# Green Bank Telescope Software

# Report of the Review Committee

Steve Blachman
Tim Cornwell
Darrel Emerson
Gareth Hunt (chair)

September 9, 1997

# Contents

# 1 Summary

A review of the software for the GBT was held on September 4-6, 1997 in Green Bank.

The committee was very impressed with many technical achievements of the different groups. The quality of the engineering staff—both hardware and software—was impressive. However, the lack of overall cohesiveness was glaringly apparent. With the present project structure, we did not feel that we could guarantee that the software will be ready to support commissioning of the GBT. The present situation also has an adverse impact on morale.

# 2 Management

The overall management of the GBT software effort (M&C, Metrology, Active Surface, and Pointing) has been poor. Failures in many areas of management are apparent, and have occurred either because the relevant person did not or could not fulfill his responsibilities or because there was no responsible person with the relevant mandate. Missing is a person with the overall responsibility, clear line of authority, and requisite wide range of abilities needed to drive this effort forwards. The required abilities and experience are in astronomical observing, software, and management.

Recommendation: Appoint a person **in Green Bank** to provide management and direction (leadership) for the GBT software effort. This effort should include M&C, Metrology, Active Surface, Pointing, and Operations since all of these are coupled. The morale of the various groups has been affected by the difficulty of working within the current management structure (or lack thereof!). Appointment of a competent manager with the requisite authority was unanimously regarded as the highest priority by all those we spoke to in our recall sessions. We think that the morale, cohesiveness, and effectiveness of the entire software effort will be improved by appointing such a manager.

We think that management of the software effort by the right person should be straightforward. The following problems must be rectified:

LACK OF FOCUS: In the GBT effort, we found it easy to find areas lacking any sign of real focus on key needed capabilities. For example, early in the project, the M&C group should have focussed on finishing key capabilities in as timely a fashion as possible and making them available for general use by other participants. When this has happened, e.g., RPC++ and the weather registry, the other groups have been aided significantly, and the cause of overall unification of the disparate software efforts has been improved. Where this has not happened, e.g., user interfaces, the other groups have gone their own way to the eventual detriment of the overall project. As a further example of the lack of focus, it is not clear what the philosophy for writing device managers for equipment actually is. Are these to be written as the hardware becomes available? Or as needed on some other basis?

Recommendation: Focus on the core capabilities needed for commissioning. Defer implementation of all other capabilities. We recommend that support of the 140-ft observing be reevaluated since it places a large maintenance burden on the M&C group.

LACK OF AGREEMENT: There is a recurring difficulty in getting requirements written and then reviewed as necessary. This occurs in many different areas, ranging from requirements on astronomical observing modes to alarm points and action for specific devices. No one mechanism seems to be effective in ensuring that real requirements will be arrived at. An example where agreement is lacking is in the clear definition of what will be required at commissioning: What receivers will be used? Will the spectrometer be necessary? Will the active surface be switched on? Is precision pointing necessary? When will these capabilities be needed, if not at commissioning? While various people hold opinions on these subjects, there appears to be no overall agreement or written documentation of such an agreement. Another example problem area is getting specifications of (e.g.) alarm points and functions from engineers for specific devices. This should be quite straightforward, involving no more than a few hours collaborative work between an engineer and the device programmers. Management help in expediting such collaborations is needed.

Recommendation: Forge and document agreements on what will be done. The set of these agreements define the working assumptions of the entire group. The agreements will inevitably involve hard choices. Not everything can be done at once. Find a core set of capabilities and work to implement those from end to end. Management must aid the group members in obtaining specifications.

NON-EXISTENT SCHEDULING: Meaningful and achievable schedules of development are non-existent. Members of the M&C group seem to work with low overall efficiency because overall priorities are not enshrined in a schedule published throughout the group. Interruptions and distractions then dilute the effort. People in other areas seem to work to no known overall schedule.

Recommendation: Set schedules. Recognizing that prediction is difficult, we think that only a list of short lead-time targets is worthwhile, perhaps with estimated dates for longer lead-time milestones such as commissioning. Attempts at a true timeline with dependencies are not likely to succeed.

