GBT MEMO 92

November 23, 1992

To: GBT Scientific Working Group
From: R. Fisher and M. Clark
Subject: Reply to GBT Memo 90

This is a reply to the Larry D'Addario's comments (GBT Memo 90) on our brief description of the GBT Monitor and Control (GBT Memo 89). Larry points out a number of critical issues in the system that were not covered in our memo. We outline here the extent to which these issues have been address so far, and, where it seems appropriate, we comment on specific points in Larry's memo.

Whether the methods of object-oriented design are fundamentally different or just common sense is debatable, but we agree that the hype surrounding them is overdone. The published design disciplines, e.g. Rumbaugh et al 1992, have required a much more rigorous definition of the system requirements, identified areas of the system that can share design and code, and helped modularize the system. We have written two subsystems (the data monitor for the spectral processor and an instrument parameter control system) in the process of learning object-oriented design, and we have experienced these benefits. The aips++ group has similar experience. This is not the only way to produce a good design, but it works for us.

Indeed, the Memos 88 and 89 make only passing reference to the timing requirements and hardware layout of the system. A preliminary cut at these issues was made early in the project, however. See the three attached figures. Now that the top level of the software design is completed, timing and hardware parameters need to be revisited. Known areas of critical timing such as Ethernet communications with the telescope control system and LO frequency switching and Doppler tracking have been either prototyped or bench tested. An LO preloading scheme has been devised to reduce frequency switching time. Control, data, and external networks have been separated. Modifications to the spectral processor are planned to reduce setup time, and the code framework used there will be reused throughout the system. The state sequencing of all parts of the system (Figure 10 of Memo 88) has gone through many revisions in an effort to optimize the setup speed for a wide range of known observing conditions.

Essentially all of the high level command communication is on an as-soon-as-possible basis. Our experience with the Ethernet system dedicated to control only and the multi-process task switching in the Sun computers indicates that this will be more than fast enough. Time-critical processes will know or be able to derive time to the accuracy needed in individual cases. The IRIG system will provide time to roughly the 1-millisecond level. Where higher time resolution is required, such as in the pulsar backend, a combination of 1-second tick plus 5 MHz from the maser will be used. This will provide a timing resolution on the order of a microsecond and a timing accuracy of about 10 nanoseconds. One unknown quantity in the system that we need to investigate is the minimum guaranteed delay time between transmission of a command from the central controller and receipt of that command by the lowest level module. This determines how far in advance of a scan start time all systems must be commanded. Our current estimate is that this is less than a few tens of milliseconds and that the scan setup time will be heavily dominated by telescope move time and backend operations such as receiver balancing. In any case, the system must not go into an undetermined state nor produce corrupted data if a command is late.

The first system tests of command transmission timing will accompany the 2/5/93 "manager" milestone in Memo 89. Timing under fairly heavily loaded network conditions will be demonstrated at the 7/23/93 "frontend beta" and "collator" milestones.

We agree that distributed processing is not an end in itself. It is reasonable to assume in the first design stages that each module is independent and to combine modules as similarities and timing demands are determined.

