PRESS INFORMATION

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July 1, 1969

NOTE TO EDITORS:

The attached photograph was made originally by Philco Houston Operations for a poster series on manned flight awareness sponsored by NASA and aerospace contractors. It was shot in a Houston laboratory by Philco-Ford photographer Glen Lilly. It may be used with or without credit.

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FOR USE AT ANY TIME

Nerve center for man's greatest adventure -- command and control of the Apollo moon mission from liftoff to recovery -- is this Mission Operations Control Room, one of two in NASA's Mission Control Center, Houston. Scene above, typical of missions which followed, was photographed during Apollo 8. Philco-Ford Corporation helped to design and implemented MCC under prime contract awarded in 1963 and has continued to update the center for each mission since it went operational with Gemini 4 in June, 1965.

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Philco-Ford Corporation, prime contractor for implementation of NASA's Mission Control Center, Houston, is applying aerospace command-and-control technology to earth resources, utilities, transportation and other areas. Typical is this California water project control center in which Herb Nyser of Philco-Ford's WDL Division, Palo Alto, Calif., checks out console.

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Monitoring and control for the Apollo Lunar Surface Experiments Package (ALSEP) program, starting with Apollo 11, will be performed by Philco-Ford personnel in this room in NASA's Mission Control Center, Houston. Experiments include detection of moonquake and other lunar tremors. Seismic recorders at right are so sensitive they can detect footsteps of astronauts on moon. Left to right at control consoles: Ed Turpin, Jack Hill and James Omoto, all of Philco Houston Operations. NASA scientists, serving as principal investigators, will occupy adjoining room at MCC.

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FOR USE AT ANY TIME

Earth control for Apollo missions to the moon is provided by flight controllers at the Mission Control Center, located in the windowless three-story operations wing (left) of Building 30 at NASA's Manned Spacecraft Center. Operational since Gemini 4 (June, 1965), the MCC is two control centers in one: it can direct two simulated missions, or one real mission and one simulated operation simultaneously. "HOUSTON" to the Apollo astronauts, the center was implemented under a 1963 contract by Philco-Ford Corporation, which continues to provide maintenance and operations and engineering support services, including the updating of MCC systems for each mission.

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FOR IMMEDIATE RELEASE

The nerve center for man's greatest adventure -- command and control of Apollo 11 from liftoff to the moon to splashdown -- is a Philco-Ford-implemented operations complex which has served the National Aeronautics and Space Administration since the early days of Project Gemini.

While U. S. launch and space vehicles have been accomplishing the incredible and American astronauts have been astounding the world with their space achievements, Houston's Mission Control Center has been performing so smoothly that it has made the technologically complicated seem routine.

The MCC (at times called "Houston" ... "Gemini Control" ... or "MOCR") is the Earth's most sophisticated ground control station and one of a half dozen key aerospace elements which made man's quest for the moon feasible in this decade.

Conceived in Project Mercury and housed in Building 30, one of the first erected at the Manned Spacecraft Center, the Mission Control Center had to be designed to do things that had never been done before but, because there wasn't time to wait, built with the electronic technology available in 1960.

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In short, what NASA needed on the ground to assure a landing on the moon in the '60s was a major computer-assisted decision-making capability which no one had when Philco-Ford received the contract for design and implementation of an integrated control center in early 1963.

Such a system was, in fact, delivered just two years later. It was first tried in the MCC's monitoring of all systems in the Gemini 3 mission in March, 1965, and became an operational reality three months later as mission control moved from Cape Kennedy, where it had been since Project Mercury, to Houston for Gemini 4. It was in Gemini 4 that the late Edward H. White, II, became the first American to walk in space.

Working side by side, Philco-Ford and NASA scientists, engineers and technicians have made, and continue to make, design and instrumentation changes as necessary to control a given mission. The center which emerged from the flat coastal lands south of Houston set the pattern for large-scale command and control: it provides a workable way to process many kinds of vital information from billions of bits of incoming and stored/reference data -- and selectively display to scores of flight controllers and system monitors what they need to see in real time.

Flexibility and adaptability were key elements in the systems design of the Mission Control Center which is updated for each mission by Philco-Ford under a continuous contract for engineering support and maintenance and operations services. These major system reconfigurations may involve as many as two million wiring changes.

To the four basic MCC systems that were available for Gemini 4 control, another has been added for Apollo 11 and subsequent flights in the lunar exploration series. The fifth system monitors and controls the Apollo Lunar Surface Experiments Package (ALSEP) in which astronauts, starting with Neil Armstrong and Edwin Aldrin, will leave scientific instruments on the moon.

The MCC ALSEP system is a joint effort of NASA, IBM and Philco Houston Operations under the direction of NASA. It will receive scientific data from the moon via radio for analysis by a team of experts at MCC.

In addition to serving as systems integrator, Philco Houston provided three of the four basic MCC systems -- Display/Control, Communications, and Apollo Simulation, Checkout and Training -- and IBM provided the Real-Time Computer Complex.

The MCC is actually two manned space flight control centers in one. It has two Mission Operations Control Rooms (MOCRs -- pronounced MOE-curs in space language) and supporting areas -- one on the second floor, the other on the third floor of the center. Two missions may be controlled simultaneously. Both may be simulated missions or one may be real and the other simulated.

The Mission Control Center is supported by a worldwide network of tracking and voice-data communications stations. In addition to mission control from launch through recovery, its functions include technical management in the areas of vehicle systems, flight dynamics, life systems, flight crew activities, recovery support and ground network support operations.

Reliability is built into the MCC's design. Every piece of equipment and system has a spare or auxiliary, including the electrical power and airconditioning systems.

In sheer numbers and scope the MCC hardware which so vastly improves man/machine communications in mission control exceeds the average layman's imagination. Its functions are so complex even to engineers and scientists that Philco Houston saw fit to develop a computer-oriented test system, which has been in use since the spectacular spacecraft rendezvous mission of Gemini 7 and 6 in December, 1965.

The size of the task, which has become even more complicated in Apollo, can be gleaned from some facts and figures on the MCC and the men who use it:

-- More than 1,500 different items of telemetry data -- from the condition of the astronauts to the results of various tests carried out during a mission -- flow into the MCC from NASA's global network of tracking stations, including its deep space stations, during an Apollo flight. The amount of information is equivalent to that which would be received by 1,000 standard teletypewriter circuits.

-- The MCC houses the largest assembly of television switching equipment in the world.

-- It contains some 1,200 cabinets of electrical and electronic equipment, 140 command consoles, 160 cameras, 561 TV displays, 64 digital-to-TV converters and more than 60 thousand miles of wire.

-- Mission flight controllers have some 1,300 individual indications available to them from the complex of five IBM 360/75 computers and peripheral equipment on the MCC's ground floor. They use more than 80 different devices to feed control information and requests into the computer. (These devices alone are capable of making more than two million inputs or requests to the computer.)

-- Flight controllers have at their fingertips more than 100 commands in the spacecraft. There is room to store 750 more commands from the computer.

-- As many as 44,000 35-millimeter, coded slides may be provided for a single mission. Multi-colored slides for projection on the MOCRs' big 10 x 20 and 10 x 10-foot screens became available in Apollo 10 for the first time as a result of a technological breakthrough in a Philco-Ford laboratory. That mission, coincidentally, marked the first live color telecasts from space.

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AN AEROSPACE CHRONOLOGY -- FOR USE AT ANY TIME

NOTE TO NEWSMEN:

Philco-Ford Corporation, a prime contractor for NASA's Mission Control Center and participant in every manned Mercury, Gemini and Apollo flight, is one of America's pioneer aerospace companies.

Its experience in the design, development and management of major space systems started with the earliest ventures into space and included Project Farside, the first vehicle to ascend outside the Earth's atmosphere.

Farside, built by Philco-Ford's Aeronutronic Division for the U. S. Air Force as a sounding vehicle to sense the Earth's magnetic field and space radiation, was launched by a four-stage rocket from a balloon over the Pacific Ocean in 1957. Tracked 2,700 miles into space, Farside is believed actually to have acheived a targeted distance of 4,000 miles from Earth. It was launched a few days before the first Sputnik satellite went into Earth orbit.

Following is an aerospace chronology, including milestone events in which this company has participated from 1957 to date. As a matter of convenience, we have chosen time frames which group programs and projects into four phases, including pre-manned spaceflight, Project Mercury, Project Gemini and Project Apollo. Philco-Ford's role in both manned and unmanned aerospace programs are listed for each phase and interim period.

PHILCO-FORD PUBLIC RELATIONS
July, 1969

PHILCO-FORD IN SPACE

PHASE I: Unmanned probes, studies, research and development programs (1957-1961)

DATE	PROJECT/MISSION	PHILCO-FORD PARTICIPATION
1957	Project Farside	Aeronutronic-built sounding vehicle, launched by four-stage rocket from balloon over Pacific in one of U. S. Air Force's first space probes; senses earth Magnetic field, space radiation; is tracked 2,700 miles from earth, believed to have gone 4,000 miles out.
1957	U. S. Air Force Satellite Control Facility subsystem	Philco-Ford begins ground-support work for USAF -- implementation of a communications and control space-borne subsystem in Satellite Control Facility program.
1958	Re-entry systems (penetration aids)	One of company's first penetration aids study contracts leads to operational hardware.
1959	Blue Scout	Philco-Ford completes engineering and integration of upper atmosphere scientific payload system.
Early 1959	Project Mercury/ worldwide tracking system	Study contracts awarded to Aeronutronic on tracking and ground instrumentation, radar coverage and trajectory computation requirements.

DATE	PROJECT/MISSION	PARTICIPATION
Sept. 1959	Manned Spaceflight Communications Network/Goddard	Provided engineering and technical support continuously to date.
1960	Air Force satellite ground stations	Philco-Ford designed, built and manned the tracking, command and communications equipment for the first satellites launched by the U. S. Air Force and still is participating--10 years later.
1960	Blue Scout Junior	First flight of experimental probe programs is successful.
Early 1960's	U. S. Air Force Satellite Control Facility	Philco-Ford provided equipment for control center at Sunnyvale, Calif., and subsequently, a large number of tracking, telemetry and command antenna systems throughout world.
10/4/60	Courier launched	Prime contractor for active repeater communications satellite for Army which proved feasibility of such communications. Launched Oct. 4, 1960, from Vandenberg AFB and operated during 286 orbits of the earth.

