopes are designed to exploit, receive the highest weight. Example weights for the basic site properties used for by the pGQPT are given in Table 1. These weights are applied if the actual conditions (the conditions for which the plan is being made) are as good as or better than the required conditions. For example, programs that require 70%-tile cloud cover will be available for selection in a 50%-tile cloud cover plan, but they will have lower weights in order to favor those programs that require 50%-tile cloud cover. Because band had priority a band 1 program that requires 70%-tile cloud cover will be chosen over a band 2 program that requires 50%-tile cloud cover if the conditions are 50%-tile. If the actual conditions are worse than required, the total weight is 0.

Table 1. Example weights for observing conditions

Site Property	Conditions	Relative Weight
Image quality	Best 20%-ile Best 70%-ile Unconstrained	25 2 1
Water vapor	Best 20%-ile Best 50%-ile Unconstrained	25 4 1
Cloud cover	Photometric (50%) Cirrus (70%-ile)	4 2
Sky brightness	Dark (50%-ile) Grey (70%-ile)	4 2

Starting in semester 2005A IR background constraints are given by a combination of water vapor and cloud cover. Sky brightness is relevant only for optical wavelengths. In the pGQPT the optical sky brightness for a given observation at a given time is calculated from the zenith distance, lunar phase, and object-moon separation using the formulas in Krisciunas & Schaefer (1991). Also, the change in sky brightness between nautical and astronomical twilights is estimated using the prescription from the program skycalc by John Thorstensen. The surface brightness limits for the sky brightness percentile bands were determined from Monte Carlo simulations of typical observing scenarios that are described on the Gemini web pages and that used the same Krisciunas & Schaefer formulae. These limits are given in Table 2. These numbers are for an arbitrary phase in the solar cycle and no correction is made for the current phase of the solar cycle.

Weights due to image quality, sky background, cloud cover, and water vapor are summed by pGQPT into a final conditions weight. In a final implementation the sky brightness constraint should be used only for optical observations while the water vapor constraint should be ignored for optical observations.

Table 2. Surface brightness percentile bands

Percentile band	V surface brightness
20%	≥23.37
50%	≥20.78
80%	≥19.61
Any	Unconstrained

Wind speed and direction are additional environmental constraints since the telescope if forbidden from pointing into a strong wind. These quantities can be given to pGPQT and it will not schedule observations that are within 20 degrees of the wind direction if the wind speed is greater than 10 m/s.

3.2.3 Target position and visibility

The location of an object in the sky affects not only the delivered image quality (see section 3.2.2) but also defines the duration it is visible on any given night, and for what fraction of the semester. This leads to two parameters that we refer to as the declination and long-term visibility weights.

The declination weight arises because southern objects (when observed from Gemini North) are visible for a shorter period of time than northern objects and therefore require an enhanced weight if they are to have a comparable likelihood of execution. The simple scheme adopted for early queue simulations (Gemini preprint 19) is shown in Figure1.

This figure illustrates how the weights of two targets with the same RA but different declinations change with their trajectory across the sky. Below an elevation of 15 degrees the targets are inaccessible. Above this elevation they have a weight which is a function of their declination with values chosen to produce approximately equal areas of (weight * duration available) i.e. comparable average likelihoods of execution. Note that execution in practice would also depend on the delivered image quality meeting or exceeding the set constraint. The weights adopted for the pGQPT are given in Table 3.

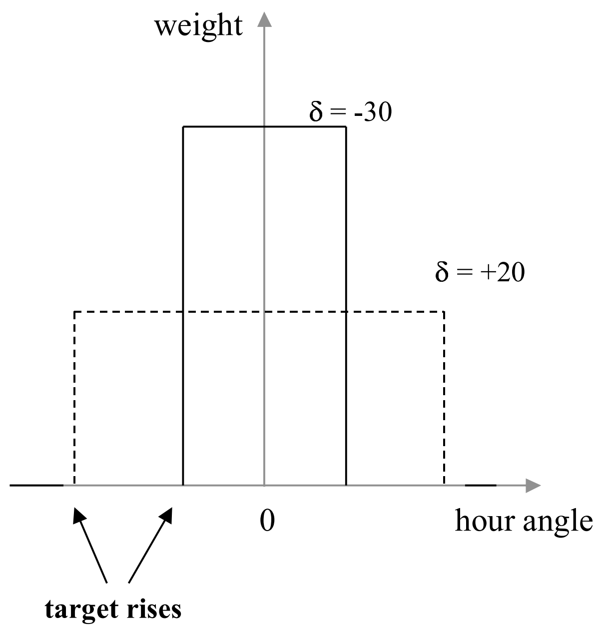

Figure 1: weights for two targets of different declination as a function of position on the sky

