# THE NNTT

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## REMOTE OBSERVING EXPERIMENTS AT KITT PEAK NATIONAL OBSERVATORY

By

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## ACKNOWLEDGMENTS

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Comments or suggestions concerning this report are invited and should be sent to either the principal authors (W. Robinson, P. Schechter, C. Janes), or to L. D. Barr, KPNO, P.O. Box 26732, Tucson, Arizona 85726-6732.

## ABSTRACT

For the past year Kitt Peak National Observatory has been conducting a pilot program of remote observing experiments. Observers who would ordinarily have travelled to Kitt Peak have instead observed from their home institutions. Three voice grade telephone lines are used. One line is used for voice communications with the telescope operator, another line is used to interface with the telescope computer which controls the telescope and instrument, and the third line is used to transmit a slow scan (34 second update time) television picture from the telescope field acquisition camera. Observers have found this system to be quite effective. Problems with telephone line noise have been encountered and several schemes for alleviating these problems are presently being implemented. Plans for more rapid video refresh rates over voice grade lines, the use of greater bandwidth communication links and the multiplexing of voice, data and video over single channel are presently being considered. The goal of the experiments is to investigate the effectiveness of this technique with respect to observing efficiency and cost savings.

# INTRODUCTION

In the interests of comfort and efficiency of operation, the control of new instrumentation at major observatories has been in large part removed from the telescope focus to a "control" or "data" room some tens of meters away. While the acquisition of data is still very much a hands-on process, the astronomer's hands are more likely to be on a computer terminal keyboard than on a filter bolt or shutter and his eyes are glued to a television monitor, not an eyepiece. Once the astronomer's presence is no longer required at the telescope focus, there is less reason for him to be close to the telescope. The electrical cables through which he controls the instrument and monitors the acquisition of data might as well be thousands of kilometers long. Such remote observing has obvious advantages, and perhaps equally obvious disadvantages. In at least some cases at Kitt Peak, and for telescopes at very remote sites, the advantages may outweigh the disadvantages.

Among the benefits are the savings of time and money in travel the savings associated with supporting fewer individuals at remote sites, the reduced disruption of the astronomer's routine at his home institution, and the possibility of adaptive telescope scheduling letting the weather and seeing determine which of several programs is pursued on a given night. On the negative side, the astronomer will understand his instrument and telescope less well, will miss the opportunity to interact with astronomers from other institutions, and will be in a limited position to help rectify any difficulties which might develop in the course of an observing run.

## EXPERIMENTAL SETUP

The initial remote observing experiments were conducted with three voice-grade communications links between the 2.1 meter telescope building on Kitt Peak and our Tucson facility. These links are shown schematically in Figure 1. One line was used as a duplex voice channel for verbal communication between the observer and the telescope operator. During the initial experiments, both a headset and a speaker phone were tried. The headsets proved somewhat uncomfortable and limited the user's movement. The speaker phone was found to be satisfactory in most instances and gave the remote observer a better "feel" of the control room environment. The second link was used as a simplex video channel to send slow scan video pictures from the memory of the acquisition TV to the remote observer. This system permitted the transfer of one complete picture frame every 34 seconds. The acquisition TV memory output (standard EIA RS170 CCTV video) served as the input for a Colorado Video Inc., model 262B video compressor at the telescope. A commercial modem, supplied by CVI, interfaced the video compressor output to the standard telephone line. At the observer's end, a CVI model 275A-1 video expander was used to convert the low frequency slow scan video back to standard RS170 CCTV video for display on a standard CCTV monitor. A commerical modem, also supplied by CVI, served as an interface between the video expander and the telephone line. The third link was used as a duplex channel to allow for remote terminal interaction with the telescope/instrument computer. The Varian 620f computer EIA RS232 port was interfaced through a KPNO constructed interface module to a Prentice model P212A modem which in turn interfaced to a standard telephone line. The KPNO interface module allowed both the telescope operator's terminal and the observer's terminal to appear as a single input to the comput This allowed the remote observer to see what the telescope operat was typing and vice versa. This last feature was particularly useful, since the observer and operator each had a good idea of what the other was doing at any moment. The remote observer's terminal was interfaced to the phone line by a Prentice model P212A modem. Both sites used Tektronics model 4010 graphics terminals with transmission rates of 1200 bps.

