

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

MANNED
SPACEFLIGHT
CONTROL
CENTER

PREPARED BY:

CENTER SUPPORT SECTION
NETWORK OPERATIONS BRANCH
FLIGHT SUPPORT DIVISION

FOREWARD

The National Aeronautics and Space Administration has evolved from the National Advisory Committee on Aeronautics (NACA) and the Project Mercury Space Task Force to become the United States agency charged with the dynamic and challenging responsibility for the peaceful exploration of space. Knowledge gained from this pioneering effort will benefit all nations; the tremendous amount of research supported by NASA has and will produce new insight into fields such as medicine, engineering and equipment and personnel management which will be of great use to humanity.

There are many NASA centers throughout the country, each concerned with a major area in the space exploration effort. The Manned Spacecraft Center at Houston, Texas, is concerned with the design and manufacture of the actual spacecraft in which U. S. astronauts will journey through space. The Manned Spacecraft Center is also the headquarters and major training site for the flight crews which will man these spacecraft. At the present time, NASA is actively engaged in two manned space flight programs - Gemini and Apollo.

The Gemini program is a series of two-man earth orbital flights. The primary purpose of Gemini is to gather data necessary for the Apollo mission and to provide experienced, well-trained flight crews for following missions. On some flights, rendezvous with another orbiting vehicle, the Agena, will be accomplished to investigate rendezvous techniques.

The Apollo project will place the first U. S. man on the moon. A three-man crew will make the translunar flight and establish an orbit around the moon. Two astronauts will descend in the Lunar Excursion Module (LEM) to the lunar surface while the third waits, in orbit, in the Command Module for their return. After landing, one crewman will remain in the LEM to monitor systems and maintain communications while the other astronaut disembarks to perform scientific experiments and explore the moon's surface. Upon completion of the exploration, the two astronauts will return to the command module for the return trip.

Both the Gemini and Apollo missions, as well as future missions, will be coordinated and controlled from the Manned Spaceflight Control Center at the Manned Spacecraft Center.

INTRODUCTION
TO THE
MANNED SPACEFLIGHT CONTROL CENTER
(MSCC)

Purpose

The Manned Spaceflight Control Center (MSCC), supported by a world-wide network of tracking and voice-data communications stations, provides centralized mission control of NASA manned space flight programs from launch to recovery. To perform this operation, the MSCC directs and controls the Ground Operational Support System (GOSS) prior to and during a flight or simulated mission, and directs the transmission of information, advice, and recommendations to the astronauts.

Functions

The specific functions of the MSCC during a mission include technical management in the areas of:

1. The Real Time Computer Complex
2. Display and Control
3. Communications

During non-mission periods, the MSCC is involved with activity in:

1. Data analysis
2. Simulation Checkout and Training System (SCATS)
3. Maintenance of MSCC technical facilities
4. Collection of status information on all GOSS elements

MISSION OPERATIONS CONTROL ROOM (MOCR)

The Mission Operations Control Room (MOCR) is responsible for detailed mission control. In its role as a command center for the manned space flight missions, the MOCR will monitor and analyze mission status and make decisions as to actions to be taken to be consistent with mission objectives.

The MOCR is staffed with key decision-making personnel. The responsibilities of the different control room positions are:

OPERATIONS DIRECTOR - Has overall mission responsibility and control of flight test operations.

DEPARTMENT OF DEFENSE REPRESENTATIVE - Has overall control of all Department of Defense (DOD) forces supporting the mission.

PUBLIC AFFAIRS OFFICER - Has the responsibility of keeping the public informed on the status of the mission.

FLIGHT DIRECTOR - Responsible to the OPERATIONS DIRECTOR for detailed control of the mission from liftoff until conclusion of the flight, and assumes the duties of the OPERATIONS DIRECTOR in his absence.

ASST. FLIGHT DIRECTOR - Responsible to the FLIGHT DIRECTOR for coordination of all MSCC/GOSS flight control activities, and assumes the duties of the FLIGHT DIRECTOR in his absence.

NETWORK CONTROLLER - Has detailed operational control of the GOSS network.

OPERATIONS AND PROCEDURES OFFICER - Responsible to the FLIGHT DIRECTOR for the detailed implementation of the MSCC/GOSS mission control procedures.

VEHICLE SYSTEMS ENGINEERS - Monitor and evaluate the status of the flight crew while checking the performance of all electrical, mechanical, and life support equipment aboard the spacecraft.