PHASE II: PROJECT MERCURY (FEB., 1961 - MAY, 1963)

5/5/61	MR-3 (Freedom 7) Manned (Alan B. Shepard) (Sub-orbital flight with Redstone booster)	
7/21/61	MR-4 (Liberty Bell 7) Manned (Virgil I. Grissom) (Sub-orbital flight with Redstone booster)	

DATE	PROJECT/MISSION	PARTICIPATION
9/13/61	MA-4 (Unmanned) (First Mercury spacecraft to obtain an earth orbit; Atlas booster)	
11/29/61	MA-5 (Chimp Enos aboard; successfully checked environmental control system in orbital flight; evaluated Atlas booster)	
2/20/62	MA-6 (Friendship 7) Manned (John H. Glenn) (First American to orbit earth; 3 orbits)	Philco engineers monitored the mechanical and electronic systems aboard Mercury spacecraft beginning with MA-6, the flight of Col. John Glenn, as key members of three-man teams at each station in NASA's global tracking network.
4/26/62	Ranger IV	Developed hard-landing seismometer for use on Ranger IV. First U. S. equipment impacted on moon.
5/24/62	MA-7 (Aurora 7) Manned (Scott Carpenter) (3 orbits)	Philco-Ford continues to provide tracking station control and monitoring personnel.
1962	Defense Communication Satellites	WDL Div. initiated work on Advent ground installations, MILSAT, and, ultimately, was awarded IDCSP contract.
1962	Hat Creek, Calif., Radio Telescope	Philco-Ford provided 85-foot radio telescope to University of Calif. under a NASA contract.
Early 1960's	Goddard Space Flight Center, Greenbelt, Md.	Communications services performed for NASA programs continuously to date.

DATE	PROGRAM/MISSION	PARTICIPATION
10/3/62	MA-8 (Sigma 7) Manned (Walter M. Schirra) (6 orbits)	Philco-Ford personnel served as controllers and monitors at NASA tracking stations throughout the world.
1/28/63	Mission Control Center Houston, Texas	Philco-Ford selected by NASA to negotiate contract for a new control center for manned spaceflight.
3/27/63	MCC-Houston	Philco team begins work in downtown Houston; NASA formally awards Philco a fixed-fee contract, initially in amount of $33,795,565.
5/15/63	MA-9 (Faith 9) Manned (L. Gordon Cooper) (22 orbits - Final Mercury flight)	Philco-Ford personnel served as controllers and monitors at tracking stations.

PHASE II-A: POST-MERCURY/PRE-GEMINI (MAY, 1963 - APRIL, 1964)

6/12/63	Mars Excursion Module (MEM)	NASA awards contract to Aeronutronic for study of a proposed Martian taxi (MEM) which would ferry U. S. astronauts from orbiting spaceship to surface of Mars and return.
6/14/63	Texas Radio Telescope	Dedication, near Austin, Tex. of 16-foot-diameter radio telescope built by Philco-Ford for University of Texas under NASA contract. Part of mission: to map potential landing sites on the moon.
Mid 1963	Four 40-foot Antennas for NASA	Philco-Ford provided systems for use in unmanned satellite tracking at NASA stations in Australia, South Africa, Ecuador and Goldstone Lake, Calif.

DATE	PROGRAM/MISSION	PARTICIPATION
Aug. 1963	Apollo Information Flow	Study contract Add-on ($1.34 M) to letter contract of April, 1962.
Aug. 1963	Advanced Solar Probe	Philco-Ford gets NASA contract for design study of an advanced solar probe. Purpose: to improve scientific knowledge of Sun and interplanetary space, supply data useful in reducing hazards of manned space flight.
Sept. 1963	ABRES	Philco-Ford receives contract from USAF to manufacture classified products for the Advanced Ballistic Re-entry Systems (ABRES) Program, to improve ability of USAF missiles to penetrate possible enemy target defenses.
9/30/63	Empire	Aeronutronic Division reports on its study for NASA on an Early Manned Planetary/ Interplanetary Roundtrip Experiment (EMPIRE), suggesting for the 1970's a 400-600 day voyage past Mars and Venus by six astronauts in a 400,000-pound spacecraft.
1964	Design of Lunar Module (LM)	Philco-Ford received contract from Grumann Aircraft Engineering Corp. for assignment of 23 engineers to its instrumentation subsystem team at Bethpage, N.Y. Philco engineers provided services in R&D of instrumentation for the prototype, test and production models of LM.

DATE	PROGRAM/MISSION	PARTICIPATION
1964	NASA-Langley (Va.) Research Center	Engineering and Technical support in various programs from 1964 to date.

PHASE III: PROJECT GEMINI (APRIL, 1964 - NOV., 1966)

DATE	PROGRAM/MISSION	PARTICIPATION
4/8/64	Gemini 1 (Unmanned test launch)	Philco-Ford TechReps, under continuing contract, were assigned to tracking stations for all manned flights of Gemini.
1/19/65	Gemini 2 (Unmanned test launch)	Flight directors at MCC-Houston monitor mission data relayed from Cape Kennedy.
3/23/65	Gemini 3 (Virgil I. Grissom- John W. Young) (3 revolutions)	TechRep Engineers on tracking station assignments as monitors and communicators; MCC-Houston monitors all command and control systems.
6/3/65	Launch of Gemini 4 (James A. McDivitt - Edward H. White, II) (4 days; 62 revolutions)	MCC-Houston went operational, serving as control center from lift-off to splashdown in this, and all subsequent, U. S. manned space flights. Philco-Ford continues MCC maintenance and operation and engineering support -- some 500 employes in these permanent roles. Stu Davis, of Philco-Ford, a member of the monitoring team at NASA's Hawaiian tracking station, was capsule communicator, in direct communication with GT-4, when the late Major White became the first American to walk in space.

DATE	PROGRAM/MISSION	PARTICIPATION
June 1965	Mariner IV	Philco-Ford provided both low- and high-gain antennas for spacecraft. The 4 x 2-foot "dish" high gain antenna was used in transmission of the first pictures ever taken of Mars as Mariner 4 passed the Red planet some 150 million miles from earth in June, 1965.
June 1965	Dr. Gibson: Astronaut	Dr. Edward G. Gibson, Aeronutronic senior scientist, one of six men selected by NASA for training as scientist-astronauts.
July 1965	FATE	Philco-Ford wins USAF contract for Fuzing and Arming Test and Evaluation (FATE) re-entry vehicles.
Aug. 1965	NASA'S STADAN (Satellite Tracking & Data Acquisition Network)	New contract of $2.4 million for two new 40-foot antenna systems for STADAN and $720,000 for modification of previously built 40-footer at Mojave, Calif. (used in Relay)
8/21/65	Launch of Gemini 5 (L. Gordon Cooper - Charles Conrad, Jr.) (8 days; 120 revolutions)	Philco-Ford continues engineering support, maintenance and operations services at MCC; provides tracking station control and monitoring personnel.
Oct. 1965	REM-B	USAF awards Philco-Ford Re-entry Measurements Program, Phase B, $30 million contract for major experimental program to extend U. S. missile re-entry technology.

DATE	PROGRAM/MISSION	PARTICIPATION
1965	ABL	Automated Biological Laboratory, conceived by Philco-Ford in mid-1960's for unmanned probe of life - or lack of life - on Mars. ABL-type vehicle might be used in project like Viking in 1970's.
12/4/65	Launch of Gemini 7 (Frank Borman, James A. Lovell, Jr.) (13 (+) days; 206 revolutions - space record)	Philco-Ford continues engineering support, maintenance and operations services at MCC; provides tracking station control and monitoring personnel.
12/15/65	Launch of Gemini 6 (Walter Schirra, Thomas P. Stafford) (17 revolutions; 25 hrs. 51 mins.) (Man's first space rendezvous--with GT-7--Dec. 15, 1965)	Same
3/16/66	Launch of Gemini 8 (Neil A. Armstrong, David R. Scott) (7 revolutions; 10 hrs., 42 mins.)	Same
6/3/66	Launch of Gemini 9A (Thos. P. Stafford, Eugene A. Cernan) (44 revolutions; 72 hrs., 21 mins.)	Same
6/16/66	IDCSP	First IDCSP launch from Cape Kennedy. Seven satellites in first Titan 3C shot designed to form Initial Defense Communications Satellite Program network for U. S. Department of Defense.

DATE	PROGRAM/MISSION	PARTICIPATION
7/18/66	Launch of Gemini 10 (John W. Young, Michael Collins) (43 revolutions; 70 hrs. 46 mins.) (GT-10 docked with an Agena & rocketed a record 475 miles into space)	Philco-Ford continues engineering support, maintenance and operations services at MCC; provides tracking station control and monitoring personnel.
9/12/66	Launch of Gemini 11 (Chas. Conrad, Richard F. Gordon, Jr.) (44 revolutions - 71 hrs., 17 mins.) (GT-11, docking with Agena, set new space mark of 853 miles)	Same
11/11/66	Launch of Gemini 12 (James A. Lovell, Jr., Edwin E. Aldrin, Jr.) (59 revolutions; 94 hrs., 35 mins.) (GT-12 rendezvoused with Agena, Aldrin set spacewalking record)	Same

PHASE IV: PROJECT APOLLO (1967 - 1969)

DATE	PROGRAM/MISSION	PARTICIPATION
1967-68	NASA launches six Apollo unmanned test flights. Fire 1/27/67 in Apollo No. 204 at Cape Kennedy claims lives of Astronauts Grissom, White & Chaffe, temporarily setting program back.	Philco-Ford continues engineering, maintenance and operations support role at MCC throughout Apollo.
1/18/67	IDCSP	Eight IDCSP satellites launched from Cape.

DATE	PROGRAM/MISSION	PARTICIPATION
3/8/67	Skynet	Philco-Ford awarded contract to build two Skynet communications satellites for the United Kingdom.
1967	NASA-Wallops Island, Va., Launchsite	Provided engineering support and related services continuously to date.
7/1/67	IDCSP	Launch of three IDCSP satellites and one experimental satellite (DATS--Despun Antenna Test Satellite) from Cape.
9/28/67	Telespazio earth station	Dedication of 90-foot antenna built by Philco-Ford for Telespazio commercial satellite communications earth station east of Rome, Italy.
1967	Mars Surface Lander	Vehicle proposed to NASA by Philco-Ford for soft landing in unmanned Martian probe in mid-1970's.
6/13/68	IDCSP	Launch of eight satellites, completing Defense Satellite Communications System--Phase I. (All 27 Philco-Ford Defense Satellites, including DATS operational in orbit as of July, 1969.)
9/27/68	Etam, W. Va., Earth Station	Dedication of 97-foot antenna built by Philco-Ford for COMSAT Corp. at commercial satellite communications earth station.
9/30/68	Defense Space Communications Study	Philco-Ford receives contract from Army Satellite Communications Agency to study and determine earth station needs in 1970's for military satellite communications.

