

## Universities Space Research Association

### *Columbia, Maryland 21044*

The report covers the period from July 2000 to July 2001.

#### I. INTRODUCTION

The Universities Space Research Association (USRA) is a private non-profit corporation, formed in 1969 under the auspices of the National Academy of Sciences. The Association was chartered for the purpose of establishing and operating cooperative institutions and other programs that serve to further the advancement of research and education related to space science and technology. USRA was vested in a university membership, now consisting of eighty-five institutions, that oversees all activities, thus inherently ensuring to the government that activities undertaken serve to benefit the broader community and not any particular institution. In fulfillment of its charter, USRA operates a number of institutes and programs in twelve locations throughout the United States. USRA has established institutes and programs in atmospheric science, applied mathematics and computer science, earth sciences and earth system science education, lunar and planetary science, microgravity materials and applications, space astronomy, space physics, space life sciences, atmospheric sciences, space technology and advanced concepts. Each of these activities includes requirements for the participation of scientists in programs with the National Aeronautics and Space Administration (NASA), the Department of the Navy, and or the Department of the Air Force.

For almost three decades, USRA has fostered harmonious and productive collaborations between government agencies, the academic community, and industry

#### II. SOFIA

In December 1996, USRA was awarded a contract to design, assemble, test, and operate the Stratospheric Observatory for Infrared Astronomy (SOFIA). SOFIA will be NASA's and DLR's premier observatory for infrared and submillimeter astronomy into the next century. A Boeing 747-SP aircraft will carry a 2.7-meter telescope designed to make sensitive infrared measurements of a wide range of astronomical objects. It will fly at and above 12.5 km (40,000 feet). The primary mirror will be configured to a focal ratio of  $f: 1.28$ . The telescope, a Cassegrain with Nasmyth focus, will have a focal ratio of  $f: 19.6$ . The entire telescope assembly is expected to weigh about 20,000 kilograms (44,000 pounds). It will operate primarily in the infrared region of the spectrum, from .3 to 1,600 microns.

The current SOFIA contract resulted from NASA's privatization program to improve efficiency and lower costs. USRA heads a team that includes United Airlines, Raytheon Systems Company, Computer Associates, University of California, the SETI Institute, and the Astronomical Society of the Pacific. Contract management is being performed by the NASA Ames Research Center (ARC). The SOFIA telescope will be provided by a consortium of German contractors, under contract to the German Space Agency, DLR.

SOFIA is now in the fourth year of development. The aircraft modification and telescope program passed major milestones in 2000, with the completion of a successful telescope Critical Design Review (CDR) in April and a SOFIA Systems CRR in August 2000. Structural modification of the aircraft is now underway with the aft bulkhead now installed and the forward bulkhead being assembled. Structural modification of the aircraft in the area of the open-air cavity is also taking place.

The SOFIA project will achieve another major milestone in November 2000 when engineers at REOSC, near Paris, France completed the polishing of the SOFIA 2.7 meter primary mirror. Cast by Schott Glasswerke of Mainz, Germany, the lightweighted blank weighs only 880 kg (1,936 pounds). REOSC is a prominent European optical fabrication company that has produced primary mirrors for the European Southern Observatory's Very Large Telescope (VLT) and the international Gemini project.

The SOFIA Science and Mission Operations Center (SS-MOC) will be located in Hangar N211 at NASA Ames Research Center, Moffett Field, California. Modifications to the N211 structure began in 1999 and will include new offices, laboratory space and an area for the mirror coating facility. Hangar N211 is expected to be completed in April 2001.

The mirror coating facility will include a mirror stripping room and a vacuum chamber specially constructed for mirror re-coating. The facility is being manufactured by the Process System Division of Chart Industries and has successfully passed its Critical Design Review. The facility will be delivered to the SSMOC in the summer of 2001.

The development of the scientific instruments to be attached to the SOFIA telescope will be the responsibility of the U.S. and German science communities. Ten instruments have been selected for development. The selection includes four Facility-class Science (FSI) instruments, five Principal Investigator-class Science (PSI) and one Special Purpose Principal Investigator-class Science (SSI) instrument. PSI instruments include instruments developed in the United States and in Germany. SOFIA's facility instrument program is nearing completion of critical design activities. All reviews are accomplished through community solicited committees.

Over the first two years of operations SOFIA will ramp-up to about 120 science flights per year of at least 9 hours duration (6.4 hours of which may be at altitudes above 12.5 km). SOFIA will fly at altitudes where the typical atmospheric water vapor column density is less than  $10 \mu\text{m}$ .

