1. SUMMARY OF PERSONNEL, COMMITMENTS AND COSTS

Personnel	Role	Year 1	Year 2	Year 3	Cost
Alan Tokunaga	Principal Investigator	.04	.04	.04	0.0
Peter Onaka	Co-I and Chief Engineer	.08	.08	.08	0.0

2. SCIENTIFIC AND TECHNICAL MANAGEMENT SECTION

2.1 Introduction

The NASA Infrared Telescope Facility (IRTF) is a 3.0-meter infrared telescope located at an altitude of approximately 13,600 feet near the summit of Mauna Kea on the island of Hawaii. The IRTF was established by NASA in 1979 to obtain infrared observations of interest to NASA. It is designed for maximum performance in the infrared portion of the spectrum, taking advantage of the high transmission, excellent seeing, minimal water vapor, and low thermal backgrounds that characterize the atmosphere above Mauna Kea. Facility instruments are provided for data acquisition, and these instruments are developed and maintained by the IRTF staff. Approximately 110 visiting astronomers use the IRTF each year.

NASA and the University of Hawaii recently entered into a 5-year Cooperative Agreement to operate the IRTF through Jan. 2006 (NASA grant number NCC 5-538). In addition discussions with NASA indicates that the IRTF will continue mission support observations at least to the end of the Cassini mission in 2008. The IRTF staff was also recently charged by its Management and Operations Working Group with producing a long-range plan for the IRTF for the next 10-15 years.

As a result of these developments we propose a program to replace the current 22-year old Telescope Control System (TCS) of the IRTF. As will be shown below, it has become increasingly difficult to maintain the TCS and it is essential to replace it as soon as possible.

2.1.1 Objectives of the Cooperative Agreement

The objective of Cooperative Agreement is to provide research data using the IRTF to support NASA-related programs in the areas of mission support and basic solar system research. In addition, we plan to use the IRTF as platform for the demonstration of new technologies for planetary observations and future missions. To accomplish these objectives we plan to:

- Provide ground-based support of major missions (Galileo, Cassini, Mars missions), Discovery missions (i.e. NEAR, CONTOUR, Deep Impact), and other missions (DS-1). Priorities will be determined in consultation with NASA.

- Conduct research by supporting observing proposals from the planetary community that are approved by a competitive process.

- Conduct research on near-Earth objects (NEOs) through a scientific program based at the IRTF and involving collaborations with various members of the planetary community.

- Develop and improve facility instrumentation, including an adaptive optics system.

- Establish technical and scientific collaboration with appropriate NASA centers and JPL to foster instrument development and to enhance the capability of the IRTF to support NASA-related research and mission support.

It should be noted that 50% of the telescope time is allocated to non-solar system research. This includes all areas of astrophysics— observations of stars, galaxies, the interstellar medium, and Origins-related research on star and planet formation. In recognition of this, the NSF provides funding for facility instruments through its Advanced Technology and Instrumentation Division (IRTF staff astronomers must submit proposals that are peer-reviewed). The NSF also provides 50% of the visitor support for living expenses at the Mauna Kea Observatory Mid-level Facility (Hale Pohaku). We are prepared to request cost-sharing with NSF for the TCS replacement as explained in Section 2.4.

2.1.2 Uniqueness of the IRTF for NASA-related Programs

The IRTF is situated at one of the best observing sites in the world, and it is maintained and operated by one of the leading centers for astronomical research, the Institute for Astronomy (IfA). The IRTF provides

> *Timely ground-based observations in support of planetary missions.* This includes support for major planetary missions such as Galileo and Cassini, as well as Discovery-class missions to comets and asteroids. Of greatest importance is the provision of time-critical observations in support of missions.
>
> *A dedicated facility for planetary astronomers*. As a facility built to support NASA-related programs, the IRTF provides a dedicated observing capability for the community of planetary astronomers and space scientists. The IRTF is designed for maximum performance in the infrared portion of the spectrum, to take advantage of the high transmission, excellent seeing, minimal water vapor, and low thermal background that characterize the atmosphere above Mauna Kea. Time-critical observations, such as observing sequences timed to observations by spacecraft or to the orbital phases of satellites, are often required. Long-term observations, such as synoptic observations of Jupiter and its satellite Io, may extend for over a decade.
>
> *A training facility and platform for new instrumentation.* The IRTF allows students and researchers hands-on experience using instruments and obtaining observations, and also allows rapid response to changing research needs. In addition, unique instruments that support planetary science can be tested at the IRTF. A good example is the Goddard Space Flight Center’s 10 µm heterodyne spectrometer that achieves a spectral resolving power of 10^6.

2.2 Why We Need to Replace the TCS

The present TCS has been in use since 1979 with many enhancements and modifications. It is now apparent that something must be done to replace it before a catastrophic failure occurs. The primary concern is that the computer hardware is now so old that spare parts cannot be found. Although a plan has been devised to replace the TCS, the IRTF operational budget is insufficient to fund this task. We are therefore seeking funds to accomplish this work.

The heritage of the current TCS is indeed obsolete. Figure 1 shows the TCS rack that was designed and built in the late 1970s for the DEC LSI 11/23 microcomputer that runs it. The LSI 11/23 has an amazing 64 kilobytes of memory and it relies on old 8-inch floppy disks for backup and for rebooting. It was programmed in FORTH, a computer language that is not currently used, and our software engineer who maintained the system retired last year (although he is available as a consultant).

There have been several previous attempts to replace the TCS, but shortages of staff time and money for equipment, as well as the daily needs of IRTF operations, have resulted in the abandonment of these attempts. *We have concluded that obtaining facility improvement funding is the only practical way to complete the TCS replacement.* It is critical to have a dedicated software engineer and electronics technician for this project.

