HISTORY AND OPERATION OF THE SATELLITE GROUND INSTRUMENTATION SECTION 1958 TO 1993

Physical Science Laboratory
New Mexico State University
Las Cruces, New Mexico

December 1993

ABSTRACT

This publication is a brief outline of the major work efforts by the Satellite Ground Instrumentation (SGI) Section of the Physical Science Laboratory of the New Mexico State University.

The report covers the period from 1958 to 1993. It was not the intent of this report to cover any topic in great detail.

Compiled by Cal Buerkle

Assisted by Dan Martin, John Linder, Jerry Holmes, Richard Rudd, Ed Schmidt, Hal Wetter and Rick Williams.

The original history of SGI was written in 1974 with an update in 1976 prior to PC word processors. The original report was scanned to produce a WordPerfect word processing file. The report was then updated and edited, and the names of program personnel were added.

Many thanks go to Betty Coughlin and Ninfa Kindt for their efforts in producing the final report.

HISTORICAL NOTE

The following historical note was taken from the Applied Physics Laboratory of Johns Hopkins University publication "Artificial Earth Satellites" SDO-1600 (Revised) published in February 1978. PSL operated a satellite tracking station in Argentia, Newfoundland which obtained data from the Transit 1A satellite.

The Laboratory's involvement in space started on a modest note shortly after the USSR announced the successful launch of Sputnik I. At that time two staff scientists,W.H. Guier and G.C. Weiffenbach, improvised a satellite tracking station consisting of a radio receiver and tape recorder. The signal from the Russian satellite exhibited the predicted Doppler frequency; there was a pronounced change in the frequency of Sputnik's "beep" as it passed over the station. In order to facilitate identification of the signal, which was in an overcrowded region of the RF spectrum, the received frequencies were carefully examined and their variation, i.e., the Doppler shift, calculated.

Encouraged by the agreement between satellite tracking results and estimates derived from the precalculated Doppler shift, Drs. Guier and Weiffenbach arduously computed the satellite's orbital parameters with pencil and slide rule. They soon put a harmonic analyzer and analog recorder to work and, by January 1958, were satisfied that they had established with considerable accuracy the parameters of the satellite's orbit by means of the Doppler principle.

Dr. F.T. McClure, then Chairman of the Research Center and Associate Director of the Laboratory, noted the results achieved by Guier and Weiffenbach and suggested the application of these results to the converse problem: knowing the orbit parameters of a satellite accurately, and observing the Doppler shift of a signal from the satellite, derive the position of the observer.[1] His recommendation to Dr. R.F. Gibson, then Director and now Director Emeritus of the Laboratory, that the development of a satellite navigation system based on the Doppler principle be strongly pursued led to the formation of the APL Space Development Division (changed to Department in 1966) and the appointment of Dr. R.B. Kershner, now also Assistant Director, as its head. With the approval of the Advanced Research Projects Agency, the US Navy adopted the scheme and APL set about building its first satellite.

This satellite, appropriately labeled Transit 1A, was launched from Cape Canaveral (later renamed John F. Kennedy Space Center), Florida on 17 September 1959. The 270-pound satellite flew only a suborbital trajectory because the third stage of its Thor-Able launch vehicle failed to ignite; however, all satellite systems operated as planned during the 24-minute flight and sufficient data were gather to demonstrate the practicality of the satellite Doppler tracking technique.

---

[1] In recognition of his contribution to satellite navigation, Dr. McClure was presented the Invention Award of the National Aeronautics and Space Administration on 17 January 1961.

TABLE OF CONTENTS

ACRONYMS

ACU	Automatic Control Unit
ADC	Astrolabe Data Collector
ANNA	Army, Navy, NASA, Air Force
APL	Applied Physics Laboratory (The John Hopkins University)
ARL	Applied Research Laboratory (University of Texas)
AUTODIN	Automatic Digital Network
AUTOVON	Automatic Voice Network
BUWEPS	Bureau of Weapons
CCID	Continuous Count Integrated Doppler
CONUS	Continental United States
CRT	Cathode Ray Tube
CTA	Centro Tecnico Aeronautica
DCI	Digital Communication Interface
DEC	Digital Equipment Corporation
DODGE	Department of Defense Gravity Experiment
DMA	Defense Mapping Agency
DPC	Doppler Processor and Clock
DSO	Doppler Satellite Office
DTRS	Dodge Time Recovery System
FPC	Frequency and Power Controller
FTM	Fiducial Time Mark
GE	General Electric (MARK III)
GEOS	Geodetic Earth Orbiting Satellite
GPS	Global Positioning Position
GUARD	Gated Unauthorized Access Restriction Device
HTP	Header Tailer Programmer
IBGE	Brazilian Geographic and Statistical Institute
INMARSAT	International Maritime Satellite
ITTL	International Telephone and Telegraph Laboratory
LORAN	Long Range Navigation System
MAC	Military Airlift Command
NACODE	Navy Correlation and Detection (tracking station)
NAG	Naval Astronautics Group
NASA	National Aeronautical and Space Administration
NAVOBS	Naval Observatory
NAVSAT	Navy Satellite (navigation)
NAVSOC	Naval Space Operations Center
NCFG	NOTS Correlated Frequency Generator
NNSS	Navy Navigation Satellite System
NOTS	Naval Ordnance Test Station
NRL	Naval Research Laboratory
NSF	National Science Foundation
NSWC	Naval Surface Weapons Center
NWC	Naval Weapons Center
O&M	Operations and Maintenance
PAP	Post Analysis Program

PC	Personal Computer
PDN	Public Data Networks
POGS	Polar Orbiting Geomagnetic Survey Satellite
PMR	Pacific Missile Range
PSL	Physical Science Laboratory
QAP	Quality Analysis Program
RADCAL	Radar Calibration
RCU	Refraction Correction Unit
SAPONET	South African Post Office Network
SATSIM	Satellite Simulator
SCC	Satellite Control Center (APL)
SECOR	Sequential Correlation and Ranging
SEUSS	South East United States Survey
SGI	Satellite Ground Instrumentation
SINS	Shipboard Inertial Navigation System
SMTP	Special Mission Tracking Project
STRU	Satellite Time Recovery Unit
TBD	Time Burst Detector
TDDS	Transit Doppler Digitizer System
TCA	Time of Closest Approach
TRANET	Transit Network
TRANET I	Transit Network Tracking Station, First Generation
TRANET II	Transit Network Tracking Station, Second Generation
TRANSIT	Name of U.S. Navy Navigation Satellite Program
USGS	United States Geological Survey
VCO	Voltage Controlled Oscillator
VLF	Very Low Frequency
VUGTK	Research Institute for Geodesy, Topography and Cartography (in Prague)

HISTORY AND OPERATION OF THE SGI SECTION

The Physical Science Laboratory had been associated with the Applied Physics Laboratory (APL) of the Johns Hopkins University since 1946 because of work done for Applied Physics Laboratory at White Sands Missile Range. The workload of the Physical Science Laboratory had mainly consisted of launch support of various missiles.

In 1958, PSL was asked by APL to participate in a new experiment to determine the orbit of a satellite using the Doppler principle. APL had previously tracked the Sputnik 1 satellite using Doppler but more ground stations were required. In late 1958, PSL fabricated a Doppler tracking station in Las Cruces while a similar station was built by the Applied Research Laboratory of the University of Texas at Austin. Three stations, including one at APL began tracking the Vanguard I satellite in December of 1958 to verify and improve earlier tracking results.

The SGI Office began in 1958 with two personnel building up the first satellite tracking station. As the first two mobile vans were built and as permanent stations were added to the system, the SGI Office expanded to include a Supervisor, a Secretary, a Supply Man, a Co-op Coordinator as well as Technical and Training Personnel.

Until May of 1965, the SGI Office was located in the original library building (Branson Hall) on the campus of New Mexico State University. Personnel, travel and security matters were handled by other PSL Departments located throughout the campus.

In May of 1965, all of the PSL Personnel were relocated in the new PSL building (Anderson Hall) on the university campus. The SGI area included offices for the supervisor, tracking station manager, the Co-op Coordinator, the supply man, the head of student training and four offices for technical personnel. Also included in the SGI area were a room for the tracking stations, a supply room, a training room and one room for equipment development and repair.

Listed below is a list of key personnel since the beginning of the satellite tracking program at PSL.

PERSONNEL

Director of PSL	1946 - 1961	Dr. G. Gardiner
	1961 - 1966	Mr. C. Ricketts
	1966 - 1968	Mr. H. Posner
	1968 - 1982	Mr. H. Lawrence
	1983 - 1987	Dr. G. Freyer
	1988 - 1993	Dr. R. Weigle
SGI Section Chief	1958 - 1964	Mr. A. Bowers
	1964 - 1965	Mr. B. Dodson
	1965 - 1985	Mr. J. Martin
	1985 - 1993	Mr. J. Linder
Co-op Coordinator	1959 - 1966	Mr. J. Melfi

1966 - 1969	Mr. S. Tracy
1969 - 1980	Mr. H. Wyman
1980 - 1993	Mr. C. Buerkle

CONTRACTS

The SGI Section was funded by several sources during its thirty-five year history. The Operations and Maintenance (O&M) contract for the operation of the field stations was originally funded by the Applied Physics Laboratory of Johns Hopkins University through the Navy Bureau of Ordnance. From February 1961 until February 1973, funding was provided by the Pacific Missile Range. The O&M contract was transferred to and funded by the Defense Mapping Agency from February 1973 until December 1993.

There were separate contracts for the shipboard operations, the NASA Tranet Manual, the TRANET II prototype station and the TRANET II production stations.

There were special fund/task numbers under the O&M contract to design, build or modify equipment for the TRANET II system, communication equipment and GUARD units for the Magnavox 1502DS stations, and so forth. The Defense Mapping Agency's (DMA) original Astrolabes were modified and a new Astrolabe built using special fund/task numbers.

DATES	CONTRACT NO.	AGENCY	PURPOSE
Dec 59-Feb 61	NORD 16710	BUORD	O&M
Nov 60-Nov 61	APL 129355	APL	Shipboard Operations
Feb 61-Aug 66	N123(6175724961A	PMR	O&M
Sep 66-Aug 73	N00123-67-C-0218	PMR	O&M
Jun 67-Dec 68	NSR32-003-042	NASA	Tranet Manual
Sep 73-Feb 74	N00123-74-C-0297	PMR (1)	O&M
Feb 74-May 79	DMA 800-74-C-0087	DMA	O&M
Jun 73-Feb 74	N00123-73-C-2285	PMR (2)	Tranet II Proto
Feb 74-Sep 78	DMA 800-74-C-0085	DMA	Tranet II Proto
Sep 77-Dec 82	DMA 800-77-C-0070	DMA	14 Tranet II
Jun 79-May 82	DMA 800-79-C-0054	DMA	O&M

DATES	CONTRACT NO.	AGENCY	PURPOSE
Jun 82-May 85	DMA 800-82-C-0053	DMA	O&M
May 85-Dec 89	DMA 800-85-C-9019	DMA	O&M
Dec 89-Dec 93	DMA 800-90-C-0001	DMA	O&M

(1) PMR contract N00123-74-C-0297 transferred to DMA 800-74-C-0087
(2) PMR contract N00123-73-C-2285 transferred to DMA 800-74-C-0085

FOREIGN CONTRACTS

SGI built complete TRANET II stations under contract for the Japanese and French governments. SGI also built various portions of the TRANET II equipment for the Belgium, German and Spanish governments.

May 80-Mar 81	LA-8081	Japan	Tranet II
Dec 80-Dec 81	886374	Germany	Tranet DPC/TBD
Jan 81-Feb 82	N/A	Spain	Antenna, preamp, receivers
Jan 81-Feb 84	GEOD810006	Belgium	Test Set
Jan 81-Feb 84	82-20233	France	4 Tranet IIs w/o receivers
Mar 83-Jan 84	82-1269-00	France	4 Tranet II receivers

CO-OPERATIVE EDUCATION PROGRAM

Since the inception of the TRANET and SMTP Programs, the Physical Science Laboratory has used co-op students in almost all of the operational phases of the program.

Approximately 1000 students from New Mexico State University have been employed in the SGI Co-op Program. The vast majority of the co-op students have majored in electrical, mechanical, and chemical engineering or in mathematics or physics and computer science. There have been a few students who have majored in agriculture and the liberal arts.

The purpose of the Co-op Program has always been to help deserving students work their way through the university. When a student applied for admission to the university and was accepted, he or she could also apply for admission to the Co-op Program. Students were accepted for the Co-op Program on the basis of their high school grade point and recommendations from references.

Until 1984 new students had two semesters of training within the SGI Section and worked approximately eight hours weekly during their training phase. The first semester of training included basic familiarization with electronics in the training laboratory. The second semester of training took place in the satellite tracking station located at PSL. During the second semester, the student was taught how to operate and maintain a tracking station.

In 1984, the training program changed and there was only one semester of training prior to assignment. The number of hours worked each week was increased to 12-14.

While the co-op student was in training, his university grades were monitored as well as his attitude and progress through the training program. If the student had successfully completed the training program and had maintained at least a 2.4 overall grade point in his university studies for the required number of course hours, he was then considered for work phase assignment at one of the overseas tracking stations.

If the co-op student was sent to a field station, he was rated by his Station Manager upon return to the university. If his rating was favorable and if he maintained an overall grade point of at least 2.0 for the next two semesters of studies, he was then again considered for additional overseas assignments.

The actual duties of the co-op student at a field station was varied depending on the location. Co-op students have operated and maintained the satellite station tracking equipment, teletype or other communication equipment and in some cases have operated communication transmitting and receiving equipment. They have also operated and maintained electrical generation equipment, station vehicles, helped with building and grounds maintenance, and made modifications to various equipment in the tracking station.

The overall experience in using co-operative education students in the SGI operation was most favorable. While the Co-op Program has enabled students to attend the university by their own efforts, the most significant result of the program has been the increased rate of maturity noted in the vast majority of the students. Typically, the experience that a co-op student has gained after two or three work phases, counted as two years of practical experience when hired after graduation.

DESIGN, FABRICATION, AND MODIFICATIONS

The design and fabrication of new equipment and modification of existing equipment was a way of life in the SGI Section. The original tracking equipment was modified to meet new specifications. It was also necessary to fabricate special function equipment that was not available from commercial sources.

The following is a summary of some major design and fabrication projects undertaken by SGI Personnel.

1958 First PSL Doppler tracking station assembled at Las Cruces.

1959 PSL Personnel helped to assemble and modify first two mobile vans at APL.

1961 - 1963 Helped design, fabricate, install and checkout Injection Stations for Naval Astronautics Group.

1961 TDDS (TRANSIT Doppler Digitizer System) assembled by SGI.

1961 Reference Injection Unit built for tracking filter stations.

1962 Vans Vl and V2 built at PSL including assembly of 3C Digitizers.

1962 Test equipment for calculating and plotting second differences of Doppler data points designed and built.

1963 Mobile Vans 307, 311, 312, and 314 built at PSL.

1963 STRUs (Satellite Time Recovery Systems) built at PSL for mobile vans.

1963 Frequency generators fabricated for coherent pairs of 150/400 MHz and 162/324 MHz.

1964 Quarter-wavelength drooping radial stub antennas built for all stations.

1965 ABACUS digitizers modified for 10 us resolution of satellite time.

1965 Coherent Clocks built for all stations.

1965 Satellite Identifiers built for high latitude stations.

1965 NACODE Station N-3 assembled for mobile use.

1966 Modifications made to ABACUS digitizers, dual-Doppler phase-lock-loop receivers and synthesizers for Department of Defense Gravity Experiment (DODGE) tracking mission.

1968 Refraction monitors for mobile vans.
1969 Mobile Van 307A assembled using Van 307 equipment mounted in new shelter.

1969 LORAN Receiver designed and built.

1970 NACODE Station N-70 assembled for use during SMTP at Argentia, Newfoundland.

1970 Visual Displays built using IC's

1970 Fixed tuned receivers built for mobile vans.

1971 All NACODE stations were modified for automatic operation and Continuous Count

Integrated Doppler (CCID) data format. This included:
(1) Design and fabrication of ACU (Automatic Control Unit).
(2) CCID (Continuous Count Integrated Doppler) modification made to ABACUS digitizers for new Doppler data format. Digitizers also modified for automatic operation.
(3) Phase-lock receivers modified for automatic operation.

1972 All tracking filter stations were modified for automatic operation and CCID data format. This included:
(1) Design and fabrication of ACU (Automatic Control Unit).
(2) CCID and automatic operation modification to DD-47 digitizers.
(3) Modification of Interstate and Electrac tracking filters for automatic operation.

1973 Time Burst Detectors built to replace STRUs.

1973 Designed and fabricated SATSIM (Satellite Simulator) test set.

1974 All permanent stations operated by PSL were equipped with either rubidium or cesium oscillators.

1974 Assembled three telemetry stations to record GEOS C satellite telemetry.

1975 Design of prototype microprocessor controlled tracking station.

1976 Fabrication of prototype microprocessor controlled tracking station. (TRANET II Prototype)

1978 - 1984 Built 21 complete TRANET II stations, including four for the French and one for the Japanese. The French and Japanese stations were purchased by their governments. Receivers and some other equipment provided for two Canadian and one German station.

1980 - 1981 Integrated a Magnavox GPS Y set, a HP MX computer, a weather station and data terminal. Also built a power supply for the Magnavox receiver. The station was sent to Buenos Aires.

1982 Built three 300/1200 baud papertape readers. The readers converted the five level baudot tape input to a serial ASCII output suitable for modem transmission.

1983 Modified all TRANET II Electrac receivers to track plus and minus Z system (150/400 Mhz) offsets. Designed and built new acquisition circuits for the receivers.

1983 Chu antennas and weather stations installed at all stations.

1983 Built the first generation Magnavox 1502DS communications system using a small terminal, printer and data communication interface box.

1984 Built an updated 1502DS communication system using a dumb terminal, printer, and updated data communication interface box and a small CPM computer. Also wrote software for CPM computer.

1988 Fabricated Ramdisk for TRANET II stations.

1989 Designed and built GUARD (remote control) units for unmanned 1502DS stations.

SGI SOFTWARE DEVELOPMENT

1975 - 1979 Wrote original Track software for the TRANET II stations. The Track program enabled and directed the search frequency for the receivers. It also set up the tracking parameters for the DPC (Doppler Processor and Clock) and the refraction counters. The program formatted the time, Doppler, refraction and satellite timing data. The data was output via punched papertape. Navsat alerts were provided on disk from DMA. Geodetic alerts were provided by Telex from DMA and hand merged into an alert file.

1982 - 1983 The second generation Track software included changes to control the receiver offset and rate aiding for Geodetic satellites.

Applied Research Laboratory at University of Texas (ARL/UT) collaborated with PSL and wrote software that used Navsat memory orbital elements and DMA provided Geodetic orbital elements to generate on site alerts, analyze data (PAP/QAP) and provided receiver rate aiding for Geodetic satellites.

1984 Wrote software for a CPM computer used with Magnavox 1502DS receivers that included an editor for messages, communication interfaces with General Electric (GE) MARK III, the 1502DS, printer and modem.

1986 Wrote software for CPM computer to download data from remote 1502DS.

1987 Wrote software for the ADC (Astrolabe Data Collector) which recorded astrolabe star transit time data in a computer readable media (Rampack). The Rampack replaced the original Datametrics recorder whose output was similar to a calculator printout.

1988 A PC version of the 1502DS remote software was written and four 1502DS could be downloaded simultaneously.

1988 - 1989 The original ADC was modified to become the VUGTK controller and software was written to calculate the drive rates for the astrolabe stepper motors. Rampack recording of the data were maintained; weather information was also read and stored.

1989 Wrote first generation GUARD (Gated Unauthorized Access Restriction Device) software. GUARD units were placed at each remote 1502DS to prevent unauthorized access to the 1502DS.

1990 Wrote second generation GUARD software that permitted on site control of the remote 1502DS. The GUARD software would download and transmit data to GE MARK III, update Geodetic alerts, provide tracking compliance, automatically reinitialize the 1502DS after a power outage and basically do any task that an operator could do via the 1502DS keyboard.

1991 The software written for the new Astrolabe (A35M) system included many features of the VUGTK controller. The astrolabe recorder station contained a ruggedized 286AT computer that calculated a realtime position solution, maintained time using a GPS (Global Positioning System) receiver, calculated and controlled the stepper motor drive rates among other functions.

1993 Modified GUARD software so that a PC could emulate GE MARK III for the U.S. Air Force RADCAL (RADar CALibration) project.

SUPPLY

The supply system was very minimal during the early years since most of the stations were located in the United States where parts were easily available.

Between 1960 and 1964, nine overseas tracking sites were implemented and the need for a central supply became apparent. A stock of central supplies was gradually built up so that by early 1965 supplies were in stock to back-up the vast majority of the equipment in the field.

The original stations supplied by the SGI Office included 12 NACODE stations and 8 tracking filter stations. One NACODE Station was operated by the Government of Australia and another by ARL (Applied Research Laboratory of the University of Texas). Three of the tracking filters stations were operated by ARL, the British Army and another by the Government of Belgium.

The SGI supply system has provided spare parts for both the tracking equipment and the test equipment at all the field stations as well as parts for air conditioners, voltage regulators, diesel and gasoline generators, vehicles, and communication equipment.

All field stations have their own parts supply for high failure rate items but the items with a lower failure rate are kept in the SGI supply room.

The vast majority of supply requests from the field stations were filled in one day and the main delay in receiving parts was due to the mailing or shipping time.

The total dollar value of the spare parts in stock was less than five percent of the total equipment value.

COMMUNICATIONS

The means of communications available in the early 1960s were very limited when the TRANET stations were installed. Existing military or government circuits were used to transmit data where possible; otherwise commercial circuits were used. The circuits were originally 60 WPM (words/minute-approximately 45 baud) but some circuits were later converted to 100 WPM (75 baud).

The original TRANET stations produced data on five-level papertape which was transmitted on a daily basis via a teletype machine at the tracking station or from a communication center to the Satellite Control Center at Johns Hopkins University. Many stations had fulltime dedicated teletype or telex circuits. These circuits were used until October 1970 when most stations began using the U.S. government AUTODIN (Automatic Digital Network) circuits.

The ability to transmit five-level papertape data became a problem in the early 1980s as many AUTODIN circuits were converted to handle eight-level tape only. The only viable alternative was to install modems at the tracking stations and transmit the data via conventional telephone lines to a central facility.

PSL made tests between the Las Cruces TRANET II station and the General Electric MARK III system in June 1981. Between 1981 and 1984, all of the PSL operated stations were modified to use GE MARK III at 1200 baud.

GE MARK III was two integrated systems. GE MARK NET was a communication system that covered the United States with links to the Pacific, Europe and parts of the Middle East. MARK NET was connected to a system of computers in Ohio, Maryland and Amsterdam which could store a user's programs to process his information. GE MARK III was used as a storage medium by the SMTP program and any processing in MARK III was minimal.

