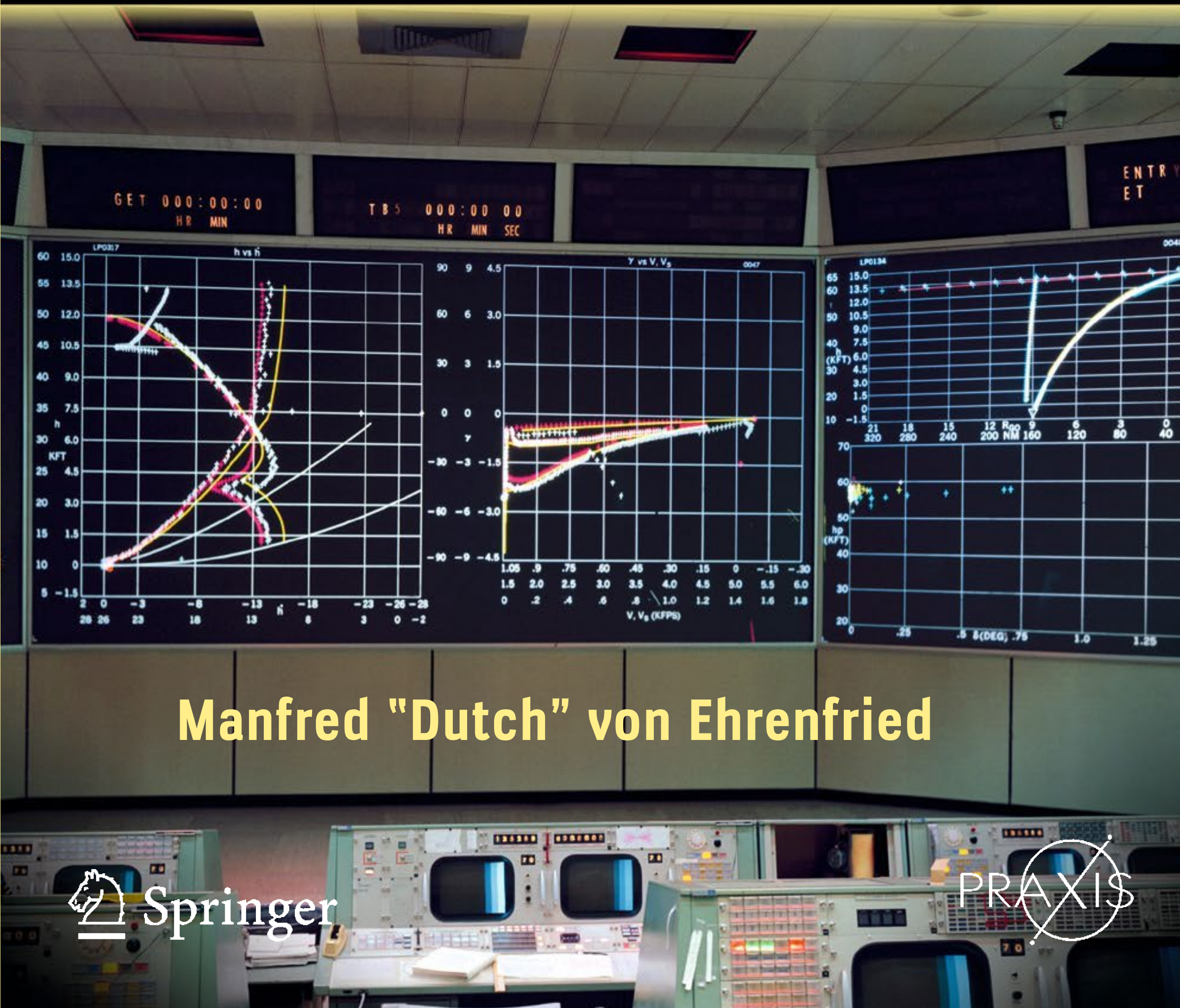
APOLLO MISSION CONTROL

THE MAKING OF A NATIONAL HISTORIC LANDMARK



Manfred "Dutch" von Ehrenfried

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Apollo Mission Control

The Making of a National Historic Landmark

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Gerry Griffin

Cliff Charlesworth

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Phil Shaffer

Don Puddy

Neil Hutchinson

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Dedication

By the summer of 1962, most of us from the Space Task Group at Langley had moved to Houston. All of us in Flight Operations monitored the construction of Building 30 at the Manned Spacecraft Center with great anticipation, for in the building were two new Mission Control Centers. We eagerly looked forward to flying Gemini out of there in 1965. Little did we know that two decades later, in 1985, one of the control rooms where we worked would be declared a National Historic Landmark. The National Park Service defined the landmark as the third floor Mission Operations Control Room (called MOCR 2) along with four of the surrounding support rooms. They called it the "Apollo Mission Control Center" because most of the Apollo flights, including all the lunar landings, were flown out of the third floor control room.

