GBT MEMO 107

A Suggested Design for the Control Facility for the Green Bank Telescope

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I. Introduction

The Green Bank Telescope (GBT), upon its completion, will be a showpiece for the NRAO. The NRAO is giving a great deal of attention in making the telescope and its electronics the finest that technology will allow. Some attention should be given to the environment in which staff and observers interact with the telescope. The environment consists not only of the software used by staff and observers to monitor and control the telescope's instrumentation and analyze its data but also the physical surroundings in which people do their work.

This report discusses what might go into the design of the control facilities for the GBT. I will discuss the control and equipment rooms plus other ancillary rooms that observers and staff will use when observing. In essence, I will describe the day-to-day work environment in which people most often will interact with the telescope.

I have tried to design a control facility that complements the bold, innovative, and modern design of the telescope structure, its equipment and software. However, my design is limited in its scope. For example, I do not include the facilities needed to maintain the telescope. I also realize that my design may not reflect the compromises that management must make to provide a control facility that fits into budget constraints. I plan to discuss in a separate paper where these facilities should be best located and whether it would be advantageous to first operate the GBT from a modest-sized control room before moving operations to a permanent and larger control facility.

Section II of the paper discusses why a control facility is needed. Section III describes the individuals whose needs should be satisfied by the design of the control facility. Sections IV through VIII gives my views on how a design should satisfy the users of the control facility. Although I will emphasize the GBT control facility, the sections might also apply to the design of the control facilities of other radio telescopes that might be in construction or are being planned. Finally, section IX gives my personal, detailed design for the control facilities for the GBT.

[Note that I have borrowed many ideas others generated both during the designing of the Joint Operations Center (J.O.C) and when I circulated a draft of this document. Since I cannot accurately remember who was responsible for an idea, I thank all

who were involved in the design of the J.O.C. and submitted their comments of the draft to me.]

II. Why a Control Facility

The distance between a telescope and the computers that control it is becoming less important than it was when high-speed and extensive computer networks did not exist and one had to place the controlling computers as close to the telescope as possible. Because of networks like the InterNet, the role played by a centralized telescope control facility has become less important. For example, the design of the monitor and control software for the GBT is based on allowing any computer connected to the InterNet some basic level of access to the software that controls the GBT.

But the interaction between humans and the telescope involves more than software for many reasons.

Anyone with a good-enough observing proposal, whatever his or her experience with radio astronomy or an NRAO facility, can get time to observe with an NRAO telescope. The possible lack of experience of observers almost forces the NRAO to supply observers a set of "guiding hands," a role performed by NRAO support staff and, especially, telescope operators. An observer's role can then be reduced to specifying observations, helping check that observations are proceeding correctly, and analyzing and interpreting data. The availability of staff and operators frees the observer to spend more time doing science and less time learning the intricate details of how to control and monitor the telescope. Thus, we need to supply telescope operators a location from which they can perform their job.

For some types of observing, the communication between the observer and the telescope operator and staff must be frequent and very interactive. In these cases, the astronomer probably should be located in the same room in which the operator oversees the observations and telescope. For other types of observing, when the interaction between observer and operator might be infrequent, the astronomer need not be in the same room as the operator to make efficient use of the telescope. Instead, the observer either can be somewhere else on site or at their home institution.

A local staff member (e.g., the operator) stationed at some well-defined location must oversee the safeties of both the telescope from unintentional misuse and of the personnel near or on the telescope structure. The equipment used for monitoring safety is best located in the control room.

Some hardware associated with a telescope need to be readily accessible and should not be located on the telescope. For practical reasons, the associated hardware should be in one

location, as much as is possible, and within easy reach of the telescope operator and staff. For example, the NRAO staff members have to mount and ship tapes for VLBI experiments. We will need to plan storage near the VLBI equipment for a sufficient supply of tapes. For all types of observing, staff will need to install and debug hardware.

Although high-speed computer links are available they are not without problems. Networks occasionally go down and they sometimes present a security problem in that anyone can try (and may succeed) getting into a sensitive area of the control software. The safety of the telescope dictates that communications to the telescope should go through a local-area-network (LAN) that is secure from unauthorized outside users and that, because of its short length and greater simplicity, is less likely to have problems. The secure LAN probably should originate from one location, like a control building, and extend to the telescope.

These reasons, and others, show that a control facility is still necessary for the economical, safe, and efficient operation of a radio telescope that is run as a visiting-observer facility. One can argue about the location of the building housing the control facility; the role of the operators, staff and observers; the contents of the control building; the amount of controlling power given to off-site computers; etc. The need for at least one control facility for the GBT is well established.

My view of the GBT control facility is that of a central location where we will locate a significant part of the GBT hardware (e.g., backends, clocks, tape drives, computers, and peripherals) and where the telescope operator and staff will interact most often with the telescope. The astronomer using the telescope can but need not be present in the facility. The control facility may be located either in its own building or in a building that has other uses. I will divide the control facility into a control room for the operators and observers use, an equipment room designed around the needs of the hardware, and the ancillary rooms that support the people and equipment in the control and equipment rooms. I plan to argue in a separate paper where I believe the control facility should be most efficiently located.

III. Occupants of the GBT Control Facility

I can broadly divide into four categories the roles people will take when they are present in the control facility: telescope operators, other NRAO staff members, observers, and visitors. Individuals might have more than one role or a role might be performed by more than one individual. An individual might at various times take on different roles. For example, an observer may be an NRAO staff member, a visitor may be a previous observer, an off-duty operator may be a visitor. For the rest of this report

I will discuss how the above roles influence the design of the control facility.

