FACILITY FORM 602

N65-35283 (ACCESSION NUMBER) | (THRU) 1

11 (PAGES) | (CODE) 1

TMX-51544 (NASA CR OR TMX OR AD NUMBER) | (CATEGORY) 21

A SIMULATOR STUDY OF THE SUPERSONIC TRANSPORT IN THE AIR TRAFFIC CONTROL SYSTEM

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[1964] 11p

NASA Langley Research Center
Langley Station, ~~Hampton~~, Va.

For presentation ~~Presented~~ at the 16th National Aerospace Electronics Conference, Institute of Electrical and Electronics Engineers

GPO PRICE $ ______

CSFTI PRICE(S) $ ______

Hard copy (HC) 1.00

Microfiche (MF) .50

ff 653 July 65

Dayton, Ohio
May 11-13, 1964

[redacted]

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ABSTRACT

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This paper presents the scope and objectives of the joint NASA-FAA simulator program studying the problems of integrating proposed designs of the SST into the already highly complex air traffic control system. Descriptions of the four-place, fixed-base SST simulator located at NASA Langley Research Center, the FAA's Model B ATC simulator located at NAFEC, and the interface between these facilities are given. The test program and method of analysis is discussed.

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Summary

An NASA-FAA cooperative program for studying the problems anticipated in integrating the SST with the ATC system is described. The program employs a technique of operating a four-place SST simulator in a real-time traffic control environment created by ATC simulation facilities. Descriptions of the equipment, technique, and test program are provided.

Introduction

In order to study the problems anticipated in connection with the integration of the supersonic transport with the air traffic control system, the National Aeronautics and Space Administration and Federal Aviation Agency have initiated a cooperative research program. This program will make use of a supersonic transport simulator located at NASA Langley Research Center, Hampton, Virginia, and the air traffic control simulator located at the FAA's National Aviation Facility Experimental Center, Atlantic City, New Jersey. By means of data and voice links connecting these facilities, projected designs of the supersonic transport will be flown in real-time air traffic control environments.

The objectives of the program are (1) to determine the effects of the ATC system on SST design and equipment requirements, and (2) to determine the effects of the SST on ATC system requirements.

The purpose of this paper is to describe the equipment, technique, and test program for this study.

The Supersonic Transport Simulator

A plan view of the fixed-base supersonic transport simulator is shown in figure 1. The flight compartment is similar to that of current jet transport aircraft with seating for the pilot, copilot, flight engineer, navigator, and a jump seat for an observer. The flight instrumentation is also similar to that used in current jet transport aircraft with instrument ranges modified only to cover the higher altitude and Mach number operation of the SST. An interior view of the flight compartment is given in figure 2.

Accessory equipment needed to provide for navigation, communication, recording, and power requirements is located in a room behind the cockpit (fig. 1). The equipment shown in figure 3(a) provides for simulation of ground-based navigation aids including up to 6 VHF omni-range (VOR) stations with distance measuring equipment (DME), marker beacons, and a simulated instrument landing system (ILS). The communications console, figure 3(b), provides the switching capability required in implementing the simulated VHF radio communications between the pilots and air traffic controllers over telephone lines. For HF communications, such as company reports, the operator at this station serves as the ground contact. A dual-channel tape recorder is provided for preserving air-to-ground and ground-to-air communications. The two X-Y recorders shown in figure 3(c) provide for continuous ground track recording over full-scale ranges from 40 to 4,000 nautical miles square.

In addition to the above equipment, five Electronics Associates' 231R d-c analog computers are programed to solve six-degree-of-freedom motion equations for an aircraft having the characteristics of a supersonic transport design. Signals from the pilot's control motions are converted into the proper aircraft instrument indications by means of this analog computer program.

The computer program is scaled to cover a Mach number range from 0 to 4.0 and an altitude range from sea level to 100,000 feet. The characteristics of the engine, autopilot, and other aircraft systems are also programed in the analog computer. Engine thrust and fuel flow characteristics are expressed as a function of Mach number, altitude, and throttle position for four independent engines. The equations representing the autopilot provide for the conventional modes of Mach-hold, attitude-hold, and altitude-hold.

