ELECTRONIC COMPUTERS IN AEROSPACE RESEARCH

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COMPUTERS IN AEROSPACE RESEARCH

We would like to welcome you to the Analysis and Computation Division. The responsibility of this division is the processing and computing of data for the Langley Research Center.

Our present national aeronautical and space efforts would be impossible without the use of electronic computers. Therefore, at this stop, we will describe some of the ways in which computers are used in support of the Langley and overall NASA mission.

Currently, hearings in Congress and special studies in the Executive Department are being conducted, prompted by the very rapid growth of the use of computers in the Government. This growth has been dominated by the administrative application of these devices for such things as inventory control, tax collection, and other accounting functions. Like the rest of the Government, NASA has also experienced a very rapid growth in computer applications, but for quite a different reason. The growth in NASA has been caused by the necessity to develop tools to accomplish its mission as contrasted to the mechanization of manual procedures. The first chart illustrates the NASA computer effort devoted to administrative and to technical support applications. As you can see, the technical area is predominant. The chart represents the whole of NASA; however, the ratios are equally true for Langley. The purpose of this stop, then, is to describe briefly how computers serve not just Langley, but all of the NASA Research and Flight Centers. At the end of the talk we will demonstrate a typical data processing operation.

Technical use of computers by NASA and the Langley Research Center can be divided into five broad categories, as shown on this next chart. These categories follow closely the steps taken in any space program whether it be manned or unmanned space flight.

The first of these is concerned with advance studies for the purpose of either mission support or pure research. The computer becomes a research tool for determination and solution of problems in such areas as those shown on the next chart. The use of the computer is not limited to these - they are only typical. For example, theoretical studies have been conducted into the effects of flow fields on radio attenuation. Trajectory studies have been conducted to outline the optimum flight path for rendezvous of two spacecraft in a lunar orbit. Mission analyses and engineering design of these typical items have been conducted with computers. Also, whole aerodynamic and aerospace systems have been subjected to computer studies for performance analysis. For instance, Langley has just recently conducted computer studies for the Federal Aviation Agency on the Supersonic Transport Program as an aid in evaluation of the transport's design.

In conducting analytical and engineering studies, only the basic computer with its peripheral input-output equipment is needed - as shown in the lower right.

As we go through the other applications, you will note that this basic computer system remains essentially the same, but becomes a part of larger data handling systems. This is not to say that it remains the same physical unit, but that it remains a general purpose computer, which by the nature of this class equipment, is versatile enough to be used in the variety of applications that will be covered.

In the next category, experimental research, models or samples of the systems to be used are tested to see that they conform to the concepts that have been determined analytically or that they meet some required performance. Often, here at Langley, experimental research is conducted to develop new theory where it cannot be predicted analytically. The testing is conducted in either or both of two areas - in ground test facilities such as those here at Langley or in flight tests through actual atmospheric or space environments.

Our next chart shows the use of computers in ground facility testing. In the previous application, only the basic computer was needed, but here the data are derived from actual measurements and must be collected and recorded before entry into the computer. Some years ago, the test data had to be handled by manual methods. Only a dozen or so measurements could be made at one time and then the test had to be rerun to collect a dozen or so additional measurements. Today's technology, however, requires that the test be conducted in a shorter time and the costs involved require that as much data as possible be collected in one test - sometimes hundreds of simultaneous measurements. So this alignment of automatic data gathering equipment is used for making the measurements, putting it into digital form compatible with the input requirements of the computer and recording it. We have in this building a number of these automatic data recording systems as shown on the wall chart. For the sake of economy, they are centralized and shared by over 20 test sites located at the ground test facilities identified in blue lettering. Most of this added equipment contains components of the same type as those used in the computer and may in some cases include another, smaller computer. The output recorded tape, then, can be used directly as one of the inputs to the computer thus speeding the processing of the data and analysis of results. This is a list of some typical problems handled by our equipment. The volume of data collected in the investigations of such problems is so large that it requires handling by electronic methods.

All of this applies equally to data collected from flight tests. The alignment of equipment is slightly different, as shown on the next chart, but again it contains components like those in the computer. The basic measurements are made onboard, transmitted by radio telemetry, received and recorded on the ground. The records are prepared for entry into the computer by the conversion step shown here. This technique will be demonstrated later. The rest of the handling is the same process as that for the ground facility collected data.

A relatively new application for computers is in spacecraft and launch vehicle checkout - as shown on the next chart. We still have the basic computing system - but it is used for an entirely different and more <u>immediate</u> purpose. A very comprehensive checkout is required after the craft is in place on the launch pad for this may be the first time that all subsystems from many different manufacturers have been mated together. A complex spacecraft like Gemini or

Apollo might require the checking of 1500 parameters with each one involving up to 400 measurements per second, taken periodically during the 72-hour countdown procedure when time is at a premium. It would not be humanly possible for this amount of data to be handled without the computer - for the results of the checks must be obtained quickly to provide information from which to spotlight malfunctions so that repairs may be initiated or controls adjusted. In some cases, as shown by this line, commands for making the adjustments may come directly from a computer output. The manual ones are made from decisions based on the computer output display.