LIFE SYSTEMS OFFICER - Directs all operational medical activities concerned with the flight.

SPACECRAFT COMMUNICATOR - Carries on voice communications with the astronauts, exchanging information with them on the progress of the mission.

FLIGHT DYNAMICS OFFICER - Monitors and evaluates the flight parameters required to achieve a successful mission, giving GO or ABORT recommendations.

RETROFIRE OFFICER - Monitors impact prediction displays and is responsible for determination of retrofire times.

MAINTENANCE AND OPERATIONS OFFICER - Responsible for the performance of installed MSCC equipment and its ability to support a simulated or flight mission.

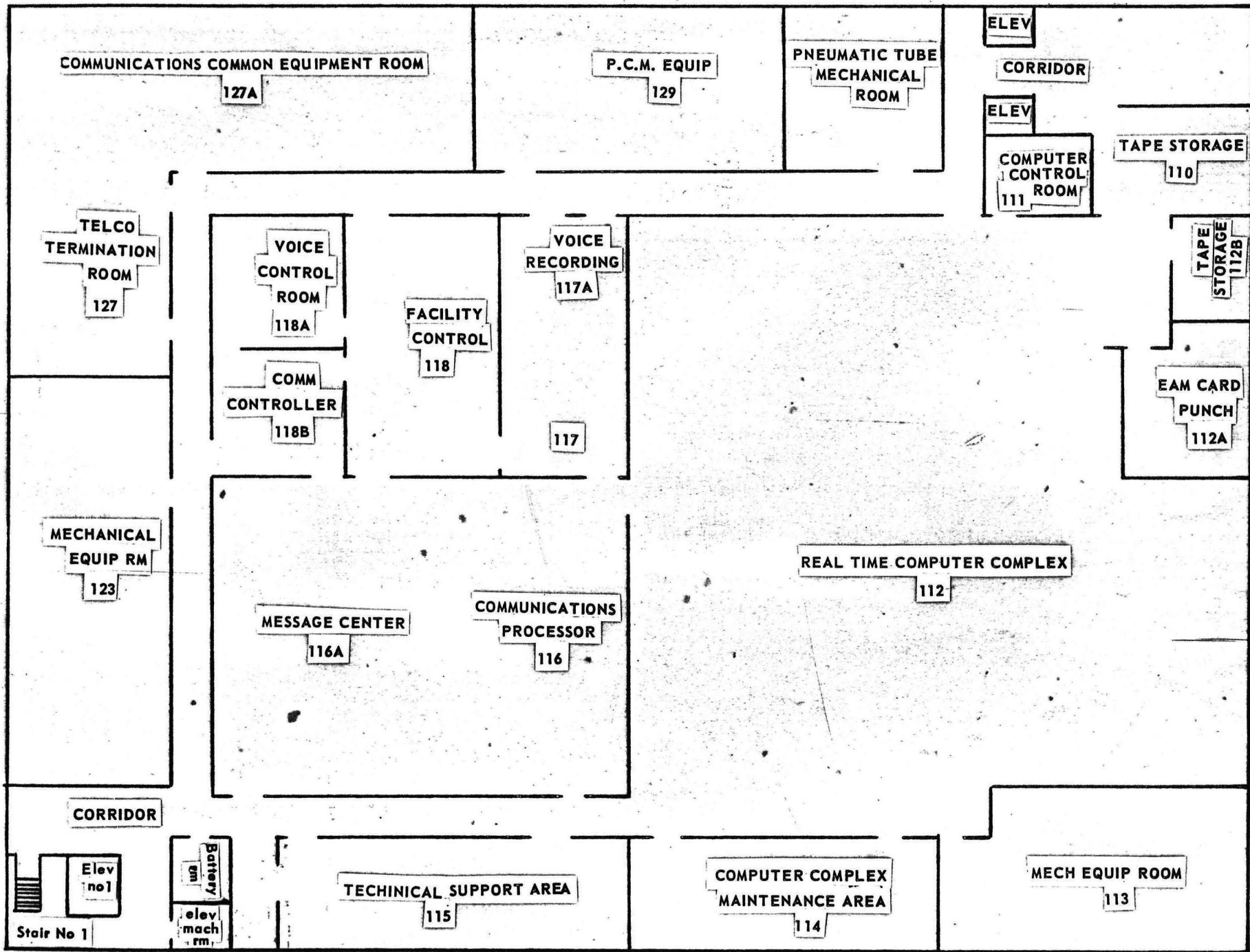
STAFF SUPPORT ROOMS

The technical staff located in the Staff Support Rooms (SSR) provide detailed support to the flight control personnel in the MOCR. The SSR personnel provide technical and administrative assistance to the MOCR in the areas of:

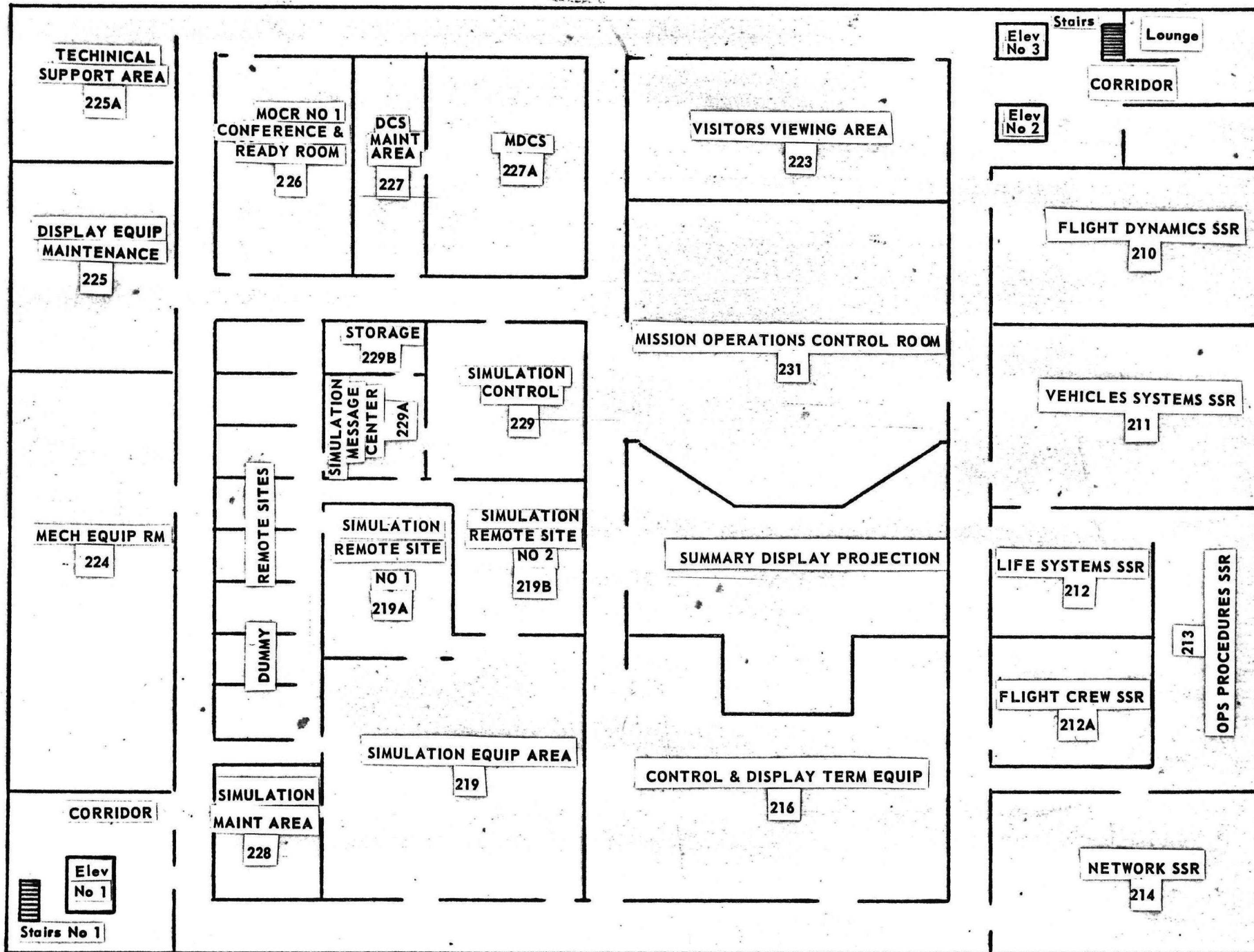
1. Flight Dynamics
2. Vehicle Systems
3. Life Support
4. Operations and Procedures
5. Crew Systems
6. Network Control

Each staff performs data analysis as related to their specialities and report to their respective counterparts in the MOCR. For example, they analyze long-term performance trends to permit the anticipation of contingencies, compare these trends to derive predictions and evaluations, and report the results of their evaluations along with any required and/or requested recommendations to the MOCR.

