A Summary of the Minimum Requirements for the Control and Operation of the GBT in the Initial Phase

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Although it is expected that the GBT will eventually have advanced hardware and software which will enable it to work at long millimeter wavelengths, it must be recognized that these developments will require experience with the telescope itself, and it will not therefore be possible to provide them in the first days of operation. However, a system must be available which will provide the basic capabilities needed for calibration of the telescope and for the initiation of astronomical observing. The following outlines the requirements of this basic system. The detailed specification of some of the features will be developed elsewhere.

1. Antenna Pointing. At the outset, the antenna pointing will be measured relative to the encoders on the two rotation axes. Observations will be made to develop an estimate of the pointing errors as a function of azimuth and elevation, relative to the encoder output. Access to relevant weather information will be needed. The pointing errors could be modelled in the conventional manner, as coefficients of various trigonometric functions of azimuth and elevation, or they might exploit the more advanced concepts described by Condon in GBT Memo No. 75. In either case, provision will be made within the Monitor and Control system to apply these corrections to ensure that the telescope is properly pointed using encoder readings only.

2. Antenna Calibration. During the evaluation of the antenna, and for general astronomical observations, there must be available a number of standard calibration procedures. These have been enumerated by R. Fisher (Aips++ Specifications for Single-Dish Data Reduction, November 11, 1992) in Section 3.6. Of particular relevance to this memo are the first eight items, repeated here for completeness. A requirement about focussing has been added.
   a) Tipping observations to measure atmospheric opacity.
   b) Determination of system temperatures from astronomical observations.
   c) Pointing offsets and flux density calibration from
      i. five-point maps
      ii. crossed continuous scans (gaussian fitting).
   d) Full sky determination of pointing coefficients by obtaining a set of pointing offsets.
   e) Full sky observations to determine flux density calibration.
   f) Beam map for application in telescope evaluation and deconvolutions.
   g) Polarized source measures for development of instrumental polarization matrices.
   h) Holographic measurements to estimate the surface accuracy.
   i) Focus of the telescope, at both prime and gregorian positions.

It is important to note the complex relationship between pointing and focus for the GBT. Provision must be made to update the pointing as the focus is changed. The focus will have to be tracked as the elevation changes. The motion of the subreflector will have to be calibrated.

It is perhaps useful to mention other types of observations that will undoubtedly be made in the course of the early telescope evaluations. These include searches for standing waves, studies of the spectroscopic baselines, measurements of far sidelobes, and the study of the off-axis feed performance. However, I believe it will be possible to make these observations if the capabilities specified above are in place.

3. Astronomical Observations. The GBT will be required to perform a wide range of observing techniques in support of the diverse observational programs it will undertake. A general discussion of the Control system has been given by Fisher and Lockman in GBT Memo No. 81, with specific examples of observing functions shown in Appendix B. Not all of this power will be available at the outset. However, as minimum, the following capabilities, in addition to those required for the calibration observations above, must be available from the beginning:

a) Tracking a source, with pointing corrections updated as appropriate. Provision to maintain a fixed parallactic angle is necessary.

b) Switching the telescope between two positions, with pointing corrections included as required.

c) Making observations at each point in a grid, specified in az-el or in standard astronomical coordinates ($\alpha \sim \delta$; l, b). The matrix of points should be generated by the Control system from simple specifications of number and spacing.

d) Taking observations "on-the-fly", over a specified track. The track could be a function described in either az-el or $\alpha - \delta$ coordinates. The speed of motion, and the frequency of sampling, should be options within the range provided by the telescope drives.

e) Making observations with either the frequency-switching or beam-switching technique.