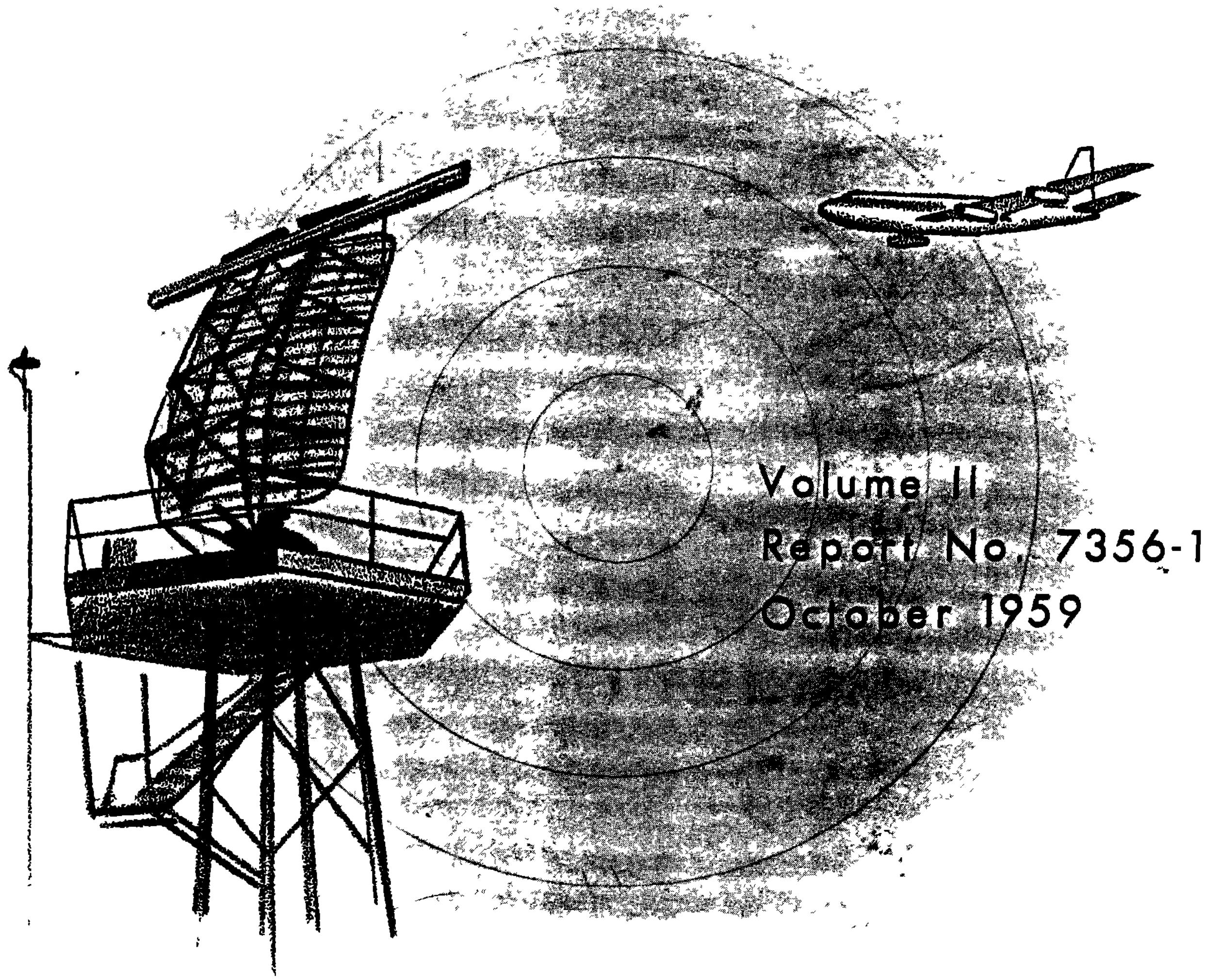
FINAL ENGINEERING REPORT ON PHASE II OF

EVALUATION OF AIR TRAFFIC CONTROL RADAR BEACON SYSTEM



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AIRBORNE INSTRUMENTS LABORATORY
A DIVISION OF CUTLER-HAMMER, INC.
MELVILLE, LONG ISLAND, NEW YORK

FINAL ENGINEERING REPORT ON PHASE II OF EVALUATION OF AIR TRAFFIC CONTROL RADAR-BEACON SYSTEMS (ATCRBS)

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APPENDIX A

DESCRIPTION OF PLANNED PROCEDURES FOR BEACON TECHNICAL EVALUATION TESTS

SYSTEM COVERAGE AND CHECKOUT (Technical Test 1)

A. OBJECTIVE

To plot the coverage pattern of each beacon installation. The test will consist of 15 radial flights, a 40-mile orbit at minimum-IFR-altitude and four 6-mile orbits at an altitude of 2000 feet. The radials are common to two sites wherever possible and include a flight over the azimuth heading from the site that is expected to produce the worst vertical-null patterns. The 40-mile orbit will provide coverage data at all sites over a full 360-degree angle. The 6-mile orbits at each site will provide reflection data and will correlate with the antenna pattern tests made during Technical Test 2.

B. FLIGHT PLAN

1. Aircraft Requirements: One DC-3 (TDC/N-182).

2. Flight Patterns and Routes:

Flight 1. 288-degree course from Idlewild FPS-8 radar.

Purpose: Minimum-IFR-altitude beacon coverage of IDL/FPS-8, IDL/ASR, EWR/ASR.

Maximum Range: 75 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar tower on a 288-degree course at 2000 feet. Pass over Newark radar antenna. At Victor Airway 3 climb to 2700 feet. Continue on course to V-29. Make left turn and return on reciprocal course of 108 degrees. Descend to 2000 feet at Victor Airway 3. Pass over Idlewild FPS-8 radar tower.

Flight 2. 108-degree course from Idlewild FPS-8 radar.

Purpose: Minimum-IFR-altitude beacon coverage of IDL/FPS-8, IDL/ASR, EWR/ASR. Clear radial from EQR/ASR.

Maximum Range: 60 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar tower on a 108-degree course at 2000 feet. Continue to the point 40° 34' N and 72° 30' W. Make left turn at the 205-degree radial of the Hampton VOR and return on reciprocal course of 288 degrees. Pass over Idlewild FPS-8 radar tower.

NOTE: Pilots must obtain clearance to enter warning areas 105 and 106.

Flight 3. 340-degree course from Idlewild FPS-8 radar.

Purpose: Minimum-IFR-altitude beacon coverage of IDL/FPS-8, IDL/ASR, LGA/ASR.

Maximum Range: 80 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar tower on a 340-degree course at 2000 feet. Pass over LaGuardia ASR-3 radar antenna. At Victor Airway 3 climb to 3000 feet. At Victor Airway 106 climb to 4000 feet. At Grossingers airport make left turn and return on reciprocal course of 160 degrees. At Victor Airway 106 descend to 3000 feet. At Victor Airway 3 descend to 2000 feet. Pass over LaGuardia ASR-3 radar antenna and Idlewild FPS-8 radar antenna.

Flight 4. 160-degree course from Idlewild FPS-8 radar.

Purpose: Minimum-IFR-altitude beacon coverage of IDL/FPS-8, IDL/ASR, LGA/ASR.

Maximum Range: 70 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna on a 160-degree course at 2000 feet. Continue to the intersection of the 110-degree radial of Coyle VOR. Make left turn and return on reciprocal course of 340 degrees. Pass over Idlewild FPS-8 radar antenna.

Flight 5. 190-degree course from Idlewild FPS-8 radar.

Purpose: Minimum-IFR-altitude beacon coverage of IDL/FPS-8, IDL/ASR. Clear radial from both IDL sites.

Maximum Range: 70 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna on a 190-degree course at 2000 feet. Continue to the inter section of the 135-degree radial of Coyle VOR. Make right turn and return on reciprocal course of 010 degrees to Idlewild. Pass over the IDL/FPS-8 antenna.

NOTE: Pilots must obtain clearance to enter warning area 107.

Flight 6. 261-degree course from LaGuardia ASR-3 radar antenna.

Purpose: Minimum-IFR-altitude beacon coverage of LGA/ASR, EWR/ASR.

Maximum Range: 75 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna on a 261-degree course at 2000 feet. Pass over Newark ASR-3 radar antenna. Continue to the intersection of the 183-degree radial of the Allentown VOR. Make left turn and return on reciprocal course of 081 degrees. Pass over Newark ASR-3 radar antenna. Pass over LaGuardia ASR-3 radar antenna.

Flight 7. 081-degree course from LaGuardia ASR-3 radar antenna.

Purpose: Minimum-IFR-altitude beacon coverage of LGA/ASR, EWR/ASR.

Maximum Range: 60 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna on a 081-degree course at 2000 feet. At the intersection of Victor Airway 16 make left turn and return on the reciprocal course of 261 degrees. Pass over LaGuardia ASR-3 radar antenna.

Flight 8. 055-degree course from LaGuardia ASR-3 radar antenna.

Purpose: Minimum-IFR-altitude beacon coverage of the LGA/ASR. Clear radial from the radar site.

Maximum Range: 60 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna on a 055-degree course at 2000 feet. Continue to Waterbury, Conn. Make right turn and return on the reciprocal course of 235 degrees. Pass over LaGuardia ASR-3 radar antenna.

Flight 9. 235-degree course from LaGuardia ASR-3 radar antenna.

Purpose: Minimum-IFR-altitude beacon coverage of the LGA/ASR.

Maximum Range: 75 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna on a 235-degree course at 2000 feet. At the Echelon intersection make a left turn and return on the reciprocal course of 055 degrees Pass over LaGuardia ASR-3 radar antenna

Flight 10. 288-degree course from Idlewild FPS-8 radar.

Purpose: Medium-altitude beacon coverage of IDL/FPS-8, IDL/ASR, EWR/ASR.

Maximum Range: 130 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna at 10,000 feet on a 288-degree course. Pass over Newark ASR-3 radar antenna. Continue to the 180-degree radial of the Williamsport VOR. Make left turn and return on reciprocal course of 108 degrees. Pass over Newark ASR-3 radar antenna. Pass over Idlewild FPS-8 radar antenna.

Flight 11. 108-degree course from Idlewild FPS-8 radar.

Purpose: Medium-altitude beacon coverage of IDL/FPS-8, IDL/ASR, EWR/ASR. Clear radial from Newark radar site.

Maximum Range: 130 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna at 10,000 feet on a 108-degree course. Continue to the 230-degree radial of Nantucket VOR. Make left turn and return on reciprocal course of 288 degrees. Pass over Idlewild FPS-8 radar antenna.

NOTE: Pilots must obtain clearance to enter warning areas 105 and 106.

Flight 12. 340-degree course from Idlewild FPS-8 radar.

Purpose: Medium-altitude beacon coverage of IDL/FPS-8, IDL/ASR, LGA/ASR.

Maximum Range: 130 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna at 10,000 feet on a 340-degree radial. Pass over LaGuardia ASR-3 radar antenna. Continue to the Rockdale VOR. Make left turn and return on reciprocal course of 160 degrees. Pass over LaGuardia ASR-3 radar antenna. Pass over Idlewild FPS-8 radar antenna.

Flight 13. 190-degree course from Idlewild radar.

Purpose: Medium-altitude beacon coverage of IDL/FPS-8, IDL/ASR. Clear radials from both radar beacon sites.

Maximum Range: 130 nautical miles.

Procedure: Pass over Idlewild FPS-8 radar antenna at 10,000 feet on a 190-degree course. Continue to the 130-degree radial of the Kenton VOR. Make left turn and return on the reciprocal course of 010 degrees. Pass over Idlewild FPS-8 radar antenna.

NOTE: This course will also pass almost over the IDL/ASR-3 antenna site. Pilots must obtain clearance to enter warning area 107.

Flight 14. 055-degree course from LaGuardia radar.

Purpose: Medium-altitude beacon coverage of LGA/ASR and IDL/FPS-8 sites.

Maximum Range: 125 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna at 10,000 feet on a course of 055 degrees. Continue to the 185-degree radial of the Gardner VOR. Make left turn and return on reciprocal course of 235 degrees. Pass over LaGuardia ASR-3 radar antenna.

Flight 15. 235-degree course from LaGuardia radar.

Purpose: Medium-altitude beacon coverage of LGA/ASR and IDL/FPS-8 sites:

Maximum Range: 150 nautical miles.

Procedure: Pass over LaGuardia ASR-3 radar antenna at 10,000 feet on a course of 235 degrees. Continue to the 107-degree radial of the Baltimore VOR. Make left turn and return on the reciprocal course of 055 degrees. Pass over LaGuardia ASR-3 radar antenna.

NOTE: Continue flight to 150 miles even if target fades from the N. Y. Center's beacon display. Local obstructions may cause temporary loss of signal at some intermediate distance. Pilots must obtain clearance to enter restricted area R-54. Obtain clearance through the Washington ATC Center.

Flight 16. 40 nautical mile orbit.

Purpose: Minimum-IFR-altitude beacon coverage and reflections for IDL/FPS-8, IDL/ASR, LGA/ASR, EWR/ASR.