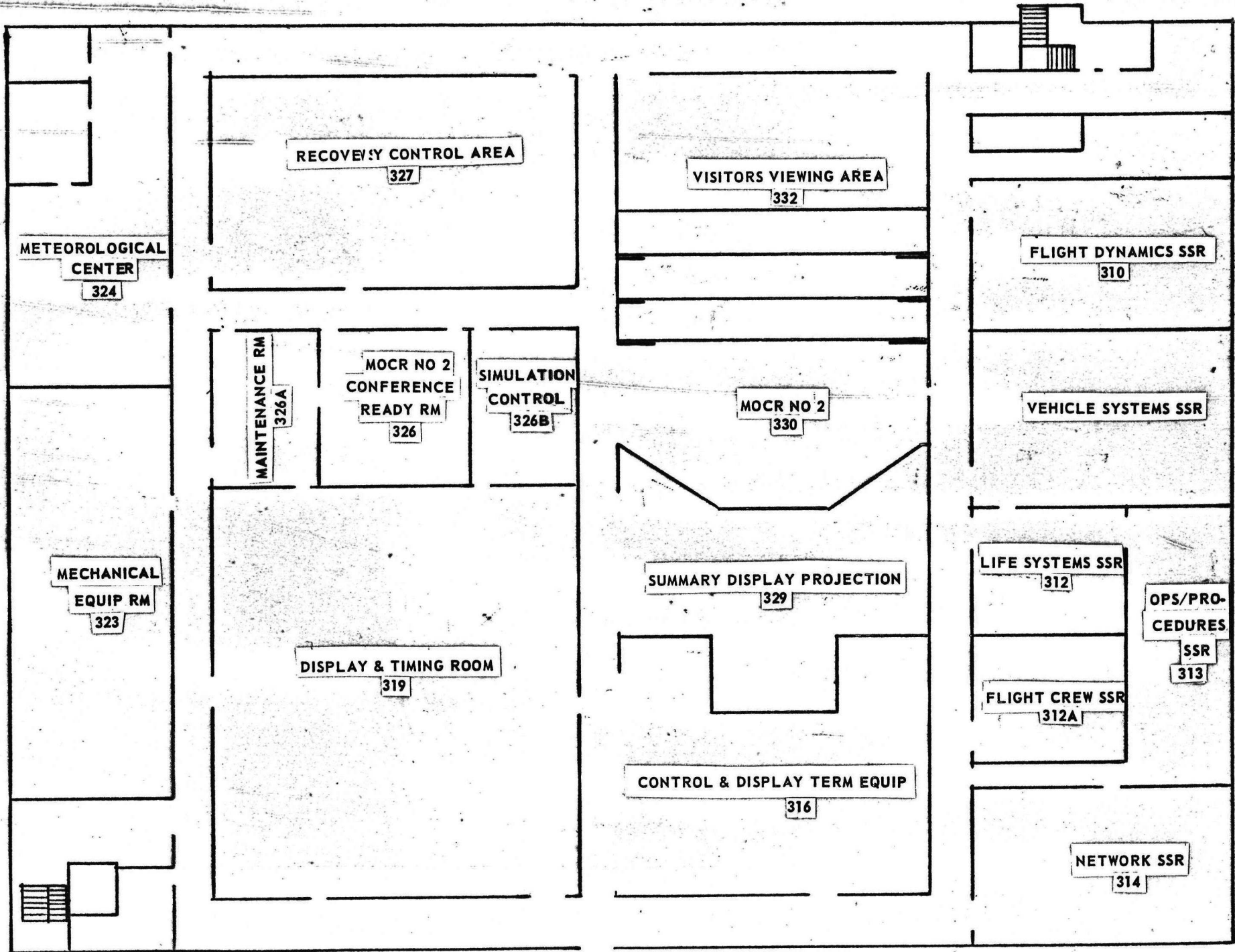
These SSR functions are of invaluable aid to the MOCR personnel, as they will be too busy monitoring current mission status to provide a detailed analysis of mission parameters for themselves.