The ATC Environment

The real-time simulated ATC environment is created by means of a combination of an air traffic control facilities simulation and an air traffic sample simulation. Both of these simulations are provided by the FAA and create the environment in which the SST simulator is operated for the tests.

The air traffic control facilities simulated consist of an entire Air Route Traffic Control Center (ARTCC), a partial adjoining ARTCC, and an approach control and tower complex for one airport. The area controlled is 400 nautical miles by 400 nautical miles. Figure 4 shows part of an Air Traffic Control Facilities simulation similar to that being prepared for the subject program. These facilities are staffed by approximately 30 experienced air traffic controllers, including some currently assigned to the area being simulated. The controllers are provided with modern TV-type bright radar displays with video maps showing airways, holding and terminal areas, and navigation aids - as well as the usual flight progress strips and interphone and radio communications equipment. The radar displays have the capability of displaying information from the proposed 4096-code radar transponder beacon system, allowing alpha-numeric display of aircraft identity and altitude alongside the coded slash marks representing the target position.

The air traffic sample simulation is created by 108 electronic target generators which provide rho-theta and transponder beacon information to the controller's radar scopes. A photograph of some of the target generators is shown in figure 5. Each target generator, representing one aircraft, consists of a console with an airways display map and an operator. By adjusting knob and lever controls and actuating switches, the operator maneuvers the simulated aircraft along the airways system and departure and arrival paths according to a preprogramed script and instructions from the controllers over a simulated radio communications network. Each target generator is programed to have the simplified overall characteristics of a particular type of aircraft. A number of types of aircraft are programed in order to create the traffic mix required.

Data Transmission and Communications

Data transmission between the SST simulator and the ATC simulation facilities is effected over leased private telephone lines. A block diagram of the data transmission system is shown in figure 6. The SST simulator ground coordinates (X-Y) and altitude (Z) information are converted from analog to digital signals for transmission via a Bell 201A data phone link to the ATC simulation facilities. Digital radar beacon transponder signals from the SST simulator for aircraft identity, altitude, and beacon code are transmitted over the same system. The SST simulator position information joins the position information from the target generators in the simulated radar system for display on the controller's radar displays and also for recording in the data collection system. The data collection system has the capability of playing back the problem for subsequent analysis. The beacon transponder information from the SST simulator joins the beacon transponder information from the radar target generators in the simulated ATC radar beacon system for display on the controller's radar displays.

Communications between the radar target generator operators and the air traffic controllers is effected via a Bell 300 telephone switching system. This system is an extremely versatile telephone system which allows many operators to dial the same controller simultaneously, thus, simulating actual radio communications. Communications between the pilots of the SST simulator and the controllers is effected over two leased long lines which are connected into the Bell 300 system. The dialing, in this case, is done by the communications controller in accordance with the radio frequencies selected by the SST simulator pilots.