Data were transmitted by the tracking station and stored in MARK III for retrieval by DMA for processing in DMA's computers. Messages could also be transmitted, stored and later retrieved by the addressee. Each tracking station had its individual user number and password which were changed periodically.

Some tracking stations could call MARK III ports directly but some overseas stations placed long distance calls via military, government or commercial circuits to MARK III ports in the United States. A few stations used local PDN (Public Data Networks) to enter MARK III.

MARK III was used by several organizations associated with the SMTP program as well as the DMA GPS (Global Positioning System) stations.

The GE MARK III system was used until the SMTP mission ended in 1993.

PERMANENT TRACKING STATIONS

Several permanent tracking stations were installed throughout the world and came to be known as the TRANET (TRAnsit NETwork). The first permanent stations were established as stations that were scheduled to remain at a site for a long period of time. Most of the original permanent stations used NACODE type equipment although some tracking filter type equipment was originally used at some sites.

The first permanent station operated by the Physical Science Laboratory was at Las Cruces, New Mexico which began operations on 1 September 1959. Below is a list of the permanent stations in the order that they were established. A history of each station follows giving the milestones during that station's history.

Installation dates of permanent stations.

Station Number	Date Established	Location
003-103-113-413-513-552	1 Sep 1959	New Mexico
014-114-414-556	30 Jan 1960	Alaska
008-408-555-571	28 May 1960	Brazil
010-100	30 Nov 1960	Hawaii
011-121-022-422-559-572	9 Mar 1961	Philippines
013-027-427-548-35054	16 Apr 1961	Japan
012-112-412-545	25 Aug 1961	Australia
015-115-105-405-554	24 Oct 1961	South Africa
117-117-024-424-560	9 Aug 1962	American Samoa
018-118-418-557	14 Nov 1963	Greenland
717-020-420-558	1 Jul 1964	Seychelles
019-419-562	5 Feb 1965	Antarctica
023-423-553-566	10 Jul 1973	Guam

More than one station number indicates that either the station antennas were moved or that the station location was moved a small distance. For more details, refer to the history of each station.

NEW MEXICO
Las Cruces
Stations 003-103-113-413-513-552

Station 003 began official operations on 1 Sep 1959 on the top floor of the library building (Branson Hall) on the campus of New Mexico State University. The station equipment included two complete tracking filter stations and telemetry equipment. Operations continued until 5 June 1965. The SGI Office was also located in the library building, although various other departments of PSL were located in various buildings throughout the university campus.

In May 1965, a new building (Anderson Hall) was completed which was to house all of the on-campus operations of the Physical Science Laboratory including the satellite tracking station. On 24 May 1965, Station 103 began operations in Room E-2101 on the second floor of the new PSL Building. The equipment used for Station 103 was the last set of second generation NACODE equipment (N-11) built at NOTS, China Lake, California. The equipment formally used at Station 003 was moved to the new building and was designated as Station 403. The antennas for Stations 103 and 403 were located on the roof of the building within 15 feet of each other. Stations 003 and 103 used non-linear array antennas and stations 113, 413 and 513 used linear array antennas.

Quarter wavelength stub antennas for each specific tracking frequency laid out in a square pattern on a common groundplane were referred to as a non-linear array antenna system. Linear array antennas were individual quarter wavelength drooping radial antennas mounted along a common horizontal fixture. The antennas were arranged so that the 150/400 MHz and 162/324 MHz pairs had a common electrical center.

All the stations at PSL were used to train the cooperative education students prior to their assignments to overseas tracking stations. The stations were also used to check out repaired and modified equipment as well as to check out newly developed equipment.

Data transmissions were by commercial dedicated circuit to SCC until October 1970. SCC was the Satellite Control Center at the Applied Physics Laboratory of The Johns Hopkins University at Laurel, Maryland. After that date, data were transmitted to the White Sands Missile Range AUTODIN Terminal for retransmission to SCC. Beginning in June 1981, data were transmitted via the General Electric Mark III communication system until the end of the program.

Station 103 was automated in January 1971. The antennas were moved from the roof of the second floor to the penthouse roof in June 1976 and the station number became 113.

A Tranet II station was installed as Station 413 in Nov 1978. A Chu antenna was installed in June 1983 and the station number became 552. The station closed on 30 September 1993.

A Magnavox 1502DS receiver was installed at PSL on 1 October 1983 as Station 35021 and was used primarily as a training station. Operations ceased on 31 January 1993.

BRAZIL

Sao Jose dos Campos

Stations 008-408-555

Station 008 became operational on 28 May 1960 at Sao Jose dos Campos, Brazil with NOTS China Lake personnel running the station. In late 1960, PSL personnel took over the operation of the station. The station was located in the old Vanguard tracking building at the Centro Tecnico Aeronautica (CTA) grounds near Sao Jose dos Campos. CTA was operated by the Brazilian Air Force and was located approximately 60 miles east of Sao Paulo.

In 1962, a large addition was made to the original small tracking building. In 1966 the original wooden antenna tower was replaced with a permanent structure which included restroom facilities and a storage area. In 1972, another addition was added to house the students assigned to the station.

The station originally used NACODE equipment and the first generation equipment was replaced on 3 October 1962 with second generation NACODE equipment. The second generation equipment was automated in November 1971. A rubidium oscillator was installed in April 1974. The NACODE station was replaced with the computer controlled Tranet II station in February 1980. A Chu antenna was installed in June 1983 and a Ramdisk was installed in January 1991. The station also provided telemetry information from various satellites from mid 1961 until mid 1970.

The original non-linear array antennas (008) were replaced with linear array antennas in May 1966 when the wooden antenna tower was replaced. The same station number was retained since the antenna position was not changed. The station number was changed to 408 in February 1980 when the TRANET II equipment was installed. A further change to Station 555 took place in June 1983 when a Chu antenna was installed.

Until 1977, communications were routed through commercial land lines from Sao Jose dos Campos to the U. S. Navy Technical Group located at the Brazilian Naval Ministry in Rio de Janeiro. From Rio de Janeiro, the data was transmitted directly to SCC. In May 1977, a commercial Telex machine was installed to transmit data to the American Consulate in Rio for retransmission via Autodin to DMA. Beginning in February 1983, data were transmitted to GE MARK III via international phone calls.

The station in Sao Jose dos Campos was closed on 31 July 1989 after a failure to renegotiate a new agreement to remain at CTA. There were no students in Brazil between August 1986 and May 1990.

BRAZIL
Brazilia
Station 571

The Tranet II equipment from Sao Jose dos Campos was moved to Brazilia in October 1989 and put in storage at the American Embassy.

An agreement was made between DMA/IAGS and IBGE (Brazilian Geographic and Statistical Institute) to install the Tranet II station at the IBGE game preserve about 12 miles south of Brazilia. An addition was added to an existing building to house the station and was completed over a year later.

Between November 1989 and January 1991, data were obtained using a Magnavox 1502DS housed in an embassy apartment near downtown Brazilia. In January 1991, the building at IBGE was finally completed and TRANET II operations began on 15 January 1991.

Data were transmitted to GE MARK III via international phone calls from November 1989 until March 1991 when an embassy communication circuit was made available.

The station closed on 30 May 1993.

HAWAII

South Point
Station 010

Station 010 was located at the Pacific Missile Range tracking site at the southernmost tip of the island of Hawaii. The first generation NACODE equipment arrived on 30 November 1960. Before the equipment was made operational, it was shipped to Puerto Rico on 6 December 1960 to support shipboard test operations.

The equipment was returned to Hawaii and was operational on 10 January 1961. Operations ceased on 22 June 1962. The station antennas were mounted on a large ground plane.

New second generation NACODE equipment was installed at South Point on 21 September 1963 and operations continued until 25 November 1964. The NACODE equipment was shipped to McMurdo, Antarctica in early 1965.

Wahiawa
Station 100 and TRACOR

Station 100 was located at the Navy receiver site at Wahiawa, Hawaii and began operations on 23 April 1962. Operations ceased on 22 December 1969 when the station equipment was moved to Wake Island. The station used second generation NACODE equipment and non-linear array antennas.

The station was originally set up for the Naval Astronautics Group (NAG) by PSL personnel. PSL operated the station while training Navy personnel. NAG was later renamed NAVSOC (Naval Satellite Operations Center).

On 14 September 1965, the control of the station was turned over to PSL which operated the station until it ceased operations. The NAG personnel moved into their own tracking station which was located approximately one-quarter mile distant.

TRACOR

Although TRACOR (TRAnet COmmunication Relay) was not operated by PSL, it was located in a room adjacent to the room housing Station 100. From early 1961 to mid-1967, communications for the Pacific TRANET stations were handled through the PMR (Pacific Missile Range) Facility at Kanehoe, Hawaii. From mid-1967 to late 1970, the TRACOR Facility relayed all Pacific data to SCC. The TRACOR Facility was closed when the TRANET stations switched to AUTODIN communications in the fall of 1970.

ALASKA

Elmendorf Air Force Base
Stations 014-114-414-556

Station 014 became operational on 30 January 1961 at Elmendorf Air Force Base, 4 miles northeast of Anchorage, Alaska. The station was originally located in the basement of the Aeronautics building number 62-250.

In April 1989, the station equipment was relocated to the top floor but the antenna position remained unchanged.

Station 014 was gradually built up to have the capability of tracking two satellites simultaneously. In 1962 telemetry equipment was installed and data were obtained until early in 1971 when the equipment was dismantled.

The station was originally set up with tracking filter type equipment. On 1 February 1972 the station began using second generation (automated) NACODE equipment which was formerly known as Mobile N3.

The station received support from the 5040th Air Base Wing. Until October 1970 the station had a dedicated circuit to the Satellite Control Center for the transmission of Doppler data. After October 1970, the data were transmitted to the local AUTODIN Terminal for retransmission to the SCC. During the period of telemetry and command operations, real-time data were transmitted via telephone links to the SCC. In July 1983, the station began using GE MARK III for data transmissions.

During the period September 1963 to November 1965, PSL personnel operated a satellite command transmitter which was located at Fort Richardson.

The station was equipped with a rubidium oscillator in April 1974.

The station antennas were changed from a non-linear array (014) located in the middle of the station roof to a linear array (114) that was located at the northeast corner of the roof. This change took place in May 1976. The station number became 414 when the TRANET II equipment was installed on September 1979. A Chu antenna was installed in June 1983 to replace the linear array changing the station number to 556.

As a historical note, a GPS monitor station was installed on the top floor of the building from approximately 1979 until 1988.

The station closed on 30 September 1993.

PHILIPPINES

San Miguel

Stations 011-121-022-422-559

Station 011 began operations on 9 March 1961 in the receiver building at the Naval Communications Station located at San Miguel. San Miguel was located 25 miles north of Subic Bay on the South China Sea.

The first generation NACODE equipment was replaced on 14 August 1962 with second generation equipment.

Station 011 ceased operations on 26 August 1966 when the tracking equipment was moved to a new area in the receiver building. The previous non-linear array antennas were replaced with linear array antennas mounted on a new antenna tower located near the northwest corner of the building. The station began operations on 17 August 1966 as Station 121. Operations continued until 17 May 1973 when the antennas were moved from the tower to the northwest corner of the receiver building. Operations began again as Station 022 on 17 May 1973. The tracking equipment was not moved. The station was automated on 7 August 1971 and a rubidium oscillator was received in July 1974.

TRANET II equipment was installed in January 1980 and the station number was changed to 422. A Chu antenna was installed in May 1983 and the station number then became 559. A Ramdisk was added in August 1989.

In 1965, the station began providing the Navy's Seventh Fleet with timing. A timing signal from the station's digitizer was transmitted over Navy transmitters to all ships in the Fleet. This practice continued through 1976.

Until October 1970, the data were transmitted over a dedicated circuit to the SCC. AUTODIN service was used until July 1985 when GE MARK III service began.

The station was closed on 6 August 1990 due to the pending closure of the Naval Communication Station.

Clark Air Force Base

Station 572

Operations at Clark Air Force Base began on 14 September 1990 in the Dau Complex near the southeastern edge of Clark, east of the runway. An eruption of Mt. Pinatubo occurred on 12 June 1991 followed by a major eruption on 15 June 1991. Station operations ended on 14 June 1991. PSL personnel departed for the U. S. on 27 June 1991. The equipment was shipped to Subic Bay by the Air Force in November 1991 for transhipment to DMA.

JAPAN

Misawa Air Force Base
Station 013

There were tracking operations in two basic locations in Japan. The first location was at Misawa from 1961 to 1974 and the second location at Mizusawa from 1974 to 1989. Operations began again at Misawa in 1989 and terminated in 1993.

Station 013 began operations on 16 April 1961 in Building S-1510 on Misawa Air Force Base, Japan. The base is located approximately 350 miles northeast of Tokyo in Aomori Prefecture on the Island of Honshu.

The station always used NACODE equipment and the first generation equipment was replaced on 31 May 1963 with second generation equipment.

The building housing Station 013 also housed a communications group of the Japanese Self Defense Force. The station was supported by the 6139th Air Base Group of the U. S. Air Force.

The station used a dedicated circuit to the SCC until October 1970 after which time AUTODIN circuits were used.

The station's non-linear array antennas were never moved although the equipment has been moved within the building.

The station was automated on 27 August 1971.

The station closed on 21 March 1974. The equipment was shipped to Shemya, Alaska.

Mizusawa
ILO
Stations 027-427-548

Station 027 began operations of 27 February 1974 in the main building of the International Latitude Observatory at Mizusawa, Japan. The Observatory is located approximately 250 miles northeast of Tokyo in Iwata Prefecture on the Island of Honshu.

The tracking filter type equipment was located in the Time and Frequency room and the antennas were located on the weather tower atop the main building. The tracking equipment had been previously located at Shemya, Alaska

Station communications were routed via commercial links to the AUTODIN refile point at Yokota. Converters were required to convert from five to six level tape for transmission over the commercial telephone link.

PSL personnel at the station were housed in Observatory housing approximately 100 yards from the main building.

The tracking filter equipment was replaced with a second generation NACODE station in November 1976. A TRANET II station was purchased by the Japanese government and installed in March 1981.

The PSL personnel departed Mizusawa in June 1981 and the observatory became responsible for station operations.

GE MARK III service began in September 1981 and a Chu antenna was installed in June 1983.

Linear array antennas were used from February 1974 until June 1983. Station number 027 was used from February 1974 until the TRANET II equipment was installed in March 1981 when the station number became 427. Station 548 began with the installation of the Chu antenna.

Operations ceased on 31 January 1989.

Misawa Air Force Base
Station 35054

With the closure of the Mizusawa station, DMA needed continued coverage from Japan and looked for a replacement site.

In February 1989, DMA personnel installed a Magnavox 1502DS receiver in building 1555 at Misawa Air Force Base. The Chu antenna was located at the northeast corner of the building. This location was about one quarter mile west of the original location.

PSL was asked to man the station and a student took over operations on 24 May 1989.

Data were transmitted via GE MARK III.

The station closed on 30 September 1993.

AUSTRALIA
Smithsfield
Stations 012-112-412-545

Station 012 began operations on 25 August 1961, in a Weapon Research Establishment building approximately two miles from Smithsfield, South Australia. The station was located approximately fifteen miles north of Adelaide.

Operations began with a PSL Representative in charge of liaison with U. S. officials and an Australian in charge of Australian affairs. The PSL representative remained until April 1967 when the Australians took over complete operation of the station. There were never any cooperative education students at this station.

The first generation NACODE equipment was replaced on 11 June 1963 with second generation equipment. The tracking equipment remained in the same building.

Station 012 continued operations until 13 October 1965 when the antennas were consolidated in a non-linear array on one antenna tower. The station number then became 112.

Until October 1970, the station had a dedicated circuit to SCC. After this date, the station used a commercial circuit to the U. S. Navy Communications Station at Northwest Cape where the data entered the AUTODIN system to SCC. The station began using GE MARK III in August 1981.

The station was automated on 12 February 1971 and received a rubidium oscillator during July 1974.

TRANET II equipment was installed in August 1979 and the station number became 412. A Chu antenna replaced the old antenna system on 14 June 1983 and the station number was changed to 545. A Ramdisk was added in February 1989.

Although the Australian station was only manned by PSL for a few years, there has always been a special relationship between the PSL and Australian staffs.

PSL provided technical, logistic and moral support throughout the entire lifetime of the tracking operations.

The station closed on 30 September 1993.

SOUTH AFRICA
Pretoria
Stations 015-115-105-405-554

Station 015 began tracking operations on 24 October 1961 near the 60 foot dish antenna at the Atlantic Missile Range Site 13. The site was located 18 miles southeast of Pretoria, Transvaal, South Africa.

The first generation NACODE equipment was replaced with second NACODE generation equipment on 3 May 1963.

Station 015 was located near the dish antenna in the supply area until 27 August 1963. The station was then moved about two miles to the Control Area and installed in a van. The station became operational again as Station 115 on 30 August 1963. Station 115 ceased operations on 30 August 1970 when it was thought that operations at the site would be closed down. After negotiations were completed, the tracking equipment was removed from the van and moved about 50 feet into the communications section of the Control Area. Station 105 began operations in the communications section on 20 October 1970.

The station used an RCA communications circuit to Patrick AFB, Florida then a commercial circuit was used to forward the data to SCC. After 20 October 1970, the data was transmitted to the American Embassy in Johannesburg for retransmission over State Department circuits to Washington. The data was then forwarded to SCC. Beginning in June 1985, the station used SAPONET (South African Post Office Network) to access GE MARK III to transmit data.

Station 105 was automated on 14 June 1971 and a rubidium oscillator was installed during April 1974.

Stations 015 and 115 used non-linear array antennas. Stations 105 and 405 used linear array antennas.

TRANET II equipment was installed on 26 August 1981 and the station number changed to 405. A Chu antenna was installed on 3 June 1983 and the station number was changed to 554. A Ramdisk was added in March 1989.

There was always a PSL representative on site. RCA provided American tracking operators for the station until 4 January 1971. Between that date and 31 December 1971, RCA provided four South African operators and one South African technician to operate the station. The first co-operative education students became station operators on 1 January 1972.

The station closed on 31 August 1992.

AMERICAN SAMOA

Tafuna

Stations 017-117-024-424-560

Station 017 became operational on 9 August 1962 near Tafuna Airport, American Samoa. The station was located in the old Army Map Service Project Betty building.

The station began operations using second generation NACODE equipment which was automated on 11 May 1971.

The station remained in the original building until 4 August 1966. A quonset building was constructed nearby and the station was moved and began operations again on 5 August 1966 as Station 117. On 17 January 1974, Station 117 ceased operations when the tracking equipment was moved into the second floor of a former USAF Butler building. Station 024 began operations on 29 January 1974 and was located approximately 300 yards east of the Station 117 location. Non-linear array antennas were used by station 017 and 117. Linear array antennas were used by stations 024 and 424.

A rubidium oscillator was installed in September 1980. TRANET II equipment was installed in October 1979 and the station number was changed to 424. When a Chu antenna was installed in June 1983, the station number became 560. A Ramdisk was added in June 1989.

Station 017 operated a four channel multiplex RF communication system between American Samoa and Hawaii until November 1963. The Federal Aviation Agency installed their own communication circuit and a channel was provided to station 017 until July 1970. Between July 1970 and August 1982, data were transmitted on an Air Force circuit to an Autodin terminal in Hawaii. In August 1982, the tracking station became the first overseas station to use the GE MARK III communication system when the Air Force circuit became unavailable.

The Government of American Samoa has supported the station throughout its operation.

Timation III tracking equipment was installed during April 1974 and the TRANET tracking equipment was connected to a cesium oscillator until Timation operations ended in late 1976.

The station closed on 30 May 1993.

GREENLAND

Thule Air Base

Stations 018-118-418-557

Station 018 began operations on 14 November 1963 in building 451 at Thule Air Base, Greenland.

The station began operations with second generation NACODE equipment which was automated in November 1971. A rubidium oscillator was installed during April 1974. Station 018 used non-linear array antennas.

In May 1977, the station moved to building 252 and became station 118 using linear array antennas.

TRANET II equipment was installed in April 1983 and the station became 418. A Chu antenna was installed in June 1983 and station 557 began operations. A Ramdisk was added in July 1988.

Until June 1970, the data were transmitted on a dedicated circuit to SCC. Autodin circuits were used from June 1970 until July 1983. GE MARK III service began in July 1983 and was used until October 1984 when local phone circuit problems developed. The station used Autovon again until the circuit problems were corrected in October 1985.

The tracking station in Thule produced more data than any other single station in the network due to its latitude and number of years of operation.

The station closed on 30 September 1993.

SEYCHELLES

Mahe

Stations 717-020-420-558

Station 717 began operations on 1 July 1964 on Mahe in the Seychelles Islands. The station was located within the U. S. Air Force compound and was housed in mobile van 306. The station operated in the mobile van until October 1969 using non-linear array antennas.

The station tracking filter equipment was moved to a newly constructed building (#84782) near the original site on 27 October 1969. The antennas were put in a linear array configuration at this time and the station number was changed to 020.

On 30 November 1971, the original tracking filter equipment was replaced with automated NACODE equipment which was previously located at Argentia, Newfoundland and known as N-70.

Station 420 began operations in December 1979 when TRANET II equipment was installed. The station number changed to 558 in June 1983 when a Chu antenna was installed. A rubidium oscillator was installed in April 1988 and a Ramdisk added in October 1988.

The station has been supported on site by the U. S. Air Force. Communications were provided through RCA circuits to Patrick Air Force Base, Florida with a relay via commercial circuits to SCC. From 1970 until October 1984 AUTODIN circuits have been used to transmit data.

Beginning in October 1984, data were transmitted via U.S. government circuits for entry into GE MARK III at Sunnyvale, California.

Transportation to the Seychelles was unique since a seaplane was used from Nairobi to Mahe until early 1972. After that time, jet aircraft used the newly constructed island runway.

Due to its unique location halfway around the world from the United States, the Seychelles station had an unique role in the development in the GPS navigation system. The station was equipped with Timation III tracking equipment during February 1974. The TRANET tracking equipment was connected to a cesium oscillator until Timation operations ended in late 1976.

A GPS (Global Positioning System) tracking station was operated by PSL personnel from August 1981 to October 1985.

The station closed on 30 May 1993.

GUAM
U. S. Naval Base
Stations 023-423-553-566

Station 023 began operations on 10 July 1973 at the U. S. Naval Station on Guam. The station was located near an abandoned runway on Orote Point. The automated NACODE equipment used was formerly used at Station 766, Wake Island.

The original small building was enlarged and the tracking equipment was moved in August 1980. Linear array antennas were used from July 1973 until June 1983.

