Flight Test Instrumentation System FTIS for Type-Certification of the Indonesian Aircraft CN 235

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ABSTRACT

Certification of an Aircraft necessitates ample instrumentation equipment to get all the data needed. The Flight Test Instrumentation System for the Indonesian Aircraft CN 235 (Fig. 1) does not consist only of the necessary data acquisition and evaluation systems, but includes moreover all the subsystems which are needed in flight testing like airborne- and ground-calibration systems, video and camera-installations etc. The Mobile Ground Station is housed in 14 shelters including a power-station and can be seen as a self-supporting system. Design and procurement by DFVLR assisted by Indonesian engineers as well as assistance through DFVLR in Indonesia was a first leading project in the course of the establishment of an Indonesian Flight Mechanics Laboratory FML. After service in Type Certification of the CN 235 the Flight Test Instrumentation System described will have a wide application range for future projects. To get a staff of engineers scilled in the art of flight-testing a training program for 10 Indonesian engineers was conducted by DFVLR, so that there are experts to operate the system in Indonesia. Since 1984 the Flight Test Instrumentation System is in use in Bandung or Jakarta resp.

INTRODUCTION

In the course of the development of the Aircraft CN 235 (2 turboprop-engines, 35 passengers) in cooperation of the companies PT. NURTANIO/Indonesia and CASA/Spain it became evident that a Flight Test Instrumentation System was needed for Type Certification Flight Testing. According to a Technical Assistance Agreement between the Indonesian Aircraft Manufacturer PT. NURTANIO and the DFVLR, which is the German Aerospace Research Establishment, the Institute for Flightmechanics of the DFVLR got the order to design and procure a complete Flight Test Instrumentation System FTIS. The system consists of an airborne part (OB-DAS = On Board Data Acquisition System) and a ground station OG-DAES (On Ground Data Acquisition and Evaluation System). The paper describes the complete Flight Test Instrumentation System FTIS.

ON BOARD DATA ACQUISITION SYSTEM OB-DAS

The function of OB-DAS is as follows:

- preconditioning of analog signals
- recording of signals
- control and monitoring of signals
- quicklook
- transmitting the data via telemetry to the ground

Fig. 2 shows in form of a block diagram the substantial parts of the On Board Flight Test Instrumentation System. The basic configuration of OB-DAS (Fig. 8) consists of

Teledyne Data Acquisition System [4]
The Teledyne Data Acquisition System gives the possibility for digitizing signals and generating a PCM Data Stream. The basic system is specified for a maximum of:

- 228 channels for analog signal conditioning (PCU)
- 60 channels for thermocouple signal conditioning (TCIU)
- 50 channels for discrete inputs (D/DMX)
- 12 channels discrete inputs for flight number information (D/DMX)
- 36 channels discrete inputs for time information (DMX-I)
- 8 channels for frequency inputs (FDC)
- 12 channels for tachometer generator inputs (TGC)
- 6 channels for pulse totalizer inputs (PTM-2)
- 4 channels for synchro signal inputs (S/RDC)

The sensors are connected by a 4 core twisted and shielded cable that ends in a 5 pole connector plug at the Input Connector Board. This allows the individual excitation to each parameter via the bridge completion network as part of the PSF signal conditioning amplifier and the signal routing back to the same PSF (2 wire each). The Input Connector Board is designed for an analog channel input capacity of 256 channels. The control part of the system is the Master RMDU (Remote Multiplexer/Demultiplexer Unit). It contains all basic control and interface electronic boards and the complete programming device. This unit outputs two independent PCM formatted serial data outputs, one to be recorded on the magnetic tape and one to be transmitted via telemetry link. Each individual channel of the DAS and the possible functions are programmable via a 16K erasable PROM. Most of the analog signal conditioning is provided by single PSF-amplifier cards housed in 64 channel PCU (Presample Conditioning Unit) chassis. Shown in Fig. 8 the PSF/R-Cal Presampling Filter amplifier module contains a 2 wire differential signal input and 2 wires for excitation output routed to the sensor if necessary. Its function is to amplify data from various sources such as straingauges, resistance thermometers and potentiometers. It also accomodates bridge completion networks and high frequency passive filters prior to amplification. The gains are selectable between 1 to 1024. Two outputs after amplification are available. The output can be filtered through a 4-pole-Butterworth or Bessel filter which is bandwidth selectable between 1 Hz and 20 KHz. The PSF/R-Cal module supplies upon command a calibration resistor which can be shunted across the bridge element for verifying gain repeatability. The R-Cal resistor is selectable during system configuration for various sensitivities. One BEU (Bridge Excitation unit) is provided for special transducer excitation. Most of the digital (discretes, parallel time), pulse and frequency input signals are wired without signal conditioning to the interface inputs at the RMDU.

Telemetry System (Fig. 6)
The FM/PCM-FM Telemetry System **[10]** consists of the devices RF-transmitter, premodulation filter, VCO-mount and an isolation amplifier and serves to telemeter the signals to the Ground Station for Quicklook-monitoring by the Flight Testing Crew on ground. The PCM-data stream is delivered by the Teledyne RMDU and merged into the FM-MUX via premodulation-filter and isolation amplifier. The FM-Multiplex-signal consists of 14 constant bandwidth channels according to IRIG (channels 1A to 13A with a nominal frequency response of 400 Hz. Further one channel with a frequency response of 1600 Hz (15C) is provided for voice or IRIG-B Timecode resp.). A reference frequency-oscillator originates a 140 kHz reference-frequency which serves for tape speed compensation purposes when recording the FM-multiplex signal on magnetic tape. For transmitting the FM-signal including voice and timecode-signal together with the PCM-serial signal an auxiliary carrier is used (see Fig. 7). This carrier originates from a further voltage controlled oscillator (VCO) which will be modulated by the above described frequency multiple signal (FM-MUX), see Fig. 6 and 7. Voice from the flight-test engineer or the pilot resp. will be derived from the aircrafts interphone bus via a special interface-box and mixed into the FM-MUX. The above signals are mixed together to one modulation-signal with an overall bandwidth of about 1280 kHz (Fig. 7) which is used to modulate two L-band-transmitters (1531 and 1537 MHz). The rf-outputs of the transmitters are fed to two antennas of the type ASLN (EMP). One antenna is mounted on top of the vertical stabilizer of the CN 235, the other below the fuselage. This system enables a frequency diversity transmission and secures reception of the telemetry signal at the ground station at all attitudes of the aircraft in flight.

