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# LORAN C Flight Inspection
## Project Plan

FEDERAL AVIATION ADMINISTRATION

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TECHNICAL CENTER

Robert D. Till
Robert Erikson

August 1985

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This project plan describes a program to develop flight inspection methods and tolerances for Loran C nonprecision approaches.

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# EXECUTIVE SUMMARY

This project plan outlines a program designed to develop flight inspection methods and tolerances for Loran C nonprecision approaches.

# INTRODUCTION

## PURPOSE.

The Loran C Flight Inspection project plan is intended to accomplish the following:

1. Develop flight inspection methods and tolerances for Loran C nonprecision approaches.

2. Develop a flight inspection program to accomplish the implementation of nonprecision Loran C instrument approach procedures.

## OBJECTIVES.

The objectives of this project are: (1) to develop Loran C flight inspection methods to accomplish commissioning and periodic inspections, (2) to determine flight inspection equipment requirements, and (3) to examine techniques to perform the task most effectively.

## BACKGROUND.

Loran C is a random area navigation system (RNAV) not restricted by line-of-sight between the receiver and transmitter. Loran C has the potential to provide nonprecision approach coverage at locations not serviced with conventional approach aids. The proliferation of commercially available low cost Loran C receivers has attracted the interest of various user groups. The National Association of State Aviation Officials (NASAO) is very enthusiastic about Loran C and the prospect of instrument nonprecision approaches to many airports. They are interested in forming a cooperative effort with the Federal Aviation Administration (FAA) to resolve outstanding issues and implement nonprecision approaches on a limited approval basis at designated sites in Vermont and/or Massachusetts, Oregon, Ohio, and Texas.

Aviation Standards National Field Office (AVN) will develop approach procedures for eight airports during the "pilot project." AVN will flight check and commission the procedures. The FAA Technical Center will provide liaison and technical support to AVN.

To support this effort AVN will be required to flight inspect the Loran C approach/missed approach to insure quality of signal-in-space and a safe, flyable procedure.

## PROBLEMS/TASK

STATEMENT OF THE PROBLEMS.

Methods and tolerances have not been established to flight check Loran C. The test has objectives to develop flight inspection methods that will insure quality of signals in space for all areas of planned usage and to insure that the procedure designed for the approach is flyable and safe.

GENERAL DESCRIPTION OF TESTS.

The Loran C flight inspection tests are to determine the best method to perform flight inspection for assuring the quality of signal in space in an effective and efficient manner.

TEST PROCEDURES.

The following procedures are to be used in developing flight inspection methods for commissioning a Loran C instrument approach procedure.

PARAMETERS THAT WILL BE INSPECTED. The following parameters will be measured and/or computed and compared with established criteria at each airport to be inspected.

| Parameter | Criteria |
|---|---|
| Signal-to-noise ratio (SNR) | $\geq$0 decibels |
| Envelope-to-cycle discrepancy (ECD) | $\leq$+/-2.4 microseconds |
| Time Difference (TD) bias correction | Computed and compared with monitor value |
| Spectrum interference | No interference 90 to 110 kilohertz |

LORAN C FLIGHT INSPECTION RECEIVER. The receiver that will be used to measure the parameters previously specified is the Advanced Navigation, Inc. (ANI)-7000 Loran C receiver. The ANI-7000 receiver is an airborne derivative of the United States Coast Guard (USCG) Austron 5000 monitor receiver and should be adequate to measure SNR's, ECD's, and TD's.

The FAA Technical Center recommends AVN use a modified ANI-7000 Loran C receiver as the flight inspection receiver. Data output is provided in an RS232C, 9600 baud rate format using a seven-bit character code. Specifications for the data format are contained in the ANI Engineering Specification, Model 7000. The existing commercially available receiver must be modified for flight inspection as follows:

1. The receiver must identify the stations selected in accordance with standard USCG nomenclature (M,W,Y,Z).

2. The receiver must accept delta TD values for nonprecision approach bias correction as specified in the seventh version of the Radio Technical Commission for Aeronautics (RTCA) Loran C Minimum Operational Performance Standards (MOPS).

3. The receiver crosstrack guidance must be updated in the approach mode at least once per second.

4. In the approach mode, the receivers must detect and annunciate blink in less than or equal to 10 seconds and must detect and annunciate loss of signal in less than or equal to 15 seconds.