The alignment of equipment for Mission Control after launch is shown in the next chart and it is similar except that the linkage of the commands back to the vehicle is by means of radio transmission from tracking stations of the global range.

During Mission Control, the launch phase is most critical. Things happen rapidly and immediate indications are needed on which to base critical decisions. For instance, during the Mercury launch phase, only 30 seconds were available after sustainer burnout in which to determine that the craft was headed into orbit satisfactorily. If it was not, the flight could be aborted and the capsule would land safely near the Canary Islands. A "too late" decision, could bring it down in the Atlas Mountains of Africa. This type of job can be done only with high-speed processing of data.

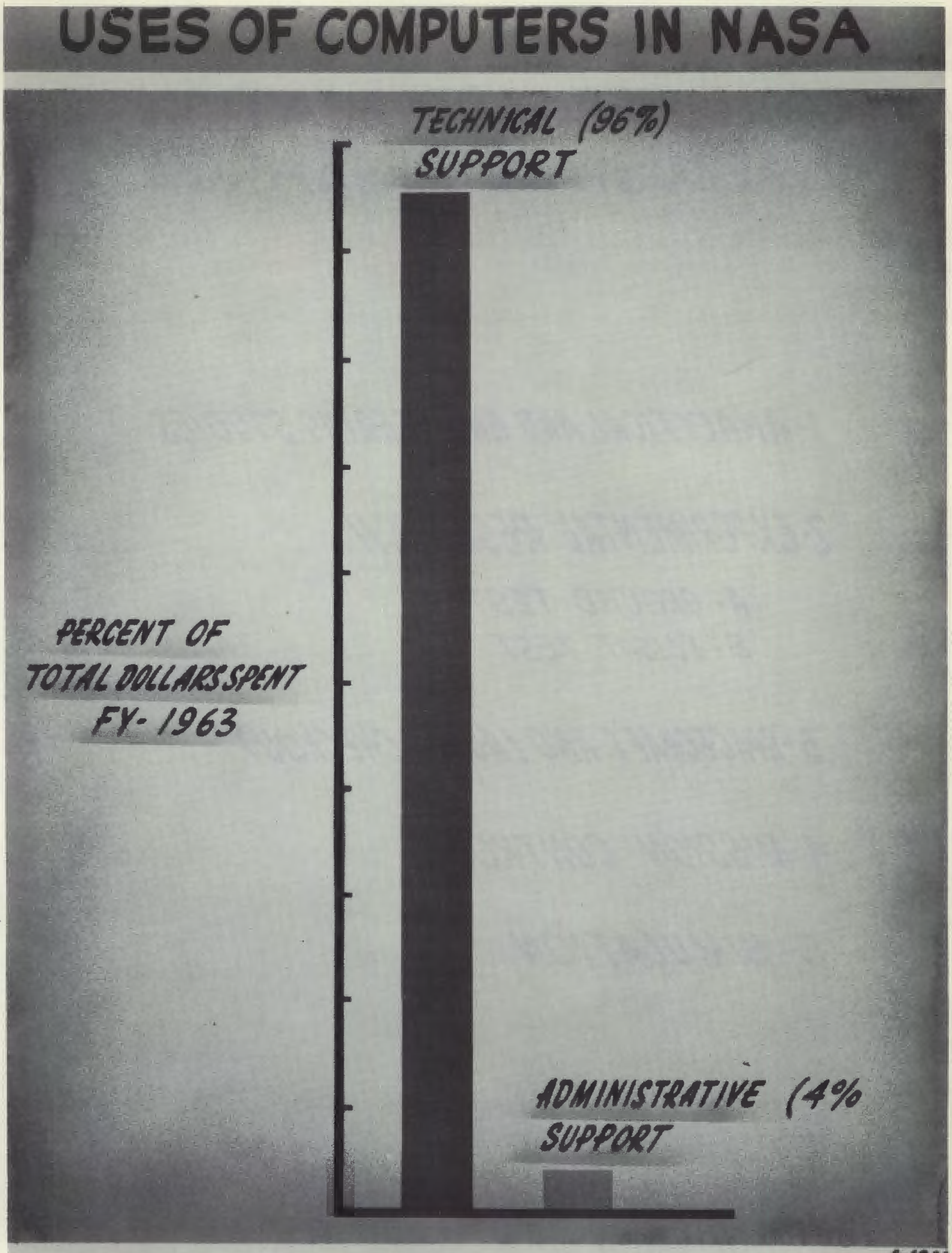
During the mission itself, the computer also serves to handle the required data rapidly so that the flight can be controlled. Because of the speeds at which a space vehicle moves, there can be very little lag in receiving the information, making the decisions, and effecting any necessary corrections. Again its only a matter of seconds before it becomes "too late."