The current TCS is very limited in its ability of perform sophisticated telescope movements required for spectral scanning. For example taking spectra at discrete positions along a disk can provide data cubes in which each point in the image has a corresponding spectrum. This will be an important capability as we improve the image quality at the IRTF and bring on-line the adaptive optics system.

The replacement TCS is also crucial for providing adequate remote observing capabilities. We are already experimenting with remote observing, and we must work around obsolete hardware and software to accommodate this. The replacement TCS will allow us to include remote observing in the design, and this will lead to more capability, speed, and reliability. There are at least four advantages of remote observing: (1) It permits the visiting astronomer to work from the Mid-Level Facility or from Hilo, thus avoiding the difficulties of working in the thin air at the summit of Mauna Kea. (2) It permits troubleshooting and maintenance to be done remotely, thus saving time and money. (3) With the high-speed network now in place, it permits the astronomer to work from his or her office on the mainland, thus saving the time and expense of traveling. (4) It permits a more flexible observing schedule. Observations with partial nights or of targets of opportunity (NEOs, comets, gamma-ray bursts) would be more readily accommodated given the convenience of remote observing.

Looking to the future, we can expect that remote observing will become the dominant form of observing, especially as the network continues to become faster and more reliable. It would not be surprising if most of our observers work remotely by the conclusion of this Cooperative Agreement in 2006. We should prepare now for this eventuality.

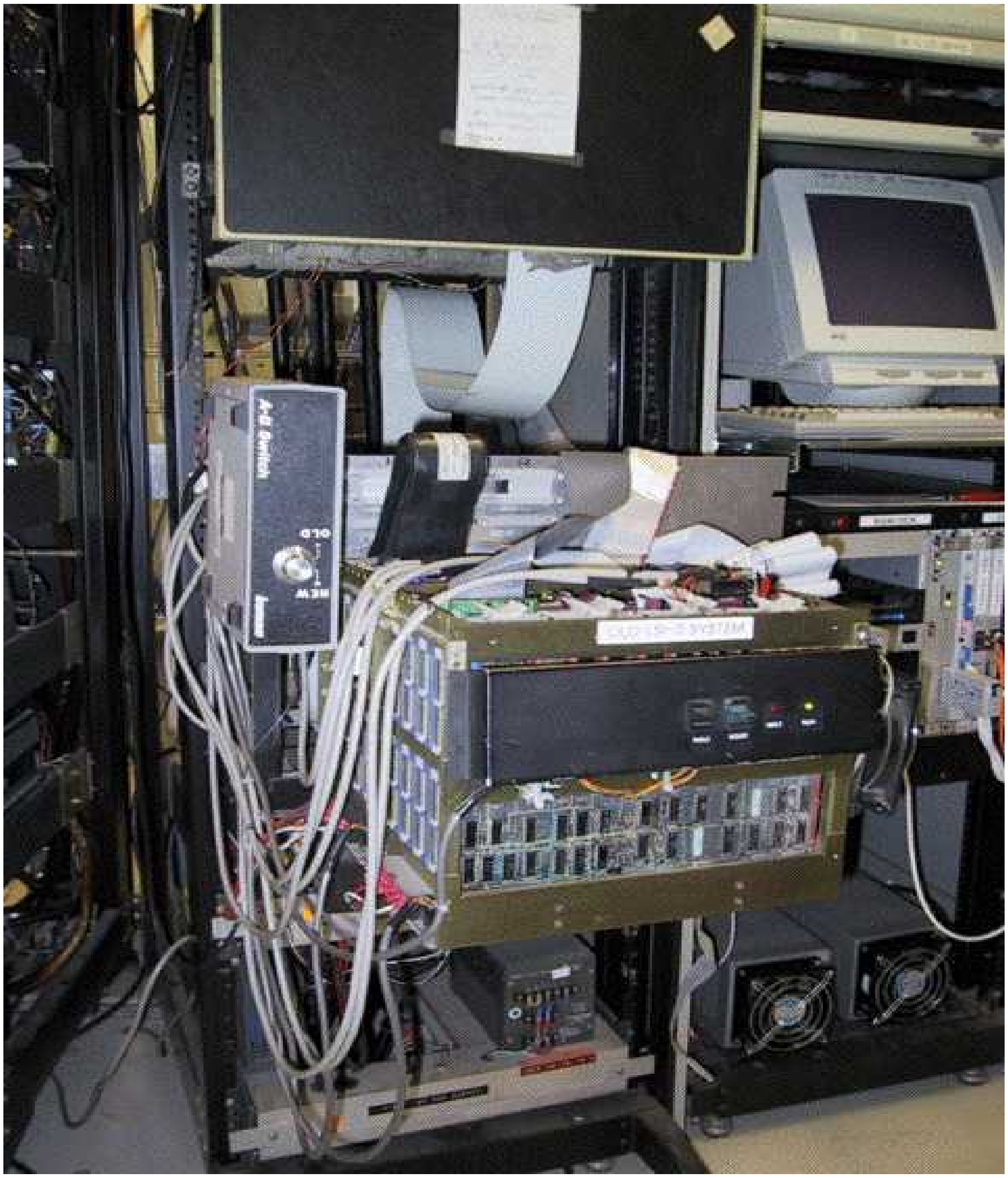

Figure 1. Vintage 1970’s technology. Photo of current TCS computer hardware.