After the initial success of our remote operation from our Tucson facility, R. Kirshner of the University of Michigan volunteered to try his June 1981 observing run from Ann Arbor, Michigan. The equipment and setup used for this experiment were identical to those described above except for the telephone lines. For Kirshner's run we had originally planned to use FTS long distance lines, which are accessed through the Tucson office Dimensic CBX. However, during two of the five nights of Kirshner's run, we encountered severe noise problems, which manifested itself both audibly and by an exceedingly large number (30 per minute) of spurious characters received in Michigan (but not on Kitt Peak). The noise was less of a problem for the voice and video channels, though the video was slightly degraded. The problem was circumvented by using a commerical direct dial long distance line through the Kitt Peak CBX, as shown in Figure 2.

## EVALUATION OF FIRST EXPERIMENTS

Our first remote observing runs used Kitt Peak's Intensified Image Dissector Scanner (a spectrometer) on the 2.1 meter telescope during January 1-3, 1981 (with the observer, P. Schechter, in Tucson) and June 4-8, 1981 (with R. Kirshner in Ann Arbor). Both runs were successful from the astronomer's standpoint. Kirshner wrote of his run:

> "This system provides enough information to the observer that he can effectively observe from a remote station. Since the observer retains control of each night's program as it develops, is responsible for identifying the objects observed and decides, based on the data coming in, how long to integrate on each object, the observer really is in charge."

Small snags and losses in operating efficiency did occur in each of the runs. Most serious was the telephone noise described in the previous section. The 34 second refresh rate on the video link made several small changes in the observing routine necessary. Confirmation of the field required anywhere from 1/2 to 4 minutes, depending on the magnitude of the object and the presence or absence of other objects in the relatively small (1 arcminute) field of the slit viewing TV camera. An observer in the control room would ordinarily move the telescope briefly in some direction to check for the presence of stars beyond the edge of the field. The remote observers made more extensive use of the field acquisition TV camera, with its wider field, and with the attendant delay in switching between TV cameras. A second difference was that the operator did the final setting of the instrument aperture on the object, an operation normally done by the observer. This maneuver requires hand-eye coordination on 1 second time scales, which the 34 second refresh does not afford.

## EFFORTS IN THE NEAR FUTURE

Of the instruments available at Kitt Peak, the IIDS is one of the best-suited for remote operation. With minor exceptions (the collimator focus and positioning of the post slit filters) the instrument can be completely controlled through the computer. Other KPNO instruments which might be readily adapted for remote operation with relatively minor modification are the following:

### CCD Systems

The KPNO CCD controllers and associated Grinnell display systems are entirely under computer control except for a few display features which are controlled through a handpaddle and joystick. In order to make remote operation of the CCD systems more effective, some of these display features will have to be remotely controlled and monitored with different techniques than we presently use.

### Fourier Transform Spectrometer

The 4 meter telescope Fourier Transform Sepctrometer (FTS) is also under computer control and lends itself to remote operation. At present, the only function that is not under computer control is an analog signal used for guiding. This guiding function can, in the future, be performed by the telescope operator.

While the off-the-shelf CVI equipment serves surprisingly well for our video application, one can imagine improvements that might be incorporated into a specially designed system. One might want to transmit a picture with more dynamic range and allow the observer to window the field acquisition picture and/or the two-dimensional data. One might allow for the transmission of variable picture depth, transmitting pictures anywhere upward from one bit of intensity. In some cases, it might be desirable to update a smaller area of the picture more rapidly. Or one might want to go to some data compression scheme, updating only those pixels whose values change, for example. In any case, we feel that during the next five years we will continue to be limited to the bandwidths available through dial-up telephone lines and we will have to be more clever in how we transmit the video signal in order to maximize the observer's operating efficiency. We are hoping to develop design specifications during the next nine months and then either build the units in-house or subcontract the construction to an outside vendor.

Because of various noise problems encountered using long distance FTS and Telco lines, we are planning to install Micom, model 512, error controllers on the terminal links. Noise on the voice and video links is usually tolerable, but noise on the terminal link is very annoying, particularly in the graphics mode.

## EFFORTS IN THE FUTURE

There are two capabilities we hope to develop in the future (five to ten years). One is to have greater bandwidth for the video transmission to permit faster refresh rate. The other is to be able to transmit digital data. It is difficult to say how these capabilities will be implemented or what additional features may be needed because of the rapid changes taking place in the communications field. We are now comparing the costs and advantages of terrestial and astellite communications links. High bandwidth fiber-optic links may eventually replace satellite links at the U.S. becomes more dependent on information exchange for business, government, and personal use.

