SPERRY RAND

PRESS INFORMATION/APOLLO

APOLLO 11 SPECIAL

SPERRY
FLIGHT SYSTEMS DIVISION
GYROSCOPE DIVISION
MICROWAVE ELECTRONICS DIVISION

UNIVAC
FEDERAL SYSTEMS DIVISION

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farm machinery for world-wide markets.

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office equipment—typewriters, adding machines, electrostatic copiers, calculators, library furnishings, electromechanical files, and other records retrieval systems.

SPERRY
aerospace and marine navigation equipment, guidance and control systems, management of systems programs.

UNIVAC
electronic data processing systems for commercial and defense applications.

VICKERS
hydraulic systems for aircraft, mobile, marine and industrial machinery applications.


UNIVAC 418 COMPUTER
UNIVAC

Special for Apollo 11

APOLLO MISSION DATA -- Before Saturn-Apollo spacecraft are launched at Cape Kennedy, this UNIVAC 418 Computer at NASA's Manned Spacecraft Center in Houston processes data on the winds in the launch area. This data is further analyzed by UNIVAC 1108 Computers at the center. The information helps scientists compute abort trajectories in the event of a malfunction during launch. After the launch, the 418 and 1108's process other data on performance of systems aboard the spacecraft. Both the 418 and 1108 are products of Sperry Rand Corporation's Univac Division.

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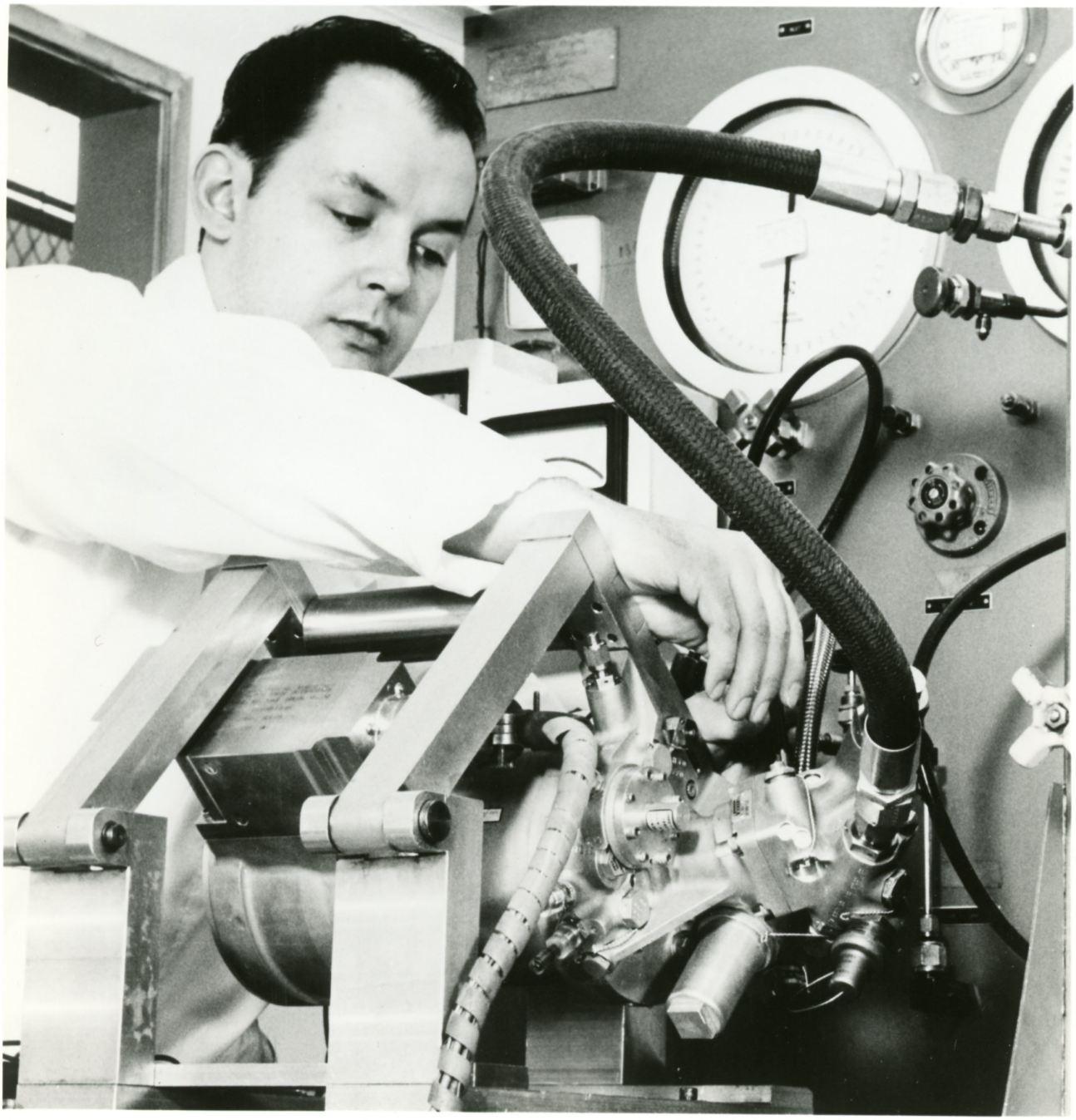
SPERRY RAND UNIVAC NEWS



Part of Apollo 11's "power steering" system on test at Sperry Rand's Vickers Division. Hydraulic motorpump, above, and an engine-driven pump supplied by Vickers, power the gimballing system that guides the Saturn V's S-IVB third-stage engine that will boost the Apollo capsule into earth orbit, then into translunar voyage. Motorpump keeps system fluid from freezing in outer space when engine and engine-driven pump are shut down.

# # #

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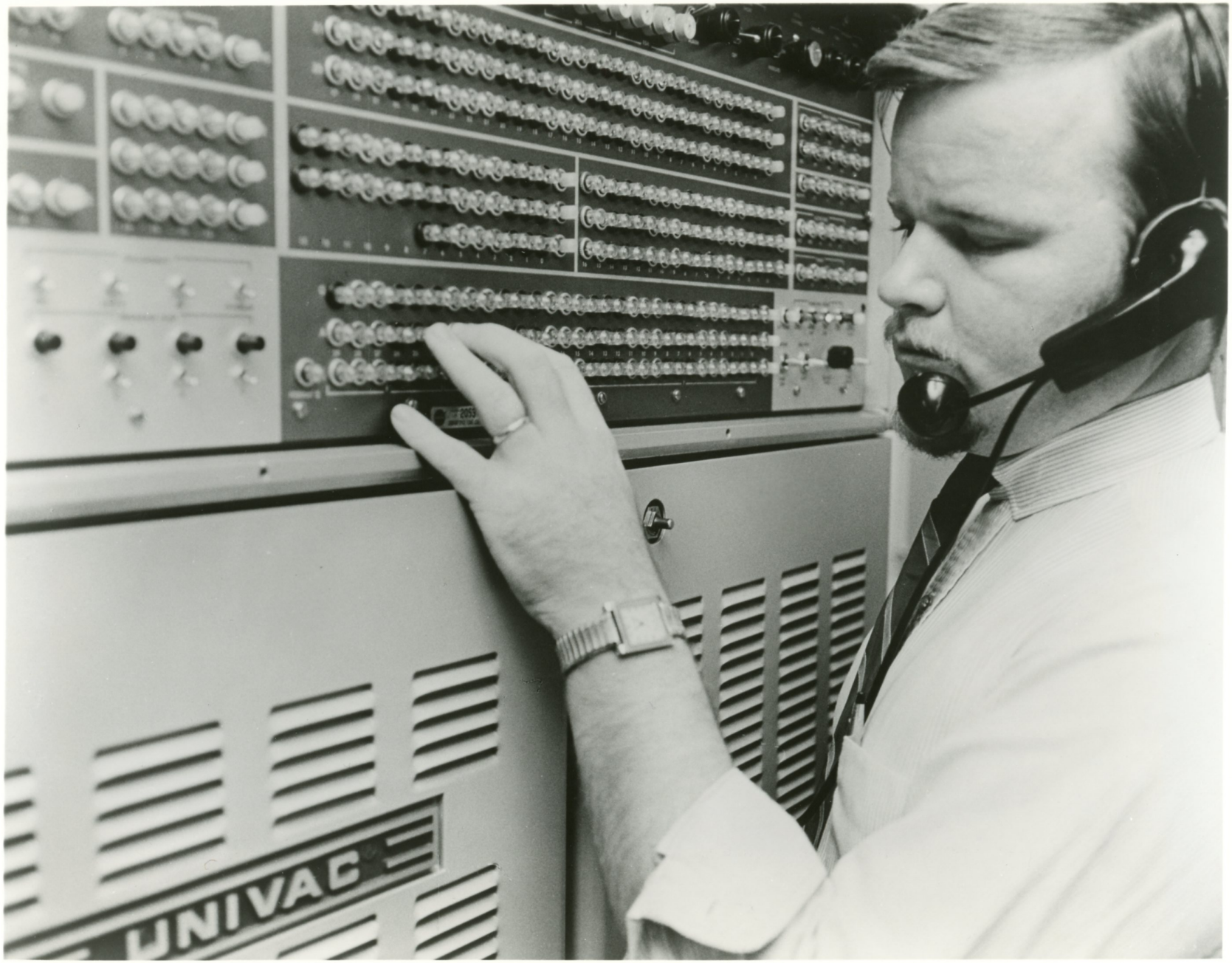
(VAD-2)


UNIVAC

LUNAR LANDING DATA -- Technician monitors one of UNIVAC 1230 (NASA M642B) computers which process data to and from the Apollo Lunar Module and Command Module during moon-landing missions. One 1230 processes telemetry data at each of 14 Unified S-Band tracking stations and aboard four Apollo Instrumentation Ships. A second 1230 at each site validates commands and transmits them to the spacecraft. Each of the computers can receive telemetry data simultaneously over three separate channels at 75,000 bits per second. Sperry Rand Corporation's Univac Division has provided 48 1230's for NASA's global tracking network.

