

CHAPTER 2

BOARD HISTORY AND PROCEDURES

PART 1. SUMMARY OF BOARD HISTORY AND PROCEDURES

The Apollo 13 Review Board was established on April 17, 1970, by the NASA Administrator and Deputy Administrator under the authority of NASA Management Instruction 8621.1, dated April 14, 1966. In the letter establishing the Board, Mr. Edgar M. Cortright, Director of Langley Research Center, was appointed as Chairman and the general responsibilities of the Board were set forth. The seven additional members of the Board were named in a letter from the Administrator and the Deputy Administrator to the Chairman, dated April 21, 1970. This letter also designated a Manned Space Flight Technical Support official, a Counsel to the Board, several other supporting officials, and several observers from various organizations. In addition, in a letter dated April 20, 1970, to Dr. Charles D. Harrington, Chairman of the NASA Aerospace Safety Advisory Panel, that Panel was requested to review the Board's procedures and findings.

The Review Board convened at the Manned Spacecraft Center, Houston, Texas, on Tuesday, April 21, 1970. Four Panels of the Board were formed, each under the overview of a member of the Board. Each of the Panels was chaired by a senior official experienced in the area of review assigned to the Panel. In addition, each Panel was manned by a number of specialists, thereby providing a nucleus of expertise for the review activity. During the period of the Board's review activities, the Chairmen of the four Panels were responsible for the conduct of evaluations, analyses, and other studies bearing on their Panel assignments, for preparing preliminary findings and recommendations, and for developing other information for the Board's consideration. To overview these Panel efforts, each member of the Board assumed specific responsibilities related to the overall review.

In addition to the direct participants in the Board activity, a number of observers and consultants also attended various meetings of the Board or its constituent Panels. These individuals assisted the Review Board participants with advice and counsel in their areas of expertise and responsibilities.

While the Board's intensive review activities were underway, the Manned Spacecraft Center Apollo 13 Investigation Team, under James A. McDivitt, Colonel, USAF, was also conducting its own analysis of the accident on Apollo 13. Coordination between the Investigation Team work and the Apollo 13 Review Board activities was effected through the MSF Technical Support official and by maintaining a close and continuing working relationship between the Panel Chairmen and officials of the MSC Investigation Team.

The Board Chairman established a series of administrative procedures to guide the Board's activities. In addition, specific assignments of responsibility were made to all individuals involved in the Board's activities so as to insure an efficient review activity. Overall logistic and administrative support was provided by MSC.

The Board conducted both Executive and General Sessions. During the Executive Sessions, plans were agreed upon for guiding the Board's activities and for establishing priorities for tests, analyses, studies, and other Board efforts. At the General Sessions, status of Panel activities was reviewed by the Board with a view towards coordination and integration of all review activities. In addition, Board members regularly attended daily status meetings of the Manned Spacecraft Center Investigation Team.

In general, the Board relied on Manned Spacecraft Center postmission evaluation activities to provide the factual data upon which evaluation, assessment, and analysis efforts could be based. However, the Board, through a regular procedure, also levied specific data collection, reduction, and analysis requirements on MSC. Test support for the Board was conducted primarily at MSC but also included tests run at other NASA Centers. Members of the Board and its Panels also visited a number of contractor facilities to review manufacturing, assembly, and test procedures applicable to the Apollo 13 mission.

The Chairman of the Board provided the NASA Deputy Administrator with oral progress reports. These reports summarized the status of Review Board activities at the time and outlined the tasks still ahead. All material used in these interim briefings was incorporated into the Board's official files.

As a means of formally transmitting its findings, determinations, and recommendations, the Board chose the format of this Final Report which includes both the Board's judgments as well as the reports of the individual Panels.

A general file of all the data and information collected and examined by the Board has been established at the Langley Research Center, Hampton, Virginia. In addition, the MSC Investigation Team established a file of data at MSC.

PART 2. BIOGRAPHIES OF BOARD MEMBERS, OBSERVERS, AND PANEL CHAIRMEN

CHAIRMAN OF THE APOLLO 13 REVIEW BOARD

EDGAR M. CORTRIGHT
NASA Langley Research Center

Edgar M. Cortright, 46, Director of the NASA Langley Research Center, Hampton, Virginia, is Chairman of the Apollo 13 Review Board.

Mr. Cortright has been an aerospace scientist and administrator for 22 years. He began his career at NASA's Lewis Research Center, Cleveland, Ohio, in 1948 and for the next 10 years specialized in research on high-speed aerodynamics there.

In October 1958, Mr. Cortright was named Chief of Advanced Technology Programs at NASA Headquarters, Washington, D. C., where he directed initial formulation of NASA's Meteorological Satellite Program. In 1960, he became Assistant Director for Lunar and Planetary Programs and directed the planning and implementation of such projects as Mariner, Ranger, and Surveyor.

Mr. Cortright became Deputy Director of the Office of Space Sciences in 1961, and Deputy Associate Administrator for Space Science and Applications in 1963, in which capacities he served as General Manager of NASA's space flight program using automated spacecraft. He joined the Office of Manned Space Flight as Deputy Associate Administrator in 1967 and served in a similar capacity until he was appointed Director of the Langley Research Center in 1968.

He is a Fellow of the American Institute of Aeronautics and Astronautics and of the American Astronautical Society. He has received the Arthur S. Fleming Award, the NASA Medal for Outstanding Leadership, and the NASA Medal for Distinguished Service.

Mr. Cortright is the author of numerous technical reports and articles, and compiled and edited the book, "Exploring Space With a Camera."

He is a native of Hastings, Pennsylvania, and served as a U.S. Navy officer in World War II. He received Bachelor and Master of Science degrees in aeronautical engineering from the Rensselaer Polytechnic Institute.

Mr. and Mrs. Cortright are the parents of two children.

MEMBERS OF THE APOLLO 13 REVIEW BOARD

ROBERT F. ALLNUTT
NASA Headquarters

Robert F. Allnutt, 34, Assistant to the NASA Administrator, Washington, D. C., is a member of the Apollo 13 Review Board.

Mr. Allnutt was named to his present position this year. Prior to that, he had been Assistant Administrator for Legislative Affairs since 1967.

He joined NASA in 1960 as a patent attorney at the Langley Research Center, Hampton, Virginia. In 1961, he was transferred to NASA Headquarters, Washington, D. C.

Mr. Allnutt served as Patent Counsel for Communications Satellite Corporation from January to September 1965, when he returned to NASA Headquarters as Assistant General Counsel for Patent Matters.

He is admitted to the practice of law in the District of Columbia and the state of Virginia and is a member of the American Bar Association and the Federal Bar Association.

Mr. Allnutt was graduated from Virginia Polytechnic Institute with a B.S. degree in industrial engineering. He received Juris Doctor and Master of Laws degrees from George Washington University Law School.

Mr. and Mrs. Allnutt are the parents of two sons. The family lives in Washington, D. C.

NEIL A. ARMSTRONG
NASA Astronaut

Neil A. Armstrong, 39, NASA astronaut, is a member of the Apollo 13 Review Board.

Commander of the Apollo 11 mission and the first man on the Moon, Mr. Armstrong has distinguished himself as an astronaut and as an engineering test pilot.

Prior to joining the astronaut team at the Manned Spacecraft Center, Houston, Texas, in 1962, Mr. Armstrong was an X-15 rocket aircraft project pilot at the NASA Flight Research Center, Edwards, California.

Mr. Armstrong joined NASA at the Lewis Research Center, Cleveland, Ohio, in 1955, and later transferred to the Flight Research Center as an aeronautical research pilot.

His initial space flight was as command pilot of Gemini VIII, launched March 16, 1966. He performed the first successful docking of two vehicles in space. The flight was terminated early due to a malfunctioning thruster, and the crew was cited for exceptional piloting skill in overcoming the problem and accomplishing a safe landing. He has served on backup crews for both Gemini and Apollo.