Test Program

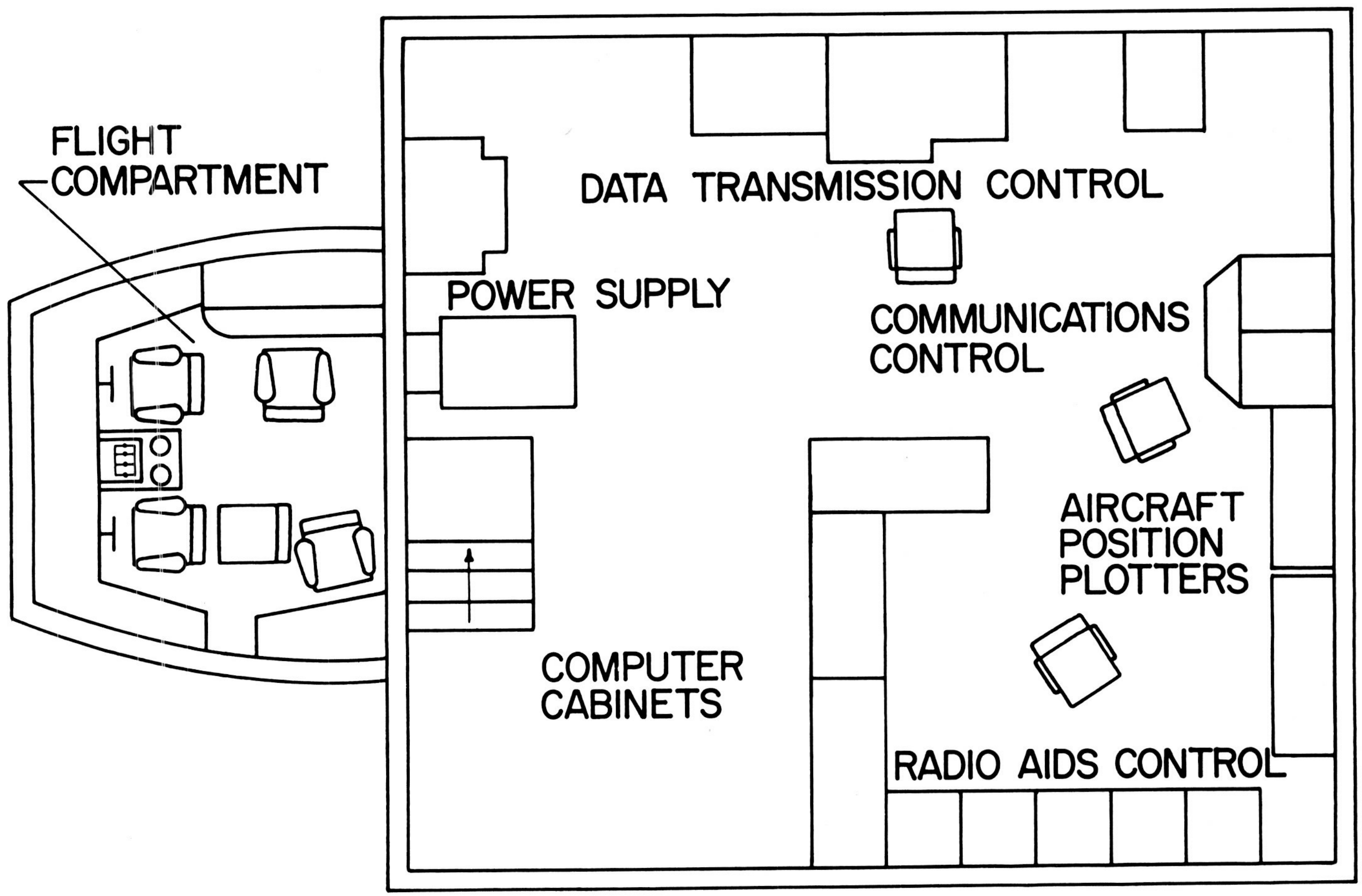
The test program is designed to study arrival and departure operations of the supersonic transport to and from the Kennedy International Airport in the multi-airport New York area. A mixed traffic sample representing conditions of high-density traffic flow including a limited number of SST aircraft, one of which is the SST simulator, is used. All traffic is under positive control of the New York Air Route Traffic Control Center, adjacent centers, and Kennedy Departure, Arrival, and Tower Facilities.

Two or three proposed design configurations for the SST, including both fixed-geometry and variable-sweep wing concepts, are included in the program. Airline pilot-copilot teams of two levels of experience who are currently engaged in jet transport operations provide the majority of the required piloting. Some piloting is provided by NASA and FAA flight test pilots. During the program, the SST simulator flight controls and instrumentation, typical of current jet transport instrumentation, will be updated to reflect current state-of-the-art advances. Such items as pictorial navigation displays, tape-type instruments, command-type instruments, automatic throttle control, side-arm controller, fuel management systems, and automatic air-ground-air communication systems are being considered.