TRANET II equipment was installed in April 1983 and the station number became 423. A Chu antenna was installed in June 1983 and the station number was changed to 553. A Ramdisk was installed in April 1989.

The TRANET II station was moved to Building 1 near the headquarters building on 3 April 1989 to become station 566. The move was required due to construction in the area of the original location.

Communications were via AUTODIN circuits to DMA until January 1985 when GE MARK III service began.

Timation III equipment was installed during March 1974 and the TRANET equipment was connected to a cesium oscillator until Timation operations ended in late 1976.

The station closed on 30 May 1993.

ANTARCTICA
McMurdo
Station 019-419-562

Station 019 began operations on 5 February 1965 at McMurdo in the Antarctic. The station was located in a National Science Foundation (NSF) building in the scientific area of the U.S. Navy facility at McMurdo. The tracking operations began with second generation NACODE equipment which was automated in early 1971.

An agreement was made in early 1965 whereby PSL would operate and maintain a Doppler station which was sponsored by the NSF. PSL operated the station until 26 December 1966.

Due to problems in renegotiating an agreement with NSF, PSL did not reopen the station. An agreement was later reached with the Applied Research Laboratory of the University of Texas at Austin (ARL). ARL personnel reopened the station on 10 October 1968. The PSL continued to support the station by supplying spare parts, technical information and personnel training.

TRANET II equipment was installed in May 1982 and the station number became 419. A Chu antenna was installed in late 1983 and the station number changed to 562.

Until 1985, data was transmitted by HF radio links to New Zealand and then relayed via AUTODIN circuits to the United States. In 1985, a satellite ground terminal was installed at McMurdo and data were transmitted via INMARSAT (INternational MARitime SATellite) to a GE MARK III port in the United States. A second, backup terminal was added later for better satellite visibility.

The McMurdo station also handled data for the Magnavox Geoceiver and later the Magnavox 1502DS station (after 1984) located at the South Pole.

Both stations in Antarctica closed on 30 September 1993.

POINT POSITIONING USING MOBILE VANS

The Physical Science Laboratory built, operated and maintained mobile tracking equipment beginning in 1959. Since that time, mobile equipment has operated at approximately 124 locations worldwide. Until 1963, the mobile operations were confined to the continental United States or to ships that operated from east coast ports of call. Beginning in 1963, observations were made from sites in the Pacific and in Europe using first generation mobile tracking equipment. In 1964, the second generation mobile tracking equipment was introduced and began occupation of worldwide sites.

In 1964, four sets of mobile tracking equipment using tracking filters were used. In late 1965, a mobile NACODE Station was built up to be used in extremely remote areas. In early 1971, a second mobile NACODE was built and used for the SMTP (Special Mission Tracking Project).

During most mobile operations, the tracking station remained on site gathering data for a period of 4-5 weeks. Some operations were of even shorter or longer duration due to transportation problems involved with a particular site.

The occupation of the worldwide sites was to accurately locate each site in a worldwide datum which is called point positioning. The requests to obtain data from certain areas came from many agencies of the United States Government as well as from many foreign governments.

In most cases, the mobile equipment occupied a site where previous data had been gathered using cameras, the SECOR System, or where first order astronomic observations had been made. When possible, the mobile equipment was set up in locations where commercial power and either commercial or military communications were available.

At 13 of the sites occupied, there were no suitable communications available and PSL personnel operated either a 1 Kw or 10 Kw communication van. There were five locations at which no facilities were available to support either the tracking equipment or personnel. Food, shelter, and fuel were taken along.

In the 1970s until the early 1980s, highly portable Magnavox Geoceivers replaced the mobile vans for point positioning operations. The Geoceivers were replaced in the early 1980's by the Magnavox 1502DS which were used until the end of the tracking program.

The operations with the early mobile vans were much more complicated than operations using either of the Magnavox receivers. The mobile vans were usually eight feet wide and nine feet tall. The lengths varied from 12 to 19 feet. The first two mobile vans were semi-trailers.

In most cases, the vans were transported by truck to an airfield, then flown by U. S. military aircraft to an airfield near their destination, then trucked to the final destination. In eight cases, the vans were transported by ship to very remote locations with no or inadequate airfield.

The mobile vans were equipped with standard satellite tracking equipment of the type that was used in laboratories. The equipment was heavy and bulky compared to equipment of the 1970s and later.

The equipment was not automated and the stations were normally manned 24 hours per day.

Please note that observations in 1970 or later were in support of the SMTP.

The following is a list of the locations that were positioned using the U.S. Navy Doppler satellites, along with the equipment used, the date of occupation and the station number.

POINT POSITIONING LOCATIONS

STATION NUMBER	LOCATION	OCCUPATION		
	VAN 200			
005	Argentia, Newfoundland	9-01-59	12-01-60	
301	Prospect Harbor, Maine	8-10-61	8-22-61	
302	NAS, Minneapolis	10-23-61	10-29-61	
	Twin City Arsenal, Minn.	11- 1-61	11-14-61	
	Pt. Mugu, California	11-28-61	12- 6-61	
	Laguna Peak, California	12- 7-61	12-14-61	
	Pt. Arguello, California	12-15-61	12-22-61	
750	Knob Noster, Missouri	2-15-67	4-23-67	
189	Pt. Mugu, California	2-23-68	6-14-68	
733	Pt. Mugu, California	2-12-70	10-31-70	
908	Nellis AFB, Nevada	11-14-70	4-17-71	
733	Pt. Mugu, California	5-11-71	7-12-71	
733	Pt. Mugu, California	9- 2-71	9-30-71	
	VAN V1			
711	Stillwater, Oklahoma	8-10-62	1-23-63	
704	Eniwetok Atoll	1-31-63	4- 1-63	
706	Canton Island	4- 5-63	5-23-63	
702	Marcus Island	6-15-63	8- 1-63	
712	Iwo Jima	8-10-63	9-30-63	
715	Guam	10- 7-63	11-16-63	
714	Yap	11-28-63	12-19-63	
	VAN V2			
710	Fort Wayne, Ind.	11- 1-62	1-22-63	
701	Mannhein, Germany	1-30-63	3-25-63	
703	Madrid, Spain	4- 5-63	4-30-63	
705	Athens, Greece	5- 5-63	6- 5-63	
713	Okinawa	6-25-63	12-19-63	
	VAN 306			
720	Pt. Arguello, California	2-20-64	4-30-64	
717	Mahe, Seychelles	7- 1-64	10-19-69	**
	VAN 307			
709	Perth, Australia	3-16-64	5- 2-64	
707	Darwin, Australia	5-18-64	10-31-64	
723	Cocos Island, Australia	12- 7-64	2-28-65	
725	Townsville, Australia	3- 8-65	7- 9-65	
726	Manus Island	7-26-65	10- 2-65	*

743	Woomera, Australia	11-21-65	1-22-66	
749	Canberra, Australia	2-28-66	3-25-66	
744	Thursday Island	4-18-66	6- 8-66	**
805	Culgoora, Australia	7-12-66	8-23-66	
810	Papakura, New Zealand	3-10-67	4-30-67	
809	Invercargill, New Zealand	5-26-67	8- 8-67	
821	Zamboanga, P.I.	9- 3-67	10-19-67	
832	Sasebo, Japan	12- 4-67	2-13-68	
731	Nandi, Fiji	3-20-68	5- 6-68	
837	Natal, Brazil	6-13-68	8-16-68	
841	Kodiak, Alaska	9-19-68	10-15-68	
842	St. Paul Island, Alaska	10-30-68	11-30-68	
843	Sitkinak, Alaska	1- 9-69	2-17-69	
951	Columbus, Ohio	9-17-69	11-29-69	

VAN 307A

950	Twin Mound, Oklahoma	7-27-69	10- 2-69	
895	Nord, Greenland	4-15-70	7-13-71	*

VAN 311

718	Johnston Island	3-15-64	4-26-64	
721	Kwajalein Island	5- 1-64	7-24-64	
722	Ascension Island	8-18-64	2- 1-65	
736	Semmes, Alabama	4- 9-65	5-25-65	
722	Ascension Island	6-23-65	10- 3-65	
742	Beltsville, Maryland	11- 6-65	12-20-65	
745	Greenville, Mississippi	1-12-66	3- 5-66	
803	Rota, Spain	6-24-66	8-20-66	
728	Canary Island	10-16-66	12- 8-66	* **
812	Catania, Sicily	3-19-67	5-11-67	
819	Oslo, Norway	6-20-67	7-25-67	
818	Tromso, Norway	8-19-67	9-16-67	
830	Hohen Peissenberg, Germany	11- 9-67	12-24-67	
816	Keflavik, Iceland	1-20-68	3-23-68	
817	Meshad, Iran	4-24-68	7- 6-68	
836	Karachi, Pakistan	8- 4-68	9-18-68	
838	Mauritius Island	11- 5-68	3-28-69	
840	Addis Ababa	4-18-69	5-24-69	
954	Fylingdales Moor, U.K.	7-17-69	8-21-69	
896	Keflavik, Iceland	2- 2-70	7-13-71	
956	Bangor, Maine	9- 3-71	9-30-71	

VAN 312

719	Kauai, Hawaii	3- 9-64	4-26-64	
708	Wake Island	5- 3-64	6-17-64	
724	Midway Island	6-20-64	1-31-65	

734	Homestead AFB, Florida	4- 9-65	5-25-65	
738	Moses Lake, Washington	6-29-65	9-30-65	
748	Grand Forks, N. D.	2- 3-66	5- 5-66	
727	Terceira, Azores	8- 8-66	9-23-66	
804	Lisbon, Portugal	10-21-66	2-19-67	
729	Funchal, Madeira	4- 6-67	5-24-67	**
813	Dakar, Senegal	8-24-67	10- 6-67	*
815	Paramaribo, Surinam	2-17-68	4-18-68	
814	Curacao, D.W.I.	5- 6-68	6-28-68	
820	Villa Dolores, Argentina	7-18-68	9-20-68	*
844	Quito, Ecuador	11-16-68	3- 3-69	
847	Punta Arenas, Chile	6- 4-69	6-30-69	
846	Easter Island, Chile	7-17-69	8- 8-69	
700	Kabul, Afghanistan	2- 2-70	4-15-71	
		6-24-71	7-15-71	
		9- 4-71	9-30-71	
899	Kandahar, Afghanistan	4-25-71	5-29-71	
900	Herat, Afghanistan	8- 8-71	8-26-71	
350	Catania, Sicily	3-11-73	6- 9-74	

VAN 314

715	Guam	5- 6-64	1-31-65	
735	Hunter AFB, Georgia	4- 9-65	6-11-65	
737	Goldstone, California	6-28-65	8-12-65	
741	Organ Pass, N. M.	8-16-65	12- 8-65	
747	Warren AFB, Wyoming	2- 3-66	5- 5-66	
802	Ulithi	7- 7-66	9- 1-66	* **
801	Koror Island	9-10-66	11-14-66	* **
811	Maui, Hawaii	5-17-67	7- 7-67	
826	Upernavik, Greenland	7-19-67	8-10-67	
827	Godthab, Greenland	8-19-67	9-14-67	
800	Athens, Greece	1-16-68	3-20-68	
822	Fort Lamy, Chad	4-27-68	6-14-68	*
828	Scoresbysund, Greenland	7-25-68	8-21-68	**
848	Faeroe Island, Denmark	10-24-68	11-30-68	*
833	Oeno Island, U.K.	2-16-69	3- 8-69	* ** ***
849	Christmas Island, U.K.	3-20-69	4-10-69	* ** ***
952	Patrick AFB, Florida	6-30-69	9- 5-69	
850	Vandenberg AFB, California	10- 6-69	11-14-69	
765	Chaing Mai, Thailand	2-17-70	7-13-71	
957	Phoenix, Arizona	9- 3-71	9-30-71	

MOBILE EQUIPMENT N3

740	Nome, Alaska	11-23-65	2- 1-66
739	Shemya, Alaska	2-24-66	5- 2-66
807	Hall Beach, Canada	7-29-66	9-13-66

806	Yellowknife, Canada	10-10-66	11-19-66	
808	Goose Bay, Labrador	12-13-66	1-20-67	
831	Revilla Gigedo, Mexico	11-19-67	12-15-67	** ***
190	San Nicolas Island	4- 3-68	6-14-68	
829	Jan Mayen Island	8-28-68	10- 8-68	*
825	Palmer, Antarctica	1-24-69	2- 4-69	*
897	Nicosia, Cyprus	2-13-70	2-24-70	
907	Nicosia, Cyprus	2-25-70	7-13-71	
		8-30-71	9-30-71	

MOBILE EQUIPMENT N70

898	Argentia, Newfoundland	3- 5-70	7-14-71

MOBILE EQUIPMENT N12

913	Gallup, New Mexico	2-14-71	4-14-71

* Communications van used
** Equipment sent by ship
*** Provided own support

GEOCEIVER OPERATIONS

The Geoceiver was a small, compact, portable tracking station made by Magnavox. It tracked 150, 162, 324, and 400 MHz. The receiver was contained in one package while the antenna and preamplifiers were contained in another package. The Geoceiver was a replacement for the van-mounted mobile tracking stations and was designed to operate unattended for periods up to 24 hours.

In April 1971, PSL personnel attended a training course at the Magnavox plant at Torrance, California to become familiar with the operation and maintenance of the Geoceiver.

The first site to be occupied by a Geoceiver operated by PSL was Nome, Alaska.

In November and December of 1971, PSL represented the Navy in a Tri-Service test of the Geoceiver in which the Army, Navy and Air Force took part. The Tri-Service test was to establish the accuracy and reliability of the Geoceiver. Geoceivers were used in a total of 21 locations during the test which PSL personnel operated at 3 locations. The Tri-Service test proved that the Geoceiver could be used in point positioning with an accuracy of 1.5 meters in each coordinate at a 90% confidence level with 35 data passes.

Following is a tabulation of the sites visited by Geoceivers, along with the dates of occupation and the reason for the occupation.

STATION NUMBER	LOCATION	OCCUPATION	SERIAL NUMBER	AGENCY REQUEST
8002	Nome, Alaska	5-11-71 to 5-14-71	002	FAA
8003	Nome, Alaska	5-15-71 to 5-16-71	002	FAA
20014	Chaing Mai, Thailand	9- 8-71 to 9-30-71	002	Beacon
20002	Las Cruces, New Mexico	11-16-71 to 12-12-71	002	Tri-Service
20035	Johnston Island	3-20-72 to 4- 6-72	002	AFWTR
20036	Johnston Island	4- 6-72 to 4-14-72	002	AFWTR
20015	Wrightwood, California	11-16-71 to 12-12-71	014	Tri-Service

STATION NUMBER	LOCATION	OCCUPATION	SERIAL NUMBER	AGENCY REQUEST
20025	Kwajalein, M.I.	5-11-72 to 2- 7-72	014	AFWTR
20015	Woodbine, Georgia	10-15-71 to 11-14-71	017	Tri-Service
20028	Puerto Escondido, Mexico	3- 6-72 to 3-16-72	017	IAGS and Mexican Government
20027	Meck Island, M.I.	2- 9-72 to 3-15-72	022	AFWTR
20026	Roi Namur, M.I.	3-16-72 to 3-26-72	022	AFWTR
20034	Illeginni, M.I.	3-27-72 to 4- 6-72	022	AFWTR

In addition to the above, at the request of the USAF, Geoceiver numbers 14 and 17 occupied a total of 27 sites in North Dakota during the period August to September 1972.

Between November 1983 and January 1985, Geoceivers were used in Alaska, Brazil, Samoa and South Africa to track the GEOS C (1975-27A) satellite. GEOS C operated on 162 and 324 MHz and could not be tracked by the TRANET II stations after they were modified for 150 and 400 MHz operation only.

PREPARATIONS FOR THE FIRST SPECIAL MISSION TRACKING PROJECT
(November 1969 to January 1970)

The Physical Science Laboratory was notified in October 1969 that a total of seventeen stations including nine permanent stations plus eight mobile or semi-mobile stations would be needed for the Special Mission Tracking Project (SMTP). The eight mobile stations were to include Vans 307A, 311, 312, 314 and N3. PSL was also to operate V200 and to move the N8 equipment from Hawaii to Wake. An additional station was built and called N70.

At the time of the request, the following equipment was already at PSL for checkout and/or rebuilding; V307A, V311, V312, N3 and equipment to build N70. Both V200 and V314 were located at PMR and the N8 equipment was at Station 100.

The following is a brief report station by station of general problems encountered in setting up the additional stations.

GREENLAND
Nord
Station 895
(Van 307, Van 406, and Van 405)
1 KW Communication Van

Equipment

Vans 307 and 405 were previously utilized at Twin Mounds, Oklahoma and were returned to PSL in October 1969. The tracking van, Van 307A, had been rebuilt into a two rack configuration at PMR prior to the Oklahoma assignment. Due to uncertainties in the final site selection and shipping date, Van 307 was the last van to leave PSL. Work on the actual tracking equipment began in earnest about mid-February. A considerable amount of time and effort was needed to put all the tracking equipment in proper operating condition.

Van 405 was picked up at Pt. Mugu NAS on 17 March 1970, by MAC. Van 307A and Van 406 were also picked up on 17 March 1970, at Holloman AFB, New Mexico for transhipment to Thule AFB, Greenland. All vans arrived at Nord, Greenland on 20 March 1970.

ICELAND
Keflavik
Station 896
(Van 311)

Equipment

Van 311 was last used in Great Britain until 21 August 1969. The van arrived at PSL in early December 1969. All equipment was removed from the van and the van was repainted inside and out. New floor covering was also installed. Van 311 was rebuilt using three equipment racks instead of four, and new cabinets were built for storage and work areas. No serious problems were encountered during the checkout.

Transportation

The van was shipped from Holloman AFB, New Mexico on 2 February 1970 and arrived in Keflavik on 7 February 1970.

On-Site Set Up

Station 896 became operational on 20 February 1970 and station communications were installed on 22 February 1970.

Personnel

Approximately seven working days were required to obtain visas and flight reservations for Iceland. The Station Manager arrived on site 8 February 1970 with three student operators.

AFGHANISTAN

Kabul
Station 700
(Van 312)

Equipment

Prior to the SMTP, Van 312 was most recently used at Easter Island until 14 August 1969. The van returned to PSL in late August 1969; however, considerable damage occurred in transit. The air conditioner was badly damaged, and a transporter was broken; both were replaced. One lifting eye was torn loose and was repaired.

In early December 1969, the van was stripped and new floor covering installed. The interior was repainted at that time. The tracking equipment was rearranged in two racks and new cabinets and work benches were installed. Van 312 was the first station to have the new PSL-built fixed tuned receivers installed. No serious problems, other than debugging the new receivers, were experienced during the checkout.

Transportation

The van was shipped from Holloman AFB, New Mexico on 23 January 1970 and arrived in Kabul on 26 January 1970.

On Site Set Up

Station 700 became operational on 3 February 1970. The first communications were established through the American Embassy about 19 February 1970. Several serious problems were experienced with the diesel generators which supplied the station's power and parts were ordered. The fixed tuned receiver for 162 MHz was returned to PSL for repairs and another receiver was shipped to the station.

Personnel

At least 12 working days were required to obtain visas for Kabul and commercial air transportation was used. A PSL staff member arrived on-site 24 January 1970 to begin setting up the station. The permanent Station Manager and three students arrived on 31 January 1970.

THAILAND
Chaing Mai
Station 765
(Van 314 and Van 408)

Equipment

Until 17 November 1969, Vans 314 and 408 were used at Vandenberg AFB, California. Van 314 was worked on at PMR and repainted. A new transporter was shipped from PSL for installation at PMR. The equipment checkout prior to shipment was routine. The equipment remained installed in four racks.

Transportation

The vans were shipped from PMR and arrived on-site on 13 February 1970.

On-Site Set Up

On 15 February 1970, Station 765 became operational and preliminary communications were established the same date through the 1980 Communications Squadron. No unusual set up problems were reported.

Personnel

Normally seven working days are required to obtain visas; however, the visa may be obtained in Los Angeles without too much delay if the individual reports in person with the application already made out. The Station Manager arrived in Chaing Mai on 2 February 1970.

CYPRUS
Van N-3
Station 897-907

Equipment

The N-3 equipment was last used at Palmer, Antarctica for three weeks ending 6 February 1969. The equipment was returned to PSL in the normal configuration. During early 1969, the equipment was installed in two racks in a mobile shelter. When the request for the expanded network was received, the equipment was already operational.

Transportation

The equipment was picked up at Holloman AFB, New Mexico about 26 January 1970 and arrived in Cyprus about 5 February 1970. There was a hole in the van upon arrival which was repaired on site.

On Site Set Up

Station 897 became operational on 13 February 1970 at the communications facility at Yerolakkos, but closed down 17 February 1970 due to severe interference. The equipment was then moved to the American Compound on 25 February 1970 to become Station 907.

Personnel

At least seven working days were required to obtain a visa since approval was required from Cyprus itself. In this case, several phone calls were made to expedite the approval. The station manager arrived on site on 7 February 1970.

WAKE ISLAND

N-8

Station 766

Station 766 began operations on 11 January 1970 in the PMR Facility at Wake Island. The purpose of locating the station at Wake was to provide coverage for the SMTP. The station ceased operations on 20 June 1973 when it was moved to Guam.

The NACODE equipment used at Wake Island had previously been used at Station 100 in Hawaii until 22 December 1969. The station was automated at Wake on 8 December 1971.

Data transmission were made through PMR circuits to an AUTODIN terminal for relay to SCC.

NEWFOUNDLAND
Argentia
Van N-70
Station 898

Equipment

The N-70 equipment used at Argentia was built at PSL from spare equipment. The biggest problem was obtaining a digitizer. Attempts to borrow an ABACUS were unsuccessful, and finally one was taken from Station 014, Alaska. All the spare modules at PSL were used to build a refraction correction unit. Test equipment normally used at PSL was shipped with the station.

Transportation

The N-70 equipment was shipped in the normal NACODE type racks from Holloman AFB, New Mexico on 17 February 1970 and arrived in Argentia on 19 February, 1970.

On-Site Set Up

Station 898 became operational on 5 March 1970 and AUTODIN communications were used until 11 March 1970. After 11 March, point-to-point communications were established.

Personnel

There was no delay in getting personnel on site and the Station Manager arrived on 18 February 1970.

CALIFORNIA
Pt. Mugu
Station 733
Van 200

Equipment

Van 200 was previously used at PMR near a radar site for Doppler tracking of GEOS B and was moved to a new site for the Doppler Beacon Program. It was necessary to provide test equipment for the van plus two new receivers.

Transportation

The station was moved by Public Works in early February 1970.

On-Site Set Up

Since the equipment had not been used in some time, a complete checkout was needed of all tracking equipment and several failures were encountered. The first data were taken on 12 February 1970 and communications were also established at that time.

Personnel

The Station Manager arrived on site 23 November 1969; however, he and his crew worked first on Van 314, then began work on Van 200.