Langley, in its flight programs, now relies upon the support of other Centers such as the Atlantic and Pacific Missile Ranges or the Wallops Station for launch and mission control, but Langley was responsible for the design and installation of the global network of tracking and data acquisition stations first used in the Mercury project. These were tied by land cables and radio links to a central computer facility located at the Goddard Space Flight Center in Greenbelt, Maryland.

The final category to be covered - though it may not come last in the sequence of events - is Simulation - as shown on the next chart. The equipment is all ground based and is used to simulate as close as possible actual conditions that might exist in a real mission. In this illustration, the pilot is sitting in a mock-up capsule in a simulated rendezvous with another spacecraft. He views a picture projection of the expected vehicle and space environment - operates controls as if actually in flight. These actions are transmitted to the computer which has been programed to solve the equations of motion under the conditions simulated - and alter the projection as well as indicate on displays to the pilot various spacecraft conditions giving him a realistic sense of maneuvering the capsule.

Langley makes extensive use of these simulation techniques in conducting research on the navigation, guidance and control of both space and aircraft. Used in this manner the computer becomes a very flexible research facility that can be used for any type of study and our computers often are used to handle a variety of tests in a single day. For instance, the same computer has been used to simulate an Apollo problem in the morning, a landing gear test in the afternoon, and a Supersonic Transport control problem in the evening.

In conclusion, the electronic computer is an extremely versatile tool that has played a major role in the Langley and the NASA mission. The extreme flexibility allows the same machine to be used in many different ways - we have tried to illustrate a few, and in them all, the computer is required because of the complexity of the technical job that has to be done. (Demonstration.)