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SPERRY RAND UNIVAC NEWS


UNIVAC
494

Special for Apollo 11

MEN ON THE MOON -- All systems are "A-OK" on engineer's console of UNIVAC 494 Real Time Computer System which routes communications to and from Apollo astronauts. Two 494's at NASA's Manned Spacecraft Center in Houston receive a continuous stream of data showing conditions inside the spacecraft. A third 494 checks out the other two. The computers, hub of the Communications, Command, and Telemetry Systems (CCATS) complex, immediately route telemetry data to the proper location in Mission Control. They were supplied by the Univac Federal Systems Division. Univac is a division of Sperry Rand Corporation.

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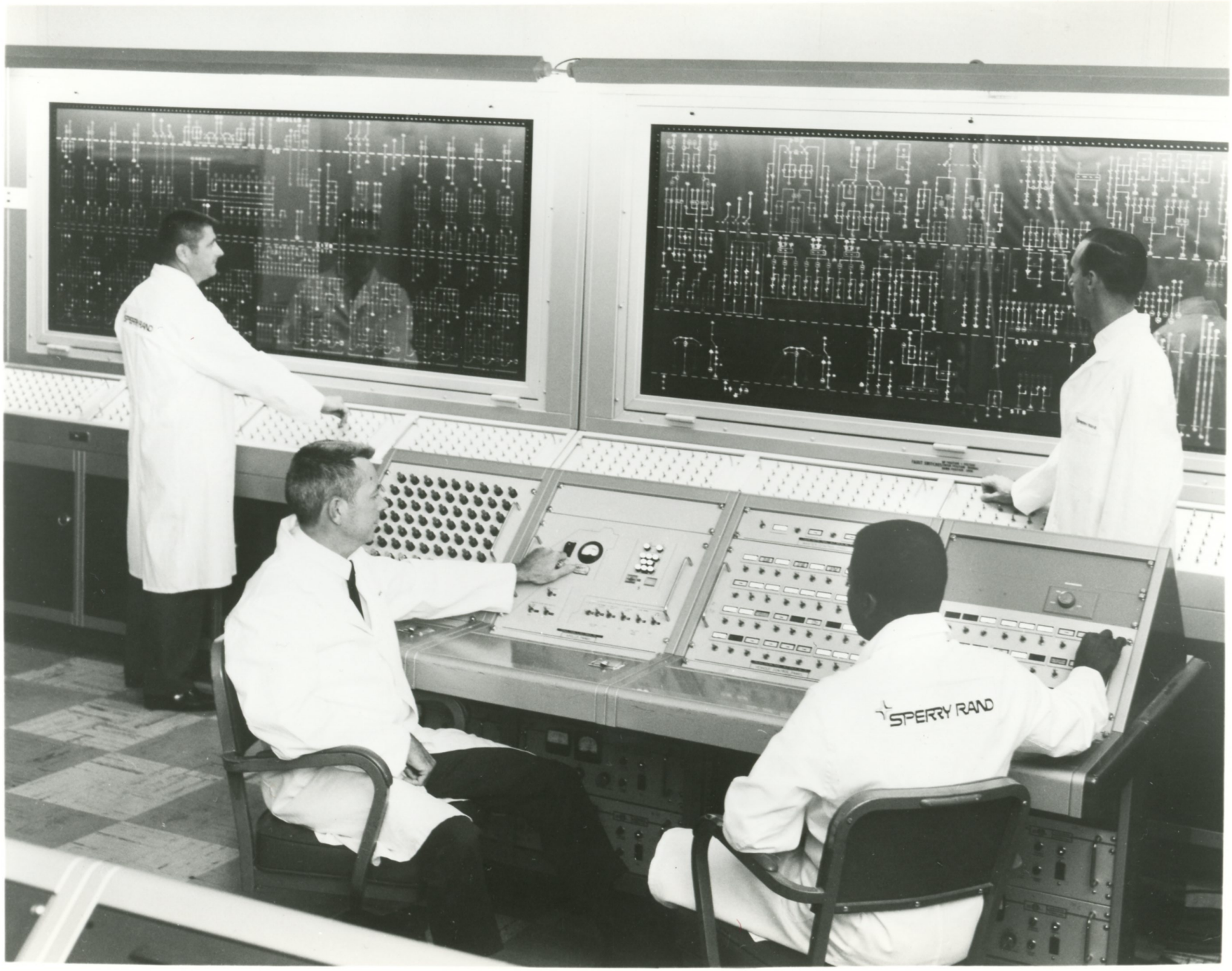
SPERRY RAND

A ground-based electronic system that simulates the Emergency Detection System aboard the Saturn boosters provides a large measure of safety for Apollo missions. The electronic simulator provides NASA and Sperry Rand engineers, who operate the system at the Marshall Space Flight Center, Huntsville, Ala., a complete EDS electrical simulation of the actual Saturn/Apollo flight. The system demonstrates some of the factors which directly contribute to the safety of the astronauts.

# # #

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Special for Apollo 11

APOLLO 11 CALCULATIONS -- During Project Apollo missions to the moon, UNIVAC 1108 computers at NASA's Manned Spacecraft Center in Houston provide astronauts and operations support personnel with vital data and predictions. The 1108's, operated by the center's Computation and Analysis Division, provide such vital information as how much power, oxygen, and other consumables remain in the spacecraft. Receiving data from a UNIVAC 418 computer, which acts as a communications processor, they also compute the effect of wind forces during launch and re-entry. The scientific computing complex shown in picture includes five 1108's from Sperry Rand Corporation's Univac Division.

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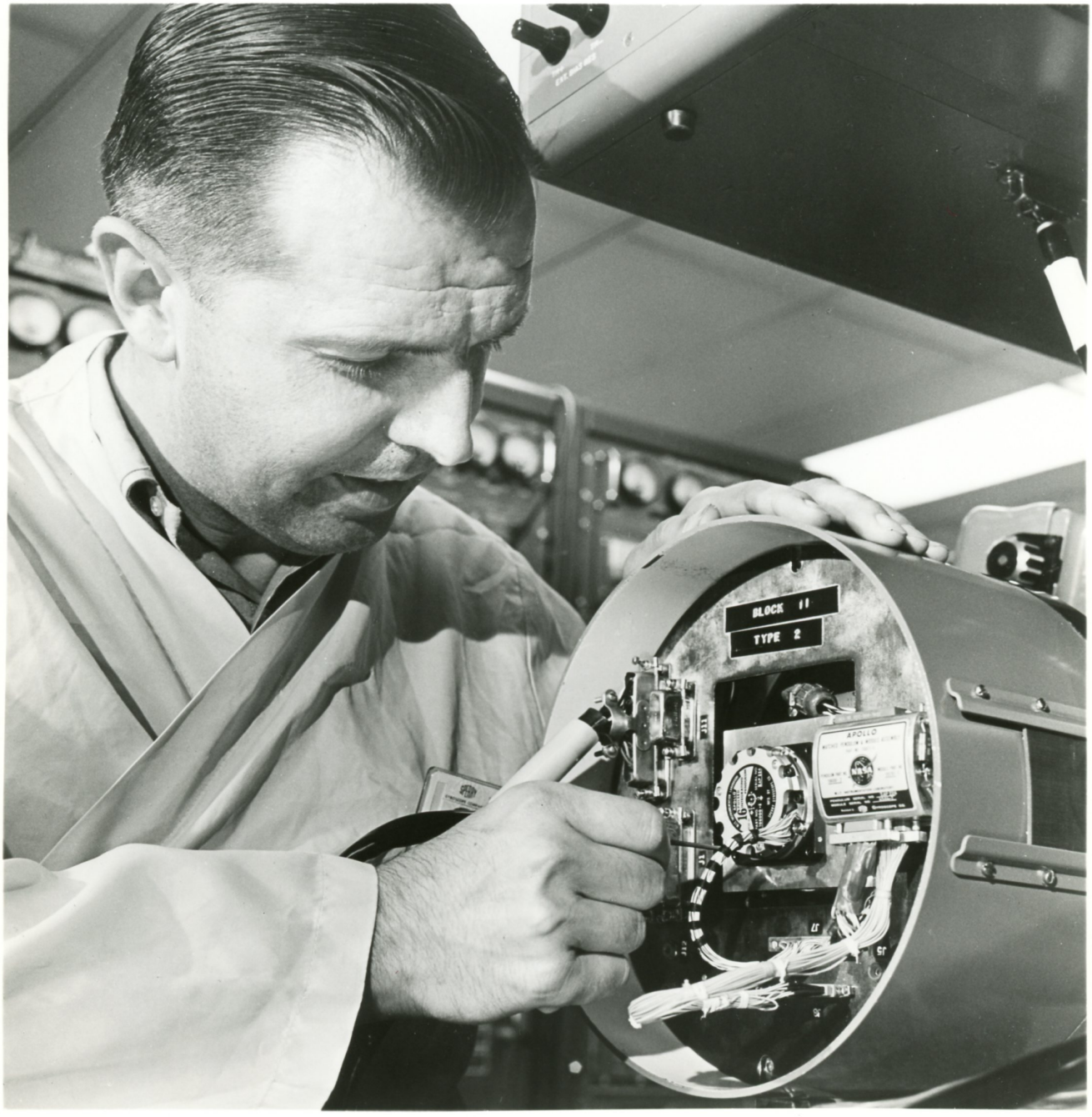
BLOCK II
TYPE 2
APOLLO

A small accelerometer -- acting like a space speedometer --- will have an important role in guidance of the Apollo Command Module. The tiny device, shown here mounted in Inertial Measurement Unit, senses the amount and direction of change in acceleration in space, and electronically "passes along" deviation information to the guidance and navigation system's computer which generates corrective steering signals to the rocket engine system. The accuracy of the navigation and guidance system will be critical in assuring the proper attitude and angle of re-entry, to prevent the spacecraft from being burned up.

# # #

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CARRIER LEVEL
MODULATION &
INCREMENTAL FREQUENCY
SET CARRIER
SET MODULATION
ATTENUATOR
F.M.
EXT.MOD.
A.M.
R.F. OUTPUT
F.M. SIGNAL GENERATOR
MARCONI
MADE IN ENGLAND
SPEAKER
MICROPHONE
OPERATING INSTRUCTIONS
PUSH TO
TALK

Apollo astronauts returning from moon missions will be able to talk to rescue crews by means of this "handi-talkie" radio if it becomes necessary for them to leave their spacecraft after touchdown on Earth. Built by Sperry Rand's Sperry Flight Systems Division in Phoenix, the 5-pound UHF radio can also be used to transmit electronic signals that will pinpoint the astronauts' location to search aircraft. Powered by six waterproof batteries, the radio is capable of operation for 24 hours and has a range in excess of 100 miles.