Table 3. Weights for declination dependence

Declination Difference from zenith	Weight
$d\delta \geq -30$	1.0
$-30 > d\delta \geq -45$	1.3
$-45 > d\delta \geq -50$	1.6
$-50 > d\delta \geq -90$	2.0

As the semester progresses, any object not yet observed has a decreasing opportunity for observation before it is no longer accessible. Thus it is desirable to have a weight which gradually increases for each object as time advances. Care must be taken that this weight does not result in objects tending only to be observed at high western air masses. Also, during any given night one wants to observe a given target at as high an elevation (low airmass) as possible.

In pGQPT the visibility of an object is also described with a parabolic weighting function that depends on hour angle (Figure 2). For targets with minimum zenith distances of less than 40 degrees the maximum weight occurs at HA = +1, or just after transit (solid curve in Figure 2). However, for objects with minimum zenith distances greater than 40 degrees (airmass > 1.3) the weighting function maximizes at HA=0 (at transit). Finally, if an object transits before or at nautical twilight then the weighting functions in Figure 2 are multiplied by 1.5 in order to improve the chances of the target being observed before it sets for the semester. A similar type of weight may also be desirable for targets only visible at the end of the night late in a semester. The final visibility weight is the product of the weight due to hour angle and the weight due to declination. Finally, the telescope has a lower altitude limit of 30 degrees (airmass = 2.0), therefore the total weight of an observation is set to 0 if the airmass if above 2.

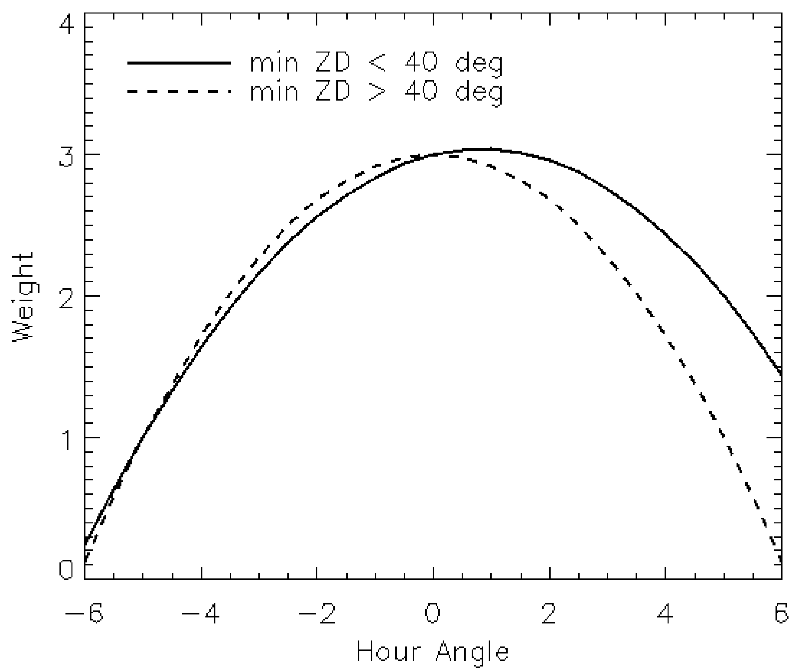

Figure 2. Visibility weights with hour angle.

3.2.4 Program status

It is generally considered desirable to complete all of the observations in fewer programs rather than several observations in more programs. However, one of the early results from queue scheduling experiments on the WIYN telescope was that an inordinate amount of time, compared to the scientific return, can be expended attempting to complete the last few observations in programs which contain long target lists. Thus a weight was introduced into the early queue simulations to favor the execution of observations in programs which had already been started, but with a monotonic decrease in weight after completion of some fraction of the program (for long