Current air traffic control procedures and equipment are employed in the initial part of the program with the exception of the handling given to the SST's. The conditions to be covered in the study are (1) present-day handling (no priority), (2) special handling (minimum holding and deviation from track), and (3) priority handling (no holding or deviation from track). For later phases of the program, the air traffic control procedures and equipment will be updated to reflect the air traffic control system envisioned for the 1970-1975 time period. Air traffic control procedures and equipment which are being considered include the use of off-airways arrival and departure routes, segregation of traffic according to performance capability, provision of altitude/identification alpha-numeric displays on the radar displays, and automation of flight program data updating.

Concluding Remarks

In summary, the joint NASA-FAA SST-ATC program will allow, in real-time simulation, a study of the problems of integrating proposed designs of the SST with the ATC system. For these studies, a four-place fixed-base SST simulator located at NASA Langley Research Center will be operated in an air traffic control environment produced by ATC simulation facilities at NAFEC. The test program is based on arrival and departure operations to and from Kennedy International Airport. Both fixed-geometry and variable-sweep wing SST concepts will be studied under different types of handling by ATC. Current aircraft flight controls and instrumentation and current ATC procedures and equipment will be updated during the course of the program to reflect conditions envisioned for the 1970-1975 time period.



NASA

Figure 1.- Langley SST simulator and control room.