2.3 Technical Approach

Our approach is to replace the current obsolete TCS with a system that will be able to grow as technology and our needs change. We will select computer hardware and interfaces that can be replaced as needed and utilize software that is likely to be supported far into the future. Since the current TCS is in use, we plan to be able to switch between the old and new TCS during the engineering and testing phases.

2.3.1 The Existing System

The Master Control Console (MCC), shown in Figure 2, is the main console that provides all hardwire functions of the TCS (power on/off, slew button, offset button, base position button, status indicators, primary mirror support system on/off, panic stop, etc.). Figure 3 shows the block diagram of the current TCS. The workstation named "max" provides the Telescope Operator (TO) with computer functions (telescope status, star catalogs, network services, etc.). For night operations the TO uses the MCC and workstation max. The visiting astronomer uses the workstation "stefan" for instrument control and data taking (the connections to the instrument are not shown in Fig. 3).

Figure 2. Photo of the Master Control Console (MCC) as viewed by the Telescope Operator. Several other workstations for star catalogs, tip-tilt guider, and network services are not shown.

The DEC LSI 11/23 computer is at the heart of the TCS. It is the main control computer that does all of the calculations for pointing the telescope, setting of track rates, time-keeping, etc. Complex operations involving taking of data are also provided by the LSI 11/23. The LSI 11/23 communicates with the outside world through a serial link to "max" and "stefan" and through extension of the QBUS to the MCC QBUS and the CCS QBUS.
Needless to say, the LSI 11/23 and QBUS technology are now of museum quality and woefully inadequate for our future needs.

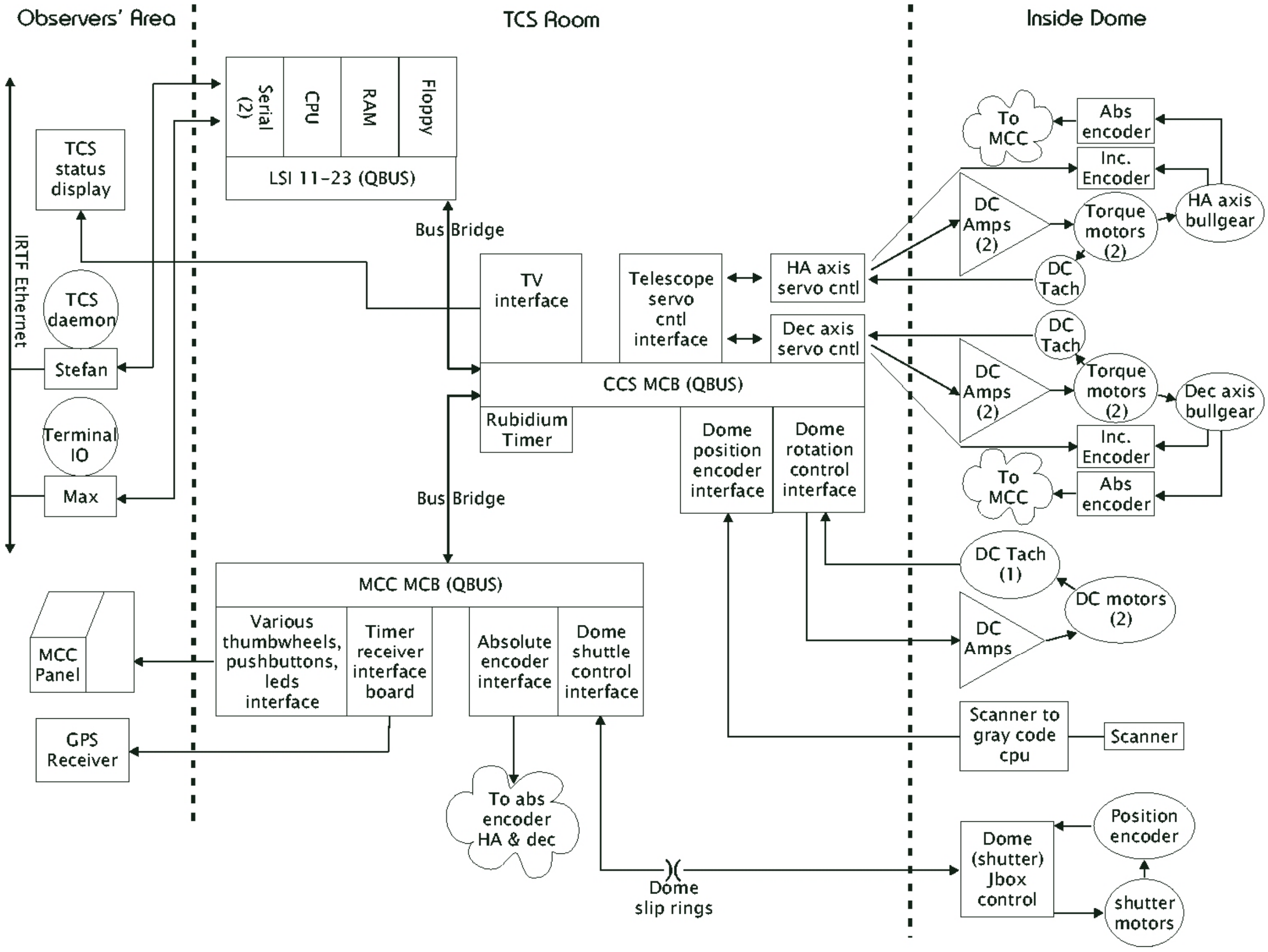

Figure 3. Block Diagram of the current TCS.