USES OF COMPUTERS IN NASA
TECHNICAL (96%)
SUPPORT
PERCENT OF
TOTAL DOLLARS SPENT
FY- 1963
ADMINISTRATIVE (4%
SUPPORT

L-1911

COMPUTER APPLICATIONS IN AEROSPACE RESEARCH

1-ANALYTICAL AND ENGINEERING STUDIES

2-EXPERIMENTAL RESEARCH

A- GROUND TEST

B- FLIGHT TEST

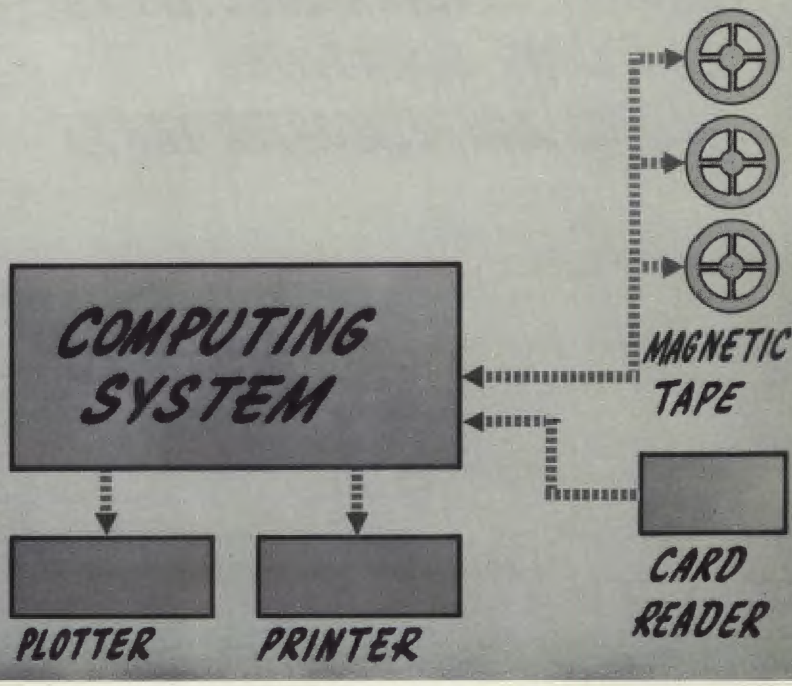
3-SPACECRAFT AND LAUNCH CHECKOUT

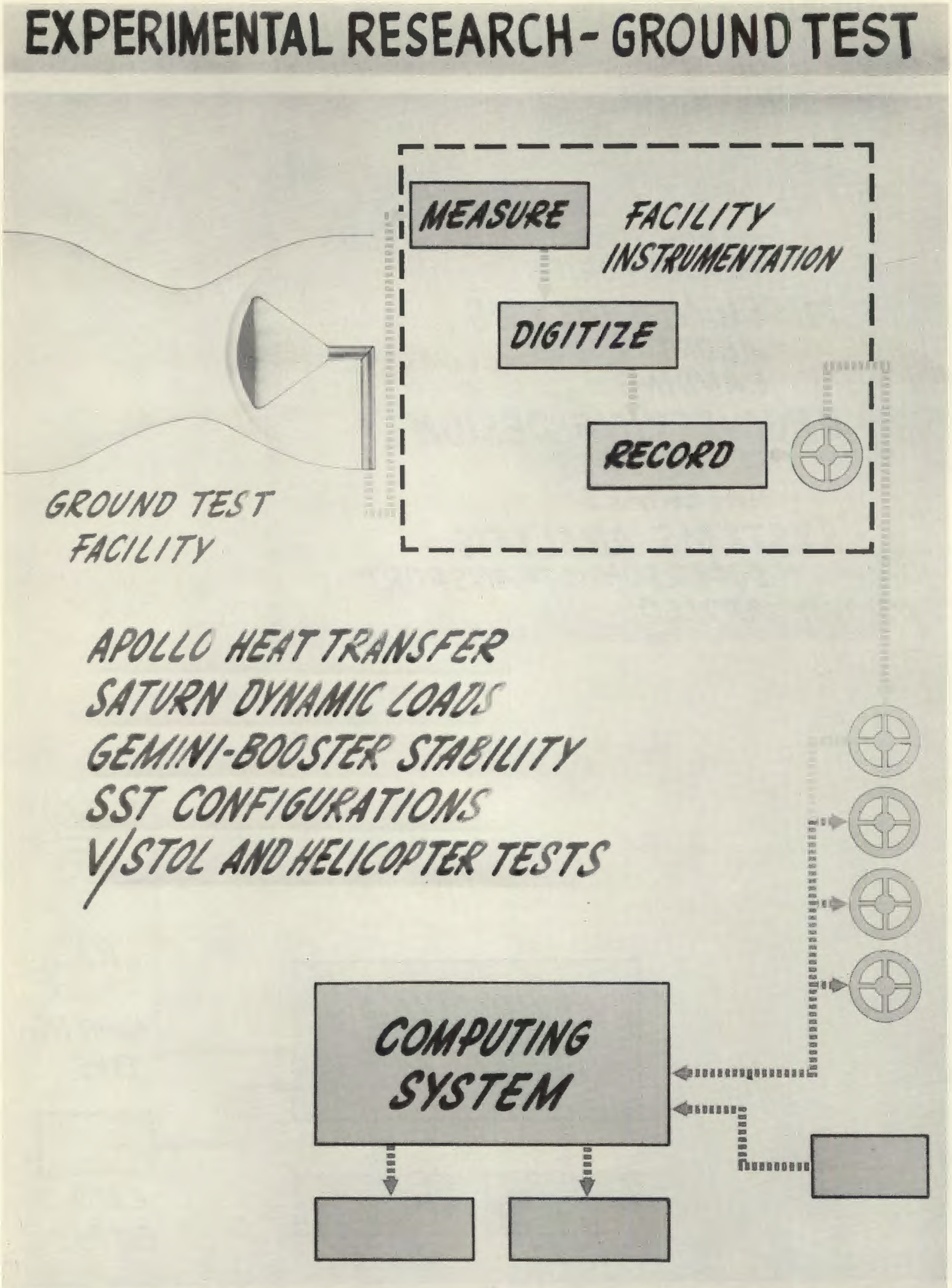
4-MISSION CONTROL

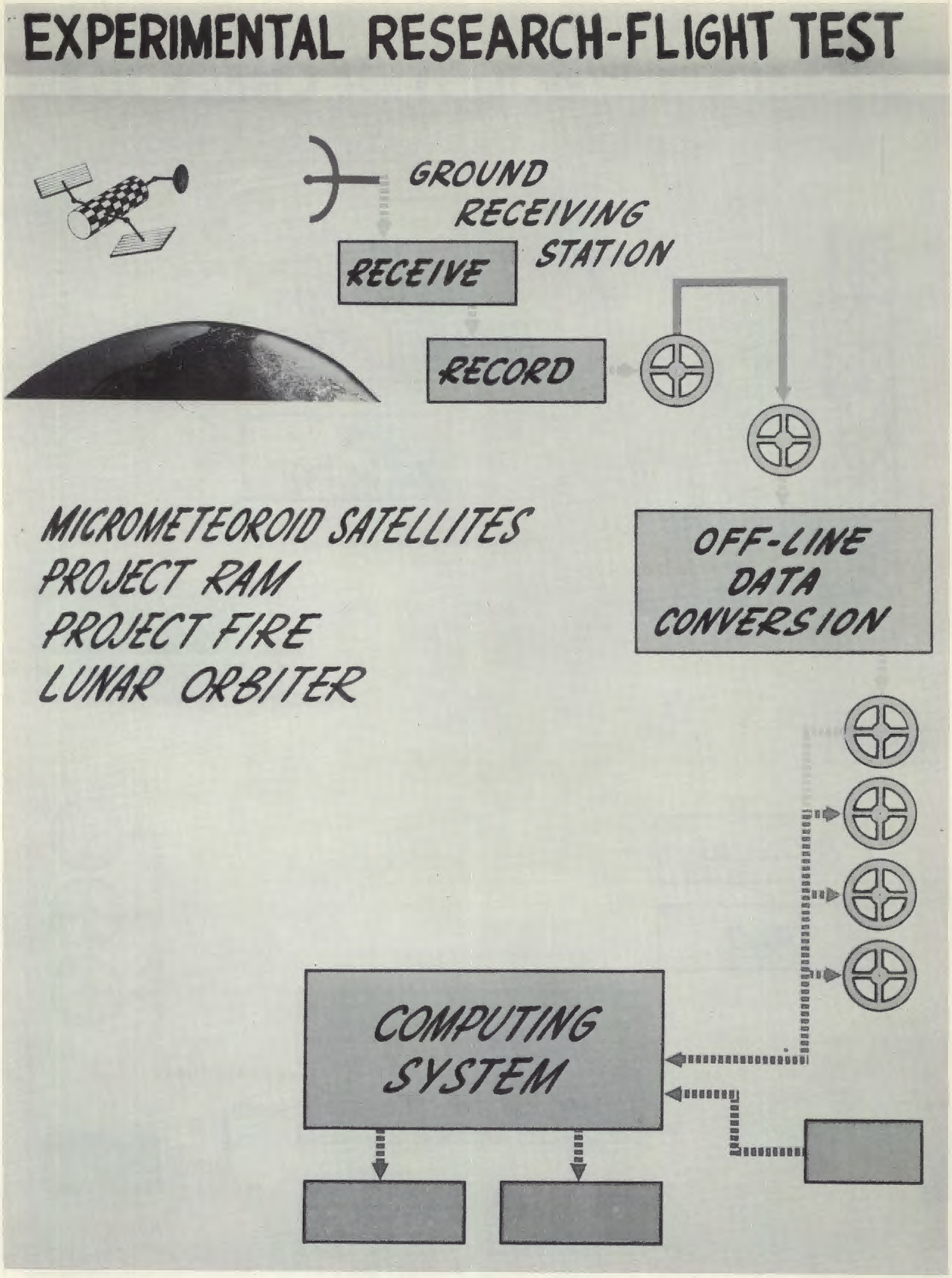
5- SIMULATION

ANALYTICAL AND ENGINEERING STUDIES