Maximum Range: Nominal 40-nautical miles from centrally located point between IDL-LGA-EWR.

Procedure: Pass over Wilton VOR at 3000 feet on a heading of 320 degrees. Aircraft will be vectored along orbital course by Idlewild controller. Check points along orbit as follows:

a. South edge of West Point City.

b. 1 mile southeast of Chester.

c. 1 mile southeast of Sussex.

d. 1 mile east of Newton.

e. Hackettstown.

f. 1 mile east of Belle Mead VOR intersection.

g. Princeton-Nassau Airport.

h. Lakewood fan marker.

i. 1 mile south of Point Pleasant VOR intersection.

j. 5 miles southeast of Woolf VOR intersection.

k. 1 mile east of Fire Island VOR intersection.

l. 1 mile east of St. James VOR intersection.

m. 6 miles southwest of Bridgeport Airport.

n. Wilton VOR.

Altitudes on orbit will follow minimum-IFR-clearances as follows:

3000 feet - Wilton VOR to 105° radial of the Stillwater VOR.

2500 feet - 105° radial of Stillwater VOR to 066° radial of Yardley VOR.

1500 feet - 066° radial of Yardley VOR to 095° radial of Idlewild VOR.

1600 feet - 096° radial of Idlewild VOR to 276° radial of Riverhead VOR.

2000 feet - 276° radial of Riverhead VOR to Wilton VOR.

<u>Flight 17.</u> 6-mile orbit at Idlewild FPS-8.

<u>Purpose:</u> To locate and record beacon reflections around the IDL/FPS-8 site.

Maximum Range: 6 nautical miles.

Procedure: Follow instructions from radar controller at the IDL/ASR-3 during the 6-mile orbit. Make flight at 2000 feet.

Flight 18. 6-mile orbit at Idlewild ASR-3.

Purpose: To locate and record beacon reflections around the IDL/ASR site.

Maximum Range: 6 nautical miles.

Procedure: Follow instructions from radar controller at the LGA/ASR-3 during the 6-mile orbit. Make flight at 2000 feet.

Flight 19. 6-mile orbit at Newark.

Purpose: To locate and record beacon reflections around the EWR/ASR-3 site.

Maximum Range: 6 nautical miles.

Procedure: Follow instructions from radar controller at the EWR/ASR-3 during the 6-mile orbit. Make flight at 2000 feet.

Flight 20. 6-mile orbit at LaGuardia.

Purpose: To locate and record beacon reflections around the LGA/ASR-3 site.

Maximum Range: 6 nautical miles.

Procedure: Follow instructions from radar controller at the LGA/ASR-3 during the 6-mile orbit. Make flight at 2000 feet.

3. Weather Conditions: VFR.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

1 normal transponder.

1 spare transponder.

VHF communications on 123.5 Mc.

2. Ground

Idlewild FPS-8

1 tape recorder at controller's direct view PPI scope.

1 35-mm camera in maintenance room on PPI scope.

VHF communications on 123.5 Mc.

1 VIE feeding controller scope and camera scope.

1 intercom unit between controller and cameraman.

Idlewild, LaGuardia, Newark ASR-3

At each site:

1 tape recorder at controller PPI scope.

1 16-mm camera in equipment room on VE PPI scope.

VHF communication between controller and aircraft on 123.5 Mc.

1 VIE feeding both controller and camera scopes (VIE set to display beacon only).

1 intercom between controller and camera position or Gonset receiver on 123.5 Mc at camera position.

D. PERSONNEL REQUIREMENTS

1. Aircraft

2 pilots.

2. Ground

Idlewild FPS-8

2 controllers.

1 engineer.

Idlewild, LaGuardia, Newark ASR-3

1 controller at each site.

1 engineer or technician at each site.

E. DUTY REQUIREMENTS

1. Aircraft

Pilots follow flight plan of radial flights and orbits. Ground controllers will provide guidance and heading corrections as required. Use radio communications on 123.5 Mc.

2. Ground

Idlewild FPS-8

Controller: Control and guide aircraft during tests. Grade the PPI target on each antenna scan and make verbal recording on tape recorder and written record on data sheets.

Engineer: Operate 35-mm camera in maintenance room. Responsible for operation of tape recorder at controller position. Record controller's comments and radio communications. Synchronize all clocks used at all radar sites (including camera clocks). Check out intercom between camera position and controller. Camera must photograph the maximum sweep range except during the 6-mile orbit. The azimuth bezel on the PPI must be correct and illuminated for photographic recording.

Idlewild, LaGuardia, Newark ASR-3

Controller: Guide aircraft during 6-mile orbit around site. Grade the PPI target on each antenna scan when within range of scope. Make verbal recording on tape recorder and written record on data sheets.

Engineer: Operate 16-mm camera in equipment room. Responsible for operation of tape recorder. Record controller's comments and radio communications. Synchronize clocks with Idlewild FPS-8. Check operation of intercom between camera position and controller. Start and stop camera and tape recorder when aircraft is within range of equipment. Camera must photograph the maximum sweep range except during the 6-mile orbit. The azimuth bezel on the VE scope must be correct and illuminated for photographic recording.

ANTENNA PATTERN AND REFLECTIONS (Technical Test 2)

A. OBJECTIVE

To obtain a complete recording of the combined effects of antenna side lobes and site reflections. The data will be used to plot an effective interrogation area for each antenna and site configuration, and will also give data on aircraft locations causing reflections. The persistence or angular extent of each reflection will be obtained from the many antenna patterns plotted by this method. A cross-correlation with photographed pulse data will also be made concerning the location and magnitude of the reflections. The vertical antenna pattern will be recorded during one radial flight from 0 to 10 miles made on a clear azimuth.

B. OPERATION FLIGHT PLAN

1. Aircraft Requirements: One DC-3 (TDC/N-182).
2. Flight Pattern: Two 6-mile orbits around each site and one 10-mile radial flight at 2000 feet.
3. Weather Conditions: VFR.
4. Flight Time: 1 hour at each site. Total of 4 hours at New York.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

   1 Maxson 25-watt CW oscillator on 1030 Mc.
   1 standby 8-watt CW oscillator on 1030 Mc.
   1 calibrated wavemeter for 1030 Mc.
   1 microammeter for wavemeter indicator (Simpson 260).
   VHF communications on 123.5 Mc.

2. Ground

   1 GR receiver connected to beacon antenna.
   1 Visicorder chart recorder and latensifier.

1 HP Signal Generator.

1 calibrated wavemeter for 1030 Mc.

1 microammeter for wavemeter indicator (Simpson 260).

VHF communications at controller scope and at transmitter site on 123.5 Mc.

D. PERSONNEL REQUIREMENTS

1. Aircraft

2 pilots.

1 engineer.

2. Ground

1 controller at ASR scope.

2 engineers at transmitter site.

E. PERSONNEL DUTIES

1. Aircraft

Pilots to fly 6-mile circles at 2000 feet around each of the four beacon sites and one radial flight from 0 to 10 miles at the following azimuths: IDL/FPS-8 - 190°; IDL/ASR-3 - 190°; LGA/ASR-3 - 055°; EWR/ASR-3 - 108°. Engineer to set oscillator on 1030 Mc and monitor operation. Flights to be made at one site and then the aircraft will return to the airport while the recording equipment is moved to the next test site.

2. Ground

Controller to advise pilot of his distance and azimuth for each 10 degrees during orbit by use of ASR-3 radar target. Engineers will operate recorder, mark the recording with azimuth and range data as received on the Gonset radio receiver. After each test the recording equipment must be moved to the next transmitter site. A signal level calibration must be placed on the pattern recording before and after each flight. The tuning of the GR receiver will be accomplished by setting the signal generator on frequency by use of the frequency meter. The GR receiver can then be tuned to the signal generator.

F. DATA RECORDING FORM

Visicorder recording of antenna pattern with aircraft azimuth and range notations. Also signal level calibration at start and end of each run.

SYSTEM PERFORMANCE IN DENSE ENVIRONMENT (Technical Test 3)

A. OBJECTIVE

To simulate New York area high-density air traffic with beacon-equipped aircraft using maximum beacon environment, without fixes. Obtain data on fruit rates, interrogation rates, and AOC action under worst possible conditions.

B. OPERATIONS

1. Aircraft Required

   a. ADC jet aircraft from Griffiss, McGuire, Otis, Stewart, and Suffolk AFB.

   b. 15 to 20 CAA, TDC, and AMB aircraft plus 1 to 5 RADC aircraft.

   c. 1 TDC aircraft, recorder equipped.

   d. Random air carriers, beacon equipped.

2. Flight Patterns and Routes

   a. ADC Jet Aircraft

Five racetrack courses have been devised for the ADC aircraft. Three aircraft will follow a racetrack course at one altitude while maintaining about 5-mile longitudinal separation between aircraft. Each racetrack will contain a maximum of 10 such groups stacked at 2000 feet separation, from 20,000 to 40,000 feet. A maximum of 30 aircraft can therefore occupy a racetrack stack and the five courses plotted for this test can accommodate a total of 150 aircraft.

(1) Riverhead-Woolf (aircraft based Suffolk)

Aircraft arrive on station at Riverhead VOR at proper altitudes. Proceed 230 degrees on V16 to Woolf. Right-hand 180-degree turn to heading 050 degrees, proceed Riverhead. Right-hand 180-degree turn and repeat course.

(2) Bridgeport-Syosset (aircraft based Otis)

Aircraft arrive on station at Bridgeport at proper altitudes. Proceed heading 234 degrees on V167 to Syosset intersection (north shore of Long Island). Right-hand 180-degree turn at Syosset to heading 054 degrees and return to Bridgeport. Repeat racetrack.

(3) Monmouth-Idlewild (aircraft based McGuire)

Aircraft arrive on station at Monmouth, Proceed heading 044 degrees on V1 V140 to Idlewild. (Do not proceed beyond Idlewild.) Right-hand 180-degree turn at Idlewild to 224 degrees and return to Monmouth. Repeat racetrack.

(4) Newark-Yardley (aircraft based Stewart)

Aircraft arrive on station at Newark. Proceed heading 246 degrees on V239 to Yardley. Right-hand 180-degree turn at Yardley to 066 degrees heading and return to Newark. Repeat racetrack.

(5) Paterson-Branchville (aircraft based Griffiss)

Aircraft arrive on station at Paterson RBn. Proceed heading 307 degrees on V36 V116 to Branchville. Right-hand 180-degree turn at Branchville to 127-degree heading and return to Paterson RBn. Repeat racetrack.

b. CAA, AMB, TDC, and RADC Aircraft

Flight plans for CAA, AMB, TDC, and RADC aircraft are intended to simulate standard approach procedures at the three New York fields. Altitude assignments to be made by Center controllers.

Depart IDL heading 000 degree to LaGuardia range.

Left turn over LGA range heading 290 degrees to Teterboro.

Left turn over Teterboro heading 217 degrees on ILS approach to Newark.

Overfly Newark.

Depart Newark on southwest-bound ILS course.

Left 90-degree turn to intercept LGA ILS at Walling.

Left turn to heading 044 degrees on ILS approach to LGA.

Overfly LGA to LGA range.

Right turn to heading 096 degrees to Syosset.

Right turn to heading 204 degrees to Lido.

Right turn to heading 224 degrees to intercept 110-degree bearing from Colts Neck VOR.

Right turn to heading 304 degrees to intercept southwest course of Idlewild ILS at Red Bank.

Right turn to 043 degrees ILS approach to Idlewild.

Land at Idlewild or continue loop to home base.

3. Weather Conditions

Visual flight rules.

4. Flight Time Required

a. ADC Jet Aircraft

Approximately 60 minutes in racetrack, depending on base of origin.

b. CAA and Other Aircraft

1 hour and 15 minutes per pattern.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

a. ADC Jet Aircraft

Standard military transponder, Code 00.

b. CAA, TDC, AMB, and RADC Aircraft

Standard ATCRBS transponder, Code 77 unless otherwise requested.

c. TDC Recording Aircraft

Standard calibrated transponder, Code 34. Modified calibrated transponder with transmitter disabled--two antennas may be required for isolation of reply signals from standard transponder. Reply on Code 34 should not trigger modified transponder.

Pulse counter to count interrogation rate at output of decoder in modified transponder. Pulse counts to be recorded with minimum display time for readout.

AOC level readout on calibrated E-A recorder on unmodified transponder. Reply rate count on unmodified transponder.

Tape recorder to record interrogation PRF's and duration.

Tape recorder to record pulse counts, position, and other data comments.

2. Ground

a. EWR Tower

VE scope with 16-mm camera (in equipment room).

Interrogator ON, GTC ON, defruiter normally in STANDBY.

Observer scope (may be controller's scope).

Tape recorder at controller's position.

Telephone line to IDL Center.

Intercom, IFR room to equipment room.

b. LGA Tower

VE scope with 16-mm camera (in equipment room).

Observer scope (may be controller's scope).

Tape recorder at controller's position.

Intercom, IFR room to equipment room.

Pulse counter - count fruit with transmitter OFF.

Interrogator normally ON, GTC OFF, defruiter normally in STANDBY.

Interrogator OFF for short intervals for fruit pulse count.