This book is dedicated to all those who worked in the Mission Control Center; not only the flight controllers but all those who supported the many missions that were flown out of that building up to and including 1992. That includes Gemini, Apollo, Skylab, Apollo-Soyuz, and the early Space Shuttle flights. But the Mission Operations Control Rooms where merely the tip of the iceberg, so to speak. Building 30 was filled with computers and equipment of all kinds and required hundreds of people to make it all come together in order to fly just one spacecraft into Earth orbit, let alone to fly multiple spacecraft to the Moon. It has been conservatively estimated that over its operational lifetime from 1964 to 1992, over five thousand people were involved in making it all happen in this one building. Other people at the Manned Spacecraft Center in other buildings were also working to support these missions.

It is the intent of this book to remember those who supported these spaceflights from the "Apollo Mission Control Center" – as many as we can by name either in the body of the book or in an appendix of Mission Manning Lists. Sadly, many are long gone and those that remain are in their seventies, eighties, and even nineties. This book is published as part of the celebration to commemorate the first Apollo Lunar Landing of July 20, 1969.

Acknowledgments

There are those who championed the cause of saving the Apollo Mission Control Center from the ravages of time and the obsolescence of technology. There were others who would have gutted the building to assign it to more mundane purposes. But there is something about a place that controlled many of the flights of the Apollo Program, including all the lunar landings, that urges its preservation. Those who first made the effort, and deserve formal acknowledgment, were the "Historical Preservationists." We must thank the management of the National Park Service for hiring Dr. Harry Butowsky in 1981 to study the situation. His report in 1984 nominated the control center as a possible National Historic Landmark. This was approved in 1985. This immediately triggered the protection of the Secretary of the Interior, who imposed Standards for the Treatment of Historic Properties. No longer could NASA reassign the historic place for other purposes. So our thanks go to the people in the Department of Interior and the National Park Service who championed this cause.

With the formal designation, other preservation organizations got involved. In Chapter 9 on the restoration of the Apollo Mission Control Center, many of those people are identified. Many in the long list (some of whom have supplied input to this book) deserve further recognition here. They include:

Johnson Space Center
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- Edward Fendell, Flight Controller
- Sandra J. Tetley, JSC Historic Preservation Officer
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Space Center Houston
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Many thanks to Wikipedia and Google, which I accessed frequently and was pleased to find that it enabled me to fill in the pieces of the puzzle for just about any subject. Their input is woven into many sections. I was able to find references to the Mission Control Center that are now over half a century old but very useful.

And many thanks to my Springer colleagues Maury Solomon and Hannah Kaufman in New York, Clive Horwood of Praxis in Chichester, England, and cover designer Jim Wilkie in Guildford, England.

I offer a special thanks to David M. Harland in Glasgow, Scotland, who has edited all of my Springer-Praxis books over the past five years. While we have communicated by email, we have never met. Nevertheless, I think of him as a trusted friend. In a way I also think of him as a diamond polisher who, bending over a grind stone, brings out the light and sparkle from an otherwise ugly rock.

Preface

Thank God there are people who want to protect historical places, as without them where would people go to learn about the past. Without them, would we not, over time, just forget? In some cases, the pieces of history can be gathered up and put in museums; a plane here, a rocket there. In every case, those pieces alone do not tell the whole story. A piece of rock from the Moon glimpsed through a barrier of glass cannot begin to tell even a sentence of the story. In other cases, there may be a desire to save the whole, only to find that no one can afford to save it or to keep up with its maintenance. Certainly, preserving a piece of history as significant as mankind's initial step into the void and unknowns of space is one of those places.

There is such a place, well protected from the elements, and in a rather unique government building that is not the whole story of man's quest for the knowledge of space, but at least represents where it all happened. It's a place which very few people have seen with their own eyes, although it will be familiar on their TV sets and in photographs. Wouldn't it be grand to see it in its original light; to see it as it was half a century ago when teams of very talented people controlled the flights that took astronauts to our nearest neighbor, the Moon. Tourists will one day sit in the Visitor Viewing Room and look through the glass wall out onto to the rows of consoles and at the "big screen" on the wall opposite, and see the actual room just as it was during the lunar landings. "See that Johnny, that's where they controlled flights to the Moon when your grandmother and I where your age."

That place is called the "Apollo Mission Control Center." Due to the efforts of many dedicated people it is now a National Historic Landmark, a designation that affords it some Federal protection. But that alone will not restore it to its original configuration and condition. However, it is a start. The government cannot spend money to restore it, but can support the efforts of others who can raise the money. It costs millions to restore a complicated facility like this to its original condition, especially after decades of neglect. But that is the story which I want to tell here, with the help of those who have served in it over many space programs.

In parallel with telling the story of the restoration, I wanted to explain things about the control center that aren't well known to the general public. In fact even though I worked in the control center, in carrying out the necessary research and communicating with colleagues who worked there, I learned some things also! It is unfortunate that the pictures which most people have seen show just those in the Mission Operations Control Room. There were many people in other rooms and other buildings that supported the flight controllers. I have managed to find pictures of people in these other rooms that most people have never seen; even space aficionados.

I also wanted to point out the people who were pioneers in spaceflight; those who developed the operational concepts, methods, and procedures for conducting spaceflight. For the most part they were there in the beginning. And they often came up with the ideas by just "brain storming" on the basis of what little spaceflight experience they had gained from Project Mercury. Such people supported all functional and operational areas, and there is a chapter about them. Some are well-known but you probably have never heard of others. It has been conservatively estimated that over the operational lifetime of the Apollo Mission Control Center, over five thousand people supported all of the missions that were flown from the beginning of the Gemini Program until 1992, when the control center was abandoned. There is a chapter that describes how that came to be.

