MAGELLAN PROJECT

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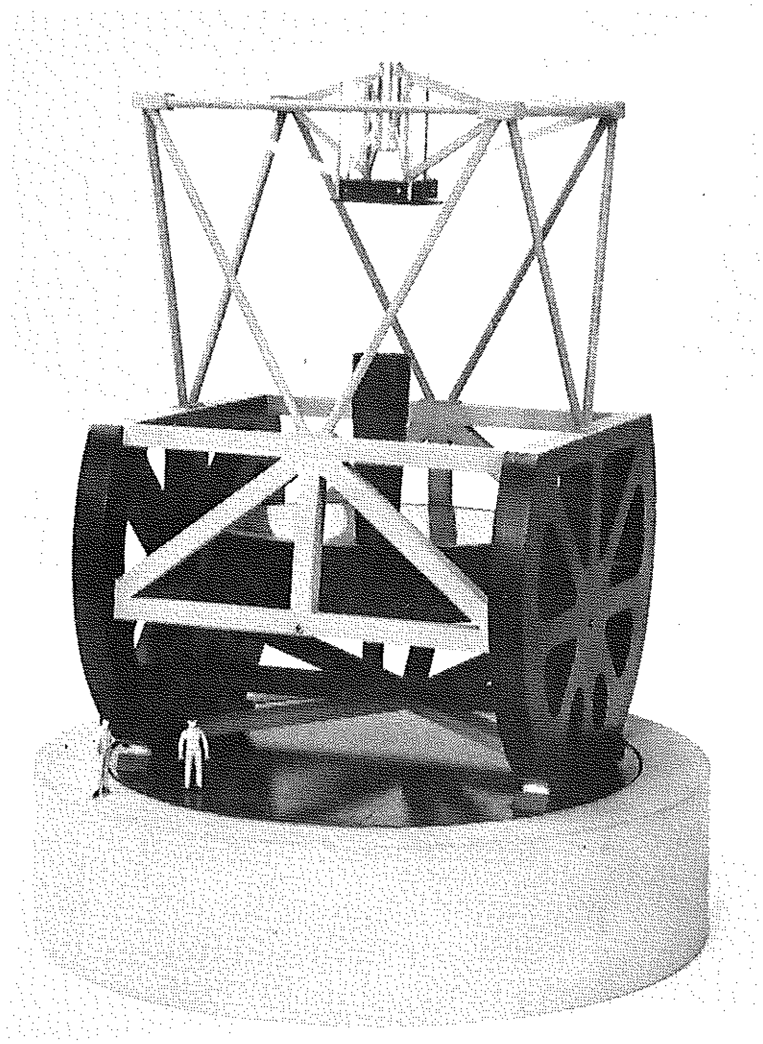

Proposed Control System Architecture

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June 1990
No. 21

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1. Introduction

This report presents a conceptual controls system design which breaks the telescope and instrument control systems into manageable subsystems. Figure 1 outlines these subsystems and their functions.

Some consideration is given to communications links and computing hardware, but hardware selection is purposely being postponed until a decision must be reached later in the project. During the next several years, the state of the art is expected to progress, and we will have the opportunity to consider the new commercially available equipment.

Several prototyping activities are presently underway, particularly in the areas of local device and servo control.

2. Design Approach and Features

The design of the control system is intended to make the various parts of the system as independent as possible, permitting, ideally, a large degree of stand alone operation. This means that the various parts are relatively self-contained, requiring little outside communications, and are responsible for their own safety and emergency operations. This further implies that some measure of computing power is present in each of these parts to enable this autonomy. The desired result is a system whose parts can be designed, implemented, tested, modified, and upgraded individually and with a minimal impact on the other parts of the system.

The conceptual (very conceptual) design presented here allows computing capability to be placed where needed so that no single processor becomes overloaded. Distributed computing and control should also allow a consolidation of communications at lower levels; so for example, instead of controlling the several hundred various actuators in the primary mirror cell from one central processor, the actuators may be placed in groups under the direct control of microcontrollers which are both fewer in number and have more sparse communications with the central processor.

The operator interfaces to the telescope are divided between telescope control and instrument control, although telescope control would still be possible through the instrument control interface. The instrument data and communications networks are largely separate from those of the rest of the telescope to permit an extra measure of flexibility in this area and to act as a buffer against potentially huge data streams clogging the telescope network.

Finally, there is one system clock available to synchronize these otherwise stand-alone parts.

3. <u>Subsystem Descriptions</u>

Referring to Figure 1, the control and communications system can be described in a roughly hierarchical manner. With the exception of the instrument and clock subsystems, each of the items in boxes represents a subsystem computer that through one port has access to a trunk network linking it to the other subsystem computers and through another port receives input and issues commands to the subsystem peripheral devices. It is not necessary for these computers to all be identical. If the cost savings turn out to be significant, computers of greater or lesser capability could be used to more nearly match the requirements of each task.