Telephone line to IDL Center.

c. IDL Tower

VE scope with 16-mm camera (in equipment room).

Interrogator ON, GTC ON, defruiter normally in STANDBY.

Observer scope (may be controller's scope).

Tape recorder at controller's position.

Intercom, IFR room to equipment room.

Telephone line to IDL Center.

d. IDL Center

One direct-view controller scope.

One VG scope with emergency alarm.

Interrogator normally ON, GTC OFF, defruiter in STANDBY.

Two direct-view scopes with 35-mm camera.

Pulse counter and printer at maintenance room position.

Tape recorder at controller's position.

AG communications channel for test.

Interphone between Center and EWR, IDL, LGA Towers.

Intercom between controller's position, maintenance room, radar transmitter site.

e. All Other User Sites

Operating log of ON times, mode of operation, PRF, rotation rate, power output, estimate of display clutter.

D. PERSONNEL REQUIREMENTS

1. Aircraft

TDC recording aircraft: Flight Observer, Engineer, 2 Pilots, Technician.

2. Ground

a. EWR Tower

Tower Controller, 1 Camera Technician.

b. LGA Tower

Tower Controller, 1 Camera Engineer,
1 Transmitter Site Technician.

c. IDL Tower

Tower Controller, 1 Camera Technician.

d. IDL Center

6 Controllers and 3 Test Monitor Engineers,
1 Camera Engineer, 1 Transmitter Site Technician.

E. PERSONNEL DUTIES

1. Aircraft

a. TDC Recording Aircraft

Transponder on Code 34. Flight Observer, Engineer, and Technician to monitor special equipment, record pulse counts, voice record aircraft position, communication and any data comments.

2. Ground

a. EWR Tower

(1) Controller

Operate interrogator Mode 3, decoders on "all aircraft," record comments on fruit level and record air-ground (AG) communications. Switch defruiter ON (single and double) as required for 1 minute in each position. Notify equipment room at change of function.

(2) Camera Technician

Operate 16-mm camera on VE display, maintain operations log, record frame number at start of each defruiter setting, photograph "Beacon Only," using 30-mile range on VE. Photograph "Beacon-Radar Mixed" for short intervals when defruiter is in STANDBY. Set up tape recorder and check out intercom system.

b. LGA Tower

(1) Transmitter Site Technician

Operate Interrogator ON-OFF switching as requested by camera engineer.

(2) Controller

Interrogator on Mode 3, decoder on "all aircraft," record comments on fruit level and record AG communications. Switch defruiter ON (single or double) as required, for 1 minute in each position. Notify equipment room of function change.

(3) Camera Engineer

Operate 16-mm camera on VE, maintain operations log, record frame number at start of each defruiter or GTC setting. Photograph Beacon Only, 30-mile range. Photograph Beacon-Radar Mixed for short intervals when defruiter is in STANDBY.

Set up tape recorder; make and record fruit pulse counts during transmitter OFF periods.

c. IDL Tower

(1) Controller

Interrogator on Mode 3, decoder on "all aircraft." Record comments on fruit level and record AG communications. Switch defruiter to ON (single or double) as required, for 1 minute in each position. Notify equipment room of function change.

(2) Camera Technician

Operate camera, maintain operations log, record frame number at start of each defruiter setting, photograph "Beacon Only" on 30-mile range. Switch to "Beacon-Radar Mixed" display on VE while defruiter is in STANDBY for short intervals. Set up tape recorder. Check intercom.

d. IDL Center

(1) Transmitter Site Technician

Interrogator normally ON. Defruiter in STANDBY. GTC switch OFF. Disable transmitter on request from Test Monitor.

(2) Controller

Control 15 to 20 CAA, AMB, and RADC aircraft on preset courses. Interrogator ON, Mode 3. Monitor "all aircraft." Record AG communications.

(3) Test Monitor

Coordinate all test activities--reschedule tests as required. Maintain voice record of test notes. Monitor EWR, LGA, IDL Towers test procedures. Coordinate controller, photographer, test site technician activities. Require test site technician to disable Interrogator transmitter at regular intervals.

(4) Photographer (maintenance room)

Beacon Control Box Mode 3, all aircraft. Coordinate with test monitor, set PPI to maximum range display (150 miles). View Beacon Video only. Photograph scan-for-scan, using 35-mm camera; record frame numbers: start, stop test; transmitter ON-OFF periods; operate counter and printer during transmitter OFF periods. Set up tape recorder. Check intercom.

(5) Photographer (high-altitude control PPI)

Beacon Control Box Mode 3, all aircraft and selected Code 77. Coordinate with Test Monitor; set display to 80-mile range (occasional 150-mile); view "Beacon-Radar Mixer"; photograph scan-for-scan using 35-mm camera; record frame numbers: start, stop test; transmitter ON-OFF periods.

F. DATA TO BE OBTAINED

1. Aircraft

TDC Aircraft

Interrogation rate (pulse counts).

Reply rate (pulse counts).

Interrogation PRF's and duration (on tape) and time.

Transponder AOC level (E-A recorder).

Aircraft position.

Observer's comments (on tape).

2. Ground

a. EWR Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixed" displays. Log of camera operations, display conditions, and defruiter settings. Controller's air-ground communications, comments.

b. LGA Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixer" displays. Log of camera operations, display conditions; controller's air-ground communications, comments; transmitter ON-OFF times; log of pulse counter readings correlated with operating conditions.

c. IDL Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixed" displays; log of camera operations, display conditions, and defruiter settings. Controller's air-ground communications, comments.

d. IDL Center

Photographs of maintenance room PPI, "Beacon Only," log of camera operations, display range, transmitter ON-OFF periods. Printer record of fruit pulse counts. Photographs of high-altitude control PPI, "Beacon-Radar Mixed." Controller's AG communications, comments. Test monitor's log of operations, recorded comments.

G. DATA RECORDING FORMS

1. Tape Recorders

   One at each controller's position (4).

   Two in TDC aircraft.

   Record test number, location, date and time, roll number.

2. Test Monitor and Observer's Date

   Log of operations. Test number, location, date and times, tape roll number.

   All test comments of import.

3. Camera Recording (scan-for-scan exposures)

   16-mm on EWR Tower VE, "Beacon Only," 30-mile range; part-time "Beacon-Radar Mixed" when defruiter is in STANDBY.

16-mm on LGA Tower VE, "Beacon Only," 30-mile range; part-time "Beacon-Radar Mixed" when defruiter is in STANDBY.

("Beacon Only" during transmitter OFF periods for pulse counts of fruit.)

16-mm on IDL Tower VE, "Beacon Only," 30-mile range; part-time "Beacon-Radar Mixed" when defruiter is in STANDBY.

35-mm at IDL Center maintenance room PPI, "Beacon Only," 150-mile range; synchronized with pulse counter and printer.

35-mm at IDL Center high-altitude control PPI, "Beacon-Radar Mixed," 80-mile range (switch to 150-mile range occasionally).

BEACON EMERGENCY DISPLAYS (Technical Test 4)

A. OBJECTIVE

To compare the 4-pulse military emergency display with the civil selected-code emergency display. (Combine with Technical Test No. 5 for density effects.)

B. OPERATIONS

1. Aircraft Required to Conduct Test

    a. 1 TDC aircraft, Idlewild based.

    b. 1 RADC aircraft, Mitchel based.

2. Flight Patterns and Routes

    a. TDC Aircraft

Depart IDL 335 degrees to LGA middle marker, 295 degrees CDW, 204 degrees New Brunswick, 124 degrees COL, 064 degrees Scotland, 043 degrees IDL and land. (Emergency to be declared at some preset point unknown to controller who is to detect and guide aircraft to base, using emergency code.)

b. RADC Aircraft

Depart Mitchel 310 degrees to LGA range, 285 degrees CDW, 204 degrees New Brunswick, 124 degrees COL, 064 degrees Scotland, 043 degrees IDL, 095 degrees Mitchel and land. (Emergency to be declared at some preset point unknown to controller who is to detect and guide aircraft to base, using emergency display.)

3. Weather Conditions

Visual flight rules.

4. Flight Time

a. CAA

110 miles, 50 minutes.

b. RADC

160 miles, 1 hour.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

a. CAA Aircraft

Standard common system transponder with control panel labeled for a particular emergency code.

b. RADC Aircraft

Standard military transponder with I/P (twice repeated code reply) and emergency (four times repeated code reply) functions. Aircraft must have KY95A coder to operate Mode 3 emergency.

2. Ground

a. IDL Center

One direct-view controller scope with emergency display (35-mm camera and hood). One VG scope with emergency alarm and display.

Tape recorder at controller's position.
AG channel for test.

Modified decoder for selected emergency code - "Bloomer" display.

Modified decoder for 4 pulse military emergency code.

D. PERSONNEL REQUIREMENTS

1. Aircraft

a. TDC Aircraft

2 pilots.

b. RADC Aircraft

2 pilots.

2. Ground

IDL Center

Controller.

Camera Engineer.

Observer.

E. PERSONNEL DUTIES

1. Aircraft

a. TDC Aircraft

Follow assigned flight plan.

Declare emergency by use of assigned emergency code at specified point in flight path.

Respond to request for I/P.

b. Military Aircraft

Follow assigned flight plan.

Declare emergency by use of standard military emergency reply at specified point in flight path.

Respond to request for I/P.

2. Ground

IDL Center

a. Camera Engineer

Set up and monitor 35-mm camera on 80-mile range, Beacon-Radar Mixed; set up tape recorder; check intercom.

b. Controller

Maintain tape record of test, AG communications, and comments. Direct test aircraft through the assigned flight paths. Watch for emergency display. Direct aircraft through emergency procedure. View "Beacon-Radar Mixed." Request I/P several times of both military and civil aircraft during early part of test.

c. Test Monitor

Time controller's ability to recognize and locate emergency displays; observe and record occurrence of garble and difficulty in tracking emergency aircraft due to interrogation countdown.

F. DATA TO BE OBTAINED

1. Aircraft

None.

2. Ground

IDL Center

Test monitor's record of controller's ability to recognize and locate emergency displays. Test monitor's comments and notes. Controller's comments on ease of recognition and location. Film record of both operations on beacon-radar mixed video.

G. DATA RECORDING FORMS

1. Tape Recording

At controller's position; record of communications with test aircraft, comments.

2. Observer's Data

Form to indicate time emergency reply first appears; time of recognition and location by controller.

3. Camera Recording

35-mm film labeled with test number and date.

SYSTEM PERFORMANCE IN DENSE ENVIRONMENT (Technical Test 5)

A. OBJECTIVE

To simulate New York area high-density air traffic with beacon-equipped aircraft using maximum beacon environment. Civil I/R units equipped with GTC and defruiting fixes. Obtain data on fruit rates and interrogation rates under improved conditions. Observe civil and military emergency codes in dense environment with defruiter ON. On last half of the flight test the Army ground environment will be turned off.

B. OPERATIONS

Same as Technical Test 3.

C. EQUIPMENT REQUIREMENTS

Same as Technical Test 3.

D. PERSONNEL REQUIREMENTS

Same as Technical Test 3.

E. PERSONNEL DUTIES

Same as Technical Test 3.

F. DATA TO BE OBTAINED

Same as Technical Test 3.

G. DATA RECORDING FORMS

Same as Technical Test 3.

AZIMUTH AND RANGE RESOLUTION (Technical Test 6)

A. OBJECTIVE

To measure the azimuth and range resolution of the beacon system, and provide data on killing action and false targets resulting from code overlap. (Operational tests of I/P function to be combined with this test.)

B. OPERATIONS

1. Aircraft Required

2 CAA aircraft.

2. Flight Pattern and Routes

The test course consists of an outbound radial from the ground site, an orbital arc at long range, an inbound radial, and a short-range orbit. The test aircraft will maintain visual contact with each other and perform closing maneuvers as directed by the controller.

a. Depart IDL 054 degrees V167 to Bridgeport, 165 degrees to Mastic, 275 degrees V30 toward IDL.

b. At about 5 miles from IDL, left turn into CW orbit about IDL.

c. At 054 degrees from IDL, repeat course to Bridgeport, Mastic, and return IDL, land IDL.

3. Weather

Visual flight rules.

4. Flight Time

2 hours.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

VHF communications.

VOR-DME.

Normal calibrated transponder.

Tape recorder for observer's comments.

2. Ground

a. IDL Center

Operating interrogator, with calibrated GTC.

Defruiter ON, single or double, as required.

Decoder set on select code and C/S.

VG display for controller.

Direct view PPI display for controller.

Direct view PPI for photography (in maintenance room).

35-mm camera and hood.

Tape recorder at controller's position.

Interphone to IDL tower.

b. IDL Tower

Interrogator ON, with calibrated GTC.

Defruiter ON, single or double, as required.

VE PPI for photography (in equipment room).

Set decoder for ALL AC operation only.

16-mm camera and hood.

Tape recorder for observer comments.

D. PERSONNEL REQUIREMENTS

1. Aircraft

CAA Aircraft

2 pilots.
Observer.

2. Ground

a. IDL Center

Controller.
Test Monitor.
Camera Engineer.

b. IDL Tower

Controller-Observer.
Camera Engineer.