STATION DEPLOYMENT FOR FIRST AND SECOND SPECIAL MISSION TRACKING PROJECTS

STATION DEPLOYMENT FOR THE FIRST SMTP

Beginning in March 1970, the TRANET started supporting the Special Mission Tracking Project (SMTP) by providing Doppler information at 162 MHz and 324 MHz.

Additional stations were located throughout the world to provide the maximum coverage possible. The satellites were launched in two series with the first series beginning on 4 March 1970 and ending on 30 September 1971. The satellites are referred to as DB-1, DB-2, etc.

Below is a listing of the satellites and the dates they were tracked, along with the additional stations that tracked them. The permanent stations also tracked the satellites.

BEACON	SATELLITE NUMBER	DATES TRACKED	STATION NUMBER AND LOCATION	EQUIPMENT
DB-1	00066	3- 4-70 to	700 Kabul	V312
		3-24-70	733 Pt. Mugu	V200
			765 Chaing Mai	V314
			766 Wake Island	N8
			896 Keflavik	V311
			898 Argentia	N70
			907 Nicosia	N3
DB-2	00067	5-20-70 to	Same as above plus	
		6-16-70	895 Nord	V307A
DB-3	00069	11-18-70 to	Same as above except	
		12-10-70	delete 733 and add	
			908 Nellis AFB	V200
DB-5	00071	3-24-71 to	Same as above except add	
		4-10-71	913 Gallup	N70
			(898 changed to tracking filter station)	
DB-6	00073	9-10-71 to	700 Kabul	V312
		9-30-71	733 Pt. Mugu	V200
			766 Wake Island	N8
			907 Nicosia	N3
			956 Bangor	V311
			957 Williams AFB	V314
			20014 Chaing Mai	Geoceiver 002

SUMMATION OF FIRST SMTP

Five satellites were launched during the first SMTP. Satellite DB-4 did not orbit so a fifth successful satellite, DB-6, was orbited. After the first four satellites were tracked, N-70, V-307A, V-311 and V-314 were recalled from Argentia, Nord, Keflavik, and Chaing Mai respectively. Prior to the launch of the fifth satellite, V-311 was sent to Bangor, V-314 was sent to Williams AFB, and a Geoceiver was sent to Chaing Mai; V307A and N70 were not used for the DB-6 satellite.

There were some other changes during the first SMTP. V-200 was moved from Pt. Mugu to Nellis AFB for the DB-3 and DB-5 launches, then moved back to Pt. Mugu for the DB-6 launch. N-70 was moved from Argentia to Gallup for the DB-5 launch.

After the SMTP was completed, the vans and equipment returned to PSL.

VAN AND NACODE EQUIPMENT DISPOSITION

During 1971 and 1972, all of the mobile vans were returned to PSL along with mobile NACODE Stations N-3 and N-70. In this period, plans were made to turn the vans over to the other agencies and to update permanent tracking filter stations to NACODE stations. The following tabulation shows the disposition of the tracking equipment.

OLD DESIGNATION	NEW DESIGNATION AND LOCATION
V307A	Equipment automated and sent to Belgium. Van turned over to Department of Transportation.
V311	Equipment automated and entire van turned over to ARL/UT. Located at Casey Station (1973)
V312	Equipment automated and then located at Catania, Sicily. (1973)
V314	Equipment automated and turned over to ARL/UT. Was located at Palmer. (1973) Van turned over to Department of Transportation.
N3	Automated and sent to Anchorage to replace tracking filter equipment.
N-70	Automated and receiving system sent to Seychelles to replace tracking filter equipment.
V200	Dismantled and equipment distributed to PSL, ARL, and APL.
Station 403	Equipment automated and sent to Shemya. (1973)
Spare equipment	Equipment automated and used to make up station at Mould Bay, NWT. (1973)

STATION DEPLOYMENT FOR THE SECOND SMTP

Upon the termination of the first SMTP, all of the mobile equipment was returned to CONUS for disposition with the exception of the N-8 equipment at Wake Island. In January 1973, three sets of tracking filter equipment were built up for the second SMTP. The equipment was sent to the locations listed below prior to the launch of the DB-7 satellite. Between the DB-7 and DB-8 missions, the equipment at Wake Island was moved to Guam.

BEACON	SATELLITE NUMBER	DATES TRACKED	STATION NUMBER AND LOCATION	EQUIPMENT
DB- 7	00075	3-11-73 to 4-26-73	197 Shemya	TF*
			350 Catania	V312
			351 Mould Bay, NWT	TF*
			766 Wake Island	N8
DB- 8	00076	7-13-73 to 8-29-73	Same as above except that 023 replaced 766	
			023 Guam	N8
DB- 9	00078	11-11-73 to 1-9-74	Same as above	
DB-10	00079	4-10-74 to 6-9-74	352 Cambridge Bay	TF*
			30254 Shemya	Geoceiver
			Stations 350 and 351 deactivated	
			352 Cambridge Bay replaced 351 Mould Bay, NWT	
DB-11	00081	10-29-74 to 1-1-75	Same as above	
DB-12	00084	6-8-75 to 7-28-75	Same as above	
DB-13	00087	12-4-75 to 2-2-76	Same as above	

*Tracking Filter

The stations in Shemya and Cambridge Bay were manned by PSL as SMTP operations continued. PSL operations in Shemya ended in 1992. PSL manned the Cambridge Bay station until 1979 when DMA took over operations with a Magnavox Geoceiver until early 1984. PSL returned to operate the Cambridge Bay site in February 1984 until June 1993. The next section, 1502DS SMTP Operations, explains PSL's continued SMTP involvement until 1993.

1502DS SMTP OPERATIONS

SGI's association with the Magnavox 1502DS began in January 1983 when a PSL engineer attended a Magnavox training session at the DMA Herndon, Virginia site.

The first 1502DS SMTP site operated by a PSL co-op was at Shemya, Alaska beginning in June 1983.

PSL was asked by DMA to take over the DMA-manned operation of several 1502DS SMTP sites as a cost saving measure. Most takeovers were in 1983/1984 and the last station was obtained in 1989.

A network of 1502DS stations had been set up within the continental U.S. which were eventually manned by PSL. This network was later converted to remote control operation beginning in late 1986. DMA controlled the remote sites until March 1991 when PSL assumed operations using the SMART GUARD system.

The table below lists the 1502DS stations operated or remote controlled by PSL and does not necessarily represent the entire history of a given station.

The station was manned by PSL Co-ops between the first two dates. The second date is the beginning of unmanned, remote controlled operations. The third date is the final closing date. The Sponsor is the organization which provided local support after a station was remote controlled. The stations in Canada, Chile, Ecuador, Japan, Paraguay and Sicily were never remoted.

	MANNED	REMOTED	CLOSED	SPONSOR
ALASKA Shemya	13 Jun 83	4 Aug 92	14 Jan 93	U.S. Air Force
ARIZONA Flagstaff	2 Jan 85	17 Dec 87	3 Dec 93	Navajo Army Depot
CANADA Cambridge Bay	29 Feb 84	-----	6 Jun 93	PSL manned
CHILE Santiago	25 Jan 84	-----	23 Dec 92	PSL manned
COLORADO Buckey Field	21 May 84	17 Dec 86	2 Mar 91	Colorado Air National Guard
ECUADOR Quito	10 Feb 84	-----	30 Sep 93	PSL manned
HERNDON	-----	6 Mar 91	23 Feb 93	DMA

IDAHO Idaho Falls	4 Jan 85	21 Jun 88	3 Dec 92	Department of Energy
INDIANA Grissom AFB	15 Jul 86	15 Aug 87	3 Dec 92	U.S. Air Force
IOWA Sioux City	1 Sep 83	6 Jul 88	3 Dec 92	Iowa Air National Guard
JAPAN Misawa AFB	31 May 89	-----	30 Sep 93	PSL manned
MISSISSIPPI Meridian NAS	-----	6 Mar 91	3 Dec 92	U.S. Navy
NEVADA Fallon NAS	8 Jan 85	5 Aug 88	3 Dec 92	Churchill County phone company
NEW MEXICO Las Cruces	1 Oct 85	-----	31 Jan 93	PSL manned
PARAGUAY Asuncion	7 Jan 88	-----	21 Feb 93	PSL manned
SICILY Sigonella*	12 Feb 84 8 Jan 88	----- -----	28 May 86 21 Feb 93	PSL manned
SOUTH DAKOTA Ellsworth AFB	29 Feb 84	17 Jan 88	2 Mar 91	U.S. Air Force
TEXAS Sheppard AFB	15 Jan 84	10 Aug 87	3 Dec 92	U.S. Air Force
WYOMING Warren AFB	-----	18 Apr 91	4 Mar 93	DMA

* Operated by DMA from May 86 to January 88

PRINCIPAL AGENCIES

APPLIED PHYSICS LABORATORY

The association between PSL and APL (Applied Physics Laboratory of the Johns Hopkins University) began in 1946. The SGI office began working with APL in 1958 when the TRANET Doppler System was conceived.

The Applied Physics Laboratory was the first agency responsible for the technical coordination of the TRANET Project. APL coordinated the effort between the data gatherers, the data processors and the data users as well as setting standards for the gathering of data.

When new tracking equipment was required, APL normally determined the specifications as well as the operating format. After the equipment was assigned to a particular location, both SGI and APL monitored the operation of the tracking station.

Until 1974, all of the Doppler data obtained in the TRANET Network was transmitted to APL for preprocessing prior to its retransmission to the data processor. Many items including compliance, tracking assignments, monitoring of data quality, and station performance were handled by APL.

Each tracking station communicated with APL on a daily basis by transmitting Doppler data and a tabulation of passes missed along with administrative messages. APL transmitted to the tracking station Doppler and timing data results, satellite priority listings, acknowledgement of data and messages received plus any special information concerning satellites to be tracked.

PSL and APL always worked closely to resolve any problem that occurred. The two organizations cooperated several times in obtaining special data of many various types, including refraction and tropospheric data.

DEFENSE MAPPING AGENCY

The SGI Section began working with the GGCA Office at DMA in February 1974 after the Pacific Missile Range contract was transferred to DMA. SGI was contracted to DMA until December 1993. The GGCA Office had been called the GGSS and GSGS Offices prior to various reorganizations within DMA.

DMA was formed in 1973 to become the principle mapping and charting agency for the U. S. government. It was comprised of civilian and military personnel who had worked in this field from the U.S. Army Topographic Service, the U.S. Air Force and the U.S. Navy Hydrographic Service.

The number of permanent tracking stations operated by PSL remained relatively constant at ten from 1963 until 1983. The original stations were upgraded and automated. Fully automated equipment was installed between 1979 and 1983.

PSL began operating the Magnavox 1502DS in 1983 and reached a peak of twelve manned 1502DS stations from 1984 to 1987 in addition to the ten permanent TRANET II stations. The SMTP

(Special Mission Tracking Project) continued under the DMA contract until the contract ended although the number of stations was slowly reduced in the final year.

At the request of DMA, PSL designed and produced several items of equipment including the permanent TRANET II stations, a GPS station using a Magnavox Y set, TRANET II receiver modifications, Ramdisks for TRANET II, GUARD units for remote 1502DS, etc. (See section on Design, Fabrication, Modifications and Software).

SGI and GGCA had an excellent working relationship for almost 20 years. SGI was the technical expert on TRANET II operations. The DMA personnel at Herndon, Virginia were initially responsible for the technical aspects of 1502DS and GPS operations although SGI assumed a greater role in 1502DS troubleshooting in the latter years of the program.

The GGCA Office provided official U. S. Government support to PSL which included Military Airlift Command passenger reservations and freight shipments, documents to obtain visas, Travel Orders, onsite government funding, etc.

NATIONAL SCIENCE FOUNDATION

Since it was desirable to locate one of the TRANET stations in the Antarctic, the Physical Science Laboratory contacted the National Science Foundation (NSF) office in Washington to explore the possibility of installing a station at McMurdo. After obtaining NSF approval, Station 019 began operations on 5 February 1965 and operated until 26 December 1966. The station remained closed with the equipment on site until 10 October 1968. The Applied Research Laboratory of the University of Texas at Austin began operations at that time and continued to operate the station until October 1993.

The Physical Science Laboratory trained ARL personnel in the operation and maintenance of the station and continued to provide technical and logistical support.

PACIFIC MISSILE RANGE

The Physical Science Laboratory became associated with PMR (Pacific Missile Range) in early 1961 when PMR became the contracting agency for the PSL contract. The previous contracts had been with the Applied Physics Laboratory of the Johns Hopkins University.

An office within PMR was created and called the DSO (Doppler Satellite Office). The functions of the DSO were greatly varied over the years and they included the support for all the TRANET stations operated by the Physical Science Laboratory. The DSO acted mainly as a technical coordinating office between the TRANET and various sections within PMR.

The various types of support provided by the DSO were site surveys, communications, transportation, and visas.

Normally one representative from both DSO and SGI travelled to the proposed tracking site and discussed with local officials details of locating a tracking station at that site. During the talks, arrangements were made for locating the station in a building or providing a site for a van, and arranging communications, transportation, power, water, telephone and housing for station personnel.

The DSO made arrangements for local and long distance handling of the station communications normally utilizing military circuits. They also made arrangements through the Military Airlift Command for transporting the tracking equipment or vans to the tracking site.

The DSO assisted in obtaining official visas for entry into various foreign countries by providing official paperwork as the sponsoring agency for the individuals assigned to a particular country.

A summation of the relationship between the Physical Science Laboratory and the Doppler Satellite Office would not be complete without mentioning the excellent working arrangements between the two organizations during the 13 years PSL was contracted to PMR. During this time there were no instances in which some arrangements could not be made, to carry out normal, or at times what appeared to be very difficult, missions.

The Doppler Satellite Office (DSO) was abolished on 1 January 1974 when the Defense Mapping Agency (DMA) took over the SGI-TRANET contract.

SPECIAL PROJECTS

APL IONOSPHERIC REFRACTION STUDY

Because of the dispersion of the TRANET stations, ionospheric refraction data could be gathered on an almost worldwide scale.

Each TRANET Station had the capability of producing refraction data as an output of the Refraction Correction Unit (RCU). The input signals to the RCU were the raw Doppler signals from the low frequency receiver and the high frequency receiver. The raw Doppler data included the Doppler shift due to the relative motion of the satellite, refraction caused by the bending of the satellite signal as it passed through the ionosphere, tropospheric refraction caused by further bending in the satellite signal as it passed through the troposphere, as well as gravity terms.

In mid-1965, the Applied Physics Laboratory of the Johns Hopkins University (APL/JHU) requested that a few selected stations provide raw recorded ionospheric data which was analyzed at APL. After determining the basic information available from this data, it was decided to expand the data gathering to more stations. These stations would analyze the data on site and provide information entered in the fields of the HTP format.

From late 1965 to March 1966, stations sent in the refraction recordings. After March 1966 until late 1968, the station-reduced data was supplied to APL.

The information provided included the day, rise time, satellite number, maximum refraction before and after TCA, approximate occurrence of the phase reversal near TCA, maximum number of phase reversals during the pass, as well as information concerning the signal quality during the pass.

The purpose of the project was to determine the daily and seasonal variations of the ionospheric density at several sites worldwide.

ARL THIRD ORDER REFRACTION STUDY

During 1965 and 1966, the Physical Science Laboratory cooperated with the Applied Research Laboratory of the University of Texas in obtaining third order refraction information. Data were obtained from satellite 04164 (1964-64A) at 40, 162, 324, and 360 MHz.

PSL loaned equipment to ARL to build a separate tracking station to track 40 MHz and 360 MHz. This station provided VCO Doppler data on the two frequencies. When collocated with other stations, the station provided VCO Doppler data from 162 MHz and 324 MHz. All four of the VCO Doppler frequencies were recorded on magnetic tape for shipment to the ARL. The ARL tracking equipment was collocated at Station 008 in Brazil from February to July 1965 then was shipped to Station 022 in the Philippines where it operated from August to October 1965.

ARL also shipped equipment to Station 014 Alaska so that the four frequencies could be recorded there from August to December 1966.

After the ARL equipment returned from the Philippines, it was modified so that the four frequency VCO Doppler data could be digitized and forwarded to the ARL via teletype circuits for near real time analysis. The equipment was then sent again to Station 008 Brazil from July to December 1966.

The loaned equipment was shipped back to PSL after operations terminated in December 1966.

ASTROLABE

In 1982, the Defense Mapping Agency procured three VUGTK Model 100/1000 astrolabes through Purdue University. VUGTK is the Czechoslovakian abbreviation for Research Institute for Geodesy, Topography and Cartography in Prague.

An astrolabe is an optical instrument which uses a medium power telescope with a tray of mercury as a local horizontal reference. The purpose of an astrolabe is to use astro positioning to determine the local deflection of vertical.

The three astrolabes used DC servo-motors with manually adjusted potentiometers as the input to set the horizontal and vertical tracking rates. Data was output as make-break mechanical switch contacts arranged between optical wedge carriers. Purdue University replaced the mechanical switches with optical switches and interrupter plates which only improved the data slightly.

In 1986, PSL received the three VUGTKs from DMA to see if a "quick fix" could be made. Some minor modifications were made to the electronics which improved tracking.

DMA requested a data collection system for the VUGTKs in 1987. Three systems were built and data were stored on a rampack which replaced the original printed paper output. New eyepieces and reticles were also installed.

Between 1988 and 1989, a data collection system was incorporated in a PSL-designed VUGTK controller. The Czech controller electronics were replaced with modern stepper motor technology. In 1991, new deflection wedges were added to one VUGTK to make it track the same as the other two instruments.

During the several years that SGI worked on the Czech VUGTKs, it became obvious that a better instrument could be built with more modern technology. DMA funded SGI to develop a prototype replacement for the VUGTK, which was called the A35M.

The A35M was a completely new instrument which included the optical station (astrolabe), the pier station (astrolabe controller) and the recorder station which included the operator interface, data processor and star transit predictor. The new system contained the FK5 star catalog to predict the star transit times as well as other required constants. After 6 of 24 stars were tracked, the system provided an updated output of the calculated position.

The A35M was completed in late 1992 and tested extensively. The results showed the A35M to be superior to the previous astrolabes.

DODGE PROJECT

On 1 July 1967, the DODGE (Department of Defense Gravitational Experiment) satellite 1967-66F was launched into an 17940/18160 N.M. orbit with an inclination of 7.2 degrees.

The primary experiment on the satellite was to test a means of passive stabilization using retractable booms built by the Applied Physics Laboratory at Johns Hopkins University (APL). The satellite also provided the first composite colored pictures of the earth.

PSL was responsible for modifying three of its TRANET Stations (Brazil, Japan and Australia) to receive 240 MHz from the satellite. The modification included changes in the receiving system, installing 240 MHz preamplifiers, installing a 240 MHz helix antenna, fabricating a sequencer for the recovery of OMEGA VLF signals and modifying the digitizer to recover satellite time to a resolution of one microsecond. APL provided the Dodge Time Recovery System (DTRS) which was incorporated in the stations.

PSL provided Doppler tracking information at 240 MHz for a ten minute period every hour for four to five days as the satellite passed over the station. PSL also provided timing information using the DTRS so that comparison could be made using both timing and Doppler information to determine the satellite's orbit.

Before the satellite was launched, APL personnel visited each tracking station to set the station time epoch and to familiarize station personnel with the time and frequency requirements for the project. The station then switched to the OMEGA VLF stations.

The tracking continued off and on until 1 February 1970 when operations ceased. The time and Doppler tracking was a low priority experiment and could only be performed when other experimenters were not using the satellite.

NASA GEOS SUPPORT

The PSL-operated ground stations tracked several NASA geodesy satellites from 1964 to 1993. The following list gives the common names, APL satellite numbers, international number, launch dates, and general mission.

Common Name	APL #	Int #	Launch	Mission
BEB	04164	1964-64A	10/09/64	Doppler, Laser tracking
BEC	01165	1965-32A	4/29/65	Same
GEOS A	02165	1965-89A	11/06/65	Same plus SECOR, laser reflectors, AF optical beacons, GSFC ranging

Common Name	APL #	Int #	Launch	Mission
GEOS B	01168	1968-02A	01/11/68	Doppler, C Band transponder, laser reflectors
GEOS C	01175	1975-27A	04/09/76	Same plus radar altimeter
SEASAT	00098	1978-64A	06/27/78	Doppler, radar altimeter, synthetic aperture radar, visual and infrared radiometer
GEOSAT	00117	1985-21A	03/12/85	Doppler, radar altimeter
RADCAL	00226	1993-	07/20/93	Doppler, C Band transponder

All of the satellites except 00117 and 00226 transmitted Doppler signals on 162/324Mhz with an offset of -50 ppm; 00117 and 00226 transmitted at 150/400Mhz with an offset of +80 ppm.

The main purpose of Doppler tracking the various NASA satellites was to obtain data to improve the knowledge of the earth's geoid and to generate a unified world datum. Some satellites were used to calibrate ground radars. The Doppler data was used to generate a precise orbit to which the other experiments could be compared or referenced.

NASA REPORT—DOPPLER GEODETIC SYSTEM

In February 1967, the SGI Section was contacted by NASA representatives concerning the preparation of a report about the Doppler Geodetic System. The contact was made because of the mutual interest of both NASA and SGI in geodetic data gathering.

NASA requested a report which could be used by any university based laboratory in building up and operating a Doppler tracking station.

In October 1968, the report, "Doppler Geodetic System" was published and copies were sent to NASA for distribution throughout the world. The report contained information about the Doppler Effect and Application to Orbit Determinations, Time and Frequency Considerations, General and Detailed Descriptions of Tracking Stations, and Testing. Another section dealt with the day to day operations of a tracking station.

Because of the circulation of the report, the SGI Section was contacted by some organizations for further information about the Doppler Geodetic System.

NAVAL ASTRONAUTICS GROUP (NAG)

After the experiments on the USS Compass Island and Observation Island (see Shipboard Operations - page 65) proved that satellites could be used for navigation of ships, NAG was created to provide the operational section of the Navy Navigation Satellite System (NNSS). The civilian TRANET Stations, including those operated by PSL, would provide the raw data for geodetic research to provide increased accuracy.

NAG included locations in Maine, Minnesota, California, and Hawaii with its own operations center in California. Between August and December 1961, the Physical Science Laboratory operated a mobile van in Maine, at two locations in Minnesota, and at two locations in California to pinpoint the locations for the installation of the NAG stations. A NACODE station had already occupied a location at South Point, Hawaii.

PSL assisted in the design and fabrication of two sets of operational experimental equipment called OX-1 and OX-2. OX-1 was installed at Prospect Harbor, Maine from 25 June 1962 until 25 January 1965. OX-2 operated at Rosemount, Minnesota from 15 July 1962 until 14 January 1965. Van 200 operated at Pt. Mugu, California from 7 August 1962 until 19 July 1965 while a NACODE station operated at Wahiawa, Hawaii from 23 April 1962 until 14 September 1965.