DATE	PROGRAM/MISSION	PARTICIPATION
10/11/68	Launch of Apollo 7 (Walter M. Schirra, Jr., Walter Cunningham and Donn F. Eisele) Earth orbit - first manned Apollo mission; first live TV from space (163 revolutions; 260 hrs., 8 mins.)	Philco-Ford supplied IC's for Block II Apollo guidance & navigation system computer which performed flawlessly in first manned test; continues engineering, maintenance and operations support to MCC.
12/21/68	Launch of Apollo 8 (Frank Borman, James A. Lovell, Jr., Wm. Anders) 6-day mission, climaxed by first manned lunar orbit, 10 revolutions of moon; greatest speed by humans - nearly 25,000 MPH; longest distance from earth - 233,000 miles.	Radiation detector built by Philco-Ford flew for first time; functioned flawlessly. Philco Houston continues engineering, maintenance and operations support to MCC.
Jan. 1969	Test Range Antennas	Philco-Ford completes checkout of three 80-foot telemetry antennas for USAF test ranges; two on Eastern, one Western. Latter, at Pillar Point, near San Francisco, is largest on Western Test Range.
1/25/69	Cayey, P.R. Earth Station	97-foot communications antenna for satellite communications earth station provided to COMSAT by Philco-Ford.
3/3/69	Launch of Apollo 9 (James A. McDivitt, David R. Scott and Russell Schweickart) 10-day mission in which lunar module (LM) was successfully flown in space; Schweickart performed EVA; 151 revolutions of earth.	Philco-Ford continues engineering, maintenance and operations support at MCC

DATE	PROGRAM/MISSION	PARTICIPATION
Early 1969	Mariner 6 & 7	Philco-Ford supplied communications subsystem, including antennas, for two vehicles scheduled to pass and photograph Mars in mid-Summer, 1969.
4/21/69	Paumalu, Oahu, Hawaii Earth Station	Dedication of 97-foot commercial satellite communications antenna built for COMSAT Corp. Big dish is 40th large antenna installed by Philco-Ford throughout world.
1969	Mars Camera	Philco-Ford designs and builds a variety of facsimile cameras weighing less than 6 pounds to be used in near earth orbit, lunar and deep space programs in the 1970's to photograph and transmit pictures back to earth.
4/25/69	COMSAT Earth Station, Jamesburg, Calif.	Dedication of last of four 97-foot communications antennas built for Communication Satellite Corp.
5/18/69	Korean Earth Station	Ground breaking for $5-million antenna system to be built by Philco-Ford at Korean commercial satellite communications earth station.
5/18/69	Launch of Apollo 10 (Thomas P. Stafford, Eugene A. Cernan and John W. Young) 8-day mission; checkout of LM in lunar orbit 9.4 miles above moon.	Philco-Ford supplied semiconductors for the Lunar Module, including diodes for the landing radar, other devices for communications subsystems.

DATE	PROGRAM/MISSION	PARTICIPATION
7/16/69	Scheduled Launch of Apollo 11 (Neil Armstrong, Michael Collins & Edwin Aldrin) Mission: "Perform a manned lunar landing and return."	Philco-Ford updates MCC, including a new (fifth) subsystem for ALSEP (Apollo Lunar Surface Experiments Package) data processing and analysis. (Seismic and environmental measuring instruments to be left on the moon.)

UPCOMING:

Nov., 1969 (10th to 17th window)	Apollo 12 (Charles Conrad, Richard Gordon & Alan Bean) Scheduled second manned landing on moon.	Philco-Ford built Lunar Surface Magnetometer scheduled to be part of Apollo Lunar Surface Experiments Package left on the moon. Provides earth-moon communications and control equipment for ALSEP program.
1970	Additional Apollo missions.	Command and control; test range and other ground hardware; spacecraft hardware.

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FOR USE ANY TIME

Philco-Ford Corporation, a defense contractor since World War I and a pioneer in the U. S. aerospace program, has seen many spinoffs and intracompany tradeoffs in technologies and personnel during the post-World War II scientific revolution which has carried men to the moon.

Cross-fertilization of ideas and techniques now is encouraged more than ever before in all areas of the company's business -- consumer, industrial and government. It has been most productive in the space program, in which Philco-Ford has been engaged since 1956.

Derivatives from its aerospace work for the National Aeronautics and Space Administration and the Department of Defense include electronic components in consumer products and products for industry, education, transportation, communications and natural resources. In addition, the company foresees potential application of its space technologies, including semiconductor and computer experience, to health, business, home and farm management and the development of new materials and other products for a variety of uses.

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While Philco-Ford scientists and engineers have been active participants in the transistor and computer revolutions and the rapid advances in space technology, they view technological benefits in other areas generally as part of a systematic, evolutionary process.

In aerospace research and development, initially, performance is the key. Then, as technology progresses and fabrication processes become more efficient, product designers and planners can adapt this know-how to consumer or industrial goods.

The semiconductor industry offers one of the prime cases in point:

The first generation of semiconductors -- the 21-year-old transistor and its associated discrete components -- has been one of the essential elements in man's accelerated flight into space. Discrete components were followed quickly by a second generation of semiconductors, the pinhead-sized integrated circuits of microelectronics. Semiconductor devices have undergone billions of hours of life tests in the extensive reliability and environmental evaluations conducted to meet stringent aerospace/ military specifications.

Production techniques have been refined in the manufacture of millions of electronic components and devices for Project Apollo alone. These and other developments advanced the semiconductor state-of-the-art at a rapid rate. As a result, today's offsprings from aerospace are economically and technically feasible for such consumer products as color television sets -- years ahead of the schedule that might have been followed had our national goals not required such ambitious technical development.

As early as 1959 Philco-Ford had an all-transistor television receiver. It sold about 15,000 of the sets but for several reasons, including the cost factor, the model was dropped. Aerospace and defense R&D has, over the years, made such products economically feasible.

Thus, while one component of Philco-Ford, its Microelectronics Division, was researching, developing and proving the reliability of an integrated circuit for Apollo (thousands of which later were built for the guidance and navigation computers now in use), other engineers were solving circuit/function problems in the highly complex color television receiver, including ways for the introduction of more transistors and, gradually, more ICs in Philco sets.

Philco-Ford now is marketing black and white TV portables in 8-inch and 12-inch screen sizes that are almost entirely transistorized. A high-performance chassis, developed for 14-inch and 18-inch color receivers in the 1970 line, has one integrated circuit and 26 transistors -- more than twice as many as previous Philco models. They provide greater reliability and longer life. Philco console stereos have been all solid-state for years. Most of its radios are also fully transistorized.

As a result of aerospace-related technological advances in both semiconductors and cathode ray tubes, Philco-Ford introduced at the EIA Consumer Products Show in New York this year (June 16-18) an advanced design black and white TV portable that is only half as deep as the ordinary television set. It fits on a six-inch shelf or a night stand. The thinline design is made possible by a Philco-Ford innovation in the picture tube which moves its yoke and electronic gun from the middle to one side. (Philco's code name for the tube development has been "Mallard" because the finished tube looks like a duck.) The set, not yet on the market, has a 13-inch-viewable-diagonal screen and is fully transistorized. Ultimately it is expected to contain mostly integrated circuitry, rather than discrete semiconductor components.

Research under way at the Ford Scientific Laboratories in Dearborn, Mich., at Philco-Ford's Aeronutronic Division in Newport Beach, Calif., at the company's Microelectronics Division in Blue Bell, Pa., and elsewhere in the industry hold even greater promise for consumer electronics and home appliances in the next five to 10 years. In its advance development activity, Philco-Ford now is looking at further improvements in TV picture tubes (a flat picture-frame configuration would be the ultimate in screens), air conditioning and refrigeration, and cooking equipment.

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Providing other futuristic possibilities are large-scale integrated devices and modules in microelectronics, adaptation of aerospace R&D capabilities in fluidic controls, from missiles and aircraft to industrial and consumer products, and the development of light but extremely strong composite laminates (plastic reinforced with boron and carbon fibers). Researchers at Aeronutronic are working on the latter two.

Electronic advances stemming from the space program also could revolutionize automobile instrumentation in a few years. Ford Motor Company, parent firm of Philco-Ford, is employing solid-state components in a number of its 1969 models. These components replace electromechanical parts (generally larger and more prone to failure because they have moving parts) and add new functions to the car that could not have been performed by the equipment previously available. Philco solid-state components now in use at Ford -- many of them safety devices -- include voltage regulators, sequential turn signals, variable-speed windshield wipers and speed-control devices. More applications are on the way.

Philco-Ford is capable today of building sophisticated electronic equipment for the tough environment of the automobile (heat, noise, vibration, etc.) partly because of expertise gained in supplying components for the even more rugged environment of space.

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One of the most pronounced space spinoffs at Philco-Ford has been the utilization of command and control technology -- employed originally in its prime contractor's role for NASA's Mission Control Center in Houston -- in a number of non-space applications.

Philco-Ford-built command consoles, computerized (digital-to-video) displays and other equipment similar to that in the MCC are being or will be used in:

-- State and municipal water and sewage systems on the West Coast;

-- For computer-assisted instruction in Philadelphia public schools;

-- In gas and electric utility energy control centers;

-- In passenger terminals of Braniff International, Eastern and National airlines at the new Houston Intercontinental Airport, in Eastern's terminal at Jacksonville, Fla. and at other EAL terminals in the United States;

-- In factory monitoring and communications systems at Ford and other companies;

-- And in train-control equipment for the rapid transit system now under construction in the San Francisco Bay Area.

An example of Philco-Ford's application of command and control capability to conservation of natural resources is its program with the state of California for water management. The state's Department of Water Resources has contracted with Philco-Ford to furnish, install and test remote control systems for segments of its distribution networks.

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Included are power plants at Oroville and Thermalito.

Another segment is the control system for the South Bay Aqueduct of the State Water Project.

Philco-Ford also is installing a process computer, consoles and displays in the Sacramento control center.

When completed, the system will be the test bed for development of centralized automatic control for the entire $2.6 billion project which will move water from northern California to points as far as 550 miles to the south.

A Philco-Ford system for the control of storm sewers in metropolitan Seattle is another application of this aerospace technology.

The Philadelphia computer-assisted instruction system employs digital-to-video displays like those in the Houston Mission Control Center.

Such displays, and allied equipment, make up the new flight information display systems installed recently at the Jacksonville and Houston jetports. More of these installations are pending by Philco Houston Operations, which also has adapted the command and control technology to gas and electric utilities throughout the country.

Manufacturing controls are provided by Philco-Ford's 7100 system. The 7100 provides automatically, in real time, the following: monitoring of all essential equipment in the factory, alarms for all nonstandard conditions, continuous visual display of general status and two-way communications throughout the plant.