The work to restore this iconic place is now underway. The famous consoles are being removed from the control room and sent for restoration. The floors and ceilings will be restored and half a century of dirt and smoke cleaned off. Only a few other adjacent rooms that will be visible to visitors will be restored. Overall, the restoration will take a little over a year. The plan is to have the work done in time to celebrate the 50th anniversary of the first lunar landing on July 20, 2019.

The story will start with a brief history of how mission control got started and how the specifications for the new Houston Mission Control Center were drawn up. Each area will be described in the context of the missions, and will describe what the support rooms did to support those in the control center that were seen on TV. Visitors will see what it took to fly a mission.

There are many appendices with relevant material such as key correspondence, mission manning lists, women flight controllers, and other interesting topics and stories with photographs.

This book highlights the people who supported NASA space missions, and is for them and their prodigy as much as it is for students of spaceflight who might one day be inspired to become the flight controllers, engineers, and scientists of the future. Enjoy the story of the Making of a National Historic Landmark called Apollo Mission Control.

Leander, TX, USA
June, 2018

Manfred "Dutch" von Ehrenfried

1

Introduction

In the 1300s, Geoffrey Chaucer said "Time and Tide Wait for No Man." While we can't stop the ravages of time, we can certainly stop and try to capture what was "a truly great" and important period of time in America's history. In this case, not only a great period in America's history, but of a noble activity called human spaceflight. And that unique place is called the Mission Control Center.

Nowadays known as the Johnson Space Center (JSC) the Manned Spacecraft Center (MSC) was opened in 1964. Its location led to it also being referred to as the Houston Mission Control Center (MCC-H). It served its function by giving operational support for the Gemini, Apollo, Apollo-Soyuz, Skylab, and the early Space Shuttle flights. It is the work to preserve some of these facilities that is the subject of this book.

Building 30 is a five story tall structure with three floors that consists of the Mission Operations Wing, the Operations Support (later redesignated the Administrative Wing) and an interconnecting Lobby Wing. It is the Mission Operations Wing from which space missions were controlled. It is here that the world sees NASA conducting spaceflight out in the open, and it is here, and especially the third floor, that has become of historical importance.

Three basic functional areas known as the Display/Control System, the Real Time Computing Complex (RTCC), and the Communications, Command and Telemetry System (CCATS) supported the primary task of conducting manned spaceflight. In the public's eye, this is the Mission Control Center.

The first floor housed the RTCC, the CCATS, and other equipment areas. It supported operations in the two upper floors and also interfaced to the Manned Space Flight Network and the Cape Canaveral launch facilities and down range tracking stations. The Display/Control System, which is distributed throughout the building, is the input/output of the other two systems.

The two floors above housed the Mission Operation Control Rooms (known then as MOCRs, and pronounced moh-kers). The one on the second floor was MOCR 1 and the one on the third floor was MOCR 2. There were many other rooms that supported the

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MOCRs, including all the functional areas providing data to the flight controllers in the MOCRs. The MOCR was quite simply “the place” for making spaceflight history.

This book will focus primarily on the third floor MOCR 2 because it is this area and surrounding rooms that, following two years of study by the National Park Service (NPS), led on December 24, 1985 to the Department of Interior notifying NASA Administrator James M. Beggs that the Apollo Mission Control Center was to be designated as a National Historic Landmark (NHL).

From MOCR 2 on the third floor came the black-and-white grainy images on 600 million people’s television sets during the first lunar landing on the evening of July 20, 1969 and all of the landings that followed. In addition to most Apollo flights, recognition also extends to most of the Gemini and Space Shuttle flights up through STS-53 in 1992. Many unmanned Apollo flights were controlled from MOCR 1, as were Apollo 7, four Skylab missions, and many Shuttle flights. But, as far as the restoration of the NHL is concerned, the period of significance runs from 1964 to the end of the Apollo lunar missions in 1972.

MOCR 2 has not supported missions since 1992, over a quarter of a century ago. Time, as well as new and different missions and advanced technology have made the original contents of the building, including the MOCRs, obsolete. The original facilities and equipment no longer support current missions. NASA has retired them “in situ,” not with a “pension” but with a “penchant” for preserving at least MOCR 2 in recognition of its contribution to America’s space program. Its new purpose will be to enable visitors to inspect up close and personal what was previously only available to television viewers two generations ago during the “Golden Age of Space.” It will serve to demonstrate to a new generation of youngsters from all nations what young people can accomplish; for many of us were only in our twenties at that time. And hopefully this historic landmark will also demonstrate to those in Congress what happened long ago when Presidents (of both parties) and the Congresses made things happen in the national interest.