# # #

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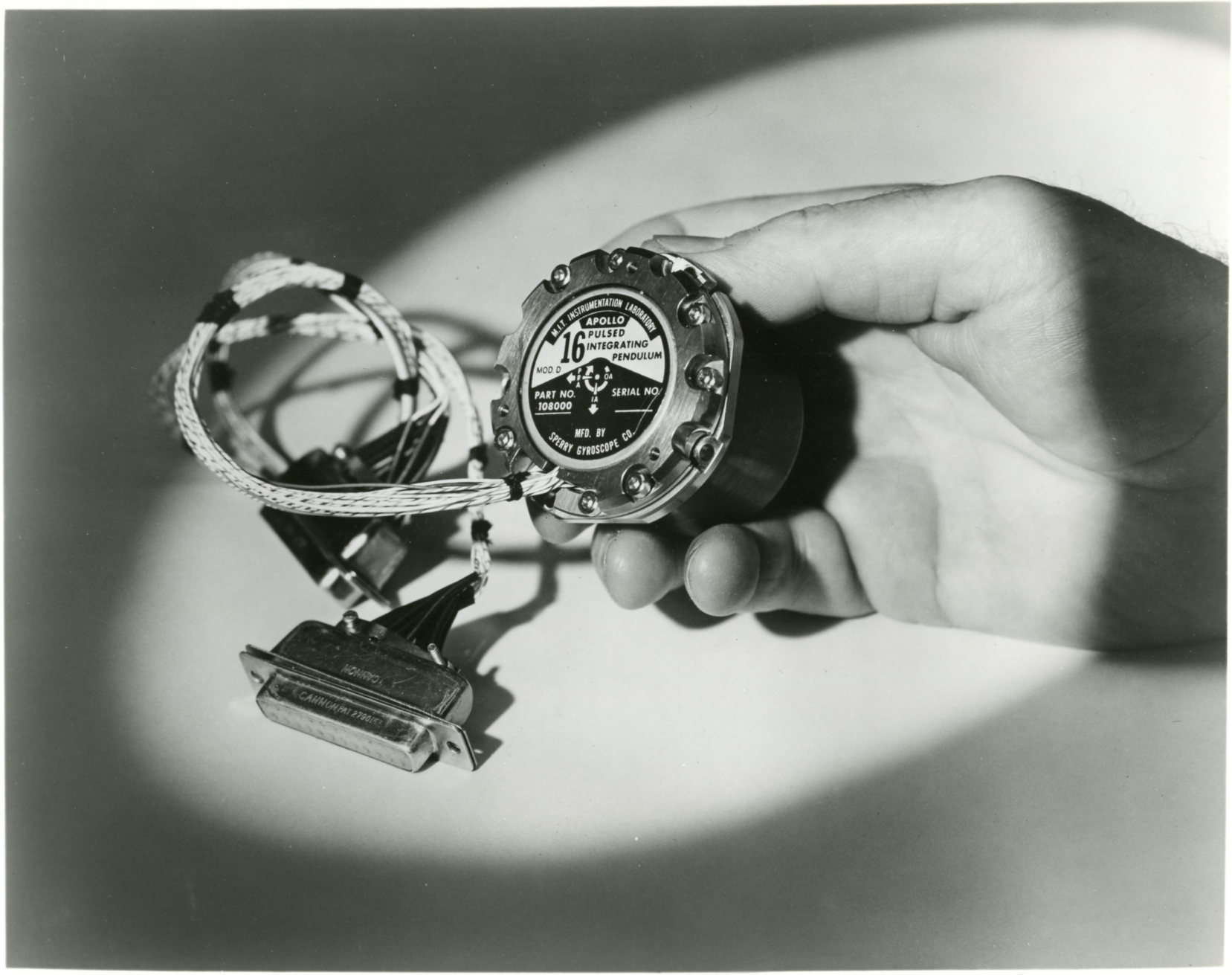
M.I.T. INSTRUMENTATION LABORATORY
APOLLO
16
PULSED
INTEGRATING
PENDULUM
MOD. D
PART NO.
108000
SERIAL NO.
MFD. BY
SPERRY GYROSCOPE CO.

SPERRY RAND

NEWS

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APOLLO 11 PRESS INFORMATION

MEMORANDUM TO EDITORS:

Sperry Rand Corporation has been one of the leading contributors to the nation's manned space flight program. Sperry Rand divisions are providing an array of spaceborne and ground-based systems and services for Apollo.

Sperry Rand's Apollo news described in this press kit includes:

Giant Univac Computers Calculate Predictions For Apollo Lunar Landing Missions	Univac Division
Univac "Tiger Team" Ensures Reliability Of Vital Ground-Based Computers	Univac Division
Univac Programmers Plot Computer's Course To Help Assure Success of Apollo Lunar Mission	Univac Division
Computerized Instrumentation Ships Bolster Coverage of Apollo Tracking and Recovery	Univac Division
Tiny "Space Speedometers" Play Major Role In Guidance System Of Apollo Command Module	Sperry Gyroscope Division
Emergency Radio Available To Astronauts In Event of Emergency Recovery Aid	Sperry Flight Systems Division
Tiny Low-Noise Communications Unit Aids Live TV Pictures From Apollo	Sperry Microwave Electronics Division
Emergency Detection System Simulator Helps Assure Safety and Reliability of Mission	Space Support Division
Rugged Hydraulic Power System Helps Control Flight of Saturn V Third Stage	Vickers Division

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UNIVAC NEWS
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FOR RELEASE:
July 15, 1969

GIANT UNIVAC COMPUTERS CALCULATE PREDICTIONS FOR APOLLO LUNAR LANDING MISSIONS

HOUSTON, TEX., -- How much radiation is expected to come through the boot of the Apollo astronaut who takes man's first step on the moon?

Where would the astronauts land, taking prevailing winds into account, if they used their emergency escape system during their launch from Cape Kennedy?

How much oxygen remains in the Apollo command module as it bears the lunar explorers back to earth?

Giant UNIVAC 1108 computers, each making over one million calculations per second, are electronic space intelligence experts supplying the answers to these and other critical questions during each Apollo mission.

M O R E

Before each Saturn-Apollo launch, the computers, located at NASA's Manned Spacecraft Center in Houston, process data on the direction and velocity of winds in the Cape Kennedy area. They tell the Mission Control Center, and recovery forces in the launch area, where the astronauts would land if they had to abort from the launch pad or during the early phases of launch.

During Apollo missions, the 1108's, working from special simulation programs, operate 24 hours a day to provide the astronauts and operations support personnel with vital data and predictions.

This function includes:

•Analyzing the consumption of electrical power, oxygen, fuel, water, and other consumables and predicting future supply;

•Determining the extent and accuracy of orbit changes caused by firing of spacecraft engines;

•Providing navigational aids;

•Computing the effect of wind forces during re-entry and pinpointing the splashdown area.

The scientific computing complex, which employs five 1108's from Sperry Rand's Univac Division, is operated by the Manned Spacecraft Center's Computation and Analysis Division. It is linked by direct line with NASA's Real Time Auxiliary Computing Facility (RTACF) at Mission Control. Through this link, the computers help such calculations as determining the number, and density, of micrometeroids

M O R E

hitting the outer skin of Apollo.

The 1108's back up the Real Time Computer Complex (RTCC) at Mission Control and can aid it in peak periods with vital calculations.

They are also used extensively during and after Apollo missions for reducing telemetry data, providing scientists with a "boiled down" picture of such variables as spacecraft temperatures and pressures.

A major part of the workload of the computers is processing mathematical and engineering simulations. Engineers construct a mathematical model of a component and test it against the stresses which an actual component will face in space or on the surface of the moon. Simulations also aid in working out the computer programs for landing astronauts on the moon and bringing them back to earth.

A UNIVAC 418 is used as a communications processor with the 1108's. The 418 formats input data into magnetic tape, places work in the proper sequence according to job priority, and feeds it to one of the large-scale computers. UNIVAC 1230 computers process telemetry and command data at each tracking station and UNIVAC 494's route this information at NASA's Goddard Space Flight Center and Manned Spacecraft Center.

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RELEASE NUMBER: 769/1025

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UNIVAC NEWS
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UNIVAC "TIGER TEAM" ENSURES RELIABILITY OF VITAL COMPUTERS

GREENBELT, MD. ... A "tiger team" from Sperry Rand Corporation's Univac Division has one prime function during Project Apollo missions: making sure that computers at critical tracking sites throughout the world continue handling hundreds of thousands of bits of data per second without interruption.

The team consists of five men, experts in every facet of the UNIVAC 1230 computers which process trillions of bits of telemetry and command information during Apollo missions.

Members of the team, called the Apollo Network Support Group, are stationed, on each mission, at the sites which are most critical to mission success. If a 1230 should fail for any reason, a Univac "tiger" is trained to have it operating again within a few minutes. All members of the group have worked with the 1230's since they were first installed in the network in 1965, and therefore are familiar with both the hardware and the operational programs.

M O R E

"Our job is to provide for any possible emergencies which can occur in the tracking station computers," comments Pierre Iskos, supervisor of the team. "On the ground, as in space, you must provide for all possible contingencies even if they are not expected."

A "tiger" usually goes to a critical site four or five days before an Apollo launching, and remains until splashdown.

On lunar missions, these sites are usually the 85-foot-antenna deep space stations at Madrid, Spain; Goldstone, Calif.; and Honeysuckle , Australia, which handle data after Apollo leaves earth orbit and during its subsequent journeys to the moon and back.

Should a computer emergency occur, the Univac expert can usually tell what has occurred almost immediately.

"We have been trained since Day One to diagnose what's happened and remedy the situation," Iskos says, "This can be a valuable addition to the capability of the computer operators at the site."