Although we have managed to maintain this system, we ultimately cannot prevent the complete failure of a critical component. Any of the following could fail: the power supply, a critical computer board, the disk drive (8-inch floppy drive), the telescope drive motor or encoder, a critical component for the servo amplifiers, a critical MCC electronics board. We have spares for most components (for example the LSI 11/23 computer boards and floppy drive). However, our confidence in maintaining the system diminishes each year since we could get to a situation where our primary component and spare both fail. In this case we would face a substantial down time for repair if the parts required cannot be found. Another important consideration is that the maintenance of the system requires the long-term memory of the support staff. As we occasionally have people changing jobs or retiring, there will be loss of critical knowledge as well. The retirement of our FORTH software engineer is a prime example. In fact we do not have the expertise on our staff to program in FORTH. This alone is a reason to replace the TCS.

Equally important is our desire to minimize the time we must currently spend to maintain a 22-year old computer system and the limitations it imposes on our operations. We need to have a new TCS that will allow us to expand our services to the astronomical community for the next 5 years and beyond.

2.3.2 General Description of the Work to Be Performed

The scope of the project is to replace the LSI 11/23 computer and peripheral equipment, its associated FORTH software, the MCC, and all of the hardware in the TCS room shown in Figure 3. The new system will be designed so future enhancement and integration with additional observatory systems will be possible.

(a) TCS FORTH and daemon: Both software items will be replaced with a single TCS application. This application will be written in C and developed under the Solaris operating system. The application will be command-line oriented, with an X-based graphical user interface for the TO. Telescope status information (for observers) will be viewed using X-based applications. Network communication will be provided using remote procedures calls.

(b) LSI 11/23: To be replaced with a SPARC computer in a VME bus. Assorted peripheral devices such as digital input/output, analog input/output, motor control, serial ports will be included.

(c) Master bus & components: The obsolete QBUS and associated analog and digital interface boards will be replaced. A new customized interface between the VME computer/servo board and IRTF mechanical systems will be built. Much of the functionality currently performed in hardware will be replaced by the TCS control software. A new TCS rack with digital and analog connectors, signal conditioners and distribution, cable breakouts, and power supplies will be installed.

(d) MCC: The current MCC panels will be replaced with a smaller MCC panel to control items not connected to the TCS (such as LED status indicators) and to provide essential TCS physical switches (power on/off, brakes, disable buttons, analog measurements, limits indicators). Because of limited space, the current MCC will be replaced with a smaller interim MCC. Both systems will be located at the IRTF for an extended period of time during the testing phase at the summit.

(e) Switching between the Old & New TCS: The new TCS system will be interfaced with the same servo amplifiers, DC tachometers, and encoders currently in use. A method of switching between the old and new systems will be provided. The major systems involved are RA and Dec amplifiers, DC tachometers, dome amplifiers and dome encoder scanner, and the shutter position encoder.

(f) RA/DEC encoder: The current absolute/incremental encoder will be replaced with a single high-resolution absolute encoder.

A block diagram of the proposed TCS is shown in Figure 4. Note the greatly simplified interfaces. As mentioned previously, careful selection of the hardware and software will allow us to more easily maintain this system for the next decade or two. We will also imbed new capabilities, especially remote observing (from Hilo or from the mainland) and remote operations from Hilo.