PSL also helped to design, fabricate and install the two injection stations which were installed at Laguna Peak, California and Rosemount, Minnesota during the period late-1961 to early-1965.

Initially all four tracking locations were operated by PSL. A few months later NAG personnel were assigned to the stations to begin training in the operation and maintenance of both the tracking and injection stations. By late 1964 and early 1965, NAG assumed the operating and maintenance responsibility of all the locations.

Between January and September 1965, Westinghouse BRN-3 receivers were incorporated into standard NACODE type stations so that all four tracking sites were identical.

NAG was later renamed NAVSOC (Naval Space Operations Command).

NAVAL OBSERVATORY—STATION 503

In mid-1963, a single frequency tracking system for 400 MHz was built at APL for the purpose of calibrating satellite time. This system was to become the master time reference station for the TRANET network and NAG.

The original equipment included a helix antenna for 400 MHz, preamplifier, receiver, tracking filter, reference injection unit, ABACUS digitizer, and a TDDS time recovery system. The ABACUS was modified to output only satellite time points during a satellite passage.

After the initial checkout at APL, the equipment was moved to the Naval Observatory on Massachusetts Avenue in Washington, D.C., where it became operational in October 1963 with PSL personnel operating the station.

The reference timing station was synchronized with the Observatory's master time clock. Since the TRANET system used the Naval Observatory as a time reference, a tracking station located at the Observatory would have a known time epoch which eliminated one of the variables in the reduction of timing data.

In late 1964, a STRU was installed in the station to make it compatible with the majority of the other network tracking stations.

The station was operated with one Staff Member and two co-op students and all satellites with timing information were tracked.

Operations ceased in September 1965 when Station 111 at APL became the reference timing station.

NAVAL ORDNANCE TEST STATION

PSL worked extensively with the Naval Ordnance Test Station at China Lake, California during the fabrication and testing of the first series of NACODE (Naval Correlation and Detection) stations beginning in 1960. Many problems were encountered during the testing of these stations and PSL was instrumental in resolving many of them. After the first generation NACODE equipment was in the field and operating, many of the field modifications and suggestions from the field were incorporated in the second generation equipment. By late 1962 all of the first generation equipment had been replaced. The second generation equipment was used for 17-20 years; however many modifications were made, including automation.

The first generation of NACODE equipment consisted of 7 sets of equipment while the second generation consisted of 11 sets of equipment. In late 1971, PSL built up a l2th station which was used to replace outdated tracking filter equipment.

PSL also cooperated with NOTS to develop logistics systems, to further equipment development and to perfect troubleshooting techniques.

Direct liaison with NOTS ended in mid-1965 although good relations were maintained for several years thereafter.

NOTS was later renamed the Naval Weapons Center (NWC).

POLAR ORBITING GEOMAGNETIC SURVEY (POGS) SATELLITE

The POGS satellite was launched 11 April 1990 into a 396/466 N.M. orbit inclined 89.9 degrees.

POGS was tracked originally by the TRANET II stations in Australia, Brazil, Guam, American Samoa, Seychelles and New Mexico.

The POGS satellite was unique because it transmitted for 20 seconds then was silent for 60 seconds then transmitted for 20 more seconds, and so on. POGS used an offset of plus 60ppm (parts per million) at 150/400MHz. This offset was 20ppm lower than other geodetic satellites.

The stations in Brazil, Guam, American Samoa and the Seychelles ceased operations on 30 May 1993. Tracking responsibilities were then transferred to the stations in Alaska, Belgium, Antarctica and Greenland.

Tracking operations ended on 30 September 1993 when the entire tracking network was closed.

PROJECT ANNA

Project ANNA was an interservice program which included the Army, Navy, NASA, and the Air Force. The purpose of the project was to include on one satellite all of the experiments used by the various agencies in their studies of Satellite Geodesy. The various experiments included Doppler beacons at 162 MHz and 324 MHz, a system of strobe lights, and a SECOR transponder.

The TRANET stations operated by PSL tracked the Doppler beacons in the normal manner and cooperated with the Naval Oceanographic Office in operating mobile camera vans at Brazil, American Samoa, the Philippines and Japan.

Although the camera vans operated properly, weather conditions in all four locations were such that very few plates were made of the flashing strobe light from the satellite.

The satellite, 62601/1962-bu1, was launched on 31 October 1962. The camera data gathering terminated in the first quarter of 1963.

SATELLITE COMMAND TRANSMITTER—ALASKA

A satellite command transmitter was located at Fort Richardson, Alaska, 7.5 miles from TRANET Station 014.

The prime purpose of the transmitter was to control certain satellites while they were within range as requested by the Applied Physics Laboratory.

The command transmitter was installed by APL in September 1963 and was manned by a crew from PSL. The satellites were commanded in order to measure the daytime magnetic disturbances at the 1100 Km level in the auroral oval as well as the nighttime aurora borealis during the long polar nights.

The project was terminated in November 1965 and the equipment was placed in a standby condition.

SHIPBOARD OPERATIONS

In order to demonstrate the practicality of a shipboard navigation system using satellites, a PSL operated mobile tracking station was installed aboard a ship. Comparisons were made between the positions obtained using a satellite and the positions obtained using the ship's SINS and LORAN.

On 5 December 1960, the USS Compass Island, EAG-153, sailed from New York with a mobile van that had previously been at Argentia, Newfoundland. The ship returned to New York on 21 December 1960. The ship again sailed on 5 September 1961 from New York and returned on 12 September 1961.

During the first shipboard operation, PSL also operated a tracking station at Sabana Seco, Puerto Rico. The station was shipped from South Point, Hawaii for the mission then returned to Hawaii. Another tracking station was operated by PSL in Puerto Rico for the second shipboard operation in September 1961.

During these cruises, the procedure was to find some predominant underwater feature with the ship's sonar, to serve as a reference point. While the ship remained at the reference point, its location was determined with its SINS and LORAN systems. Several satellite passes were tracked and the data were transmitted to the Satellite Control Center at APL and were processed to obtain a latitude and longitude fix for the ship. After determining the ship's position with satellites, the ship left the reference point and then navigated back to the reference point using satellite fixes. Comparisons were then made using the other navigation systems on board.

The mobile van was loaded aboard the USS Observation Island, EAG-154, on 6 June 1961 for further sea tests. These tests continued off and on until 21 October 1961. The results of the test were determined to be successful.

SOUTHEASTERN UNITED STATES SURVEY (SEUSS)

The purpose of the SEUSS project was to compare three basic satellite surveying methods to determine which system was to be used in the future.

Comparisons were made between the Army SECOR System, cameras (USGS), and the Navy Doppler method. The comparisons were made although the three systems were not operated simultaneously.

Three vans operated by PSL were shipped to APL/JHU for modification and calibration by PSL personnel. An AN/SRN-9 portable Doppler system was installed in each van. All of the van oscillators were tested and calibrated at APL and were then taken to the site with power applied.

The three vans were transported to Homestead AFB, Florida; Hunter AFB, Georgia; and Semmes, Alabama.

The basic requirements for the operation of the three vans, as well as the TRANET Station at APL, were to maintain a time epoch of less than 50 microseconds; the tracking antennas were surveyed with an accuracy of better than 0.5 meters in respect to local survey marks, and the same station oscillator was used for the van equipment as well as the AN/SRN-9 equipment.

After the vans were on-site, their time epoch was synchronized using a portable clock. The time was checked about half-way through the test, again using the portable clock. The Doppler vans used hemispheric antennas while the AN/SRN-9s used whip antennas.

The actual tracking exercise started on 20 April 1965 and terminated on 25 May 1965. The AN/SRN-9s were moved but the vans continued to track for a post-calibration period.

Along with the Doppler data submitted, weather data, refraction data, and ionospheric sounding data were also used in determining the position fixes.

After all the data were compared from the various tracking systems, it was found that the Doppler data compared best to the east coast baseline which was previously measured using a geoidometer.

TELEMETRY OPERATIONS

Stations in Las Cruces, Brazil, and Alaska obtained telemetry and Doppler information. Data gathering began in mid-1961 at the Brazilian station and terminated in mid-1970. Operations at the Alaskan station began in 1962 and continued until early 1971. The Las Cruces station obtained telemetry data from 1960 until 1964.

The majority of the telemetry data came from satellite 63032. Other satellites tracked were 63031, 63041, 03164, 30010, 04164, 30020, 05264, INJUN and TRAAC.

The normal procedure was to airmail the telemetry tapes to the Applied Physics Laboratory of Johns Hopkins University. The Alaskan station obtained telemetry information and relayed it real-time to APL for newly launched satellites in order to closely monitor the performance of the satellite.

TIMATION/GPS OPERATIONS

PSL became involved with the GPS (Global Positioning System) concept beginning in 1967 and a short history follows.

PSL's first involvement with NRL (Naval Research Laboratory)/Timation was tracking the Timation I satellite (1967-50A) launched 22 May 1967. Only APL and PSL tracked this satellite, and the operations lasted a few weeks.

On 30 September 1969, the Timation II satellite (00065/1969-82B) was launched into a 488/505 N.M. orbit with an inclination of 70 degrees. The satellite carried several clocks operating at different frequencies which were decoded from the telemetry signal. After processing the data, the position of the satellite could be determined using interferometer techniques.

The satellite also transmitted 149.5 MHz and 399.4 MHz in addition to the telemetry signal. In order to confirm the satellite position with Doppler techniques, several TRANET stations were modified to track these two frequencies. A separate reference injection unit was installed in the station as well as means of switching the injection frequencies.

In November 1969, the Las Cruces and Alaskan stations were modified to track Timation II. By May 1970, ten other stations were also modified to track Timation II, which was tracked for about four years.

During early 1974, NRL sent additional equipment to the TRANET stations in Guam, Samoa and the Seychelles to track the Timation III satellite (00080/1974-50A). Timation III was launched on 14 July 1974 into a 7262 x 7436 N.M. orbit inclined 125 degrees.

The three tracking stations were equipped with receivers to track 335 MHz and 1575 MHz. The Doppler frequencies were recorded by frequency counters and formatted with time. The stations were totally automated and the data were forwarded to NRL on a daily basis. The stations were equipped with cesium oscillators which were also used by the TRANET stations. Operations continued until late 1976.

In 1981, PSL was asked by the Defense Mapping Agency to build a GPS tracking station based on a Magnavox Y set. The Y set was a four channel, sequential GPS receiver designed for Air Force airborne operation. The Y set was integrated with two Hewlett Packard MX computers, a rubidium oscillator, magnetic tape recorder, weather station, power supplies and a display terminal.

The GPS station was sent to Buenos Aires, Argentina in late 1982 and was replaced with newer equipment in mid-1986.

Another GPS station was operated by PSL in the Seychelles from August 1981 until October 1985. Records were incomplete but it was thought that the equipment was supplied by NRL.

SGI operated the DMA GPS station in Ecuador from its installation in February 1987 until October 1993. SGI also operated the DMA GPS station in Argentina from June 1989 until the DMA contract ended October 1993.

TRANET II HISTORY

The concept for the TRANET II tracking station was first presented in 1975 as a replacement for the aging Tranet stations which had been in operation since 1962. At that time it appeared that Doppler satellite tracking would continue for several more years and electronics were then available to design a station having more capability with lower manning requirements than the existing TRANET stations.

The TRANET II station was originally designed for simultaneous tracking of one Transit and one Geodetic satellite. The station consisted of a receiver for tracking Transit signals on the 150/400 MHz frequency pair, a second receiver for tracking Geodetic signals on the 162/324 MHz frequency pair, a Doppler Processor and Clock with dual channels for simultaneous processing of the Doppler output of either or both of the receivers, a Time Burst Detector which detected fiducial time marks emitted from the Transit satellites at two minute intervals, a rubidium oscillator which provided 1 and 5 MHz reference frequencies, a Frequency and Power Control Unit which monitored the station operating environment and provided buffered sources for the reference frequencies, two Test Sets for equipment testing and calibration, a paper tape punch for recording data for transmission and a PDP 11/V03 computer which controlled the station and provided floppy disk storage for data archiving.

The Continuous Count Integrated Doppler data format was retained and enhanced by providing a software selectable data interval and N sub C which yielded evenly distributed data through each pass while optimizing data density for the end user's requirements versus the cost of data transmission. A major upgrade of the TRANET II stations occurred in 1983 when it was learned that the Geodetic satellites transmitting on the 162/324 MHz frequencies were interfering with radio astronomy observations. The 162/324 MHz pair was abandoned and it was decided that all future Geodetic satellites would transmit on the 150/400 MHz frequencies utilizing a positive offset so they would not interfere with the TRANSIT navigation satellites which were designed with a negative offset.

Hardware modification of the TRANET II stations consisted of increasing the tracking range of the receivers to the positive side of the 150/400 MHz frequency pair, conversion of all of the 162/324 MHz receivers, redesign of the TBD to enable it to decode the full TRANSIT satellite memory, addition of a positive offset capability to the Test Sets and the addition of automatic recording of local weather measurements.

Software modification included complete revision of the TRACK program, addition of on-site alert generation and scheduling capability, aided tracking and post pass analysis capability.

Two versions of post pass analysis were developed. The Quality Analysis Program (QAP) analyzed both timing and Doppler data from TRANSIT satellites. The Timing portion of the analysis provided an average error for the station clock and an RMS error indicating the scatter in the timing points received from a single pass, while the Data portion of the analysis provided two dimensional long track and long range errors based on differences between the known station position and the position determined from the Doppler data points. A Data RMS was also provided which indicated the scatter in the positions calculated from the data points.

The Post Analysis Program (PAP) compared slant range differences from data points to those calculated from the current orbit file for a Geodetic satellite. Orbit elements were then adjusted to minimize the differences between the calculated and observed slant range differences. Updated orbit element sets were saved and became the reference orbit elements for the next pass to be analyzed. Adjustment of the orbit elements was constrained such that no single pass could corrupt the element set to the extent it would be unusable as a reference set for the next pass.

Other significant equipment changes are summarized below with their implementation windows:

Chu antennas replaced linear arrays	1983
PDP-11 CPUs were upgraded from 11/03 to 11/23	1986-1989
Ramdisks were added to PDP-11 systems	1988-1989

SATELLITE DESIGNATIONS

The following listing shows most of the satellites tracked by the SGI Section. Satellites listed O-xx were U.S. Navy navigation satellites. Satellites listed DB-xx were called Geodetic satellites.

1-Common Name
2-Catalog#
3-APL#
4-International#
5-NWL#
6-Launch Date
7-Offset/Frequency(1)
8-Inclination
9-Period(minutes)
10-Apogee/Perigee(NM)
11-Transmissions ended or other information

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1-A					9/59	Did not orbit				
1-B			1960r2		4/60	- BC	51.3	96	402/201	7/60
2-A	00045	60072	1960x1		6/60	- BC	66.7	102	582/338	10/62
4-A	00116	61151	1961o1	30	6/61	-35CZ	67.5	103	540/480	
4-B	00202	61311	1961a1	31	11/61	-78CZ	32.4	105	605/516	8/62
Anna1B	00446	62601	1962bu1	32	10/62	-77BC	50.1	108	642/585	
5A3	00594	63021	196322A	35	6/63	-80 Z	90.1	101	418/392	
5BNl	00670	63031	196338B	36	9/63	-80 Z	89.9	107	609/582	12/63
5E1	00671	63032	196338C	37	9/63	-80 Y	89.9	107	609/582	
5BN2	00704	63041	196349B	38	12/63	-80 Z	90.0	107	598/582	7/65
5E3	00705	63042	196349C	39	12/63	-80CY	90.0	107	598/582	3/64
5C1	00801	03164	196426A	40	6/64	-80 Z	90.6	103	517/459	8/65
BEB	00899	04164	196464A	42	10/64	-80 Y	79.7	105	586/481	
5E5	00959	05264	196483C	43	12/64	-80 Y	90.0	104	582/558	
BEC	01328	01165	196532A	45	4/65	-80 Y	41.0	108	732/506	
0-4	01420	30040	196548C	46	6/65	-80 Z	90.0	107	617/554	1/66
0-5	01514	30050	196565F	47	8/65	-80 Z	90.0	108	642/589	10/65
GeosA	01726	02165	196589A	48	11/65	-50YT	59.4	120	1228/603	6/68
0-6	01864	30060	196509A	49	12/65	-80 Z	89.1	105	488/487	5/66
0-7	01952	30070	196605A	51	1/66	-80 Z	89.1	105	654/467	4/66
0-8	02119	30080	196624A	52	3/66	-80 Z	89.7	105	606/482	2/67
0-9	02176	30090	196641A	53	5/66	-80 Z	89.8	104	526/467	1/67
0-10	02401	30100	196676A	54	8/66	-80 Z	88.9	107	600/564	8/67
D1A	02017	66131	196613A	55	2/66	-200Z	34.0	107	1481/273	French
D1C	02674	67111	196711D	56	2/67	-200Z	40.0	104	730/307	French

1	2	3	4	5	6	7	8	9	10	11
D1D	02680	67141	196714A	57	2/67	-200Z	40.0	110	1020/320	French
0-12	02754	30120	196734A	58	4/67	-80 Z	90.2	106	587/561	
0-13	02807	30130	196748A	59	4/67	-80 Z	89.6	107	598/574	
0-14	02965	30140	196792A	60	9/67	-80 Z	89.3	107	602/559	
GeosB	03093	01168	196802A	63	1/68	-50YT	105.8	112	853/582	
0-18	03133	30180	196812A	64	3/68	-80 Z	90.0	107	618/553	
TimII	04256	00065	196982B	65	9/69	(2)	70.0	103	505/488	
DB-1	04342	00066	197016A	66	3/70	-50 Y	88.0	89	153/97	3/70
DB-2	04405	00067	197040A	67	5/70	-50 Y	83.0	89	143/83	6/70
0-19	04507	30190	197067A	68	8/70	-80 Z	90.0	107	653/520	
DB-3	04721	00069	197098A	69	11/70	-50 Y	83.0	89	126/99	12/70
DB-5	05059	00071	197122A	71	3/71	-50 Y	82.0	89	132/83	4/71
DB-6	05468	00073	197176A	73	9/71	-50 Y	75.0	89	131/84	10/71
Triad	06173	01172	197269A	74	9/72	-84 Z	90.1	101	437/393	4/75
DB-7	06382	00075	197314A	75	3/73	-50 Y	95.7	89	120/85	4/73
DB-8	06727	00076	197346A	76	7/73	-50 Y	96.2	89	154/88	
0-20	06909	30200	197381A	77	10/73	-80 Z	90.2	106	622/480	
DB-9	06928	00078	197388A	78	11/73	-50 Y	97.0	89	153/88	1/74
DB-10	07242	00079	197420A	79	4/74	-50 Y	95.0	89	157/95	
NTS1	07369	00080	197454A	80	7/74	(3)	125.0	469	7436/7262	
DB-11	07495	00081	197485A	81	10/74	-50 Y	97.0	89	162/88	
GeosC	07734	01175	197527A	83	4/75	-50 Y	115.0	102	456/452	1/85
DB-12		00084		84	6/75	-50 Y				7/75
Ap/So	(4)	00085		85	7/75	-50 Y	51.8	88	123/92	7/75
TIPII	08361	30460	197599A	86	10/75	-80 Z	90.4	97	410/300	
DB-13		00087	1975114A	87	12/75	-50 Y	96.2	88	130/85	4/76
DB-14		00088	197638A	88	4/76	-50 Y	63.4	107	659/540	
DB-15		00089	197665A	89	7/76	-50 Y	97.0	88	126/84	9/76
DB-16		00091	197756A	91	6/77	-50 Y	96.9	89	135/85	10/77
Transat	10457	30110	1977106A	93	10/77	-80 Z	89.9	107	595/574	
DB-17	10502	00094	1977112A	94	12/77	-50 Y	63.0	108	616/582	
DB-18	10733	00096	197829A	96	3/78	-50 Y	96.8	89	135/85	7/78
Seasat	10967	00098	197864A	98	6/78	-50 Y	108.0	101	424/422	10/78
DB-19		00101	197925A	101	3/79	-50 Y	96.7	89	140/87	9/79
Magsat	11604	00102	197994A	102	10/79	-50 Y	96.8	93	275/184	6/80
DB-20	11850	00103	198052A	103	6/80	-50 Y	97.9	89	128/122	3/81
Nova	12458	30480	198144A	105	5/81	-84 Z	89.9	109	646/625	
DB-21	13113	00107		107	5/82	-50 Y	97.8	89		10/82
HiLat	14154	00108	198363A	108	6/83	-140Z	97.8	107		
DB-22	14137	00109		109	6/83	-50 Y	97.8	89		3/84
DB-23	86655	00113		113	6/84	80 Z	97.8	89		10/84
Nova	15362	30500	1984110	115	10/84	-84 Z	90.1	109	644/627	
DB-24	86613	00116		116	12/84	80 Z	97.6	97	547/145	10/88

1	2	3	4	5	6	7	8	9	10	11
Geosat	15595	00117	198521A	117	3/85	80 Z	108.0	101	409/409	4/90
0-24	15936	30240	198566A	118	8/85	-80 Z	89.8	108	677/547	
0-30	15935	30300	198566B	119	8/85	-80 Z	89.8	108	681/543	
0-27	18361	30270	1987080A	126	9/87	-80 Z	90.0		635/547	
0-29	18362	30290	1987080B	127	9/87	-80 Z	90.0		635/547	
DB-25	86711	00123		123	10/87	80 Z	98.0	97	548/147	6/92
0-23	19070	30230	1988033A	124	4/88	-80 Z	90.3	108	709/546	
0-32	19071	30320	1988033B	125	4/88	-80 Z	90.3	108	709/546	
Nova	19223	30490	1988052	128	6/88	-84 Z	90.0	108	711/618	
0-25	19419	30250	1988074A	129	8/88	-80 Z	90.0	108		
0-31	19420	30310	1988074B	130	8/88	-80 Z	90.0	108		
DB-26	86785	00131		131	11/88	80 Z	98.0	97	621/186	
POGS		00132		132	4/90	60 Z	89.9	102	466/396	
RADCAL	22698	00226	1993-	226	7/93	80 Z	89.5	107	629/537	

NOTES

(1) Frequency Designators (no sign indicates positive offset)
B...162/216 MHz
C... 54/324 MHz
T...324/972 MHz
Y...162/324 MHz
Z...150/400 MHz

(2) 149.5/399.4 MHz Tracked by selected Tranet I stations

(3) 335/1575 MHz Tracked at selected Tranet sites

(4) Apollo/Soyus Tracked by Tranet I

SUMMARY

The main purpose of the U.S. Navy Transit navigation program was to provide a worldwide, all-weather navigation system for Navy ships. PSL's role began with a few satellite tracking stations in the U.S. and sea tests in the Atlantic Ocean to prove the navigation satellite concept.