The Apollo Network Support Group is attached to the Manned Flight Engineering Division at NASA's Goddard Space Flight Center in Greenbelt. Univac's Federal Systems Division provides the team under a network support contract from Goddard. Members of the group also provide NASA with engineering advice on special problems.

The Apollo tracking network includes over 40 UNIVAC 1230's. Each land-based tracking site has two 1230's, one for telemetry and the other for command data. If one computer fails while handling critical data, the other computer can immediately take its place. Each tracking ship has a third 1230 computer used as the ship's central processor.

M O R E

The UNIVAC 1230 (NASA M624B) computer is a rugged general purpose real-time processor (similar to the CP-642B processor) originally designed for use in the Navy's Naval Tactical Data System (NTDS). During Apollo missions, each 1230 can handle separate channels of telemetry data from three space vehicles such as the Apollo Lunar Module, Command Module, and S-IVB stage. The computers can process 75,000 bits of data per second on each channel, or a total of almost two trillion bits per day.

The 1230's usually go on mission status one month before launch and continue operating 24 hours a day until after splashdown.

Univac supplied 14 UNIVAC 1218 computers for telemetry data handling at worldwide sites during the Gemini program. NASA subsequently awarded Univac the contract for the 1230's. Most of the Apollo Network Support Group also worked with the 1218's during Gemini.

What's it like at a site during an Apollo mission?

"Very tense," replies Iskos, "until splashdown , that is."

How does he feel about his work, which has taken him over 200,000 miles in the last four years?

"I don't think I could describe my feelings," Iskos says. "Nothing can compare with working on a national project like Apollo. All five of us are totally dedicated to it."

Members of the Tiger Team are:

Pierre Iskos, with the support group since before the initial checkout of the 1230's in May, 1965.

Gerald Spitzer, who worked with the 1218's during Gemini and subsequently was named to the Apollo group.

M O R E

Roger Christensen, stationed in Bermuda for Gemini, subsequently named to the Apollo team.

Marvin L. Williams, at Grand Turk during Gemini, subsequently named to the Apollo team.

Fred Vey, who has worked with the 1230's since before they were installed for Apollo.

Besides supervising the support team, Iskos also functions as an advisor to the station director of the Network Test and Training Facility at Goddard. The Univac "tigers" also give on-the-job training to maintenance and operations people at the global sites.

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UNIVAC PROGRAMMERS PLOT COMPUTER'S COURSE TO HELP ASSURE SUCCESS OF APOLLO LUNAR MISSIONS

GREENBELT, MD. -- About 130 Apollo computer programmers have traveled to the moon and back, before each lunar mission.

The group, assigned to the National Aeronautics and Space Administration's Goddard Space Flight Center here, writes the programs for the Sperry Rand UNIVAC 1230 (NASA M642B) computers at worldwide tracking sites. These computers serve as the vital link with the astronauts.

The programs -- prestored instructions -- guide the computers as they process a continuous stream of telemetry and command data during flights to the moon and back.

"Speaking figuratively, we fly to the moon and back since our programs must cover every stage of the mission," comments Jay Longbottom, manager of the Apollo Remote Site Data Programming Group for Sperry Rand's Univac Federal Systems Division.

During the lunar mission, according to Longbottom, the programs tell the 1230's which data from the spacecraft should be transmitted immediately to the Mission Control Center in Houston, and they assure that every command

M O R E

from the ground to Apollo is correct. The telemetry includes such critical data as the length of burn of the rocket which sends the astronauts from lunar orbit to earth. Commands include the vital signals to position the command module into safe attitude for re-entry into the earth's atmosphere.

The Univac group writes special programs for the 1230's before each Apollo mission. The effort may take from 60 to 90 days, including system design changes, reprogramming and checkout. The programs are then sent to worldwide sites at least 60 days before the Apollo is launched.

Each tracking station, called a "remote site", since the operation of the program is controlled from Houston, receives three reels of magnetic tape. The package contains the operational telemetry and command programs, as well as a number of off-line support programs. The Command Program processes the command information, which is handled by one computer. The Telemetry Program processes spacecraft data passing through a second 1230.

The Command Program and the Telemetry Program each consists of 48,000 computer words which can cover an entire trip to the moon and back. Each word contains 30 "bits" of information. The basic command or telemetry software systems for a 1230's operation during a lunar mission consists of about 1,400,000 bits , on about 25 feet of magnetic tape, for each program.

Commands are prestored in the remote site program or are received in real-time from Mission Control and "verified" by the computer. In the verification process, the command data processing program first checks that what has been received is a valid command. It then transmits the command to the spacecraft and inspects the telemetry data to assure that the information was properly uplinked.

M O R E

The system is designed to assure less than a 10^{-9} (.000000001) chance of Apollo accepting a single bit of bad data. This is one chance in one billion.

"We must be absolutely certain that no incorrect command data is accepted by the spacecraft," Longbottom comments. We can't have a mistake."

The telemetry program at each site collects telemetry data in real-time from the various stages of Apollo and continuously transmits selected combinations of processed data, to Goddard on two lines, each capable of handling 2,400 bits per second.

This program includes 25 high-speed formats, any one of which can be selected by Houston, which govern types and priority of telemetry data.

The command and telemetry programs are each capable of processing high rates of telemetry data -- up to 288,000 bits per second. During a mission to the moon and back, remote sites can handle a total of 200 billion bits of information from the spacecraft.

During Apollo missions, UNIVAC 1230's process data at 14 land-based and four shipboard remote sites in NASA's worldwide communications network.

The data from the global stations is sent to Goddard, where UNIVAC 494 Communications Processors route it over ultra-high-speed lines to other 494's at the Houston Manned Spacecraft Center. These 494's, in turn, route the information to other computers in the Center's Real-Time Computer Complex for display on flight controller consoles. The entire process, from spacecraft to console, takes between 5 and 10 seconds.

Separate Univac programming groups also support each of the 494 complexes. The programmers at Goddard assure that the 494's there properly switch communications between Houston and worldwide tracking sites. The program consists of 64,000 30-bit words.

M O R E

At Houston, a group of about 95 programmers uses a total program of 320,000 words to ensure that only correct commands are sent out, and to validate that incoming communications are in the correct format and are routed to the correct location in Mission Control.

The Univac programming group at Houston is now using UNISCOPE 300 cathode ray tube displays to show any of about 40 formats of information during Apollo missions.

# # #

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PROJECT APOLLO

LOCATION OF UNIVAC COMPUTER SYSTEMS

	UNIVAC				
	642B	1218	494	1108	418
CARNARVON	2	3			
CANBERRA	2	1			2
GUAM	2				
HAWAII (KAUAI)	2	1			
GOLDSTONE	2	1			
GUAYMAS	2	3			
CORPUS CHRISTI	2	1			
MANNED SPACECRAFT CENTER	1	4	3	5	2
CAPE KENNEDY (MILA)	4	4			
GODDARD SPACE FLIGHT CENTER	5	3	3	2	1
BERMUDA	2	1			
GRAND BAHAMA	2	1			
ANTIGUA	2	1			
GRAND CANARY	2	1			
MADRID	2	2			2
ASCENSION	2	2			
USNS REDSTONE	3	1			
USNS VANGUARD	3	1			
USNS MERCURY	3	1			
USNS HUNTSVILLE	3	1			
TOTAL	48	33	6	7	7

(UD-2B)

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UNIVAC SPACE PROJECTS

Computers from Sperry Rand Corporation's Univac Division support NASA's Apollo manned lunar landing program, earth orbital scientific satellite missions, and special scientific and engineering projects. Installations and functions of the computers, include the following:

Goddard Space Flight Center, Greenbelt, Md.

UNIVAC 494 Real Time Computer Systems switch high speed Apollo data between worldwide tracking stations and the Mission Control Center in Houston. The 494's also process scientific satellite data from stations in NASA's Scientific Tracking and Data Acquisition Network (STADAN). Goddard is using a UNIVAC 1108 computer for scientific and engineering calculations.

Jet Propulsion Laboratory, Pasadena, Calif.

A UNIVAC 1108 II Multiprocessor Computer performs a wide variety of scientific calculations relating to future unmanned space exploration.

Manned Spacecraft Center, Houston, Texas

During Apollo missions, UNIVAC 494 Real Time Computer Systems route information to and from worldwide tracking stations, update displays for

M O R E

flight controllers, and feed incoming data to other computers. UNIVAC 1108 computers perform engineering and scientific calculations before, during, and after missions. UNIVAC 494 and 418 computers help provide simulation data for training flight controllers.

Manned Space Flight Network

UNIVAC 1230 (NASA M642-B) computers accept and process data to and from the Apollo spacecraft at land-based and shipboard Unified S-band Stations in the global Apollo communications and tracking network. UNIVAC 1218 computers aid antenna positioning at these stations.

Marshall Space Flight Center, Huntsville, Ala.

UNIVAC 1108 computers perform scientific and business calculations, both at Huntsville and at the Mississippi Test Facility in Slidell, La. Marshall Space Flight Center 1108's perform important data reduction tasks supporting Apollo missions before and after launches.

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COMPUTERIZED INSTRUMENTATION SHIPS
BOLSTER COVERAGE OF APOLLO MISSIONS

HOUSTON, TEX. .... Four computerized ships, carrying much of the same advanced equipment as ground-based tracking stations, serve as vital communications outposts during Apollo missions.

Three of the vessels, called Apollo Instrumentation Ships, aid communications and tracking while Apollo orbits the earth and as it is fired into its moon-bound trajectory. The other helps provide coverage during the Apollo spacecraft's re-entering of the earth's atmosphere and its return from the moon.

The ships rely on computers from Sperry Rand's Univac Division, for two critical functions: (1) processing the continuous flow of information between the spacecraft and the Mission Control Center in Houston; (2) and computing exact ship position and attitude.

TELEMETRY COMPUTER

A UNIVAC 1230 (NASA M642-B) computer is used for accepting telemetry data from Apollo at three different rates, decommutating (decoding) it, and providing the information to the Mission Control Center in Houston. The computers can handle up to 200 measurement parameters. The information on the status of the astronauts and the spacecraft is shown on consoles in the nearby Shipboard Mission Control Center.