Time Code System
The Datum Time Code Generator Type 9150 (Fig. 8) gives a time reference for the recording of data. The unit provides an IRIG-B modulated serial output and 2 outputs with parallel BCD information, one for remote display on the FTI control board and the other for remote display of time (seconds to hours) in the cockpit area.

A third parallel BCD output is provided for time insertion into the PCM data stream via the RMDU. The resolution of this information is within milliseconds. An additional output is provided for slow code time information to be used if strip chart recorders are installed for operation during flight testing. The time code generator also generates a 1 Hz up to 1 KHz TTL reference pulse train for time synchronization of external devices (e.g. film camera systems).

Control and Display Units [8]
Control Instruments (CI) are further provided in the OB-DAS Instrument Panel (see Fig. 4) for display and monitoring of selected signals by the Flight Test Engineer.

Tape Recorder System (Fig. 6, 8)
The Bell and Howell Tape Recorder MARS 1414 LT 30 allows recording and record control of analog signals, time code information and PCM Data Stream. Provision is made for 10 FM-Recording wideband- and 4 direct-recording wideband-channels.

Calibration System OBCS [3] (Fig. 2)
The On Board Calibration System consists of a test rack with integrated measuring and calibrating instruments. The ruggedized rack is mounted into the aircraft. The central part of the OBCS is a desk computer type HP 9826. The calibration data acquisition unit can be operated manually via the front panel. All functions are also controllable from the computer. Furthermore a number of single portable instruments for calibration purposes are available.

Video System [5] (Fig. 2)
The Video System can be used for recording the video signal of a video camera, which can be installed in the aircraft.

Cine Camera System [6] (Fig. 2)
A Cine Camera System is installed operationally for all purposes during flight testing demanding a device as such.

Power Supply System [11] (Fig. 2)
The Power Supply System provides proper power distribution to the various devices of the OB-DAS. The incoming 28 V DC power is distributed via the circuit breaker box. Furthermore there are 4 static inverters installed to generate 115 V AC 400 Hz power.

Mechanical Installation (Fig. 3, 5)
Starting with the input connector board, all equipment and devices used for data acquisition and recording are mounted on a rack, designed and manufactured to the special requirements to fit inside the aircraft passenger compartment. Care is also taken to provide easy accessible break points for trouble shooting and check-out. The data acquisition system configuration is split off in smaller units to allow a remote installation if required.

ON GROUND DATA ACQUISITION AND EVALUATION SYSTEM OG-DAES

The Mobile Ground Station MGS of FTIS-CN 235 consists of the systems described below. The short description refers to Fig. 9. The subsystems are mentioned in a clockwise sequence referring to the blockdiagram.

Mobile Data Acquisition and Evaluation System MDAES (Fig. 11)
The system accepts PCM data from either a telemetry link or an instrumentation tape, and analog data. The system separates the streams of data into their individual components, stores the acquired data, processes specified measurements to enable an instant analysis, and displays the data. Two computer systems are provided. Both systems consists of a PDP 11/44 with MOS memory 256 KWords, floating point processor, LA 120 console terminal and several VT 100 terminals with graphics. The CPU is supported by a RUA 80 Winchester disk drive (121 MByte), a RL02 removable disk drive (10 MByte) and a TU 58 cartridge tape drive. TS11 magnetic tape drive systems are used for storage of digitzed telemetry data. The system is provided with extensive printing and plotting capabilities. Both PDP 11/44 are linked by a computer communication network with features like “file-transfer”, “virtual terminal” and “remote device access”. A long line interface enables transmission of calibration data from a HP 9836 computer to the PDP 11/44. In the event of failure of one CPU the two computer configuration guarantees continuous operation.

Mobile Telemetry System MTS (Fig. 10)
The Mobile Telemetry System is a substantial part of the Mobile Ground Station MGS. Purpose is always to secure monitoring and quick-look of flight testing. Because a wide-band combined PCM/FM-System has been selected (see description of airborne telemetry systems), rf-transmission will use the L-band according to IRIG (1435-1535 MHz). So a tracking-antenna-system for reception of incoming signals must be used. In order to minimize costs and sophisticated operation of the tracking-antenna station, a single axis telemetry tracking antenna Model GTS-04C (manufacturer Electro Magnetic Processes

EMP) is proposed, which provides both narrow and broad beam-modes of operation. The narrow-beam antenna is used for tracking the aircraft at long ranges and the broad-beam antenna is used for short range tracking and overhead passes. Switching between the antenna is accomplished automatically based on received signal strength. An onmidirectional antenna serves for receiving purposes for telemetry in a short distance area, i.e. when the aircraft is on the ground for adjustment and calibration of systems. The antennas are mounted on the roof of the telemetry container and fastened to the antenna-base-frame (Fig. 12). The telemetry system enables reception of telemetry data as described and data reduction of PCM and FM-signals as well as recording those data on two tape recorders. All data can be distributed in the desired manner by crossbar-distributors and coordinated patch-panels. The PCM-EXPRT Data System can supply 16-analog-channels at choice for display on strip-chart recorders or scopes. The same applies to the 14 available CBW-FM-channels. The tape recorders (Bell&Howell 3700E) enable recording of 14 FM- or direct-signals and reproducing of 10 FM- and 4 direct-channels. Copies of tapes can be made. A time code system combined with a tape search unit is provided.

Communication System Com (Fig. 9)
For the manifold applications requested an ample communication system described below in short was provided.

VHF-Aircraft/Ground Communication
The flight director room ist provided with two aircraft to ground communication sets of the type Becker TG 264. One set is located at the flight directors desk and serves to establish the communication between flight director and aircraft.

Interbase Communication
For communication in between the shelter (container) groups an interbase communication system is used.

Intercommunication
The intercommunication voice from the aircraft crew (flight engineer) is transmitted in the course of the FM telemetry together with the telemetry signal to the ground station.