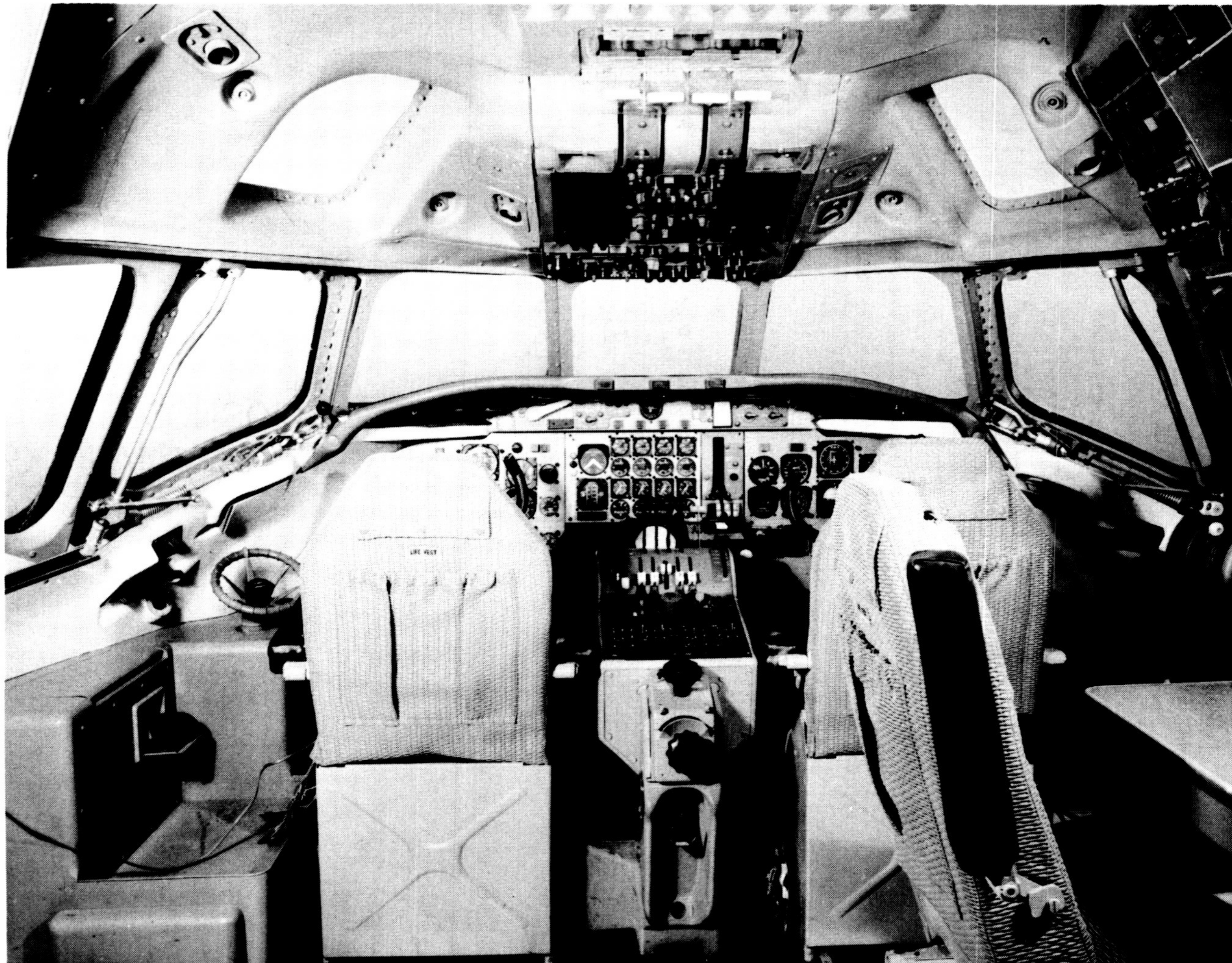


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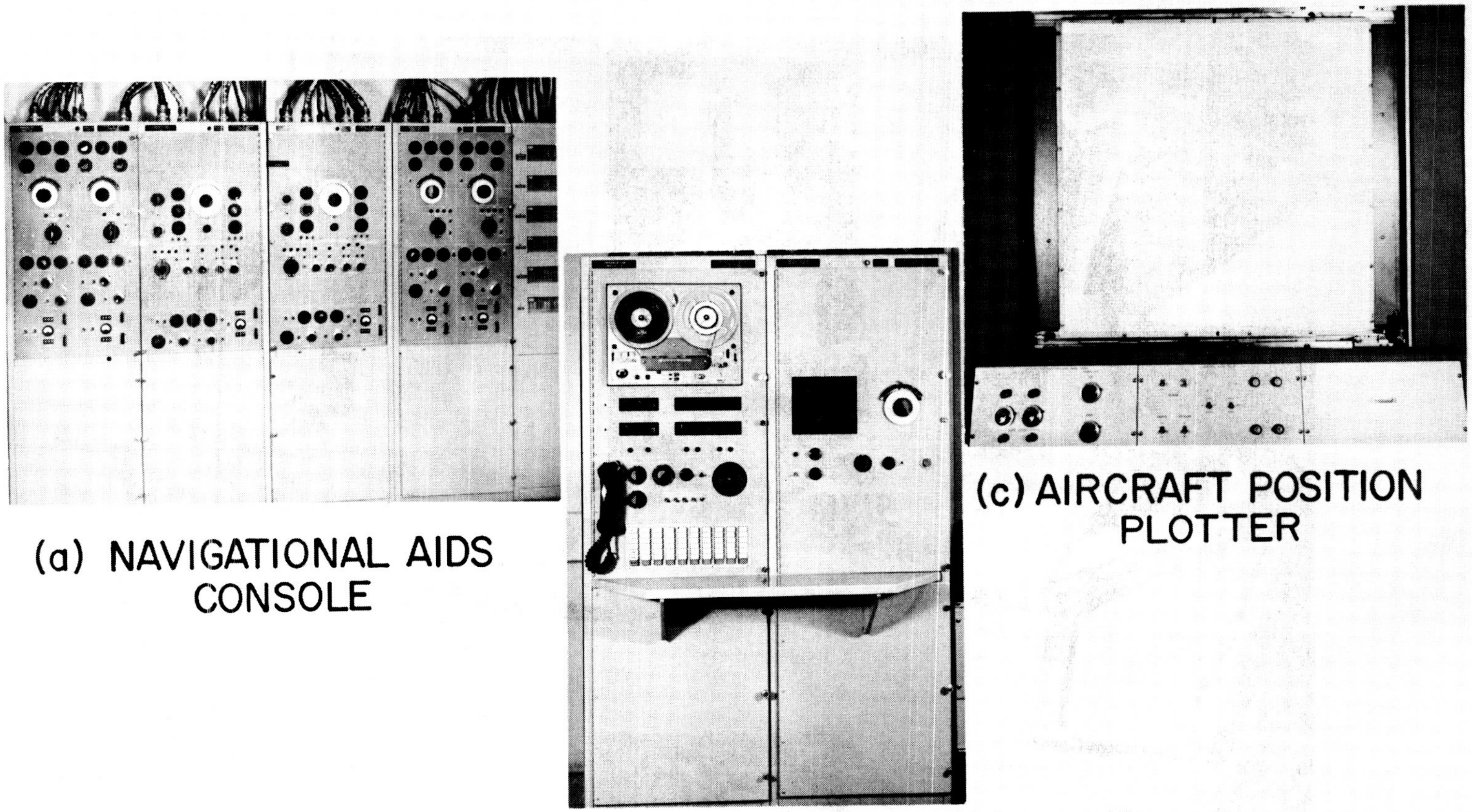
Figure 2.- Interior view of the Langley fixed-base SST simulator cockpit.