I consider operators a special class of the NRAO staff whose responsibilities dictate that they must be present at all hours that the telescope is in operation. At a minimum, they will oversee the safety of telescope and personnel and have some yet-undefined role in the making of observations. Since operators will work day and night in the control room and will not leave it for very long while on duty, the control room must be designed especially for their needs and be an excellent environment in which they can do their jobs. For example, if an operator must frequently monitor or adjust a piece of equipment, than we should place the displays and controls for the equipment where it will best suit the operator.

Besides operators, other NRAO staff members will occasionally work in the control room. Engineers will need to debug or install a piece of hardware, programmers will need to interact closely with the telescope, friends-of-the-telescope will need to instruct and help observers in how to accomplish their observations. Although staff members will not be permanently present in the control room, we must make allowances in the design to see that their needs are satisfied. For example, we don't want a design that interferes with a programmer's ability to solve problems. When the GBT starts operation, we can expect much activity by the staff in the control facility so we should allocate enough space for them to do their jobs efficiently.

The most important occupants of the control facility will be the observers for whom the telescope was built. As pointed out above, observers may or may not be present according to the level of interaction they need with staff, operators, and the telescope. If observers are present, the environment in the control facility should not inhibit their ability to specify observations, analyze data, and interpret results. When not present, the environment should provide easy communication between the operator and the absent observers.

I must also consider the role of visitors to the control facility. These are individuals who are entering the control facility not to perform a specific task but just to see what is there. Since the GBT will be a showcase for the NRAO, its control facility should also be a showcase. Some visitors to the control facility might be dignitaries who could have influence over the NRAO's budget; thus, we must make sure we give a correct impression of the NRAO operations. The design of the GBT control facility should give an impression of sophistication and utilitarianism. The control facility cannot be plush, messy, or slipshod in its design.

The NRAO must also consider the equipment that it will house

in the control facility. Some equipment requires special environments. All the equipment not only takes up the space it occupies but also the space needed for a staff member to work efficiently on the equipment.

I will now consider how we can satisfy the needs of the above four roles and equipment in the design of the GBT control facility.

IV. Satisfying the Needs of the Operators

Although I am not a telescope operator, I have interacted very heavily with them over the last eight years and, as such, have some idea of their requirements. In addition, I was involved with the operators in designing the control rooms that were to be located in the J.O.C. Nevertheless, I suggest that operators and their supervisors be involved in the final design of the control facility.

Most of the design of the control facility revolves around the requirements of the operators. For the most part, their requirements will not be difficult or expensive to meet. The following is a list of items that will be located in the control facility for the operator's use and the specifications these items should meet.

- Work Area

  Tables and desks must be sturdy and stand up to abuse such as people sitting and standing on them.

  Tables must be of the correct heights. Those that will have keyboards on them must be at keyboard height, those for writing should be at desk height.

  Tables must be easily reconfigured since needs might change.

  We should supply enough desks for the anticipated workstations, CRT's, keyboards, mouse pads, telephones, and other frequently used equipment. [After studying the number and type of analog and digital displays we now present 140-ft and interferometer operators, I imagined how many critical screens the GBT operators will need to refer to frequently. When I consider the size of today's CRT screens, I estimate we will need to provide desk space for something between two and four CRTs capable of window displays.]

  Supply enough unused desk space for writing.

  Sufficient drawer space for pens, papers, forms, etc.

Desks and tables arranged so that the operator will be as close as possible to all of the desks. Arranging the desks in a U shape should accomplish this.

The area within the U must be large enough to comfortably fit three to four people in chairs. The space will be needed when a group of people try to debug problems.

- Chairs — Sturdy, easily adjustable, proper back support, and on wheels.

  Chairs should withstand constant, 24-hours, use

- Lighting — Soft, sufficient, and even. Lights should be divided into separately controllable banks.

  They should not be a source of radio interference.

  Lights should not produce a glare on the operator's computer screen.

- Floor — Shouldn't interfere with chair wheels.

- Ceiling — Any equipment hung from the ceiling should provide sufficient clearance so as to not pose a work hazard.

- Windows — Should have shades or blinds to screen out any direct sunlight. If the window is large enough, multiple shades or blinds will be needed.

  If possible, locate control facility so that direct sunlight will never enter through its windows.

  Someone should look into whether tinting or other factors will reduce the possibility of glare on computer screens.

  If we decide that operators should have a complete view of the telescope from their desk, and if we use standard-size windows, then the control facility must be placed something like two thousand or more feet from the telescope. If the control facility is closer, than either the windows will need to be proportionally larger or the view of the telescope will be compromised.

  Monitor and computer screens should be arranged so that light from windows will not produce glare

- A/C and Heating — Comfortable, shirt-sleeve environment.

- Library — Frequently-used reference material available at the operator's desk; less-used items can be on bookshelves elsewhere in the control room.

- Noise — Any equipment that makes a constant noticeable "noise," such as computer disks, should be either soundproofed or, if access to the equipment is not important, moved to someplace away from people's work area.

- Security — Enough TV monitors to check simultaneously key and sensitive areas of the telescope and its environs.

  Security monitors should be placed so they can be easily seen from the operator's desk (e.g., in front of and above the operator's desk).

  Someone needs to decide what views of the telescope have to be by eye and which can be provided by close circuit television.

  An intercom with handset, headset, and speaker-phone should be at the operator's console. Cords should be long enough or jacks provided so that the operator can use the intercom from anywhere in the control room. Cordless intercoms would be great if they aren't a source of interference.