The ANI receivers used by the Technical Center will not be modified at this time.

PROCEDURES. AVN will furnish approach procedures for each airport. The initial Loran C procedures are planned to overlay existing navigation aid (NAVAID) procedures. Consideration should be given to using the established methods for these NAVAIDS to accomodate Loran C inspections. The procedures will identify the dedicated triad and designate in latitude and longitude the initial approach waypoint (IAWP), final approach waypoint (FAWP), and missed approach waypoint (MAWP). The delta time difference bias correction for the approach will be obtained from the Transportation System Center (TSC) (as measured and determined from the monitor located at the approach site). TSC will also provide a pilot evaluation questionnaire.

## TEST EQUIPMENT AND LOCATION

### AVN TEST EQUIPMENT.

TEST AIRCRAFT SYSTEMS. Flight tests will be conducted using a flight inspection aircraft. Due to lead time required to equip a flight inspection aircraft, it will be necessary to conduct some of the testing using the Technical Center CV-580 that is presently equipped with Loran C and is currently being used to support other research engineering and development (RE&D) (Loran C, Microwave Landing System (MLS), etc.) projects. The final test results, however, must address a Loran C equipped flight inspection aircraft.

AVN is currently fabricating a data reader/printer to access data from the Bendix MLS Cabin Class Receiver. It may be feasible to add to this reader/printer the required bus and software to accomodate Loran C. The Technical Center will provide AVN liaison with this decision.

COCKPIT DISPLAY AND CONTROLS. The flight inspection aircraft should be equipped so as to present guidance information through a conventional course deviation indicator (CDI). The Loran C control head/keyboard should be located in the cockpit in such a way as to permit access by either pilot. It is highly desirable to consider Supplemental Type Certification (STC) requirements for the installation in the flight inspection aircraft.

AIRBORNE DATA AQUISITION AND RECORDING SYSTEM (ADARS). The flight inspection test aircraft will be equipped with an ADARS specially designed for Loran C flight inspection testing. The system is interfaced with aircraft avionics systems, including Loran C, and records readings on digital cassette tapes twice each second. Time correlation is provided on the tapes from a satellite timing reference receiver contained in the ADARS. The Technical Center will provide liaison to AVN in application of this system to the flight inspection task.

TECHNICAL CENTER TEST EQUIPMENT.

TECHNICAL CENTER AIRCRAFT SYSTEMS. The Technical Center CV-580 aircraft is equipped with five airborne Loran C receivers: Teledyne TDL-711, Micrologic ML-4000, Texas Instruments TI-9100, and two Advanced Navigation ANI-7000 units. All units are production models. The ANI-7000 receiver will be primarily used for the flight inspection task. Other receivers may be replaced or deleted as the need arises.

COCKPIT DISPLAY AND CONTROLS. The Loran C receiver control heads are mounted in the rear cabin of the Technical Center CV-580 and will not be mounted in the cockpit for the flight inspection tests. Crosstrack deviation and a navigation valid flag will be provided the pilot on a CDI. Distance to the missed approach point (MAP) will be provided the pilot on separate distance measuring equipment (DME) indicator.

TECHNICAL CENTER AIRBORNE DATA ACQUISITION SYSTEM. A Norden militarized PDP 11/34M computer will be used to collect the data. The data will be recorded on a Miltope nine-track tape recorder and a floppy disk. A Technical Center designed aircraft systems coupler (ASC) is used to interface the Loran receivers, aircraft state sensors, and position reference system to the Norden computer. Figure 1 is a block diagram of the system. Data recorded on the nine-track tape recorder is presented in table 1.

POSITION REFERENCE SYSTEM. The Technical Center will provide a GPS receiver, the Magnavox Z-set, as a position reference system for the Technical Center CV-580 aircraft.

SPECTRUM ANALYZER. AVN will provide a Hewlett Packard (HP) 8566 spectrum analyzer for installation in the Technical Center CV-580 aircraft. Currently, a Tektronix 7L5 spectrum analyzer is installed in the CV-580 and will be used if AVN cannot furnish an HP 8566 spectrum analyzer.