(a) NAVIGATIONAL AIDS CONSOLE

(b) RADIO AIDS CONSOLE

(c) AIRCRAFT POSITION PLOTTER

NASA

Figure 3.- Supporting equipment for the Langley fixed-base SST simulator.

NASA

Figure 4.- View of simulated air traffic control center at NAFEC.

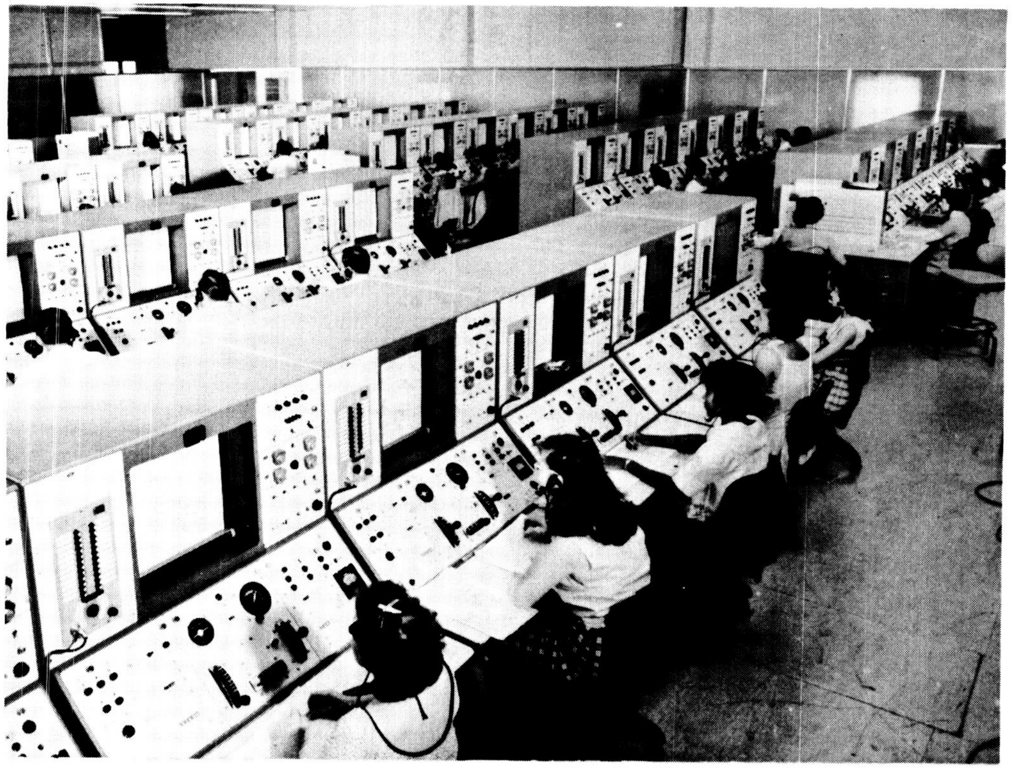


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Figure 5.- View of target generators at NAFEC.