Mr. Armstrong is a Fellow of the Society of Experimental Test Pilots, Associate Fellow of the American Institute of Aeronautics and Astronautics, and member of the Soaring Society of America. He has received the Institute of Aerospace Sciences Octave Chanute Award, the AIAA Astronautics Award, the NASA Exceptional Service Medal, the John F. Montgomery Award, and the Presidential Medal of Freedom.

He is a native of Wapakoneta, Ohio, and received a B.S. degree in aeronautical engineering from Purdue University and a M.S. degree from the University of Southern California. He was a naval aviator from 1949 to 1952 and flew 78 combat missions during the Korean action.

Mr. and Mrs. Armstrong have two sons.

JOHN F. CLARK
NASA Goddard Space Flight Center

Dr. John F. Clark, 49, Director of the NASA Goddard Space Flight Center, Greenbelt, Maryland, is a member of the Apollo 13 Review Board.

He is an internationally known authority on atmospheric and space sciences, holds four patents in electronic circuits and systems, and has written many scientific papers on atmospheric physics, electronics, and mathematics.

Dr. Clark joined NASA in 1958 and served in the Office of Space Flight Programs at NASA Headquarters until 1961 when he was named Director of Geophysics and Astronomy Programs, Office of Space Sciences. From 1962 until 1965, he was Director of Sciences and Chairman of the Space Science Steering Committee, Office of Space Science and Applications.

In 1965, Dr. Clark was appointed Deputy Associate Administrator for Space Science and Applications (Sciences), and later that year, Acting Director of Goddard. He was named director of the center in 1966.

Dr. Clark began his career in 1942 as an electronics engineer at the Naval Research Laboratory, Washington, D.C. From 1947 to 1948 he was Assistant Professor of Electronic Engineering at Lehigh University, Bethlehem, Pennsylvania. He returned to NRL in 1948; and prior to joining NASA, served as head of the Atmospheric Electricity Branch there.

He is a member of the American Association of Physics Teachers, American Geophysical Union, Scientific Research Society of America, Philosophical Society of Washington, the International Scientific Radio Union, and the Visiting Committee on Physics, Lehigh University. He received the NASA Medals for Exceptional Service, Outstanding Leadership, and Distinguished Service.

Dr. Clark was born in Reading, Pennsylvania. He received a B.S. degree in electrical engineering from Lehigh University, M.S. degree in mathematics from George Washington University, and Ph. D. in physics from the University of Maryland.

Dr. and Mrs. Clark have two children and live in Silver Springs, Maryland.

WALTER R. HEDRICK, JR.
Headquarters, USAF

Brig. Gen. Walter R. Hedrick, Jr., 48, Director of Space, Office of the Deputy Chief of Staff for Research and Development, Headquarters, USAF, Washington, D.C., is a member of the Apollo 13 Review Board.

He has participated in most of the Air Force's major nuclear test projects and has extensive experience as a technical project officer and administrator.

General Hedrick joined the Army Air Corps as an aviation cadet in 1941 and flew in combat with the 86th Fighter Bomber Group during World War II. After the War, he was assigned to the 19th Air Force, the 14th Air Force, and as a project officer under Air Force Secretary Stuart Symington. From 1952 to 1955, he was assigned to the Air Force Office of Atomic Energy.

In 1955, he was assigned to the Technical Operations Division, Air Force Special Weapons Command, Kirtland Air Force Base, New Mexico. In 1957, he was named Commander of the 4951st Support Squadron, Eniwetok; and the following year, he was reassigned to Kirtland AFB as Assistant to the Group Commander and later as Air Commander of the 4925th Test Group.

General Hedrick joined the Special Systems Office, Air Force Ballistics Division, Los Angeles, in 1960. He was named Commander of

the Satellite Control Facility in 1965, and in 1966, he was appointed Deputy Commander, Air Force Systems Command. He received his present assignment in 1967.

General Hedrick is a Command Pilot and has received numerous Air Force awards.

His home town is Fort Worth, Texas, and he attended Texas Technological College, Lubbock, prior to joining the service. He received B.S. and M.S. degrees in physics from the University of Maryland.

General and Mrs. Hedrick are the parents of two sons.

VINCENT L. JOHNSON
NASA Headquarters

Vincent L. Johnson, 51, Deputy Associate Administrator for Space Science and Applications (Engineering), NASA Headquarters, is a member of the Apollo 13 Review Board.

Mr. Johnson was appointed to his present position in 1967. Prior to that time, he had been Director of the Launch Vehicle and Propulsion Programs Division, Office of Space Science and Applications, since 1964. He was responsible for the management and development of the light and medium launch vehicles used for NASA's unmanned earth orbital and deep space programs. His division also directed studies of future unmanned launch vehicle and propulsion system requirements.

Mr. Johnson joined NASA in 1960, coming from the Navy Department where he had been an engineer with the Bureau of Weapons. His first assignments with NASA were as Program Manager for the Scout, Delta, and Centaur launch vehicles.

He was a naval officer during World War II, serving with the Bureau of Ordnance. Prior to that, he was a physicist with the Naval Ordnance Laboratory.

Mr. Johnson was born in Red Wing, Minnesota, and attended the University of Minnesota.

He and Mrs. Johnson live in Bethesda, Maryland. They are the parents of two children.

MILTON KLEIN
NASA Headquarters

Milton Klein, 46, Manager, Space Nuclear Propulsion Office, NASA Headquarters, is a member of the Apollo 13 Review Board.

Mr. Klein has been in his present position since 1967. Prior to that he had been Deputy Manager since 1960. The Space Nuclear Propulsion Office is a joint activity of the Atomic Energy Commission (AEC) and the National Aeronautics and Space Administration. The office conducts the national nuclear rocket program. He is also Director of the Division of Space Nuclear Systems of the AEC, responsible for space nuclear electric power activities.

Mr. Klein became associated with atomic energy work in 1946, when he was employed by the Argonne National Laboratory. In 1950, he joined the AEC's Chicago Operations Office as staff chemical engineer. Later, he was promoted to Assistant Manager for Technical Operations. Generally engaged in reactor development work for stationary power plants, he had a primary role in the power reactor demonstration program.

Mr. Klein was born in St. Louis, Missouri. He served in the U.S. Navy during World War II.

He has a B.S. degree in chemical engineering from Washington University and a Master of Business Administration degree from Harvard University.

Mr. and Mrs. Klein and their three children live in Bethesda, Maryland.

HANS M. MARK
NASA Ames Research Center

Dr. Hans M. Mark, 40, Director of the NASA Ames Research Center, Moffett Field, California, is a member of the Apollo 13 Review Board.

Prior to being appointed Director of the Ames Research Center he was, from 1964 to 1969, Chairman of the Department of Nuclear Engineering at the University of California, Berkeley, California.

An expert in nuclear and atomic physics, he served as Reactor Administrator of the University of California's Berkeley Research Reactor, professor of nuclear engineering and a research physicist at the University's Lawrence Radiation Laboratory, Livermore, California,

and consultant to the U.S. Army and the National Science Foundation. He has written many scientific papers.

Except for 2 years as an Assistant Professor of Physics at the Massachusetts Institute of Technology from 1958 to 1960, Dr. Mark's administrative, academic, and research career has been centered at the University of California (Berkeley).

Dr. Mark received his A.B. degree in physics from the University of California, Berkeley, in 1951, and returned there as a research physicist in 1955, one year after receiving his Ph. D. in physics from M.I.T.

He is a Fellow of the American Physical Society and a member of the American Geophysical Union, the American Society for Engineering Education and the American Nuclear Society.

Dr. Mark was born in Mannheim, Germany, and came to the United States when he was 11 years old. He became a naturalized U.S. citizen in 1945.

Dr. and Mrs. Mark are the parents of two children.

COUNSEL TO THE APOLLO 13 REVIEW BOARD
GEORGE T. MALLEY
NASA Langley Research Center

George T. Malley, 57, Chief Counsel, Langley Research Center, Hampton, Virginia, is the Legal Counsel to the Apollo 13 Review Board. He also served as Counsel to the Apollo 204 Review Board.

Mr. Malley is the Senior Field Counsel of NASA and has been assigned to Langley since 1959. He was with the Office of the General Counsel, Department of the Navy, from 1950 to 1959, where he specialized in admiralty and international law.