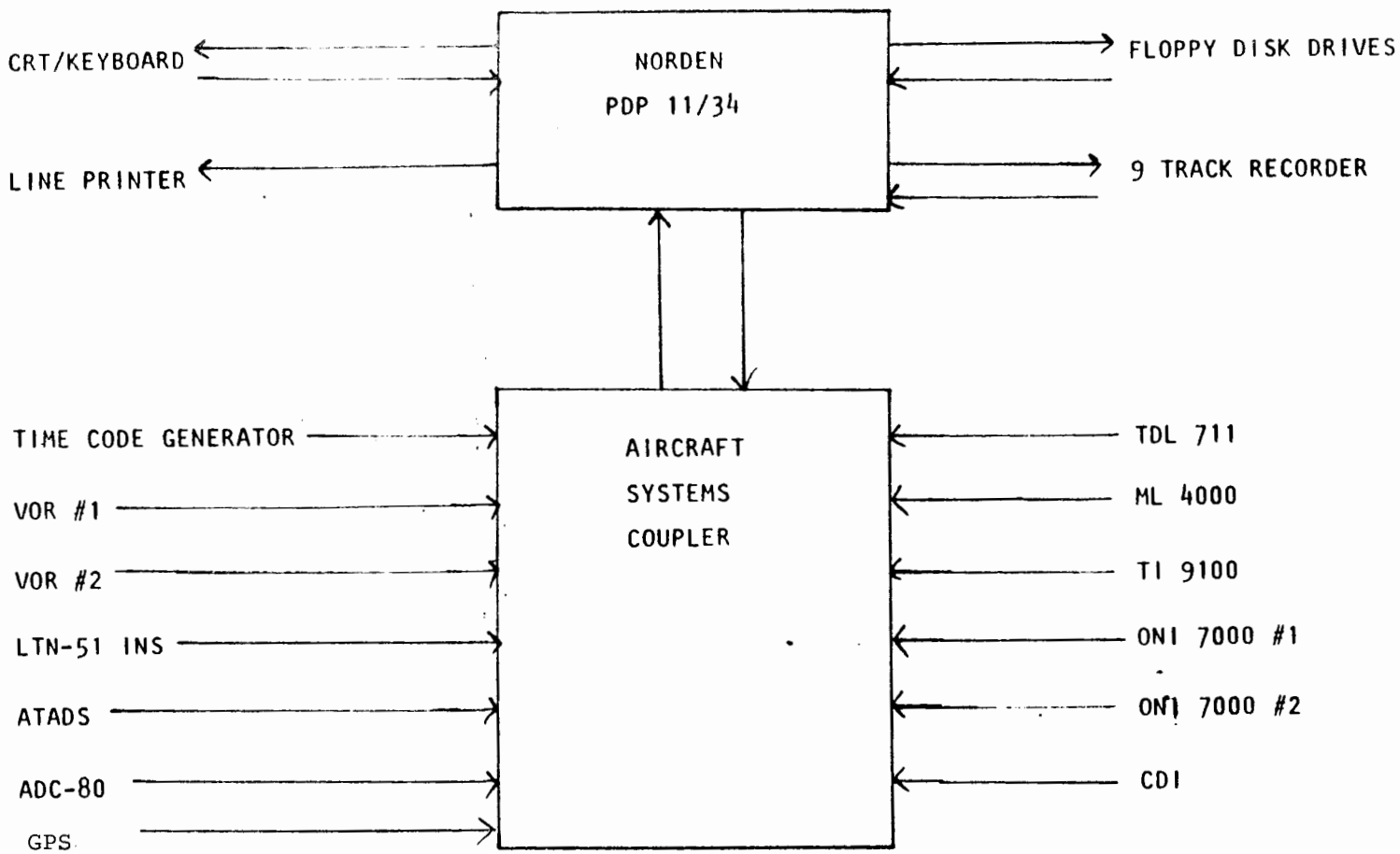


FIGURE 1. DATA COLLECTION SYSTEM

TABLE 1. RECORDED DATA

Aircraft Sensors and Time

| | |
|---|---|
| Time: | Hours, minutes, seconds |
| LTN-51 INS: | Present position, heading, track angle, ground speed |
| ADC-80: | True airspeed, altitude |
| ATADS: | Multi-DME ranges with time tags |
| VOR No. 1: | Bearing |
| VOR No. 2: | Bearing |
| CDI: | Analog CDI |
| INS: | Inertial navigation system. |
| GPS: | Earth centered position, velocities, and time |