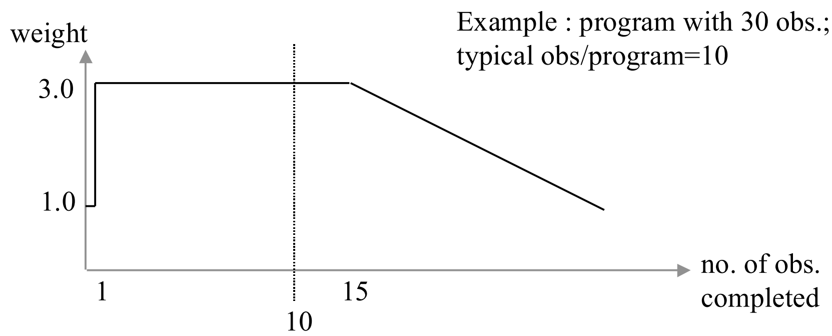

Figure 3. Weighting due to program completion.

programs with many targets only). Figure 3 illustrates the weighting function adopted for early queue simulations. The weight has an initially neutral value, is boosted after the first observation has been executed, then, if the total number of observations is larger than some adopted typical value (10, in this case), decreases after completion of one half of the observations back to the initial value. A similar weighting scheme has been included in pGQPT but it is not currently used because the pGQPT does not know the number of observations already observed.

3.2.5 User priority

The user priority (Low, Medium, High) for each observation in the OT gives the PI's relative ranking of their targets. This should be used to select observations within a given program but should not affect how the program is ranked with respect to others. The pGQPT currently does not treat the user priority very well. It adds 1 to the weight of Medium priority observations and 2 to the weight of High priority observations. The idea is to have the user priority break close ties between observations without producing a significant impact on what is scheduled.

3.2.6 Final weights

If the required conditions are better than the current (plan) conditions, the airmass is greater than 2.0, or the azimuth is within 20 degrees of the direction of a wind that is stronger than 10 m/s then the final weight of an observation at a given time is 0. If this is not the case then the final weight is the sum of the weights for band, observing conditions, visibility (which is a product of HA and declination weights), completion status, and user priority.

3.3 Queue Scheduling Algorithm

The following describes the current algorithm used by pGQPT to schedule observations during a night.

1. Hour angles, airmasses, and sky brightnesses are computed for all observations at 0.1 hour time steps between nautical twilights.
2. Weights are computed for each observation at each time step based on the algorithms given above.
3. The observation with the maximum weight is selected and "optimally scheduled" based on the integral of the weighting function over either the total time needed for the observation or the available visibility window, whichever is shorter.
4. For each unscheduled time period the selection process is repeated, taking the observations with the maximum weight in that time interval and trying to schedule it optimally within the interval.
5. The amount of time that an observation is scheduled is recorded and on subsequent nights, if making a multi-night plan, the observation can be scheduled until the total planned time is scheduled. Note that this does not account for the time needed for the repeated acquisitions.

The current weighting and scheduling algorithms do produce reasonable nightly plans (see Appendix A). Further improvements and more thorough testing will be done using the pGQPT. The current limitations to the scheduling as it is done now include:

1. Once an observation is scheduled for a given night it is not allowed to be scheduled again, even if it might be visible and have high weight, in order to avoid the loss of efficiency due to repeated acquisitions. In principle this should not be done but this will require a more complicated scheduling algorithm, perhaps iterative, that will try to rearrange scheduled observations in order to minimize repeated acquisitions.
2. The minimum scheduling block is 30 minutes unless the total needed time is less that that. If the total time required is more than 30 minutes but the available time interval is 30 minutes or less, then the observation is not scheduled even if it has the maximum weight. Some restriction like this is needed since some acquisitions can take 30 minutes, but the restriction should depend on the type of program (imaging vs spectroscopy) and the lengths of the individual exposures.
3. Groups within the OT are not respected since this information is not preserved in the ASCII catalog written by the OT. Also, at this time groups are often used as folders rather than to group observations that must be observed together.
4. Program completion status is not currently used. This could be implemented if pGQPT is given additional information about the time accounting.

4 Requirements for queue planning tools

The main features of the pGQPT should be implemented as a tool that can access the OT observing database directly so that all of the information about the observations is available.

Basic requirements

- Selection of Ready observations based on current instrument configurations (done now with the OT browser). Daytime calibration and acquisition observations must be avoided. It should be easy to select the programs from the current semester plus active rollover programs.
- Produce optimally scheduled plans based on weighting algorithms. Limitations in the pGQPT should be addressed.
- Need to define "smallest schedulable unit" for different observing modes in order to optimally break long observations
- User adjustable weighting factor for times when the queue coordinator needs to override the standard weighting
- Include the ability to save and recall nightly plans
- Produce list of needed calibrations (day and night) based on the current plans
- Provide a variety of data products and visualization options
- Eventually we would like to include all on-sky baseline calibration observations (standards, fringe frames, etc) and any engineering in the nightly plan
- Eventual capability to help the queue coordinator decide which instrument configurations (e.g. GMOS gratings) would be optimal for the next few nights.