  The intercom should connect the operator with personnel at critical locations on and near the telescope. The intercom should be "patchable" with the phone system.

  Someone needs to design a well-planned intercom system for the GBT.

  An emergency stop button should be at the operator's desk. The switch should be protected from accidental use.

  NRAO must establish some method by which an injured operator can get help quickly. For example, it would be wise to station the operators of all Green Bank telescopes within the same building so that operators can provide emergency aid to their coworkers. Maybe we can have the computer system keep track of the operator's presence and have it generate a warning alarm if it senses that the

operator has been away from the control room and hasn't used the computer for an abnormally long time. A set of emergency call buttons, located throughout the control room, should be provided.

- Phone

A handset, headset, and speaker-phone should be provided. Cords or jacks should be sufficient to reach any part of the control room.

Since some users of the telescope may be working from their home institutions and communicating with the operators via computers, we should provide the operators with a handset, headset, and speaker-phone that work with the audio output of the operator's computer.

All offices in the facility should be provided with enough phones.

- Computer Monitors and Displays

Near enough to be readily understandable from the operator's desk.

- Other Equipment

The displays and controls for frequently used or monitored equipment should be available at the operator's desk.

Infrequently used equipment can be away from the desk.

Any two pieces of equipment, displays, or controls that are used in conjunction should be placed near each other.

Other equipment the operator will probably need is: chart recorder, excellent spectrum analyzer, clocks, status and security monitors, workstations, computer terminals, PC's, blackboard, bulletin board, intercom, and phone.

All monitors and display screens, if not on the operator's computer screen, should be mounted on the ceiling above and in front of the operator's desk.

Monitors and display screens should produce low ELF/VLF emissions.

- Amenities

The operators need a nearby kitchenette containing a sink, refrigerator, stove, oven, cabinets, counter space, coffee pot, pots and pans, table and chairs. We should either provide a well-shielded

microwave oven or, at least, an IR oven.

The kitchenette should not be too near the control and equipment rooms to minimize traffic through the rooms and to prevent cooking fumes from entering the rooms.

Men's and women's bathrooms should be close by and, if not too costly, provided with showers. Bathrooms should be well ventilated and sound-proofed.

The design of the control room should be open, uncluttered, well-designed, airy, and be a pleasant place to work.

Operators should be given a shared office containing possibly a desk for each operator, lockers, mail boxes, bulletin board, hard-hat storage, and blackboard.

The operator's supervisor should have his or her own office containing desks, filing cabinets, and their necessary computer equipment.

All offices should have windows.

The control room should have a good amount of bulletin boards and a pair of high-power binoculars.

Office and computer supplies should be stored nearby.

The control room, operator's offices, and lavatories should be accessible by the disabled

The operators should have a water cooler nearby (filtered, if the water quality requires it).

NRAO should provide the operators with a stereo system (radio, tape-player, CD-player) that has been checked for not generating interference.

V. *Satisfying the Needs of Other Staff Members*

By satisfying the needs of the telescope operators, NRAO will also satisfy many of the needs of other members of the staff; I will not repeat needs that are common between the two groups. I invite programmers, engineers, and other staff members to review and comment on this section of the document.

- Work Area — Engineers will require sufficient workbenches and cabinets for storing test equipment, spare parts, cables, connectors, tools, etc.

  Eventhough significant amounts of debugging will be performed from staff offices, programmers and engineers will need access to computers in the control room. Probably the number of computers (three to four) needed by the operator and located within the operator's work area will also satisfy staff's computing needs.

  Engineers, to debug equipment, may need to use a computer. To simplify this, a computer on a rolling cart should be available. Connections to the LAN should be scattered throughout the control room.

  Most of the staff's needs in tables and desks are identical to operator's needs.

  We should provide a room of sufficient size near the chief operator's office for holding the drawings and documentation for the telescope and its equipment. The room should also have a drafting desk, filing cabinets, book shelves, blackboard, etc.

- Chairs — Enough extra chairs for about four staff members.

  Other requirements are the same as for operators.

- Lighting — Portable lighting for illuminating the interior of racks should be available.

  Other requirements are the same as for operators.

- Ceiling
- A/C and Heating

  Requirements are the same as for operators.

- Noise — While debugging equipment, staff can tolerate the short times they will be subjected to noisy equipment.

- Floor — Should be computer flooring or its equivalent so that engineers can modify the setup of equipment easily.

- Windows — Other requirements are the same as for the operator.

- Library — Reference manuals for the equipment in the control room should be available within the control room. Reference manuals for the equipment in the equipment room should be available within the equipment room. Drawings and documentation for the telescope and its equipment should be in a separate room near the chief operator's office. Similarly, computer manuals should be available for use by the programmer's in the control room.

- Phone — Requirements are the same as for the operator.
- Computer Monitors and Displays

- Other Equipment — Staff will need computer peripherals such as tape drives, printers, CD-Roms, etc.

  Equipment should be spaced to make working on the equipment easy. The amount of space depends upon how one gets to the equipment and how many people need to work together on a problem. Generally, we should provide a four- to six-foot area in front of and behind every rack of equipment.

  Floors, windows, and desk tops should be easily cleaned and uncluttered.

  Storage cabinets for janitorial supplies should be located nearby. A slop sink should be available.

  If the room will need vacuuming, we should supply a central vacuum system with conveniently located connection points throughout the facility. The system would significantly cut down the noise level when the control facility is being cleaned.

  Much of the equipment I have listed for the operator's use will also be needed by staff.

- Amenities — To facility solving problems, strong consideration should be given to locate staff offices within an easy walking distance of the control room.