Over the years, Doppler data obtained by the worldwide tracking network were used to determine an accurate location of the tracking stations while determining an accurate orbit of the satellite. A new understanding of the earth's geodesy was an inevitable output since the worldwide changes in gravity affected the satellite's orbit and had to be accounted for. The final coordinate system used at the end of the program was WGS-84.

The initial error in the location of either the tracking station or the satellite was approximately 1000 meters using data from only a few stations located in the United States. The error fell to about 100 meters in the mid to late 1960s after the worldwide tracking network was in place. By the mid 1970s, the error had fallen to about 10 meters. From the late 1970s to the end of the program, the accuracy slowly dropped to approximately one-half meter. The accuracy was about 50-100 meters for a slow moving ship.

The maintenance of accurate timing at a tracking station was critical in obtaining good navigation results. WWV or other HF time signals were used in the early 1960s with an accuracy of plus or minus .5 to 1 milliseconds. Stations later used timing signals from the navigation satellites along with prepublished propagation time to obtain accuracies of about 100 microseconds. Time errors decreased to about 10 microseconds after the Tranet II station's software and hardware were modified to obtain station time errors as part of the station's Quality Analysis Program.

The Transit satellite navigation concept was used by a limited number of users because it was a low dynamic system. It could only be used by users at fixed location or users moving very slowly (ships) if reasonable accuracy was expected. It did not provide continuous coverage as there could be delays of one hour or more between fixes.

In the late 1960s the concept for a high dynamic system was conceived, which later developed into the GPS (Global Positioning Satellite) system. The U.S. government's interest was to provide a single navigational system that could be used to navigate a ship or plane and/or to determine a precise location on earth or the satellite's position in space. DMA's specific interest in GPS was to determine if it had geodetic accuracy (one meter error or less) which could be used for point positioning. GPS was approaching this level of accuracy as the TRANET program ended. The initial GPS constellation of 21 satellites was completed in late 1993. The GPS system became extremely popular due to its flexibility and fast navigation results.

Both military and civilian users of navigation satellites have found them indispensable. The satellites are being used for navigation of space vehicles, airplanes, ground vehicles, and ships. They are also being used for ground surveying and point positioning. Navigation satellites now provide worldwide, all weather, continuous coverage. Everyone who worked on the PSL satellite tracking program can be proud of the contribution they made over more than three decades.

PERSONNEL
SGI STAFF MEMBERS

The persons listed below were employed in the SGI Section with two invited "guests" listed first. Much of the location data was from memory and some dates were estimated using E(early), M (mid), or L (late) along with the decade. If the location column is blank, that person worked in Las Cruces.

In most cases, the personnel titles were the last title held.

NAME/TITLE	DATES	LOCATIONS
DR. GEORGE GARDINER Founder of PSL	L40s-E60s	
C.I. RICKETTS Director	M40s-L60s	
Mike Annett Engineer	E60s	Minnesota
Phil Bergman Tech	5/64- 6/65	
Paul Beruff Geodesist	7/88-12/89	
Neil Boutin Tech	7/77- 6/82	Thule,Alaska,Guam
Al Bowers Section Chief	6/59- 6/64	
Larry Bradford Tech	4/89-10/90	Seychelles
Lloyd Branum Engineer	M60s	Thule,South Africa
Bill Bridges Tech	L60s	Thule,Seychelles
Russell Brooks Tech	11/84-11/86	Thule
Pat Brummett Engineer	E60s	Germany,Greece,Spain

NAME/TITLE	DATES	LOCATIONS
Cal Buerkle Supervisor	1/61-12/93	7 Continents
Bill Butko Tech	11/86- 8/92	Ecuador
Larry Cammack Tech	2/64- 8/66	Azores
Don Cramer Engineer	E60s	
Ben Carter Tech	M60s	Samoa,Philippines
Paul Chamberlin Tech	E60s	Samoa,South Africa
Don Coleman Tech	E60s	
Paul Cordery Tech	8/75-9/76	Thule
Oma Creighton Secretary	11/59-3/64	
Naomi Crum Secretary	9/62-7/64	
Bill Dodson Section Chief	6/60-7/65	
George Dodson Tech	6/62-5/66	Brazil,Madeira,Portugal, PMR,Minnesota
Earl Downing Engineer	6/62-8/65	
Bob Ecklund Engineer	12/54-1/89	Argentia,Washington
Larry Edmonson Engineer	5/66-2/67	Antarctica

NAME/TITLE	DATES	LOCATIONS
Handy Fairchild Tech	6/60-7/74	Washington
Don Forrester Engineer	E60s-M60s	Germany,Spain,Greece
Hugh Gardner Engineer	E60s	Argentia
Art Gilcrease Division Mgr.	E60s-L60s	Alaska,California
Gary Glazner Programmer	L70s	
Dave Gose Engineer	3/62-7/66	Brazil,Guam,Okinawa
Florence Gonzales Secretary	7/66- 7/73	
Janet Greenlee Programmer	11/80- 8/83	
Nyle Groth Tech	4/61-10/75	Hawaii,South Africa,PMR
Lonnie Guin Tech	4/79-11/81	
Mack Haley Engineer	8/66- 4/72	Greenland,Brazil,Chile, Easter Island,Ecuador, Afghanistan
James Hankamer Engineer	E80s	
Rick Hardin Programmer	9/76-10/78	
Wayne Harper Engineer	6/61-10/93	South Africa,Antarctica, Japan,Thule,Argentina Hawaii, Seychelles

NAME/TITLE	DATES	LOCATIONS
Kathy Harris Secretary	E60s	PMR
Don Helfrich Tech	3/64- 7/65	Kwajalein,Florida,Sicily, Guam
Ed Hines Engineer	3/64- 6/68	Guam,Ulithi,Koror,Maui, Mexico,Greenland
Cal Hoggard Engineer	E60s-M60s	Alaska,Brazil,Canton, Marcus,Iwo Jima
Fred Hogsett Tech	6/62-10/93	Japan,Guam,Philippines, Alaska,Cyprus,Marshall Islands
Luis Holguin Tech	3/87- 1/88	Seychelles
Jerry Holmes Supervisor	3/65-10/93	Argentia,Chad,Brazil, Palmer,Mexico,Greece, Puerto Rico,Hawaii, Thule,Jan Mayen,Alaska, North Dakota, California
Don Isbell Engineer	E60s-M60s	Brazil,South Africa
Arlen Iverson Tech	4/61- 3/66	NAVOBS
Hugh Johnson Tech	4/62- 3/67	Canton,Marcus,Iwo Jima, Eniwetok,Seychelles, California
Jay Jordan Engineer	6/70- 5/79	Seychelles
Fred Kidd Engineer	E60s	Philippines,Hawaii
Ninfa Kindt Secretary	8/91- 5/93	

NAME/TITLE	DATES	LOCATIONS
Ken Lane Engineer	1/64- 2/67	California,Seychelles, Spain,Ascension,Alabama, Maryland,Mississippi,Canary Islands,Sicily,Norway,Germany
Jim Lawshe Engineer	2/70- 8/71	Afghanistan
Dan Lee Engineer	6/65-12/65	
Dwayne Legg Engineer	6/59- E60s	Australia,Alaska
John Linder Section Chief	1/61-12/93	PMR,APL,Florida
Luis Linggi Tech	1/88- 7/89	Seychelles
Mac Maclaren Tech	E60s	Argentia
Larry Madewell Tech	9/82-10/93	California
Dan Martin Manager	7/60-12/93	Hawaii,PMR,Puerto Rico, Branch Alaska Official visits:Thule, Japan,Philippines,Okinawa,Guam, Samoa,Seychelles, Norway,Denmark,Brazil,New Zealand,Australia
Bjorn Martinez Tech	8/81-12/84 10/85 -6/93	Thule,Seychelles,Guam
Don Martinez Tech	10/77- 8/93	Alaska
June May (Forrester) Secretary	E60s	

NAME/TITLE	DATES	LOCATIONS
Yvonne McClellan Secretary	9/85- 6/90	
Bernie McCune Engineer	6/65- 8/68 2/74- 6/81	Japan,Spain,Seychelles, Alaska,Wyoming,Oklahoma, Argentina,Surinam,Canary Islands,Curacao
Jim McLimans Tech	7/60- 2/82	Brazil,Samoa,Iceland, Wake,Guam,South Africa, Okinawa,Hawaii
Jim Melfi Administrator	6/60- 7/66	
Dave Methvin Engineer	9/61- 2/63	Hawaii
Charles Mullin Tech	7/76-10/93	Guam,Ecuador,Philippines
Rose Nakayama Secretary	2/78- 7/87	
Randy Nelson Engineer	6/81- 8/69	Hawaii,Antarctica,Samoa, Japan,Philippines, Oeno South Africa,Christmas Island
Marvin Nuce Tech	3/70- 8/71	Greenland
Jim Oshel Tech	6/79- 2/80	Thule
Vic Parkerson Engineer	M60s	Samoa,Canton,Kwajalein
Tom Paul Tech	7/88-10/93	Thule, Guam
Tom Perrott Geodesist	5/91- 9/91	

NAME/TITLE	DATES	LOCATIONS
Colman Polvado Engineer	2/64 -7/93	Samoa
Bob Raby Engineer	5/66- 4/72	Kwajalein,Greenland, Faeroes,Argentina
Dan Raby Tech	1/66- 9/69	Norway,Germany
Clyde Robinson Tech	4/80- 2/91	Brazil
Doug Robinson Engineer	9/69- 9/73	Thule
Richard Rudd Engineer	12/59- 9/93	Brazil,Guam,Australia Philippines,Alaska,Canada Ecuador
Rudi Salvermoser Geodesist	7/85-10/93	
Jim Sanders Engineer	12/71- 1/79	Seychelles,Thule
Ed Schmidt Engineer	3/62- 8/93	Canton Island,Hawaii, Eniwetok,Alaska,Canada
Ray Spiller Tech	6/60-11/74	Japan,Brazil,Philippines
Scott Stephens Tech	9/90-7/93	Seychelles
Andy Still Engineer	E60s	
Sadrid Sutton Tech	8/80- 7/82	Thule,Guam
Norman Takashiba Engineer	12/66- 3/72	Thailand,Iran,Iceland, Pakistan,Mauritius, Ethiopia,England

NAME/TITLE	DATES	LOCATIONS
Marco Terrazas Tech	9/77- 4/80	Brazil
Virgil Tharp Tech	9/87- 6/88	Guam
Jim Togami Engineer	9/60- 7/65	Australia,Hawaii
Elvira Torres Secretary	L80s- E90s	
Bart Timbers Administrator	E60s	
Jim Weeks Tech	11/77-12/85	Seychelles
Gerald Welch Engineer	6/61- 2/79	Alaska
Tony Welch Tech	3/69- 2/72	Thule
Hal Wetter Supervisor	6/64-10/93	NAVOBS,Greenland,Alaska, Chad,Portugal,Oeno, Senegal,Greece,Azores, Madeira,Faeroes, Christmas Island,Florida, North Dakota,California, Nevada
Cathy Wiley Tech	5/91-10/92	Brazil
Rick Williams Systems Analyst	1/86-10/93	
Ed Wooff Engineer	2/61- 5/67	Philippines,South Africa, Japan
Bud "Gunner" Wyman Co-op Coordinator	1/63- 1/80	Samoa,Alaska

NAME/TITLE	DATES	LOCATIONS
Bob Yarbrough Engineer	E60s	Washington

SGI CO-OPERATIVE EDUCATION STUDENTS

Approximately 1,005 co-operative education (co-op) students began the SGI satellite tracking program in its 35 year existence, and about 832 actually went on at least one work phase (WP).

Several co-ops were trained by SGI, then transferred to other sections within PSL during the 1960s and early 1970s. Their training and WP expenses were paid by other PSL contracts, most of which were funded by NASA. The co-op assignments were at telemetry stations at Cape Canaveral, Kwajalein, Vandenburg AFB, and Wallops Island.

The co-op program existed long enough to become multigenerational, with five cases of father/son or father/daughter in the program. These cases are indicated with asterisks after the names.

The following table shows the percentage of co-ops that were on each WP. The left-hand column under percentage is based on the total number of co-ops who started in the program. The right-hand column is based on the co-ops who actually went on WP.

Work Phase	Percentage	
0	17.1*	---
1	82.9	100.0
2	51.9	62.6
3	24.4	29.5
4	4.8	5.8
5	.4	.5

* The number of co-ops that never went on a WP was largely due to poor academic records.

The next table shows the percent of co-ops in each major, based on their declared major when they started in the program.

Major	Percentage
Engineering	
Electrical	46.9
Mechanical	18.7
Chemical	9.9
Mathematics	6.3
Physics	4.4
Computer Science	2.2
Arts & Sciences	1.8

It is estimated that approximately 65-70 percent of the SGI co-ops graduated from NMSU.

The name of each known co-op follows, along with the year he/she started the program, his/her major (if known), and the number of WPs. Although every effort was made to list each co-op, undoubtedly a few names are missing. There were no records kept prior to late 1960, and some information was obtained from people with good memories.

SGI CO-OP STUDENTS

	NAME	YEAR STARTED	MAJOR	WORK PHASES
1				
2	ABEYTA, ALEJANDRO R.	77		0
3	ACCETTA, VITO W.	64	EE	2
4	ADAMS, DONALD	75	EE	1
5	AKINS, GERRY A.	71	EE	3
6	ALBRIGHT, DENNIS	62		0
7	ALDRIDGE, RICHARD W.	61	EE	3
8	ALLEN, BLAISE	90	ETE	2
9	ALLEN, JERALD G.	69	PHYS	1
10	ALLRED, RICHARD	84	EE	1
11	ANDERSON, PAUL B.	70	PHYS	2
12	ANGELL, LAURIE	81	WLSC	4
13	APODACA, HECTOR H.	72	EE	1
14	ARCHER, JAMES O.	61	ME	2
15	ARCHULETA, JOSEPH	72	CE	1
16	ARCHULETA, EDMUND	60	CE	3
17	ARMER, TIM	85	CHE	2
18	ARMER, THOMAS	71	CHE	2
19	ARMSTRONG, JAY	78		0
20	ARMSTRONG, MIKE	87	PHYS	2
21	ARNOLD, ROCKLAND A.	68	ME	3
22	ARNOLD, FRANKLIN B.	70	EE	1
23	ARRIETA, ARMANDO R.	74	AGE	0
24	ATMAR, JOE W.	63	EE	3
25	AUSTIN, DUNCAN A.	77	ME	3
26	AUSTIN, JON H.	70	ME	0
27	AVALOS, GEORGE	70	CE	3
28	AVANT, IRA M.	70	EE	1
29	BAILEY, BOBBY P.	61	MATH	2
30	BAIRD, BENJAMIN T.	62	EE	3
31	BAKER, DAVID C.	67	EE	2
32	BALDOCK, LESLIE	66	MATH	0
33	BALL, LARRY D.	66	EE	3
34	BALLARD, JOHN	63		0
35	BALLEW, JOHN Z.	68	ME	1
36	BANKS, DAVID P.	63	EE	2
37	BARLOW, JOHN	63		0
38	BARNARD, ROBERT L.	63	EE	2
39	BARNES, TED	65	CHE	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
40	BARRETT, RONALD	61		0
41	BARRETT, RICHARD	65	ME	2
42	BARRETT, ROBERT	62		0
43	BARRETT, DENNIS	61		0
44	BARRICK, LARRY M.	65	EE	2
45	BARROS, PHILLIP A.	60	EE	3
46	BATTON, DONALD E.	66	ME	2
47	BEALL, THOMAS M.	68	CHE	2
48	BEENE, GREGORY L.	69	MATH	0
49	BELL, MICHAEL	66	EE	1
50	BELTRAN, PEDRO L.	71	CHE	1
51	BEMIS, DONALD A.	70	EE	1
52	BENAVIDEZ, RAYMUNDO B.	62	EE	3
53	BENEDICT, GREGORY	76	EE	2
54	BENNETT, WILLIAM S.	67	PHYS	2
55	BENNETT, CHARLES	72	CHE	3
56	BENTLEY, RADEL L.	81	CHE	1
57	BERRETT, PATRICK L.	68	PHYS	2
58	BIGBEE, JOHN D.	62	ME	3
59	BIGGS, DAVID L.	80	CHE	1
60	BINNING, DAVID	60		0
61	BIRKENSTOCK, JESSE	62	PHYS	3
62	BLANN, DALE R.	63	ME	1
63	BLANTON, BERT H.	60	ME	3
64	BLUM, CURTIS	74	CE	4
65	BODNER, HOWARD	67	ME	1
66	BOGGS, DAVID L.	72	ME	2
67	BOLDRA, GARY	66	EE	1
68	BONESTEEL, DAN H.	66	ME	2
69	BOYCE, JOHN T.	69	ME	1
70	BRACK, WILLIAM S.	67	MATH	2
71	BRADDI, LOUIS	76	CE	3
72	BRADT, DAVID	76	ME	3
73	BRAITHWAITE, GENE	65		0
74	BRISENO, RAUL	62	EE	1
75	BRISENO, DAVID R.	74	EE	0
76	BRITO, DAVID	59	EE	2
77	BROWN, ROBERT N.	68	ME	2
78	BROWN, HOWARD	66	CE	1
79	BROWN, JOHN L.	62	CE	3
80	BROWNING, GEORGE	62		1
81	BROWNSON, ROLLIN	63	ME	3

	NAME	YEAR STARTED	MAJOR	WORK PHASES
82	BRUCE, LEROY B.	69	PHYS	1
83	BRUNER, RICHARD K.	60	EE	3
84	BRUTON, WILLIAM L.	63	EE	3
85	BUCHENAU, BERNIE E.	61	MATH	2
86	BULLOCK, VAN A.	67	ME	2
87	BULLOCK, JOE S.	67	ME	2
88	BUNKER, BEN	61		0
89	BUNTEN, BYRON L.	65	EE	3
90	BURCH, ROGER G.	67	EE	2
91	BURCH, GARY	65	EE	2
92	BURCKHARDT, EDWARD	60	EE	3
93	BURKE, FRANK T.	69	ME	0
94	BURNETT, WILLIAM	61		0
95	BURNETT, MICHAEL T.	69	CHE	0
96	BURNS, MICHAEL D.	69	PHYS	0
97	BURNS, DENNIS	61	CHE	3
98	BURSTEIN, DAVID	66	CE	3
99	BURTNER, WILLIAM	66	EE	1
100	BUSH, GEORGE W.	66	ME	3
101	BUTLER, HOWARD P.	69	EE	1
102	BYNUM, GAITHER	61	PHYS	3
103	BYRD, WALLACE	60	EE	1
104	CAMACHO, ISAAC	70	ME	1
105	CAMPBELL, CHRISTOPHER	79	CE	3
106	CAMPBELL, CLYDE	66	CHE	1
107	CAMPBELL, STEPHEN	76	CE	3
108	CAMPBELL, JOE	83	CE	3
109	CAMPBELL, DAVID L.	84	ME	3
110	CAMPBELL, HARLEN J.	62	MATH	1
111	CAMUNEZ, KEVIN	76	CE	1
112	CARL, ROGER	66	CHE	1
113	CARPENTER, KEN H.	65	EE	2
114	CARR, BILL	91	EE	2
115	CARRICK, JOHN C.	61	EE	2
116	CARROLL, RICHARD T.	69	MATH	0
117	CARSEY, THOMAS P	63	A&S	3
118	CARTER, GARRETT M.	61	EE	3
119	CASTILLO, ROBERT	71		0
120	CERVIN, MICHAEL	61	EE	1
121	CHAMBERLAIN, TERRY	74	ME	1
122	CHAMBERS, RICHARD L.	65	CHEM	3
123	CHAMPIE, CLARK L.	69	EE	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
124	CHANDLER, LARRY W.	70	CHE	1
125	CHANDLER, LARRY N.	66	EE	2
126	CHAPMAN, WILLIAM G.	72	EE	1
127	CHATFIELD, MARK M.	63	ME	2
128	CHAUVIN, RONALD	61		0
129	CHAVEZ, SOLOMAN	61	EE	1
130	CHAVEZ, ERNEST J.	70	CE	1
131	CHEGLIS, CHARLES	66	EE	1
132	CHOWNING, RAY E.	64	EE	3
133	CHRISTENSEN, COY	87	EE	2
134	CHRISTIAN, DAVID L.	64	ME	0
135	CHUMBLEY, JAMES F.	63	ME	2
136	CHURCH, ROBERT	61	EE	1
137	CLARK, DONALD	76	ME	2
138	CLIFTON, DONALD	66	MATH	0
139	COINMAN, WILLIAM M.	60	CE	2
140	COLBERT, GILBERT L.	68	EE	1
141	COLE, RONALD C.	64	EE	0
142	COLEMAN, MICHAEL	61	EE	4
143	COLEMAN, WILLIAM	66	PHYS	2
144	COLLINS, STEPHEN L.	67	EE	3
145	COLLINS, ERIC	90	ME	1
146	COLWELL, RONALD G.	67	MATH	3
147	COMPARY, ROCKNE J.	69	ME	2
148	COOK, PAUL D.	82	EE	1
149	COOLEY, DAVID B.	73	BA	1
150	COOPER, ROGER	73	EE	1
151	COOPER, DENNIS	64	EE	2
152	CORBIN, CLINTON	89	EE	3
153	CORNETT, FRANK N.	66	EE	1
154	CORPENING, LOUIS J.	92	EE	1
155	COULTER, JAMES C.	68	EE	2
156	COUSINEAU, STEVE	83	ME	1
157	COWAN, TROY E.	67	EE	2
158	COX, STEPHEN	65	MATH	1
159	CRAIG, RAYMOND B.	73	MATH	1
160	CRAWLEY, RICHARD	61		0
161	CREERY, RICHARD H.	80	WLSC	1
162	CREWS, MARK	73	CE	1
163	CROSS, MICHAEL D.	67	EE	1
164	CROWELL, MAX E.	60	EE	3
165	CRUME, LARRY	67	EE	0