He is a retired Navy officer and served on active duty from 1939 to 1946, mainly in the South Pacific. His last assignment was commanding officer of the U.S.S. Fentress.

Mr. Malley has an A.B. degree from the University of Rochester and an LL.B. degree from Cornell University Law School. He is a native of Rochester, New York, and is a member of the New York Bar and the Federal Bar Association.

Mr. and Mrs. Malley and their two children live in Newport News, Virginia.

MANNED SPACE FLIGHT TECHNICAL SUPPORT
CHARLES W. MATHEWS
NASA Headquarters

Charles W. Mathews, 49, Deputy Associate Administrator for Manned Space Flight, NASA Headquarters, Washington, D. C., directs the Office of Manned Space Flight technical support to the Apollo 13 Review Board.

Mr. Mathews has been a research engineer and project manager for NASA and its predecessor, the National Advisory Committee for Aeronautics (NACA), since 1943. In his present assignment, he serves as general manager of manned space flight.

Prior to his appointment to this position in 1968, he had been Director, Apollo Applications Program, NASA Headquarters, since January 1967.

Mr. Mathews was Gemini Program Manager at the Manned Spacecraft Center, Houston, Texas, from 1963 until 1967. Prior to that time, he was Deputy Assistant Director for Engineering and Development and Chief of the Spacecraft Technology Division at MSC.

Mr. Mathews transferred to MSC (then the Space Task Group) when Project Mercury became an official national program in 1958. He served as Chief of the Operation Division. He had been at the Langley Research Center, Hampton, Virginia, since 1943 engaged in aircraft flight research and automatic control of airplanes. He became involved in manned spacecraft studies prior to the first Sputnik flights, and he conducted early studies on reentry. Mr. Mathews was chairman of the group which developed detailed specifications for the Mercury spacecraft.

Mr. Mathews has been awarded the NASA Distinguished Service Medal and the NASA Outstanding Leadership Medal. He has received the NASA Group Achievement Award - Gemini Program Team.

He is a Fellow of the American Astronautical Society and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He is the author of numerous technical articles published by NASA.

Mr. Mathews, a native of Duluth, Minnesota, has a B.S. degree in aeronautical engineering from Rensselaer Polytechnic Institute, Troy, New York.

Mr. and Mrs. Mathews live in Vienna, Virginia. They have two children.

APOLLO 13 REVIEW BOARD OBSERVERS

WILLIAM A. ANDERS
National Aeronautics and Space Council

William A. Anders, 36, Executive Secretary, National Aeronautics and Space Council, Washington, D.C., is an official observer of the Apollo 13 Review Board.

Prior to being appointed to his present position in 1969, Mr. Anders was a NASA astronaut and an Air Force lieutenant colonel. He was lunar module pilot on the Apollo 8 lunar orbital mission, man's first visit to the vicinity of another celestial body.

Mr. Anders joined the NASA astronaut team at the Manned Spacecraft Center, Houston, Texas, in 1963. In addition to his Apollo 8 flight, he served as backup pilot for Gemini 11 and backup command module pilot for Apollo 11, the first lunar landing mission.

Mr. Anders was commissioned a second lieutenant in the Air Force upon graduation from the U.S. Naval Academy. After flight training, he served as a pilot in all-weather interceptor squadrons of the Air Defense Command. Prior to becoming an astronaut, he was a nuclear engineer and instructor pilot at the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

He is a member of the American Nuclear Society and has been awarded the Air Force Commendation Medal, Air Force Astronaut Wings, the NASA Distinguished Service Medal, and the New York State Medal for Valor.

Mr. Anders was born in Hong Kong. He received a B.S. degree from the U.S. Naval Academy and an M.S. degree in nuclear engineering from the Air Force Institute of Technology.

Mr. and Mrs. Anders are the parents of five children.

CHARLES D. HARRINGTON
Douglas United Nuclear, Inc.

Dr Charles D Harrington, 59, President and General Manager, Douglas United Nuclear, Inc., Richland, Washington, is an official observer of the Apollo 13 Review Board.

Dr. Harrington, who has been associated with all phases of the chemical and nuclear industrial fields since 1941, is Chairman of the Aerospace Safety Advisory Panel, a statutory body created by Congress.

From 1941 to 1961, he was employed by the Mallinckrodt Chemical Works, St. Louis, Missouri. Dr. Harrington started with the company as a research chemist and in 1960, after a procession of research and management positions, was appointed Vice President, Mallinckrodt Nuclear Corporation and Vice President, Mallinckrodt Chemical Works.

In 1961, when the fuel material processing plant of Mallinckrodt became the Chemicals Division of United Nuclear Corporation, Dr. Harrington was named Vice President of that division.

He became Senior Vice President, United Nuclear Corporation, Centreville, Maryland, in 1963.

In 1965, Dr. Harrington was appointed President and General Manager, Douglas United Nuclear, Inc. The company manages production reactors and fuels fabrication facilities at Hanford, Washington, for the Atomic Energy Commission.

He is the co-author of a book, "Uranium Production Technology," and has written numerous technical papers. He has received the Mid-West Award of the American Chemical Society for contributions to technology in the nuclear energy field.

He is director of several corporations, including United Nuclear, as well as professional councils and societies.

Dr. Harrington has M.S., M.A., and Ph. D. degrees in chemistry from Harvard University.

I. IRVING PINKEL
NASA Lewis Research Center

I. Irving Pinkel, 57, Director, Aerospace Safety Research and Data Institute at the NASA Lewis Research Center, Cleveland, Ohio, is an official observer of the Apollo 13 Review Board.

Until recently, he directed research at Lewis Research Center on rocket propellant and electric power generation systems for space vehicles, compressors and turbines for advanced aircraft engines, and lubrication systems for rotating machines for these systems.

Mr. Pinkel entered Government scientific service in 1935 as a physicist with the U.S. Bureau of Mines, Pittsburgh, Pennsylvania. In 1940, he joined the staff of the Langley Research Center, Hampton, Virginia, as a physicist. When the Lewis Research Center was built in 1942, he transferred there.

He has been elected to Phi Beta Kappa, Sigma Xi, honorary scientific society, and Pi Mu Epsilon, honorary mathematics fraternity. He is an Ohio Professional Engineer, served on the former NACA subcommittees on Meteorological Problems, Icing Problems, Aircraft Fire Prevention and Flight Safety, and is a member of the NASA Research and Technology Advisory Subcommittee on Aircraft Operating Problems. He has been a Special Lecturer, Case Institute of Technology Graduate School.

Mr. Pinkel has received the Flight Safety Foundation Award for contributions to the safe utilization of aircraft, the Laura Taber Barbour Award for development of a system for suppressing aircraft crash fires, the NACA Distinguished Service Medal, and the NASA Sustained Superior Performance Award.

He was born in Gloversville, New York, and was graduated from the University of Pennsylvania.

Mr. and Mrs. Pinkel live in Fairview Park, Ohio. They are the parents of two sons.

JAMES E. WILSON, JR.
Committee on Science and Astronautics
United States House of Representatives

James E. Wilson, Jr., 39, Technical Consultant, United States House of Representatives Committee on Science and Astronautics, is an official observer of the Apollo 13 Review Board.

Mr. Wilson has been technical consultant to the Committee since 1963. From 1961 to 1963, he was Director of Research and Development, U.S. Naval Propellant Plant, Indian Head, Maryland. Mr. Wilson managed the Polaris Program at Indian Head from 1956 to 1961.

From 1954 to 1956, Mr. Wilson served as an officer in the U.S. Army Signal Corps. He was a development engineer with E. I. DuPont, Wilmington, Delaware, from 1953 to 1954.

Mr. Wilson is a member of Phi Sigma Alpha, a National Honor Society; American Institute of Chemical Engineers; American Chemical Society; and American Ordnance Association.

Mr. Wilson is co-author of several publications of the House Committee on Science and Astronautics.

He received a B.S. degree in chemical engineering from the University of Maine and a Master of Engineering Administration degree from George Washington University.

Mr. and Mrs. Wilson live in LaPlata, Maryland. They have two children.