INTERMITTENT TRACKING OF PROGRESS: Overall tracking of progress of the entire software group is intermittent at best. In addition, the members of any given subgroup appeared to be disturbingly unaware of the status of progress in other groups or even the scheduled goals of other groups.

Recommendation: Track progress on scheduled targets week by week, and react appropriately to delays or other problems such as unexpected dependencies. Update milestones as necessary. If meeting a milestone seems to be threatened, react early and appropriately. We think that weekly tracking meetings of the entire group are vital.

POOR COMMUNICATIONS: Communications between the various groups is very poor. In our meeting, it was apparent that many pieces of information crossed from one group to another for the first time. Communications with other software efforts at NRAO should be improved. Along these lines, we strongly recommend that the GBT M&C group visit the 12M.

Appointment of a project manager for the software effort and implementation of **any** project management method will help tremendously. Our estimate is that with both these in place, it should be possible to produce the necessary software systems in time for a realistic commissioning of the telescope in late 1998. Without these steps, such progress seems to us to be unlikely.

## 3 On-line Software

The on-line software groups have concentrated on the lower and middle levels of control. These are the levels concerned with handling the devices of the GBT. This work is well advanced in most cases, especially in areas where the hardware is ready, but also includes undelivered major systems such as the antenna and active surface actuator controls.

There are however several separate groups, which, although they have made localized progress, have yet to integrate their software into a single coherent system. As mentioned earlier, there are four groups: M&C, Metrology, Active Surface, and Pointing. Further, the entire system spans five software operating systems and several computer architectures, programming languages, tool chains, and methodologies. Together, these problems represent a significant obstacle to completion of the GBT on-line software.

The M&C group has produced a set of software designs with excellent modularity, flexibility, testability, and maintainability characteristics. This library handles generalized device control, coordination, monitoring, and logging. They have also produced system communication software (RPC++) with the same characteristics which has been adopted by the Metrology and Active Surface groups.

It is our view that the adoption of both the M&C groups communication system and the control and monitoring libraries by the rest of the groups is a necessary step in producing a workable GBT software system. It is however, not feasible to change the underlying software and computing platforms of the other groups, particularly that of Metrology, to match that of the M&C group. This will therefore represent a long term maintenance cost for the GBT.

The M&C group has been advancing on too wide a front (as mentioned in the management section). Together with its supervisory scientific staff, it must identify the critical set of GBT requirements. In conjunction with defining these requirements, an end-to-end GBT software core must be defined. This core must include critical elements of monitor and control, metrology, active surface, and pointing. Priority should be given to constructing working software with participation of all groups in a way which minimizes the effort. This software should be constructed, deployed, and tested as soon as possible. New functionality should then be added incrementally to this set until the GBT critical requirements can be met.

The scan control devised by the M&C group resides on non-real-time platforms. Both scan control and inter-scan timing have real-time attributes which require these operations to reside in a real-time environment. Similarly, observing mode control may not be the sole purview of the user interface, and must be engineered into the real-time side of the system, although the user interface side of these modes may be left under GUI control.

The real-time nature of the active surface computation and pointing correction must be carefully examined, especially with a view to their coordination with metrology, observing, and scan control. These functions should also be moved onto a real-time platform.

The philosophy of using predicted scan times should be reviewed, especially for the possibility that some devices may not be able to make such predictions.

The M&C group should improve their code documentation practices, and make better use of standard coding practices and the available engineering tools such as Purify(tm). This should be done in new code. Revisions of older software should occur when it is updated, otherwise only as time allows.

# 4 (Graphical) User Interfaces

User interfaces are needed in four basic categories: operator, engineer, observer, and data analysis. The needs of those groups are not independent; each group will need to use applications from the others.

Operator: Although the M&C group have made prototypes of an operator interface, these will be abandoned.

Engineer: Within the Metrology group only, engineering displays are available.

Observer: The prototype GUI designed by Rick Fisher looks very good, although its status within the project is unclear. We encourage continued development. Our one concern is the development of a separate language for this effort. The final GUI may require all of the features of the underlying Glish language; the new language will have to duplicate this functionality. In our opinion, unless there are excellent reasons, Glish should be adopted directly.