	NAME	YEAR STARTED	MAJOR	WORK PHASES
166	CRUME, BARRY E.	74	EE	1
167	CULLUMBER, JOHN S.	69	EE	0
168	CUMMINGS, LARRY B.	70	CHE	2
169	CUNNINGHAM, SAMUEL L.	63	EE	1
170	CUNNINGHAM, DALE J.	71	CE	1
171	CUNNINGHAM, LARRY E.	65	EE	3
172	CUNNINGHAM, ROBERT	68	EE	2
173	CURRY, CHARLES	80	EE	1
174	CURRY, DAVID B.	68	EE	1
175	CURRY, RONALD L.	65	EE	3
176	DAHLGREN, STEVEN P.	67	EE	1
177	DANIEL, WILLIAM H.	69	ME	2
178	DANIEL, ROBERT M.	67	ME	2
179	DAVALOS, SERGIO V.	68	EE	1
180	DAVILA, JOE	60	EE	2
181	DAVIS, JERRELL K.	68	CE	1
182	DAVIS, JEREMIAH W.	70	CHE	2
183	DAVIS, ROY L.	69	EE	0
184	DAVIS, JON E.	76	ME	2
185	DAVIS, JERRY	70		0
186	DAVIS, JUDSON	62		0
187	DAWSON, COLIN	90	CS	1
188	DAY, ROBERT T.	62	ME	2
189	DAY, LARRY	59	CE	2
190	DE FRANK, KAREN A.	79		0
191	DE LA RUE, TIM	80	ME	2
192	DEANS, JOHN	66	EE	1
193	DEBO, FRED	62		0
194	DEHAVEN, RUSSELL A.	60	EE	4
195	DEMOULIN, DON	59	EE	0
196	DENNIS, RONALD N.	63	MATH	0
197	DENNIS, DAVID R.	65	ME	2
198	DENNISON, ARNOLD	64	PHYS	0
199	DENNY, GERALD W.	74	PHYS	0
200	DENZLER, DAVID W. R.	60		0
201	DERBY, JERRY L.	60	ME	4
202	DESHAZO, GARY	72	EE	3
203	DEWLEN, GERALD E.	69	EE	1
204	DICK, STEPHEN	71	CE	4
205	DICK, RICHARD L.	61	EE	4
206	DIETZMAN, WILLIAM B.	66	EE	3
207	DILLARD, RICHARD D.	66	CE	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
208	DILLON, ROBERT A.	63	EE	2
209	DIMSHA, STANLEY J.	63	EE	1
210	DIMSHA, ALAN	64	EE	2
211	DINTELMAN, ROBERT L.	68	EE	1
212	DITTMER, JIM	61		0
213	DOTTS, RICHARD IRWINS	63	ME	0
214	DOUGAL, MICHAEL K.	82	EE	1
215	DOWNEY, LEWIS	66	EE	1
216	DOWNING, EARL	59	EE	1
217	DREIBELBIS, DONALD	64	ME	2
218	DUARTE, RICARDO	82	CHE	1
219	DUGGAN, MICHAEL T.	65	MATH	3
220	DUNLAP, ROBERT A.	61	EE	3
221	DUNN, DENZIL R.	69	EE	0
222	DURAN, STEVE	86	EE	3
223	DURSCHLAG, JAMES C.	64	A&S	1
224	DWYER, DENNIS	61	EE	2
225	EAGAN, STEVEN	70	CE	1
226	EBY, THOMAS L.	67	ME	1
227	ECKHARD, RALPH	59	EE	1
228	EDMONDS, CLAUDE	63		0
229	EDMONDSON, BILLY	63	MATH	0
230	EDMONSON, LARRY D.	60	EE	1
231	EDWARDS, JAMES E.	71	CE	3
232	EGER, RICHARD F.	63	A&S	2
233	EGGLESTON, JAMES H.	69	EE	1
234	ELLSBURY, WALTER	68	EE	0
235	ELMS, DERYL L.	68	CHE	1
236	EMERSON, ASHER D.	68	CHE	2
237	ENGLE, ROGER E.	65	EE	1
238	ENGLE, EDWARD J.	80	CHE	2
239	ENSEY, BRUCE M	71	MATH	4
240	ERB, MARK	73	EE	2
241	ESPINOSA, ORLANDO G.	80	CE	1
242	ESQUIVEL, MICHAEL	90	EE	2
243	ESTES, DASHA	79	EE	1
244	ESTES, GLENN H.	66	EE	3
245	ESTES, TROY J.	81	EE	1
246	EVANS, DANIEL	65	MATH	2
247	EVERETT, SCOTT R.	77		0
248	EWING, MARK	75		0
249	EYER, MICHAEL W.	63	EE	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
250	EYER, HAROLD H.	60	EE	4
251	FAGOT, MARTIN	60	EE	3
252	FAHNERT, JOSEPH A.	68	CHE	0
253	FALKENSTEIN, RICHARD	72	A&S	2
254	FARRAR, ROGER W.	83	EE	1
255	FASEL, JOSEPH H.	67	A&S	3
256	FENZI, KEVIN R.	87	EE	1
257	FINKBEINER, WALTER	62	CE	4
258	FINN, DENNIS A.	66	MATH	1
259	FISHER, DAVID L.	66	CHE	2
260	FISHER, RONNIE W.	64	EE	4
261	FISHER, ROBERT	64	PHYS	4
262	FITZPATRICK, DAVID	60	EE	3
263	FLEMING, WILLIAM	59	EE	0
264	FLEMING, CHARLES S.	70	CHE	1
265	FLORY, MICHAEL R.	69	ME	0
266	FOLLMER, SCOTT P.	85	EE	2
267	FORD, CURTIS D.	75	EE	2
268	FOSHEE, JOHN F.	80	EE	1
269	FOWLER, JOHN	65	EE	1
270	FRANKFATHER, WILLIAM	62		0
271	FRANKLIN, NELSON M.	64	CE	3
272	FRANZMEIER, WILLIAM E.	64	EE	2
273	FRAZIER, MICHAEL	69	MATH	0
274	FREEMAN, BURTON	66	EE	2
275	FRENCH, DENNIS	68	ME	0
276	FRUSTERE, MICHAEL	62		0
277	FULKERSON, BENJAMIN	69	ME	1
278	FUTRELL, RAYMOND	60	EE	4
279	GAFFORD, DAYLA	74	EE	1
280	GAINER, JOHN	64	A&S	0
281	GALLIVAN, JAMES	62		0
282	GALVAN, JOSE C.	69	EE	0
283	GAMBLE, STEVE	70	CHE	4
284	GAMON, JOSE	73	EE	2
285	GANDARA, ARTURO	62	EE	3
286	GARCIA, RAYMOND M.	71		0
287	GARCIA, CHRIS	86	CS	3
288	GARCIA, DANIEL	84	EE	2
289	GARCIA, RAUL	76	EE	3
290	GARDNER, STEPHEN S.	67	ME	2
291	GARNER, STEPHEN P.	69	EE	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
292	GARNER, JAY	89	EE	2
293	GASTON, GLENN B.	69	EE	0
294	GAULTNEY, JAKE R.	68	EE	1
295	GAUME, ARTHUR N.	66	EE	2
296	GAYLORD, TODD	91	EE	1
297	GEMOETS, RICHARD S.	62	MATH	2
298	GILBERT, JESSE R.	68	CHE	0
299	GILBERT, MARK	85	CS	2
300	GILDON, LARRY	61		0
301	GILES, JERRY	90	ET	2
302	GILL, WALTER	64	ME	4
303	GILL, JAMES F.	66	ME	2
304	GILMAN, GARRY	61		0
305	GIRARD, PHILLIP A.	65	EE	3
306	GISLER, GARY L.	70	ME	4
307	GLEGHORN, RONALD R.	68	EE	2
308	GOLDEN, BOBBY A.	70	EE	0
309	GOMEZ, ROBERT	75		0
310	GOMEZ, EDWARD	68	EE	1
311	GONZALEZ, XAVIER	72	EE	3
312	GOODWIN, MICHAEL	84	FIN	3
313	GOULD, JEFFREY A.	67	EE	2
314	GRAGG, KERRY M.	70	ME	1
315	GRAHAM, RANDY S.	81	WLSC	1
316	GRAHAM, BEN	61		0
317	GRANDLE, STEVEN	73	EE	1
318	GREAVES, LLOYD	66	EE	1
319	GRIFFIN, MICHAEL	83	EE	3
320	GRISSOM, GLEN	72	EE	3
321	GROSS, STANLEY R.	71	ME	1
322	GROSS, PAUL	86	EE	1
323	GRUBAUGH, ELSTON K.	71	AGE	1
324	GUINN, ROGER W.	69	ME	1
325	GUTIERREZ, ALFONSO	70		0
326	HADLEY, BONNER	61	ME	1
327	HAFEN, BLAINE	66	ME	0
328	HAGGUIST, RONALD F.	65	CHE	1
329	HAGLER, BOBBY G.	69	CE	3
330	HAILES, JOHNNY E.	69	CE	0
331	HALEY, MACK W.	61	CE	3
332	HALL, BILL	90	EE	1
333	HALL, THOMAS	65	ME	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
334	HALL, BRUCE	65	PHYS	0
335	HALL, SCOTT A.	67	EE	2
336	HAMMERS, EDWARD M.	73	ME	1
337	HANCOCK, BILLY G.	81	CHE	1
338	HANKAMER, MICHAEL	62	EE	2
339	HANKAMER, JAMES	62	PHYS	4
340	HANSEN, ROBERT K.	65	EE	3
341	HANSEN, MICHAEL	81	EE	0
342	HANSON, WESTY B.	69	EE	1
343	HARDEE, NICOLE	92	ME	1
344	HARDIN, RICHARD B.	69	PHYS	2
345	HARKEY, DANIEL	71	EE	4
346	HARRELSON, WILLIAM M.	67	MATH	1
347	HARRIS, ALTON	83	ME	3
348	HARRIS, WESLEY	65	BA	1
349	HARRISON, THOMAS	65		1
350	HARRISON, JAMES 0.	62	EE	2
351	HARTLE, RICHARD W.	75	EE	3
352	HAVENER, PATRICK C.	71	EE	2
353	HAY, THOMAS F.	68	CHE	1
354	HAYENGA, CRAIG 0.	70	A&S	3
355	HEAD, STUART R.	76	EE	3
356	HEAD, JAMES	84	AGE	2
357	HEATHMAN, KENNETH	65	ME	1
358	HEATON, WILLIAM B.	70	EE	0
359	HEATWOLE, ERIC	90	PHYS	0
360	HECHART, CHARLES C.	67	BIOL	3
361	HEIDENREICH, GARY L.	67	CE	2
362	HEINE, PAUL R.	78	EE	1
363	HENDERSON, MARK S.	69	MATH	1
364	HENDRIX, RICKEY	75	ME	0
365	HEPP, RICHARD	73	ME	3
366	HERRING, GREG D.	73	EE	2
367	HEYSER, RICHARD G.	64	CHE	1
368	HIGHTOWER, STEVE	71	A&S	3
369	HILL, GREGORY N.	67	EE	2
370	HILL, JAMES	67	EE	0
371	HILL, RICHARD W.	63	PHYS	2
372	HINDERER, JOE E.	70	IE	3
373	HINE, BART L.	72	EE	2
374	HINES, DENNIS E.	66	EE	2
375	HINKLE, MARK	90	EE	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
376	HIRTH, WILLIAM B.	69	EE	1
377	HOBART, GERALD K.	60	PHYS	2
378	HOBBS, STEVE P.	86	ME	2
379	HODGE, JESSE L.	63	EE	3
380	HOFER, SCOTT	91	EE	1
381	HOFER, CHRIS	87	EE	2
382	HOFFMAN, CARL	62		1
383	HOLLIDA, TINA M.	77	CHE	2
384	HOLLIDA, SONYA F.	78	CHE	2
385	HOLLOWAY, CHALMER O.	69	ME	2
386	HOLMES, VICTOR P.	64	EE	2
387	HOLMES, GERALD	59	ME	3
388	HONEYCUTT, JAMES B.	67	CE	1
389	HOOCK, DONALD W.	65	MATH	3
390	HOOVER, GARY W.	68	ME	3
391	HOPPER, ROY H.	66	EE	1
392	HORN, DELMER	61		0
393	HORTON, STEVEN L.	65	EE	2
394	HORTON, STANLEY K.	67	EE	1
395	HOWELL, DAVID R.	63	PHYS	3
396	HOWELL, RAYMOND E.	69	EE	2
397	HUCHINGSON, JOHN D.	64	EE	0
398	HUDSON, WILLIAM V.	63	EE	3
399	HUDSON, SHARON E.	77	CHE	1
400	HUFF, KURT E.	81	ME	2
401	HUFF, GARY B.	63	ME	2
402	HUME, ROBERT B.	60	MATH	3
403	HUMPHREY, RONNIE K.	67	ME	0
404	HUMPHRIES, LISA D.	85	PHYS	3
405	HUNT, BRIAN	86	EE	2
406	HUZDOVICH, JAMES	61		1
407	IBARRA, JOSE G.	69	EE	1
408	INGEROI, SONJA	87	CE	1
409	INGRAHAM, GREGORY M.	76	EE	0
410	IVES, HARRY	68	ME	1
411	IVES, BERRY C.	66	EE	3
412	JACKSON, PELHAM L.	66	PHYS	3
413	JAEGER, DWIGHT L.	60	ME	3
414	JAKEWAY, BILL B.	66	ME	2
415	JAMESON, DOUGLAS L.	65	EE	1
416	JANKOWSKI, JEFF	85	EE	1
417	JAQUEZ, JOHN N.	71	EE	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
418	JEFFERS, PATRICK A.	74	EE	2
419	JEFFERS, EDWARD A.	69	EE	2
420	JENSEN, ROBERT S.	70	MATH	2
421	JENSEN, ROBERT E.	62	EE	4
422	JENTGEN, LAWRENCE A.	67	EE	4
423	JETER, BOBBY, M.	66	ME	3
424	JIMENEZ, DAVID	75	ME	0
425	JOHN, RICHARD	65	EE	2
426	JOHNSON, ANTHONY R.	65	EE	0
427	JOHNSON, RUSSELL A.	67	EE	1
428	JOHNSON, ED	60	EE	4
429	JOHNSON, JOHN ALVIN	69	ME	3
430	JOHNSON, JOHN M.	74	ME	3
431	JOHNSON, ROBERT W.	81	CS	2
432	JOLLEY, WARREN R.	66	ME	0
433	JONES, DANIEL C.	69	EE	1
434	JONES, CHARLES W.	66	EE	1
435	JONES, THOMAS J.	62	EE	2
436	JONES, WILLIAM R.	66	MATH	1
437	JONES, RONALD W.	65	EE	2
438	JORDAN JAY B.	65	EE	2
439	JOURDAN, RICHARD E.	66	EE	2
440	KEIZER, RICHARD P.	67	CE	2
441	KELLY, KEVIN J.	63	MATH	3
442	KENNEDY, WILLIAM D.	67	ME	0
443	KENNEDY, WILLIAM B.	61	EE	3
444	KERNAN, DAVID P.	69	IE	2
445	KEW, BILL	86	ME	1
446	KILCREASE, JAMES P.	68	CHE	1
447	KING, STEPHEN R.	64	MATH	3
448	KING, DAVID L.	67	EE	3
449	KING, DAVID A.	78	EE	1
450	KING, KENDALL J.	66	PHYS	2
451	KING, JAMES	66		0
452	KIRKPATRICK, ROBERT E.	65	CHE	2
453	KNAUF, KIM B.	64	ME	2
454	KNAUF, RANDALL J.	66	ME	2
455	KNORR, JOHN A.	68	MATH	2
456	KNORR, DANIEL	61	EE	1
457	KOELTZOW, LONNIE R.	68	CHE	2
458	KORZEKWA, KEN R.	76	CHE	3
459	KOTOVSKY, STANLEY K.	68	EE	1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
460	KUMPUNEN, HENRY R.	67	EE	1
461	LACKEY, ALVA J.	67	EE	1
462	LAMB, MICHAEL D.	63	EE	3
463	LAMBETH, WILLIAM L.	77	EE	0
464	LAMBSON, MAXWELL	61		0
465	LAMM , ROBERT A.	82	CHE	0
466	LANCE, JAMES D.	67	EE	0
467	LANGHAM, RANDALL D.	68	IE	3
468	LANGLEY, BRITTON R.	69	PHYS	1
469	LANNING, RICHARD L.	68	EE	1
470	LAPOINT, JOE	62		0
471	LARA, JOE M.	66	ME	0
472	LARA, JAMIE R.	84	EE	0
473	LAREY, JAMES	61		0
474	LARSON, KENNETH	60		0
475	LARSON, JAMES K.	68	ME	1
476	LAWSHE, BARRETT C.	70	EE	1
477	LAWSHE, JAMES S.	66	EE	2
478	LEDOUX, LEE F.	78	CE	1
479	LEDOUX, HERMAN C.	77		1
480	LEE, MICHAEL C.	68	MATH	1
481	LEE, JACK	60		0
482	LEESON, MARK W.	71	CE	0
483	LEGG, GARY D.	64	EE	3
484	LEIGHTON, ROY D.	78	EE	2
485	LEMONS, DON S.	67	PHYS	2
486	LEMONS, MICHAEL A.	65	EE	3
487	LEMONS, PATRICK R.	67	ME	3
488	LESLIE, LONNIE L.	67	ME	1
489	LESLIE, DON	61		1
490	LEWIS, DAN C.	68	CHE	1
491	LILLIEBJERG, ERIK M.	85	EE	3
492	LIND, DAVID	62		0
493	LINDER, JOHN	86	EE	1
494	LINDSEY, GARY F.	62	ME	4
495	LITTLE, WILLIAM W.	61	CE	2
496	LOCKWOOD, JAMES D.	65	ME	3
497	LONDON, WILLIAM D.	77	CE	0
498	LONG, ABRAHAM	75	IE	1
499	LONG, ROBERT J.	76	A&S	1
500	LONG, ED	84	CE	1
501	LOPEZ, CHRIS	91	EE	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
502	LOPEZ, ROBERT	88	EE	3
503	LOPEZ, DAVID E.	65	EE	1
504	LOWE, JIM B.	68	MATH	1
505	LOWERY, KIMBERLY *	85	CS	2
506	LOWERY, GENE E. *	64	EE	1
507	LUSK, DANIEL G.	69	ME	2
508	LYDICK, ROBERT C.	67	CE	2
509	LYLE, TERRY A.	71	EE	1
510	MAAG, JOHN A.	61	CE	4
511	MAC CALLUM, GREGORY J.	76		0
512	MACKIE, MARK D.	84	ME	3
513	MADRID, CHARLES	61	MATH	3
514	MAGEE, PAUL	62	ME	3
515	MAGILL, PATRICK F.	67	CE	2
516	MAIN, KENNETH E.	66	CE	2
517	MAISANO, FRANK	90	EE	1
518	MANES, TODD	82	EE	1
519	MANN, JOHN L.	62	EE	1
520	MANNING, CARL	59	EE	1
521	MARACCHINI, DAVID J.	62	EE	2
522	MARKER, CARL	80	CHE	2
523	MARQUEZ, MARK A.	73	EE	2
524	MARTIN, MICHAEL D.	60	ME	3
525	MARTIN, JOSEPH A.	66	EE	0
526	MARTINEZ, BENNY	74	EE	0
527	MARTINEZ, WILLIAM D.	75	EE	3
528	MARTINEZ, LOUIS J.	63	MATH	1
529	MARTINEZ, RONALD D.	69	CHE	2
530	MASCHEK, THOMAS D.	66	MATH	3
531	MATHEWS, JAMES	61	ME	1
532	MATHIS, STEPHEN	61		0
533	MATLOCK, STEVE	90	EE	1
534	MATLOCK, ROGER L.	60	ME	3
535	MAURTUA, JUAN	78	EE	2
536	MAXWELL, JAMES H.	64	EE	4
537	MAYNES, ROBERT	62	EE	1
538	MAYO, STEVE J.	64	ME	0
539	MCAFEE, MICHAEL D.	65		0
540	MCBRAYER, GARY L.	75	CHEM	2
541	MCCARTER, LAWRENCE A.	64	ME	3
542	MCCLAIN, JIM	87	CE	3
543	MCCLENDON, EDWARD D.	67	EE	0