APOLLO 13 REVIEW BOARD PANEL CHAIRMEN

SEYMOUR C. HIMMEL
NASA Lewis Research Center

Dr. Seymour C. Himmel, Assistant Director for Rockets and Vehicles, Lewis Research Center, Cleveland, Ohio, heads the Design Panel of the Apollo 13 Review Board.

Dr. Himmel joined Lewis in 1948 as an aeronautical research scientist. He has occupied supervisory positions since 1953.

He has been awarded the NASA Exceptional Service Medal and the NASA Group Achievement Award as manager of the Agena Project Group. Dr. Himmel has served on a number of advisory committees. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a member of Tau Beta Pi and Pi Tau Sigma. He is the author of more than 25 technical papers.

Dr. Himmel has a Bachelor of Mechanical Engineering degree from the College of the City of New York and M.S. and Ph. D. degrees from Case Institute of Technology.

Dr. and Mrs. Himmel live in Lakewood, Ohio.

EDWIN C. KILGORE
NASA Langley Research Center

Edwin C. Kilgore, 47, Deputy Chief, Engineering and Technical Services, Langley Research Center, Hampton, Virginia, heads the Project Management Panel of the Apollo 13 Review Board.

Mr. Kilgore joined the Langley science staff in 1944 and served in a variety of technical and management positions until promotion to his present position in 1968.

He has received the Honorary Group Achievement Award for his role in achieving a record of 97 consecutive successes for solid propellant rocket motors and the NASA-Lunar Orbiter Project Group Achievement Award for outstanding performance. He is a member of Pi Tau Sigma, honorary mechanical engineering society.

Mr. Kilgore was born in Coeburn, Virginia. He was graduated from Virginia Polytechnic Institute with a B.S. degree in mechanical engineering.

Mr. and Mrs. Kilgore and their two daughters live in Hampton.

HARRIS M. SCHURMEIER
California Institute of Technology Jet Propulsion Laboratory

Harris M. Schurmeier, 45, Deputy Assistant Laboratory Director for Flight Projects, California Institute of Technology Jet Propulsion Laboratory, Pasadena, California, heads the Manufacturing and Test Panel of the Apollo 13 Review Board.

Mr. Schurmeier was appointed to his current position in 1969. Prior to that he was Mariner Mars 1969 Project Manager, Voyager Capsule System Manager and Deputy Manager of the Voyager Project, and Ranger Project Manager at JPL.

He has received the NASA Medals for Exceptional Scientific Achievement and Exceptional Service. In addition, he has received the Astronautics Engineer Award, and the NASA Public Service Award.

He was born in St. Paul, Minnesota. He has received a B.S. degree in mechanical engineering, M.S. degree in aeronautical engineering, and a professional degree in aeronautical engineering from the California Institute of Technology.

Mr. Schurmeier was a naval officer in World War II. He and his wife and four children live in Altadena, California.

FRANCIS B. SMITH
NASA Headquarters

Francis B. Smith, 47, Assistant Administrator for University Affairs, NASA Headquarters, is leader of the Mission Events Panel of the Apollo 13 Review Board.

Mr. Smith has been in his present position since 1967. Prior to that he had been Assistant Director, Langley Research Center, Hampton, Virginia, since 1964. He joined the Langley science staff in 1947. He is an expert in several fields, including radio telemetry, radar, electronic tracking systems, and missile and range instrumentation.

Mr. Smith was born in Piedmont, South Carolina, and received a B.S. degree in electrical engineering from the University of South Carolina, where he was elected to Phi Beta Kappa. He remained at the University as an instructor from 1943 to 1944 and then served in the U.S. Navy until 1946.

Mr. and Mrs. Smith and their three children live in Reston, Virginia.

PART 3. BOARD ORGANIZATION AND GENERAL ASSIGNMENTS FOR BOARD PANELS

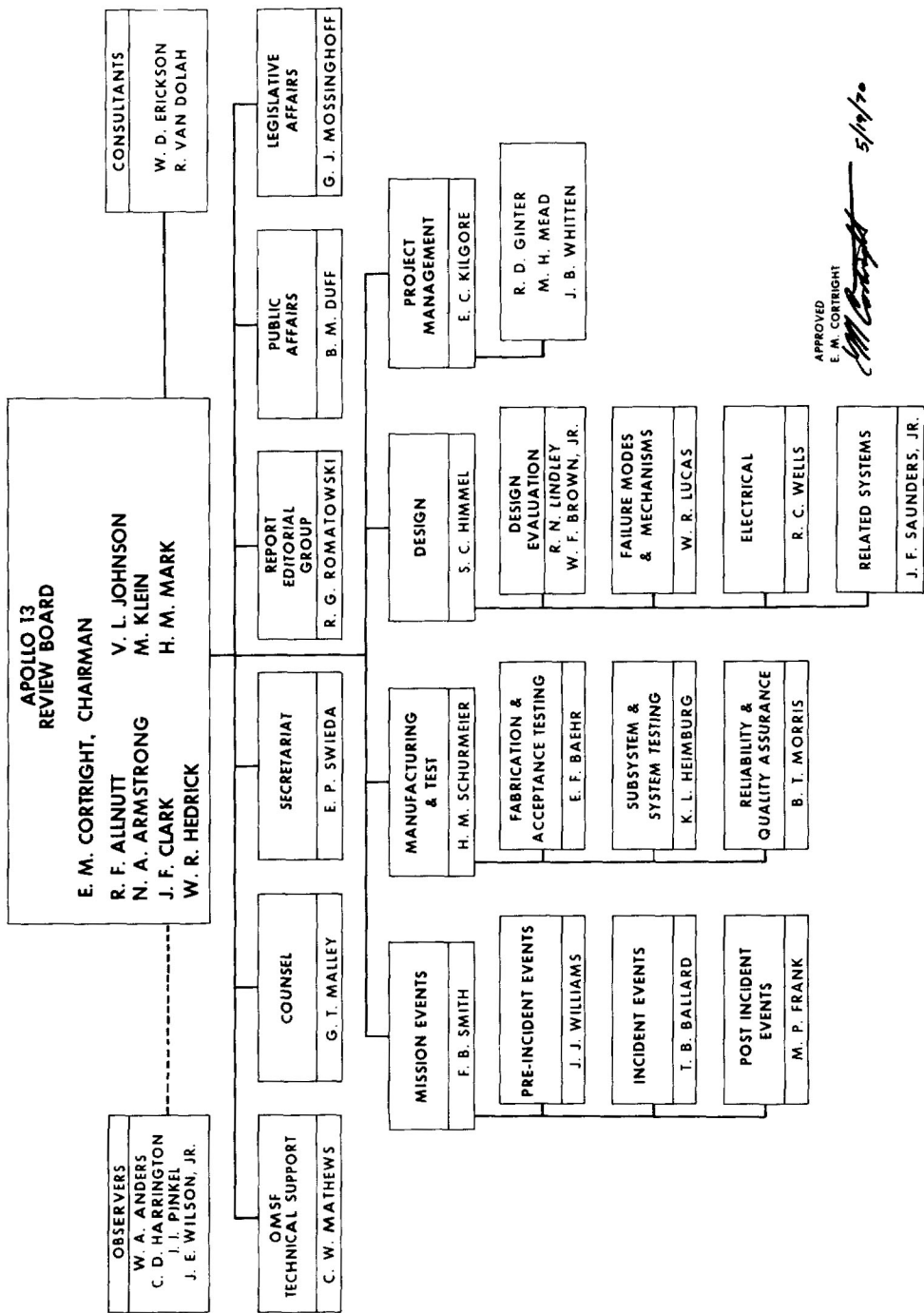
BOARD ORGANIZATION

After reviewing the scope of the Board's charter, the Chairman and Board Members agreed upon the Panel and Support Office structure depicted on the following organization chart. Each Panel was assigned specific responsibilities for reviewing major elements of the overall Board task, with particular emphasis upon establishing a sound and independent technical data base upon which findings, determinations, and recommendations by the Board could be based. The Panels were staffed with individual NASA specialists and established working arrangements with the Manned Space Flight line organization personnel working in analogous areas.