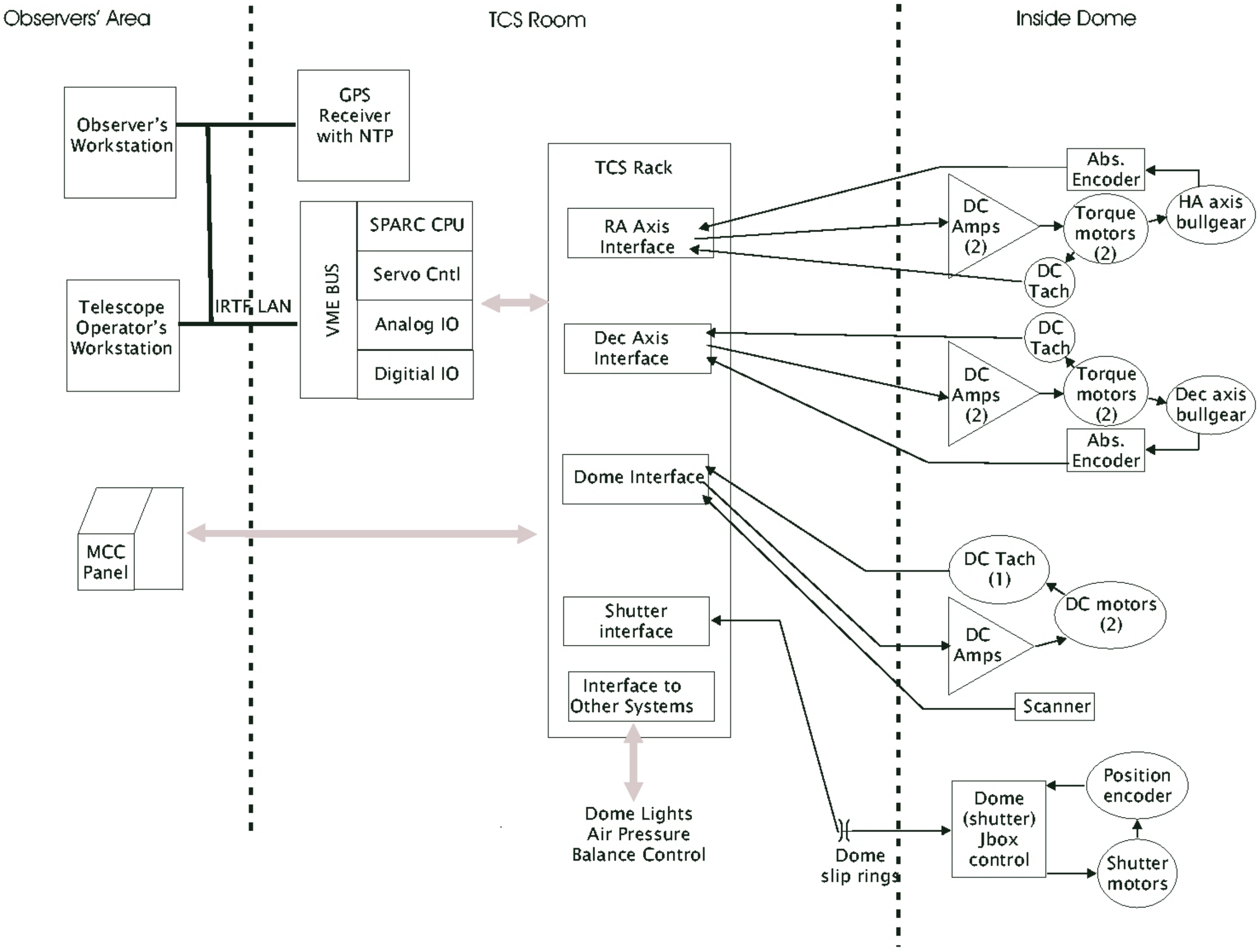

Figure 4. Block diagram of the proposed replacement TCS.

Remote observing is relatively straightforward to implement, and we have the infrastructure in place (for example, a fast fiber-optic link to Hilo). The new TCS will allow for greater simplicity and reliability in supporting remote observing. We have already successfully experimented with remote observing over the internet both from Oahu and from the mainland. In the case of remote observing over the internet, we have successfully operated our facility instruments from Arizona, Missouri, and New York.

Remote operations from Hilo require opening the facility, operating normally, and closing the facility from a remote operation room in Hilo. Ideally there will not be any need for IRTF staff or observers at the summit at night. We do not have any plans at the present time for remote operations, but the new TCS will be designed to accommodate such operations in the future if it is required.

2.3.3 Equipment Costs

Replacing any observatory TCS is an enormous undertaking. It is more so with the IRTF since nearly all of the equipment is obsolete and must be replaced.

> **(a) New Computer System:** We propose to purchase a VME-based SPARC computer with a servo board, digital and analog peripheral boards, and LAN-based input/output modules. Two computer systems are required: a development/test system and the final deployed computer system. The development system would be used as a spare system as well as a platform for further improvements to the TCS. A working spare system will allow improvements to be made without interrupting night-time observations, and in any case spare boards are required to ensure continuous nightly operations. Also included is a LAN-based NTP GPS receiver for the summit. A lab servo simulator is also required to test performance of the software during development.
>
> **(b) New MCC panel**: This panel consists of a new rack and switches, meter, and status indicators for the TCS.
>
> **(c) TCS Rack**: This rack holds the interface electronics, connectors, cable breakouts, and electronic components used for the interface between the computer system and the new MCC and observatory equipment.
>
> **(d) Observatory hardware**: We are planning for both the old and new TCS to co-exist at the observatory. Unnecessary hardware on the old TCS will be removed. Hardware to allow the day crew to quickly switch between the old system and the new system needs to be purchased, manufactured, and installed. We also plan to install new encoders for the RA and DEC axes.
>
> **(e) Software**: We have already purchased the TCS pointing and tracking software by Patrick Wallace. This software package is used at the Anglo-Australian telescopes and elsewhere.

2.3.4 Personnel Costs

The core TCS development team for whom we request funding consists of the following:

> **(a) Software Engineer:** Assemble the computer system; develop device drivers for the peripherals boards and input/output devices; develop TCS application code; integrate the pointing software into the TCS; integrate servo control; and develop the graphical user interface. Requires 2.0 person-years of development followed by 0.5 person-years of maintenance/operational enhancement after installation.
>
> (**b) Electronics Engineer:** Plans and directs the observatory preparation for new/old TCS switchover; designs the electronics for the MCC and TCS racks; directs an electronic technician; develops the interface between the TCS computer systems and the observatory analog/digital systems. Evaluates the servo performance. Requires 0.3 person-years of development and testing and 0.3 person-years of operational enhancement after installation.
>
> **(c) Electronics Technician:** Requires 1.5 person-year to build, test, and integrate all TCS hardware under the direction of the Project Manager and electronics engineer.

Other services we will require include:

> **(d) Consulting**: To expedite the work, we propose to hire a consultant familiar with TCS development and the person who maintained our current system until his retirement.

(e) Machine Shop Services (4 person-months): Machine shop time will be required to fabricate custom parts and also for modifying electronic racks to fit in the available space. Special mounts will also be needed for drive motors and encoders.

In addition we require the following individuals on the IRTF staff, who will provide support and project management. The total estimated time commitment is shown in parentheses, but no funds are requested for salaries for these people.

(a) Principal Investigator (Alan Tokunaga; 1.5 person-months): Responsible for completion of the project and ensuring that adequate resources are committed. The PI is also the Director of the IRTF and therefore has sufficient authority to carry out this responsibility.

(b) IRTF Chief Engineer (Peter Onaka; 3.0 person-months): Currently has responsibility for coordination of IRTF project schedules. He is also the IRTF Senior Electronics Engineer. As the IRTF Chief Engineer, he will be providing input to the electronics plan for the TCS as well as coordinating the work load of the IRTF technical staff.

(c) Project Manager (Tony Denault; 6 person-months): Currently has responsibility for IRTF instrument software, management of the computer networks, and TCS planning. He will provide day-to-day supervision of the TCS work.