M O R E

The telemetry computer is a major contribution in remote site data processing. The telemetry data is decommutated by the computer itself, instead of by the special purpose processor which was emplcyed during the Gemini Program to "bcil down" the information. The new system increases the amount of information available to the Mission Control Center and is far more adaptable to prcgramming changes than the cld system.

COMMAND COMPUTER

A second UNIVAC 1230, similar to the cne used for telemetry, processes and encodes command data for transmission to the spacecraft. This data may come from either the Mission Control Center or the Shipboard Flight Controller.

Both the command and telemetry 1230's are powerful, medium scale, real-time computers, designed for rapid processing of continuous high rate data. The solid state computers are equipped with a 400-nanosecond control memory operating in synchronism with a two microsecond main core memory. Command execution time is two microseconds. The computers can handle 500,000 30-bit words per second. The memories of the 1230's have been exparded especially for Apollo from 32,000 30-bit words to 65,000 30-bit words.

CCIA AND PERIPHERAL EQUIPMENT

The command and telemetry computers use a Computer/Console Input Output Adaptor, comprised of two UNIVAC 1218 computers, to buffer data to and from ship flight control consoles. The Univac system also accepts time code words, and provides this time information to the 1230's.

M O R E

Each computer uses a UNIVAC 1232 input/output console, a UNIVAC 1540 magnetic tape unit, and a UNIVAC 1259 teletype device.

CENTRAL NAVIGATION COMPUTER

The UNIVAC 1230 is the central navigation computer on each Apollo ship. It receives data on the vessel's attitude, velocity, and position and computes the most reliable estimates for navigation and for acquiring and tracking the spacecraft with shipboard radar systems.

The Integrated Navigation System supplied by Sperry Rand's Sperry Gyroscope Division, Great Neck, N. Y., provides the computer with attitude, position, and velocity data. Attitude data also comes from the ship's MK-19 Gyrocompass, provided by the Sperry Marine Systems Division.

Both the 1230's and 1218's are products of Univac's Federal Systems Division in St. Paul, Minn.

UNIVAC 494 Real-Time Systems at the Goddard Space Flight Center, Greenbelt, Md., and the Manned Spacecraft Center in Houston process communications. These computers are manufactured at Univac's Data Processing Division facilities in Roseville, Minn.

The Apollo Instrumentation Ships used during the earth orbital and translunar injection phases of the mission are the USNS Redstone, USNS Vanguard, and USNS Mercury. The USNS Huntsville assists coverage during Apollo's re-entry.

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SPERRY RAND
UNIVAC NEWS
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MORE THAN 100 SPERRY RAND UNIVAC COMPUTERS CONTROL
APOLLO COMMUNICATIONS LIFELINE ON TRACKING NETWORK

HOUSTON, TEXAS ... A worldwide communications network, controlled by more than 100 Sperry Rand Univac computers, serves as the communications lifeline between Apollo spacecraft and Mission Control at the NASA Manned Spacecraft Center here.

The computer-controlled NASA communications network (NASCOM) is an integration of three major networks, including the Manned Space Flight Network (MSFN), and is the overall responsibility of the Goddard Space Flight Center, Greenbelt, Md.

The network is charged with the important task of processing the continuous stream of messages between the spacecraft and Mission Control, from countdown to final recovery.

It consists of ground, sea, and airborne tracking stations, designed to collect, process, and act upon vital information flowing between the Apollo spacecraft and Mission Control.

M O R E

The Sperry Rand computers, products of the Univac Federal Systems Division headquartered in St. Paul, Minn., augment the network, which consists of three major message switching and communications processing systems:

- The Remote Site Data Processing (RSDP) systems at 14 global ground tracking sites and aboard four Apollo Instrumentation ships.
- The Automatic Data Switching System (ADSS), centered at the Goddard Space Flight Center, and
- The Command Communications and Telemetry Systems (CCATS), located at Houston.

Principal function of RSDP systems, where 48 UNIVAC 1230 Computers (NASA M642B) are installed and operating, is to accept, record and transmit data originating from the spacecraft ("down" data), and compute and issue commands to the spacecraft ("up" data).

"Up" information is communicated over an ultra-high-frequency radio (Apollo Unified S-Band) link at a rate of 2400 bits of information per second. Communication between the ground tracking sites and Houston, via high-speed communications links, occurs at the same rate.

In the case of "down" data, sensors built into the spacecraft continuously sample the pressure and temperature inside the capsule, its attitude and position in space, and, on manned missions, such physical factors as the astronauts' respiration, heart beat and temperature. This data is transmitted to ground stations at the rate of more than 51,200 bits of information per second.

M O R E

In addition, UNIVAC 1218 Computers, in use since the Gemini program, control radar antenna pointing positions during the flights.

The principal Automatic Data Switching System (ADSS) facility at Goddard utilizes multiple UNIVAC 494 Real-Time Computers -- many times faster than the Univac computers used in Project Gemini -- to relay communications over new high-speed data lines. For Apollo, UNIVAC 418 Computers, located at widely separated overseas switching centers, have been installed to provide additional stepped-up computerized message handling capability for the network.

Messages arriving at Goddard from remote stations are read by the 494's, formatted, checked for validity, automatically assigned a priority, and immediately routed over new high-speed communications lines to the two 494's at Houston at a rate of 40,800 bits per second.

These computers, which form the heart of the Command Communications and Telemetry Systems (CCATS), serve as the "super clearing house" for the handling and routing of a communications between Mission Control, the remote stations, and the spacecraft.

Incoming data keeps flight controllers at Mission Control constantly posted on the status of every major system within the spacecraft. This information is evaluated and compared with a computer-stored "mission profile", a description of conditions at any point in time for a normal flight.

Fourteen land stations are equipped with UNIVAC 1230 Computers to process, pre-process and relay telemetry and command information between

Mission Control and the spacecraft: Canberra, Australia; Guam; Kauai, Hawaii; Goldstone, Calif.; Corpus Christi, Texas; Cape Kennedy; Grand Bahama; Bermuda; Madrid, Spain; Antigua; Grand Canary; Carnarvon, Australia; Guaymas, Mexico; and Ascension Island. Four Apollo Instrumentation Ships also carry 1230's: The USNS Mercury, USNS Redstone, USNS Vanguard, and USNS Huntsville.

Univac delivered the 1230's in less than 1 1/2 years following the development phase, which began in January 1965. The first was shipped from St. Paul in August 1965, and the last in October 1966.

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(UD-6)

SPERRY RAND

NEWS

1290 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10019

SPERRY GYROSCOPE DIVISION
Great Neck, New York 11020

TINY SPACE SPEEDOMETERS PLAY KEY ROLE IN APOLLO GUIDANCE

GREAT NECK, N. Y. ...Three small metal cylinders, although no larger than spools of thread found in a housewife's sewing basket, have a king-size role in helping guide the Apollo 11 Command Module being launched aboard the Saturn V rocket for man's first lunar landing.

The devices -- called accelerometers -- are in a sense "space speedometers." They sense the amount and direction of change in acceleration in space, and electronically "pass along" deviations to the guidance and navigation system's computer which generates corrective steering signals to the Apollo spacecraft's rocket engine system.

One of the most crucial aspects of the Apollo mission is the test of the Apollo Command Module's heat shield on re-entering the earth's atmosphere. The accuracy of the craft's navigation and guidance system is critical in assuring the proper attitude and angle of re-entry, to prevent the capsule from burning up if the angle is too steep.

Produced by Sperry Rand's Sperry Gyroscope Division, under contract to NASA, these tiny sensors are vital to Apollo's Inertial Measurement Unit (IMU). The basic design was developed by M.I.T.

M O R E

The Inertial Measurement Unit -- a ball-shaped structure measuring some 14 inches across -- is the unit that establishes and holds a stable on-board frame of reference, and then measures accelerations against that reference. The IMU consists of three gyroscopes and three accelerometers mounted on a stabilized inner structure which, in turn, is suspended inside three concentric spherical gimbals connected to each other by drive motors and angle resolvers.

Two of the accelerometers are mounted flat on the inertial system platform, at 90-degree angles from each other, the other vertically to sense the three basic elements of direction. Working in unison on the gyro-stabilized platform, they continually flash signals to the computer.

The accelerometer -- technically called "16 Pulsed Integrating Pendulum" -- contains a sensitive element within the fluid-filled, two-inch long cylinder. This metal float is free to move when it is pushed or pulled by an accelerating or decelerating force. Instead of moving back and forth, like a clock's pendulum, however, the float element is made to rotate around its lengthwise axis, much like a rolling pin that is rolled by shoving the table on which it is resting.

The float can rotate no further than some 30 millionths of an inch before artificial twisting forces, torque, push it back to null. The electric signal from the accelerometer's torquers is proportional to the force on the float -- and on the vehicle itself. This signal alerts the computer to make corrections.

The size of almost every tiny part in the Lilliputian-sized device must be precise to 50 millionths of an inch. Extreme care is required in production. At Sperry technicians worked in super-clean laboratories in manufacturing the navigation instruments.

M O R E

When NASA's Lunar Module (LM) ultimately sets down on the lunar surface, on board will be three such Sperry accelerometers having helped to guide it there.

# # #

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SPERRY RAND

SPERRY
MICROWAVE ELECTRONICS DIVISION
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NEWS

1290 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10019

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TINY ELECTRONIC DEVICE TO AID LIVE TV RECEPTION FROM APOLLO SPACECRAFT ON MOON

CLEARWATER, FLA. ...A tiny electronic component no larger than a pin head enables NASA to receive live television pictures from lunar distances. The electronic component is part of a special communications amplifier produced by Sperry Rand that will allow live TV reception from the Apollo astronauts on their lunar landing mission.

The special radio device, built by Sperry Microwave Electronics Division, is known as a parametric amplifier, a communications component that has been installed at selected tracking stations of NASA's world-wide Apollo communications network. The amplifier permits the reception of weak television signals by reducing the signal interference generated in earth-based receiving equipment. Television is also used by NASA for evaluation of the Saturn V fuel tanks during launch.

The parametric amplifiers are all part of the Project Apollo communications network, designated the Unified S-Band System (USB). The network combines the multi-function operations of tracking, communications and telemetry to and from the Apollo spacecraft, lunar module, and Mission Control.