Operational VHF-Communication
For operational communication in between flight director room, telemetry room, aircraft (during checkouts and adjustments on the ground) as well as staff moving at the test site (e.g. in cars) a VHF-communication system consisting of stationary desk mounted devices and walkie-talkies is used.

Mobile Power Generator MPG (Fig. 9)
The power supply of the mobile ground station will be secured by a mobile power generator MPG or by the local mains. Normal operation of the station will be by local mains, in case of mains drop out or during flight test power supply will be from the mobile power generator MPG. The performance of this aggregate is 217 kVA.

Mobile Calibration System MCS (Fig. 9)
The Mobile Calibration System MCS is a combination of calibration and test equipment, designed for the requirements of TCFT. Apart from calibration systems for testing and calibration of FTIS under laboratory conditions, housed in one of the shelters, also equipment is available to do calibrations and adjustments on board of the aircraft. Integral part of the MCS is a desk top Mini Computer System HP 9836S, which enables control of tests and calibrations, interactive processing of calibration results, sensor data management and data transfer between MCS and MDAES by a computer link.

A number of instruments is connected with the computer via the IEEE bus system.

Additional Test Equipment ATE (Fig. 9)
Additional Test Equipment ATE is the rubrum under which the equipment can be found, which is not stringently coordinated to the other groups of FTIS. In particular there are special user requirements regarding meteo-data and video-monitoring, which can be fulfilled with system described as follows.

Video System
Video-systems are provided as well for airborne as for on ground applications. The provision for an airborne video system arises from user-requirements. Purpose is to monitor on board of aircraft special parameters and phenomena as well as function of outside equipment (gears, doors, flaps etc.). The system consists of one or more video-cameras and a recorder with necessary accessories. The on ground video system serves for reproduction of video-recordings during flight testing. Another application is to give demonstration to observers.

Meteo Stations
In flight testing it is indispensable to be informed any time regarding weather data. For that reason a meteo station coordinated to the Ground Station (display in Flight Director Room) and additionally 5 smaller stations distributed along the runway were provided. The following meteo-data are measured at or in the vicinity of the ground station: 1. Wind-Direction. 2. Wind-Velocity. 3. Temperature. 4. Barometric Pressure. 5. Relative Humidity.

Spareparts
A special block Spareparts (Fig. 9) in the figure indicates that relevant spareparts for all systems were provided to be on storage.

Mobile Electronic Workshop MEW (Fig. 9)
The mobile electronic workshop MEW is equipped with work benches, laboratory desks and cabinets. Purpose of MEW is to enable all maintenance and repair-work which becomes necessary in the course of ground station operation in as short time as possible. Therefore all kinds of tools and components are provided, which are necessary for doing the described work. Also the necessary devices for measurement and adjustment of the entire flight test instrumentation equipment is provided as far as it is possible in a mobile workshop.

Crew Residence (Fig. 9)
During Flight Testing it is very important that the crew is always available. Because not necessarily they are all on duty, rooms must be provided as a residence for redundant crew members or as office-rooms for doing the paper work requested in the job. Three containers are provided. One serves as a rest-room, one as a meeting-room (for discussion-meetings) and the third as office-room. The entire On Ground System is housed in containers or shelters (Fig. 12-14). The ground station is housed in three groups of shelters which are installed on strip foundations or on stell pedestals. The shelters can be used in groups or as stand-alone units. All shelters of the Mobile Ground System (MGS) are supplied by Three Phase Alternating Current 380/220 VAC/50 Hz. Shelters external dimensions:

	ISO	DIN
Length	20 feet	6058 mm
Width	8 feet	2438 mm
Height	8,5 feet	2591 mm

Max.-mass 10,000 kg, that is appr. 10 tons or 22.046 lbs.
Fig. 14 shows an arrangement of the MGS-container-group. For illustration inside views of the Flight Director Container are shown (Fig. 13).

SUMMARY

The paper gives a survey of the complete Flight Test Instrumentation System FTIS (airborne- and ground-equipment) provided by the Institute for Flightmechanics of DFVLR (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V. = German Aerospace Research Establishment) for the Indonesian Aircraft Manufacturer PT. NURTANIO. A short description of the general layout and of the subsystems is given and illustrated.