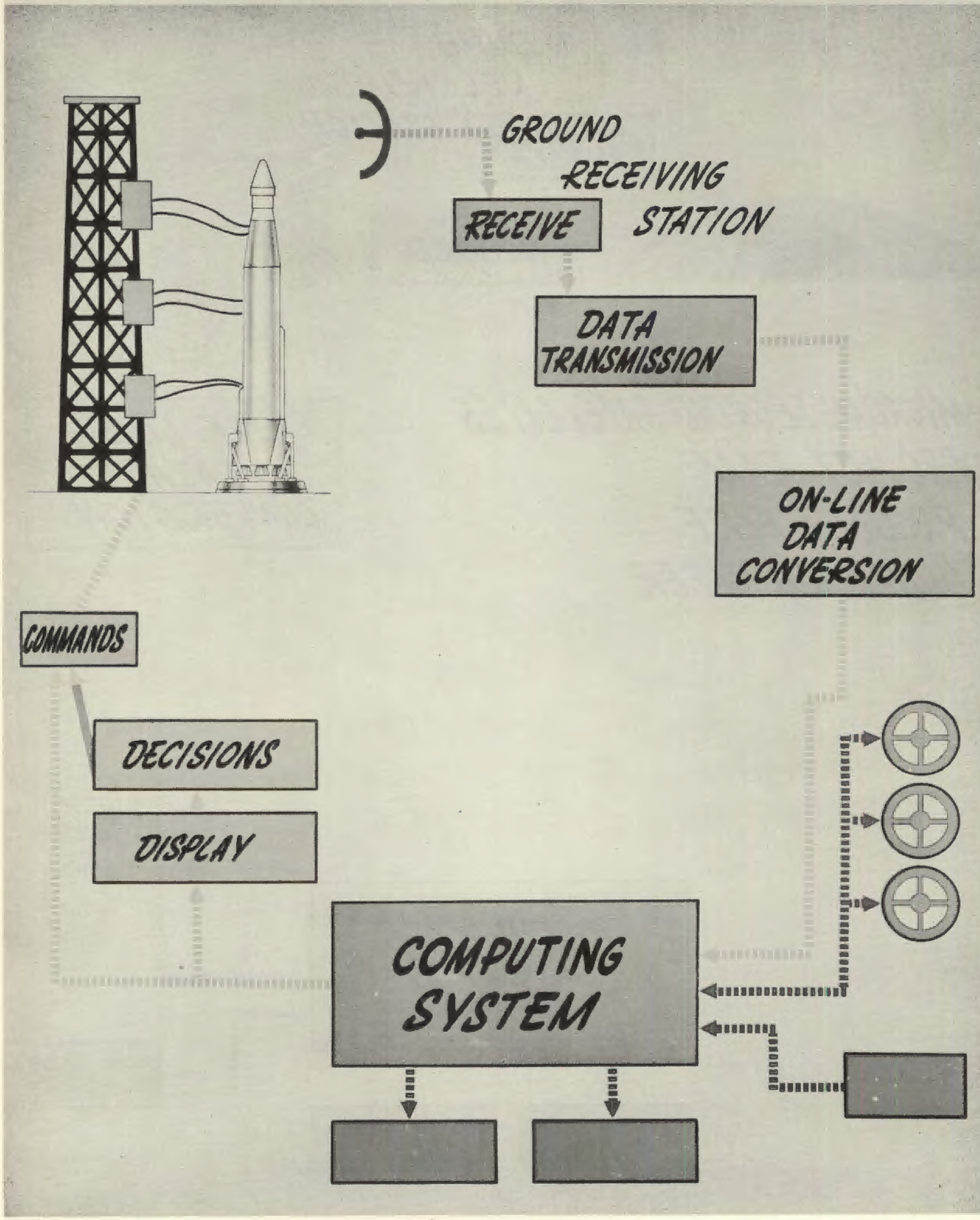
- **THEORETICAL STUDIES**
  - HYPERSONIC FLOW FIELDS
  - TRAJECTORIES
- **MISSION ANALYSIS**
  - ABORT
  - LANDING
- **ENGINEERING DESIGN**
  - STRUCTURES
  - MATERIALS
- **SYSTEMS ANALYSIS**
  - SUPERSONIC TRANSPORT
  - APOLLO