The same techniques developed for command and control of spacecraft were used by Philco-Ford also in designing equipment and instruments that recorded car performance data in operation of the Bay Area Rapid Transit District's test track near San Francisco. The track tests were started in 1965. Subsequently the company received two additional contracts -- one for the communications subsystem for the billion-dollar BARTD system, the other for a control and communications system in the district's Southern Alameda Yard Facility.

In the fall of 1967 the Philadelphia School District placed into classroom operation one of the most comprehensive computer-assisted instruction systems in the nation. The system was designed and installed by Philco-Ford in four secondary schools. It consists of a central computer and four clusters. Each cluster has a central processor, data storage and student terminals.

Students are now using the system to learn reading and biology. The curriculum was developed by teachers of the school district, working with computer and programming experts at Philco-Ford.

A student responds to his lesson over a terminal, which appears as a combination TV monitor and electric typewriter. Each terminal also has a "light pen," an electronic device resembling a ball point pen, that enables the student to point to answers directly on the TV screen. Using the attached typewriter, he can also type in his answer in text form.

Another potential application of Philco-Ford's aerospace capability to education is the use of satellites for televised instruction to large groups of people, including proposed national systems.

Philco-Ford has 27 defense communications satellites in orbit and is building others. It has proposed the application of orbiting space vehicles in earth resources surveys, air traffic control and marine navigation.

As costs come down, aerospace control and display technology will be applied in other areas, including business management, farm management and, ultimately, the home, Philco-Ford believes. In 1967, as a part of its 75th anniversay observance, the company produced a motion picture called "1999 A. D." in which a house-of-tomorrow concept was expounded. Most of the computer-oriented, automatic equipment depicted in the movie is technically feasible now.

In both its short- and long-term applications of space technology vis-a-vis the customer, Philco-Ford is looking for basic, tangible improvements which will assure purchasers of its products greater reliability and performance, improved mean service life and, ultimately, lower costs. (Relative costs of home products, compared to 1959, already are down.)

Another example of space fallout is in the area of health applications. Philco-Ford's bioastronautics research and development efforts, under government contracts, have been directed toward assuring the well-being of astronauts in space. The company emphasized a method of acquiring physiological and psychological information without interfering with astronaut activities by attaching extensive sensor networks.

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An automatic medical monitoring system was developed from this research. The multi-phasic screening permits the subject to sit in a chair or lie on a couch in a normal relaxed position while a variety of readings are taken and displayed -- such as pulse, respiration and galvanic skin resistance. The system is adaptable to such mechanical forms as operating tables and dental chairs.

In addition, Philco-Ford has installed a system in an automobile for Ford's driver safety research program. The equipment monitors driver behavior and stress. Sensors are located in the steering wheel. None need be attached to the driver's body.

Sensors may also be embedded unobtrusively in the upholstery of chairs, couches, medical examination tables or operating room tables.

With its background in biotechnology, Philco-Ford is looking at the enormous public health problem as a whole and sees the hospital of the future significantly benefitting from space technology.

International communications, particularly live telecasts which require far more carrier capacity than telegraph or telephone, are another derivative of space technology. Philco-Ford, a leader in the design, construction and installation of large, movable dish-shaped antennas for NASA and the Air Force, has delivered five systems, 90 to 97 feet in diameter, at commercial satellite communications earth stations in Italy, Puerto Rico, West Virginia, California and Hawaii, and recently broke ground for another station in South Korea. The antennas are used to send and receive telephone, telegraph, television, computer data and other signals to and from satellites orbiting some 21,000 miles above the earth.

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As a highly diversified company, Philco-Ford has for many years promoted the exchange of ideas and techniques among its scientists and engineers at all levels.

Some tradeoffs among personnel -- changes in assignments that kept pace with the advancing technology in electronics -- are worth noting:

Philco engineers who worked first in radio and other consumer electronics before World War II helped to provide America with the technological base it so desperately needed to design and build our war machine after Pearl Harbor and bring victory in 1945.

Some in the same group of engineers, who also pioneered in the research and development of television starting in the late '20s, later went into space work and, in turn, became pioneers in that technology.

Philco experts in the manufacture and servicing of radar during World War II became designers and production managers of color television picture tubes and other cathode ray tubes used in displays for NASA, schools, utilities and airlines.

Men who wrestled with military specifications and licked the reliability and yield problems in the early days of microelectronics later designed and made integrated circuits and hybrid devices for automotive and industrial applications and Philco home entertainment products.

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Thus, with space spinoff into other areas of business today, the interaction technological benefits has gone full cycle in 30 or so years -- from consumer goods, to military, to space, to industry and back to the consumer.

Shortly after he was named board chairman and president of the company last September, Robert E. Hunter appointed Louis A. deRosa vice president of engineering and research. He directed Mr. deRosa to assume cognizance over all Philco-Ford technical activities and identify areas in which the company can develop expertise as a team in using its total technology.

Mr. deRosa established a special committee which seeks to increase the reliability of all Philco products -- from $5.95 transistor radios to sophisticated hardware for space and defense.

He also chairs the Senior Engineering Board, comprising the top technical man of each operating division and assuring the ready availability of this talent and its direction toward a common interst.

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7/1/69

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FOR USE ANY TIME

BACKGROUND INFORMATION: PHILCO HOUSTON OPERATIONS

Philco Houston Operations, located at 1002 Gemini Avenue near the NASA Manned Spacecraft Center, was established in 1963 as a component of the Western Development Laboratories Division, Philco-Ford Corporation, and is now an organizational element of the corporation's Electronics Group, Palo Alto, Calif.

Robert T. Benware is Director of Philco Houston Operations (PHO).

PHO was established after the National Aeronautics and Space Administration chose Philco as prime contractor for its Mission Control Center (MCC), Houston. As prime contractor, Philco Houston was responsible for the definition of functional requirements, system design, hardware and software design, manufacture, installation, start-up, and test of this complex control center. PHO's effort extended from the data and control links to NASA's remote tracking sites into the flight controllers' consoles in Building 30 at the Manned Spacecraft Center.

PHO also has provided technical and engineering support at the center continuously since it went operational for Gemini 4 in June, 1965.

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One of the major subsystems of the MCC is the Display Control System, which represents approximately one-half of the hardware (other than computers) in the center. This system contains 64 channels of digital-to-TV converters, the world's largest video switching matrix (two matrices with 80 inputs by 150 outputs each), more than 120 consoles, more than 350 TV monitors, and a multitude of other display, digital interface, and control keyboard equipment.

Philco Houston is a prime example of space contractors which have applied space technology to business and industry requirements. Its diversification programs include the development, manufacture and installation of control and display systems for utilities and airlines.

As a major subcontractor to Leeds and Northrup, PHO is supplying operator-oriented control and display consoles for Houston Lighting and Power Company's Energy Control Center. Control devices developed under Philco Houston's previous NASA and industry experience are going into this modern electric utility control center.

Similar energy-control equipment and systems are under development at PHO for other companies and groups of utilities.

Philco Houston also is a major supplier of computerized flight information display systems to airlines. The first systems of this type went into operation in early 1969 at Eastern Airlines' terminal in the new airport at Jacksonville, Fla. and in Eastern, Braniff International and National airline terminals at the new Houston Intercontinental Airport.

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7/1/69

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Following is a summary of products, systems and services provided to NASA for Project Apollo by Philco-Ford Corporation, a subsidiary of Ford Motor Company:

--Mission Control Center, Manned Spacecraft Center, Houston: Prime contractor with responsibility for the definition of functional requirements, system design, hardware and software design, manufacture, installation, start-up, test, maintenance and operations and continuous engineering support, including updating of MCC for each manned space flight. Approximately 1,000 Philco Houston Operations employes in support roles.

--Goddard Space Flight Center, Greenbelt, Md.: Communications services throughout manned spaceflight program.

--Apollo spacecraft hardware: 4,800 integrated circuits for each of two navigation and guidance computers on board (one in the command module, the other in the lunar lander); diodes, other semiconductors and engineering design services for the lunar module; nuclear particle detection systems, designed for the safety of the astronauts against radiation during space flight.

- more -

--Scientific experiments: Apollo Lunar Surface Experiments Package (ALSEP) telemetry communications; ALSEP Lunar Surface Magnetometers, designed to send lunar magnetic field measurements back to Earth for a year starting with Apollo 12.

--Lunar Landing Training Vehicle Operations: Contractor support to NASA in pre-flight planning for LLTV at Ellington Air Force Base, Texas; operation of vehicle control consoles by Philco Houston Flight Control teams during simulations, test flights and training flights by astronaut Neil Armstrong in preparation for Apollo 11.

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7/1/69

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FOR USE AT ANY TIME

The first American astronauts to set foot on the moon will leave more than their footprints behind. They will deploy and turn on two scientific instruments. One of these is an extremely sensitive seismometer designed to measure "moonquake" which, among other things, will immediately begin radioing back to Earth the sounds of the astronauts' lunar walk.

Long after their return to Earth, Philco Houston Operations monitors and controllers and NASA scientists will be busy receiving, recording and processing data from the instruments.

The lunar hardware and the people in NASA's Mission Control Center are involved in a new program called the Apollo Lunar Surface Experiments Package (ALSEP). ALSEP Monitoring and Control will be in a small center just a few steps from the Mission Operations Control Room in the MCC. It is the fifth major system to be implemented in the MCC, for which Philco-Ford Corporation is a prime contractor.

IBM Corporation provides a computer for the ALSEP control center and five computers in the MCC's main Real Time Computer Complex. Philco Houston has responsibility for the other subsystems of ALSEP Monitoring and Control and three other basic systems--Communications, Display/Control and Apollo Simulation, Checkout and Training.

- more -

The ALSEP control center will process data from eight different experiments to be conducted following each of the next four manned missions to the moon. The experiments will measure everything from moonquakes and the lunar surface magnetic field to the pressure of the barely detectible lunar atmosphere.

The first lunar landing crew will deploy only two of the experiments, known as the Early Apollo Scientific Experiments Package or EASEP, since their total work time on the surface will be only two and one-half hours. Subsequent flights will carry four ALSEP experiments each -- three of them to be repeated but in different locations on the moon.

Each experiment can be controlled by radio from the ground. Each also will send back from the moon a stream of telemetry signals showing results of whatever it is designed to measure.

The telemetry will be received and recorded continuously by at least one tracking site during the life of the ALSEP, in some cases up to two years.