(d) Mechanical Engineer (TBD; 3 person-months): Advises on the selection, purchase, and installation of mechanical hardware.

(e) Day Crew Support (TBD; 12 person-months): As with any observatory installation, we assume the Day Crew will provide support during development and installation of the TCS, especially assistance in preparing both old and new systems to co-exist. Once the new TCS has been installed at the Observatory, the Day Crew will provide the bulk of the technical support that is required to troubleshoot and improve the new TCS.

(f) Astronomer/Telescope Operations (TBD: 6 person-months): During the design and testing phases, an astronomer and telescope operator would participate by advising the team on the design, requirements, and functionality to insure a practical and efficient TCS is produced.

(g) Facility Software Engineer (TBD; 3 person-months): Almost every system, especially the facility instruments, communicates to or relies on the TCS for information. All these applications will have to be updated to work with the new TCS.

2.3.5 Schedule

Our schedule for the proposed work is shown in Figure 5. The work would begin in July 2002 and this is timed to coincide with the completion of the Adaptive Optics System. Major tasks and the personnel required are shown in Figure 5 and summarized below:

Design:
<u>Primary Personnel</u>: Project Manager, Electronics Engineer, Software Engineer.
<u>Task</u>: Evaluate previous TCS design/equipment, develop conceptual design and detailed purchasing.
<u>Time Needed</u>: 2 Months.

Procurement:
<u>Primary Personnel</u>: Project Manager, Electronics Engineer, Software Engineer, Electronics Technician.

Task: Purchase items needed to start the development work. Actual work is about 1.5 months, but administrative overhead and purchasing time requires 4 months.
Schedule: 4 Months.

Development and Testing:
Primary Personnel: Project Manager, Electronics Engineer, Software Engineer, Electronics Technician.
Task: Construct the TCS in the lab. Simulate the Observatory RA and Dec servo systems and the dome motors for the purpose of testing. Prepare the Observatory for installation of the new TCS.
Schedule: 10 Months.

Installation at the Observatory:
Primary Personnel: Electronics Engineer, Software Engineer, Electronics Technician, Day Crew
Task: Deliver and install all new equipment at the Observatory with the capability to switch between the old and the new systems.
Schedule: 3 Months.

Testing at the Observatory:
Primary Personnel: Project Manager, Electronics Engineer, Software Engineer, Electronics Technician, Day Crew, Telescope Operators.
Task: Test control and operation of the TCS at the IRTF. Requires a series of engineering days when the new system can be swapped in for testing and debugging.
Schedule: 3 months.

Operational Shakedown:
Primary Personnel: Project Manager, Software Engineer, Day Crew, Telescope Operators, Support Astronomers.
Task: As with any complex new system, a period of time is required to fix problems that occur during actual operations.
Schedule: 6 months.