This book briefly takes us back to the origins of the American space program, to describe how the concepts of spaceflight and mission operations came about, and why and how the Houston Mission Control Center was built. It describes the rooms and positions for both operations and support personnel, and the consoles and displays that they operated. It goes behind the scenes that were shown on TV and describes the facilities and equipment that supplied the flight operations team with the data and functionality they required to support those amazing (and now iconic) missions. It is the place where we heard those words and phrases that are now part of our language and psyche, such as “Houston, Tranquility Base here, the Eagle has landed” and “Houston, we’ve had a problem.” When astronauts in space called home, they were talking to flight controllers in what the NPS calls the “Apollo Mission Control Center.” This is what many of us are eager to save from, as Chaucer so elegantly put it, the ravages of time. Those same people are now calling out to others for help. Thousands of people all across the world are donating funds to help with the restoration of these historic facilities. Yet more money will most likely be needed.

The book describes how, during more than half a century since MCC-H was built as a state-of-the-art facility, space missions have changed and why it could no longer support future activities without extensive modifications in hardware, software and operational concepts. It was quite simply time to move on! This led to the eventual abandonment of the third floor MOCR 2. After the lunar missions ended in 1972, it was deactivated and modified for the Space Shuttle, reopening in 1982. It continued to support missions until 1992, when it was abandoned for good. The facility was spent; it was time for others to carry on the nation's space program. The room had seen it all; from the momentous to the tragic.

The rooms lay empty for years and were then used for storage, and for visitor tours and social gatherings. This led to some console degradation and even theft of items. In some places, rips in the carpets were hastily covered over with duct tape. JSC provided power and air conditioning to the facility, but undertook no maintenance and took little interest in its deteriorating condition.

As former flight director Gene Kranz observed, "The overall condition is not emblematic of a National Historic Landmark."

While some people at JSC focused on newer control facilities, now known as Flight Control Rooms (FCR), others were concerned about the historical value of Building 30 and especially its MOCRs.

This book describes the efforts to restore to a presentable level those portions of MOCR 2 and some of the surrounding support rooms and facilities. It focuses on the research, the contracting, the raising of funds, and the industrial team that was contracted to undertake the work. By 2014, a formal working group of only 14 people gathered to plan the proposed work. This included people from various JSC organizations such as the facility and property people, the History Office, the Planning & Integration Office, former NASA flight controllers, as well as people from the National Park Service and the Public Lands History Center at Colorado State University and subcontractors.

By June 2015, an Interagency Agreement initiated by NASA and the NPS had prepared various documents to initiate the necessary work. One of the reports was the Historic Furnishings Report and the Visitor Experience Plan. This defined the depth of detail needed during the restoration of the rooms, consoles and displays, furnishings, and even personal effects of former flight controllers. Five rooms are included: MOCR 2, the Display Projection Room, the Simulation Control Room, the Recovery Control Room, and the Visitor Viewing Area. The report described how the restoration would affect the visitors' experiences – plural because formal tours involving many different groups are envisaged in the Visitor Viewing Room overlooking MOCR 2. Ideally, all this work will be completed well in advance of the 50th Anniversary in July 2019 of the Lunar Landing. The plan is that stories will be told during the tours by experienced people and historic videos played in the restored National Historic Landmark. In this way, memories of the "Golden Age of Spaceflight" will live on.

Since 2017, a JSC Apollo MCC NHL Restoration Project Working Group has routinely met to monitor and manage the restoration effort. Also that year, former NASA flight controllers and astronauts were interviewed; many of them seated at their former consoles in order to provide the contractors with vital information to be used in the restoration process. In order to make the environment as realistic as possible, people have donated documents, reports, plots, and photos that they had at their consoles. And the archives are being searched for as much information as possible. These include the University of Houston-Clear Lake, Rice University's Woodson Research Center, JSC's History Office and even the National Archives in Fort Worth, Texas. The intent is, as former NASA flight controller

Ed Fendell said, "Apollo Mission Control should be restored to a degree of accuracy that will feel to visitors like the day we walked out."

Also in 2017, Space Center Houston, the official NASA JSC visitor center for human spaceflight activities, launched a $5 million campaign to raise funds for a major restoration of the MOCR. $3.5 million had already been contributed by a generous lead gift from the City of Webster, Texas. Then, during July 20 through August 19, Space Center Houston undertook a crowdfunding project called "The Webster Challenge: Restore Historic Mission Control" on Kickstarter, which is a fund raising platform of the American Public Benefit Corporation. The Webster Challenge invited people from around the world to donate over a 30-day period to raise funds for the restoration. As a result, 4,251 people pledged $506,905 to the Kickstarter. The first $400,000 of this will be generously matched by the City of Webster. Thus, the funding was obtained and the restoration got underway. The Apollo Mission Control Center will be saved from the ravages of time and follies of man. But even that amount of money will not be enough, and efforts continue to raise further funds. If you would like to help, then please contact Space Center Houston. Go to: https://spacecenter.org/support/restore-mission-control/donate-now. We heartily thank all of those who have served!

The book will also include many appendices with details of the history, photos, quotes, names, and work of the people involved in capturing a historic period and place during the Golden Age of Space; the iconic Apollo Mission Control Center.