Certain periods within the life of an experiment will be of greater interest than others. For example, for 60 hours during the moon's terminator crossing (sunrise and sunset) the MCC will monitor continuously the effect of severe thermal changes. A lunar day is a sweltering 250 degrees Fahrenheit but darkness brings on a 14-day cold spell of minus 250 degrees.

"During the terminator crossing," Paul Audel of Philco Houston notes, "we will have flight controllers on the main consoles all the time."

The first ALSEP experiments will be powered by solar cells and therefore will work only during the lunar day -- equivalent to about 14.5 Earth days. Later experiments will be powered by a small radioisotopic thermal generator and will be able to signal their findings to Earth continuously.

Seismic recorders in the ALSEP control room are so sensitive that they can easily measure tremors from an astronaut's footsteps on the lunar surface. They also will take note of meteorite impacts and quakes originating from the lunar interior.

Just outside the main ALSEP control room at MCC is what is known as the principal investigators' room. There scientists will direct the use of the experiments and study the results.

Philco Houston designed special equipment for ALSEP Monitoring and Control, including a digital display driver interface unit which, as backup equipment to the computer, can remember the position of every status light on every console in the system.

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7/1/69

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BACKGROUND INFORMATION: MISSION CONTROL CENTER

The Mission Control Center (MCC) at the Manned Spacecraft Center, Houston, Texas, was developed by Philco-Ford Corporation to provide complete control of NASA manned spaceflight missions from launch to recovery.

As a prime contractor, Philco Houston Operations implemented the MCC and is providing continuous maintenance and operations support and systems engineering services.

Under its contract, Philco-Ford is responsible for updating the MCC to meet the changing requirements for each manned spaceflight mission. Philco-Ford engineers and technicians are assigned to the MCC during each mission for around-the-clock support.

The MCC is actually two control centers in one. It can control two manned missions simultaneously. Both may be live missions, or one may be live and the other simulated.

Reliability as well as flexibility were key elements in the MCC design. Every piece of equipment and system has a spare or auxiliary, including the electrical power and airconditioning systems.

- more -

The center has five basic systems: Display/Control, Communications, Apollo Simulation, Checkout and Training; Apollo Lunar Surface Experiments Package (ALSEP) Control and Monitoring, and Real-Time Computer Complex, the latter provided by IBM Corporation under a separate NASA contract.

Following are descriptions of these systems:

DISPLAY/CONTROL SYSTEM

The Display/Control system, one of the world's most versatile information retrieval systems, displays the wide variety of data required by flight controllers in directing NASA's manned spaceflights.

Mission operations personnel, using buttons or switches on their consoles, can call up any of hundreds of different computer-updated graphs, tables and pictures in less than three seconds. The data may concern flight dynamics, spacecraft systems and crew status, or ground support systems in fixed sites, ship stations or aircraft located about the globe.

Standard display devices such as multicolor projection systems and chart recorders are used in some areas, but the heart of the MCC's Display/Control is a high-resolution television system. Included in the closed TV circuit are 561 TV displays, 160 cameras, 64 digital-to-TV converters, and four video switching matrices of solid-state design, two of which are among the largest ever built (including those in use by the major networks in New York).

Inputs to the TV display come from three sources -- computers, cameras, and slide files. About 1,000 different data displays may be controlled from computers. As many as 44,000 of the 35-millimeter, coded slides may be provided for a single mission.

The slides are arranged so that new batches may be readily loaded into the slide generators as a mission or simulation progresses. Background maps or charts required at launch, for example, can be removed and stored once that phase is passed.

In addition to the high-resolution TV monitors in the MCC's 140 control consoles, the two Mission Operations Control Rooms (MOCR's) feature a massive expanse of rear projection screens on which are flashed TV images, maps, trajectories and other information vital to the mission controllers. The screens are 10 feet high and total 60 feet in width.

The largest, located at the front and center of each of the second and third-floor control rooms, is a 10 x 20 foot projection plotter for the display of a world map and bright-line orbital tracts.

To the right of the summary mission display in each MOCR is a 10 x 10-foot system for the display of an automated multiple-plot graph of critical flight-dynamic data in real time. There are three other screens, of the same width, for television projection.

Ringing the top of the large-screen displays and the operating consoles are computer-driven time and data displays which report instantly the status and times of predetermined events to NASA decision-makers.

The video switches, one for each control room, have 80 input channels -- 40 carrying digital TV from computers and 40 from high-resolution TV cameras. There are 160 outputs in each matrix. Each of the 80 inputs may be connected to any or all of the console monitors or group displays simultaneously. The switches were provided by COHU Electronics, Inc., of San Diego, Calif.

A variety of keyboards are built into the command consoles in and supporting each operations control room. There are 68 Manual Selection Keyboards, 9 Display Request Keyboards, and other special panels for the display of telemetry data and other summary messages associated with each control room.

Display Request Keyboards supplement Manual Selection Keyboards on important consoles. Each can control up to three monitors.

Most of the information to be displayed during missions reaches the MCC over land lines. After being processed by computers the data flows through output channels which service Digital Display Drivers, the system's five X-Y plotboards and 19 Projection Plotter Drivers, the Digital-to-TV Converters, and the Converter Slide File Data Distributors associated with each MOCR.

The Computer Input Multiplexer accepts the display request initiated by automatic and manual display request devices from the controller consoles and routes the requests to the computers in the Real-Time Computer Complex.

The Digital Display Driver Subchannel Data Distributor routes display information generated by the computers to various other electronic equipment and to the lamp displays in the consoles and group displays. There are 19,000 lights for each system in five colors, indicating to the console controllers normal, marginal or dangerous situations.

Five X-Y plotting boards are located in each of the two Flight Dynamics Staff Support Rooms on the second and third floors. These boards display information generated by the computers.

There are 14 projectors behind the plotting screens in each MOCR and five projectors serving a 6 x 12-foot screen in the Recovery Control Room on the third floor.

The Digital-to-TV Data Converters, supplied by General Dynamics/Electronics of San Diego under a subcontract from Philco-Ford, convert digital data into TV signals by using special cathode ray tubes. This system permits optical mixing of static information from slides with the dynamic data processed by the computer. Forty operational converters and four auxiliaries are available for support of each MOCR during mission support.

- more -

The Converter Slide File Data Distributor sends data to the 44 converters and the TV switches of each system.

A television tape-recording facility on the third floor provides intermediate and permanent storage of TV picture sequences for later use by NASA or release to television media for broadcasting to the public.

Hardcopy equipment, located on the second and third floors, enables flight controllers to photograph automatically, for historical record, any display appearing on their television monitors. Dry 8½ x 11-inch paper copies can be produced at the rate of six per minute by the three hardcopy machines in each system.

COMMUNICATIONS SYSTEM

The Communications System links the MCC with a worldwide network for manned spacecraft tracking, data acquisition, command, and voice communications. Called the Manned Spaceflight Network (MSFN), it is composed of facilities at the launch site, remoted land-based sites, and tracking ships and aircraft.

The Communications System of the MCC has a variety of equipment to perform three functions: internal and external communications, pneumatic tube systems, spacecraft commanding, the telemetry ground station operations.

All information comes into and leaves the MCC over commercial common carrier communication lines. The external lines enter the building at the Telco Termination Room, where they are connected to the Facilities Control Room.

The Facilities Control Room provides traffic routing, quality monitoring, and maintenance and testing functions. It assures that all conditions of traffic loading, equipment failure, or circuit breaks can be handled efficiently.

With two major exceptions, all incoming and outgoing traffic passes through the Communications, Command and telemetry System (CCATS), "nerve center" of the MCC. The exceptions are television transmission lines, which are routed directly to the display and control system, and private telephone lines, which are routed to individual telephone sets located throughout the MCC.

The CCATS in the MCC provides the capability of simultaneously performing the functions of digital communications data handling, telemetry data decommutation and distribution and digital command initiation, verification and control. The nucleus of the CCATS consists of a real-time digital computing system (three Univac 494 computers) which process and distribute large volumes of data on a real time basis. The system is integrated into a complex system of display and control devices and other special purpose terminal facilities, which provide for the presentation of processed data to the flight controllers and operations support personnel and for the processing of their instructions to the spacecraft and MCC systems.

The CCATS is designed to provide simultaneous support of two mission activities. Although CCATS was implemented as a full MCC system, most of the non-communications processor components (multiplexers, consoles, encoders, monitors) have since been integrated into the respective display systems.

The message center monitors and distributes text or hard-copy messages. It accepts messages originating at the MCC and prepares them for transmission, monitors all incoming text messages, and directs traffic to the proper destinations. Hardcopy messages are distributed by a pneumatic tube system which has stations at every major point in the MCC. The message center also intercepts garbled traffic and initiates corrective action.

All voice circuits entering or leaving the MCC pass through the manually operated switchboard in the voice control room. This permits flexibility in tying together intercom loops and remote sites, spacecraft-to-ground circuits, and external circuits.

The entire MCC-MSFN communications system is supervised by the communications controller in the Communications Control Room. He is informed of communications system status by a control console and displays.

Telemetry provides the capability to exchange great amounts of information among the spacecraft, ground stations, and the MCC. The data is used for operational real-time control and for engineering analysis.

- more -

The pulse-code-modulated (PMC) data transmission technique is used to telemeter measurements, including biomedical data, from the spacecraft to stations in the MSFN. Then each station picks out the biomedical data and routes it to the MCC in frequency-modulated (FM) form. All other data is routed to the MCC by wide-band data, high-speed data, or teletype.

Incoming tracking data is sent to the Real Time Computer Complex (RTCC) for generation of dynamic display information and to aid in computing acquisition data.

All outgoing voice communications, facsimile messages, and teletype textual messages originate within the communications system, as does most command data. The remaining outgoing communications are routed through the system for conversion to the proper transmission format and assignment to an outgoing communications line.

During the launch phase of a mission, televised images of the space vehicle are transmitted from Kennedy Space Center to the MCC. These TV signals are routed over video lines.

In carrying out its assigned functions, the MCC requires many other types of information exchange with the MSFN and certain government agencies during a manned mission. Examples are meteorological data, MSFN equipment status, and status of recovery forces.

A great deal of this information is obtained through voice communications with the appropriate station or agency. Teletype or facsimile message traffic between the MCC and the station or agency satisfies all other information flow requirements.

SIMULATION, CHECKOUT AND TRAINING SYSTEM

The Apollo Simulation, Checkout and Training system (ASCATS) creates realistic simulations of Apollo missions for training of flight control and tracking station personnel.

ASCATS integrates the MCC simulations with flight crew trainers at the Manned Spacecraft Center or at Kennedy Space Center. The MCC can be exercised from simulation control consoles, using source data from the flight trainers, ASCATS special equipment, a ground support simulation computer, or any combination of these.