SOFIA is expected to operate for at least 20 years, primarily from Moffett Federal Airfield, but occasionally from other bases around the world, especially in the Southern Hemisphere (probably Christchurch, New Zealand). Logistics and operations of day-to-day missions from Moffett field and operations of worldwide deployments will be accomplished under USRA's direction by United Airlines. Mr. Tom Bonner is the USRA Project Manager for SOFIA, overseeing aircraft modification activities ongoing at Waco, TX and integration, test and verification activities between U.S. and German contractors. Dr. Eric Becklin is the USRA Chief

Scientist and SOFIA Observatory Director designate. Dr. Jacqueline Davidson is the USRA SOFIA Project Scientist. Dr. Sean Casey is the SOFIA Instrument Scientist. Ms. Maureen Savage is the On-Site Manager for SOFIA at the Ames Research Center and Assistant Observatory Director designate. Dr. Goeran Sandell is a USRA Senior Scientist and Patrick Waddell is the USRA Mission Operations Scientist. USRA's approach to SOFIA, involving science and management operations personnel in the development phase, has been lauded by NASA as an excellent strategy for providing a seamless transition from development to operations.

SOFIA organization, aircraft, telescope assembly and science instrument development status is updated regularly at the following Internet web site: <http://sofia.arc.nasa.gov/>.

### III. LUNAR AND PLANETARY INSTITUTE

The Lunar and Planetary Institute (LPI), established in 1968 as the Lunar Science Institute, is now a focus for academic participation in studies of the current state, evolution, and formation of the solar system. The Institute is housed in the USRA Center for Advanced Space Studies, in Houston Texas. The LPI includes a computing center, extensive collections of lunar and planetary data, an image-processing facility, a scientific visualization facility, an extensive library, publishing services, and meeting/conference facilities.

Current major LPI research topics include: the origin and early evolution of the solar system; studies of the moon, meteorites, and the Earth; the outer solar system with emphasis on icy satellites. The scientific staff of the LPI consists of approximately 10-15 staff scientists and a number of long-term visitors. LPI is a Broker/Facilitator in the "Education Ecosystem" of NASA's Office of Space Sciences.

For further information and for extensive on-line scientific and education services, visit the LPI website at: [lpi@cass.jsc.nasa.gov](mailto:lpi@cass.jsc.nasa.gov)

### IV. RESEARCH SCIENTISTS PROGRAMS

#### a. Cooperative Program in Space Science (at GSFC)

USRA and NASA/GSFC signed a cooperative agreement that became effective in October, 1998. This Program, known as the Cooperative Program in Space Sciences (CPSS), involves activities undertaken within the Goddard Space Flight Center's four Space Science Laboratories: the Laboratory for High Energy Astrophysics, the Laboratory for Extraterrestrial Physics, the Laboratory for Astronomy and Solar Physics, and the Space Science Data Operations Office.

The mission of the CPSS is to conduct space science research and leading-edge instrumentation and technology development, enable research by the space sciences communities, and to expedite the effective dissemination of space science research, technology, data, and information to the educational community and the general public.

To fulfill this mission, USRA recruits and maintains a staff of scientific researchers, operates a series of guest investigator facilities, organizes scientific meetings and workshops, and encourages various interactions with students and university faculty members.

While not limited to these, the primary scientific areas for research, community support, and education/outreach include:

- Astrochemistry
- Cosmic ray Astrophysics
- Extraterrestrial Physics
- Gamma ray Astrophysics
- Gravitational Physics
- Infrared Astrophysics
- Instrument Development
- Interplanetary Physics
- Planetary Systems & Magnetospheres
- Solar Physics
- Space and Plasma Physics
- Space Science Data Archiving & Operations
- UV and Optical Astronomy
- X-ray Astrophysics

Research activities under the CPSS fall within three categories: 1) analysis and interpretation of data obtained from competitive guest investigator awards, from observations utilizing operational satellites, and from archival data; 2) the development of flight hardware for future missions, and 3) theoretical and/or modeling investigations related to Space Science.

USRA/CPSS scientists are integrally involved in almost all of the major programmatic activities within the GSFC Laboratory for High Energy Astrophysics - the Lab where most of the CPSS activities currently take place. They support both space-flight projects, such as the SWIFT, and balloon-borne instruments, such as NIGHTGLOW. Other scientists work on instrument development projects, including the thin-foil x-ray mirrors and micro-well detectors. USRA also conducts research within the LHEA theoretical program. A significant fraction of the Program is devoted to supporting the High-Energy Astrophysics community at large. Within the LHEA's Office of Guest Investigator Programs (OGIP), USRA scientists provide a wide range of products and services to guest observers and investigators. OGIP activities, in which USRA scientists play key roles, include the High Energy Astrophysics Science Archive Research Center (HEASARC), and the guest observer facilities for XMM, ASCA, and RXTE.

The CPSS is also quite active in running scientific meetings - when there is a direct tie to the scientific research activities of our scientific staff.

For further information and updates, visit the CPSS website at <http://phoenix.gvsp.usra.edu/cpss>.

#### b. Marshall Space Flight Center (MSFC)

USRA astronomers have pursued scientific research at NASA/Marshall Space Flight Center since 1995 as part of the Institute for Space Physics, Astrophysics and Education (ISPAE), a collaboration between USRA and The University of Alabama in Huntsville (UAH). After September 2000, this program will be a part of the newly formed National Space Science and Technology Center (NSSTC).