  Most of the operator's other requirements also apply to staff.

VI. Satisfying the Needs of Observers

In this section, I will discuss the observer's requirements. I will not repeat needs that are common between observers and the

two roles I have already discussed and I wish potential users of the GBT to review this section.

- Work Area

  Sufficient work area (stations) for at least two current observers within the control room.

  Each station in the control room should consist of a desk for writing and a table top to hold a computer. Each should be of the correct height and be next to each other, probably in a L-shaped configuration.

  The desks and tables should be easily reconfigured.

  The work areas should be close to the operator's work area but not too close (i.e., within loud talking distance) to allow easy communication between operator and observer but also to give operator and observer a sense of privacy.

  The observer's work areas should be for their use only -- staff should be provided with their own work areas.

  Most of the observer's needs in tables and desks are identical to the operator's needs.

- Chairs
- Lighting
- Floor
- Ceiling
- A/C and Heating
- Noise

  Requirements are the same as for operators.

- Windows

  If NRAO needs to conserve money, then the observer's view from their work area need not be of the complete telescope.

  Other requirements are the same as for the operator.

- Library

  Highly desirable if a full astronomical library were available within a short walking distance.

  A set of manuals and astronomical references should be located in the control room near the observer's area. The size of the library must be large if the full astronomical library is some distance from the control room.

- Phone — Each work area should have its own phone and phone line.

  In-coming calls should be answerable by the operator from his or her work area when the observer is not present.

- Computer Monitors and Displays — Some important computer and monitor displays should be reproduced at or legible from the observer's work area.

- Other Equipment — Observers will need such peripherals as tape drives, printers, CD-Roms, etc. located within the control room and within at most a few steps of their work areas.

  Fax machines and copiers should be located within a short walking distance of the control room.

- Amenities — Observers will want nearby offices for their use while on site. Offices should contain desks, computers, blackboards, filing cabinets, shelves and maybe some reference manuals.

  All observer's offices need not be located in the control facility. Most should be located in or near the Jansky Lab. This will reduce the traffic of non-current observers in the control room.

  In addition, at least one or (and better yet) two offices, each holding two desks and two computers, should be located close to the control room for use by the current observing teams. If the J.O.C. were to be built using its current design, these extra facilities for the current observers probably will not be needed.

  Some offices should hold a single observer while at least one office should be large enough to hold a group of observers.

  All offices should have windows. Offices should have some level of sound proofing.

  The number of offices depends upon the number of astronomers one anticipates will be on site at once. Initially, we should anticipate six observers on site at once. It would be wise if we designed the location of the observers' offices so that, if we find later that we have provided too many or too few offices, we can either free offices for other uses or provide more offices by

rearranging facilities.

Both the control room and observers' offices should be near staff offices so that staff can quickly and efficiently address questions.

Observers will also request a nearby room containing a cot for napping. This room should be soundproofed and should not be the same as an observer's office.

Observers may want their own stereo system independent of the operator's system.

Most of the operator's requirements also apply to observers.

VII. Satisfying the Needs of Visitors

Visitors to the GBT control room will have few requirements. Tourists will prove the most difficult to satisfy so I will concentrate on their needs. The Green Bank education officer and tour guides might want to review my list of requirements.

Tourists who come to Green Bank can be divided into three types:

- Those that need not see inside the control room (usually the general public).

- Those we want to enter the control room (special-interest groups such as politicians, visiting scientists, students, attenders of Green Bank conferences, etc.).

- Those that we think will only need to view its contents and need not enter the control room (those whose presence might interfere at the time of their visit with the observer's or operator's ability to work).

We cannot ignore the first type of tourist since the general public has a right to know how their tax dollars are being spent. We could possibly allow tourists to view inside the control room by including a visitor's viewing gallery next to the control room. If we believe the almost constant presence of tourists in the gallery might be distracting to observers and operators, we instead might provide a way tourists could get a sense of what the contents of the control room look like, either through, for example, a model or a pre-recorded video presentation of a typical working day in the control room. Management and the education officer must decide how to handle tourists and the design of the control facility must reflect their decision. For the rest of this report, I will assume

for simplicity that the general public will not be allowed to directly view the contents of the control room.

The last two types of visitors (those we want to enter or view inside the control room) are important in the designing of the GBT control room. Either we can allow both types of tourists to enter the control room or, for the last type, we can provide them with a special area outside the control room that has a view of the control room through, for example, glass windows. I will first describe my ideas on how to handle tourists inside the control room and then give my ideas on the special viewing gallery we might want to provide.

To accomodate tourists that enter the control facility, we must provide enough open floor space for about twenty people, the typical size of tour groups that have visited Green Bank control rooms over the years. This open area should have a good view of the general layout of the control room, especially the operator's desks, and maybe a view of the telescope through the control room windows. The area should be sufficiently away from the operator's and observer's work area so that the group will not interfere with work. To make for an easy flow of people, the control room should be provided with double doors and probably two exits, one by which the group can enter and another by which they can leave. We want viewers to go away with the impression that the control facility was well-planned (practical and utilitarian) and pleasant to look at and work in (open and airy, uncluttered, and sophisticated).

The special viewing area or gallery, if we provide one (and I think we should), can be either inside the building housing the control room or outside the building and should hold a group of about twenty. The glass separating the visitors from the control room should have some level of sound-proofing. The window may need to be shielded. One should not assume that doors (if the gallery is inside) can be usefully shielded because of the time it will take for large groups to enter and leave the gallery. We should design the area so that visitors will have a good view of the layout of the control room and the operator's desks. Operators and observers may want some type of sensor that covers the viewing area and that will tell them when their privacy is being invaded by a group of visitors. Or, NRAO should set a policy that operators and observers should be notified before hand of such visits. Never should the presence of visitors interfere with the running of the telescope.