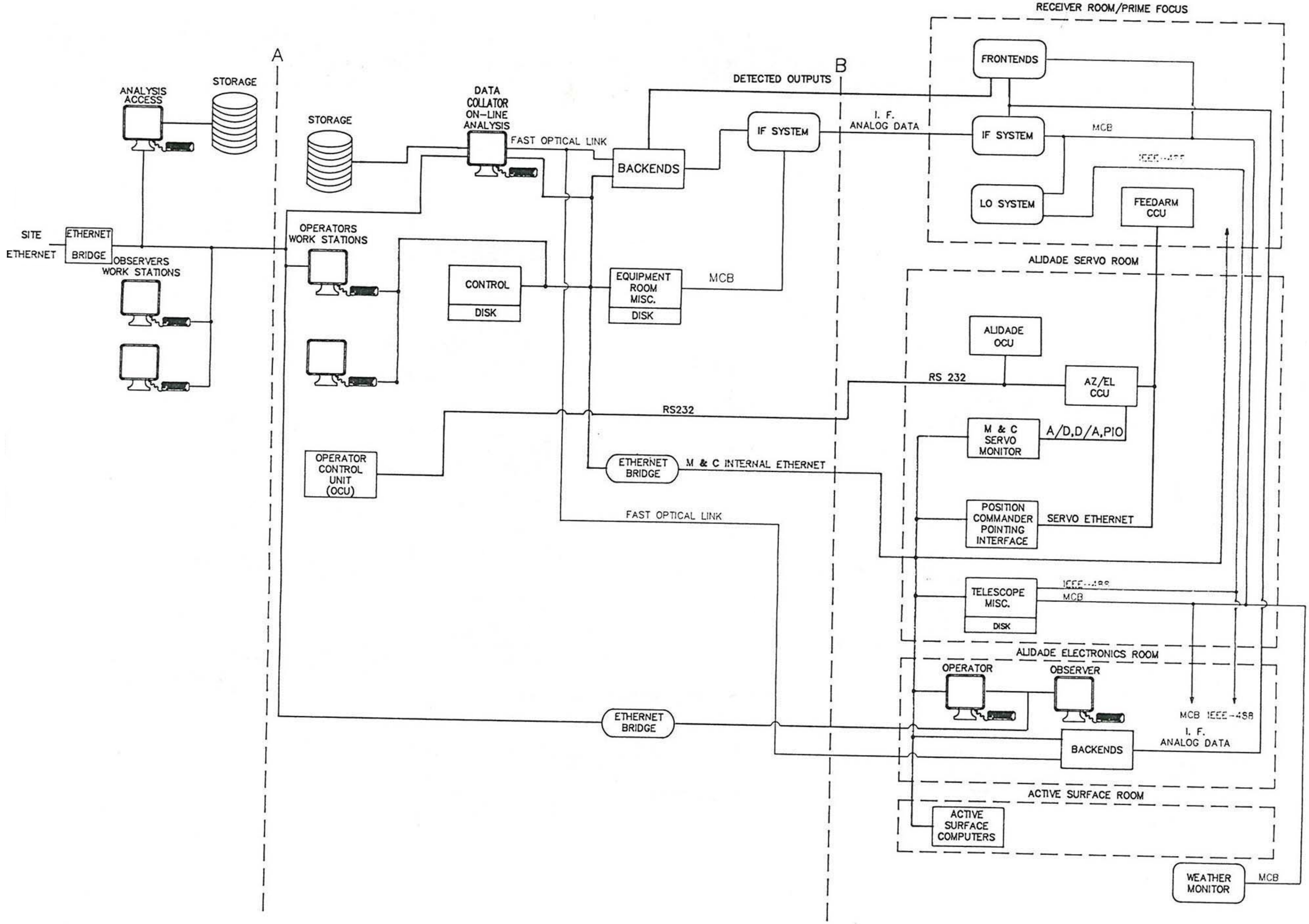
Yes, the use of absolute time as a synchronization mechanism is a design decision, and it is not the only way of maintaining module isolation. However, it is one that we know works. It incorporates an industry standard (IRIG) for which interface boards are commercially available.

Yes, our selection of UNIX, Sun computers, and VX-Works is biased by the installed base of these systems at NRAO and the project staff's own level of experience with them. To do otherwise, there would need to be a good reason why the monitor and control system will not work with these components or an overriding performance advantage to adopting components with which we are not experienced. We have made the assumptions that the cost and time scale of the project would be increased significantly if we were to investigate all of the possible trade-offs in operating systems and hardware and that the experience of our colleagues at NRAO and elsewhere with our selected components under similar circumstances can save the project a lot of time and work and guarantee the manufacturers' claims for their products. We believe that those two assumptions are justified. By adopting existing standards we accrue many secondary benefits: shared maintenance contracts, existing development tools and software, and Observatory-wide purchasing and licenses. Will the system meet specifications, and will the total cost in manpower and hardware be close to the minimum for any possible selection of components under the constraints of the project? We think so. By far the greatest part of the cost is in manpower so some overkill in hardware or adaptation of a known operating system is easily recovered in programming labor saved.