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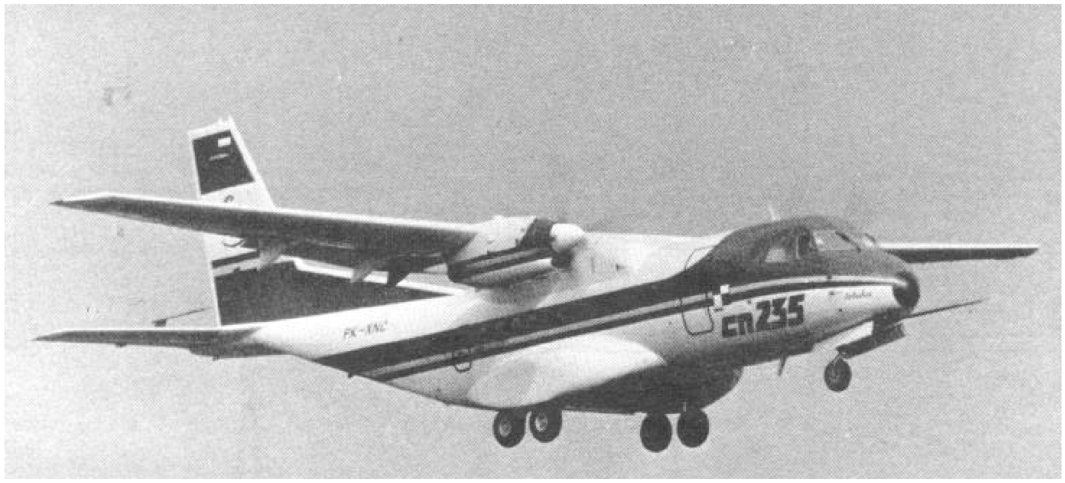
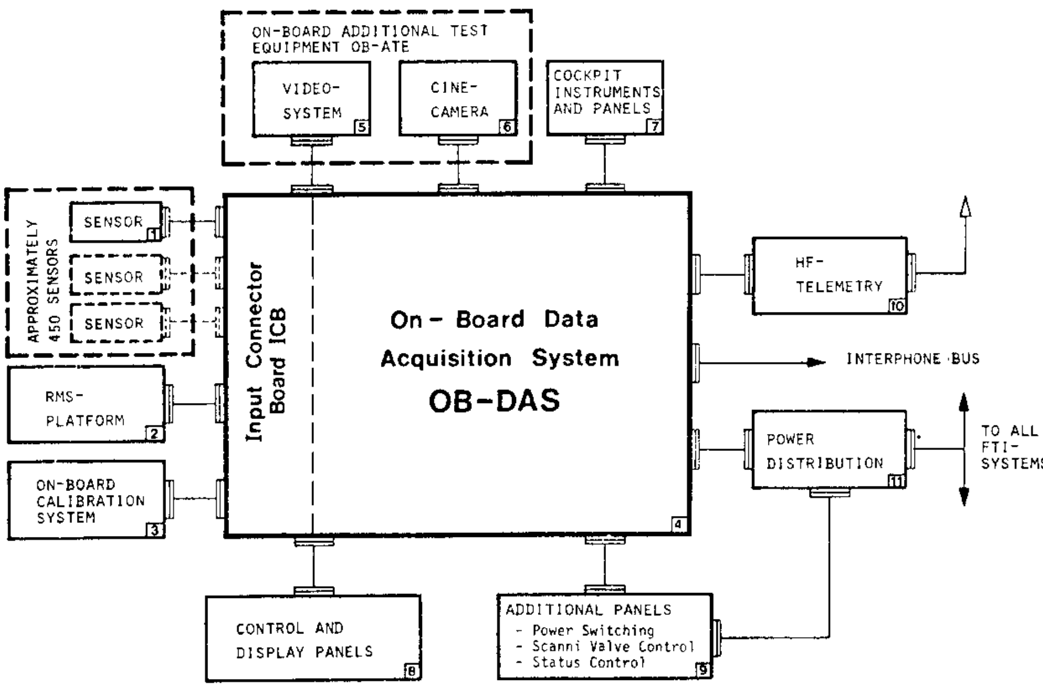
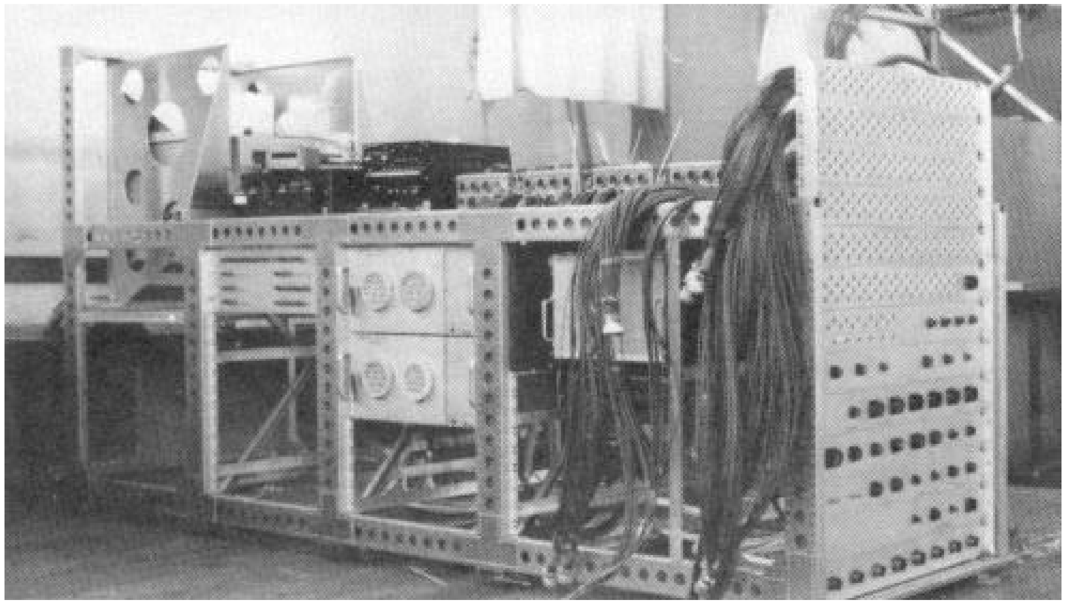


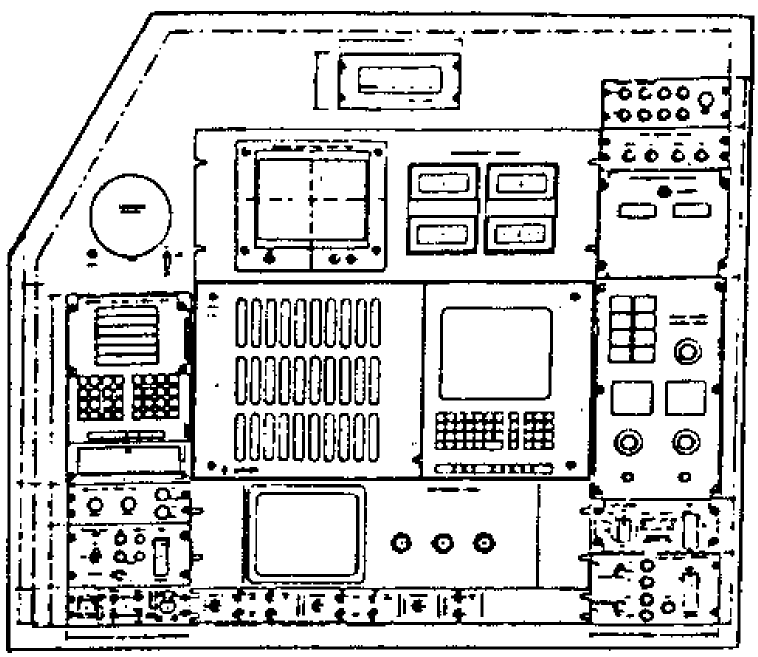
<u>Fig. 1</u> Aircraft CN 235



<u>Fig. 2</u> Schematic of On-Board Flight Test Instrumentation (OB-FTI)