Starting at the top are two operator interfaces: one for the telescope and building and the other for the instrument being used on the telescope. The telescope control interface is likely to be split into a combination of a flexible and dedicated control and monitoring displays. The dedicated controls and displays would be used for the functions that are routinely referenced such as the sidereal time or the telescope's current position on the sky. The flexible display could be implemented with windows on a video monitor, and through it one would have access to all telescope functions including those of the dedicated display. Access to the functions would be at the operator's discretion as the various windows were opened and closed.

In addition to the instrument itself, the instrument control interface would have control of the instrument support functions, shown in Figure 1 as the instrument utilities and additional computing and data storage. The instrument control interface is likely to have only a flexible display for access to all the available instrument functions.

Subsystems associated with the instrument control interface (the instrument, instrument utilities, and the additional computing and data storage) are shown having communications links that are separate from the rest of the telescope control system. The goal of this arrangement is to make the instrument subsystem reasonably self-contained so that it may be implemented, tested, and upgraded without substantially affecting the other telescope subsystems or communications links. Equally important is to leave the data and command interfaces in the instrument subsystem as flexible as possible in order to accommodate a wide variety of instruments and perhaps other operator interfaces. Furthermore, the potentially large amounts of data transferred in this subsystem will almost certainly mean the availability of separate data and control links for the instrument.

Subsystems associated with the telescope control are connected to the same trunk network as the instrument and telescope control interfaces, again as shown in Figure 1. This is so that information may be readily communicated between the subsystems themselves and so that subsystem information (such as telescope position) may be transmitted to the instrument being used.

Additionally, the common trunk network would also allow the instrument control computer direct access to the telescope functions. This would permit the instrument to, for example, reorient the instrument rotator or change the chopping frequency of the IR secondary.

The functions of the telescope control subsystems have been arranged in an attempt to minimize the communications traffic on the trunk network. For instance, the guide camera control and guiding image processing are handled by the same subsystem. Otherwise, in this example large amounts of image data would be transferred between subsystems. Such an arrangement also contributes to the "modularity" of each of the subsystems since each subsystem is less dependent on external information from other subsystems. This feature helps simplify the implementation, testing, modification, and eventual upgrading of the hardware and software.

In the breakdown shown in Figure 1, we believe all the major functions of the control system have been identified, but they admittedly have not yet been well defined. This raises the question of whether the subsystems as grouped in Figure 1 can actually be implemented, or whether the computational or communications capabilities of any one subsystem might be exceeded. This question can be answered by assuming that by placing varying amounts of computational power local to the immediate task, the computational requirements can be spread out in some manageable fashion, and the communications requirements (over as yet undefined communications links) can be kept acceptable. This local computational ability might range from a microcontroller such as the 8752 currently used by the Carnegie Observatories, to a more substantial computer. Presently, it appears possible to tailor the computational capabilities to the task at hand, and this should become even easier as the state of the art in computers and communications progresses.

Finally, Figure 1 shows a clock distribution system that is available to all of the subsystems. This separate system is obviously for the synchronization of the subsystems. It is anticipated that the trunk network itself will not be suitable for this task because of the indeterminate delays that are likely to be present in the eventually selected network.

4. Computation and Communications Hardware

The selection of specific computers and communications networks is purposely being postponed in order to take advantage of the new developments that will occur before telescope construction begins. Nonetheless, we have candidate systems in mind for at least some parts of the system.

Presently, it appears that a form of ethernet may be suitable for the trunk network shown in Figure 1. Alternatively, an optical fiber or coax implementation of the fiber distributed data interface standard (FDDI) may be desirable, but this will depend to some extent on how well this new standard is commercially supported.

For some of the subsystems, the RS-485 communications standard would be suitable. This is particularly true for the slower subsystem functions such as dome slit or dome position control. This is the communications link currently used between the previously mentioned 8752 controllers.

Some of the faster functions such as the fast guiding with the secondary mirror will almost certainly need a faster communications link. These fast links may again be an implementation of the FDDI standard. Alternatively, there exists a so-called "Taxi" chip set for fast point-to-point serial communications. Furthermore, as we await the progress of other commercially available communications networks, we continue to entertain notions of fast serial links of our own design.

With regard to the computing hardware, almost anything is possible. Nothing has been firmly decided since mid level computers are outdated in about one and one half to two years after their commercial introduction. This will result in mid level computer performance improving significantly before a decision must be made about the computers for the telescope of the Magellan Project.