E. PERSONNEL DUTIES

1. Aircraft

Pilot

Depart IDL, following test course outlined, maintaining visual contact with other test aircraft. Both aircraft maintain assigned altitude, headings, and airspeeds. Pilots will perform closing maneuvers on controller's request, and report separating distances. Code 77 set in both aircraft on outbound radial and code 00 used in both aircraft on inbound radial.

2. Ground

a. IDL Center

(1) Controller

Outbound radial, direct aircraft in closing and opening lateral separation maneuvers. Set decoder select code 77 and C/S.

Arc (Bridgeport to Mastic), direct aircraft in longitudinal separation and vertical separation maneuvers.

Inbound radial, direct aircraft in lateral separation and vertical separation maneuvers. Set decoder to select code 00 and C/S.

Five mile orbit, direct aircraft in lateral, longitudinal, and vertical separation maneuvers.

Repeat course and settings, reversing maneuvers as outlined below.

Outbound radial: longitudinal separation.
Arc: lateral separation.
Inbound radial: longitudinal separation.
Record all communications.

(2) Test Monitor

Observe controller's scope, enter observations on tape recorder. Provide correlation with IDL Tower test personnel.

(3) Camera Engineer

Operate scope controls and camera to obtain record of transponder replies. Scope settings: 80-mile range, beacon only.

Maintain log of frame numbers corresponding to closing maneuvers as they are performed.

b. IDL Tower

Camera Engineer

Operate scope controls and camera to obtain record of transponder replies. Set decoder to All AC for entire run. Select code is off. 50-mile-range display "beacon only" on Bridgeport-Mastic Arc. 30-mile-range normally used for rest of test.

F. DATA TO BE OBTAINED

1. Aircraft

Pilot report separation distances during closing maneuvers. Observers comments on tape recording.

2. Ground

a. IDL Center

Test monitor notes quality of targets during closing maneuvers; records resolution of display corresponding to pilot's report of separation distances; records any irregularities or garbling.

Photographs of direct-view scope with record of frame numbers at start of each closing maneuver.

b. IDL Tower

Photographs of direct-view scope with record of frame numbers at start of each closing maneuver.

G. DATA RECORDING FORMS

1. Tape Recording

Recorder at IDL Center Controller's position; air-ground communications; controller's notes; observer's notes. List roll number, section number, title of test, date and time.

Recorder at IDL Tower observer position: observer notes, roll number, section number, title of test, date and time.

Recorder in aircraft: same as at IDL Tower.

2. Observer's Data

Test monitor at IDL Center will maintain data sheet recording titled test, date and time, quality and resolution of targets (scan-by-scan) during closing maneuvers. Final data on film record.

3. Camera Recording

a. IDL Center

Scan-for-scan photography on DV, using same display range as controller. Record number of film roll, test starting and ending frame, starting frame of each closing maneuver. Azimuth Bezel and calibrated range marks must be visible in film record.

b. IDL Tower

Scan-for-scan photography on VE, 50-mile range. Record number of film roll, test starting and ending frame, starting frame of each closing maneuver. Azimuth Bezel and calibrated range marks must be visible in film record.

FALSE CODES AND KILLING EFFECTS (Technical Test 7)

A. OBJECTIVE

To evaluate false code generation or killing effects caused by reflections based on high-speed camera data on individual reply pulse trains.

B. OPERATIONS

1. Aircraft Required

1 CAA aircraft, with normal calibrated transponder.

2. Flight Pattern and Routes

The test aircraft will perform 6 to 10 mile radius orbits about the ground station and run several radials similar to the coverage tests at the Idlewild ASR-3 site.

3. Weather Conditions

Visual flight rules.

4. Flight Time Required

2 hours.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

Normal calibrated transponder.

VHF communications.

2. Ground

VHF communications.

High-speed camera on A-scope display.

A-scope display at decoder input.

2 pulse counters and printers to count outputs of decoder selected code and bracket decoding channels before mixing.

Tape recorder.

Delayed trigger generator for A-scope presentation and camera trip.

D. PERSONNEL REQUIREMENTS

1. Aircraft

2 pilots.

2. Ground

1 Controller.

1 Camera Engineer.

1 Observer.

E. PERSONNEL DUTIES

1. Aircraft

Pilots

Follow assigned course.

Select transponder reply code as directed by controller (Code 40).

2. Ground

a. Controller

Direct aircraft. Record all communications, comments.

b. Camera Engineer

Photograph A-type oscilloscope display. Operate counter and printer.

c. Observer

Evaluate quality of code replies on display; record missed replies. Maintain delayed trigger for proper target centering.

F. DATA TO BE OBTAINED

Photographs of A-scope display showing incoming reply structure. Count of proper code structures passed by decoder per scan.

G. DATA RECORDING FORMS

1. Tape Recording

At controller's position - record of communications, comments.

2. Observer's Data

Record of scan-for-scan quality of received replies.

3. Camera Recording

High-speed camera on A-scope, photographs of reply code structure applied to decoder.

SIDE-LOBE-SUPPRESSION SYSTEM (Technical Test 8)

A. OBJECTIVE

To simulate New York area high-density air traffic with beacon-equipped aircraft using SLS equipped beacon environment (includes 14 sites). Civil I/R units equipped with GTC, defruiting, and Setrin side-lobe-suppression system. Obtain data on fruit rates and interrogation rates under improved conditions, with SLS (defruiter ON and OFF) and without SLS (defruiter OFF) operating.

B. OPERATIONS

Same as Technical Test 3.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

a. ADC Jet Aircraft

Standard military transponder, Code 00.

b. CAA, TDC, AMB, and RADC Aircraft

Standard ATCRBS transponder, Code 77.

c. TDC Recording Aircraft

Standard calibrated transponder, Code 34.

Modified calibrated transponder--transmitter disabled--two antennas may be required for isolation of reply signals from standard transponder. Reply on Code 34 should not trigger modified transponder.

Pulse counter to count valid interrogation rate at output of decoder in modified transponder. Interrogations per second to be recorded with minimum display time for readout.

Pulse counter to count SLS coincident pulse outputs on modified transponder.

Tape recorder to record interrogation PRF's and duration.

Tape recorder to record pulse counts, position, and other data comments.

2. Ground

a. EWR Tower

VE scope with 16-mm camera (in equipment room). Interrogator with calibrated GTC operating. Defruiting equipment ON, single and double, as required. Observer scope (may be controller's scope). Tape recorder at controller's position. Intercom, IFR room to equipment room. Setrin SLS system. Telephone line to IDL Center.

b. LGA Tower

VE scope with 16-mm camera (in equipment room). Interrogator ON with calibrated GTC operating. Defruiting equipment normally OFF - ON only during part of SLS-ON time. Observer scope (may be controller's scope). Tape recorder at controller's position. Intercom, IFR room to equipment room. Pulse counter to count fruit with transmitter OFF. Setrin SLS system ON and OFF. Defruiter OFF.

c. IDL Tower

VE scope with 16-mm camera (in equipment room). Interrogator with calibrated GTC ON. Defruiting equipment normally OFF - ON only during part of SLS-ON time. Observer scope (may be controller's scope). Tape recorder at controller's position. Intercom, IFR room to equipment room. Setrin SLS system.

d. IDL Center

One direct-view controller scope. Interrogator with calibrated GTC ON. Defruiting equipment normally off--on only during part of SLS-ON time. One VG scope with emergency alarm. Two direct-view scopes with 35-mm camera (one at High-Altitude control position, one in maintenance room). Pulse counter and printer at maintenance room position. Tape recorder at controller's position. AG communications channel for test. Interphone between Center and EWR, IDL, LGA Towers. Intercom between controller's position, maintenance room, radar transmitter site. Setrin SLS system.

e. <u>All Other User Sites</u>

Setrin SLS system - operating log of on times, mode of operation PRF, rotation rates power output, estimate of display clutter.

D. PERSONNEL REQUIREMENTS

Same as Technical Test 3.

E. PERSONNEL DUTIES

1. Aircraft

TDC Recording Aircraft

Transponder on Code 34. Flight Observer, Engineer, and Technician to monitor special equipment, voice record aircraft position, record interrogation and suppression counts, communication and any data comments.

2. Ground

a. EWR Tower

(1) Transmitter Site Technician

Switch SLS from OFF to ON at preset time.

(2) Controller

Operate interrogator Mode 3, decoders on "all aircraft" and "select" Code 77. Record fruit-level comments and AG communications. Switch defruiter from OFF to ON during SLS-ON time as required. Notify equipment room of changes.

(3) Camera Technician

Operate 16-mm camera on VE, maintain operations log, record frame number at start of each new function, photograph "Beacon Only," 30-mile range on VE. Photograph "Beacon-Radar Mixed," for short intervals. Set up tape recorder - check intercom.

b. LGA Tower

(1) Transmitter Site Technician

Operate interrogator ON-OFF switching; operate SLS system ON-OFF switching at preset time.

(2) Controller

Interrogator on Mode 3, decoder on "all aircraft" and "select" Code 77. Record comments on fruit levels and AG communications. Switch defruiter from OFF to ON during SLS-ON time as required.

(3) Camera Engineer

Operate 16-mm camera on VE, maintain operations log, record frame number at start of each new function. Photograph "beacon only" 30-mile range. Photograph "Beacon-Radar Mixed," for short intervals. Set up tape recorder - check intercom.

c. IDL Tower

(1) Transmitter Site Technician

Switch SLS from OFF to ON.

(2) Controller

Interrogator on Mode 3, decoder on "all aircraft" and "select" Code 77. Switch defruiter from OFF to ON during SLS-ON time as required.

(3) Camera Technician

Operate camera, maintain operations log, record frame number at start of each new function, photograph "Beacon Only" on 30-mile range. Switch to "Beacon-Radar Mixed" display on VE for short intervals. Set up tape recorder. Check intercom.

d. <u>IDL Center</u>

(1) <u>Transmitter Site Technician</u>

Interrogator normally ON; defruiter normally OFF, GTC ON; disable transmitter for pulse counts. SLS system switched from OFF to ON at preset time.

(2) <u>Controller</u>

Control 15 to 20 CAA, AMB, and RADC aircraft on preset courses. Interrogator "ON" Mode 3. Monitor "all aircraft" and "select" Code 77. Record AG communications and display comments.

(3) <u>Test Monitor</u>

Maintain voice record of test notes. Coordinate all test activities - reschedule as required. Monitor EWR, LGA, and IDL Tower test procedures. Coordinate controller-photographer and test site. Technician activities require test site technician to disable Interrogator transmitter at regular intervals. Coordinate SLS OFF to ON switching time.

(4) <u>Photographer (maintenance room)</u>

Beacon Control Box Mode 3, "all aircraft" and "select" Code 77; coordinate with test monitor; set PPI to maximum range display (150 miles); view Beacon Video Only; photograph scan-for-scan, using 35-mm camera; record frame numbers, start and stop test, SLS ON-OFF periods, and transmitter ON-OFF periods; operate counter and printer during transmitter OFF periods. Set up tape recorder. Check intercom.

(5) <u>Photographer (high-altitude control PPI)</u>

Beacon Control Box Mode 3, "all aircraft" and "select" Code 77; coordinate with test monitor; set display to 80-mile range (occasional 150-mile); view "Beacon-Radar Mixed," photographer scan-for-scan using 35-mm camera; record frame numbers: start, stop test; transmitter ON-OFF periods, SLS ON-OFF, defruiter ON-OFF.

F. DATA TO BE OBTAINED

1. Aircraft

TDC Aircraft

Interrogation rate (pulse counts).

Interrogation PRF's and duration (on tape).

Suppression coincidence rate (pulse count).

Aircraft position.

Observer's comments.

2. Ground

a. EWR Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixed" displays.

Log of camera operations, display conditions.

Controller's air-ground communications, comments.

b. LGA Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixed" displays.

Log of camera operations, display conditions, transmitter ON-OFF times, SLS ON-OFF times, defruiter ON-OFF times.

Controller's air-ground communications, comments.

Log of pulse-counter readings correlated with operating conditions.

c. IDL Tower

Photographs of VE (30-mile range) "Beacon Only" and "Beacon-Radar Mixed" displays.

Log of camera operations, display conditions.

Controller's air-ground communications, comments.

d. IDL Center

Photographs of maintenance room PPI, "Beacon Only."

Log of camera operations, display range, transmitter ON-OFF periods, SLS ON-OFF periods, defruiter ON-OFF periods.

Printer record of fruit pulse counts for various functions.

Photographs of High-Altitude Control PPI, "Beacon-Radar Mixed."

Log of camera operations, display range.

Controller's communications, comments.

Test monitor's log of operations, recorded comments.

G. DATA RECORDING FORMS

1. Tape Recorders

1 at each Controller's position (4).

2 in TDC aircraft.

Record test number, location date and time, roll number.

2. Test Monitor and Observer's Data

Log of operations. Test number, location, date and time, tape roll number. All test comments of import.

3. Camera Recording (scan-for-scan exposures)

16 mm on EWR Tower VE, "Beacon Only," 30-mile range.

16 mm on IDL Tower VE, "Beacon Only," 30-mile range.