The Board's support offices were structured to provide necessary staff, logistics, and administrative support without duplication of available MSC assistance.

In addition to this structure, the Board and Panels also utilized the special assistance of expert consultants.

Panel assignments, complete Panel membership, and the official Board organization approved by the Chairman are included in this part of the Board report.



APOLLO 13 REVIEW BOARD ORGANIZATION

GENERAL ASSIGNMENTS FOR BOARD PANELS
(AS DOCUMENTED IN THE BOARD'S ADMINISTRATIVE PROCEDURES)

Panel 1 - Mission Events Panel

It shall be the task of the Mission Events Panel to provide a detailed and accurate chronology of all pertinent events and actions leading to, during, and subsequent to the Apollo 13 incident. This information, in narrative and graphical time history form, will provide the Apollo 13 Review Board an official events record on which their analysis and conclusions may be based. This record will be published in a form suitable for inclusion in the Review Board's official report.

The Panel will report all significant events derived from telemetry records, air-to-ground communications transcripts, crew and control center observations, and appropriate documents such as the flight plan, mission technique description, Apollo Operation Handbook, and crew checklists. Correlation between various events and other observations related to the failure will be noted. Where telemetry data are referenced, the Panel will comment as appropriate on its significance, reliability, accuracy, and on spacecraft conditions which might have generated the data.

The chronology will consist of three major sections: Preincident Events, Incident Events, and Postincident Events. The decision-making process leading to the safe recovery, referencing the relevant contingency plans and available alternates, will be included.

Preincident Events. - This section will chronicle the progress of the flight from the countdown to the time of the incident. All action and data relevant to the subsequent incident will be included.

Incident Events. - This section will cover that period of time beginning at 55 hours and 52 minutes after lift-off and continuing so long as abnormal system behavior is relevant to the failure.

Postincident Events. - This section will document the events and activities subsequent to the incident and continuing to mission termination (Splash). Emphasis will be placed on the rationale used on mission completion strategy.

Panel 1 Membership

Mr. F. B. Smith, Panel Chairman
Assistant Administrator for University Affairs
NASA Headquarters
Washington, D. C.

Dr. Tom B. Ballard
Aerospace Technologist
Flight Instrument Division
Langley Research Center
Hampton, Virginia

Mr. M. P. Frank
Flight Director
Flight Control Division
Manned Spacecraft Center
Houston, Texas

Mr. John J. Williams
Director, Spacecraft Operations
Kennedy Space Center
Florida

Mr. Neil Armstrong, Board Member and Panel Monitor
Astronaut
Manned Spacecraft Center
Houston, Texas

Panel 2 - Manufacturing and Test Panel

The Manufacturing and Test Panel shall review the manufacturing and testing, including the associated reliability and quality assurance activities, of the flight hardware components involved in the flight failure as determined from the review of the flight data and the analysis of the design. The purpose of this review is to ascertain the adequacy of the manufacturing procedures, including any modifications, and the pre-flight test and checkout program, and any possible correlation of these activities with the inflight events.

The Panel shall consist of three activities:

Fabrication and Acceptance Testing.- This will consist of reviewing the fabrication, assembly, and acceptance testing steps actually used during the manufacturing of the specific flight hardware elements involved. Fabrication, assembly, and acceptance testing procedures and records will be reviewed, as well as observation of actual operations when appropriate.

Subsystem and System Testing.- This will consist of reviewing all the flight qualification testing from the completion of the component-level acceptance testing up through the countdown to lift-off for the specific hardware involved. Test procedures and results will be reviewed

as well as observing specific tests where appropriate. Results of tests on other serial number units will also be reviewed when appropriate.

Reliability and Quality Assurance.- This will be an overview of both the manufacturing and testing, covering such things as parts and material qualification and control, assembly and testing procedures, and inspection and problem/failure reporting and closeout.

Panel 2 Membership

Mr. Harris M. Schurmeier, Panel Chairman
Deputy Assistant Laboratory Director for Flight Projects
Jet Propulsion Laboratory
Pasadena, California

Mr. Edward F. Baehr
Assistant Chief, Launch Vehicles Division
Deputy Manager, Titan Project
Lewis Research Center
Cleveland, Ohio

Mr. Karl L. Heimborg
Director, Astronautics Laboratory
Marshall Space Flight Center
Huntsville, Alabama

Mr. Brooks T. Morris
Manager, Quality Assurance and Reliability Office
Jet Propulsion Laboratory
Pasadena, California

Dr. John F. Clark, Board Member and Panel Monitor
Director
Goddard Space Flight Center
Greenbelt, Maryland

Panel 3 - Design Panel

The Design Panel shall examine the design of the oxygen and associated systems to the extent necessary to support the theory of failure. After such review the Panel shall indicate a course of corrective action which shall include requirements for further investigations and/or redesign. In addition, the Panel shall establish requirements for review of other Apollo spacecraft systems of similar design.

The Panel shall consist of four subdivisions:

Design Evaluation.- This activity shall review the requirements and specifications governing the design of the systems, subsystems and components, their derivation, changes thereto and the reasons therefor; and the design of the system in response to the requirements, including such elements as design approach, material selection, stress analysis, development and qualification test programs, and results. This activity shall also review and evaluate proposed design modifications, including changes in operating procedures required by such modifications.

Failure Modes and Mechanisms.- This activity shall review the design of the systems to ascertain the possible sources of failure and the manner in which failures may occur. In this process, they shall attempt to correlate such modes with the evidence from flight and ground test data. This shall include considerations such as: energy sources, materials compatibility, nature of pressure vessel failure, effects of environment and service, the service history of any suspect systems and components, and any degradation that may have occurred.

Electrical.- This activity shall review the design of all electrical components associated with the theory of failure to ascertain their adequacy. This activity shall also review and evaluate proposed design modifications, including changes in operating procedures required by such modifications.

Related Systems.- This activity shall review the design of all systems similar to that involved in the Apollo 13 incident with the view to establishing any commonality of design that may indicate a need for redesign. They shall also consider the possibility of design modifications to permit damage containment in the event of a failure.

Panel 3 Membership

Dr. Seymour C. Himmel, Panel Chairman
Assistant Director for Rockets and Vehicles
Lewis Research Center
Cleveland, Ohio

Mr. William F. Brown, Jr.
Chief, Strength of Materials Branch
Materials and Structures Division
Administration Directorate
Lewis Research Center
Cleveland, Ohio

Mr. R. N. Lindley
Special Assistant to the Associate Administrator for Manned Space Flight
NASA Headquarters
Washington, D. C.

Dr. William R. Lucas
Director, Program Development
Marshall Space Flight Center
Huntsville, Alabama

Mr. J. F. Saunders, Jr.
Project Officer for Command and Service Module
Office of Manned Space Flight
NASA Headquarters
Washington, D. C.

Mr. Robert C. Wells
Head, Electric Flight Systems Section
Vehicles Branch
Flight Vehicles and Systems Division
Office of Engineering and Technical Services
Langley Research Center
Hampton, Virginia

Mr. Vincent L. Johnson, Board Member and Panel Monitor
Deputy Associate Administrator for Engineering
Office of Space Science and Applications
NASA Headquarters
Washington, D. C.

Panel 4 - Project Management Panel

The Project Management Panel will undertake the following tasks:

1. Review and assess the effectiveness of the management structure employed in Apollo 13 in all areas pertinent to the Apollo 13 incident. This review will encompass the organization, the responsibilities of organizational elements, and the adequacy of the staffing.
2. Review and assess the effectiveness of the management systems employed on Apollo 13 in all areas pertinent to the Apollo 13 incident. This task will include the management systems employed to control the appropriate design, manufacturing, and test operations; the processes used to assure adequate communications between organizational elements; the processes used to control hardware and functional interfaces; the safety processes involved; and protective security.

3. Review the project management lessons learned from the Apollo 13 mission from the standpoint of their applicability to subsequent Apollo missions.

Tasks 1 and 2, above, should encompass both the general review of the processes used in Apollo 13 and specific applicability to the possible cause or causes of the mission incident as identified by the Board.