VIII. Satisfying the Needs of Equipment

The equipment that we will need to place in the GBT control room will have the requirements I list below. The engineers designing and building this hardware and the plant engineer might want to review my ideas.

- Area

People might not have to interact with some equipment so we can place that equipment in its own area or room separated from the observer's and operator's work areas. Some equipment need an environment that is not well suited for humans (e.g., equipment may need to be in room whose temperature is unpleasantly low for people to work in full time). In the design of the J.O.C., much of the equipment was placed in rooms next to the control room and I suggest that the control facility be similarly designed.

If we decide on a separate room for equipment, the room should not have any windows since windows increases the costs in maintaining the environment the equipment needs.

Equipment that people interact with should be placed as close as possible to their work area. The more frequent or intense the interaction, the closer the equipment should be. Sometimes the displays and controls can be located away from the hardware in which case the hardware can be in a place convenient for it and the controls and displays can be in a place convenient for people.

Any two pieces of equipment, displays, or controls that someone needs to work on simultaneously should be placed together.

We should provide sufficient storage for ancillary items. For example, correct and sufficient storage for a week's or month's worth of VLBI tapes near the VLBI equipment. Tapes might need to be stored in the same environment in which they will be used.

The control room should be located to minimize through traffic. That is, people should not need to pass through the control room to get to another major site of activity.

We should allow enough space for growth. For example, the space that was allocated for the J.O.C. for control and equipment rooms was somewhat larger than that we anticipated we would need the day the GBT starts operation.

To allocate sufficient space, we need a good estimate of the equipment that will be placed in the control room. The design of the J.O.C. reflects the anticipated space requirements.

We cannot anticipate all future uses the control facility will have. We should provide the largest area we can anticipate ever using. Partitions should not bear any weight so that we can rearrange the layout of the control facility as needs change.

The control facility should have a well-designed and shielded cable entry. Someone should look into this as well as how to pass cables from one room to another in the facility.

- Floor

Should be computer flooring so that cables can be easily rearranged. Computer flooring can also provide the air necessary to keep equipment cool (i.e., acts as a plenum of cooling air). The noise level from cooling the equipment will be low if we properly use computer flooring.

Floors should withstand the weight load we anticipate the planned equipment will generate.

If no computer flooring, we should provide a way to run cables that is easy to modify and use and that is not too ugly.

Waxed floors should be avoided if there is a possibility of wax flakes getting into the equipment.

Staff should be able to easily roll equipment in and out of the control room or from one place to another. We should look into whether rugs would hamper the moving of equipment. Any change in grade should be gradual.

- Shielding

Should provide adequate interference shielding. The closer the control room is to the telescope the more shielding we will need. Someone should look into the specifications and anticipated costs for the shielding we will need (e.g., the shielding of the J.O.C., some 7000 feet from the GBT, was to provide 60 dB of attenuation).

Walls, ceilings, and windows from one shielded area to another may not need shielding.

Shielded area should be the largest we anticipate ever to use.

Offices that might contain computer equipment should be shielded.

Individual equipment racks might need special shielding.

If the equipment and control rooms are next to each other (as I suggest they are), the wall or windows between the rooms should be shielded to minimize the interference generated by the control room's computer in the equipment room.

- Doors

Wide and tall enough to easily allow racks to pass through. Probably double doors should be used whenever necessary for us to move racks in and out of rooms or buildings.

Shielded if a door exits to a non-shielded area. Doors going from one shielded area to another need not be shielded.

We may want a well-spaced, shielded 'air lock' for all doors that exit a shielded area so that interference will not escape the area when someone enters or leaves. The shielding provided by an 'air lock' will not work if we anticipate large groups of people will frequently move through the doors.

- Power

Some equipment will need regulated power, others an uninterruptable power supply (UPS), and others can work off the main lines. We need to estimate the necessary capacity for each power source and I suggest we start with the specification of the J.O.C. design.

Some equipment in the control facility may need to be switched to a back-up generator when there is a power outage.

Electrical outlets, labeled as to whether they carry UPS, regulated, back-up, or line power, should be arranged conveniently throughout the control facility.

The mechanical equipment room servicing the control facility should be of sufficient size to hold the necessary power equipment.

- A/C and Heating

Both humidity and temperature must remain within the specifications of the equipment. We need to estimate both the cooling and heating requirements of the control and equipment room hardware and their occupants.

Air handlers should have a good filter system to minimize dust.

The mechanical equipment room servicing the control facility should be of sufficient size to hold the necessary A/C and heating equipment.

- Fire — Someone needs to look into providing the best type of fire-extinguishing and alarm systems. For example, are there alternatives to the soon-to-be-banned halon systems? If we use water sprinklers, all the control room sprinklers should not go off but, instead, there should be a time delay between when an alarm goes off and when the sprinklers are started so that the operator can cancel an alarm if a problem has been resolved.

  Proper drainage should be designed into the floor of the control facility to carry off sprinkler water (if we choose such a fire control system).

- LAN — Connections to the LAN should be arranged so that any equipment in the control room can be connected to the LAN.

  Two types of networks should be provided -- one that works in series and another in parallel.

  The LAN should originate from a central location, probably a small closet near the control room.

- Phone — Phone lines should originate from a central location, probably a small closet near the control room (and maybe the same closet as the LAN).