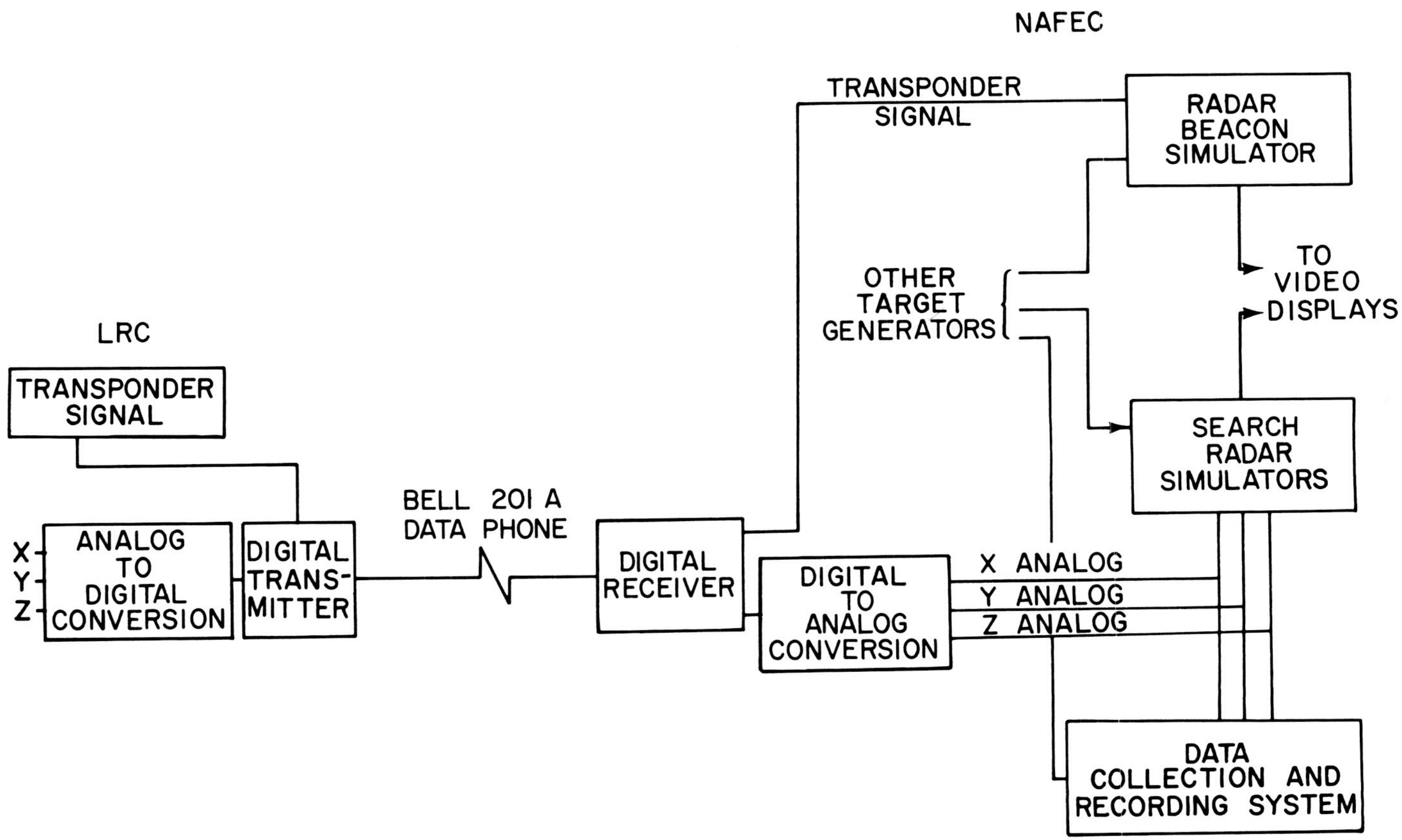

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Figure 6.- Interface between Langley and NAFEC facilities.

NASA-Langley, 1964