Some 24 land and shipboard tracking sites of NASA's Manned Space Flight Network will maintain continuous world-wide communications and provide the only link between Mission Control in Houston and the astronauts.

M O R E

Sperry's parametric amplifier has been installed at eight key stations of the worldwide network. The special equipment was supplied under a sub-contract to the Collin Radio Company, Dallas Division, the prime contractor to NASA for the Unified S-Band.

At the heart of each parametric amplifier system, which is mounted in the tracking antenna, is a special semi-conductor element approximately the size of a pin head. In operation, the parametric amplifier processes and amplifies incoming radio signals 1,000 times without significant distortion.

Sperry engineers explained that the strength of microwave television signals coming from the Apollo spacecraft at 240,000 miles away are extremely weak by the time they reach the earth. Moreover, internal noise generated within receivers tend to further interfere with the already faint signals.

By utilizing the special component, NASA scientists will be able to receive live TV signals that might otherwise be lost.

The parametric amplifiers are installed inside a cryogenic refrigerator, a super "deep freezer" that cools the semi-conductor device to 425 degrees Fahrenheit, just a few degrees above absolute zero. The super cooling of the component reduces the motion of the molecules, the source of the interference in radio receivers. The overall result is to reduce the interference and enable the amplification of intelligible signals from the spacecraft.

The Sperry equipment is installed at tracking stations located at Ascension Island, Madrid, Carnarvon and Canberra, Australia; Guam, Hawaii, Goldstone, Calif.; and Greenbelt, Md.

# # #

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SMD-1

SPERRY RAND

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NEWS

1290 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10019

APOLLO ASTRONAUTS WILL HAVE "HANDI-TALKIE" RESCUE RADIOS

PHOENIX, ARIZONA ... America's Apollo moon explorers will have double protection against losing contact with recovery crews if an emergency prevents them from using communications equipment in their capsule after returning to Earth.

Two "handi-talkie" radio transceivers, produced by Sperry Rand's Sperry Flight Systems Division in Phoenix, will be stored in the Apollo command module with other survival equipment such as life rafts and emergency food supplies.

Powered by waterproof batteries, the radios will transmit a beeping tone on an international distress frequency, 243 Mhz. Search aircraft can pick up this signal and use direction-finding receivers to locate the astronauts.

The radios also may be used by the astronauts to carry on two-way conversations with rescue crews.

The Sperry transceivers, which were carried on all of the Gemini flights, transmit with 2 watts of power and have a range of more than 100 miles, depending on the altitude of the aircraft with which they are in contact. Each transceiver weighs 5 pounds and is capable of continuous operations for 24 hours.

# # #

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SPERRY RAND

NEWS

1290 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10019

SPACE SUPPORT DIVISION
Huntsville, Alabama

EMERGENCY DETECTION SYSTEM HELPS ASSURE APOLLO ASTRONAUTS' SAFETY

HUNTSVILLE, ALA. ... An electronic simulator being used by NASA to analyze the Saturn/Apollo's Emergency Detection System will contribute to the safety of the Apollo mission. The ground-based equipment provides a complete electrical simulation of the Saturn/Apollo flight from lift-off until orbit and demonstrates some of the factors which directly contribute to the safety of the astronauts.

The Emergency Detection System on-board the Saturn vehicle monitors and provides safety for the Apollo flight crew from the time of launch until the vehicle enters orbit.

The electronic simulator, built at NASA's Marshall Space Flight Center, displays all the electronic circuits of the Saturn launch vehicle associated with the detection system. Located in the Astrionics Laboratory at Marshall, the simulator is operated and maintained by personnel of Sperry Rand's Space Support Division.

Purpose of the simulator is to provide the capability for analyzing the actual EDS circuitry and to demonstrate the results of circuit improvement before actual hardware changes have been made to the flight

M O R E

equipment. Moreover, the EDS simulator is used to familiarize the astronauts with their emergency detection system and trains them to understand what is happening when certain information is displayed on their spacecraft panel.

By using the simulator, Sperry Rand and NASA engineers have the capability to "switch-in" any possible fault or combination of faults that could be encountered during a mission and provides an instantaneous readout on the lighted display and simulated spacecraft panel.

Working with Apollo astronauts and members of the Crew Safety Panel, Sperry Rand engineers are continually updating and testing the EDS simulator. Prior to launch, a complete EDS flight simulation is run and all simulator circuitry is reviewed and updated, if necessary.

# # #

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SPERRY RAND

VICKERS NEWS

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HYDRAULIC POWER STEERING HELPS CONTROL FLIGHT PATH OF SATURN V STAGE

Troy, Mich. ... What similarity is there between the giant Saturn V launch vehicle and your automobile?

Power steering. Both the Saturn V and the modern automobile use hydraulic pumps for power to steer. Of course, the hydraulic pumps built by Sperry Rand's Vickers Division for the Saturn V third-stage S-IVB engine are many times more powerful and complex than those in an auto.

Two Vickers units make up the hydraulic systems of the McDonnell Douglas S-IVB, a main steering pump and an auxiliary motorpump, that help to control the flight of the important third-stage. The S-IVB stage boosts the Apollo spacecraft into earth parking orbit and later re-starts to send the astronauts on to their translunar voyage.

Driven by the Saturn's third-stage J-2 engines, the main hydraulic steering pump powers the gimballing mechanism to change the flight path by varying the angle of the engine exhaust.

The Vickers motorpump, a specially designed unit, is utilized to circulate the main steering pump's hydraulic fluid to prevent it from freezing prior to launch and before re-starting in outer space.

The motorpump goes to work some 18 minutes before lift-off. Its tasks are to keep the steering system fluid moving, to keep the exhaust cone centered until ignition, and to provide supercharge for the main (engine-driven) steering pump when activated. The main steering pump

NEWS VICKERS

starts at 9 minutes and 41 seconds into the mission at 119 miles altitude, with the ignition of the S-IVB stage engine.

The main steering pump will then power the gimballing system to direct the spacecraft and third-stage into earth orbit. The pump shuts down at the first engine cut-off after two minutes and 30 seconds of operation. The motorpump shuts down four seconds later. At 45 minute intervals, the motorpump will cycle on briefly to warm portions of the hydraulic system by circulating fluid.

Six minutes before the third-stage engine is to re-start for the vital translunar injection (TLI) burn, the motor pump re-starts to pressurize and supplement the main steering pump. After a $5\frac{1}{2}$ minute burn the S-IVB shuts down for the last time, and the engine-driven main steering pump has completed its mission.

The motorpump, however, still has one remaining function to perform. Following separation of the Apollo spacecraft from the third-stage and the docking and extraction maneuvers with the Lunar Module have been completed, the S-IVB stage will be "passivated" to make it safe. The pneumatic controls, gas and remaining fuel will be ejected from the engine, an experimental maneuver foreshadowing conversion of the spent stage into an orbiting workshop in space in future missions. During passivation, the Vickers motorpump holds the engine centered. The thrust developed during this maneuver will place the S-IVB out of moon trajectory and into a solar orbit.

# # #

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Background for Editors

Prepared by the Public Information Department of Sperry Rand Corporation's UNIVAC Division

UNIVAC SYSTEMS IN THE APOLLO PROGRAM

July, 1969

AUTOMATIC DATA SWITCHING SYSTEMS (ADSS)

The worldwide NASCOM (NASA Communications) network has undergone dramatic changes since Project Mercury; tracking stations, communications links and switching centers have been endowed with greater speed, power, and flexibility than had been available during previous programs.

The Apollo program will be the direct beneficiary of NASCOM's new, enhanced capabilities. One of NASCOM's chief responsibilities will be to transmit, receive, convey, and route the flood of data and messages which will be flowing between the Apollo spacecraft and Mission Control Center in Houston, Texas.

In order to insure reliable and accurate transmission of communications to Mission Control, the NASA Communications Division operates a computerized data and communications processing system, known as the Automatic Data Switching Systems (ADSS).

The hub of ADSS is the primary switching center at the Goddard Space Flight Center, Greenbelt, Maryland, where three UNIVAC 494 Communication Processors function as an "electronic switchboard" for all teletype messages streaming in from the world wide tracking network.

In preparation for the added requirements of Apollo, the ADSS network has been refitted with high-speed data lines and advanced communications processing equipment.

New high-speed circuits operating at 1200 and 2400 bits per second have replaced the slow 30-bit-per-second lines between the overseas and the primary switching center at Goddard.

Four extremely high speed data arteries - each with a capacity of 50,000 bits per second - have been installed between the important Goddard and Houston path.

At the overseas switching centers, high speed data blocks will be received from the remote tracking stations at 45, 50 and 75 bits per second.

At Goddard, the messages from 17 different high speed lines are read by the UNIVAC 494's, combined, and retransmitted over the broad band channel to Houston. The line incorporates a number of unique error-detection techniques to insure accurate message transmission to Houston.

As presently implemented, the NASCOM automatic message switching system not only provides economical real-time communications, but it is also designed to meet the growing needs of the nation's manned and unmanned space flight missions.

COMMUNICATIONS, COMMAND AND TELEMETRY SYSTEMS

Mission success or failure depends on instantaneous real-time processing of communications to and from the Apollo spacecraft. Incoming data must be fed into the command computer in seconds, evaluated, and compared against a mission profile, the pre-calculated picture of conditions under normal conditions.

Thousands of urgent messages must be routed to their proper terminals in Mission Control on a continuing basis during the entire mission. This is the vital task assigned to the Communications Command and Telemetry Systems (CCATS), located in the Manned Spacecraft Center in Houston. The CCATS complex automatically routes incoming messages from a large number of incoming circuits, updates displays for flight controllers, and feeds data to the Real-Time Computer Complex at Mission Control. CCATS sends the "turn around" command data back to the spacecraft via the appropriate worldwide tracking station. All of these tasks are performed in seconds by computerized communication processing equipment.

The CCATS complex is centered around two UNIVAC 494 Real-Time Systems, which act as master communication processors. While one 494 is in operation, the other is constantly on standby, ready to be cut into operation instantaneously, if needed.