IX. Detailed Design of a Possible Control Facility

I can now use the above ideas and requirements to create a design for the GBT control facility. Many designs satisfy the above list of ideas so the design I give is not unique. I present the design not to suggest it is the best possible but to provide a concrete example of a control facility that others can debate and criticize. The design may not have any resemblance to the final form of the control facility.

I have divided the design into three parts: ancillary facilities, equipment room, and control room. The three rough sketches I provide are to a scale of 1 inch = 10 feet. An architect should, of course, be hired to correct any design flaws and to provide all the details necessary for a successful control room.

Ancillary Facilities: Ancillary facilities are the rooms that should probably be best located near the control room for the users of the control room. These rooms include the operators' offices, restrooms, drawing and documentation room, janitor's closets, mechanical equipment room, and current observers' offices and nap room. Figure 1 gives my view of these rooms, their sizes, and their contents; Figure 2 is a key to the design elements I have used in Figure 1. I have designed rooms that are on the small end of what we should provide (i.e., smaller and fewer rooms than what would be provided by the J.O.C). If possible, larger and more rooms should be provided. I assume that a full suit of observer's offices (e.g., two small offices for individuals, one large for a group) will be located elsewhere (e.g., in the Jansky Lab) for the observers who aren't currently observing or who choose to not work in the control room while observing. I have not included the necessary corridors, elevators, stair cases, fire exits, etc., since these are details that depend upon the design of the building in which we place the control facility. I have no idea how large a mechanical equipment room we will need so I have not sketched one in. My hope in this aspect of the design is to show that something like 1900 square feet of ancillary facilities must be part of the control room design.

Equipment Room: The equipment room in my design includes the equipment that was to be located in the VLBI and GBT equipment room that we thought was going to be needed when we designed the J.O.C. Unlike the design of the J.O.C, I have placed the VLBI equipment in the same room as other equipment. If the VLBI equipment is to be shared by other telescopes whose control rooms are in the same building, then we should return to the separate VLBI equipment room of the J.O.C. design.

The space I have sketched out in figure 3 includes a modest margin for growth and takes up approximately 2400 square feet. However, someone should study in detail, before we commit to a room of this size, the amount of equipment that will be placed in the room. The room will have to be shielded and be accessible from the GBT control room. Windows between the equipment room and the control room, if (as I suggest) the rooms are adjacent, would be nice and would have to be shielded.

Control Room: The control room I have sketched out in figure 4 represents a synthesis of most of the ideas I presented above. Note the space I have provided for visitors behind the operator's work area and in a desirable viewing area outside the control room. The control room is approximately the same size as that which was designed into the control room for the J.O.C. since both control rooms were designed for the same use and the same occupants. The GBT control room in figure 4 needs about 1400 square feet (not including the visitor's viewing area) and provides some modest room for growth.

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In total, the NRAO should anticipate needing something like 5700 square feet for the GBT control room and the rooms associated with the control room. The estimate DOES NOT include the space needed for maintenance (offices, storage areas, work benches, etc.), non-current observer's offices, viewing gallery, corridors, elevators, mechanical equipment rooms, or storage closets.