Panel 4 Membership

E. C. Kilgore, Panel Chairman
Deputy Chief, Office of Engineering and Technical Services
Langley Research Center
Hampton, Virginia

R. D. Ginter
Director of Special Programs Office
Office of Advanced Research and Technology
NASA Headquarters
Washington, D.C.

Merrill H. Mead
Chief of Programs and Resources Office
Ames Research Center
Moffett Field, California

James B. Whitten
Assistant Chief, Aeronautical and Space Mechanics Division
Langley Research Center
Hampton, Virginia

Milton Klein, Board Member and Panel Monitor
Manager, AEC-NASA Space Nuclear Propulsion Office
Washington, D.C.

Board Observers

William A. Anders
Executive Secretary
National Aeronautics and Space Council
Washington, D.C.

Dr. Charles D. Harrington
Chairman
NASA Aerospace Safety Advisory Panel
Washington, D.C.

I. Irving Pinkel
Director
Aerospace Safety Research and Data Institute
Lewis Research Center
Cleveland, Ohio

Mr. James E. Wilson
Technical Consultant to the Committee on Science and Astronautics
United States House of Representatives
Washington, D.C.

Apollo 13 Review Board Support Staff

Brian M. Duff
Public Affairs Officer
Manned Spacecraft Center
Houston, Texas

Gerald J. Mossinghoff
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NASA Headquarters
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Edward F. Parry
Counsel to Office of Manned Space Flight
NASA Headquarters
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Raymond G. Romatowski
Deputy Assistant Director for Administration
Langley Research Center
Hampton, Virginia

Ernest P. Swieda
Deputy Chief, Skylab Program Control Office
Kennedy Space Center, Florida

Consultants to the Board

Dr. Wayne D. Erickson, Head
Aerothermochemistry Branch
Langley Research Center
Hampton, Virginia

Dr. Robert Van Dolah
Acting Research Director
Safety Research Center
Bureau of Mines
Pittsburgh, Pennsylvania

MSC Support to the Board

These persons were detailed by MSC to support the Apollo 13 Review Board during its review activity at MSC. They are identified by MSC position title.

Roy C. Aldridge
Assistant to the Director of Administration

Mary Chandler
Secretary

Jamie Moon
Technical Editor

Rex Cline
Technical Writer/Editor

Dorothy Newberry
Administrative Assistant

Evon Collins
Program Analyst

Lettie Reed
Editorial Assistant

Leroy Cotton
Equipment Specialist

Charlene Rogozinski
Secretary

Maureen Cruz
Travel Clerk

Joanne Sanchez
Secretary

Janet Harris
Clerk Stenographer

Billie Schmidt
Employee Development Specialist

Marjorie Harrison
Secretary

Frances Smith
Secretary

Phyllis Hayes
Secretary

George Sowers
Management Presentations Officer

William N. Henderson
Management Analyst

Elaine Stemerick
Secretary

Sharon Laws
Secretary

Mary Thompson
Administrative Assistant

Carolyn Lisenbee
Secretary

Alvin C. Zuehlke
Electrical Engineer

Judy Miller
Secretary

PART 4. SUMMARY OF BOARD ACTIVITIES

APRIL 19, 1970

Chairman E. M. Cortright met with Langley officials to begin planning the Apollo 13 Review Board approach. Tentative list of Panel Members and other specialists were developed for consideration.

APRIL 20, 1970

Chairman Cortright met with the NASA Administrator, Deputy Administrator, and key NASA officials in Washington, D.C., to discuss Board membership.

The Chairman met with NASA Office of Manned Space Flight top officials while enroute to MSC on NASA aircraft and discussed program organization plans for review of the accident, and coordination with Apollo 13 Review Board activity.

APRIL 21, 1970

Chairman Cortright met with MSC officials to discuss Apollo 13 Review Board support.

A formal MSC debriefing of the Apollo 13 crew was conducted for MSC officials and Apollo 13 Review Board personnel already at MSC.

Detailed discussions between early arrivals on the Review Board and the MSC Investigation Team were held to provide quick-look data on the Apollo 13 accident and to develop detailed procedures for MSC support of the Apollo 13 Board.

Chairman Cortright met with members of the Press to report on early activity of the Board and to inform them of plans for keeping the Press current on Board activities.

The first meeting of the Board was held at 8 p.m. to discuss Board composition, structure, assignments, and scope of review. Preliminary plans were developed for appointing various specialists to assist the Board in its analysis and evaluation.

APRIL 22, 1970

The Board met with Colonel McDivitt's MSC Investigation Team to review the progress made by MSC in identifying causes of the accident and in developing an understanding of sequences and relationships between known inflight events. In addition, MSC officials briefed the Board on MSC Investigation Team structure and assignments.

The Board met with Panel 1 of the MSC Investigation Team for detailed discussion of inflight events and consideration of early conclusions on implications of preliminary data analysis.

The Board held its second meeting to discuss MSC investigative efforts and additional appointments of Panel specialists.

Board members attended Panel 1 evening roundup of day's evaluation activities, which included detailed discussions of specific studies, data reductions, and support test activities already underway.

APRIL 23, 1970

The Apollo 13 Review Board established itself in proximity to the MSC Investigation Team in Building 45, and arranged for all administrative and logistics support to the Board.

A daily schedule of meetings, reviews, briefings, and discussions was established, including preliminary plans for contractor meetings, special support tests, and accumulation of accident-related information.

Initial task assignments and responsibilities were made to Board Panels as guidance for detailed review work. Individual Board members were assigned Panel overview responsibilities or other special tasks.

Administrative procedures were developed for Board activity, particularly to provide efficient interface with MSC personnel.

Board and Panel Members again met with MSC officials to further review the sequence of events in the Apollo 13 mission and to examine early hypotheses concerning causes of these events.

The Board convened for an evening meeting to discuss the progress to date and to coordinate Panel activities for the next few days. Discussion centered upon immediate requirements for data collection and analysis.

Chairman Cortright appointed additional NASA specialists in order to bring Panels up to strength.

APRIL 24, 1970

Board Members, Panel Chairmen, and MSC officials reviewed additional data analysis made by MSC and contractor personnel with particular emphasis upon the service module (SM) cryogenic system.

The Board convened and reviewed the progress to date. Tentative approvals were given for Board trips to North American Rockwell (NR), Downey, California, Beech Aircraft, Boulder, Colorado, and other locations.

Chairman Cortright briefed the Press on progress to date.

Panel Chairmen and Members continued their detailed analysis of failure modes, test histories, mission events, and other data bearing upon the accident.

Board Members and Panel Chairmen met with Mr. Norman Ryker of NR on NR's activities involving design, qualification, and tests of SM cryogenic oxygen tanks.

APRIL 25, 1970

The Board met to discuss details of onsite inspections of command service module (CSM) flight hardware at principal contractor installations.

Panels examined in detail probable failure modes based on data analyzed at that time.

Specific plans were discussed by the Board relating to evaluation of oxygen tank assembly and checkout operations, including review of component histories.

The MSC Investigation Team members briefed Board personnel on Kennedy Space Center checkout operations of the service module cryogenic and electric power systems, including a detailed briefing covering oxygen tank detanking operations.

APRIL 26, 1970

Board and Panel Members traveled to North American Rockwell, Downey, for detailed briefings by NR engineers and management. NR reviewed its

progress in an intensive analysis of the Apollo 13 malfunction, including a review of approved special tests. Oxygen tank, fuel cell components, assemblies, and other hardware were also inspected.

APRIL 27, 1970

An Executive Session of the Board met to discuss progress of specific analyses required to verify tentative conclusions on oxygen tank failure and service module EPS failure.

Additional Board specialists arrived at MSC and received detailed briefings by MSC and Board personnel on selected aspects of the Apollo 13 data.

Panel Members received and assessed a preliminary MSC evaluation of the Apollo 13 accident, including tentative conclusions on the most probable failure modes.

Procedures were established to provide information flow on the status of review to Board observers.

The Board reviewed work plans for the coming week with each Panel and established review priorities and special task assignments.