16 mm on LGA Tower VE, "Beacon Only," 30-mile range, switch to "Beacon-Radar Mixed" for short periods during each function.

35 mm at IDL Center maintenance room PPI, "Beacon Only," 150-mile range.

35 mm at IDL Center High-Altitude Control PPI, "Beacon-Radar Mixed," 80-mile range (switch to 150-mile range for short periods during each function).

COMPARISON OF SLS SYSTEMS (Technical Tests 9, 10, and 11)

TECHNICAL TEST 9

A. OBJECTIVE

To evaluate the Setrin system of side-lobe suppression on a single site comparison basis with the Stewart-Warner system and a combined system.

B. OPERATIONS

1. Aircraft Required

1 TDC aircraft, specially equipped.

2. Flight Patterns and Routes

Choose best and worst radial for reflection generation, fly in and out to at least 25 miles at several altitudes between 1000 and 10,000 feet.

3. Weather Conditions

Visual flight rules.

4. Flight Time Required

2 hours.

C. EQUIPMENT REQUIREMENTS

1. Aircraft

VHF communications.

SLS-modified transponder.

Pulse counter for interrogation count.

Tape recorder for interrogation PRF and voice comments.

2. Ground

IDL Tower (ASR-3)

Controller's scope.

Tape recorder.

Stewart-Warner antenna modification.

Trigger pulse position for Setrin system.

UPX-6 or UPX-4 for control pulse transmitter.

16-mm camera on VE, 30-mile range, "Beacon Only."

GTC OFF.

Pulse counter at decoder output (with printer).

D. PERSONNEL REQUIREMENTS

1. Aircraft

2 pilots.

Flight observer.

2. Ground

IDL Tower

Transmitter site technician.

Controller.

Test monitor.

Camera engineer.

E. PERSONNEL DUTIES

1. Aircraft

a. Pilots

Maintain course according to flight plan.

Set reply code to 77.

b. Observer

Maintain record of interrogation count as a function of range.

Operate tape recorder for interrogation PRF and comments.

2. Ground

a. Transmitter Site Technician

Interrogator ON, GTC OFF; connect trigger pulse to second interrogator and set trigger pulse position, on orders from test monitor.

b. Controller

Direct aircraft through test course, first without SLS fix; on second trip use SLS equipment. Record communications, comments.

c. Test Monitor

Coordinate controller, transmitter site technician, and camera engineer activities. Instruct transmitter site technician when to activate SLS fix. Record comments. Monitor pulse counter and printer on decoder output for pulses per scan.

d. Camera Engineer

View "Beacon Only" on equipment room VE; 30-mile range. Photograph complete radial runs on single frame exposure with and without SLS. Photograph 5-mile orbit scan-for-scan. Log frame number (or time) of each test start with and without SLS fix.

F. DATA TO BE OBTAINED

1. Aircraft

Pulse count of interrogations.

Interrogation PRF's, with time and position of aircraft.

Observer's comments.

2. Ground

IDL Tower

Tape recording of communications, controller's comments.

Photographs, VE 30-mile display, "Beacon Only."

Pulse counts per scan out of decoder as a function of range.

G. DATA RECORDING FORMS

1. Tape Recordings

   a. In aircraft.

   b. At controller's position IDL Tower.

2. Observer's Data

   IDL Tower

Record of test start, stop times; SLS equipment ON-OFF times; comments.

3. Camera Recording

   16-mm camera on VE in IDL Tower equipment room.

   Multiple exposures of 30-mile "Beacon Only" display for each radial with and without SLS.

   Frame-for-frame exposures for 5-mile orbit.

TECHNICAL TEST 10

A. OBJECTIVE

To evaluate the combined Setrin-Stewart Warner system of side-lobe suppression (using SW antenna configuration and Setrin pulse configuration) on a single site comparison basis with each individual system.

B. OPERATIONS

Same as Technical Test 9.

C. <u>EQUIPMENT REQUIREMENTS</u>

Same as Technical Test 9.

D. <u>PERSONNEL REQUIREMENTS</u>

Same as Technical Test 9.

E. <u>PERSONNEL DUTIES</u>

Same as Technical Test 9.

F. <u>DATA TO BE OBTAINED</u>

Same as Technical Test 9.

G. <u>DATA RECORDING FORMS</u>

Same as Technical Test 9.

TECHNICAL TEST 11

A. <u>OBJECTIVE</u>

To evaluate the Stewart-Warner system of side-lobe suppression on a single site comparison basis with the Setrin system and a combined system. (This test may be performed at TDC.)

B. <u>OPERATIONS</u>

Same as Technical Test 9.

C. <u>EQUIPMENT REQUIREMENTS</u>

Same as Technical Test 9 plus ground omni-antenna for Setrin system.

D. <u>PERSONNEL REQUIREMENTS</u>

Same as Technical Test 9.

E. PERSONNEL DUTIES

Same as Technical Test 9.

F. DATA TO BE OBTAINED

Same as Technical Test 9.

G. DATA RECORDING FORMS

Same as Technical Test 9.

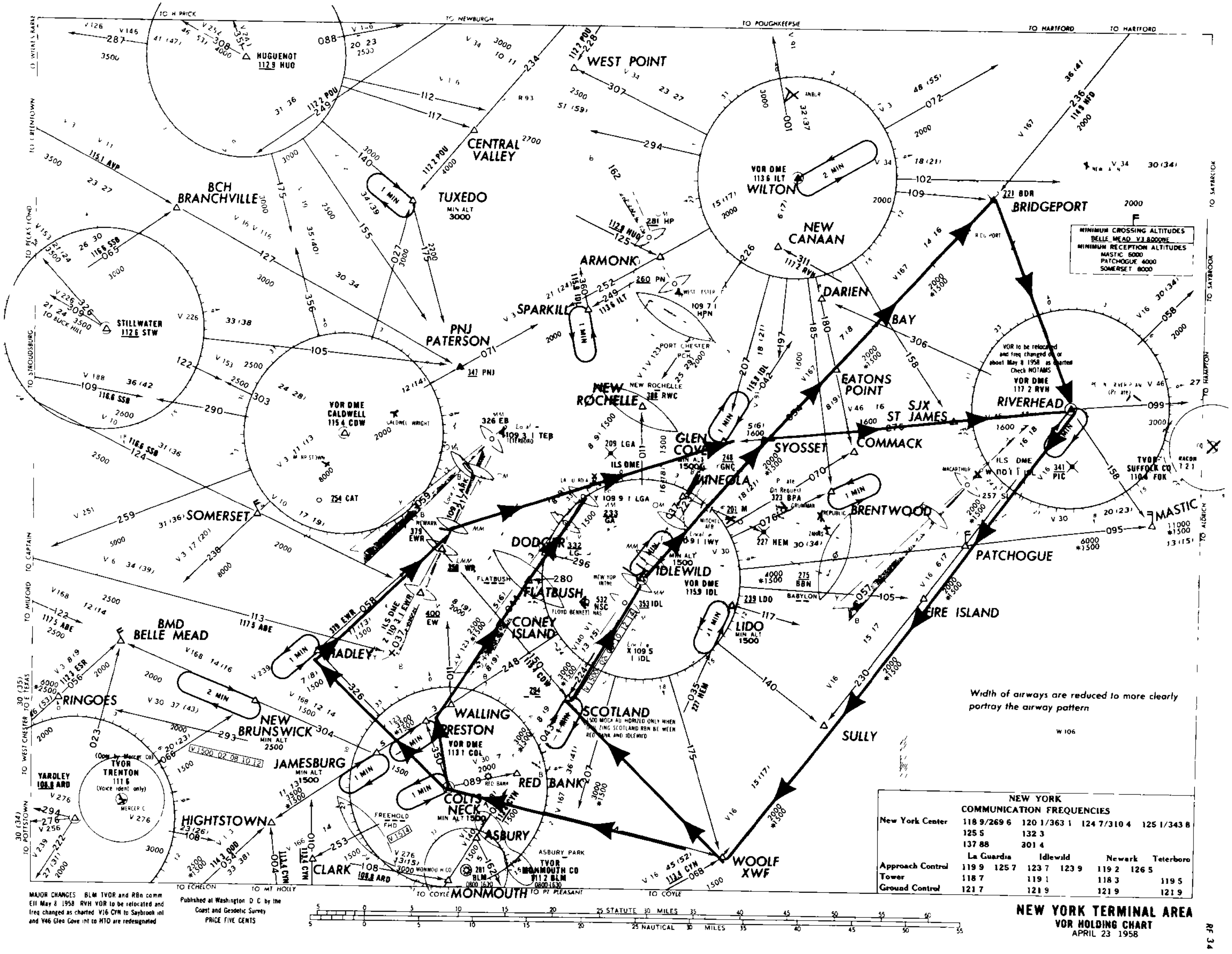

FIGURE A-1. VOR HOLDING CHART OF NEW YORK TERMINAL AREA

APPENDIX B

DESCRIPTION OF FLIGHT PROCEDURES FOR BEACON OPERATIONS EVALUATION TESTS

I. OPERATIONS TESTS 1 THROUGH 4

A. OBJECTIVE: To compare beacon and primary radar returns under various conditions of primary radar operation and effectiveness.

B. OPERATIONS: To obtain comparison data on beacon and primary radar performance in a radar blind area, several runs in the vicinity of Woolf Intersection were made using aircraft N183 (DC-3). Observations of beacon and radar performance were made throughout the tests, and data for comparing radar and beacon characteristics were collected.

II. OPERATIONS TEST 5

A. OBJECTIVE: To examine the effects of close proximity between beacon targets during I/P.

B. OPERATIONS: Two aircraft, operating from Indianapolis, participated in the test. The test lasted an hour and 10 minutes.

1. Routes

The two aircraft departed from the Indianapolis VOR, proceeded out along the 315-degree radial for 50 statute miles, then flew a heading of 180 degrees to intercept the 293-degree radial. The aircraft then proceeded inbound on the 293-degree radial to the Indianapolis VOR.

2. Patterns

Upon departure, the pilots identified on code 01 when over the field boundary. The aircraft climbed to 3000 feet and reported to the beacon test center when reaching that altitude. The Beacon Test Center then issued instructions to obtain the following configurations:

a. Same direction and altitude, in trail, varying distances.

b. Parallel, same direction and altitude, varying distances.

c. Opposite direction, same altitude.

When a desired configuration was established, the pilots were asked to operate the IDENT feature. This procedure was repeated several times to obtain the effect of the I/P at varying distances.

The aircraft were returned to a holding stack at the Indianapolis VOR (5000 feet and 6000 feet) and passed to tower jurisdiction. The tower controller asked the pilots to rearrange their horizontal relationships in the pattern and to identify themselves at frequent intervals. Following this procedure, the aircraft were lowered and given approach to land clearances. The second aircraft to approach was not more than 3 miles behind the number one aircraft. Pilots, unless otherwise instructed, operated their IDENT feature continuously from the Indianapolis VOR to the runway threshold.

III. OPERATIONS TEST 6

A. OBJECTIVE: To test the principle of coding by altitude and the use of codes and the IDENT feature in transferring control jurisdiction.

B. OPERATIONS: Four aircraft, operating from Idlewild, participated in the test. The test lasted 3 hours and 8 minutes, and was divided into three phases.

1. Flight Patterns and Routes

a. Routes

All aircraft followed a common route to Syosset, along V46 to the Riverhead VOR, along V16 to the Woolf Intersection, and thence direct to the Scotland Intersection.

b. Patterns

The patterns flown were the same throughout the three phases of the test.

2. Phase 1

a. Upon reaching any 1000-foot level, the test aircraft changed to the code associated with that altitude.

b. Vertical separation of at least 1000 feet was maintained throughout the test, except when the aircraft made approaches.

c. Altitude code assignments used in this test were:

Code	Altitude	Code	Altitude
00	Surface	06	6000 feet
01	1000 feet	07	7000 feet
02	2000 feet	10	8000 feet
03	3000 feet	11	9000 feet
04	4000 feet	12	10,000 feet
05	5000 feet	13	11,000 feet

Prior to takeoff, pilots had their transponders set to respond on code 00 and had the equipment on standby. After takeoff, the transponders were turned on. The aircraft proceeded directly to the Syosset Intersection; as each 1000-foot level was reached, the pilot shifted his transponder to the code associated with that altitude.

Upon reaching 3000 feet, each pilot called the Idlewild Test Center on the assigned test frequency, stating his position and altitude. The test center had its decoder set to receive the aircraft on code 03. As the aircraft were detected by the center, they were instructed to climb in orbital patterns at Syosset to altitudes providing vertical spacing of 1000 feet between the aircraft. When all the aircraft had reached Syosset and their proper altitudes, the center instructed them to maintain their altitudes and to leave Syosset on course with 1 to 3 miles horizontal spacing between them so that a vacant altitude occurred in the test altitudes. The controller was asked to locate the vacant altitude by the use of code switching and to determine whether altitude changes could be made with radar separation but without the use of off-course vectoring. This was repeated at Riverhead, Patchogue, and Sully.