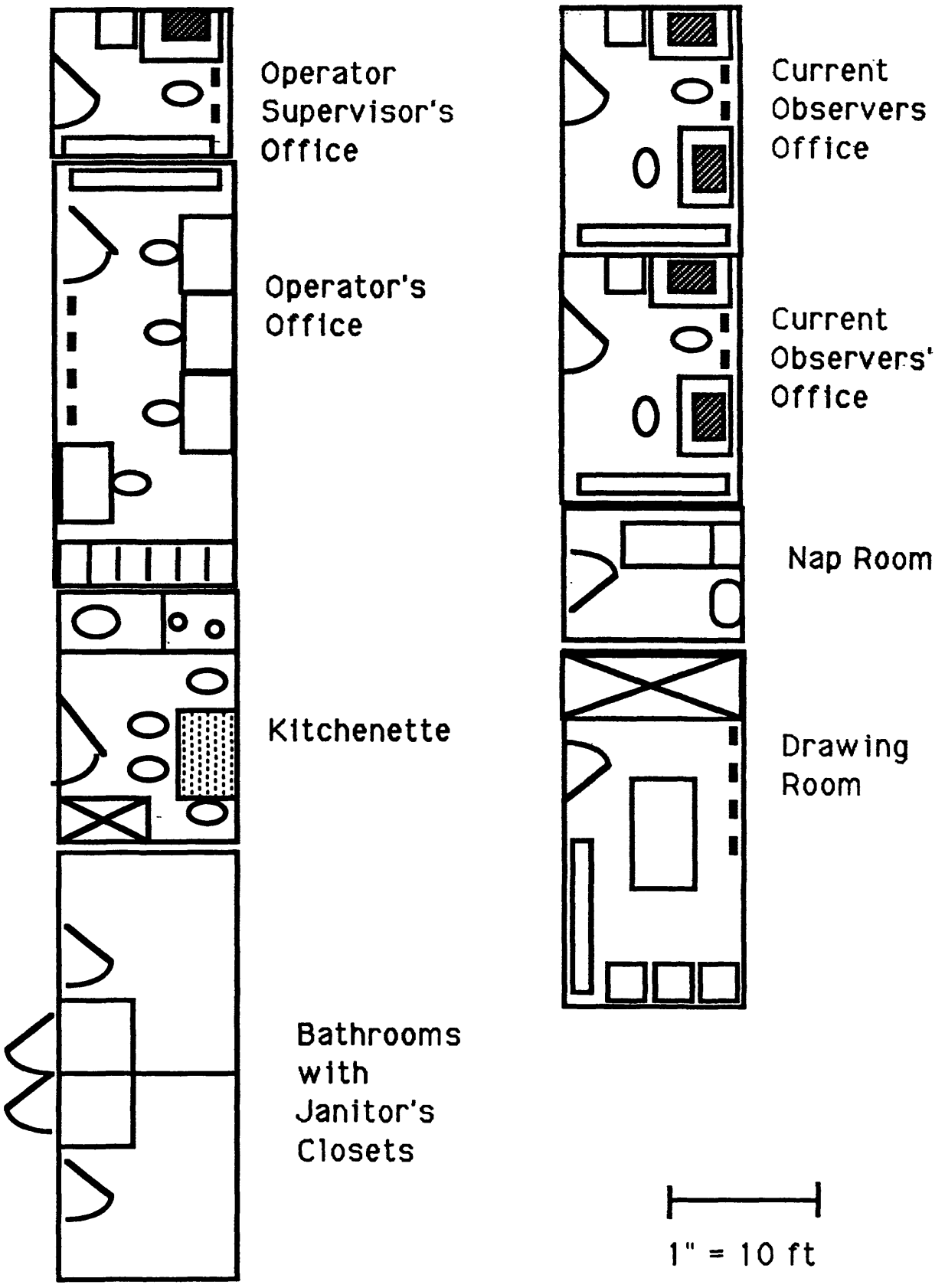


Figure 1: Sketches of ancillary rooms associated with the control facility. Windows, corridors, mechanical equipment room, staircases, elevators, offices for non-current observers, etc. are not shown.

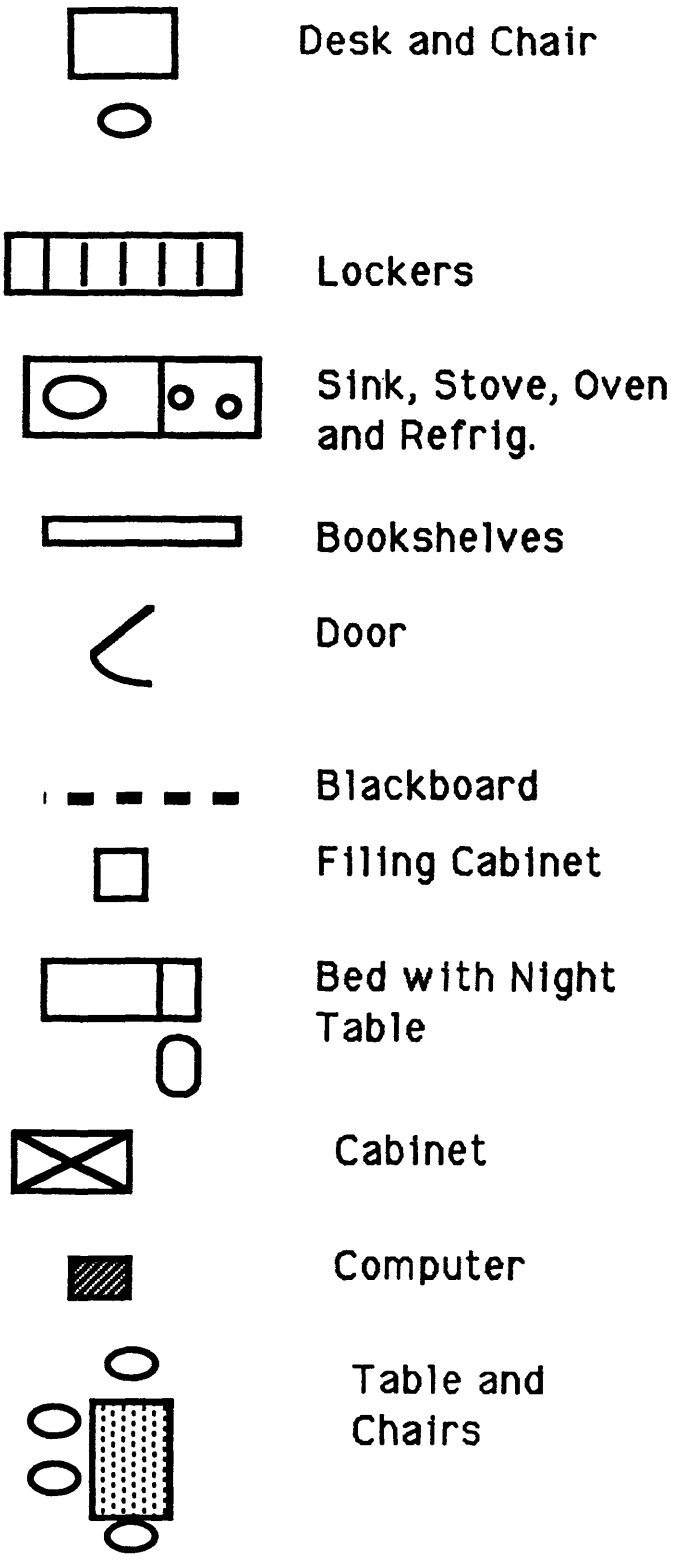
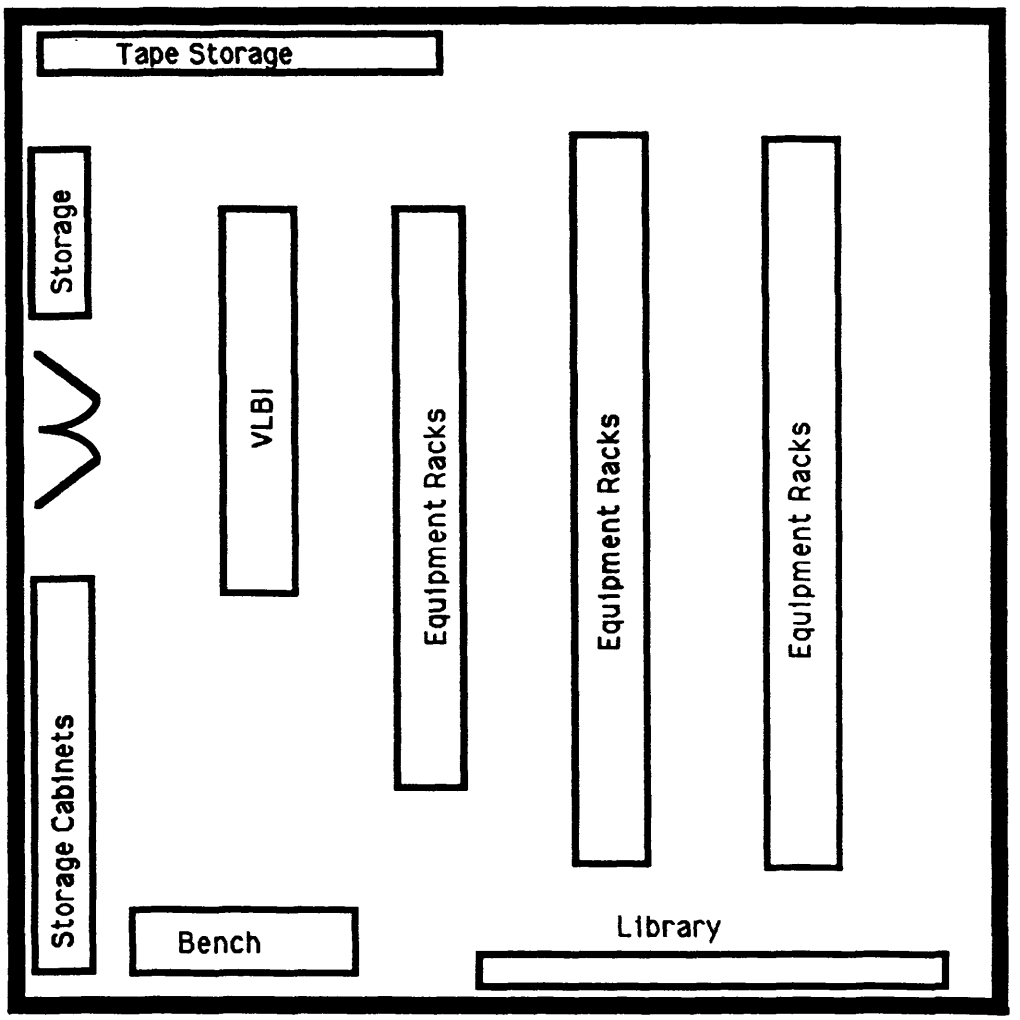