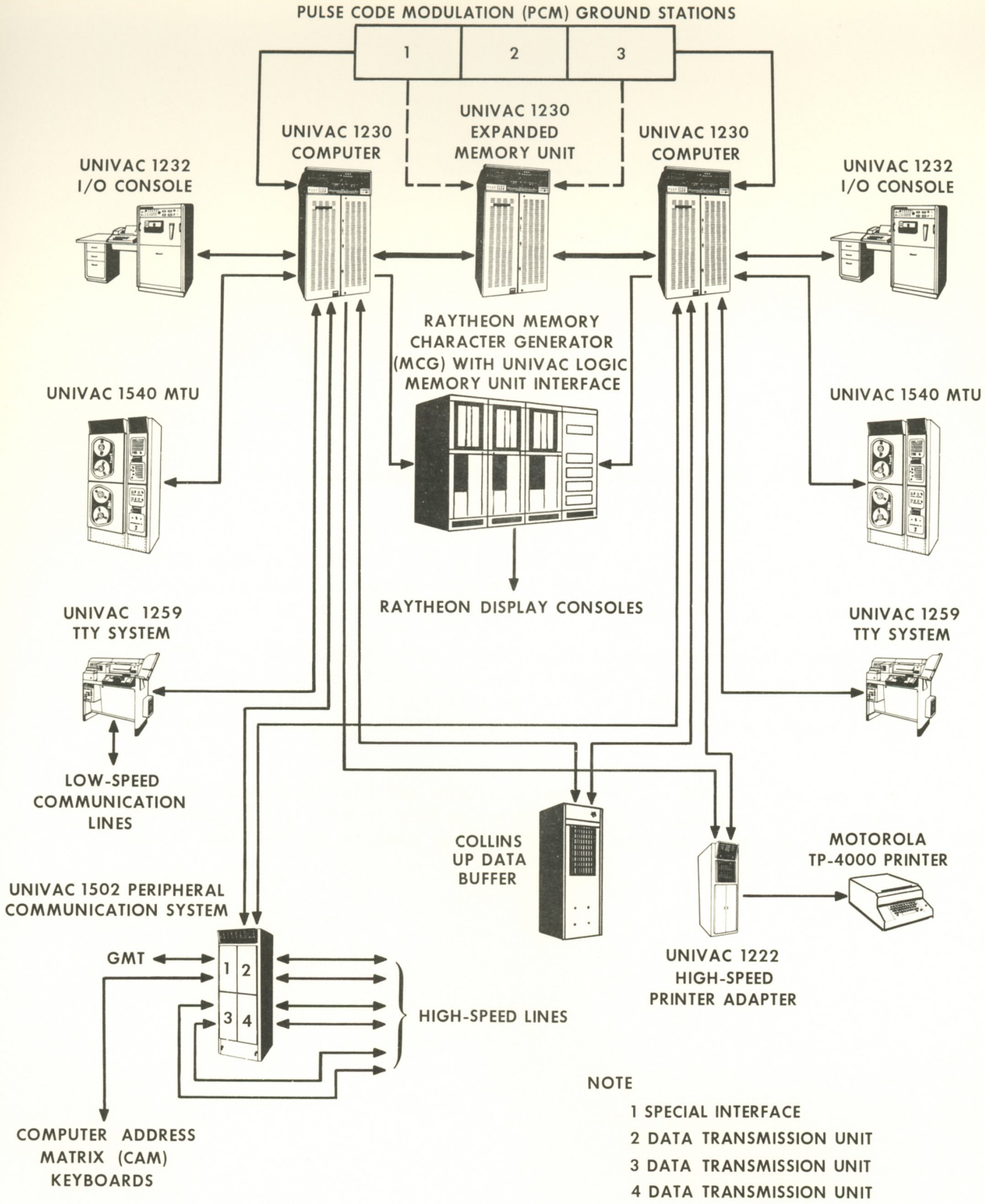
In order to maintain the continuous stream of real-time status information on the complex Apollo mission, CCATS is designed to relay tremendous amounts of data - as much as 15,000 words <u>each</u> <u>second</u>.

CCATS will handle traffic from up to 30 two-way 100-word-per-minute teletype links and up to 20 high speed data lines operating at 3200 words per minute.

The CCATS function is to instantly route messages, convert the speed of incoming traffic into a speed compatible with outgoing lines, check for accuracy, maintain a log of messages, store all messages, recall them if necessary, file messages, and control the important circuits.

In the case of a high-priority message, the UNIVAC 494 begins necessary speed conversion and re-transmission to the addressed terminal even as the message is feeding into the system. Every message is recorded on a large "memory" drum that can store up to 786,432 computer words or 3,932,160 alphanumeric characters. Information stored on the drum can be retrieved in 17 millionths of a second.

Data headed for the command computer complex is converted and forwarded over four duplex lines which each transmit 40,800 bits a second or about 217,600 words per minute.


PULSE CODE MODULATION (PCM) GROUND STATIONS
1
2
3
UNIVAC 1230 COMPUTER
UNIVAC 1230 EXPANDED MEMORY UNIT
UNIVAC 1230 COMPUTER
UNIVAC 1232 I/O CONSOLE
UNIVAC 1232 I/O CONSOLE
RAYTHEON MEMORY CHARACTER GENERATOR (MCG) WITH UNIVAC LOGIC MEMORY UNIT INTERFACE
UNIVAC 1540 MTU
UNIVAC 1540 MTU
RAYTHEON DISPLAY CONSOLES
UNIVAC 1259 TTY SYSTEM
UNIVAC 1259 TTY SYSTEM
LOW-SPEED COMMUNICATION LINES
COLLINS UP DATA BUFFER
MOTOROLA TP-4000 PRINTER
UNIVAC 1502 PERIPHERAL COMMUNICATION SYSTEM
GMT
1 2
3 4
HIGH-SPEED LINES
UNIVAC 1222 HIGH-SPEED PRINTER ADAPTER
COMPUTER ADDRESS MATRIX (CAM) KEYBOARDS
NOTE
1 SPECIAL INTERFACE
2 DATA TRANSMISSION UNIT
3 DATA TRANSMISSION UNIT
4 DATA TRANSMISSION UNIT

ASCATS (APOLLO SIMULATION, CHECKOUT, AND TRAINING SYSTEM)

ASCATS employs a UNIVAC 494, a UNIVAC 418 and other computers to provide the Mission Control Center with data simulating Apollo missions. This data is used in training flight controllers for actual missions.

The 494 Real-Time System interfaces with Command Module and Lunar Module mission simulators to receive telemetry data much as an actual remote site would. At a given time, it can simulate up to three remote sites plus their interface with 494's at the Goddard Space Flight Center.

The UNIVAC 418 is used for multiple functions in ASCATS, including providing data, like simulated information from Goddard, on a smaller scale, and helping prepare tapes used to check out programs.

UNIVAC 494 COMMUNICATIONS PROCESSORS

Sperry Rand UNIVAC 494 Communication Processors are at the heart of the Automatic Data Switching Systems at the Goddard Space Flight Center and the Communications Command and Telemetry Systems at the Manned Spacecraft Center. The 494 is 15 times more powerful than the previous UNIVAC 490 C.P.'s used by NASA during the Gemini missions.

The UNIVAC 494's consist of a basic central processor and associated peripheral storage and communication subsystems. The central processor features a cycle time of 375 nanoseconds (billionths of second) and has a capacity of some two million bits of random access core memory.

Peripheral equipment to the central processor is an extremely fast FH-880 mass storage drum with a capacity for storing 46 millions bits of information or nearly 8,000,000 alphanumeric characters. Anyone of these bits of information can be retrieved in 17 millionths of a second.

The mass storage system for the ADSS switching system will employ two FH-880 drums which will be used for messages, traffic queues and message recall storage. Infrequently executed programs will also be stored in the drums.

The UNIVAC 494 includes 24 full duplex input-output channels for gaining access to the central processors. Eight of the channels will be used for standard communications, with four assigned to low-speed (60 to 100 bits per second) traffic and four to high-speed (2400 bits per second) traffic. The other channels service the standard peripherals.

UNIVAC 418

UNIVAC 418 Real-Time Systems serve in Spain and Australia as automatic sub-switching centers in NASCOM. They accept information from stations in the Manned Space Flight Network, and expedite the handling of the data to computers in the U.S.

The NASA Communications Network utilizes four 418 Systems - two each at Madrid, Spain and Canberra, Australia. While one of the systems at a center is operating, the other remains on standby.

The 418 central processor has a storage capacity of 4,096 to 65,536 words of 18 bits each, average access time of one microsecond, and cycle time of two microseconds. Peripheral equipment includes two FH-880 drums, each with storage capacity of 4.7 million alphanumeric characters, for low priority messages, traffic queues, and other requirements.

UNIVAC 1230 COMPUTER (NASA M642-B)

Principal mission of the more than 40 UNIVAC 1230 (NASA M642-B) computers at the Apollo remote sites is to act as a relay station for the data to and from the spacecraft. To accomplish this, the remote site data processing systems must accept, record, format and transmit data originating from the spacecraft and relay this information to the Manned Spacecraft Center in Houston. In addition, the computers are responsible for accepting commands from the land-based flight controllers and issuing these commands to the spacecraft in real-time.

The remote site systems accept data from the spacecraft via the telemetry data link connected directly to the computer. The telemetry data processing program stored in the computers collects telemetry data in real-time from the various systems within the Apollo spacecraft and continuously transmits selected combinations of data. Such information is then transmitted to the MSC via the UNIVAC 2.4 kilobit per second Data Transmission Units. Five to ten seconds after a data word is telemetered by the spacecraft, it is processed by the remote site computing system, transferred by data lines through the UNIVAC 494 NASCOM communications processor at Goddard to the UNIVAC 494 CCATS communications processor at Houston, and then displayed at the MSC. As telemetry data enters the remote site computer system, the actual data history is being recorded on digital magnetic tape for possible analysis and data reduction during post mission periods.

To provide complete communication between the flight controllers and the Apollo spacecraft, a command data path is provided through the remote site computers. The program within the command computers automatically transmits commands to the spacecraft and inspects the telemetry data from the spacecraft to verify that the commands are properly received. The program automatically re-transmits commands that are not successfully completed.

Commands transmitted vary in complexity from single on-off switch commands to the spacecraft to a series of commands which specify the spacecraft attitude for such functions as re-entry. Content of the commands is obtained basically from : 1. data pre-stored in the program, and 2. data received in real-time from the MSC.