MANNED SPACEFLIGHT CONTROL CENTER 1st FLOOR



MANNED SPACEFLIGHT CONTROL CENTER 2nd FLOOR



MANNED SPACEFLIGHT CONTROL CENTER 3rd FLOOR

GROUP DISPLAYS

MISSION OPERATIONS CONTROL ROOM

BOOSTER SYSTEMS ENGINEER	RETROFIRE OFFICER	FLIGHT DYNAMICS OFFICER	ASST FLIGHT DYNAMICS OFFICER
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M&O
SUPER-
VISOR

LIFE SYSTEMS OFFICER	SPACECRAFT COMMUNI- CATORS	SYSTEMS ENGINEER # 1	SYSTEMS ENGINEER # 2	AGENA SYSTEMS ENGINEER
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OPERATIONS & PROCEDURES OFFICER	ASST FLIGHT DIRECTOR	FLIGHT DIRECTOR	NETWORK CONTROLLER
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PUBLIC AFFAIRS OFFICER	OPERATIONS DIRECTOR	DOD REP
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VISITORS VIEWING AREA

NETWORK SITES

MSCC	Manned Spaceflight Control Center, Houston, Texas
GSFC	Goddard Space Flight Center, Greenbelt, Maryland
KSC	Kennedy Space Center, Cape Kennedy, Florida
BGI	Grand Bahama Island
SSI	San Salvador Island
GTI	Grand Turk Island
ANT	Antigua Island
ASC	Ascension Island
BDA	Bermuda
CYI	Canary Island
KNO	Kano, Nigeria
CRO	Carnarvon, Australia
CTN	Canton Island
HAW	Kauai, Hawaii
CAL	Pt. Arguello, California
GYM	Guaymus, Mexico
WHS	White Sands, New Mexico
TEX	Corpus Christi, Texas
EGL	Eglin, Florida

GROUND OPERATIONAL SUPPORT SYSTEMS

(GOSS)

The world-wide GOSS communications network is controlled by the MSCC and is composed of facilities located at the launch site, remote land based sites, tracking ships, and aircraft. The communications network performs four basic functions vital to mission success:

1. Tracking
2. Telemetry
3. Command
4. Spacecraft-to-ground voice communication

The radar tracking data obtained by the network sites as the spacecraft passes overhead is transmitted to the MSCC where it is evaluated and used to provide the Mission Operations Control Room with continuous position information and to predict landing points to aid recovery forces should any contingency arise.

Telemetry data from the spacecraft provides a means of monitoring the status of vehicle systems, spacecraft systems, and astronauts. Since continuous coverage cannot be assured, telemetry data is stored when the spacecraft is out of range of a network site and periodically "dumped" rapidly upon command from major receiving stations (chiefly over continental U. S.).

The command system provides the MSCC the capability to command either, or both, of two spacecraft for orbital maneuvers, retrofire, or updating systems aboard the spacecraft. Voice communication circuits provide the necessary station-to-station communications as well as direct communication between the astronauts and the ground.

COMMUNICATION SYSTEM

Telephone Company (TELCO) Termination Room

All external lines to MSCC enter the building at the TELCO Termination room. Since there are no radio links to the MSCC, all data entering or leaving is transmitted via hardlines. In the TELCO termination room, the external lines are connected, through distribution frames, to the Facilities Control Room. This room also houses the main interconnecting equipment for the MSCC intercommunications system.

Facilities Control Room

All circuits entering or leaving MSCC pass through the technical Facilities Control Room. This is the central controlling point of the entire MSCC/GOSS communications network operation and can be compared to the "heart" of mission operations. The Facilities Control Room serves three primary functions: traffic routing, quality monitoring, and maintenance and testing. The Facilities Control Room assures that all conditions of traffic loading, equipment failure, or circuit breaks can be handled efficiently.

Communications inputs to the Facilities Control room are of several modes:

1. Video from KSC during pre-launch and launch operations
2. Voice circuits from remote sites
3. Teletype (TTY) from remote sites and commercial sources
4. High speed data (HSD) lines from remote sites

Communications Processor

The Communications Processor can be described as the "nerve center" of the MSCC since all incoming and outgoing traffic pass through it, with the exception of voice circuits and incoming KSC video.

The UNIVAC 490 stored program digital computer is utilized as an automatic high speed switching center. Data inputs to the Communications Processor are separated and routed to their appropriate destinations. This data is also converted, if necessary, into the proper format for use at its destination.

Message Center

The message center acts as a monitoring and distribution center for text form or hardcopy messages. It accepts messages originating from MSCC and prepares them for transmission. It monitors all incoming text form message traffic and directs it to the proper destinations. Garbled traffic is also intercepted here and corrective action is initiated.

Hardcopy messages are distributed by means of a pneumatic tube system which has stations at every major area in MSCC.