Prior to the arrival of the aircraft over Sully, the center passed to the Idlewild Tower the order in which the aircraft would go over Sully. After passing this fix, the pilots shifted their radios in the tower frequency and contacted that facility, giving position and altitude. The tower controller identified the aircraft and though code switching arranged the flights, using radar separation standards, to arrive at Scotland on a first-come first-served basis. When all aircraft were established in a holding pattern at Scotland, the Idlewild Tower controller identified them through the use of code switching and vectored the aircraft from the stack for an approach to Idlewild Airport. The following order was observed in arranging the approach to be made at 3000 feet.

1st aircraft to approach--aircraft at 5000 feet
2nd aircraft to approach--aircraft at 6000 feet
3rd aircraft to approach--aircraft at 4000 feet
4th aircraft to approach--aircraft at 3000 feet

Prior to starting their approaches, the center was informed of the order in which the aircraft would arrive over Idlewild. The center's direct-view scope decoder was set to select on code 03. As each aircraft left Scotland, the stack was adjusted downward and the center's VG scope observer tested the scope display's effectiveness for determining the highest altitude occupied by the test aircraft at Scotland. As the approaching aircraft passed over the runway threshold at 3000 feet, they entered Phase 2 of this test.

3. Phase 2

a. Upon leaving any 1000-foot level, test aircraft changed to the code associated with the next altitude.

b. Code assignments were the same as those assigned in Phase 1.

c. Vertical separation of at least 1000 feet was maintained throughout this test, except when aircraft were to approach the airport.

When passing over the threshold of the runway, test pilots transferred jurisdiction from the approach control to the test center by switching their radio frequencies to that of the beacon test center and simultaneously operating the IDENT feature of their transponders. The center acknowledged the transfer of control jurisdiction by clearing the flight to an orbital pattern at Syosset, maintaining at least 1000-foot vertical spacing between test aircraft. When the test aircraft arrived at Syosset, the same patterns and procedures as those used in Phase 1 were used to complete Phase 2.

4. Phase 3

   a. When passing through the 500-foot increment after leaving a 1000-foot altitude level, each pilot changed to the code associated with the next 1000-foot level.

   b. Vertical separation of at least 1000 feet was maintained throughout this phase, except when the aircraft were to approach the airport.

   c. Altitude code assignments in this test were the same as those used in Phase 1.

   d. Test procedures for this phase were the same as those used in Phase 1.

IV. OPERATIONS TEST 7

A. OBJECTIVE: To test the principle of assigning discrete beacon codes to aircraft operating in a tower/center environment.

B. OPERATIONS: Eleven aircraft participated in the test: four from Newark, four from LaGuardia, and three from Idlewild. The test lasted 2 hours and 15 minutes, and was divided into two phases.

1. Flight Patterns and Routes

   a. Routes

Each aircraft followed a direct route from its airport to Syosset, and then followed V167 to Bridgeport, then flew direct to Riverhead, and then followed V16 to the Woolf Intersection. From the Woolf Intersection the aircraft were diverted as follows:

Newark aircraft: From Woolf via Colts Neck VOR direct to Hadley Intersection and held.

LaGuardia aircraft: From Woolf via Colts Neck VOR direct to Preston Intersection and held.

Idlewild aircraft: From Woolf direct to Scotland Intersection and held.

b. Patterns

Altitudes in both Phases 1 and 2 were normally 5000, 6000, 7000, 8000, and 9000 feet. Patterns flown were the same throughout both phases of the test.

2. Phase 1

a. Each aircraft was assigned a specific beacon code, which was used throughout both phases of this test.

b. Each facility associated each code with the pertinent aircraft. This was accomplished by means of a tabular display.

c. Code assignments in this test were:

Newark aircraft: 01, 02, 03, and 04
LaGuardia aircraft: 05, 06, 07, and 10
Idlewild aircraft: 12, 13, and 14

d. The order of departures was: Newark, LaGuardia, and Idlewild.

e. Test aircraft reported when passing Bridgeport, Riverhead, and Sully. Position reporting was accomplished as in the following manner:

> "Idlewild Test Center, this is N183." The center controller determined the code assigned to N183 and switched the decoder to that code, located the aircraft, and answered the call. N183 then gave its position and altitude.

Each group of aircraft climbed on course, using radar separation if necessary, to 5000, 6000, 7000, 8000, and 9000 feet. Departures were arranged so that the groups were about 5 minutes apart when they reached Syosset on the outbound flights.

f. The control jurisdiction was passed from the tower to the Idlewild Test Center when:

1. The Newark aircraft were overflying LaGuardia.

2. The LaGuardia aircraft were overflying Glen Cove.

3. The Idlewild aircraft reached Syosset.

Transfer of control was effected in the following manner:

> An aircraft called the test center on the assigned test frequency. The center controller determined from the tabular display the code assigned to that aircraft and switched the decoder to that code. The controller located the aircraft and accepted jurisdiction by issuing an appropriate ATC clearance.

g. The center, through code switching, maintained updated information regarding aircraft identity, progress, and interrelationships. From time to time, the center controller determined whether climbs or descents could be made without off-course vectoring.

h. As the aircraft approached Woolf Intersection, the order in which they would arrive at their respective primary fixes was conveyed to the appropriate tower controllers. Newark aircraft passed to the control of Newark when over Colts Neck; LaGuardia aircraft passed to the control of LaGuardia after passing Woolf; Idlewild aircraft passed to the control of Idlewild Tower at Woolf.

i. The transfer of control from center to approach control was accomplished in the following manner.

The aircraft called the appropriate facility, giving the aircraft position--for example, "Newark Tower, this is N182 over Colts Neck." The Newark controller determined the assigned code, set the decoder to that code, and accepted jurisdiction by issuing an appropriate clearance to Hadley. When the aircraft reached their respective holding fixes, the approach control facilities functioned as follows.

(1) Idlewild Tower Control--The order of approaches at Idlewild was 1, 2, and 3, with 1 being the lowest

aircraft in the stack and 3 being the highest. The Idlewild controller set the decoder to SELECT on the code of the aircraft to approach. Then, following identification, he issued a clearance for an approach to be made at 3000 feet. As the aircraft left Scotland, the stack was lowered and the center's VG scope observer tested the component equipment effectiveness as an aid in determining the identity of those aircraft remaining in the stack.

(2) LaGuardia Tower Control--The order of approaches at LaGuardia was 3, 2, 1, and 4, with 1 being the lowest aircraft in the stack and 4 being the highest. The procedures were otherwise the same as those for Idlewild.

(3) Newark Tower Control--The order of approaches at Newark was 2, 1, 3, and 4, with 1 being the lowest aircraft in the stack and 4 being the highest. The procedures were otherwise the same as those for LaGuardia and Idlewild.

As the aircraft crossed the runway thresholds at their respective airports, they entered Phase 2 of this test.

3. Phase 2

a. When initiating a call, pilots stated their assigned codes--for example, "Idlewild Approach Control, this is N183 on code 07."

b. Patterns were the same as in Phase 1.

c. Code assignments were the same as in Phase 1.

d. Departures were not applicable.

e. Position reports were made as in Phase 1. Procedures were changed to the extent that pilots always stated their assigned codes when initiating calls.

f. Control jurisdiction passed from the tower control facilities to the test center when the aircraft crossed the thresholds of the runways on approaches at 3000 feet. The execution of the change was the same as in Phase 1, except that pilots included their assigned codes upon initiating calls.

g. En-route procedures were the same as in Phase 1.

NOTE

Aircraft from the three airports entered the en-route control area at random intervals. Consequently, they became intermingled. To obtain the desired horizontal spacing and altitudes, and to divert the aircraft to their respective airports from Woolf Intersection, it was necessary for the test center to ask some of the pilots to hold at Syosset or other locations. In such events, the decoder was the exclusive tool used to select the aircraft to be held.

h. Approach to Woolf Intersection: Same as in Phase 1, except that the pilots included their assigned code numbers when initiating calls.

i. Transfer of control from center to approach control was the same as in Phase 1. Pilots included their assigned code numbers when initiating calls.

j. The procedures used at Idlewild control tower in Phase 1 were used by LaGuardia control tower in Phase 2.

k. The procedures used by LaGuardia approach control in Phase 1 were used by Newark control tower in Phase 2.

l. The procedures used by Newark control tower in Phase 1 were used by Idlewild approach control in Phase 2.

The test concluded with the landing of all aircraft.

V. OPERATIONS TEST 8

A. <u>OBJECTIVE</u>: To test the use of beacon codes when a discrete code is assigned to each control facility.

B. OPERATIONS: Eleven aircraft participated in the test: three from Newark, four from LaGuardia, and four from Idlewild.

1. Flight Patterns and Routes

a. Routes

Each aircraft followed a direct route from its airport to Syosset, then along V167 to Bridgeport, then to Riverhead, then along V16 to Woolf Intersection. The aircraft were diverted from Woolf as follows:

Newark aircraft: From Woolf via Colts Neck to Hadley and held.

LaGuardia aircraft: From Woolf via Colts Neck to Preston and held.

Idlewild aircraft: From Woolf direct to Scotland and held.

b. Patterns

(1) Altitudes used in Phases 1 and 2 were normally 5000, 6000, 7000, 8000, and 9000 feet.

(2) Patterns flown were the same in Phases 1 and 2.

(3) Phase 3 was the same as the first two, except that the coding was changed.

The test lasted for 3 hours and 51 minutes.

2. Phase 1

a. Each tower (approach control) was assigned an individual code.

b. The center was assigned an individual code.

c. Code assignments were:

(1) Newark, 01

(2) LaGuardia, 02

(3) Idlewild, 03

(4) Idlewild Center, 04

d. The order of departures was: Newark, LaGuardia, Idlewild.

e. Position reports.

Test aircraft reported passing Bridgeport, Riverhead, and Sully. Reporting was accomplished in the following manner: "Idlewild Test Center, this is N183."

Each group of aircraft was climbed to the test altitudes on course, using radar separation if necessary. Departures were arranged so that the groups were about 5 minutes apart when they reached Syosset on the outbound flights.

f. The control jurisdiction passed from control tower to the test center when:

1. The Newark aircraft were overflying LaGuardia.
2. The LaGuardia aircraft were overflying Glen Cove.
3. The Idlewild aircraft reached Syosset.

Transfer of control was effected as follows:

> Aircraft called the test center and, when contact had been established, gave their positions and altitudes. The test center accepted control jurisdiction of the aircraft by asking the pilot to change the transponder to code 04. When this was done, the tower controller knew that the aircraft was established under the control of the center.

g. The center had pilots IDENT to maintain updated information regarding aircraft identity, progress, and relationship with other test aircraft. In addition, the center controller from time to time determined whether climbs or descents could be made without off-course vectoring.

h. As the aircraft approached Woolf Intersection, the order in which they would arrive at their respective fixes was forwarded to the appropriate control tower. Newark aircraft passed to the control of Newark control tower when over Colts Neck; LaGuardia aircraft, after passing Woolf; and Idlewild aircraft when at the Woolf Intersection.

i. The transfer of control was executed as follows:

When instructed by the center to do so, the pilots switched to the appropriate approach control frequencies and called their respective control facilities, giving positions and altitudes. The approach facility accepted control jurisdiction by requesting the pilot to switch to the appropriate tower code. When this was done, the center controller knew that the aircraft was established under approach control jurisdiction.

NOTE

The aircraft were given a clearance to Syosset as they initially overflew the primary fix--that is, Scotland, Hadley, and Preston Intersections. Upon receipt of such clearance, the aircraft entered Phase 2.

3. Phase 2

a. Each control tower was assigned an individual code plus a common departure code.

b. The center was assigned an individual code.

c. Code assignments used were:

Newark, 01

LaGuardia, 02

Idlewild, 03

Idlewild Center, 04

Common Code, 05

d. Position reports were the same as in Phase 1 of this test.

e. Control jurisdiction passed from approach control to the test center immediately after the receipt of a clearance from the control tower to proceed to Syosset. (See note after description of Phase 1.) Each aircraft, upon receipt of an ATC clearance to proceed to Syosset, switched the transponder to code 05 and called the test center, giving position and altitude. The center accepted jurisdiction of the aircraft by requesting the pilot to switch to code 04 and to complete identification by operating the IDENT feature.

f. The same procedures as in Phase 1 were used, except that in lieu of code switching to establish identity, the controller relied upon the IDENT feature.

g. The transfer of control was effected as follows. Upon direction from the test center the pilot called the appropriate control tower facility, giving position and altitude. The tower accepted jurisdiction by requesting the pilot to switch to the appropriate code. (See Item c in description of Phase 2.) The tower facility cleared the aircraft to Syosset as they overflew their primary fixes--that is, Scotland, Hadley, and Preston Intersections. As each aircraft received such clearance, it entered Phase 3.

4. Phase 3

a. Phase 3 was the same as Phase 2 except for the coding. The code assignments were:

(1) Newark Approach Control: arrival, 01; departure, 02
(2) LaGuardia Approach Control: arrival, 03; departure, 04
(3) Idlewild Approach Control: arrival, 05; departure, 06
(4) Idlewild Test Center: 07

As the aircraft left the primary fixes with clearance to Syosset, they maintained their last assigned altitudes and flew over the airports served by such fixes. At the time that they left the primary fixes, they shifted their transponders to the departure codes assigned to the airports and changed their radios to contact the test center, giving position and altitude. The center controller confirmed the identification by requiring the IDENT feature to be operated, after which he issued an appropriate ATC clearance, thus accepting control jurisdiction.