The two UNIVAC 642B computers at each remote site (fourteen land tracking stations and aboard four Apollo Instrumentation Ships) have independent tasks to perform. One computer does telemetry data processing and the other performs commanding tasks.

UNIVAC 1108's - HOUSTON

The Computation and Analysis Division at the Manned Spacecraft Center uses UNIVAC 1108 Computer Systems for engineering and scientific calculations before, during, and after Apollo missions.

Before missions, the 1108's aid general mission planning by providing such information as types of orbit, weights, launch times, structural integrity of booster and spacecraft, and abort conditions for various wind forces.

During the missions, the 1108's can operate special simulation programs providing Mission Control with information on expected future conditions. This can include fuel loads, oxygen consumption, locations of stars which will aid the astronauts' celestial navigation, de-orbit maneuvers, and other data.

The 1108's also reduce data, including telemetry from the spacecraft, and pressure, temperature, and vibration information from space chambers. They can perform special data processing tasks aiding financial management at the center.

UNIVAC 1108's - HUNTSVILLE

NASA's Marshall Space Flight Center in Huntsville is operating one of the most complex third generation systems in existence, built around a multi-processor system consisting of three UNIVAC 1108 computers and two Input-Output Controllers. The complex includes about 80 remote terminals located in each major laboratory and many management offices.

Apollo support applications were among the first and most critical functions converted to Marshall's 1108 system, which provided complete and successful support of the Apollo 10 launch during its acceptance evaluation period.

Applications include preflight, launch, and post-flight data analysis. Real time data is provided by microwave analog interface at Huntsville from the Cape Kennedy data bank. This data is digitized, inputed to the 1108 by a DDP-224 interface, and processed in real time by several data reduction programs. The computer provides an output display to ten CRT monitors, each in a unique format. Data can be displayed in up to 50 formats and is preserved for structural, trajectory, velocity, and dynamic fluid analysis.

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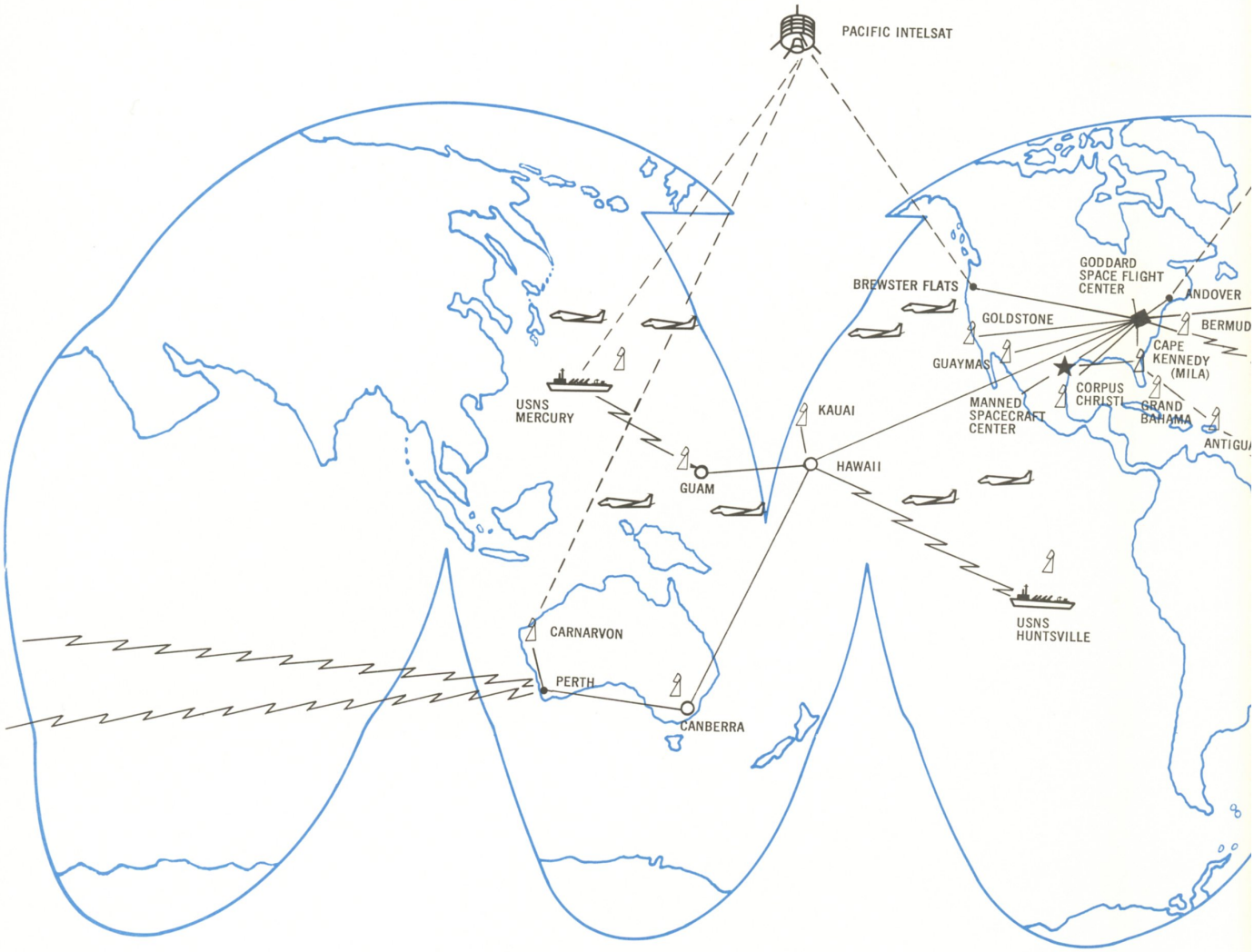

legend

- Apollo Unified S-Band Sites (UNIVAC 642B's & 1218's)
- Apollo Instrumentation Ships (UNIVAC 642B's & 1218's)
- Apollo Range Instrumentation Aircraft
- ■ Goddard Space Flight Center (Primary Switching Cer (UNIVAC 494's)
- ○ NASCOM Overseas Switching Centers (UNIVAC 418's at Madrid & Canberra)

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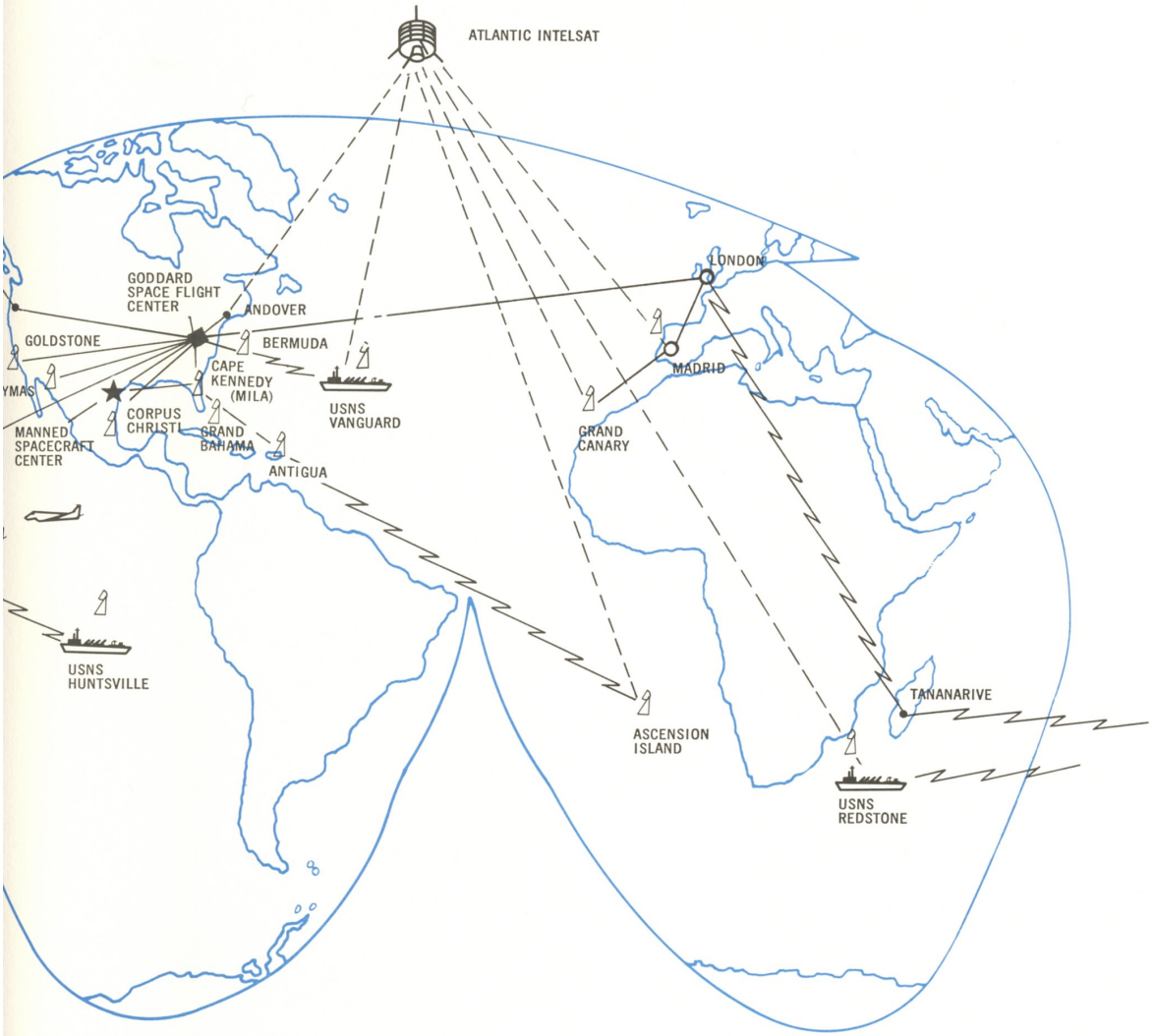

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Instrumentation Aircraft

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s at Madrid & Canberra)

Mission Control Center
(UNIVAC 494's, 1108's, 642B's, 1218's & 418's)

Communications Satellites

Satellite Communications

High Speed Data

Radio and Teletype