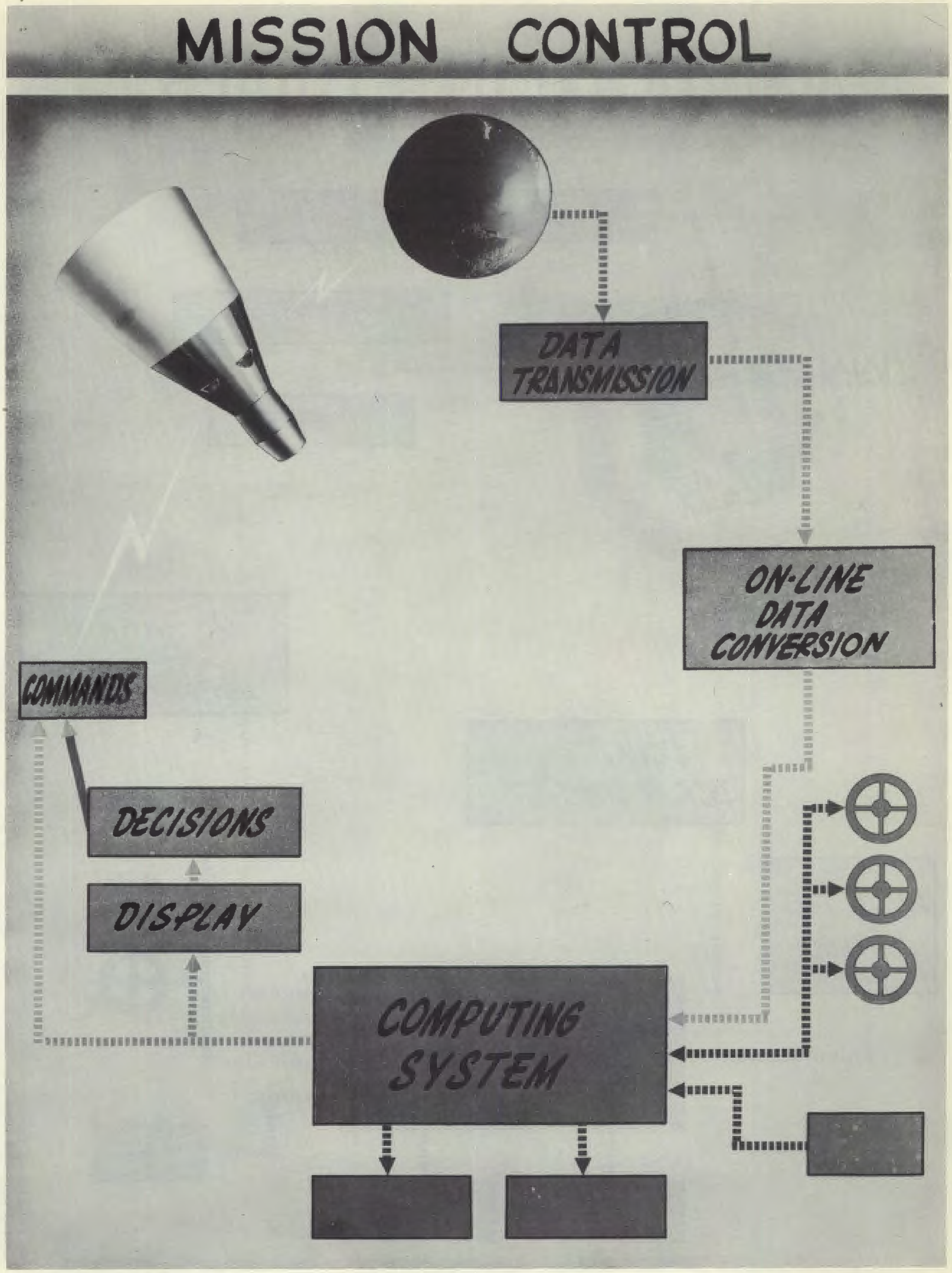


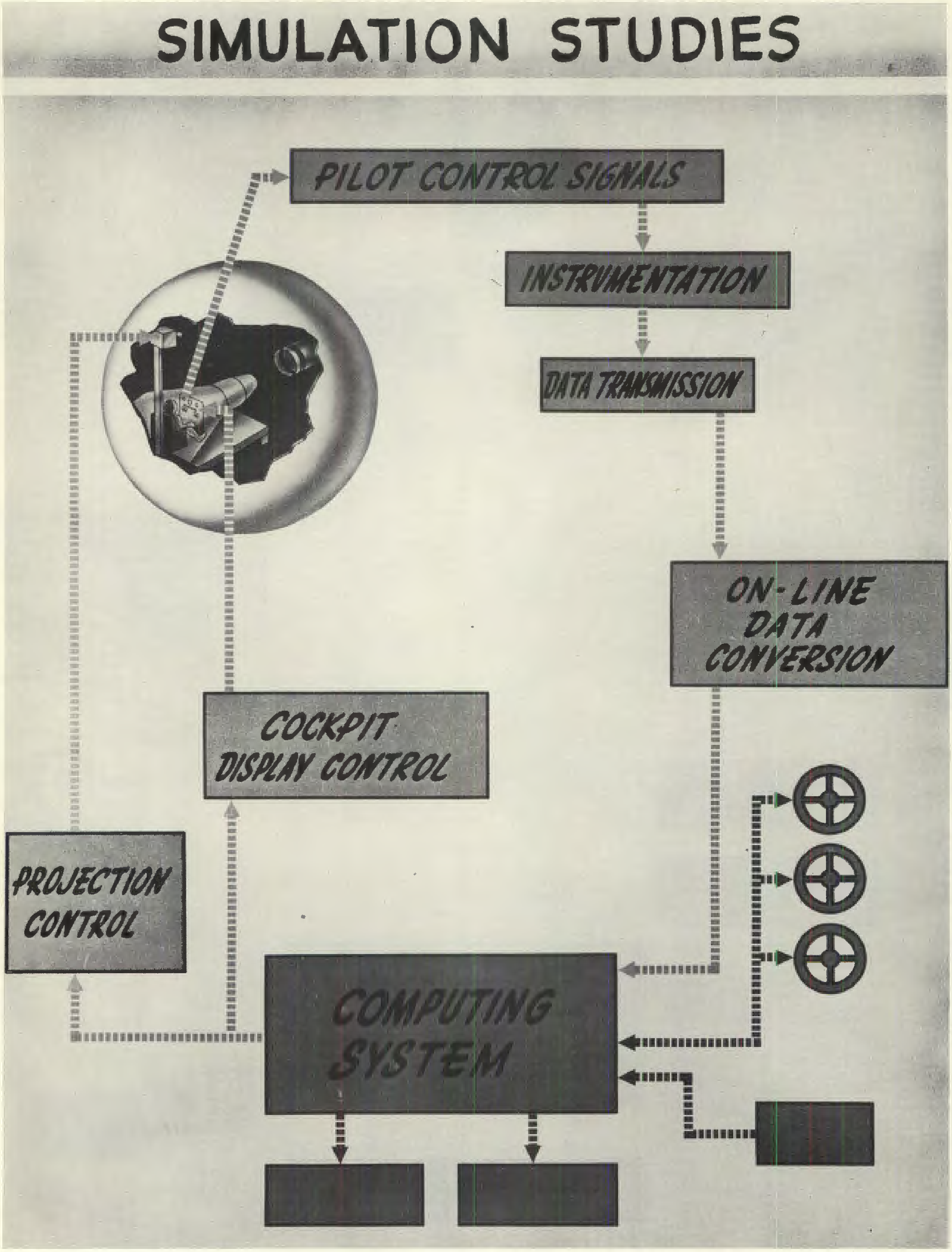

EXPERIMENTAL RESEARCH - GROUND TEST
MEASURE
FACILITY INSTRUMENTATION
DIGITIZE
RECORD
GROUND TEST FACILITY
APOLLO HEAT TRANSFER
SATURN DYNAMIC LOADS
GEMINI-BOOSTER STABILITY
SST CONFIGURATIONS
V/STOL AND HELICOPTER TESTS
COMPUTING SYSTEM