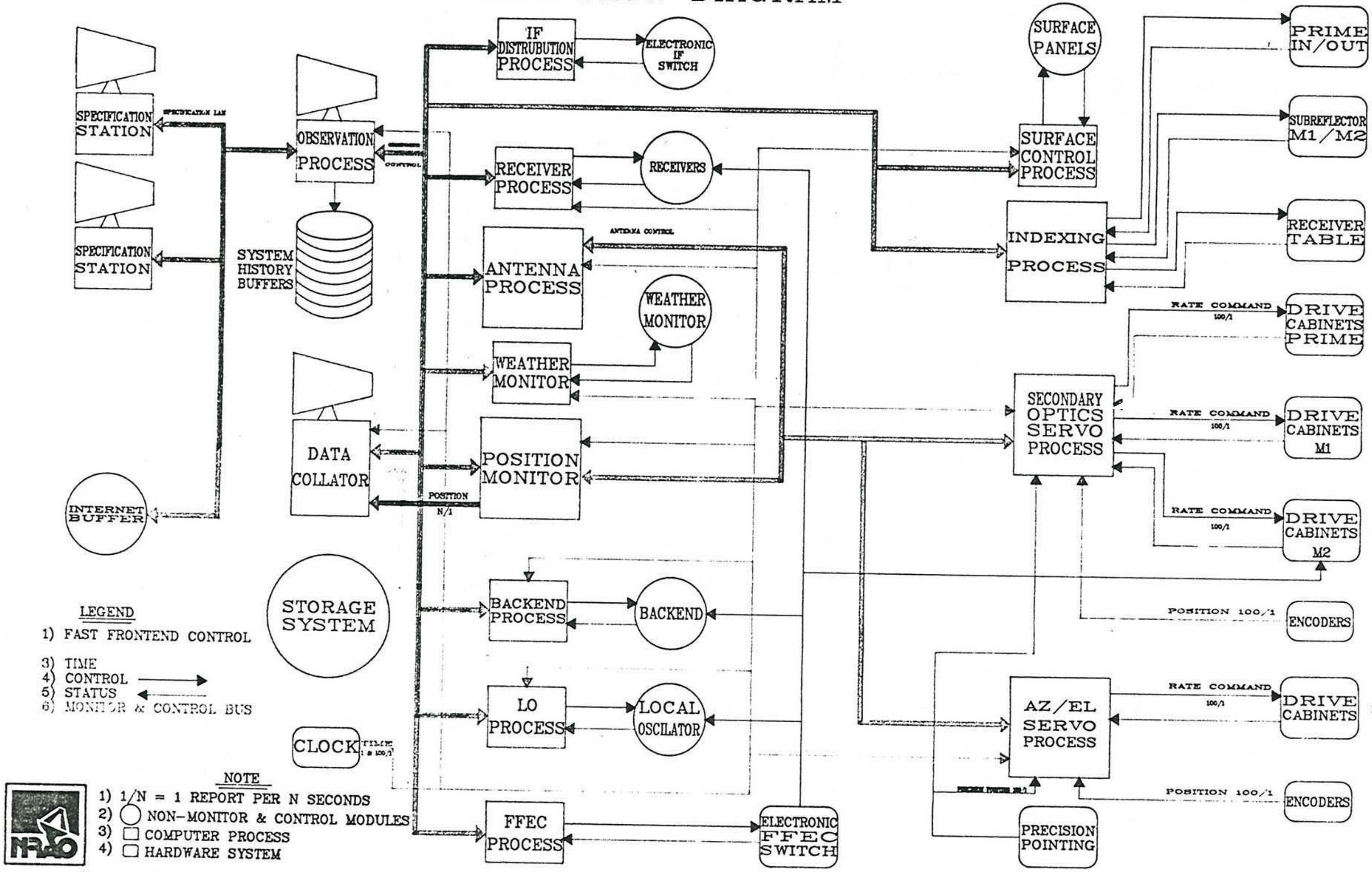
We were aware of the pejorative connotations of the phrase "micro-managed," but it seemed to fit the distinction better than any other phrase that we could think of. Johan Schraml understood the term and said that he preferred the "micro-managed" approach. The antenna motion control is not the only part of the system for which "commands that are to be executed at some specified time in the future" is an appropriate control strategy. It is an important part, however, and we spent a lot of time looking for a good solution. After working with antenna control, a number of similarities with other parts of the system became evident, and the transfer of this design to them was quite natural. Spectrometers need level balancing time, LO's may need to be preloaded, pulsar timing offsets need to be computed and loaded before the appropriate 1-second tick, etc. The unnecessary memory and code overhead in specific cases is far more than offset by being able to reuse an existing more general design. Simple control situations such as routers and LO's will be handled by one hardware processor, but there is no advantage to developing a simpler software design for each subsystem. This is a very good example of where the extra level of abstraction led to an unexpected solution of several design problems at once.

Ref.
Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, F., and Lorensen, W., 1992, "Object-Oriented Modeling and Design", Prentice-Hall, Englewood Cliffs, NJ.

MONITOR AND CONTROL BLOCK DIAGRAM



GBT MONITOR AND CONTROL FLOW DIAGRAM



LEGEND
1) FAST FRONTEND CONTROL

3) TIME
4) CONTROL
5) STATUS
6) MONITOR & CONTROL BUS

NOTE
1) 1/N = 1 REPORT PER N SECONDS
2) ◯ NON-MONITOR & CONTROL MODULES
3) ☐ COMPUTER PROCESS
4) ▢ HARDWARE SYSTEM

NON-STRUCTURAL MONITOR & CONTROL FUNCTIONS (except weather)