APRIL 28, 1970

Chairman Cortright outlined a plan for the Board's preliminary report scheduled for presentation to the Deputy Administrator during his visit to MSC on May 1. Each Panel Chairman was to summarize the status of his Panel's activities for Dr. George Low on Friday, April 29, 1970.

Board Member Neil Armstrong completed arrangements to provide each Board Member and Panel Chairman an opportunity for detailed simulation of the Apollo 13 inflight accident using MSC's CSM simulation equipment.

Board and Panel Members reviewed enhanced photographs of the Apollo 13 service module at the MSC Photographic Laboratory.

Dr. von Elbe of Atlantic Research Company briefed Board and Panel Members on cryogenics and combustion phenomena.

A representative of the Manufacturing and Test Panel performed an onsite inspection at Beech Aircraft, Boulder.

Manufacture and Test Panel personnel reviewed detanking procedures followed at KSC during the Apollo 13 countdown demonstration test (CDDT).

Board and Panel personnel reviewed progress to date at a general Board meeting involving all Review Board personnel.

APRIL 29, 1970

Dr. Charles Harrington, Board Observer and Chairman of the Aerospace Safety Advisory Panel, arrived for a 2-day detailed review of Board procedures and progress in the accident review.

The Board reviewed North American Rockwell preliminary recommendations involving oxygen tank redesign.

The Board continued to review and examine oxygen tank ignition sources and combustion propagation processes with specialists from MSC, other NASA Centers, and contractor personnel.

The Mission Events Panel continued to examine and record details of all significant mission events as a basis for other Panel evaluations and study.

Chairman Cortright convened two Board meetings to review Panel progress to date and to discuss work plans for the next several days.

The Project Management Panel visited North American Rockwell at Downey to review detailed procedures for acceptance tests, subcontractor inspections, project documentation, and other management interface areas.

APRIL 30, 1970

The Safety Advisory Panel continued discussions with Board Chairman and MSC officials on progress of total Apollo 13 review efforts.

Panel Members reviewed instrumentation used in Apollo 13 spacecraft in order to establish the validity of telemetry data being used in Board analysis.

Chairman Cortright convened two Board meetings to review progress of the work and to discuss preliminary findings of the Board.

Project Management personnel visited Beech Aircraft Corporation to review procedures used for assembly of cryogenic oxygen tanks and to discuss communication and information systems within the Apollo Program.

Panels continued to review detailed data in their respective areas.

MAY 1, 1970

Board and Panel personnel participated in a joint MSC/Apollo 13 Review Board status presentation to the NASA Deputy Administrator. The meeting covered all significant Apollo 13 findings and early conclusions on the cause of the accident and appropriate remedial actions.

The MSC staff briefed Board Members on initial evaluations of proposed design changes in oxygen tank system.

Panel Members continued to assess data accumulated from the Apollo 13 mission with particular emphasis upon the design and performance of electric power systems used in the service module.

Board Members and Panel Chairmen reviewed specific test matrix being proposed by Apollo 13 Review Board specialists covering most significant unknowns involved in understanding failure mechanisms.

MAY 2, 1970

Board Members met in General Session to discuss preparation of a complete "failure tree" as an additional guide in conducting a complete review and investigation. Specific aspects of this approach were reviewed.

The Project Management Panel reviewed oxygen tank reliability history and quality assurance criteria used in assembly, test, and checkout of these systems.

Panel specialists continued reviewing data from the mission with emphasis upon integrating various data points into logical failure mode patterns established by MSC and Board personnel.

MAY 3, 1970

Chairman Cortright and Board Members conducted a detailed review of individual Panel status and progress and established milestones for additional analytical work and preparation of preliminary findings.

The Board and Panel agreed to tentative report structure, including required exhibits, tables, drawings, and other reference data.

The Board established a system for tabulating all significant mission events and explanatory data, including the support tests required to clarify questions raised by events.

Panel Members worked on individual analyses with particular attention to developing requirements for additional test activity in support of tentative conclusions.

The Board agreed to strengthen its technical reviews of combustion propagation and electrical design by adding specialists in these areas.

MAY 4, 1970

The Design Panel continued its intensive review of the "shelf drop" incident at NR involving the cryogenic oxygen flight tank used in Apollo 13 in order to understand possible results of this event.

The Mission Events Panel continued to analyze telemetry data received by MSC, with particular attention on data received in proximity to the data dropout period during the Apollo 13 mission and on fan turnons during the flight.

The Board transmitted a formal listing of 62 requests for data, analyses, and support tests required for Board review activity.

The Board continued to meet with individual Panels and support offices to review the status of preliminary findings and work completed.

MAY 5, 1970

The Board met in General Session to discuss the scope and conduct of support test activity, including careful documentation of test methods and application of test results.

MSC personnel briefed Panel Members on availability of additional telemetry data in the MSC data bank in order to insure Board consideration of all possible useful data.

Panels commenced initial drafting of preliminary findings in specific areas, including summary descriptions of system performance during the Apollo 13 flight.

The Board met with the MSC Investigation Team for complete review of the proposed test program.

MAY 6, 1970

Board Members, MSC personnel, and Members of NASA's Aerospace Safety Advisory Panel met for detailed discussions and evaluation of accident review status and progress. The review covered oxygen tank questions, recovery operations, and a mission simulation by MSC astronauts.

Panel Members continued to work on the preparation of preliminary Panel drafts.

Chairman Cortright transmitted additional requests for tests to MSC and modified procedures for control of overall test activity relating to the Apollo 13 accident.

MAY 7, 1970

The General Board Session reviewed complete analysis and test support activities being conducted for the Board and MSC at various governmental and contractor installations.

Board and Panel Members met to discuss Ames laboratory tests concerning liquid oxygen combustion initiation energies required in the cryogenic oxygen tank used in the Apollo 13 SM.

Panel 1 Members reviewed mission control equipment and operating procedures used during the Apollo 13 mission and reviewed actual mission events in detail.

The Panels continued to develop preliminary drafts of their reviews and analyses for consideration by the Board.

MAY 8, 1970

Dr. Robert Van Dolah, Bureau of Mines, joined the Board as a consultant on combustion propagation and reviewed Apollo 13 Review Board data developed to date.

The General Board Session convened to review proposed report format and scope. An agreement was reached on appendices, on the structure of the report, and on the degree of detail to be included in individual Panel reports.

Chairman Cortright assigned additional specific test overview responsibilities to members of the Apollo 13 Review activity.

Panel 1 conducted a formal interview with the MSC Flight Director covering all significant mission events from the standpoint of ground controllers.

Panels 2 through 4 continued developing preliminary reports. Panel 4 announced a formal schedule of interviews of MSC, contractors, and NASA Headquarters personnel.

Board Members explored in detail possible failure mode sequences developed by MSC personnel involving ignition and combustion within the SM cryogenic oxygen tank.

The Board recessed for 3 days, leaving a cadre of personnel at MSC to edit preliminary drafts developed by the Panels and to schedule further activity for the week of May 11.

MAY 9, 1970

Board in recess.

MAY 10, 1970

Board in recess.

MAY 11, 1970

Board in recess. MSC support personnel continued work obtaining additional technical data for Board review.

MAY 12, 1970

Board Members returned to MSC.

Board Members attended a General Session to review progress and status of the report.

Panel Chairmen reported on individual progress of work and established schedules for completion of analyses and evaluations.

Chairman Cortright reported on the Langley Research Center support test program aimed at simulation of SM panel ejection energy pulses.

MAY 13, 1970

Board Members reviewed preliminary drafts of report chapter on Review and Analysis and Panel 1 report on Mission Events.

Mission Events Panel Members interviewed Electrical, Electronic, and Communications Engineer (EECOM) and one of the Apollo 13 Flight Directors on activities which took place in the Mission Control Center (MCC) during and after the flight accident period.

Panel 4, Project Management Panel, conducted interviews with principal Apollo 13 program personnel from MSC and contract organizations.

Panel Members continued drafting preliminary versions of Panel reports for review by the Board.

Manufacturing and Test Panel representatives discussed program for oxygen tank testing to be conducted at Beech Aircraft.