Visualization

- Text plans like pGQPT – the queue coordinator should be able to add text notes
- Text or graphic queue summary like The Big Sheet
- Elevation plots (pGQPT)
- Alt-Az plots (like on TSD, example needs to be provided)
- Multi-night plan graphic summary (like runplot)

User interaction and running in real time

- Give ranked list by weight of all observations visible at a given date and time
- Allow plan to begin at an arbitrary time (ToO just observed, the conditions just changed, or there was a technical problem; what is the best use of the rest of the night?)

5 Additional OCS requirements

More details on OT/OCS requirements are given in the requirements documents for 2005B OT changes (OT2005B_req.doc).

1. Electronic observation log
2. The OCS must not produce duplicate data labels (data labels must be unique)
3. Time accounting calculated by the OT

4. Be able to flag calibration observations that should not be charged to the program (basecalib) or included in the total planned time
5. Incorporation of acquisition observations into the spectroscopic observations or flag them as acquisition so that they aren't charged and aren't included in the total planned time.   They should not be flagged as calibration as done now to avoid them being included in the planned time.
6. Flag for rollover programs --- can use Active flag
7. Folders for organizing related observations, allowing groups to be used for their original purpose.
8. Consistent handling of long observations
9. Additional fields in the OT conditions constraints component are needed for the PI to specify HA or airmass limits.
10. Additional constraints for observation timing.

Appendix A

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Instructions for using the prototype Gemini Queue Planning Tool

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March 3, 2005

The prototype of the Gemini Queue Planning Tool is designed to test
the algorithms for selecting the best observation to do at a given
time.  It is currently in a state in which it can be used for planning
queue nights with one or several instruments.  Eventually features of
this tool will be incorporated into the OT/OCS.

Steps

1. Select the observations for the queue plan using the OT browser.

   a. In the General screen, select the instruments to be used,
      the RA range, and the semester.  The RAs can wrap around 0
      hours, e.g. you can select 17hr as the min RA and 10hr as
      the max RA.

   b. In the instrument screens select and special instrument
      configurations. For GMOS this should include selecting the
      dispersers, including the mirror, that are currently in the
      instrument.

   c. Query the database and then save the result as an ascii catalog.

   d. If you need to select observations from two semesters to include
      roll-overs then you will need to do multiple queries or use the
      'or' operator (||) to search for different program ids
      (e.g. GS-2005A-Q-* || GS-2004A-Q-15).  Multiple output catalogs
      should be merged into a single file using 'joincat'.