The simulation system can pre-test the mission plan, procedures, flight controllers, and astronauts by the purposeful introduction of faults into the information data streams. At the option of the simulation team, faults may be inserted in a variety of ways into all forms of data normally presented to controllers and astronauts.

The concept of realistic simulation can include situations in which an actual mission is being controlled by personnel in one MOCR while simulation exercises for a mission are taking place in the other.

By using the simulation system, NASA can pre-fly a mission, detect and correct weak points, and develop the reaction capability required by the operational staff and astronauts.

ALSEP MONITOR AND CONTROL

The Apollo Lunar Surface Experiments Program (ALSEP) levies unique operating concepts and requirements on the remoted sites, communication facilities and the Mission Control Center. The monitoring and control requirements for each Apollo Lunar Surface Experiments package is over an extended time duration, approximately 1 year, and demands unique data handling and control.

The MCC ALSEP system is a joint effort of NASA, IBM and Philco-Ford's operation in Houston, under the direction of the NASA.

The ALSEP Monitor and Control System consists of three major subsystems -- Computer Subsystem, Display/Control Subsystem and Console Subsystem -- each of which is independent of the two MOCR control center systems. IBM Corporation provides the computer subsystem and Philco-Ford supplies the Display/Control and Console Subsystems.

An IBM 360/50 Central Processing Unit, main memory, magnetic tape and disc files, and standard IBM peripherals comprise the Computer Subsystem provided under a separate NASA contract.

The Display-Control Subsystem consists of an analog data distribution and interface unit, a digital data distribution and interface unit, Seismic drum recorders, strip chart recorders, digital display drivers, and the ALSEP Computer Input Multiplexer Command Unit. The purpose and use of this equipment is to enable the display and presentation of experiment data transmitted from the lunar surface via the ALSEP package(s).

A Console Subsystem comprising monitor and control areas for both NASA and principal scientific investigator personnel is provided to monitor ALSEP package performance and real time observation and analysis of experiments data.

REAL-TIME COMPUTER COMPLEX

The Real-Time Computer Complex (RTCC) provides the computation facilities in the MCC for flight dynamic analysis, telemetry processing, acquisition predictions, and flight controller display generation. The complex consists of five IBM 360/75 computers, computer switching devices, computer room display equipment, and associated support equipment such as magnetic tape units.

The primary functions of the RTCC are to process incoming tracking and telemetry data for evaluation of overall mission conditions. Parameters critical to this evaluation are position and velocity of the spacecraft establishing the go/no go information for each powered flight phase.

To facilitate recovery operations, the computers predict where the spacecraft will be at any predetermined time throughout the mission. Also, the computers provide each tracking station with acquisition information which can be used to position antennas and advise station personnel of times they can expect to acquire the spacecraft.

The computers are also used to monitor and evaluate telemetry information received from the spacecraft to determine if both personnel and equipment are performing satisfactorily within predetermined environmental and operational parameters.

Two computers are used for each live mission, one operating in dynamic standby. Two computers are available for practice exercises to simulate a mission at the same time that a live mission is in progress.

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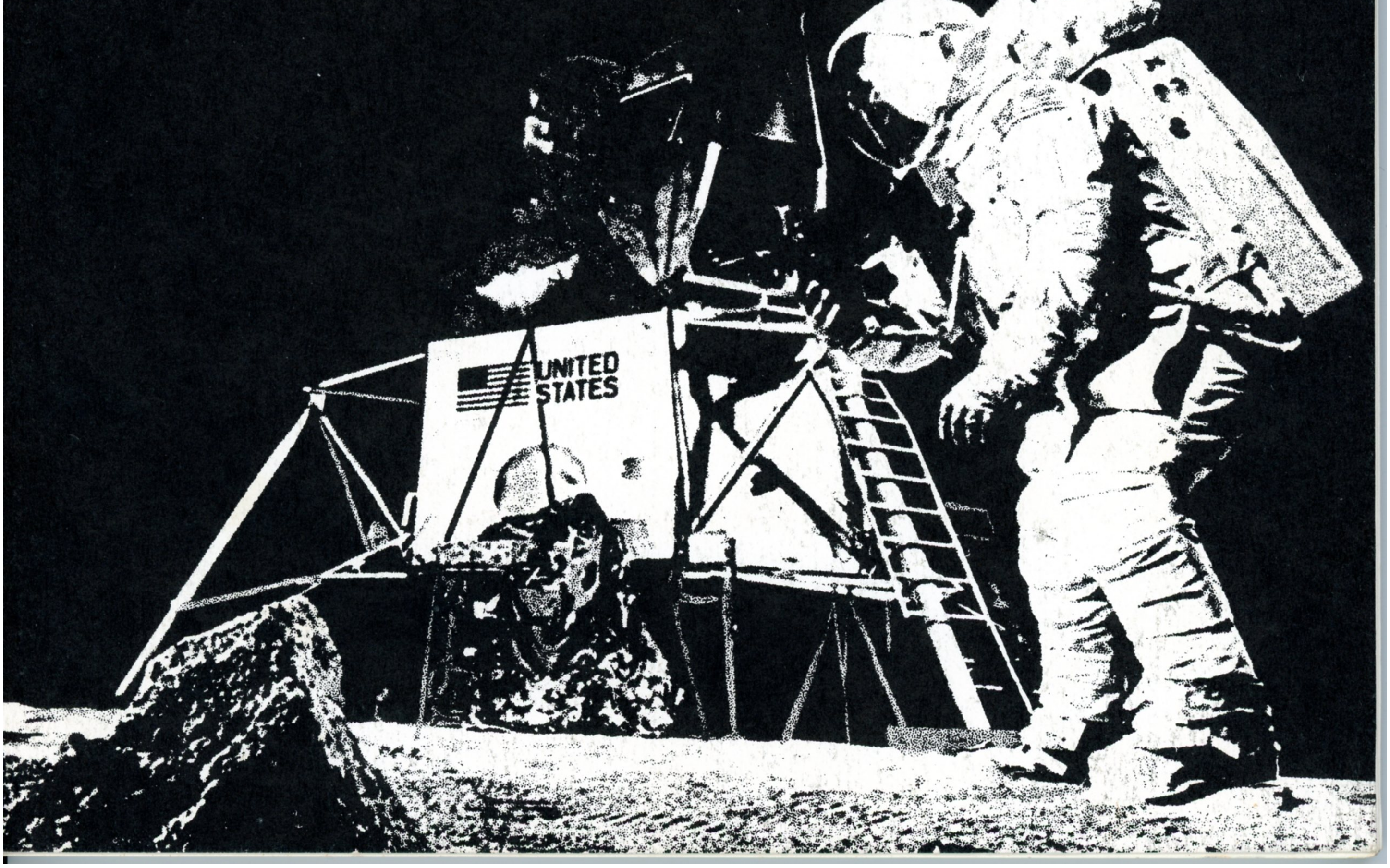
PRESS INFORMATION

PHILCO Ford

AND PROJECT APOLLO



NOTE TO EDITORS:

The information in this fact sheet has been prepared for your background. It covers Philco-Ford Corporation participation in Project Apollo.

Ford Motor Company and its Philco-Ford subsidiary have played pioneering roles in man's efforts in flight. Ford built America's first all-metal passenger aircraft, conducted the first United States flights into space, and built the first United States payload landed on the moon. Philco-Ford, which Ford acquired in 1961, designed and built the world's first active, repeater type communications satellite and had extensive roles in projects Mercury and Gemini. The firm's participation in Apollo is detailed in the following background material.

Illustrations included in this document have been coded by negative number and are available as black and white glossy prints through our Eastern Public Affairs Office. A picture order form has been inserted at the end of the text for your convenience.

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PHILCO-FORD AND PROJECT APOLLO

INTRODUCTION

Following is a summary of products, systems and services provided to the National Aeronautics and Space Administration for Project Apollo by Philco-Ford Corporation, a subsidiary of Ford Motor Company:

-- Mission Control Center, Manned Spacecraft Center, Houston: Prime contractor with responsibility for the definition of functional requirements, system design, hardware and software design, manufacture, installation, start-up, test, maintenance and operations and continuous engineering support, including updating of MCC for each manned space flight. Approximately 1,000 Philco Houston Operations employes in support roles at peak of program.

-- Apollo spacecraft hardware: 4,800 integrated circuits for each of two navigation and guidance computers on board (one in the command module, the other in the lunar lander); diodes, other semiconductors and engineering design services for the Lunar Module; Nuclear Particle Detection Systems, designed for the safety of the astronauts against radiation during space flight.

-- Scientific experiments: Apollo Lunar Surface Experiments Package (ALSEP) telemetry communications and ALSEP Lunar Surface Magnetometers.

-- Lunar Landing Training Vehicle Operations: Contractor support to NASA in pre-flight planning for LLTV at Ellington Air Force Base, Texas; operation of vehicle control consoles by Philco Houston flight control teams during simulations, test flights and training flights by Apollo commanders.

- more -

MISSION CONTROL CENTER

The nerve center for man's greatest adventure -- command and control of Apollo flights to the moon -- is a Philco-Ford implemented operations complex which has served the National Aeronautics and Space Administration since the early days of Project Gemini.

The Mission Control Center (MCC) at the Manned Spacecraft Center near Houston, Texas, is the Earth's most sophisticated control station. It was developed under a contract awarded to Philco-Ford in 1963 to give NASA real-time direction of manned spaceflight missions from launch to recovery.

Philco Houston Operations implemented the MCC and is providing continuous maintenance and operations support and systems engineering services.

As prime contractor, Philco-Ford is responsible for updating the MCC to meet the changing requirements for each manned spaceflight mission. Company engineers and technicians are assigned to the MCC during each mission for around-the-clock support.

The MCC was designed as a dual control center. It can control two manned missions simultaneously. Both may be live missions, or one may be live and the other simulated.

Reliability and flexibility also were key elements in the design. Every piece of MCC equipment and system has a spare or auxiliary.

The center has five basic systems: Display/Control; Communications; Apollo Simulation, Checkout and Training; Apollo Lunar Surface Experiments Package (ALSEP) Control and Monitoring; and Real-Time Computer Complex, the latter provided by IBM Corporation under a separate NASA contract.

Following are descriptions of these systems:

DISPLAY/CONTROL SYSTEM

The Display/Control system, one of the world's most versatile information retrieval systems, displays the wide variety of data required by flight controllers in directing NASA's manned space flights.

Mission operations personnel, using buttons or switches on their consoles, can call up any of hundreds of different computer-updated graphs, tables and pictures in less than three seconds. The data may concern flight dynamics, spacecraft systems and crew status, or ground support systems in fixed sites, ship stations or aircraft located about the globe.