	NAME	YEAR STARTED	MAJOR	WORK PHASES
544	MCCONNELL, KEITH	84	BIO	3
545	MCCREADY, KEM E.	75	CHE	2
546	MCDANIEL, JAMES R.	63	MATH	3
547	MCDANIEL, MICHAEL L.	65	EE	3
548	MCDANIEL, ROGER	61		1
549	MCENDREE, STEVEN R.	76	EE	4
550	MCENDREE, CHARLES A.	63	EE	2
551	MCENTYRE, MAURICE N.	69	MATH	2
552	MCGINNIS, PAUL E.	67	ME	1
553	MCGOUGH, PHILLIP W.	68	EE	0
554	MCGRATH, PATRICK W.	70	EE	0
555	MCGREGOR, SCOTT	80	EE	1
556	MCILHANEY, SAM F.	63	CHE	3
557	MCKEEVER, BRUCE A.	63	EE	2
558	MCKINNEY, ROY F.	69	ME	1
559	MCLAUGHLIN, GLENN	82	PHYS	2
560	MCLEOD, JAMES	62		0
561	MCNABB, CHRISTOPHER T.	84	EE	2
562	MCNAIR, WILLIAM W.	66	PHYS	1
563	MCNEIL, STEPHEN L.	69	PHYS	0
564	MCPHEETERS, RICHARD E.	65		0
565	MCVAY, MICHAEL C.	68	MATH	0
566	MCWILLIAMS, MICHAEL	77	CE	1
567	MEIER, RON *	88	EE	2
568	MEIER, CLIFFORD M. *	62	ME	2
569	MELFI, WILLIAM J.	60	EE	4
570	MERKINS, ROBERT K.	75	EE	3
571	METCALF, BRADLEY G.	66	EE	3
572	MEYERS, KENNETH L.	79	EE	1
573	MICHAUD, VICTOR	85	EE	5
574	MICHNOVICZ, MARGARET	84	MATH	2
575	MICHNOVICZ, ANDREW T.	70	A&S	2
576	MILAKOVICH, RYAN	91	CE	1
577	MILLER, MARKUS L.	69	ME	0
578	MILLER, BRUCE D.	64	ME	2
579	MILLER, DANIEL R.	61	EE	3
580	MILLER, JIMMY H.	63	CE	0
581	MILLS, LEONARD A.	64	EE	1
582	MINNEHAN, BURKE F.	66	ME	2
583	MINNICK, DON	83	CE	3
584	MINYARD, WAYNE A.	74	IE	2
585	MINYARD, JANET M.	78	A&S	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
586	MITCHELL, LOGAN	91	CE	1
587	MITCHELL, MARSHALL W.	69	EE	1
588	MOHR, ROBERT C.	68	EE	0
589	MONDRAGON, JOE	85	ME	4
590	MONTEITH, JEFF	85	ACCT	2
591	MONTES, RICARDO	74	EE	1
592	MONTGOMERY, DAN C.	65	EE	1
593	MONTMAN, JAMES H.	66	ME	2
594	MONTOYA, GILBERT L.	66	CHE	1
595	MONTOYA, GEORGE P.	63	ME	2
596	MOON, DENNIS R	64	MATH	2
597	MOON, DAVID T.	68	MATH	1
598	MOORE, WAYNE E.	63	EE	2
599	MOORE, BRUCE P.	64	CHE	2
600	MORAN, MARK B.	68	ME	1
601	MORAN, RAY O.	66	ME	2
602	MORAN, RALPH G.	70	EE	3
603	MOREHART, THOMAS	61	EE	1
604	MORGAN, DAVID	73	EE	1
605	MORGAN, WENDELL E.	67	ME	3
606	MORGAN, THOMAS P.	69	CHE	3
607	MORGAN, JAMES P.	65	CHE	1
608	MORRIS, STEVEN	81	EE	2
609	MORRISON, ROY K.	74	CS	0
610	MORRISON, WILLIAM A.	69	CHE	2
611	MOULDER, MICHAEL	59	EE	2
612	MOUNT-CAMPBELL, CLARK A.	60	MATH	3
613	MUELLER, LARRY M.	62	EE	3
614	MUELLER, ROBERT L.	62	EE	1
615	MURPHY, BRIAN *	89	EE	2
616	MURPHY, JACK P. *	62	ME	2
617	MURPHY, ROBERT L.	64	ME	3
618	NAIVAR, CHRISTOPHER	84	CS	3
619	NAYLOR, JAMES L.	68	MATH	2
620	NELSON, JOHN L.	61	ME	2
621	NEVAREZ, JOSE G.	77	EE	1
622	NEVAREZ, ALFREDO A.	67	EE	3
623	NEWCOM, JEFFREY C.	92	ME	1
624	NEWELL, ANDREW M.	74	CE	3
625	NEWLIN, GRANT D.	65	CHE	2
626	NICHOLS, STEPHEN D.	63	ME	4
627	NICHOLSON,, MICHAEL	62		1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
628	NIMROD, DANIEL	63	EE	1
629	NIMS, THOMAS K.	64	MATH	1
630	NUSSER, MICHAEL A.	66	EE	1
631	O'BRIEN, GIRARD J.	60	EE	4
632	O'DELL, GAYLON K.	65	ME	0
633	OFFUTT, ALLEN L.	63	EE	2
634	OLIVER, CLIFFORD E.	60	EE	4
635	ONG, HOWARD	75	IE	1
636	ONTIVEROS, ROSENDO V.	69	CE	0
637	ORR, ROSS D.	73	ACCT	1
638	ORTEGA, RAMON	84	CHE	1
639	OSBURN, S. RANDALL	63	A&S	1
640	OSUNA, ROBERTA	76	CHE	2
641	OTT, DAVID E.	65	EE	0
642	OTTENHOFF,HENRY	85	EE	1
643	OUTLAW, ARTHUR T.	67	ME	3
644	OVERLAND, GREGORY A.	79		0
645	PALMER, JACK	59	CE	3
646	PALMER, ELMO L.	60	MATH	3
647	PANOWSKI, THOMAS M.	61	JOUR	3
648	PARKER, GARY E.	65	ME	1
649	PARKER, ARTHUR L.	68	CHE	2
650	PARRISH, DERYL R.	83	CHE	1
651	PARSON, THOMAS S.	78		0
652	PARSONS, JOHN D.	74	EE	3
653	PATE, THOMAS P.	68	MATH	2
654	PATNODE, DAREN	90	EE	2
655	PATTISON, WILL	87	ME	2
656	PATTNI, MEHUL	91	CE	0
657	PATTNI, SHITAL	92	EE	1
658	PATTON, WILLIAM G.	67	ME	3
659	PAUL, ALLEN L.	71	CHE	1
660	PAULOWSKY, MICHAEL G.	70	ME	1
661	PAZ, LUIS A.	79	CHE	1
662	PEETE, EUGENE A.	61	EE	2
663	PELZER, WM. F.	63	EE	4
664	PETTERSON, LISA M.	78	ME	2
665	PHILLIPS, RAY	65	EE	3
666	PHILLIPS, GEORGE D.	66	ME	3
667	PHINNEY, MARK C.	74	A&S	0
668	PICKELSIMER, BRUCE	72	PHYS	1
669	PINO, KENNETH N.	76	EE	3

	NAME	YEAR STARTED	MAJOR	WORK PHASES
670	POE, MICHAEL T.	72	EE	1
671	POKRZYWA, JOSEPH 61 A&S 1			
672	POLK, CARROLL R.	65	EE	1
673	POLSTON, DERALD L.	78	ME	1
674	POOLER, JERRY L.	66	EE	3
675	POPE, MATHEW	83	EE	2
676	POPP, WAYNE N.	68	EE	0
677	POTOSKY, DAVID *	90	EE	1
678	POTOSKY, DENNIS E. *	65	IE	3
679	POTOSKY, DAVID A.	65	EE	2
680	POWELL, CALVIN L.	63	CE	2
681	POWELL, ERNEST A.	73	ME	2
682	PRICE, LETICIA	86	EE	2
683	PRICE, THOMAS A.	84	CHE	2
684	PRIEBE, PRYDE D.	70	EE	1
685	PRIETO, AUGUSTINE R.	65	ME	1
686	PRUITT, RALPH T.	78		1
687	PURDOM, DON L.	59	EE	1
688	PUTNAM, TERRY L.	60	ME	5
689	QUINONES, DAVID F.	71	PHYS	2
690	QUINTANILLA, DIONICIO	61		1
691	RADOSEVICH, ROGER A.	60	EE	4
692	RAGLAND, DAVID	63		0
693	RAGSDALE, PAUL	73	ME	2
694	RAGSDALE, MICHAEL	86	CS	2
695	RAGSDALE, RALPH H.	67	EE	3
696	RANKIN, RICKY D.	75	EE	3
697	RAY, JEFFERY M.	73	MATH	2
698	RAYKOVICS, ANDREW	82	CS	1
699	REAY, DEWEY V.	63	EE	3
700	REED, BARRY W.	64	CE	3
701	REED, CLIFTON R.	69	CHE	1
702	REESE, JAMES C.	61	ME	0
703	REESOR, NEVITT D.	77	EE	1
704	REGRUTTO, RAY M.	63	ME	3
705	REINHART, TIM	89	ME	3
706	REITER, JOSEPH S.	66	EE	3
707	REITER, ARTHUR M.	78	EE	3
708	REITER, PHILIP J.	68	EE	0
709	RENCHLER, RONALD S.	70	PHYS	1
710	RENNE, BRUCE J.	71	EE	3
711	RENOUARD, KENNETH S.	63	PHYS	3

	NAME	YEAR STARTED	MAJOR	WORK PHASES
712	REVNELL, MICHAEL D.	70	EE	3
713	REYES, DENNELL	89	EE	1
714	REZELMAN, JAMES A.	60	EE	4
715	RICKERSON, WOODY	88	EE	1
716	RIDDLE, PHILLIP O.	84	EE	2
717	RIDENER, FRED L.	63	MATH	3
718	RIORDAN, MARGARET	79	MATH	2
719	RIOS, RUBIN A.	72	EE	1
720	RIVERA, CARLOS D.	61	EE	2
721	RIVERA, GINA	84	EE	1
722	ROBASON, LYNN M.	69	ME	1
723	ROBBINS, JAMES M.	65	PHYS	3
724	ROBERTS, PHILLIP D.	71	ME	0
725	ROBERTSON, GERALD L.	68	PHYS	1
726	ROBERTSON, BILL A.	81	EE	2
727	ROBINSON, DOUGLAS J. 65	MATH	2	
728	ROBINSON, RICK A.	74	EE	2
729	ROBINSON, TERRANCE D.	61	ME	3
730	RODGERS, SAMUEL S.	63	EE	2
731	RODWELL, TIMOTHY	76	ME	0
732	ROETHER, PHILLIP L.	61	EE	3
733	ROGERS, RALPH	61		0
734	ROGERS, RICHARD A.	70	MATH	1
735	ROOT, GARY A.	73	EE	2
736	ROSE, DONALD T.	68	EE	0
737	ROSENBURY, JEFF	90	EE	1
738	ROSS, MICHAEL E.	65	PHYS	1
739	ROTH, ROGER R.	63	EE	2
740	ROUNDY, DENNIS M.	68	EE	1
741	ROYBAL, MATT	90	IE	1
742	RUBIN, SCOTT	90	ME	2
743	RUDOLPH, CARL C.	63	EE	0
744	RUDOLPH, JAMES H.	62	PSY	2
745	RUGG, THOMAS F.	66	CHE	0
746	RUMINER, JOHN	61	ME	2
747	RUNYAN, GARY J.	63	ME	1
748	RUTLEDGE, ROBERT	72	EE	1
749	RYALL, PETER	71		1
750	SALAZAR, CHARLENE	88	BCS	2
751	SANDERS, RONALD L.	71	EE	0
752	SANDERS, RON	87	ME	1
753	SANDERS, JAMES H.	68	EE	3

	NAME	YEAR STARTED	MAJOR	WORK PHASES
754	SANDERS, JAMES E.	66	ME	1
755	SANDLIN, SAMMY H.	63	CE	0
756	SATTERFIELD, JACK W.	62	EE	1
757	SAUCEDO, RAY	90	ME	1
758	SAUNDERS, JAMES A.	68	CE	0
759	SAUVE, EMERY L.	66	MATH	1
760	SAWYER, JOSEPH O.	63	ME	2
761	SCHANEFELT, GERALDINE L.	78	ME	1
762	SCHLETTER, STANLEY L.	65	EE	1
763	SCHMIDT, FELIX C.	66	MATH	0
764	SCHMIDT, JEFFREY	89	CS	4
765	SCHMIDT, DOUGLAS R.	82	EE	4
766	SCHMIEDESKAMP, ROBERT W.	60	EE	1
767	SCHNAKENBERG, RONALD	63	CE	3
768	SCHNEDAR, DAVID F.	84	CS	1
769	SCHNEDAR, MICHAEL J.	75	CHE	2
770	SCHNEIDER, KARL C.	78		2
771	SCHNEIDER, KURT F.	76	CS	2
772	SCHOFIELD, ERNEST A.	76	ACCT	2
773	SCHOONOVER, EDWARD	61		1
774	SCHRAMM, ROLAND J.	70	EE	1
775	SCHRODER, RODNEY R.	68	CHEM	1
776	SCHULTZ, WALTER L.	68	ME	1
777	SCHWADERER, WILLIAM D.	66	MATH	1
778	SCOTT, CHARLES E.	67	EE	2
779	SEAL, HENRY A.	66	ME	2
780	SEARS, DAVID	61		0
781	SEARS, PATRICK A.	64	ME	1
782	SEEKER, STEVEN A.	68	EE	3
783	SEETS, GREG	84	CS	4
784	SEETS, JULIANNE	88	BA	3
785	SEIBEL, DAVID M.	60	EE	3
786	SEIDEL, FRANK A.	76	CHE	2
787	SEIDEL, RONALD B.	64	ME	3
788	SENKEL, RAYMOND	62		0
789	SEWARD, JOHN E.	63	EE	1
790	SEWARD, WALTER D.	60	EE	4
791	SHARP, THOMAS M.	69	IE	2
792	SHAW, HAROLD L.	63	EE	2
793	SHELTON, DAVID G.	69	EE	1
794	SHERMAN, LAWRENCE M.	67	EE	1
795	SHERRILL, MICHAEL	62		1

	NAME	YEAR STARTED	MAJOR	WORK PHASES
796	SHIPLEY, JAMES	60		1
797	SHOAFF, WILLIAM E.	66	MATH	2
798	SHOVER, WILLIAM R.	68	EE	0
799	SHUMARD, GEORGE E.	67	EE	1
800	SIDES, LARRY D.	69	ME	1
801	SIERRA, ADOLFO N.	71	CHE	3
802	SIERRA, STANLEY	67	EE	3
803	SILLAMPA, RAYMOND	60	CE	4
804	SILVA, ADALBERTO R.	71		0
805	SILVA, JAMES W.	68	EE	3
806	SIMONSON, DAVID P.	61	ME	3
807	SIMPSON, SCOTT	83	CS	1
808	SINGLETON, WILLIAM F.	64	EE	3
809	SLADE, WILLIAM C.	67	EE	0
810	SLETTEN, ROBERT S.	62	CE	2
811	SLOAN, WILLIAM S.	66	CHE	1
812	SMITH, DAVID E.	60	ME	2
813	SMITH, JEROME C.	61	ME	3
814	SMITH, LEE ROY	63	EE	2
815	SMITH, DAVID J.	64	MATH	2
816	SMITH, MONTGOMERY W.	70	ME	1
817	SMITH, LON M.	66	EE	1
818	SMITH, WILBERT	61		1
819	SMITH, STEPHEN W.	68	EE	0
820	SMITH, MICHAEL L.	76	EE	4
821	SMITH, CLOTHILDE M.	83	A&S	2
822	SNIEGOWSKI, JOHN	83	IE	1
823	SNYDER, TOMMY A.	66	ME	2
824	SPEIR, ROBERT E.	71	ME	2
825	SPENCER, CHARLES	74	ACCT	0
826	SPENCER, CHARLES V.	60	EE	4
827	ST. JOHN, DONALD H.	60	EE	4
828	STANKEVITCH, BERNARD	59	EE	1
829	STANTON, THOMAS A.	68	CHE	2
830	STAPLIN, LORIN J.	69	EE	1
831	STAPP, STEPHEN T.	66	EE	2
832	STEELE, JOHN P.	67	PHYS	1
833	STEINMAN, BENNY M.	72	IE	1
834	STELL, DENNIS	73	CHE	2
835	STEPHEN L.	67	CHEM	3
836	STEPHENS, FRANCIS G.	68	PHYS	0
837	STEPHENS, JOHN F.	63	EE	3

	NAME	YEAR STARTED	MAJOR	WORK PHASES
838	STEPHENSON, EARL B.	64	PHYS	1
839	STEPHENSON, TERRY E.	70	EE	0
840	STEWART, DAVID R.	73		0
841	STEWART, OLIN W.	67	EE	1
842	STICE, CLIFFORD M.	60	EE	2
843	STIEGELMEYER, SCOTT D.	72	EE	1
844	STIFF, JOHN L.	72	CHEM	2
845	STOCKTON, GEORGE D.	68	ME	1
846	STOHR, ROSEMARY	76	CHE	1
847	STORR, LLOYD N.	60	EE	3
848	STRANBERG, EDWIN W.	68	CHE	2
849	STREBECK, SIDNEY G.	70	AGE	0
850	STREICH, RONALD G.	60	PHYS	2
851	STREIT, BRANDY	87	CS	1
852	STRICKLAND, ROBERT H.	68	EE	3
853	STRINGER, HERBERT	61		1
854	STUBBS, CHARLES W.	71	ME	4
855	STULTING, ROY M.	64	EE	2
856	STULTSMAN, RICHARD	64		0
857	STUMPGES, FREDRIC J.	66	ME	1
858	STURTZ, RODNEY J.	66	MATH	0
859	SUITS, JERRY P.	66	CHE	2
860	SULLIVAN, MARK J.	67	EE	2
861	SULLIVAN, MICHAEL E.	62	ME	2
862	SULLIVAN, TERRENCE D.	66	CHE	3
863	SWALANDER, ZACH G.	87	A&S	2
864	SWIFT, LARRY D.	67	EE	1
865	SWINNEY, JAY C.	78	ME	2
866	SZALAY, TOM	59	EE	1
867	TAKASHIBA, NORMAN K.	61	ME	3
868	TALICH, JAMES R.	60	EE	3
869	TALLEY, ARNOLD	60		1
870	TAMURA, HENRY H.	71	EE	1
871	TAWES, JOHN P.	61	EE	3
872	TAYLOR, DAVID A.	61	EE	2
873	TAYLOR, ERNEST A.	68	CE	1
874	TAYLOR, MICHAEL V.	66	PSY	2
875	THARP, GEORGE W.	74	CHE	1
876	THOMAS, RONALD	61		1
877	THOMPSON, PAUL C.	71	CHE	1
878	THOMPSON, STEPHEN P.	67	CHE	2
879	THURM, GARY E.	63	PHYS	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
880	TICHENOR, STEPHEN L.	66	EE	2
881	TILGHMAN, JIMMIE S.	60	ME	2
882	TILLERY, HUGH M.	66	ME	3
883	TILLEY, JOE	61		0
884	TILLEY, JOHN M.	69	EE	1
885	TILMONT, JAMES	62	EE	1
886	TISLER, ANDREW L.	65	CHE	3
887	TOHILL, DAN	62		0
888	TOLLESON, GARY SCOTT	75		0
889	TORREZ, JOSE E.	65	EE	1
890	TOWNSEND, CHARLES	60		0
891	TOWNSEND, ROBERT K.	63	HIST	3
892	TRICE, JOHN M.	67	ME	2
893	TRICE, RONALD W.	66	MATH	2
894	TROY, BRUCE, L.	69	CE	0
895	TUCKER, ROBERT	63	EE	2
896	TUPPER, THOMAS S.	63	CE	2
897	TURNAGE, DOUGLAS L.	63	EE	3
898	TURNER, JAY L.	68	EE	2
899	TUTTLE, VERNAL D.	67	EE	0
900	TUTTLE, WILLARD N.	65	CHE	0
901	ULVOG, PETER C.	69	EE	0
902	UNDERWOOD, PORTER J.	66	ME	3
903	UPTON, TED M.	63	EE	1
904	UXER, JR., JOHN E.	65	PHYS	2
905	VALDEZ, CARLA JEAN	85	EE	1
906	VALENTINE, JERRY 60	EE	1	
907	VAN EATON, KAREN	84	CS	1
908	VANCE, DAVID B.	69	PHYS	1
909	VAUGHN, EMERY	60		0
910	VEALE, PAUL D.	74	EE	0
911	VEAZEY, DAVID C.	65	ME	3
912	VEITH, GEORGE	60	ME	1
913	VER PLOEGH, JAMES H.	63	PHYS	0
914	VIGIL, MANUEL G.	61	ME	1
915	VIGIL, VINCENT	84	EE	0
916	WADSWORTH, JESSE L.	67	EE	4
917	WAGGONER, CARROLL L.	68	CE	0
918	WAGGONER, MICHAEL G.	80	CE	3
919	WAGNER, CHRIS	88		3
920	WAGNER, DAVID	61	MATH	0
921	WAHLENMAIER, JESS	60		0

	NAME	YEAR STARTED	MAJOR	WORK PHASES
922	WALDON, BILLY E.	64	ME	1
923	WALKER, BOBBY G.	61	EE	3
924	WALKER, JOHN L.	60	MATH	4
925	WALKER, MICHAEL R.	71	EE	0
926	WALLACE, KELLEY W.	73	EE	3
927	WALLER, JACK T.	71	ME	1
928	WALTERSCHEID, WILLIAM J.	67	AGE	2
929	WALTON, JAMES C.	64	EE	2
930	WANT, GERALD A.	64	EE	0
931	WASHAM, LARRY E.	65	EE	1
932	WASSON, PHILIP	63	EE	3
933	WATT, CHARLES M.	66	EE	2
934	WEBB, DOUGLAS G.	67	EE	2
935	WEEMS, DOUGLAS M.	70	EE	4
936	WERNER, JOHN T.	78	EE	1
937	WESSON, TERENCE G.	67	CHE	3
938	WEST, CHARLES D.	69	ME	1
939	WEST, RAYMOND T.	68	PHYS	3
940	WHEELER, THOMAS S.	66	ME	2
941	WHITAKER, JERRY L.	61	EE	0
942	WHITE, ROBERT E.	67	EE	2
943	WHITE, THOMAS W.	65	EE	3
944	WHITFIELD, GREGORY	84	EE	4
945	WHITLOW, LORI M.	86	EE	1
946	WHITNEY, JAMES T.	68	EE	2
947	WIANT, JERRY	61		1
948	WIDNER, RONALD D.	65	EE	2
949	WIDNER, TERRY K.	69	ME	2
950	WIGGINS, RONALD K.	68	EE	2
951	WILCOX, AMY	89	CHE	1
952	WILCOXSON, CHARLES W.	63	ME	1
953	WILEY, CATHY	83	EE	5
954	WILKISON, DAVID	61		0
955	WILLARD, RONALD G.	65	EE	3
956	WILLIAMS, DANNY B.	69	EE	0
957	WILLIAMS, CYNTHIA A.	74	EE	2
958	WILLIAMS, LESLEY S. *	65	ECON	3
959	WILLIAMS, NELSON	60		1
960	WILLIAMS, JOEL D.	70	CHE	2
961	WILLIAMS, RICK	80	CS	1
962	WILLIAMS, CHARLES H.	74	CHE	0
963	WILLIAMS, THOMAS C.	64	T.ED	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
964	WILLIAMS, RUSSELL *	91	EE	1
965	WILLIAMS, REBECCA L.	76	EE	2
966	WILLIAMS, STEPHEN L.	72	EE	3
967	WILLIS, LARRY D.	64	EE	2
968	WILLMON, MICHAEL L.	68	CHE	1
969	WILSON, TOMMY J.	67	EE	1
970	WILSON, JON	61		0
971	WILSON, DANNY R.	65	MATH	2
972	WILSON, RANDALL L.	67	CE	2
973	WILSON, CHRIS	92	EE	1
974	WINDSHEIMER, GEORGE H.	61	EE	3
975	WISDOM, MICHAEL L.	71	CHE	5
976	WISE, ROBERT	60		0
977	WITTER, ROBERT E.	66	EE	1
978	WOLCOTT, TOM	91	CS	2
979	WOLF, DAVID W.	67	EE	2
980	WOLF, JOHN D.	64	EE	2
981	WOLLE, BRUCE	85	CE	3
982	WOOD, BILLY J.	64	EE	3
983	WOOD, RANDY D.	65	EE	3
984	WOOD, WARREN	61		0
985	WOODARD, JEFF	73	EE	2
986	WOODARD, NORMAN	91	EE	1
987	WOODHOUSE, JULIAN G.	63	EE	3
988	WORTHINGTON, GREG D.	68	EE	2
989	WRIGHT, JEFF	92	EE	1
990	WRIGHT, MARK W.	74	EE	3
991	WRIGHT, STANLEY J.	66	EE	2
992	WRIGHT, BRADLEY K.	60	EE	3
993	WRIGHT, W. ALLEN	75	MATH	3
994	WYLIE, MICHAEL J.	66	MATH	2
995	WYNN, KENNETH S.	61	EE	2
996	YARBRO, STEPHEN L.	77	CHE	1
997	YARYAN, ROY 0.	68	MATH	2
998	YARYAN, TERRY L.	63	EE	3
999	YBARRA, JOE T.	70	EE	2
1000	YEARLEY, ROBERT	59	ME	1
1001	YODER, ELDEN L.	63	EE	2
1002	YOUNG, TROY	83	EE	1
1003	YOUNG, VINCENT	61		0
1004	YUCIKAS, TRACY J.	68	MATH	0
1005	ZIEGLER, ERIC J.	73	ME	2

	NAME	YEAR STARTED	MAJOR	WORK PHASES
1006	ZURA, TIM	90	EE	2