Voice Control Room

All voice circuits entering or leaving MSCC pass through the Voice Control Room's manually operated switchboard. This provides flexibility in interfacing intercom loops with one another as well as with remote sites, spacecraft to ground circuits and other external circuits.

Communications Control Room

The Communication Controller exercises supervisory control over the entire GOSS/MSCC communication system. He is informed of communication system status by means of a control console and various wall displays.

REAL TIME COMPUTER COMPLEX

The Real Time Computer Complex (RTCC) provides the computation facilities for the MSCC, including trajectory analysis, acquisition predictions, and flight controller display calculations and information requests. To accomplish this mission, the RTCC consists of four IBM 7094 computers, functional assignment switching devices, computer room display equipment, and associated support equipment such as magnetic tape drives, and IBM 1401 computers.

In addition to the real-time processing of incoming data, the RTCC has developed support programs to aid the flight control personnel. For example, in the area of trajectory analysis, the RTCC has developed programs that provide the nominal trajectory necessary for a successful mission. This nominal trajectory is used as a basis for the indication of trajectory status during a mission.

During a mission period, the display output from the RTCC is sent to the Display and Control System for evaluation by the flight control personnel. In support of simulated missions, the RTCC executes dynamic simulation programs and real-time control of data inputs to the Simulation, Checkout, And Training System. Like all other functional systems, the RTCC is equipped to support real and simulated missions simultaneously.

DISPLAY AND CONTROL SYSTEM

The display and control system provides mission control personnel with information concerning booster and vehicle systems, flight dynamics, life systems, GOSS network, and recovery. This information is used to make the necessary decisions to assure mission success and to advise proper action by means of voice circuits and the digital command system.

Both computer derived data from the RTCC and unprocessed data from the communications system and telemetry inputs, as well as stored reference material, are displayed. To provide flexible and varied combinations of display data, the system includes selection and display generation equipment which operate in conjunction with the control and terminal display devices in the MOCR and the staff support rooms.

The MSCC employs one of the world's largest video matrix switching systems to provide each console operator with a vast selection of displays. A library of 64,000 prepared reference slides is available along with digital-to-TV converters which can superimpose computer generated data on the reference slide.

Thus, a vast variety of information is available to the Staff Support Rooms and the MOCR in many different formats and combinations including pictorials, meter type information, alphanumeric and XY plots. Large wall displays are used for group functions while matters of individual concern can be displayed on the control console.

A master timing system, synchronized with the National Bureau of Standards time station, WWV, supplies the time standard for the entire MSCC. Since accurate timing data is essential for mission success the timing system generates displays of Greenwich Mean Time (GMT), time to go before retro-fire, time elapsed since launch and other important time based data.

The Master Digital Command System (MDCS) in the MSCC provides the capability to perform updating and correcting operations in the spacecraft and vehicle systems without actually talking to the astronauts. To perform this function, the MDCS must receive, store, verify and route digital commands to real time sites such as BDA and TEX; also the MDCS must relay pre-pass information to the Digital Command System (DCS) units at remote sites.

Teletype lines are used as the primary command link to the remote sites.

When data is received at the remote sites, it is automatically checked for errors and valid data is placed in storage for future use. Unacceptable data is recorded and the originating source is requested to retransmit the information. Upon acceptance of the command sent by a DCS unit, the spacecraft acknowledges receipt and validation of the command by means of a telemetry signal known as a Message Acceptance Pulse (MAP).

SIMULATION CHECKOUT AND TRAINING SYSTEM

The Simulation, Checkout, and Training System (SCATS) provides realistic simulation of manned space flight missions for training mission control personnel. The system has the capability to integrate the MSCC Simulation Systems with flight crew trainers located at the Manned Spacecraft Center and the Kennedy Space Center. In addition, the system has two Simulated Remote Sites (SRS) for indoctrination and training of remote site flight control personnel. These simulated stations can be exercised from the simulation control consoles using source data from the flight trainers, SCATS special equipment, the Ground Support Simulation Computer, or any combination of these.

Another example of the realistic concept of simulation at MSCC, is the situation in which a mission is being controlled by the personnel in one MOCR, while simulation exercises are taking place in the other MOCR and the SRS. This feature provides training for the flight controllers which would otherwise not be available, as future space flight missions will have lengthy flight times that will prohibit the use of one MOCR for simulation purposes. The use of two MOCR's will provide adequate facilities for simulation of the two manned space flight projects presently under development (Gemini and Apollo).