Standard display devices such as multicolor projection systems and chart recorders are used in some areas, but the heart of the MCC's Display/Control is a high-resolution television system. Included in the closed TV circuit are 561 TV displays, 160 cameras, 64 digital-to-TV converters, and four video switching matrices of solid-state design, two of which are among the largest ever built (including those of major U.S. TV networks).

Inputs to the TV display come from three sources -- computers, cameras, and slide files. About 1,000 different data displays may be controlled from computers. As many as 44,000 of the 35-millimeter, coded slides may be provided for a single mission.

The slides are arranged so that new batches may be readily loaded into the slide generators as a mission or simulation progresses. Background maps or charts required at launch, for example, can be removed and stored once that phase is passed.

In addition to the high-resolution TV monitors in the MCC's 140 control consoles, the two Mission Operations Control Rooms (MOCRs) feature a massive expanse of rear projection screens on which are flashed TV images, maps, trajectories and other information vital to the mission controllers. The screens are 10 feet high and total 60 feet in width.

The largest, located at the front and center of each of the second and third-floor control rooms, is a 10 x 20-foot projection plotter for the display of world or lunar maps and brightline orbital tracks.

To the right of the summary mission display in each MOCR is a 10 x 10-foot system for the display of an automated multiple-plot graph of critical flight-dynamic data in real time. There are three other screens, of the same width, for television projection.

Ringing the top of the large-screen displays and the operating consoles are computer-driven time and data displays which report instantly the status and times of predetermined events to NASA decision-makers.

A variety of keyboards are built into the command consoles and in supporting areas for each operations control room. There are 68 manual selection keyboards, 9 display request keyboards, and other special panels for the display of telemetry data and other summary messages associated with each control room.

Display request keyboards supplement manual selection keyboards on important consoles. Each can control up to three monitors.

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Most of the information to be displayed during missions reaches the MCC over land lines. After being processed by computers the data flows through output channels which service digital display drivers, the system's five X-Y plotboards and 19 projection plotter drivers, the digital-to-TV converters, and the converter slide file data distributors associated with each MOCR.

The computer input multiplexer accepts the display request initiated by automatic and manual display request devices from the controller consoles and routes the requests to the computers in the Real-Time Computer Complex.

The digital display driver subchannel data distributor routes display information generated by the computers to various other electronic equipment and to the lamp displays in the consoles and group displays. There are 19,000 lights for each system in five colors, indicating to the console controllers normal, marginal or dangerous situations.

Five X-Y plotting boards are located in each of the two Flight Dynamics Staff Support Rooms on the second and third floors. These boards display information generated by the computers.

There are 14 projectors behind the plotting screens in each MOCR and five projectors serving a 6 x 12-foot screen in the Recovery Control Room on the third floor.

The digital-to-TV data converters convert digital data into TV signals by using special cathode ray tubes. This system permits optical mixing of static information from slides with the dynamic data processed by the computer. Forty operational converters and four auxiliaries are available for support of each MOCR during mission support.

The converter slide file data distributor sends data to the 44 converters and the TV switches of each system.

A television tape-recording facility provides intermediate and permanent storage of TV picture sequences for later use by NASA or release to television media for broadcasting to the public.

Hardcopy equipment enables flight controllers to photograph automatically, for historical record, any display appearing on their television monitors. Dry $8\frac{1}{2}$ x 11-inch paper copies can be produced at the rate of six per minute by the three hardcopy machines in each system.

COMMUNICATIONS SYSTEM

The Communications System links the MCC with a worldwide network for manned spacecraft tracking, data acquisition, command, and voice communications. Called the Manned Spaceflight Network (MSFN), it is composed of facilities at the launch site, remote land-based sites, and tracking ships and aircraft.

The Communications System of the MCC has a variety of equipment to perform these functions: internal and external communications, pneumatic tube systems, spacecraft commanding, the telemetry ground station operations.

All information comes into and leaves the MCC over commercial common carrier communication lines. The external lines enter the building at the Telco Termination Room, where they are connected to the Facilities Control Room.

The Facilities Control Room provides traffic routing, quality monitoring, and maintenance and testing functions. It assures that all conditions of traffic loading, equipment failure or circuit breaks can be handled efficiently.

With two major exceptions, all incoming and outgoing traffic passes through the Communications, Command and Telemetry System (CCATS), "nerve center" of the MCC. The exceptions are television transmission lines, which are routed directly to the display and control system, and private telephone lines, which are routed to individual telephone sets located throughout the MCC.

The CCATS in the MCC provides the capability of simultaneously performing the functions of digital communications data handling, telemetry data decommutation and distribution and digital command initiation, verification and control. The nucleus of the CCATS consists of a real-time digital computing system (three Univac 494 computers) which process and distribute large volumes of data on a real time basis. The system is integrated into a complex system of display and control devices and other special purpose terminal facilities, which provide for the presentation of processed data to the flight controllers and operations support personnel and for the processing of their instructions to the spacecraft and MCC systems.

The CCATS was designed to provide simultaneous support of two mission activities. Although CCATS was implemented as a full MCC system, most of the non-communications processor components (multiplexers, consoles, encoders, monitors) have since been integrated into the respective display systems.

The message center monitors and distributes text or hard-copy messages. It accepts messages originating at the MCC and prepares them for transmission, monitors all incoming text messages, and directs traffic to the proper destinations. Hard-copy messages are distributed by a pneumatic tube system which has stations at every major point in the MCC. The message center also intercepts garbled traffic and initiates corrective action.

All voice circuits entering or leaving the MCC pass through the manually operated switchboard in the voice control room. This permits flexibility in tying together intercom loops and remote sites, spacecraft-to-ground circuits, and external circuits.

The entire MCC-MSFN communications system is supervised by the communications controller in the Communications Control Room. The controller is informed of communications system status by a control console and displays.

Telemetry provides the capability to exchange great amounts of information among the spacecraft, ground stations, and the MCC. The data is used for operational real-time control and for engineering analysis.

The pulse-code-modulated data transmission technique is used to telemeter measurements, including biomedical data, from the spacecraft to stations in the MSFN. Then each station picks out the biomedical data and routes it to the MCC in frequency-modulated form. All other data is routed to the MCC by wide-band data, high-speed data, or Teletype.

Incoming tracking data is sent to the Real Time Computer Complex (RTCC) for generation of dynamic display information and to aid in computing acquisition data.

All outgoing voice communications, facsimile messages and Teletype textual messages originate within the communications system, as does most command data. The remaining outgoing communications are routed through the system for conversion to the proper transmission format and assignment to an outgoing communications line.

During the launch phase of a mission, televised images of the space vehicle are transmitted from Kennedy Space Center to the MCC. These TV signals are routed over video lines.

In carrying out its assigned functions, the MCC requires many other types of information exchange with the MSFN and certain government agencies during a manned mission. Examples are meteorological data, MSFN equipment status and status of recovery forces.

A great deal of this information is obtained through voice communications with the appropriate station or agency. Teletype or facsimile message traffic between the MCC and the station or agency satisfies all other information flow requirements.

SIMULATION, CHECKOUT AND TRAINING SYSTEM

The Apollo Simulation, Checkout and Training System (ASCATS) creates realistic simulations of Apollo missions for training or flight control and tracking station personnel.

ASCATS integrates the MCC simulations with flight crew trainers at the Manned Spacecraft Center or at Kennedy Space Center. The MCC can be excercised from simulation control consoles, using source data from the flight trainers, ASCATS special equipment, a ground support simulation computer or any combination of these.

The simulation system can pre-test the mission plan, procedures, flight controllers, and astronauts by the purposeful introduction of faults into the information data streams. At the option of the simulation team, faults may be inserted in a variety of ways into all forms of data normally presented to controllers and astronauts.

By using the simulation system, NASA can pre-fly a mission, detect and correct weak points, and develop the reaction capability required by the operational staff and astronauts.

ALSEP MONITOR AND CONTROL

The Apollo Lunar Surface Experiments Program (ALSEP) levies unique operating concepts and requirements on the remote sites, communication facilities and the Mission Control Center. Each Apollo Lunar Surface Experiments Package is designed to function for approximately one year.

The MCC ALSEP Monitor and Control system is a joint effort of NASA, IBM and Philco Houston Operations under the direction of NASA.

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The system consists of three major subsystems -- computer subsystem, display control subsystem and console subsystem. IBM Corporation provides the computer subsystem and Philco-Ford supplies the display control and console subsystems.

The display-control subsystem consists of an analog data distribution and interface unit, a digital data distribution and interface unit, seismic drum recorders, strip chart recorders, digital display drivers, and the ALSEP computer input multiplexer command unit. This equipment permits the display and presentation of experiment data transmitted from the lunar surface via ALSEP.

A console subsystem comprising monitor and control areas for both NASA personnel and principal scientific investigators is provided to monitor ALSEP performance and real-time observation and analysis of experiments data.

REAL-TIME COMPUTER COMPLEX

The Real-Time Computer Complex (RTCC) provides the computation facilities in the MCC for flight dynamic analysis, telemetry processing, acquisition predictions and flight controller display generation. The complex consists of five IBM 360/75 computers, computer switching devices, computer room display equipment, and associated support equipment such as magnetic tape units.

The primary functions of the RTCC are to process incoming tracking and telemetry data for evaluation of overall mission conditions. Parameters critical to this evaluation are position and velocity of the spacecraft establishing the go/no go information for each powered flight phase.

To facilitate recovery operations, the computers predict where the spacecraft will be at any predetermined time throughout the mission. The computers also provide each tracking station with acquisition information which can be used to position antennas and advise station personnel of times they can expect to acquire the spacecraft.

The computers monitor and evaluate telemetry information received from the spacecraft to determine whether personnel and equipment are performing as expected.

NEW COLOR DISPLAYS DEVELOPED

Prior to the historic lunar flights in 1969, photographic technologists at Philco-Ford perfected a color slide technique to aid flight controllers in guiding astronauts to safe landings on the moon.

Reference slides used at MCC contain data on the acceptable limits of performance for each mission. Stored in disk containers selected by computer signals, they are used to monitor missions from launch to splashdown. Flight controllers compare current mission information against the reference slides to judge whether or not the mission is going well.

Any spacecraft performance deviation which exceeds acceptable limits can result in attempts to fix the malfunctioning system, an abort or an early termination of the mission. Validity of the slides is tested over and over in preflight simulations of each mission before the spacecraft ever leaves the ground.

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Prior to the laboratory breakthrough a reference slide could be projected in only one color on the 10 x 20-foot screen in the Mission Operations Control Room, this color being variable by means of seven selective color filters on the projector.