Figure 2: Key to the symbols used in Figure 1.



1" = 10 ft

Figure 3: Sketch of equipment room associated with the GBT control room.

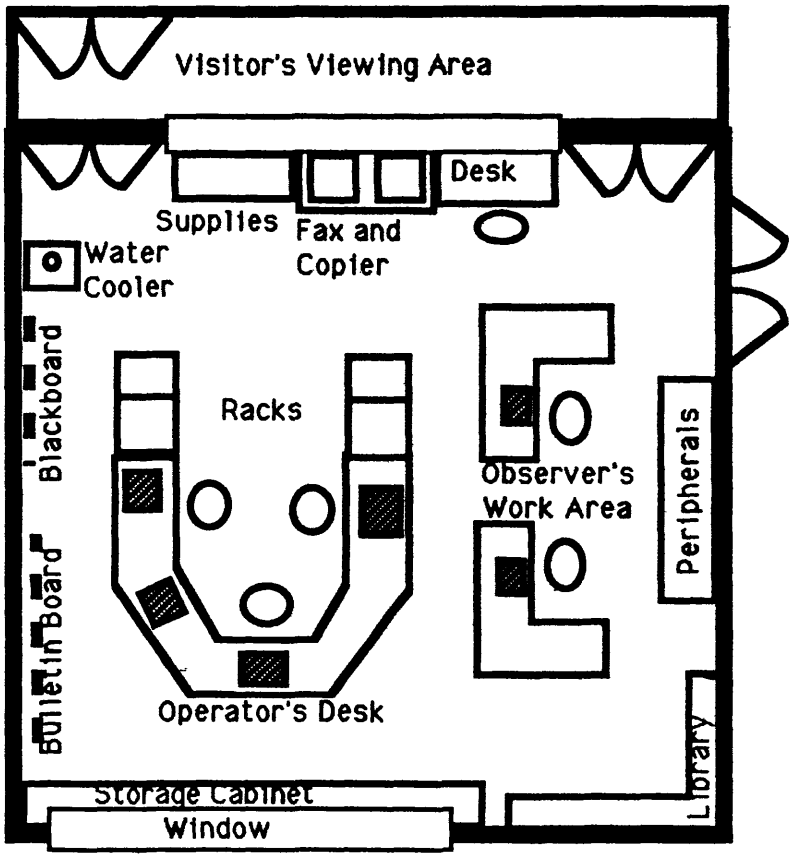


Figure 4: Sketch of GBT control room and suggested visitor's viewing area.