Procedures and practices observed while en route were the same as in Phase 2. The transfer of control from the center to the towers was as follows:

> At the direction of the center, the pilots contacted the appropriate control tower facilities, giving position and altitude. Each tower accepted jurisdiction of aircraft by requesting the pilots to switch to the appropriate arrival code established for that airport.
>
> All aircraft were cleared for landing, ending the test. Approaches were made at 500 feet. During all phases of the tests, irregularities were recorded. Prior to the pilots making low approaches to the airports from the holding patterns, they were instructed to select Code 77 and to use the IDENT feature intermittently when advised by the radar controller. When these displays were observed on the PPI, in the IFR room, the observer used the defruiter in both single and double defruiting to determine what effects if any the defruiter would have on the select code. Concurrently, the observer at the test center was looking at the scope where all three airports could be seen, and he recorded pertinent data. When sufficient information had been collected, pilots were cleared for low approaches at each airport--by the respective airports--at altitudes ranging from 500 feet to 50 feet.

VI. OPERATIONS TEST 9

A. OBJECTIVE: To examine the various concepts for displaying beacon returns signifying aircraft emergency; also, to compare the performance of the ATCRBS with that of the primary radar as a means of providing aircraft identification in areas of high traffic and high interrogation densities.

B. OPERATIONS: Participating in the test were three aircraft operating from Idlewild, and about 36 high-performance military aircraft operating above 20,000 feet in the patterns shown in Figure 2-1. There were 28 ground interrogators operating.

1. Flight Patterns and Routes

a. Routes

(1) Runs 1, 2, 3, 7, and 8 required that the aircraft proceed over the following points: Caldwell, Colts Neck, Lido, Glen Cove, and return to Lido.

(2) Runs 4, 5, and 6 required that the aircraft fly between the Red Bank and Scotland Intersections.

b. Patterns

(1) An orbital pattern was flown at each of the points listed.

(2) A track was flown between the Red Bank and Scotland Intersections.

NOTE

In runs 1, 2, 3, 7, and 8, the aircraft were stationed by the test coordinator in the environment at locations unknown to the controller. Test aircraft N182 was used to (1) study the primary radar display as a method of locating and identifying a lost aircraft in an area where the pilot could advise the center of his general location and (2) study the ATCRBS display using code switching as a method of locating and identifying a lost beacon-equipped aircraft. Test aircraft N183 was used to (1) examine the primary radar display as a method of locating and identifying a lost aircraft that had no functioning navigational equipment except a magnetic compass and (2) examine the ATCRBS display using code switching and the identification pulse as a method of locating a lost beacon-equipped aircraft and (3) study the use of Code 77 of the ATCRBS for indicating emergencies and actuating a prototype audio-visual alarm system.

APPENDIX C

STORAGE-TUBE DEFRUITER-SWEEP STUDY

Part of the overall contract was an individual task assignment related to the use of storage tubes as a method of defruiting. Several storage-tube sweep methods were studied. This appendix is a report on that short study of sweep circuits and methods for increasing signal-to-noise ratios in storage-tube circuits.

A major disadvantage inherent in the delay-line defruiting equipment evaluated in the test program is the necessity of accurately matching the defruiter delay lines with those of the associated radar. A storage tube instead of a delay line was suggested and an experimental model was constructed on another contract (Noas-57-405-c). This unit demonstrated the feasibility of the storage-tube approach to the defruiting problem, but it did not attain sufficient signal-to-noise ratios for completely reliable operation. It was determined that the major reason for this deficiency was the type of sweep circuitry used on the storage tube. In an attempt to overcome the inherently poor output signals at the corners of the ladder sweep, a study of a spiral sweep was undertaken on this contract at the request of TDC. The results were favorable and indicate an increase in the signal-to-noise ratio from about 3:1 to 10:1. Prospects for satisfactory double defruiting using storage tubes are much improved by these new ratios.

To complete this task, the 2.3NS9 experimental storage-tube defruiter was evaluated to determine the maximum signal-to-noise ratio improvement obtainable. A spiral-type sweep was constructed, and comparison data were taken on the ladder and spiral sweeps.

The evaluation of noise level was difficult; the noise encountered was not noise in the strict sense, but consisted of interfering signals or disturbances and variations of the wanted signals. The output at the collector of the RCA6499 consisted of:

1. Signals varying in amplitude as their positions on the storage-tube screen varied,
2. Disturbances induced by the sweep,
3. Variations of the baseline with the sweep.

The variation in signal amplitude is attributed to:

1. Nonuniformity of focusing over the storage-tube screen,
2. Change in sweep speed over the storage-tube screen,
3. Shading.

The nonuniformity of focusing and the change in sweep speed are the most troublesome factors. The focusing problem is believed to be mostly an astigmatism effect. The nonuniformity of focusing is about the same on both the ladder and spiral sweeps, though it is more noticeable on the spiral sweep because the beam travels from the top to the bottom of the storage-tube surface in a half-scan as compared with thirty scans for the ladder sweep.

The speed of the ladder sweep is constant except at the corners. The change in sweep speed at the corners results in loss of signal. The speed of the spiral sweep increases linearly as the spiral progresses outward. The minimum inner diameter of the spiral is determined by the sweep speed.

Shading is the change in collection efficiency that is produced when the position of the storage-tube beam changes. Shading produces a reduction in signal amplitude at the outer portions of the storage-tube screen. The observed effect of shading was masked by defocusing effects. From observations of the defruiting equipment, the change in signal amplitude caused by defocusing amounted to 25 percent of the signal or more, depending on the beam current.

The disturbances induced in the storage-tube collector by the ladder and spiral sweeps were comparable. For the ladder sweep, the disturbance was periodic at the scan rate and had a constant amplitude. The frequencies used in generating the corners of the ladder sweep were not completely filterable, and disturbance signals remained whose amplitudes were 10 to 20 percent of the true signal amplitude. The disturbances induced by the spiral sweep were proportional to the spiral radius. These signals were periodic at the spiral generating frequency. Since sine waves within the audio region generate the spiral sweep, it is easier to filter the induced signals. Induced signals from the ladder sweep, which was left in operation, masked the spiral output somewhat, but the residue was considerably less than that of the ladder sweep.

Since the baseline variations were filterable, the signal-to-disturbance ratio depended primarily on the ratio of the output signal amplitude to the induced disturbances from the sweep. There was sufficient resolution to obtain output signals with a spiral sweep whose amplitude at the inner portion of the spiral was equal to the amplitude of the signals from the ladder sweep. Since the induced disturbances were considerably less for the spiral sweep, the signal-to-disturbance ratio of the spiral sweep was better than that of the ladder sweep.

Some experimenting was done with a circuit designed to produce a constant-velocity spiral sweep. The circuit used a saturable reactor that was swept during the range sweep period to lower the sweep angular velocity as the spiral increased outward. Too much inductance was present in the control winding of the saturable reactor to obtain entirely satisfactory results. A change of about 1.5 to 1 in frequency was accomplished, but the investigation was deferred until a modified saturable reactor could be obtained. The constant-velocity spiral sweep should be further investigated, since it provides greater signal output at the center of the spiral for a given scanning time.

A constant-angular-frequency spiral (variable-velocity) generator was constructed and used in conjunction with the defruiter. Measurements indicated that about 35 spiral lines (a total of 70 lines per diameter) could be applied to the storage tube before the lines merged. The number of lines allowable was dependent primarily on the linearity of the spiral and was not limited by the storage-tube resolution. About 30 lines are necessary to obtain a spiral-sweep speed of 50 μsec/inch (at a 0.5-inch spiral diameter) and a ladder sweep speed of 50 μsec/inch. However, for the spiral sweep, 30 lines represent a total of 60 lines per diameter.

As the spiral sweeps outward, the writing speed is decreased, and the output is improved. The ladder sweep is theoretically more efficient, since the spiral sweep is limited by the sweep speed at the inner diameter, even though the output improves as the sweep diameter increases. Actually, it is easier to maintain equal spacing of the sweep lines in the spiral sweep; consequently, more lines can be scanned.

Data were taken on the amplified storage-tube output for a fixed-frequency spiral sweep. The data are given relative to the leakage disturbances from the ladder sweep. The disturbances were impressed on the background trace of alternate periods and were partially coupled into the storage-tube amplifier being checked.

For a 12-kc spiral sweep of 2500-μsec length, a 20-volt minimum output was observed at the 2500-μsec point (the 2-inch diameter of the storage tube). At the 100-μsec point in the sweep (the 1-inch diameter of the storage tube), a 10-volt minimum output was observed. The maximum leakage signal at any point on the sweep was 1 volt.

The results indicate that a minimum signal-to-disturbance ratio of 20 db is possible for the constant-angular-frequency spiral sweep. If the constant-velocity spiral sweep proves feasible, a signal-to-disturbance ratio of better than 26 db could be obtained. Both these values are based on the noise of the ladder sweep; therefore, another 6-db improvement will probably be obtained.

Observations were made with a single pulse and with groups of pulses. There was no loss of signals for the spiral sweep such as the loss observed on the corners of the ladder sweep. The loss of signals on the corners of the ladder sweep was one of the major defects of the defruiting equipment. The spiral sweep therefore provides a basic improvement in the defruiting ability. In addition, because of the increased signal-to-disturbance ratio, the double-defruiting capability should also be enhanced by a spiral sweep.

To check the double-defruiting capability, the defruiter was placed in interlace operation, and the storage-tube gates were adjusted to permit two read cycles. The output obtainable on both cycles was 6 db less than that obtainable with single-defruiting operation. Although this reduces the signal-to-noise output of the storage tube to 14 db, it is considered possible to work with this level. However, as pointed out previously, this level might be improved further. Several methods of separating signals for double defruiting were considered. The two most promising are:

1. Diode separation of added output levels,
2. Coincidence or multiplication of outputs.

The first method is similar to that used in the present defruiter. It is easy to accomplish but offers only 6 db in level separation. Each storage-tube output would be limited, and an adder circuit would sum all outputs. In double defruiting, a doubled-amplitude output would be required. The only drawback of this method is the narrow range of separation. However, with limiting of the amplified storage-tube outputs, it is believed that a 6-db operation would be sufficient.

The second method would require three coincidence circuits and three or more auxiliary driver stages. A pair of signals for each of the three possible combinations of the storage-tube outputs (A and B, A and C, B and C) would be applied to separate grids in the respective coincidence tubes. The coincidence outputs would be added to the common plate output to produce either AB, AC, or BC outputs when double defruiting. This methods seems, theoretically, to be the better of the two. However, it is doubtful whether sufficient space could be found in the present cabinet to accommodate the increased number of components that it would require.

APPENDIX D

TEST PERIOD EXPERIENCE ON BEACON SYSTEM MAINTENANCE AND RELIABILITY

This section is the chronological history of beacon system operability in the New York area during the test period from October 1958 through January 1959. It is included to early equipment difficulties and to serve as a base for data on equipment reliability. Many of the system failures and troubles reported here are similar to those experienced during the early days of operation of the New York Center facility. In addition, system fixes and modifications were in the process of being introduced as a result of that earlier experience--for example, the instability of the ASR-3 radar's counted-down pretrigger was remedied.

The dual S-band L-band (S-L) rotary joint of the LaGuardia ASR-3 radar failed during the first week in October 1958. An S-band joint, formerly used at the Idlewild ASR-3 radar facility, was installed at LaGuardia as a temporary measure. The dual S-L joint originally intended for installation in the Washington ASR-3 radar was brought to New York for use at LaGuardia, and the original LaGuardia S-L joint was rescheduled for installation at Washington when the required repairs were completed.

The following modifications recommended by TDC were incorporated in the Video Interconnection Equipment (VIE) at the New York Center, Idlewild, Newark, and LaGuardia sites.

1. Voltage-dropping resistors R346 and R347 (68 ohms, 1 w) for VIE power supply pilot lamps were replaced with 390-ohm 20-w wire-wound resistors.

2. The 115-v input line on the VIE 28-v DC supply transformer T302 was moved from pin 3 to pin 4.

3. Voltage-divider resistor R301 (56 kilohms, 2 w) of the VIE power supply was replaced with a 55-kilohm 20-w wire-wound resistor.

The first two changes were made to reduce the excessive consumption of the VIE pilot lamps resulting from voltage overloads. The third change was made to prevent power-supply-output-voltage drift caused by damage to underrated components.

Early in the program, the quartz delay lines in the defruiter and in both channels of the Idlewild ASR-3 radar were replaced with improved sets of matched lines. The original delay lines were returned to the manufacturer (1) for repackaging to improve the insulating qualities of the oven, and (2) for installation of an improved thermostat to be mounted externally to the sealed delay line. This improvement was made to stabilize the temperature fluctuations of the lines and to reduce the frequency of the defruiter-delay-correcting servo. In addition, the thermostats could easily be replaced in case of failure. The thermostats in all four delay lines at this installation were adjusted and have since remained stable.