LORAN C Receivers Recorded

| | TDL-711 | ML-4000 | ANI-7000 | TI-9100 |
|---|---|---|---|---|
| Present position lat/long | x | x | x | x |
| Station status | - | M + 5 | 8 | - |
| Station SNR's | M + 3 | M + 5 | 8 | - |
| Time differences | 2 | 2 | 8 TOA | - |
| ECD's | M + 3 | - | 8 | - |
| To waypoint lat/long | x | x | x | x |
| From waypoint lat/long | x | x | - | x |
| Crosstrack error | x | x | x | x |
| Ground speed | - | x | x | x |
| Distance to go | x | x | x | x |
| Front panel switch setting | - | x | x | - |
| En route/approach | - | - | x | - |
| Annunciator lamps | - | - | x | - |
| Receiver status | x | - | x | x |
| Grid reference | - | - | x | - |
| Bearing to waypoint | - | - | x | x |
| Desired track | - | - | x | x |
| Estimated time en route | - | - | x | x |
| Notch filter setting | - | - | x | - |
| Secondary phase delay | - | - | x | - |
| Triad in use | - | - | x | - |
| Station field strength | - | - | x | - |

Note:

x = Data present in digital output
M = Master
TOA = Time of Arrival

TEST LOCATION.

The flight tests will be conducted at the FAA Technical Center, Atlantic City Airport, New Jersey, to develop test methods and procedures. Loran C approaches, landings, missed approaches, and departure procedures will be conducted at the selected test runways. Other sites that may be selected will be evaluated using the methods developed at the Atlantic City test site. Adjustments to the test methods and procedures may be required over the duration of the project.

## DATA REDUCTION

Data recorded will be processed at the Technical Center. Mean and two sigma errors will be determined for northing and easting errors, along track, crosstrack, flight technical error, and total system crosstrack for each approach. Composite statistics will be determined for multiple approaches. Mean values for the SNR and ECD will be determined for each approach; composite mean values will be determined for multiple approaches. Software will be developed to measure and determine the time difference correction values of the selected triad for comparison with the published TD correction values provided by the monitor.

## RESPONSIBILITIES

1. The objectives of the the Loran C Flight Inspection project will be defined by the FAA Flight Inspection Branch, AVN-230, located in Oklahoma City. AVN-230 will accomplish the following:

a. Develop the approach procedures.

b. Provide flight inspection personnel to assist in conducting the test.

c. Provide liaison in the analysis of the data and writing of final report.

2. Test planning, test conduct, and data reduction and analysis will be accomplished by the FAA Technical Center, ACT-140. ACT-140 will accomplish the following:

a. Write the test plan.

b. Conduct the test consistent with test objectives and requirements for data reduction and statistical analysis.

c. Provide a summary of conclusions based on analysis performed.

d. Write the final report with assistance from AVN-230.

3. APM-420 will be responsible for subprogram management and allocation of project funding.



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3. Overseeing of operations will be conducted by the Operations Specialist from the Flight Inspection Branch, AVN-230. This person will have responsibility to:

a. Coordinate test activities with the Test Director.

b. Participate in pretest evaluation flights to identify and help resolve any operational problem in the test design.

c. Monitor and participate in data collection flights.

d. Assist in preparing summary of conclusions based on statistical analysis of data.

e. Assembly project report.

f. Help prepare interim data and technical reports.

g. Develop an appropriate draft order 8240.xx to clearly identify Loran C requirements and tolerances.

4. On location flight test program management will be the responsibility of the ACT-140 Project Manager. He will accomplish the following:

a. Assembly the test plan.
b. Provide direction and coordination support of all test activities.
c. Coordinate communications between ACT-140 and AVN-230.

(1) Scheduling of aircraft and facilities.
(2) Collecting, merging, and reducing data.
(3) Briefing and debriefing of crew.
(4) Make necessary changes to hardware and software.

d. Function as primary test observer.
e. Help prepare interim data and technical reports.