The one possible exception to the otherwise undetermined computing hardware is the use of 8752 microcontrollers to perform the smaller local tasks. This microcontroller in combination with electronically programmable logic devices (EPLDs) and other special function chips (such as dedicated PID controllers) are beginning to find use in a number of systems for the Carnegie Observatories. Even in this area however it is quite possible that by the time telescope construction begins we will have identified another microcontroller better suited to the tasks.

5. Current State of Affairs

As previously mentioned, the 8752 microcontroller is currently being used for imbedded control applications. It has already been built into several instruments and pieces of auxiliary equipment.

Additionally, three pieces of mechanical hardware specifically applicable to Magellan are under construction and will provide further opportunity to test means of control and communications: a secondary mirror collimation and focus actuator, a secondary mirror fast guiding actuator, and a telescope main drive unit.

Lastly, an upgrade to the drive system of Carnegie's 40" Swope Telescope at Las Campanas is currently underway. This will allow testing of several aspects of an integrated mount control subsystem involving two axis servo control and pointing model computations.

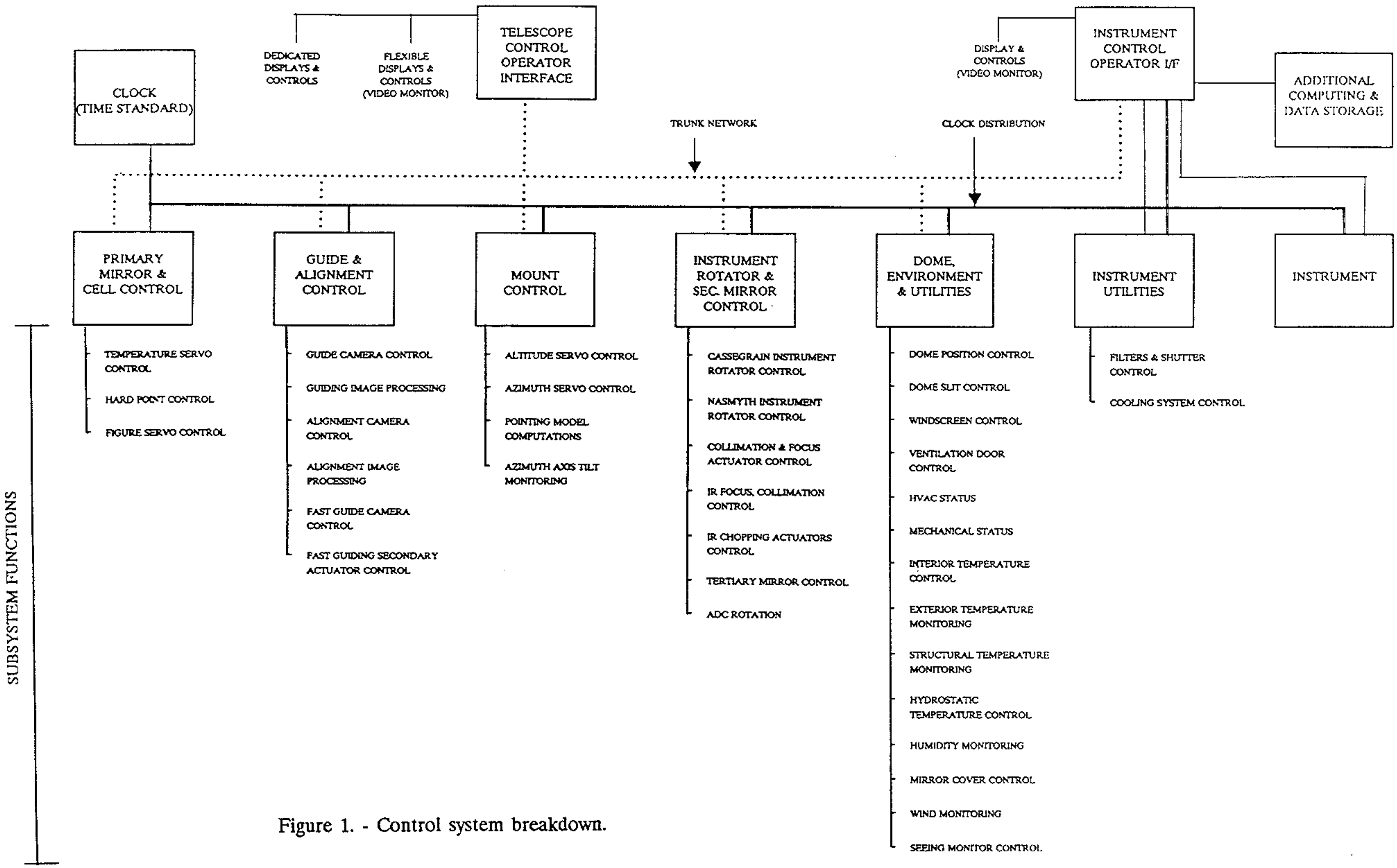

Figure 1. - Control system breakdown.