2

Mission Control Concepts

2.1 FLIGHT OPERATIONS

The term "flight operations" has had a variety of meanings to different groups of people and at different points in time. During and after WW-II it was used by the military and described preparing for, and executing fighter and bomber missions. At the National Advisory Committee on Aeronautics (NACA) Langley Memorial Aeronautical Laboratory during this period it was the testing of both military and civilian aircraft. This involved wind tunnels and the acquisition of large amounts of data. Pilots would fly aircraft in order to acquire data in various portions of the flight envelope. There were not "control centers" as we use the term today; there were people in a room inside the hanger who would gather to monitor the "flight test." And at the Wallops Island Station, the Pilotless Aircraft Research Division launched all manner of unmanned craft in the late 1940s and did not use the term so much as "flight test" because for those flights, once you'd "lit the fuse" it was gone!

The same is true of the NACA Muroc Flight Test Unit (later called the High Speed Flight Test Station) while testing the various X planes in the 1940s. The actual flights were monitored by a small group in a room (probably in a hanger) mostly just looking at telemetry and one or two people communicating with the pilot to ascertain his status and the progress through the flight test plan. Control was in the hands of the pilot; there was no control, so to speak, from the ground.

Even before Sputnik, thoughts about how to control orbital flight was a topic of great interest. While there were plans in 1955 for tracking objects from space as part of the International Geophysical Year (IGY), these were really "tracking stations" not control centers as we think of them today. There was no control of the payload once the missile (and they were missiles) was launched.

After Sputnik, and just after the formation of NASA on October 1, 1958, and the Space Task Group later that month, 34 year old Christopher Columbus Kraft, Jr. was given the responsibility to write a "flight test" plan for an orbital mission. Kraft was from an aircraft flight test world so he was an "operations" guy. In his 2001 book, *Flight: My Life in*

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Mission Control, he describes his initial thoughts for monitoring and controlling an orbital mission. The word “control” came up often because the situation suddenly included not only the capsule but the Army, Air Force, and Navy, as well as NASA. While one would expect this to be more political than operational, it proved to be both.

The more that Kraft and the Space Task Group (STG) studied the problem of how to control an orbital mission, the more the concepts fell into place. During this same period, the Air Force and Army Corps of Engineers were constructing Receiver Building #3 to operate as a telemetry and data processing facility at the Cape Canaveral Air Force Station in Florida, for the Atlantic Test Range. It was intended that the design of that building would accommodate the new “Mercury Control Center” (MCC). The STG specified the overall design of this building, and in particular its layout. As a result, in the STG Organization charts of 1959 the words “Flight Control” and “Control Central” were used. Some people were being hired for their aircraft flight test and operations experience, and others for their understanding of systems and the manner in which these might be used for analysis of capsule performance and potential problems.

Along the way, ideas were coming from contractors who were designing the worldwide tracking stations, in particular how these could be used to “monitor and control” the mission while the capsule was passing over their site. One such contractor was asked what he thought would be required in the way of a facility for analysis and control of the mission; he thought a desk with three telephones ought to do it! Kraft knew that this was the wrong contractor for his concept of how the Mercury missions would be controlled. He presented those concepts to the Society of Experimental Test Pilots on October 9, 1959. Kraft described the Mercury Control Center concept in terms of very specific positions with duties and responsibilities. These “operational functions” were duly manifested in the consoles and displays that defined the Mercury Control Center facility and the main control room.

This methodology of identifying who has responsibility for what during the various phases of a mission, then specifying the displays and controls that they will require in order to perform their individual duties, still defines spaceflight operations and mission control over half a century later. This is a testament to Kraft’s vision.

2.2 MILITARY VERSUS CIVILIAN CONTROL

The management of all the “control” elements of a mission were relatively clear by 1959; or at least workably so. The Army made the Redstone missile and they controlled its launch from the blockhouse. Then NASA controlled the remainder of the flight through to completion. The Air Force owned the Cape Canaveral Air Force Station and controlled its land and facilities as well as the tracking stations down the Atlantic Missile Range (the Eastern Test Range as of May 15, 1964). It included Receiver Building #3 and the Mercury Control Center. There would be a console for an Air Force Range Safety Officer. He would blow up a missile which went astray and endangered populated areas. That was his “control” capability. In addition, Air Force contractors assured the facility was ready for mission support. The Navy controlled the recovery forces – except when Admirals fought with the Air Force Generals over which service’s air or sea craft would recover the NASA capsule and its astronaut; as it turned out, that battle was won by the NASA Flight Director. The world-wide tracking stations were owned and controlled by NASA Goddard Space Flight Center, although the land on which they stood was owned by the host nation and they were operating under international agreements and at the good graces of the host. The State Department solved most of those problems. Once Project Mercury got underway, some 20 government agencies had become involved. How do you "control" such a bureaucracy?

Dr. Robert Gilruth, the STG Project Manager, appreciated the importance of the various branches of the military and established liaison positions on this staff for very senior officers, most of them at the rank of Colonel or its equivalent. For the most part they wore civilian clothes, even in the Mercury Control Center. The only men in uniform in the MCC were an Admiral in charge of the USN recovery forces, an Air Force General, and Air Force Captain Henry "Pete" Clements who monitored the network and the Atlantic Missile Range assets. There were also a number of uniformed naval officers in the Recovery room, which was alongside the main control room.

These "turf" questions became less of an operational problem as time went on, and NASA made it abundantly clear to all concerned that in matters involving the safety of the crew, the Flight Director in the "control" center was the one who had the life and death responsibility for the astronaut, and his decision would be final. There was no doubt that NASA ran the Mercury Control Center. Two generations later, the international partners and multitudes of contractors acting in support of the International Space Station greatly complicated the process of making decisions, but the authority of the Flight Director is still very clear to all concerned.