<u>Fig. 3</u> Rack-mounted OB-DAS for CN235 Aircraft



<u>Fig. 4</u> OB-DAS Instr. Panel

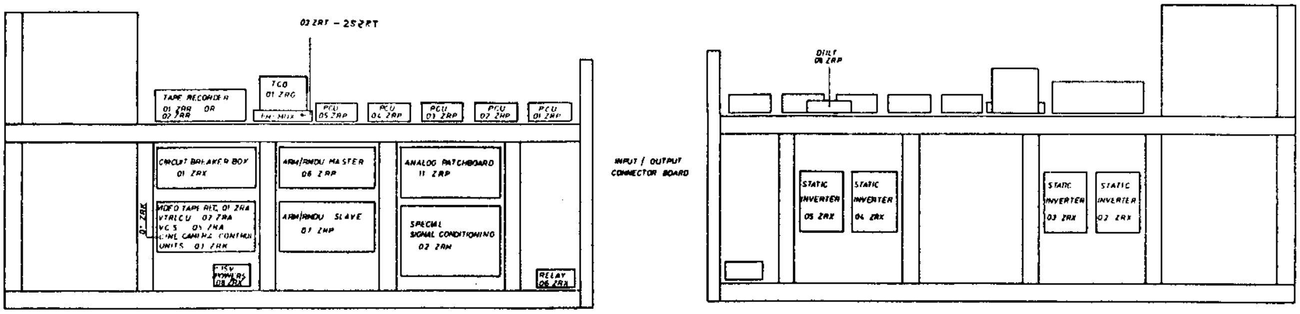


Fig. 5 **Arrangement of Devices (OBDAS-Rack - Sideviews)**

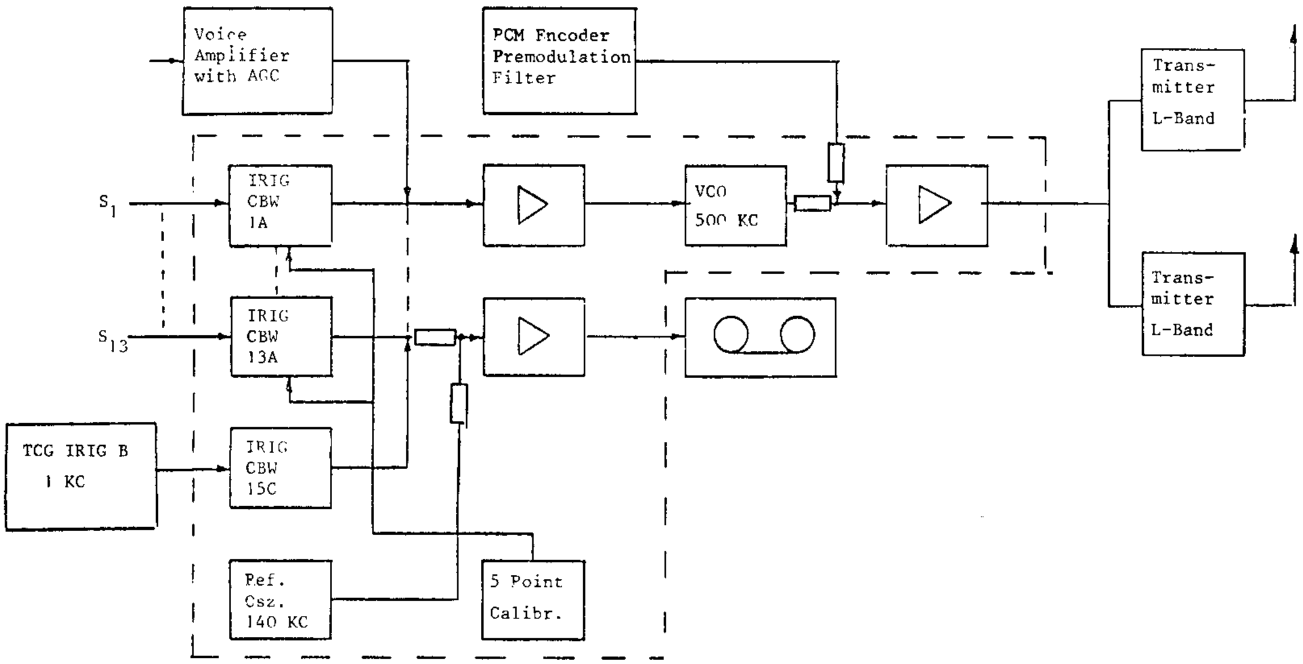


Fig. 6 **Airborne FM Telemetry Blockdiagram with Time Code IRIG B**