Long term, one could envision a world-wide astronomy network using a multiplexing scheme to permit simultaneous use of a single high bandwidth media for several channels of data transmission and the voice, telecommunications, and video links to operate a number of telescopes from remote locations. Such a network would allow dozens of observatories and data centers to be linked with hundreds of observers throughout the world. One such hypothetical network is shown in Figure 3.

## CONCLUSION

We can anticipate that transportation, lodging and personnel costs will increase; that communications costs will decrease; and that instrumentation and data reduction will become more complex and costly. If so, remote observing and remote data reduction will become a more cost effective means of producing science.

The experiments being performed at KPNO will, hopefully, give us the needed experience to identify the advantages and disadvantages of remote observing and data reduction for our own organization, our users and the astronomical community in general. We also anticipate that there would be larger cost savings if more of the astronomical community were involved with the overall communications system; to that end, we are attempting to coordinate our efforts with other observatories.

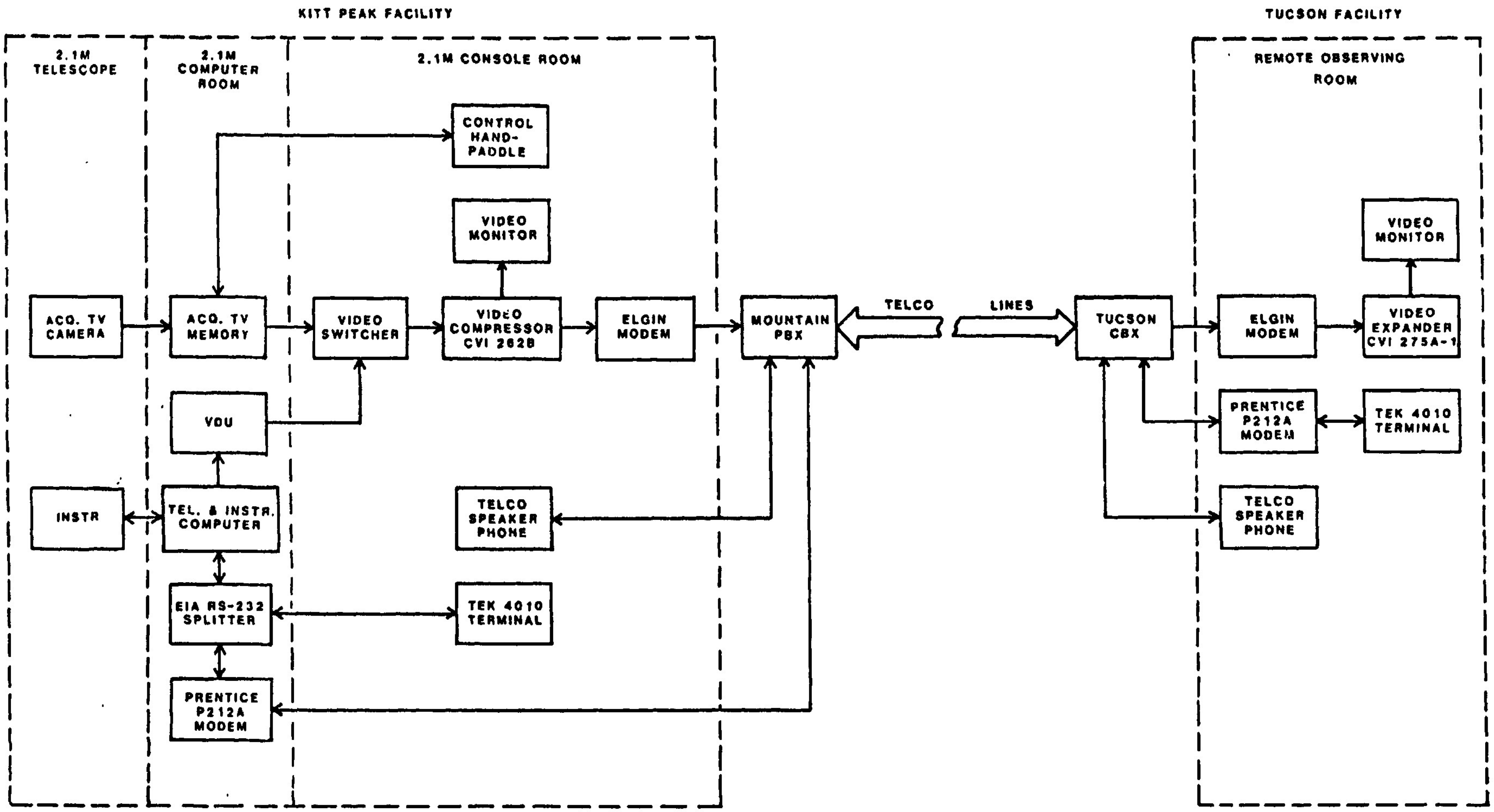


Figure 1. Initial Remote Observing Experimental Configuration

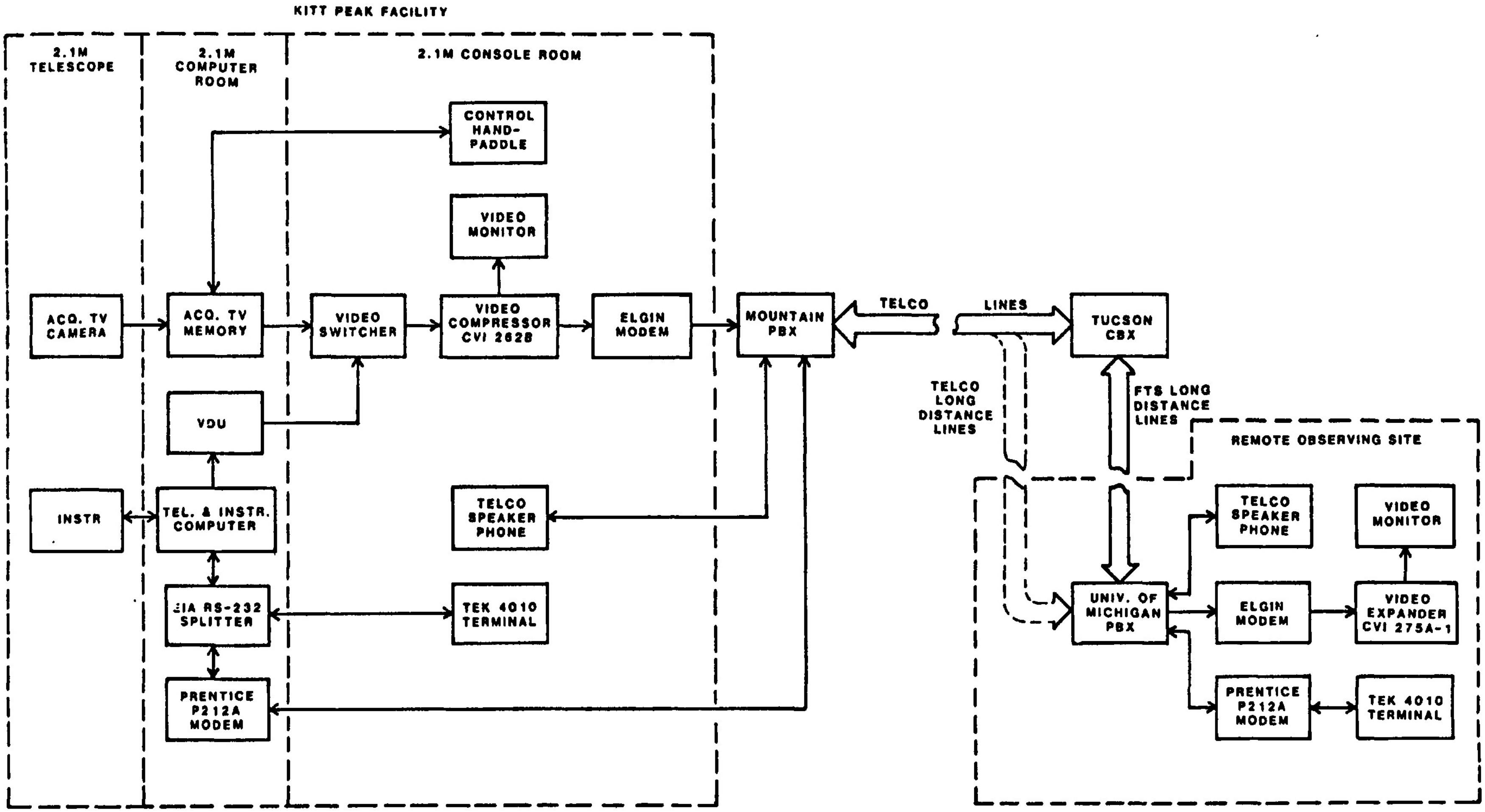


Figure 2. Transcontinental Remote Observing Experimental Configuration

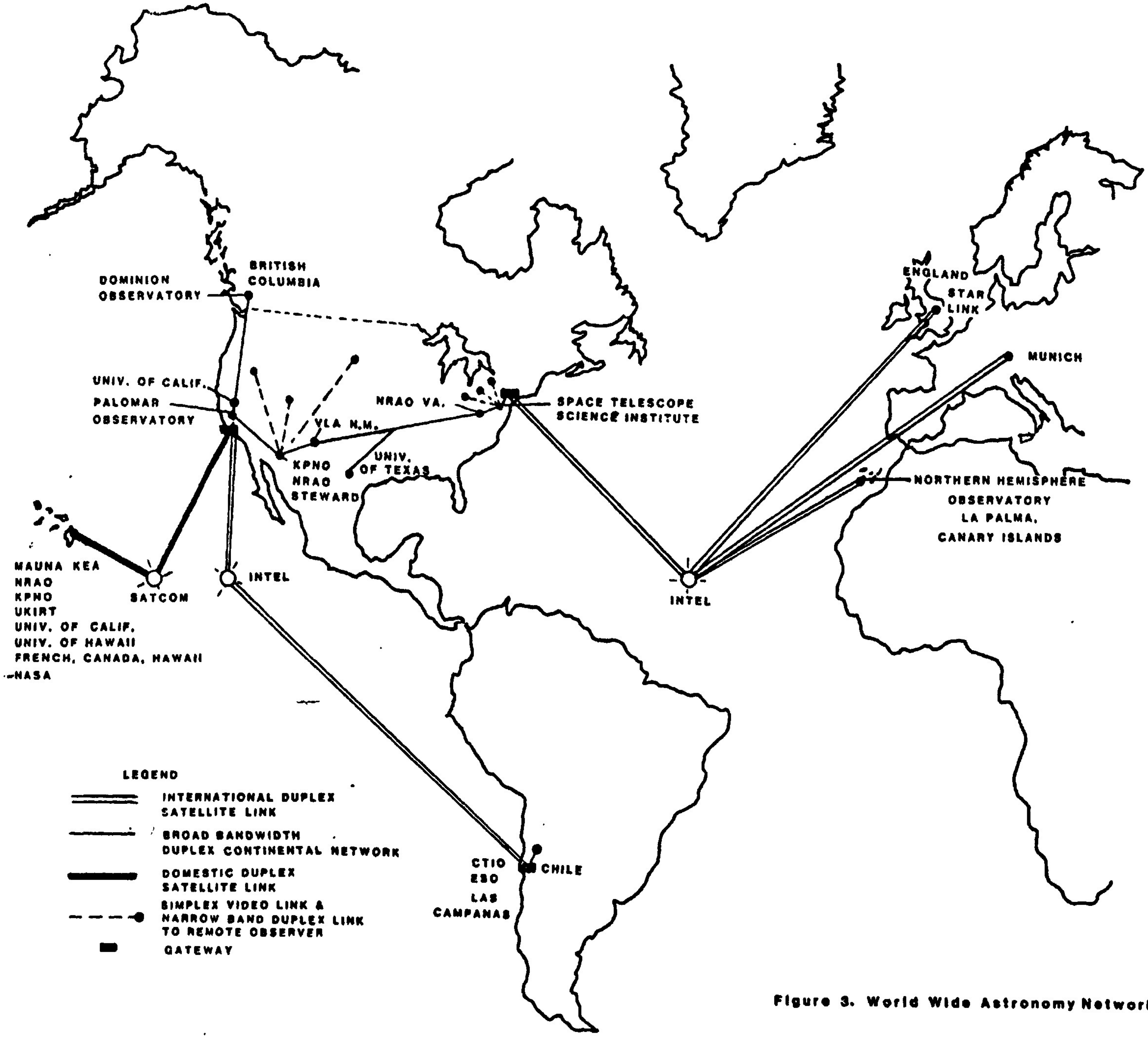


Figure 3. World Wide Astronomy Network

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Ken,

You might like to read this

We slowly adjusted to Austin and we start to enjoy it.

Greetings!

Woon-Yin