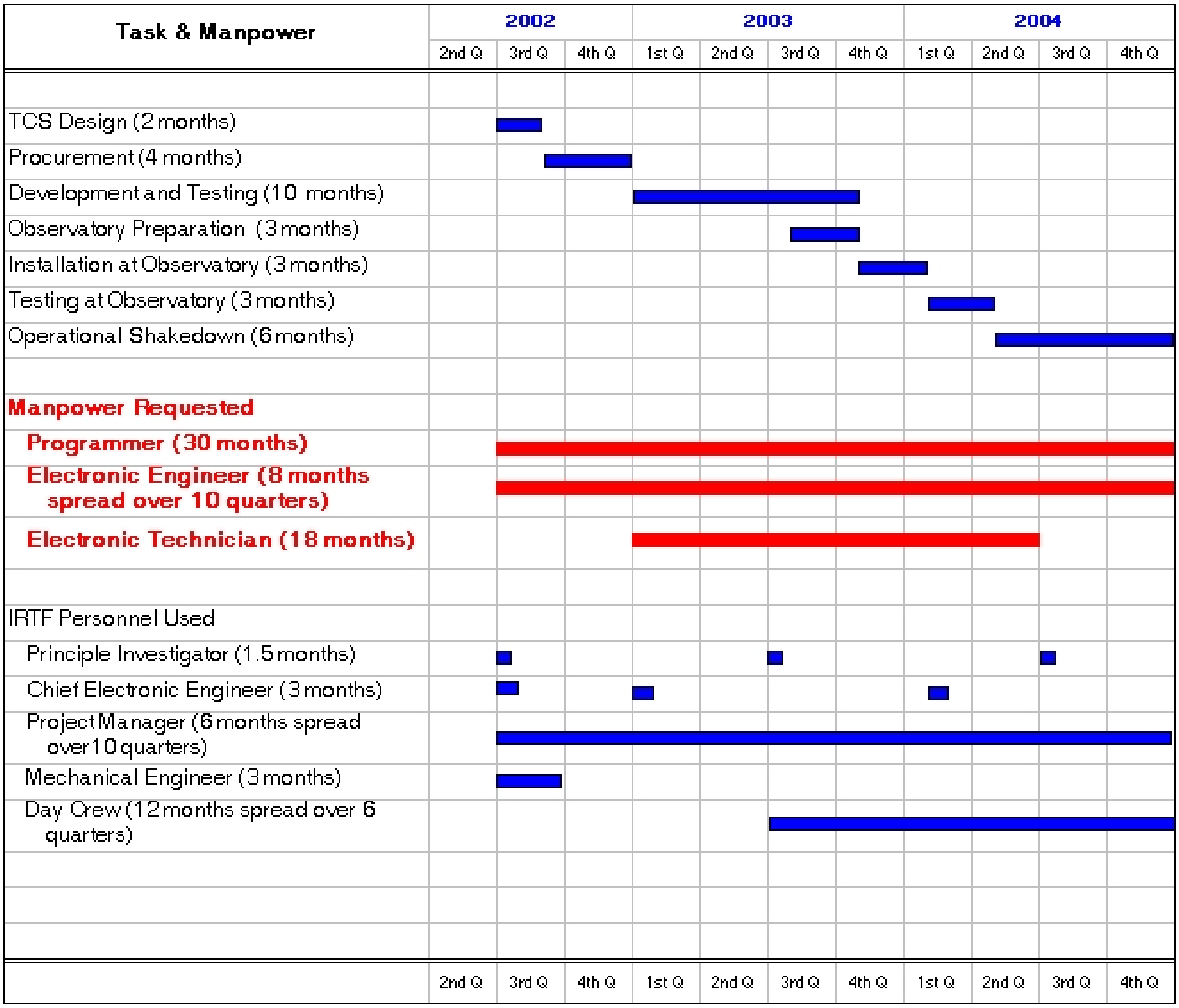

Figure 5. Schedule for completion of the new TCS.

2.4 Cost Sharing Approach

In light of the relatively large cost of this project, we are prepared to submit this proposal to the NSF Major Research Instrumentation (MRI) Program with the intention of providing a means for cost sharing. The rationale for cost sharing is the split between planetary and non-planetary programs. 50% of the telescope time is available for non-planetary observations. In recognition of this, the NSF has supported 50% of the visitor accommodation costs while observing at Mauna Kea, and it has funded all the facility instruments now in use at the IRTF. The NSF has not, however, provided any funding for operations. In this proposal we are seeking funds to upgrade the observational capability of the IRTF and to ensure its long-term usefulness as a facility for planetary science. It would seem appropriate that the NSF share the cost of this upgrade initiative.

The due date for the NSF MRI program will be in February 2002. As a result, it is very important to know if cost sharing is a viable approach for this program so that we can submit a proposal to the NSF by the end of January.

3. FACILITES AND EQUIPMENT

The Institute for Astronomy, one of the major centers in U.S. astronomy, has a total staff of over 270 that includes approximately 60 Ph.D. astronomers and 25 graduate students. It has all the infrastructure associated with a major research institution, including a library with over 4,000 volumes and more than 50 journals, computing facilities and staff, a publications office, and well-equipped machine and electronics shops.

The University of Hawaii (UH) provides office, laboratory, and other required space at two locations: the IfA facility in Honolulu and the IfA facility in Hilo. At the IfA facility in Honolulu, the IRTF is assigned nine offices and a 1700-square-foot instrumentation laboratory in which all of the IRTF instrumentation has been developed. The building also houses a machine shop with the range of machine tools required for building instrumentation for astronomy, including three numerically controlled milling machines, one of which is the largest computer-controlled bed mill in the state. The electronics shop is equipped with test instruments and other facilities required for the design and fabrication of electronics associated with astronomical instrumentation. Computer equipment at IfA includes a number of less common peripherals available on the IfA network, including a dye-sublimation color printer, a high-resolution color film writer, and a CD-ROM writer. High-bandwidth connectivity to the Internet is provided both in Honolulu and in Hilo.

The IfA also has a major new building in the University Park in Hilo. It is here that a number of the Mauna Kea observatories have already established their sea-level headquarters, including the Joint Astronomy Centre (UKIRT and the JCMT), the Caltech Submillimeter Observatory, the Subaru Telescope, the Gemini North Telescope, and the Smithsonian Submillimeter Array. The IRTF is presently allocated seven offices and two laboratories totaling 1300 square feet. The IfA Hilo building also has a major machine shop that will be used for instrument development. Major equipment has been purchased for the new Hilo building, including milling machines, lathes, Zygo interferometer, infrared spectrophotometer, optical benches, and remote audio-visual equipment.

Most of the IRTF support staff works in Hilo, including the Project Manager for the proposed work, the Day Crew, a support astronomer, instrumentation engineer, and instrumentation technician. The software engineer, electronic engineer, and electronic technician requested under this proposal will all be located in Hilo. The development system will be constructed and tested at the IfA Hilo building. All of the proposed work will be accomplished in Hilo or at the IRTF facility.

VITA

Alan Tokunaga
Principal Investigator

a. Education:

B.A., Physics, 1971, Pomona College, Claremont, California
M.S., Astronomy, 1973, State University of New York at Stony Brook
Ph.D., Astronomy, 1976, State University of New York at Stony Brook

b. Employment history:

NASA Infrared Telescope Facility Division Chief, April 2000–present
Astronomer, Institute for Astronomy, University of Hawaii, July 1990–present
Associate Director for Research Support, Institute for Astronomy, 1990–1992
Associate Astronomer, Institute for Astronomy, University of Hawaii, 1983–1990
Assistant Astronomer, Institute for Astronomy, University of Hawaii, December 1979–June 1983
Research Associate, Steward Observatory, University of Arizona, December 1977–June 1979
Assistant Astronomer, Steward Observatory, University of Arizona, July 1979–December 1979
National Academy of Sciences/National Research Council Research Associate, NASA Ames Research Center, Moffett Field, California, August 1976–December 1977

c. Research activity:

Dr. Tokunaga has worked on astronomical instrumentation and studies of the solar system, interstellar medium, and star formation. His Ph.D. thesis involved the construction of a Fourier-transform spectrometer for planetary spectroscopy in the 10 and 20 μm spectral regions. At the NASA Ames Research Center he worked on a far-infrared Fourier transform spectrometer and conducted research on H II regions with the Kuiper Airborne Observatory. At Steward Observatory, he pursued research on star formation and on the outer planets using the facilities at Kitt Peak. Since joining the Institute for Astronomy in 1979, he was a staff member of the NASA IRTF until 1990 and a staff member of the IfA until the present time. While on the staff of the IRTF, he was Principal Investigator for the construction of two facility instruments, the Cooled Grating Array Spectrometer and the Cryogenic Echelle Spectrograph. His research with these instruments included the spectroscopy of comets, planets, and satellites; spectroscopy of carbonaceous infrared emission features in the interstellar medium; and high-resolution spectroscopy of the circumstellar material of young stellar objects. He was the Principal Investigator on the Infrared Camera and Spectrograph, a facility instrument for the 8.2 m Subaru Telescope at Mauna Kea. This instrument has two sections, an infrared camera and a high-resolution cross-dispersed echelle spectrograph. His current research includes studies of the carbonaceous material in the interstellar medium, star formation, and the search and characterization of substellar objects.

d. Principal publications:

Tokunaga, A. T. 2000. Infrared Astronomy in Allen's Astrophysical Quantities, 4th edition, ed. A. N. Cox, p. 143. New York: Springer-Verlag.
Kobayashi, N., & Tokunaga, A. T. 2000. Discovery of Young Stellar Objects at the Edge of the Optical Disk of Our Galaxy. Astrophys. J., 532, 423.
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Tokunaga, A. T. 1997. A Summary of the "UIR" bands. In Diffuse Infrared Radiation and the IRTS, ed. H. Okuda, T. Matsumoto, & T. Rollig. ASP Conf. Ser., 124, 149.

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Tokunaga, A. T., et al. 1998. Infrared Camera and Spectrograph for the Subaru Telescope. In Infrared Astronomical Instrumentation, ed. A. M. Fowler, Proc. SPIE, 3354, 512.

Tokunaga, A. T., Toomey, D. W., Carr, J., Hall, D. N. B., & Epps, H. W. 1990. Design for a 1–5 m Cryogenic Echelle Spectrograph for the NASA IRTF. In Instrumentation in Astronomy VII, Proc. SPIE, 1235, 131.

Peter Onaka
Co-Investigator

a. Education:

B.S., Electrical Engineering, 1984, University of Hawaii at Manoa

b. Employment history:

Chief Engineer, NASA Infrared Telescope Facility, August 2000–present
Senior Electronics Engineer, NASA Infrared Telescope Facility, March 1990–present
Design Engineer, Intelect Inc. (telecommunications and air traffic control systems), 1988–1990
Analog and Digital Design Engineer, Boeing Aerospace, Anti-Satellite Project (ASAT) 1984–1988

c. Technical/research activity:

Mr. Onaka has been responsible for the design, fabrication oversight, integration, and testing of state-of-the-art, cryogenically cooled (30 K), infrared-array-based electronic instrumentation for NASA IRTF instruments, including a 256 × 256 InSb-based imager (1–5 micron sensitivity), a spectrograph, and a 1024 × 1024 InSb dual array imager and spectrograph. Other instrumentation included a 1024 × 1024 CCD based sensor for tip-tilt image correction system using a piezo-based mirror actuator. Research areas pursued are in infrared array characterization and optimization involving cryogenic, optical, and semiconductor testing of infrared and optical devices, as well as extremely low noise, high-speed data and image-processing electronics design. He has additional extensive design experience with telescope controls, cryogenic electronics, thermal, and stepper and servo motor control.

Co-inventor US Patent Number 5,276,678 Distributed Switching and Telephone Conferencing System. (Inventors: Herbert Hendrickson, Christopher Stevens, Verne Munson, Peter Onaka). Major invention contribution was the design of time division multiplexed (TDM) very high speed conferencing design for u-law and a-law digitized voice in a proprietary nonblocking switch. Responsible for the design of ISDN (integrated services digital network) line interface boards for the RTSS (Red Telephone Switching System) installed in the Pentagon and several U.S. military installations. Designed analog interface line boards for JSS (Joint Security System–military air traffic control regional centers).

d. Principal publications:

Onaka, P. M., Tokunaga, A. T., Kobayashi, N., Weber, M., Rayner, J. T., Denault, A. J., Watanabe, D. Y., & Ching, G. K. 1998. Test and Selection of Aladdin II Arrays for IRCS: Redline Electronics for IRCS. In Infrared Astronomical Instrumentation, ed. A. M. Fowler, Proc. SPIE, 3354, 30.

Onaka, P. M., Denault, A. J., Watanabe, D. , Ching, G. K., Toomey, D. W., & Rayner, J. T. 1998. Redline Multiple-Array Controller for SpeX. In Infrared Astronomical Instrumentation, ed. A. M. Fowler, Proc. SPIE, 3354, 139.

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--------Current and Pending Support *[Chris to provide this]*

---------Budget Summary 1

---------Budget Summary 2

---------Budget Summary 3

---------Budget Summary 4

---------General Information on the Budget

---------Proposed budget 1

---------Proposed budget 2

---------Proposed budget 3

---------Proposed budget 4

APPENDIX 1

Acronyms used.

CCS MCB	Central Control System Master Control Bus
DC	Direct Current
Dec	Declination
HA	Hour Angle
IfA	Institute for Astronomy, Univ. of Hawaii
IO	Input/Output
Jbox	Junction Box
MCC	Master Control Console
MCC MCB	Master Control Console Master Control Bus
NTP/GPS	Network Time Protocol/Global Positioning System
QBUS	QBUS is an LSI-11 computer system bus
RA	Right Ascension
RAM	Random Access Memory
TCS	Telescope Control System
TO	Telescope Operator