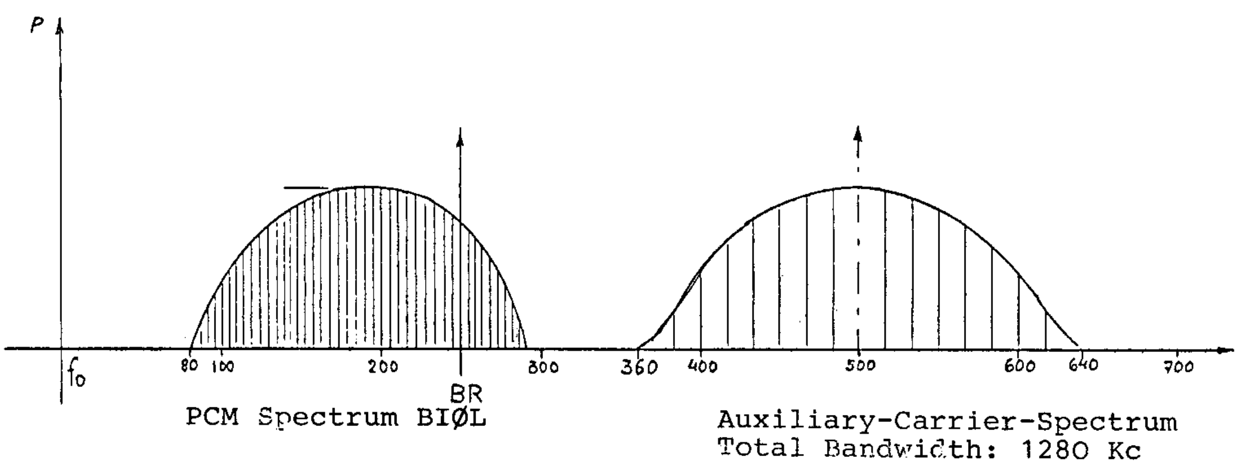


Fig. 7 **Frequency Spectrum PCM and 500 kHz Auxiliary Carrier**

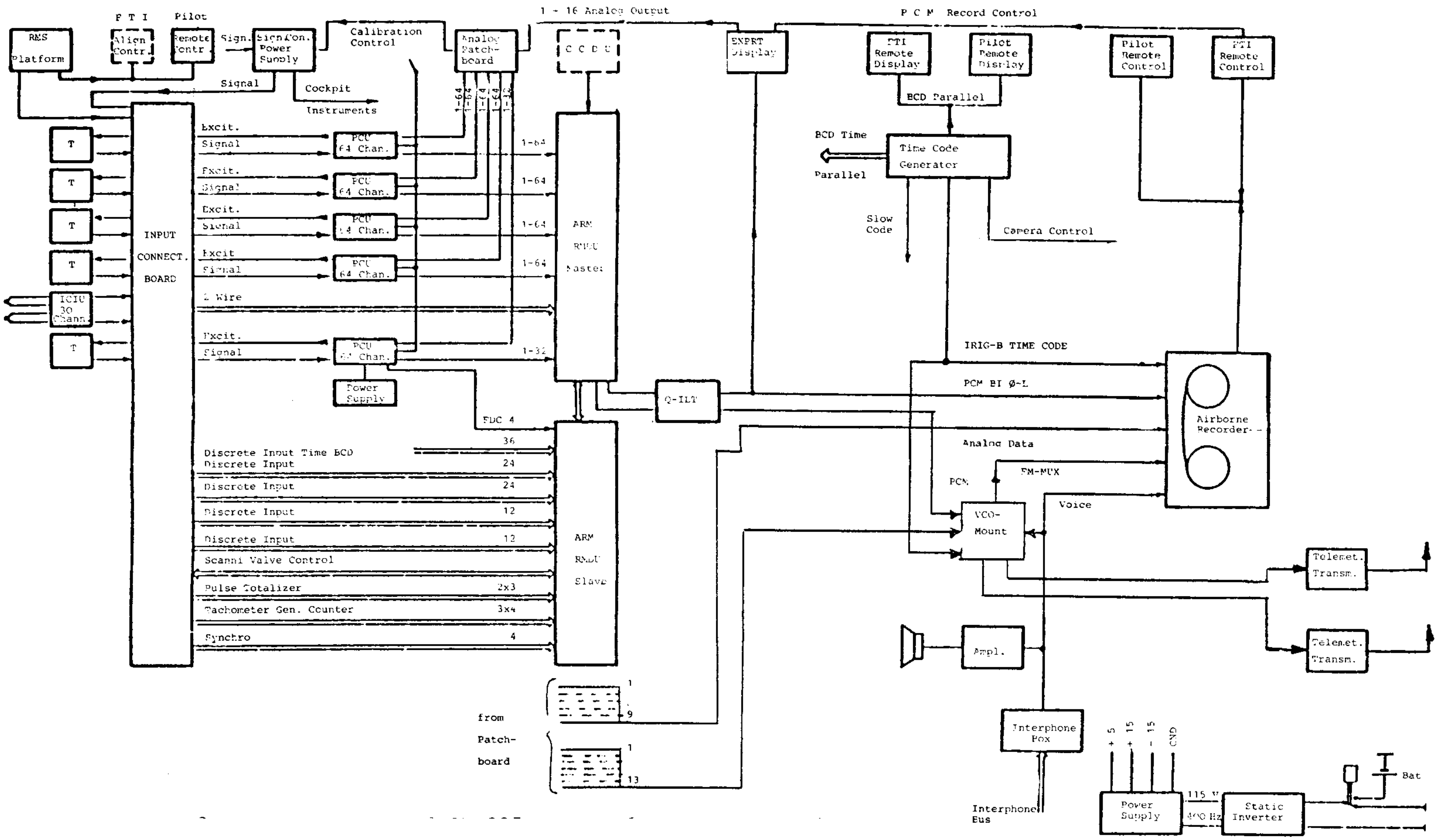


Fig. 8 **Blockdiagram of CN 235 On Board Data Acquisition System**

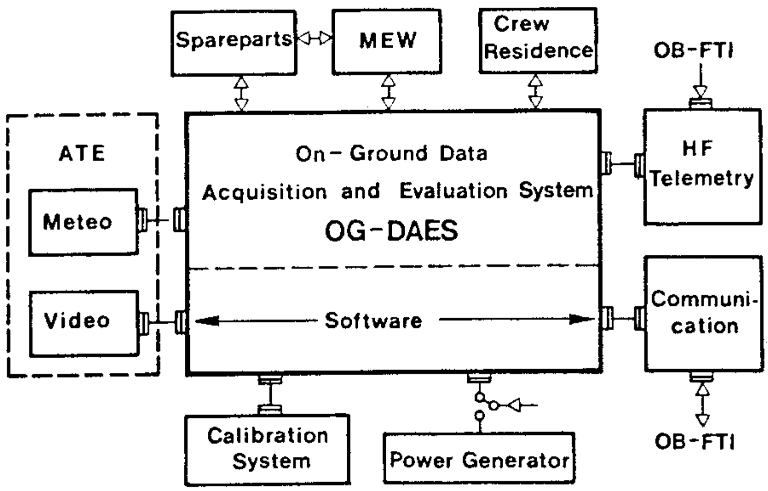