A major emphasis of the USRA X-ray scientists was preparation and flight-support for the MSFC balloon-borne x-ray experiment. A successful launch (from Ft. Sumner,

NM) and recovery was completed in the fall of 2000 with the acquisition of data from the Crab Nebula, GRS1915, and Cyg X-1. Included in the payload were two gas scintillation proportional counters coupled to nested sets of high-energy replicated optics, sensitive at energies up to 50 keV. USRA scientists were key to the development of the detectors and fabrication of the optics. Analysis of x-ray data is on going. USRA X-ray scientists also supported optics development and testing for Constellation-X and for the High Energy Replicated Optics (HERO) programs. USRA scientists continued supporting the Chandra X-ray Observatory (CXO) Project Science efforts at MSFC and have obtained and analyzed CXO data from SN 1993J in NGC 3031 and from the Crab nebula and pulsar.

USRA scientists working in collaboration with the Gamma-ray astrophysics group at MSFC have conducted research using data from BATSE on CGRO, RXTE, ASCA, Chandra and other instruments. They have also provided data analysis support for BATSE on CGRO, and since the de-orbit of CGRO, coordination and support of final data archiving activities. A monitoring campaign was initiated in 1999 of two Soft Gamma-ray Repeaters (SGRs) using the PCA on RXTE, which is revealing erratic spin-down behavior in these high magnetic field objects. Investigations are being conducted of Anomalous X-ray Pulsars (AXP's) using Chandra, and fast X-ray transients using BATSE and BeppoSAX WFC data. Gamma-ray afterglows are being investigated in collaboration with the University of Amsterdam using radio, optical and X-ray observation. USRA scientists participated in multi-wavelength observations of the relativistic jet sources Cyg X-3, GRS1915+105 and the transient black hole candidates XTE J1550-564, XTE J1859+226, and V4641 Sgr, with USRA scientists acting as PI's on CGRO (BATSE), RXTE, ASCA, Chandra, and UKIRT observations. Extensive monitoring of X-ray pulsars has been conducted using the BATSE data, and detailed investigations of the X-ray pulsars Her X-1, LMC X-4, 2S 1845-024 and XTE J1906+09 are being conducted using BATSE, RXTE, Ginga, and EUVE data.

USRA arranged travel and support for visiting scientists, and provided logistics and travel assistance for 5<sup>th</sup> Huntsville Gamma-Ray Bursts Symposium held in October 2000.

### c. Naval Research Laboratory

Research is conducted within the Space Science Division and focuses on the fields of solar physics, solar-terrestrial physics, ionospheric and thermospheric research, and high energy astrophysics. Scientists are working on developing a new class of x-ray detectors using properties of super conducting materials at low temperatures. Scientists are analyzing data from the LASCO and EIT experiments on the SOHO mission, specifically coronal mass ejections. One scientist is now involved in the next generation of solar coronagraphs for the STEREO mission. One scientist is developing new x-ray sources to be used in instrumentation on the

International Space Station. Scientists are working on mesoscale models of water vapor in the upper atmosphere.

USRA provides logistics and travel assistance for speakers in the E.O. Hulbert Colloquia Series in the Space Science Division at NRL. USRA assisted in organizing the STEREO Consortium Meeting held in November 2000 at the Tidewater Inn in Easton, Maryland. USRA is a member of the local organizing committee for the GAMMA 2001 Conference, to be held April 4-6, 2001 in Baltimore, Maryland. USRA is assisting in organizing the LASCO/EIT Science Consortium Meeting, to be held in the Washington, DC area in May 2001.

### d. U.S. Naval Observatory, Washington, DC

USRA research at the U.S. Naval Observatory (USNO) in Washington, DC is focused within the Interferometric Division. Scientists are involved in support of the Navy Prototype Optical Interferometer (NPOI) Project, a joint NRL and USNO effort to construct an optical interferometer at Anderson Mesa in Flagstaff, Arizona. Scientists and engineers have worked on the optical testing of components to be used on the interferometer, the environmental chamber for the beam alignment system, and the design of the spectrograph. Development of optical aperture synthesis imaging algorithms, optical and infrared imaging of surfaces and environments of evolved stars, determination of orbits of spectroscopic binaries, and reduction of astrometric data from the instrument are being done at the USNO. One scientist is analyzing binary star data from the NPOI.

### e. U.S. Naval Observatory Flagstaff Station, Arizona

USRA research at the U.S. Naval Observatory Flagstaff Station, Arizona is related to astrometry. Analysis of the Southern Proper Motions will be done using the data from the Palomar Sky Surveys and other sources. Data analysis and reduction of infrared sources in the Galaxy are also being done as well as the development and fabrication of an advanced IR camera. Work on the radio-optical reference frame is being done at the USNO. Observations of more than 400 extragalactic sources have been reduced to establish a link between the radio VLBI system and the ESA HIPPARCOS satellite catalog, representing the future optical system. Analysis of data observed with the astrometric telescope at the Cerro Tololo Observatory in Chile continues. An initial catalog has been produced from this data. Several scientists are working on software development needed for the data reduction of the instruments on the Full-sky Astrometric Mapping Explorer (FAME) satellite, to be launched in 2004.

### f. Publications

Over 200 papers were published in refereed journals, conference proceedings, and chapters in books during 1999 and 2000.