EXPERIMENTAL RESEARCH-FLIGHT TEST
GROUND RECEIVING STATION
RECEIVE
RECORD
MICROMETEOROID SATELLITES
PROJECT RAM
PROJECT FIRE
LUNAR ORBITER
OFF-LINE DATA CONVERSION
COMPUTING SYSTEM

SPACECRAFT/BOOSTER CHECKOUT




MISSION CONTROL
DATA TRANSMISSION
ON-LINE DATA CONVERSION
COMMANDS
DECISIONS
DISPLAY
COMPUTING SYSTEM



NASA-Langley, 1964

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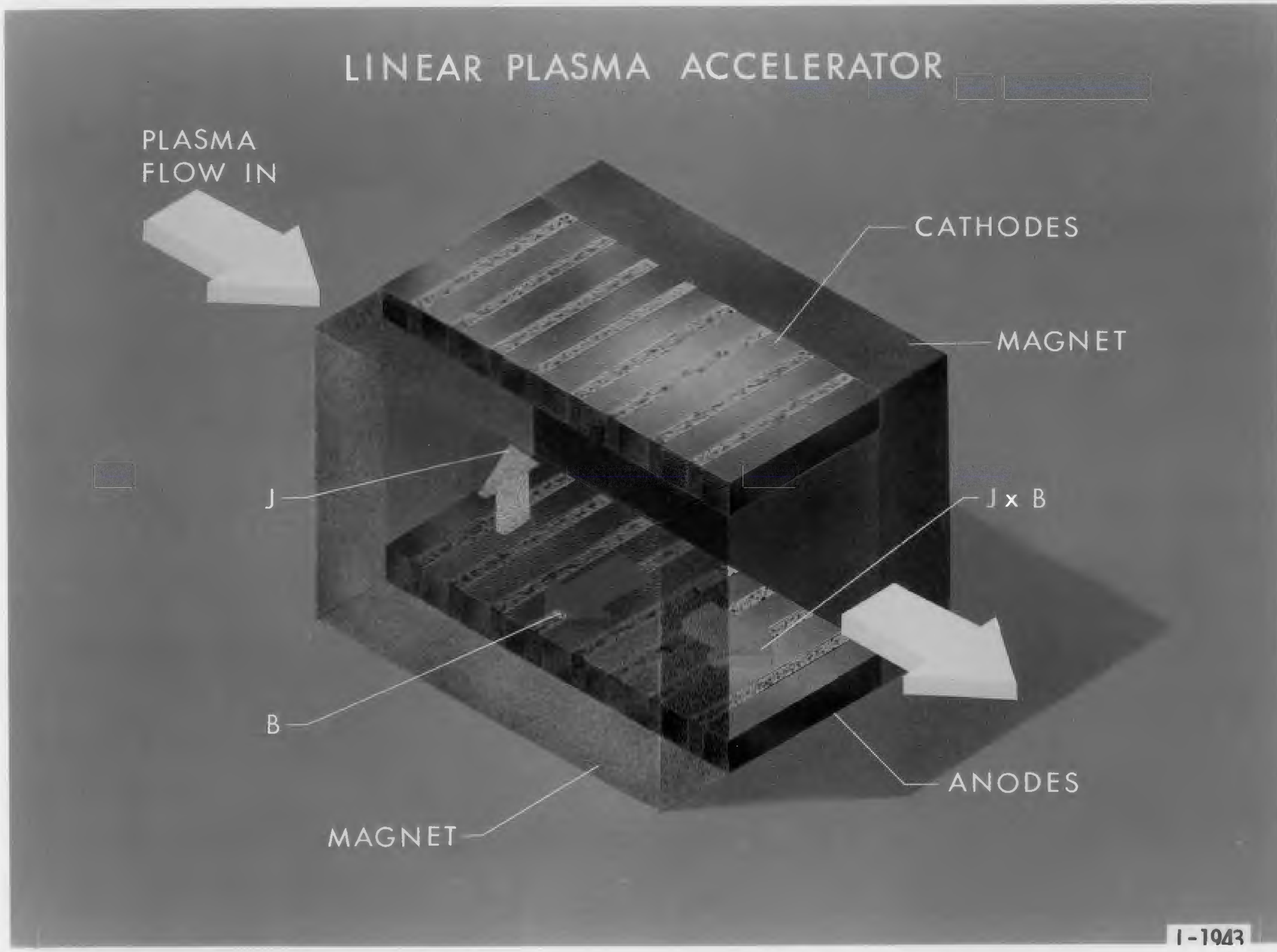
LINEAR PLASMA ACCELERATOR
PLASMA FLOW IN
CATHODES
MAGNET
J
J x B
B
ANODES
MAGNET
I-1943