      % joincat cat1.log cat2.log > cat.log

      At this stage one could also remove any observations that are
```

not wanted (daytime calibration, acquisitions, etc.)

An example combined catalog is
/home/dataproc/queueplans/04B_nov2-3b.cat

The gqpt program will convert the target name to lower case and then reject observations with target names of 'twilight', 'maskimage', 'test target', 'gcalflat', 'day calibration', 'cuar', 'null', 'arc' and 'blank*'. It also rejects GMOS observations with the CCD2 ROI selected (longslit acquisitions) and observations with both 'Mirror' and 'Custom Mask' selected (MOS acquisitions).

2. Start IDL with 'gqpt' as dataproc on a Solaris machine. It will be easiest to do this in the directory containing the OT catalog.

3. Run the tool to generate a queue plan. It can either be run from the command line using the 'gqpt' command (see example below), or by bringing up a simple GUI with the command 'wgqpt'. The input parameters are:

   otfile - ascii OT catalog, required

   actcond - actual observing conditions constraints for this plan as a vector of strings in the format ['IQ','CC','SB','WV']. For GMOS the sky background constraint is not used, the background is calculated from the lunar phase, moon/object distance, and zenith distance.

   wind - array of wind parameters [speed(m/s),direction(deg)]. If the wind speed is greater than 10m/s then observations with azimuths within 20degrees of the wind direction are excluded.

   startdate - YYYY-MM-DD string of the starting date

   stopdate - YYYY-MM-DD string of the ending date, if neither startdate or stopdate are included then it uses the current date.

   observatory - 'cp' or 'mk', defaults to cp if not given

   logfile - name of output logfile, if not given then the output is only to the screen. If the logfile exists then it will be appended to, not overwritten.

   psfile - The name of the postscript file that will be written with elevation plots of the selected observations. If 'auto' then then the name of the postscript file is <root>_iq<IQ>cc<CC>wv<WV>.ps where the root is from the logfile name, if given, or 'gqpt'. A condition of 'Any' will appear as 'An'.

   On the elevation plots the complete tracks of the objects through the night are shown as thin solid lines. The times when the observation is selected to be observed are shown with a tick solid line. The position of the moon is

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         given with a dotted line.

   utc - If set then startdate and stopdate are interpreted as UT
         dates, otherwise the dates are the local dates at the
         beginnings of the nights

   dst - this should be set for nights when daylight savings time is
         in effect in Chile


   Command line example

   gqpt,'04B_nov2-3b.cat',actcond=['70%','70%','Any','80%'],startdate='2004-
11-02',stopdate='2004-11-03',logfile='test.log',/utc,/dst

   should generate the following output.  It will also produce a
   graphics window with the airmasses of the selected
   observations. If you get errors about an unsupported X Windows
   visual, run the IDL demo ('demo') to set the proper graphics mode.

### IQ=70%, CC=70%, WV=80% ###

-----------------  2004-11-2 UT --------------------

Julian date at 0 UT:  2453311.5000
LST midnight: 01 04 01.6
Moon at    00 26 02.536  +28 29 27.46   (Equinox J2004.8388) at UT=3.00
Moonrise: 00:27:35.    Moonset: 10:42:20.
Lunar illumination: 78.0%
Time between twilights [hrs]: 8.90

Local  UTstrt  UTstop   ST    Prgid      Target          Inst    Airm    HA
ParAng | MoonH  MoonD  SB
-----  ------  ------  -----  ---------  --------------  ------  ----  -----
------ + -----  -----  ---
20:14   Sunset
21:01   Evening 12deg twilight
21:00   00:00   01:54  22:04    04B-Q-8    DMS2139-0405  GMOS-S  1.12    0.4
147.9 |  -8.3  126.9  20%
23:00   02:00   03:30  00:04   04B-Q-14        NGC 1399  GMOS-S  1.41   -3.6
-94.2 |  -6.4   75.4  20%
00:36   03:36   04:00  01:40   04B-Q-13         NGC0337   GNIRS  1.10    0.7
153.4 |  -4.9   87.5  20%
01:06   04:06   06:54  02:10   04B-Q-13         NGC0337   GNIRS  1.13    1.2
127.3 |  -4.4   87.7  80%
04:00   07:00   08:54  05:05   04B-Q-13         NGC2915   GNIRS  1.74   -4.4
-59.3 |  -1.5  108.5  80%
05:51   Morning 12deg twilight
06:39   Sunrise

### IQ=70%, CC=70%, WV=80% ###

-----------------  2004-11-3 UT --------------------

Julian date at 0 UT:  2453312.5000
LST midnight: 01 07 58.1
Moon at    00 29 35.828  +27 41 26.80   (Equinox J2004.0082) at UT=3.00
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```
Moonrise: 01:16:29.    Moonset: 11:37:11.
Lunar illumination: 69.7%
Time between twilights [hrs]: 8.80

Local  UTstrt  UTstop   ST    Prgid      Target          Inst    Airm    HA
ParAng | MoonH  MoonD  SB
-----  ------  ------  -----  ---------  --------------  ------  ----  -----
------ + -----  -----  ---
20:15   Sunset
21:02   Evening 12deg twilight
21:00   00:00   02:00  22:07    04B-Q-8    DMS2139-0405  GMOS-S  1.12    0.4
144.8 |  -9.1  138.0  20%
23:06   02:06   04:42  00:14   04B-Q-14        NGC 1399  GMOS-S  1.36   -3.4
-87.7 |  -7.1   82.3  20%
01:48   04:48   05:48  02:56   04B-Q-13         NGC0337   GNIRS  1.23    1.9
128.4 |  -4.5   99.6  80%
02:54   05:54   06:48  04:02   04B-Q-13         NGC1566   GNIRS  1.10   -0.3
3.3 |  -3.5   92.1  80%
03:54   06:54   08:48  05:03   04B-Q-13         NGC2915   GNIRS  1.75   -4.4
-59.9 |  -2.5  105.9  80%
05:50   Morning 12deg twilight
06:38   Sunrise
```

An example graphics output