Data Analysis: This is provided by the AIPS++ group using Glish and Glish/Tk.

There is clearly a large amount of work still to be done in the user interfaces and the layered applications.

We are alarmed by the total number (seven) of different GUI systems that have been used. The number of GUIs in the final system must be more constrained for eventual operation. In addition, it is very desirable to have a common GUI for all types of users. If at all possible, all GUI applications should be based on a single GUI.

Unless there are very cogent reasons, we believe that the M&C group should not become involved in the development of GUI-building tools. We do not wish to see the programmers disappear into the well-known trap of everlasting GUI development.

We are concerned that the enthusiasm for a decision on a GUI interface has not included sufficient consideration of the need for command line interfaces and the functions for which these will be used. Only partial requirements are available; this lack could lead to an incorrect decision.

## 5 Operational Support

We are concerned that no concrete plans exist to support GBT operation. Based on experience with other instruments, this is a significant effort. These functions include telescope scheduling, proposal tracking, data archiving, backups, observing logs, etc.

We were encouraged that the new operations group is beginning to address the requirements. However, there seems to be no staffing to produce the tools. We are concerned that this will, by default, be assigned to the M&C engineers without concern for their other priorities.

## 6 Off-line Software

Although the software for data analysis is far from complete, a good set of specifications exist, and a good infrastructure is already available. The AIPS++ group has adequate manpower directed towards this effort.

One eventual operational concern is the issue of data collation, or the filling of the multiple GBT FITS files into a single structure in AIPS++. A significant amount of GBT-specific knowledge resides in the data filler. Support of this function in AIPS++ (responding to changes in GBT observing, new keywords, etc.) properly remains with the AIPS++ project at present. However, in operation it will have to be taken over by the GBT staff.

## 7 Active Surface

The committee is encouraged by the use of M&C libraries in the active surface software. We encourage further use of these libraries, especially in the monitor and control areas.

The committee believes that this software should eventually run in a machine—perhaps under VxWorks—with a real time operating environment, rather than a stand-alone Unix machine. It is important that the required update rate for the surface be specified, after consideration of the wide range of observing modes that may take advantage of the active surface, but also considering practical issues like lifetime of the surface actuators. The "about once every 30 seconds" which seems to be assumed at present may not be nearly fast enough for some observing conditions.

Careful thought is needed on how use of the active surface is to be integrated into observing strategies. For example, in some modes it may be desirable to synchronize surface adjustment with data integrations. The astronomer will probably want the choice of whether to turn the active surface on or not, and will require some feedback as to the gain obtained from the system, the residual surface rms error, uncertainties introduced into accurate flux calibration, etc. Some of these commanded and derived surface and pointing parameters will become parameters stored with the astronomical data. The entire system needs to be thought through end-to-end, including the integration with the message system and log files.

## 8 Metrology

The committee was very impressed with the laser metrology system. The demonstration of using the laser system to track the moving 140-ft telescope is an important milestone. The Metrology group deserves congratulations.

The metrology system is unique in the overall GBT project in using NT and DOS operating systems; this will make for slightly higher software maintenance costs in the long run. However, the potential incompatibilities between these systems and the rest of the M&C system should be largely overcome through the good cooperation that we now see beginning between the Metrology and M&C groups.

## 9 Pointing

The integration of the active surface and metrology systems into a total solution of the pointing problem has clearly made encouraging progress.

However, we noted a variety of opinions as to exactly what was expected from Cotton's contribution to the analysis of metrology data; the details of the interfaces to Cotton's work, and precise specification of the product to be delivered need to be clarified to all parties.

## 10 Other hardware

Other devices will of course need integration with the M&C system, before and after the start of the GBT operational phase. The detailed interaction of future devices with other hardware and software components, as well as the necessary user interfaces, needs to be thought through carefully. Even although some devices have not yet been built or may only exist as vague hardware concepts, the potential implications for the M&C should be considered now, to avoid possible problems later on. Devices in this category may include the feed arm quadrant detector, accelerometers and a possible future active damper mounted on the feed arm.