Although the Mercury Control Center was completed in 1958, the STG was not yet ready to occupy it because the organization was in the formative stages. Work went on for the tracking and telemetry capabilities of the building. NASA finally occupied the MCC in late 1960 during preparations for the first Mercury Redstone flight.

This history of operational control has been tested and played out many times in the Mercury Control Center, in the Mission Control Center, and in the Apollo Control Center. This book will discuss that history and the efforts to preserve it for posterity.

3

The Original Mission Control Center

3.1 THE MERCURY CONFIGURATION

As initially configured, the floor plan of the Mercury Control Center essentially matched Kraft's 1959 concept of operations as shown in Figure 3.1. After a few simulations and experience with Mercury Redstone 1 in November 1960, some changes were made.

The Range Safety Observer (Position 6) was no longer needed, as the Range Safety Officer was in direct communications with the Flight Director from the facility on the Cape and had the responsibility to destroy the launch vehicle if it went out of limits. This position was assigned to Gene Kranz as the Operations and Procedures Officer (a role that would later evolve into the Assistant Flight Director). And the Recovery Status Monitor (Position 5) was no longer needed because the entire recovery operation was managed from an adjacent Recovery Operations Room. This position also went to Operations and Procedures. (I first occupied this console for John Glenn's MA-6 flight.) The Recovery Task Force commander (Position 2, usually an Admiral) sat on the upper row, behind these two positions.

The Missile Telemetry Monitor (Position 9) was only used for the unmanned MR-1 test on November 21, 1960. The equivalent Redstone and Atlas monitoring positions were in the launch control areas with direct voice communication to the Flight Director. The Booster Systems Monitor position was later added to monitor the launch vehicles. His seat was next to that of Captain Henry Clements, the Air Force Network monitor who was responsible for the status of the Atlantic Missile Range and the remote sites of the Mercury Space Flight Network.

The Support Control Coordination (Position 11) was for John Hatcher, the RCA Maintenance and Operations person who made sure that all the systems in the building that were required by the flight controllers were functional. These included telemetry, displays, power, communications, lighting, data, voice and teletype. This position was later moved over to the left side of the room, facing the flight controllers. It responded to the Operations and Procedures Officer to assure mission readiness.

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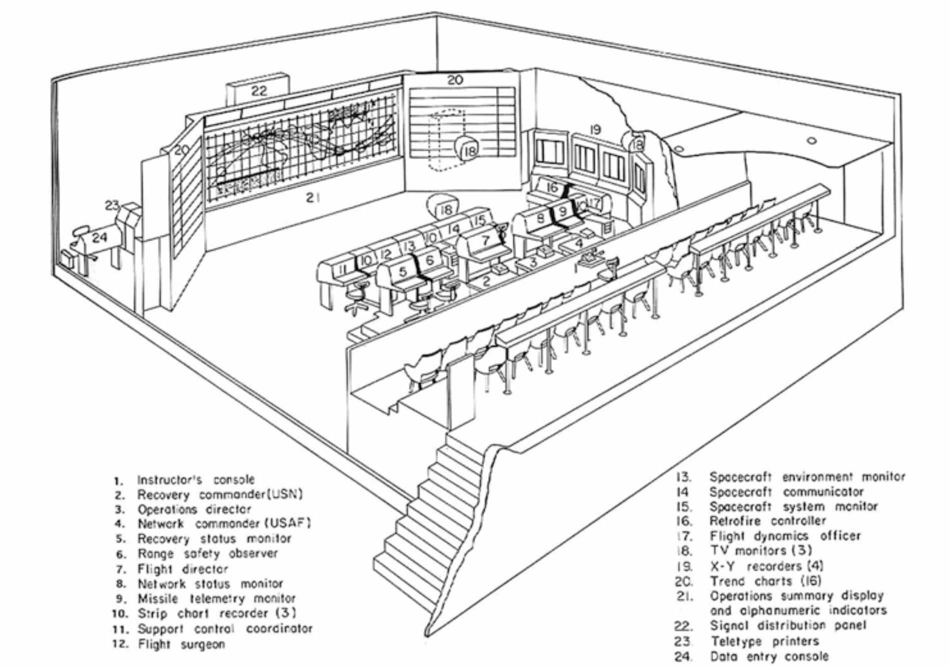


Figure 3.1 The initial MCC configuration. Drawing courtesy of NASA.

Most of the early pictures of the MCC were in black-and-white and somewhat crowded and blurry. Figure 3.2 is a clear, color photo showing how the restored control room looks now that it has been relocated to the Kennedy Center's Early Space Exploration exhibit. The building that housed the MCC was demolished.

3.2 THE GEMINI MODIFICATIONS

After every Mercury mission, ideas for better functional displays were collected for subsequent implementation. Gemini was a two-man spacecraft that flew on a new launch vehicle, the Titan II, so some new positions were added. While the control room functioned about the same as during Mercury, it started to look a little different. For Gemini missions, changes were made to the existing console lineup. Two consoles were added on the left side of the room, facing inward, for the Support Coordinator. And on the right side of the room a fifth plot board was added to the row of four which were used for the Flight Dynamics and Retrofire Officers. More group displays were also added.