Fig. 9 **Schematic of On-Ground Flight Test Instrumentation**

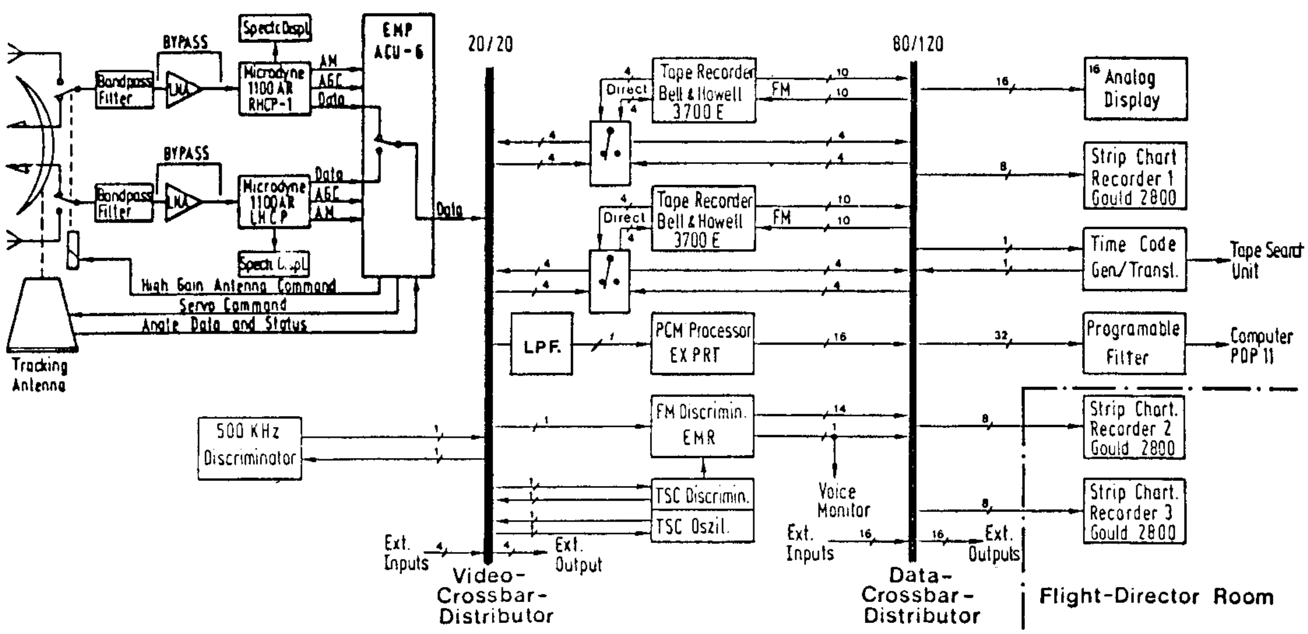


Fig. 10 **Telemetry-Ground Station**

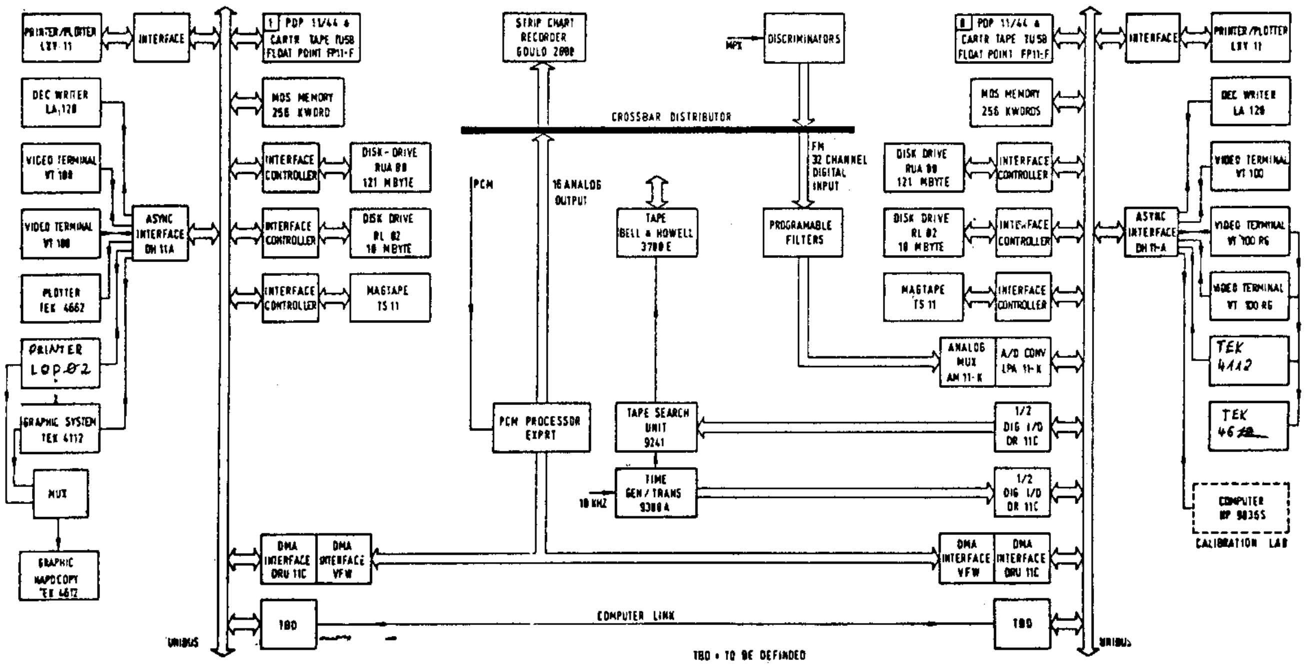


Fig. 11 Data Acquisition and Evaluation System

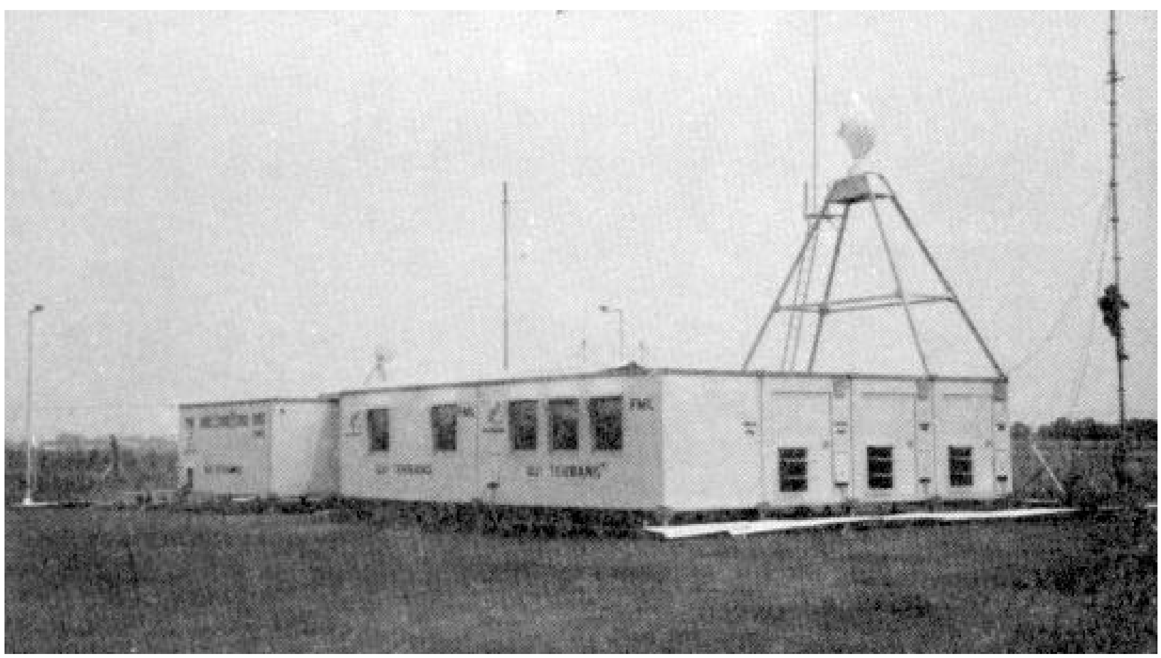