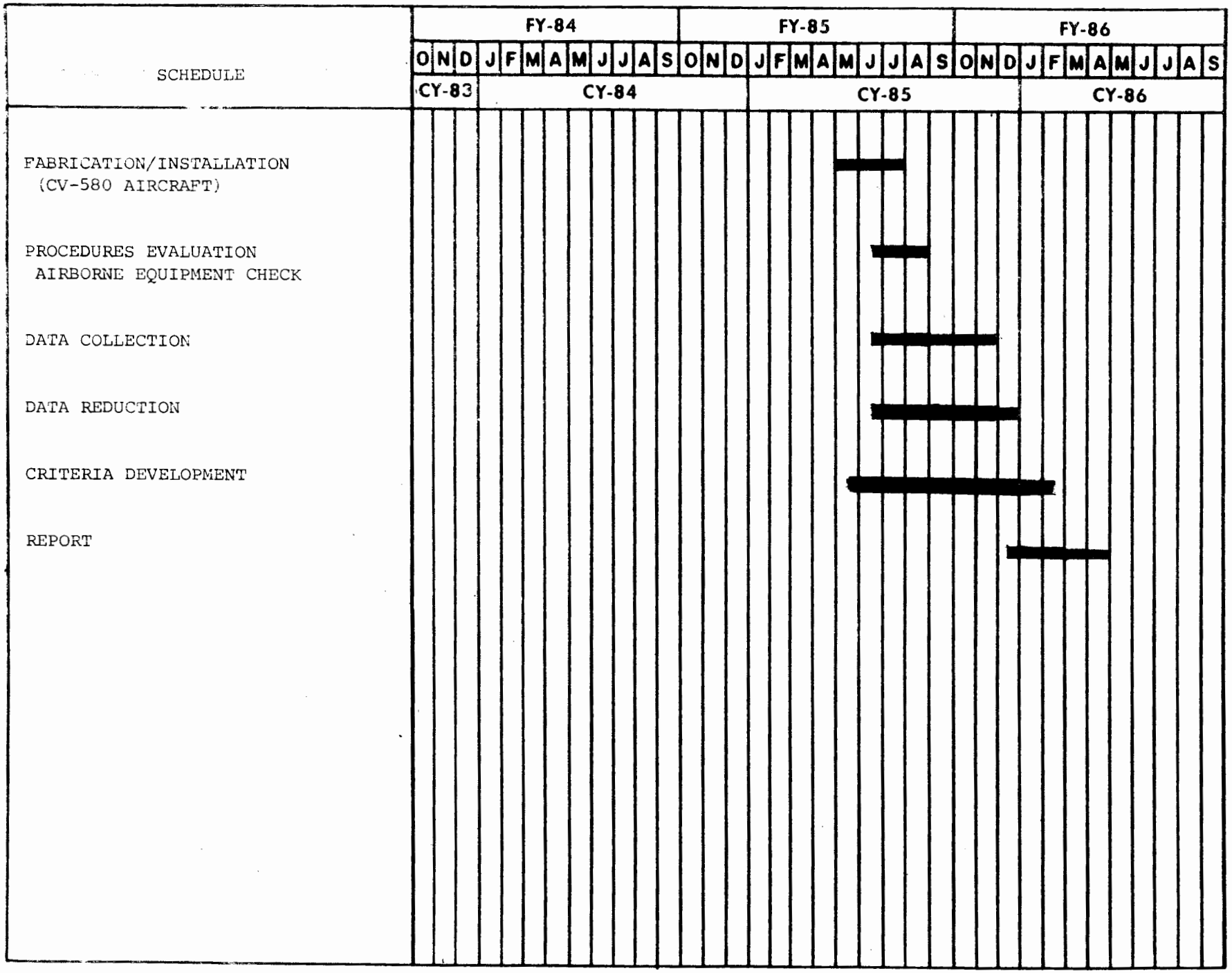
5. The Safety Pilot will be the pilot whose responsibilities are to:

a. Coordinate with the project manager on all aspects of each flight, including profiles to be used.
b. Conduct normal preflight activities, such as:

(1) Obtain weather briefing.
(2) File flight plan(s).

c. Brief crew on procedures and safety items.
d. Fly prearranged Loran C approach and observe proper operation of instruments.
e. Land and provide coordination for calibration of onboard equipment as necessary.
f. Relay to the pilot the type of approach termination at decision height (DH) as determined by observer or prearrangement.
g. Act as pilot in command.

6. APM-420 will be responsible for subprogram management and allocation of project funding.


SCHEDULE
FY-84
FY-85
FY-86
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
CY-83
CY-84
CY-85
CY-86
FABRICATION/INSTALLATION (CV-580 AIRCRAFT)
PROCEDURES EVALUATION AIRBORNE EQUIPMENT CHECK
DATA COLLECTION
DATA REDUCTION
CRITERIA DEVELOPMENT
REPORT