Figure 3.2 The Restored Mercury Control Center. Photo courtesy of NASA KSC.

Figure 3.3 Receiver Building #3 housed the MCC. Photo courtesy of NASA.

Figure 3.4 This picture was taken on March 9, 1964 and shows the MCC modified for Gemini. At that time preparations were being made for the launch of Gemini 1, which occurred on April 8. It was also used for Gemini 2, 3, and 4. Photo courtesy of NASA.

This configuration of the MCC continued for the early Gemini missions. The final one to be controlled from this facility was Gemini 3 in March 1965. It was the first manned Gemini with Gus Grissom and John Young. This configuration acted as backup to the new Houston Mission Control Center for Gemini 4, when Ed White made his famous EVA.

Afterwards, the building continued to serve as a remote site tracking station transmitting real time voice, telemetry and data from the Eastern Test Range to the new Houston Mission Control Center. The era of Project Mercury was very definitely over!

3.3 THE TRANSISTION TO HOUSTON

Even before John Glenn's flight in February 1962, the plans to move the NASA STG to Houston, Texas were underway. As the STG had just started to support manned Mercury missions, the plans for a new control center were not yet fully developed.

On September 19, 1961 NASA Administrator James E. Webb announced the new Manned Spacecraft Center would be located on the 1000 acre (subsequently 1620 acre) tract south of Houston near Clear Lake. This move from Virginia was not completed until July 1962, but construction work actually began on this tract of cow pastures in April 1962.

Immediately following Glenn's flight, work began on the plans for the new Mission Control Center-Houston. Even the contracts for Gemini and Apollo were not let until the final months of 1962. During this same timeframe, construction was underway at all of the NASA centers and facilities; the new Mission Control Center was just one of many new facilities which were being built around the country at that time.

Even before all of the STG flight operations people relocated to Houston, they began to provide input to the design of the new control center. There were many contractors involved with the buildings, but those most involved with the control center design were picked by a formal procurement process with due inputs from the Operations Division led by Chuck Mathews and Christopher Kraft. Kraft was pleased with the way that IBM and Philco had supported Project Mercury. It was clear that they were the best qualified for the job, and fortunately theirs were the best proposals of the bids by ten companies. After discussions with James Webb and completion of the formal procurement process, IBM and Philco received the contracts. The STG flight control elements most involved with the design effort and with providing input to the winning contractors were the Flight Control and Flight Support Branches of the Operations Division, plus the Mission Planning and Analysis Division. In addition to Kraft, the key players were John D. Hodge, Gerald W. Brewer, Howard C. Kyle, C. Frederick Matthews, Tecwyn Roberts, and John Mayer.

As their duties on Project Mercury wound down, the STG flight controllers started to move to Houston in 1962. There the flight controllers and operations support personnel – the only NASA people with real operations experience of manned spaceflight – focused their efforts on providing inputs to the IBM and Philco contractors. This became a major effort. It resulted in the production of very detailed documents which then drove the console and display designs and support equipment. The results were formally published in the "Flight Control Requirements for the Integrated Mission Control Center."

In the 19 months after the MA-9 flight by Gordon Cooper on May 15, 1963 that wrapped up Project Mercury, Building 30 and the MCC was made ready to conduct mission simulations in support of Gemini.

On December 9, 1964, the partially completed new control center was used passively and in parallel with MCC at the Cape for the Gemini-Titan 2 launch attempt, primarily to validate the computer launch programs. Due to an engine shutdown one second after ignition, the launch had to be scrubbed. The mission finally got underway on January 19, 1965. Considerable utility was made of the telemetry processing program and related TV display formats. The new center received, processed, and displayed live and simulated Gemini launch vehicle and spacecraft data. The results were considered very successful.

The new Houston MCC was backup to the Cape MCC for Gemini 3, which launched on March 23, 1965 when Gus Grissom and John Young flew the first manned Gemini mission. It became the prime control center for the mission of Gemini 4, which launched on June 3, 1965 with Jim McDivitt and Ed White – with the latter making America's first Extra Vehicular Activity (EVA).

It is this same third floor control center that is being honored as a National Historic Landmark and is the subject of this book.