Introduction of a second color to the reference slides has a special meaning during lunar flights. The map of the moon's surface has few familiar landmarks for flight controllers to grasp at a glance.

Use of the second color permits controllers to distinguish special points of importance quickly.

NUCLEAR PARTICLE DETECTION

Aboard each Apollo spacecraft is a three-pound electronic device which helps to protect the astronauts on their missions to the moon. Resembling a cigar box, the package contains the space vehicle's Nuclear Particle Detection System, designed and manufactured by Philco-Ford under a $1.7 million subcontract with North American Rockwell Corporation.

Among the hazards Apollo astronauts face is the possibility of solar flares -- eruptions on the surface of the sun -- occurring while the spacecraft is in orbit. Solar flares bombard broad areas of space with radioactive alpha particles and protons.

Should a solar flare occur during a mission, the radiation measuring system would telemeter the data to Mission Control, where medical specialists would evaluate its significance.

The Nuclear Particle Detection System consists of a detector assembly in the form of a telescope and a signal analyzer assembly.

Pulse rates from the detector assembly at which particles enter the various energy intervals are converted to d-c voltage levels by ratemeters in the signal analyser. Outputs of the ratemeters are telemetered to Mission Control.

The device measures proton and alpha particle rates in four proton and three alpha differential energy bands and one integral proton energy band.

LUNAR SURFACE MAGNETOMETER

The Lunar Surface Magnetometer, a scientific instrument resembling a box camera on a tripod lying upside down, was left on the moon's surface by the Apollo 12 astronauts. It radioed the first lunar surface magnetic measurements back to Earth late in 1969.

Developed by Philco-Ford's Space & Re-entry Systems Division, the magnetometer helped scientists determine the deep electrical properties of the moon and calculate how the solar wind or plasma stream above the moon reacts with the moon's surface.

The magnetometer weighs 19 pounds on Earth. Its electronics are contained in a metal box 11 x 11 x 6-inches.

Three directional magnetic probes are supported by arms evenly spaced at 120 degrees around the outside of the box. They were folded out and extended by the astronauts on the moon, then tilted 34 degrees above the surface. The extended arms are approximately three feet long.

The three-axis magnetometer showed the strength of the total magnetic field in the Ocean of Storms to be surprisingly greater than scientific investigators had expected.

The magnetometer is among the geophysical instruments in ALSEP.

ALSEP COMMUNICATIONS UNIT

A sophisticated one-pound package which transmits data at up to 10,000 bits per second relays to Earth the output from ALSEP's scientific instruments.

The telemetry communications, built by Philco-Ford, consists of two identical transmitters (operational and backup units) and one receiver through which commands are sent from the MCC. The command receiver weighs 1-1/2 pounds and the entire 3-1/2 pound microminiature system requires less space than a family-size box of cereal.

The solid-state, S-band data transmitter incorporates automatic gain control to maintain a constant output power of 1 watt with maximum efficiency over a temperature range of minus 35 to plus 75 degrees Centigrade.

Its primary carrier source is a crystal-controlled oscillator. Four frequency multipliers and amplifiers are used to increase the power level and frequency to the S-band level.

Pulse-taking of the unit is provided by telemetry points for the crystal temperature, transmitter hot spot temperature, the power stage current drain and the output power.

Power consumption is nominally 7.5 watts at 29 volts DC.

LLTV GROUND CONTROL

Six-man operations control teams at Houston have key roles in helping Apollo commanders train for the last two crucial minutes of flight in their journeys to the moon.

The teams are composed of a NASA flight director and five flight controllers from Philco-Ford who assist in checkout of the astronauts in the Lunar Landing Training Vehicle.

The LLTV, a non-aerodynamic machine powered by rockets and a jet engine, closely simulates in Earth atmospheric flight the Lunar Module spacecraft's actual approach and touchdown on the moon.

LLTV ground controllers man a van filled with instrumented consoles at Ellington Air Force Base. Their objective is to protect both the pilot and the LLTV through real-time monitoring of all vehicle systems and major flight events, which require immediate reaction.

Philco-Houston's LLTV Operations Section provides support in a number of areas. These include pre-flight tasks; compatibility analysis of flight objectives, ground systems, LLTV systems and flight control capabilities; information for mission rules, console procedures, ground support procedures, flight plans and a vehicle systems handbook.

Its five-man controller teams operate the vehicle consoles during simulations, test flights and training flights.

Control procedures are patterned after real-time techniques used in directing Apollo missions to the moon.

The LLTV flight director observes every move of the LLTV in flight through a window at the end of the operations van.
He monitors attitude, altitude rate, wind velocity, LLTV flight modes and major events and is constantly updated on vehicle systems by four controllers through a panel of status lights on his console.

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The flight director's role is comparable to that of the missile range safety officer, who must act immediately when a malfunction occurs.

He shares his console with, and is assisted by, an operations and procedures controller who provides liaison with the control tower, medical forces, fire and rescue unit, the Air Force weather detachment and the LLTV ground crew.

LLTV operations also impose severe tasks upon the other four Philco-Houston controllers, who monitor avionics, vehicle dynamics, rocket and engine system parameters.

Each controller observes about a dozen displays -- analog meters or strip recorders.

The avionics flight controller monitors the electronics system which controls the firing of 16 attitude control rockets and also monitors the velocity rates in pitch, yaw and roll axes. He helps keep the pilot in what aviators call the flight envelope, that is, within their range of capabilities.

The vehicle dynamics flight controller monitors generally the attitude of the vehicle including yaw changes, roll rate changes and pitch and altitude rates.

The rockets flight controller monitors the LLTV's two lift rockets and tank pressures and fuel consumption rates for the entire rocket system (including the 16 attitude thrusters) powered by hydrogen peroxide.

The engine flight controller monitors the operation characteristics of the vehicle's General Electric Model CF-700 jet engine -- including exhaust gas temperature, chamber discharge pressure and engine and fan RPMs -- and JP-4 fuel utilization. The engine, a version of that used in the U.S. T-38 jet trainer, is vertically mounted in a gimbal ring in the LLTV.

This mount permits mobility and compensation for external forces on the vehicle. For example, gimbaling can compensate for any wind encountered at Ellington in simulating a lunar landing in which there is no wind.

Checkout of the astronauts in the LLTV, with ground control from the start, begins with a series of flights in which the jet engine is gimbal-locked in the vertical center of the vehicle.

Pilots progress to the use of the lift rockets in the gimbal-locked mode and then to a series in a lunar simulation mode.

In lunar simulations the LLTV jet engine compensates for five-sixths of the vehicle's weight, depicting lunar gravity, which is one-sixth that of Earth's. The rocket system provides the rest of the power.

Initial lunar landing simulation flights are flown to and from a maximum of 300 feet altitude, do not include a touchdown, and are mainly designed to acquaint the astronauts with the control capability in that mode.

In the final series, the LLTV is flown from 300 feet altitude to touchdown, simulating the last two minutes of descent to the lunar surface.

PHILCO HOUSTON OPERATIONS

Philco Houston Operations, located at 1002 Gemini Avenue near the NASA Manned Spacecraft Center, were established in 1963 after the National Aeronautics and Space Administration chose Philco to implement the Mission Control Center.

As prime contractor, Philco Houston was responsible for the definition of the MCC's functional requirements, system design, hardware and software design, manufacture, installation, start-up, and test of this complex control center. PHO's effort extended from the data and control links to NASA's remote tracking sites into the flight controllers' consoles in Building 30 at the MSC.

PHO also has provided technical and engineering support at the center continuously since it went operational with the Gemini 4 mission in June, 1965.

Philco Houston is a prime example of space contractors which have applied space technology to business and industry requirements. Its diversification programs include the development, manufacture and installation of control and display systems for utilities and airlines.

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PHOTO NO. B-6596

Captions

Mission Control Center (MCC), Manned Spacecraft Center (MSC), Houston, Texas. Wing on the left contains the control center proper. Offices for support and operating personnel are on the right.

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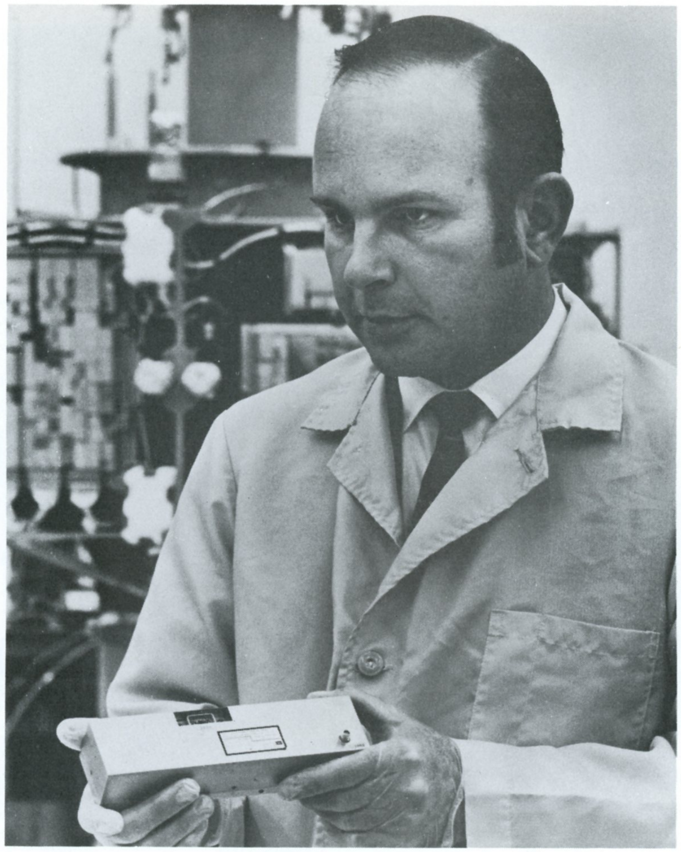

Philco-Ford employe holds small transmitter that sends scientific information from the moon to receiving stations here on earth. The small package is the transmitter for the Apollo Lunar Surface Experiments Package (ALSEP), which is left behind on the moon by astronauts to gather scientific information. The transmitter was designed and built by Philco-Ford Corporation.

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PHOTO NO. B-6611 A

Monitoring and control for the Apollo Lunar Surface Experiments Package is performed by Philco-Ford personnel in this room at NASA's Mission Control Center, Houston. NASA scientists, located in an adjoining room, serve as principal investigators in ALSEP experiments which in Apollo 12 include passive seismic, magnetometer and solar wind instruments and a suprathermal ion detector, including a cold cathode gauge. Philco-Houston Operations also is a prime contractor to NASA for continuous engineering, maintenance and operations support at MCC in directing all manned space flights.

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