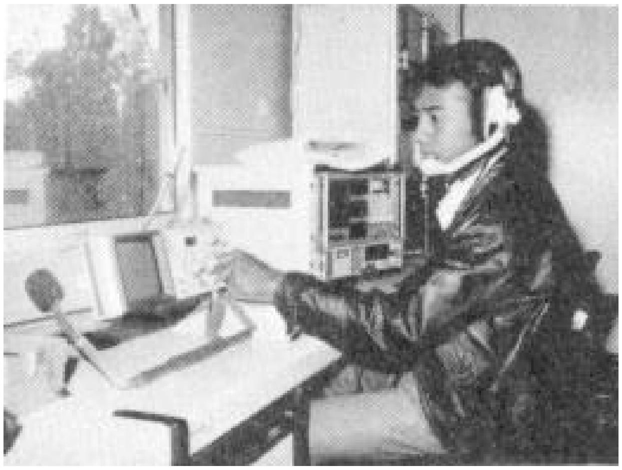
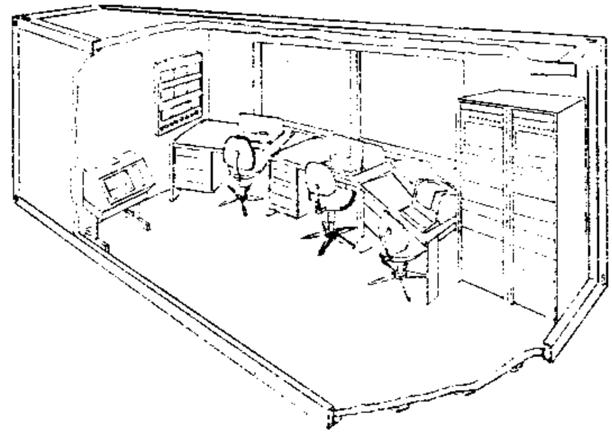


Fig. 12 FTIS-Ground Station in Kemayoran/Jakarta

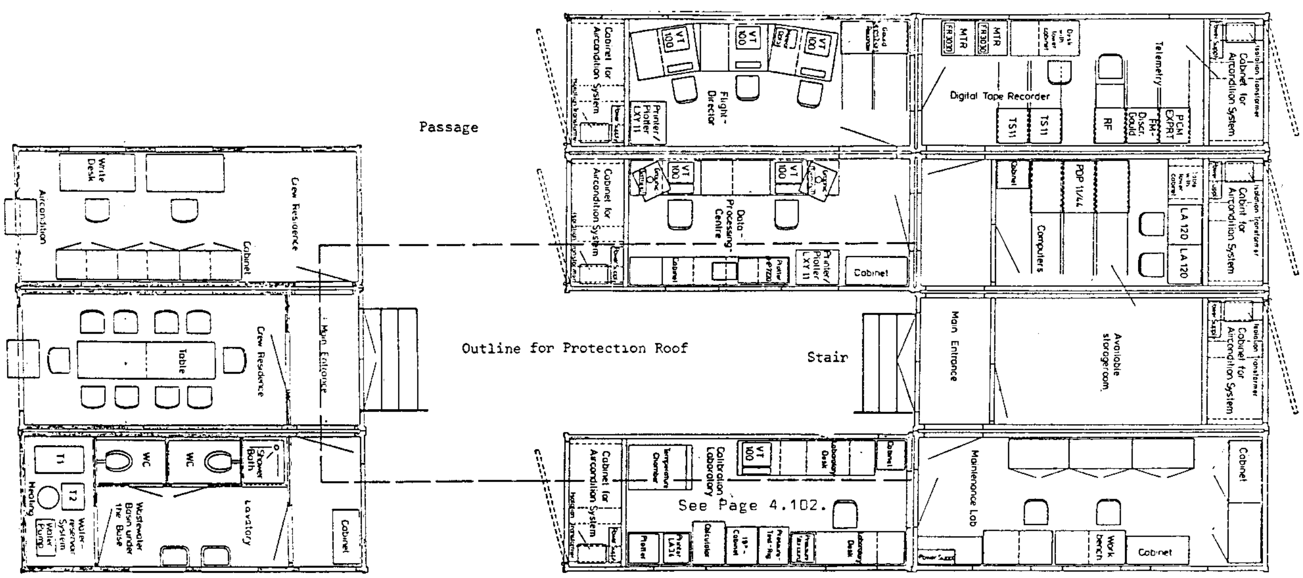


Inside View



Prospective View

<u>Fig. 13</u> Flight Director Compartment



<u>Fig. 14</u>   Shelter (Container) Arrangement