4

A Control Center for the Future

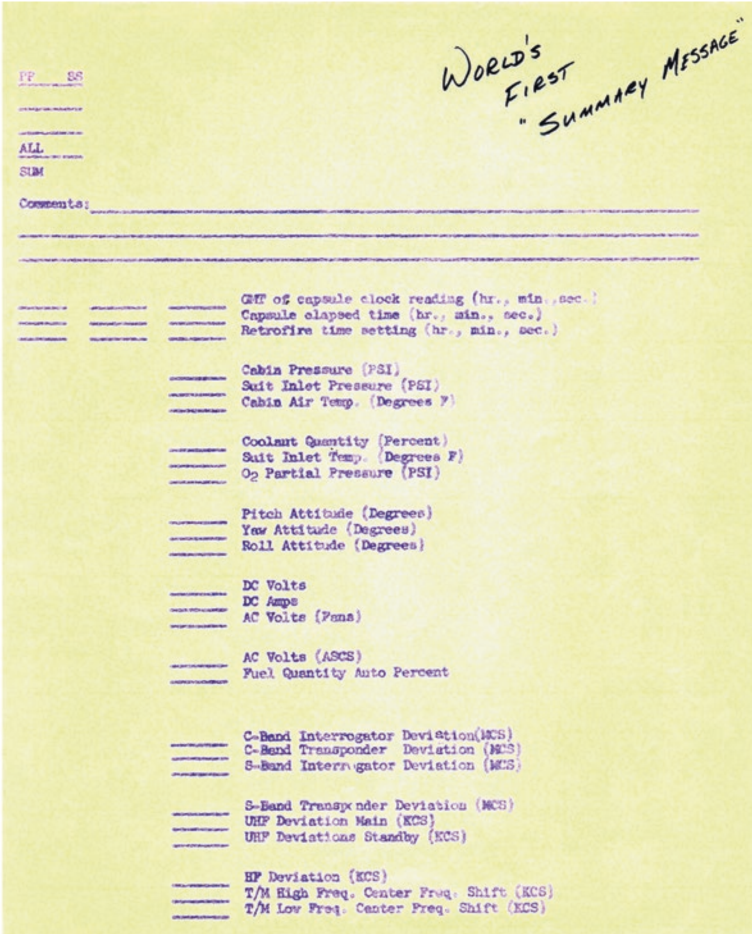
4.1 A NEW CONCEPT

The mental shift from Mercury to Gemini, let alone to Apollo, in the years 1962 and 1963 required some futuristic conceptual thinking. The available technology did not match the sophistication of the spacecraft and the necessary operational concepts. There was something of a disconnect between operations and reality. Operations people are very pragmatic; they contemplate and visualize but don't dream, they rely on scientists and engineers to create the hardware and software they conceive for supporting mission operations. Often, the operational concepts become the requirements that the designer must satisfy. Then too, the operators know that the manufacturers build using their own technologies, therefore flight controllers must learn how systems operate. Operators let others worry about the technology that will go into the spacecraft, launch vehicle and tracking network, and they focus on the control center technology that they will need.

The existing Mercury Space Flight Network of remote sites that provided the control center with data worked fairly well for a one-man spacecraft which flew initially for only three low orbits, mostly over land. This allowed assessment of the astronaut and his "capsule" (as the spacecraft was referred to in those days), and provided "Air/Ground" voice communications when the vehicle was over a remote site station. During a period in contact, information would be passed via voice to the Mercury Control Center, then the "Capsule Communicator" would hastily prepare a message with the pertinent telemetry and doctor's information and send it via low speed teletype (TTY) back to the Mercury Control Center, as illustrated in Figure 4.1. Although this seems rather primitive today, it worked.

Some sites were more capable than others in terms of radars. Only about one third of them had the ability to send a command up to the Mercury capsule. The Bermuda tracking station was a "mini" control center. It had real time capability that could send high speed data via submarine cable to the Goddard Space Flight Center for forwarding to the Mercury Control Center. In fact, it was designed to take operational control of a mission in the event of an accident disabling the Mercury Control Center.

M. von Ehrenfried, *Apollo Mission Control*, Springer Praxis Books,
https://doi.org/10.1007/978-3-319-76684-3_4


WORLD'S FIRST "SUMMARY MESSAGE"

PP SS

ALL

SUM

Comments:

GMT of capsule clock reading (hr., min., sec.)
Capsule elapsed time (hr., min., sec.)
Retrofire time setting (hr., min., sec.)

Cabin Pressure (PSI)
Suit Inlet Pressure (PSI)
Cabin Air Temp. (Degrees F)

Coolant Quantity (Percent)
Suit Inlet Temp. (Degrees F)
O_2 Partial Pressure (PSI)

Pitch Attitude (Degrees)
Yaw Attitude (Degrees)
Roll Attitude (Degrees)

DC Volts
DC Amps
AC Volts (Fans)

AC Volts (ASCS)
Fuel Quantity Auto Percent

C-Band Interrogator Deviation(MCS)
C-Band Transponder Deviation (MCS)
S-Band Interrogator Deviation (MCS)

S-Band Transponder Deviation (MCS)
UHF Deviation Main (KCS)
UHF Deviations Standby (KCS)

HF Deviation (KCS)
T/M High Freq. Center Freq. Shift (KCS)
T/M Low Freq. Center Freq. Shift (KCS)

Figure 4.1 An original Mercury Post-Pass TTY summary message. Photo courtesy of Arnie Aldrich.

Longer Mercury flights required some readjustments to flight operations, and especially recovery of the astronaut in case of an emergency. Gemini would fly much longer durations, sometimes spending long periods over vast expanses of ocean with little spacecraft contact. In some cases, in much higher orbits, it was possible to maintain contact with certain sites for extended times. Apollo would fly a quarter of a million miles to the Moon, and transmit almost too much data with continuous communication with the MCC all the way there and back. How would the flight control teams get the data they needed in order to monitor and control much more complicated missions flying even more complex spacecraft and launch vehicles? How would the new control center and tracking networks obtain and process the data for display? What would the flight controllers in the new control center need for computation and communications? What would the displays look like?