Board Members met in General Session to review report milestones and required test data for the week ahead.

MAY 14, 1970

Board met in General Session to review Panel report progress and to agree to firm schedules for completion of all Review Board assignments.

Project Management Panel continued to interview key Apollo project personnel from NASA Centers and contractors.

Panel Members circulated first drafts of all Panel reports to Board Members for review and correction.

MAY 15, 1970

Mission Events Panel personnel interviewed Apollo 13 Command Module Pilot John Swigert to verify event chronology compiled by the Panel and to review crew responses during Apollo 13 mission.

Project Management Panel continued interviewing key project personnel with NASA Centers and contractors.

MSC personnel provide Board Members and Panel Chairmen with a detailed briefing on all support tests and analyses being performed in connection with the MSC and Board reviews.

Board Members met in Executive Session to review preliminary drafts of Panel reports and findings and determinations and to provide additional instructions and guidance to Panel Chairmen.

Panel Members continued to review and edit early Panel drafts and to compile reference data in support of findings.

MAY 16, 1970

Board met in General Session to review further revisions of preliminary findings and determinations and to establish working schedules for completion of the Board report.

Panel Members continued to edit and refine Panel reports on basis of discussions with MSC personnel and further analysis of Apollo 13 documentation.

MAY 17, 1970

Draft material for all parts of Board report was reviewed by Panel Members and staff. Changes were incorporated in all draft material and recirculated for additional review and comment.

Board Members met in General Session to review report progress and to examine results from recent support tests and analyses being conducted at various Government and contractor installations.

The Apollo 13 Review Board discussed a continuing series of support tests for recommendation to MSC following presentation of report and recess of the Board.

MAY 18, 1970

Board Members reviewed Special Tests and Analyses Appendix of the report and examined results of completed tests.

Board met in General Session to discuss control procedures for reproduction and distribution of Board report.

Mission Events Panel distributed a final draft of their report for review by Board Members.

Board reviewed a preliminary draft of findings and determinations prepared by Panel Chairmen, Board Members, and Board Chairman.

A Manufacture and Test Panel representative reviewed special oxygen tank test programs at Beech Aircraft.

MAY 19, 1970

Board Members met in Executive Session to continue evaluation and assessment of preliminary findings, determinations, and recommendations prepared by individual Board Members and Panel Chairmen.

Board met in General Session to review final draft of Mission Events Panel report.

Manufacture and Test Panel preliminary report was distributed to Board Members for review and comment.

Design Panel preliminary report was distributed to Board Members for review and comment.

Design Panel Members met with MSC Team officials to discuss further test and analyses support for the Board.

MAY 20, 1970

Board Members met in Executive Session to review and evaluate reports from the Design Panel and from the Manufacturing and Test Panel.

Project Management Panel distributed final draft of its report to Board Members for review and comment.

Chairman Cortright met with Mr. Bruce Lundin of the Aerospace Safety Advisory Panel to discuss progress of Board review and analysis.

MAY 21, 1970

Board Members met in Executive Session for final review of Project Management Panel report.

Board Members and others met with MSC officials to review in detail the activities and actions taken after the Apollo 204 accident concerning ignition flammability for materials and control in the CSM.

A third draft of preliminary findings, determinations, and recommendations was developed and circulated by the Chairman for review and comment.

Arrangements were made with NASA Headquarters officials for packaging, delivery, and distribution of the Board's final report.

Mission Events Panel conducted an interview with Lunar Module Pilot Haise to review selected mission events bearing on the accident.

MAY 22, 1970

Mission Events Panel representatives met with MSC officials to review in detail several events which occurred during later flight stages.

Board met in Executive Session to assess latest drafts of findings, determinations, and recommendations circulated by the Chairman.

Board met in General Session to review total progress in all report areas and to establish final schedule for preparation of Board report.

Langley Research Center representative M. Ellis briefed the Board on ignition and combustion of materials in oxygen atmosphere tests being conducted in support of the Apollo 13 Review.

Board Observer I. I. Pinkel briefed the Board on Lewis Research Center fire propagation tests involving Teflon.

MAY 23, 1970

Board Members reviewed Chapter 4 of Board report entitled "Review and Analysis."

Panel Chairmen reviewed draft findings and determinations prepared by the Board.

MAY 24, 1970

Board Members reviewed NASA Aerospace Safety Panel report covering Apollo activities during the period of 1968-69.

Board met in Executive Session for detailed review of support test status and progress and of documentation describing the results of test activity.

Board met in Executive Session for further review of findings, determinations, and recommendations.

MAY 25, 1970

Board met in Executive Session to review test progress and decided to postpone submittal of final report until June 8 in order to consider results of Langley Research Center panel ejection tests.

Board Members continued to review MSC Investigation Team preliminary drafts and refine Apollo 13 data in the various Board appendices.

Board met in Executive Session for further consideration of findings, determinations, and recommendations.

MAY 26, 1970

Board met in General Session and interviewed Astronaut James Lovell regarding crew understanding of inflight accident.

Board Members reviewed proposed MSC tank combustion test and agreed to test methodology and objectives.

Panel Members continued preparation of individual Panel reports.

MAY 27, 1970

Board and Panel Members received a detailed briefing on thermostatic switch failure during MSC heater tube temperature tests.

Aerospace Safety Advisory Panel met with Chairman Cortright, Board Members, and Panel Chairmen to review Board progress and status of findings and conclusions.

Board met in General Session to review status of Panel reports, documentation of test data and results, and plans for report typing and review.

Board agreed to recess for several days to accumulate additional test information on panel separation and full scale tank ignition data.

MAY 28, 1970

Board in recess.

MAY 29, 1970

Board in recess.

MAY 30, 1970

Board in recess.

MAY 31, 1970

Board in recess.

JUNE 1, 1970

Board Members returned to MSC.

Board and Panel Members met in General Session to discuss revisions of Panel reports in light of latest information regarding thermostatic switch failure during CDDT at KSC.

Board approved new schedule for Board report calling for final versions of Panel reports by Monday, June 8.

JUNE 2, 1970

Chairman Cortright briefed the Press on the status of the Board's work and future plans.

Board and Panel Members participated in a detailed interview and discussion with MSC and contractor personnel regarding specific coordination steps taken during oxygen tank no. 2 detanking operations at KSC.

Board Members met in Executive Session to review latest test results and to assess status of Board findings and determinations.

JUNE 3, 1970

Board and Panel Members met with MSC Program Office personnel for a detailed update of recent MSC information and analyses stemming from on-going test programs.

Board Members and Panel Chairmen completed final reviews of Panel reports and also reviewed final draft of findings, determinations, and recommendations.

Board and Panel Members received a detailed briefing on thermostatic switch questions with emphasis upon actions of various organizations during and after detanking operations at KSC.

JUNE 4, 1970

Board Members met in Executive Session and completed final revisions of Chapter 4 of the Board summary.

Board and Panel Members witnessed a special full-scale tank ignition test performed at MSC.

Panel Chairmen completed final revisions of individual Panel reports and submitted copy to the Reports Editorial Office.

Board met in Executive Session and agreed to final schedule for report printing and delivery to the Administrator on June 15, 1970.

JUNE 5, 1970

Board Members met in Executive Session and completed work on Chapter 5 of the Board Summary Report (Findings, Determinations, and Recommendations).

Board Members reviewed final version of Project Management Panel report and authorized printing as Appendix E.

Board Members Hedrick and Mark completed final tabulation of test support activities performed for the Board.

Board Members reviewed films of special test activities performed at various NASA Centers.

JUNE 6, 1970

Board met in Executive Session throughout the day and completed its review of Chapter 5 of its report (Findings, Determinations, and Recommendations).

Board Members completed review of analyses to be incorporated in Appendix F, Special Tests and Analyses.

JUNE 7, 1970

The Board met in Executive Session and approved plans and schedules for final editorial review and publication of the Board report.

The Chairman recessed the Board until June 15 at which time the Board is scheduled to reconvene in Washington, D.C., to present its report to the NASA Administrator and Deputy Administrator.

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