The normal and interlaced delay lines in the defruiter at the New York Center were also replaced with modified lines. Delay lines for the defruiter and radar at the LaGuardia and Newark sites and all other delay lines purchased under the defruiter contract were similarly modified by the vendor.

Early in October, representatives of the FAA Washington office visited the Idlewild Tower installation to help formulate an installation and tuning procedure for the temperature-stabilized quartz delay lines in the ASR-3 radar. The tuned input and output circuits associated with the delay lines were adjusted during establishment of tuning procedures to obtain proper amplifier band pass with the new lines.

The radar-trigger countdown circuit was also modified to provide a more stable beacon-pretrigger countdown repetition rate. The values of components C14 and R17 (on the pretrigger modification schematic) were changed from 100 to 500 μμf, and from 330 to 470 kilohms, respectively. The countdown circuit has performed satisfactorily since these changes were made.

On 30 October, radar maintenance personnel from the various facilities met at the New York Center at the request of the FAA New York office. A discussion of the beacon system was presented at this meeting to familiarize the maintenance personnel with its operation. The tuning and maintenance procedures were demonstrated and maintenance problems and routines were discussed. The session was primarily intended to assist those personnel having little or no previous experience with the beacon system. Instruction and assistance of this nature was given by AIL representatives, whenever feasible, during the course of the evaluation program in the New York area.

At the New York Center facility, the beacon system required the following repairs and maintenance procedures during October.

1. During routine maintenance of the line compensating amplifier, tubes V6 (12AU7), V10 (12AT7), V12 (12AU7), V18 (6 x 4), and V21 (OA2) required replacement.
2. During routine maintenance of decoder 5, tubes V103 (12AT7), V106 (12AT7), V107 (5687), V112 (12AT7), and V126 (12AT7) required replacement.
3. During routine maintenance of decoder 6, tubes V102 (12AT7) and V103 (12AT7) required replacement.

4. V114 (12AT7), the second select pulse amplifier of decoder 6, failed and was replaced.
5. V123 (5814), the capacitor dunking stage of decoder 3, failed and was replaced.
6. C209 (10 μf, 25 v) of decoder 4 shorted and was replaced.
7. V126 (12AT7) of decoder 1 failed and was replaced.
8. V305 (5751), the control tube in the power supply of decoder 4, had intermittent contact in its socket and caused ripple on the B+ supply. Tightening of the pin contacts of the tube socket removed the ripple.
9. During routine maintenance of the line driver, tube V8 (6AQ5) required replacement.
10. During routine maintenance of the pulse-pair generator, tubes V607 (6AS6), V608 (6AS6), and V767 (5814) required replacement.
11. During routine maintenance of the interrogator unit, tubes V304, V305, V306, (6AK5's) and V403 (6AS6) required replacement.
12. V13 (OA2) in the line driver failed and was replaced.
13. V308 (6A15) in the IF strip of the interrogator receiver failed because of a cracked envelope and was replaced.

At the Idlewild Tower facility, the following repairs were required by the beacon system during October.

1. V103 (12AT7), the gate-pedestal cathode follower of decoder 2, failed and was replaced.
2. V611 (6D4) in the pulse-pair generator failed and was replaced.
3. The printed-circuit lead from CR117 to R617 in decoder 2 opened, thereby permitting raw video to appear on the display when in common-system operation.

At the New York Center facility, the following repairs and maintenance procedures were required by the beacon system during November.

1. Diode CR179 (1N198) in the grid circuit of cathode follower V110 (5687) of VIE 1 and 2 shorted, causing a low output in select code operation. Type 1N69 diodes were used as replacements with no noticeable deterioration in performance.
2. Diodes CR101 and CR102 (1N198's) in the grid circuit of V125 (12AT7) in VIE 4 shorted, causing a loss of the gate pedestal. Type 1N69 diodes were used as replacements with no noticeable deterioration in performance.
3. Capacitor C117 (0.082 μf) in VIE 5 shorted, causing a loss of output in the ALL AC position. Replacement of the capacitor restored proper output.
4. V103 (12AT7) in VIE 1 and 4 required replacement to obtain proper gate-pedestal output.
5. During routine maintenance of VIE 5 and its power supply tubes, V113, V124, V125 (12AT7's) and V301 and V302 (5R4WGY's) required replacement.

At the Idlewild Tower facility, the following repairs and maintenance procedures were required by the beacon system during November.

1. V610 (6D4), the first modulator pulse generator, failed and was replaced.
2. V611 (6D4), the second modulator pulse generator, failed and was replaced.
3. V1616 (2D21), the GTC trigger generator, failed and was replaced.
4. CR501, a selenium rectifier in the power supply of test set AN/UPM-4A, failed because of an overload caused by frozen bearings in a blower motor.
5. T203, a pulse transformer in the internal PRF generator of the video test generator, failed because of an open winding and was replaced.

At the LaGuardia Tower facility, the following repairs were required in the pulse-pair generator.

1. Capacitor C1609 in the V1602 delay generator circuit shorted, thereby removing the trigger input to the pulse-pair generator.

2. T1606, a pulse transformer in the first pulse line driver, failed because of an open winding and was replaced.

3. Resistor R1648 in the V1606 1-Mc timing oscillator required adjustment to obtain output pulses from V1610, the second pulse-coincidence tube.

During the installation of the SLS fix-equipment at the Newark beacon facility, prior to the scheduled density test of 2 December, the pulse-pair generator was found to be incapable of stable operation. The spacing of the pulse pairs was subject to jitter and an occasional lock-in at incorrect spacing. Proper operation of the pulse-pair generator could not be restored by adjustment of the equipment settings or by tube replacement. This malfunction was also found at the LaGuardia installation during a pretest check of the system. Both installations were equipped with newly modified pulse-pair generators containing 1-Mc timing oscillators to increase pulse-spacing accuracy.

To permit both sites to operate during the immediate test period, the pulse-pair generator was temporarily modified. This modification consisted of:

1. Opening the connection between C1657 and the grid of V1613,
2. Opening the connection between C1656 and the grid of V1614,
3. Adding a 56-kilohm resistor in parallel with R1715,
4. Adding a 56-kilohm resistor in parallel with R1708.

The effects of these changes were (1) to remove the coupling between the 1-Mc timing oscillator and the first and second pulse line drivers, and (2) to decrease the blocking oscillator bias so that the delay-line signal alone would be of sufficient amplitude to fire the first and second pulse line drivers.

With this temporary modification, it was possible to achieve satisfactory single-mode operation with either 3-, 5-, or 8-μsec pulse spacings, Interlaced operation of multiple modes was not possible; therefore, when remote control of the interrogator was attempted, the system functioned only on mode 3. Further corrective action to the pulse-pair generator circuits was accomplished at TDC later in the program and restored the system's capability while maintaining good reliability and serviceability.

During the week of 12 January, AIL representatives visited the four FAA sites to conduct a pretest inspection after a one-month period of no test work, and to prepare the beacon installations for the next series of scheduled flight tests. Cameras, tape recorders, counters, and printers were set up. The beacon installations at the New York Center, LaGuardia, and Idlewild Towers were in good working condition. The decoders at these sites were checked out and set up for the tests. At the Newark site, the pulse-pair generator output was again faulty and was found to consist of only the first modulator pulse. The second pulse was restored by replacing V1610 (5727), resetting the 1-Mc timing oscillator, and adjusting capacitor C1613. The Newark site was checked out later that same week, and similar troubles were again found in the pulse-pair generator. In this case, the second modulator pulse was restored by replacing V1616 (5727) and V1608 (5814). To maintain the second modulator-pulse output, the V1608 (5814) tube required replacement at frequent intervals. During this same period, the input-trigger blocking oscillator, V1601 (5670), failed and was replaced.

The receiver sensitivity of the Newark interrogator was found to be normal, but received signals were weak. Three IF amplifier stages (6AK5's) were replaced to restore normal signal strength.

During the test program, there were instances when a decoder at one of the tower installations would fail just prior to or during a test run. To service the decoder in the present setup, radar video must be temporarily removed from the tower display because it passes through the unit. It was therefore recommended that a radar bypass circuit be added to the VIE installed in the FAA Towers. At present, there is a temporary loss of radar video when the radar video input and video output cables are removed from the VIE to be reconnected with an external connector. In addition to causing a temporary loss of radar video, this method of bypassing the radar video may result in damage to the video cables.

After several discussions concerning the possibility of bypassing radar video from the beacon VIE, FAA requested an investigation of the feasibility and means of accomplishing this action.

Radar-beacon mixing for ASR sites is presently accomplished in the VIE. This method of mixing is unsatisfactory for several reasons.

1. Maintenance of the beacon system can be accomplished only when the primary radar is not in constant use at the prescribed beacon position. At the present time, the maintenance technician waits until the control position can be released for a few minutes. The radar is bypassed by disconnecting the VIE radar input and VIE video output cables from their respective connections at the VIE and connecting them through an external junction.
2. When the VIE is in use and the VIE control box is in any position other than standby or off, the radar video must pass through VIE mixing circuits. Unless the VIE is switched to off or standby, radar video information is subject to the reliability of the VIE circuits. Loss of radar video can occur as a result of malfunctions in either the VIE power supply or mixing circuits.

3. When a malfunction in the beacon system causes a temporary cessation of power to the VIE rack, a temporary loss of radar video may occur. This is a result of the time-delay relay action in the VIE. When power is removed, radar video is automatically switched to bypass the VIE. However, when power is reapplied, radar video is switched to pass through the VIE before the time-delay relay has closed. Radar video is therefore lost from the time that power is reapplied until the time that the time-delay relay closes. This may be a result of:

   a. VIE interlock failure,

   b. VIE blower motor failùre,

   c. VIE air flow interlock failure,

   d. Overload in the VIE 60-cps power source,

   e. Overload in the VIE convenience outlet circuit. (This has occurred when test equipment was connected to the VIE convenience outlet.)

In view of these deficiencies in the present radar-beacon mixing system, it was recommended that the following procedures be established to minimize the effects of the VIE on radar system performance.

1. When the system is being used on radar only, the beacon power switch must be in the standby or the off position. Do not place the power switch in the on position unless beacon or mixed targets are to be displayed.
2. If there is a loss of power to the beacon system, immediately turn the beacon power switch to the standby position. A loss of power can be recognized by the absence of illumination in the beacon control box. Notify the maintenance technician immediately.
3. If there is a sudden loss of beacon video, immediately place the beacon power switch in the standby position. Notify the maintenance technician immediately.

Changing the mixing to one of the following methods has been recommended as a permanent modification.

1. Mix the video at the PPI by adding a small video mixer at the console. This requires that a separate video line be provided from the VIE to the console. The video mixer could be a simple common-cathode vacuum-tube mixer with the mixer power secured from the PPI, if possible, or from a separate power supply. A possible configuration is shown in Figure 5-1. The mixer could also be a small transistorized mixer that is the equivalent of the common-cathode vacuum-tube mixer. A possible configuration is shown in Figure 5-2. The method is similar to that used at the New York Center where video is mixed within the indicator. Operating personnel at the New York Center have been satisfied with this method of mixing. In this method, a separate mixer would be constructed and installed at each PPI and a separate beacon video cable provided for each PPI. The video cabling at the PPI would then be changed as shown in Figure 5-3. The advantages of this method are:

   a. Video is mixed at the console without passing through other equipments.

   b. No complicated relay circuits or contron circuits are required.

   c. If video mixer problems develop, a small bypass switch could be provided at the console.

   d. Maintenance of the beacon system could be performed without interrupting radar service.

2. Modify the existing VIE so that radar video passes through the VIE when the video control switch is in the mixed position. In addition, a radar bypass switch could be added to the VIE. Figure 5-4 shows the bypass-switch configuration The decoder could be modified so that K114 is energized only when the VIE power is on and the video selector switch is in the mixed position. To accomplish this, remove the +28 v connection to K114 (K114-12) and connect K114-12 to J112-21. This method would permit (1) the VIE to be used as a mixer when the video selector switch is in the mixed position, and (2) the radar signal to pass through the VIE without

being affected by the VIE when the video selector switch is in the radar-only position. In addition, a radar bypass switch would be required for beacon maintenance. A possible disadvantage of this method would be a change in the radar video level when the video is switched from radar-only to mixed.

During December 1958 and January and February 1959, the New York Center conducted an informal survey of ATCRBS operations as observed on the various sector displays. Controllers observed and graded the beacon replies obtained from transponder-equipped civil and military traffic in the area as a means of determining the relative reliability of transponder operation. Log entires were made describing the quality and correctness of the beacon display as the various system functions were tested. Preliminary evaluation of data gathered during the period from 19 December through 9 February yielded the following results:

	Number of Cooperating Aircraft	Good Indication		Poor Indication		No Indication	
		Number	Percent	Number	Percent	Number	Percent
Air Carriers	121	96	79	8	6.6	17	14
Military	6	2	33	3	50.0	1	17
Total	127	98	77	11	8.7	18	14

The breakdown of the various beacon returns was based upon the controller's ability to obtain a satisfactory beacon indication for each applicable system function tested. Where a good reply indication was present for only certain functions--for example, Common System, Selected Code--and missing for others--for example, IDENT--or where all applicable function indications were weak, the results were classified as poor indications. Where no reply signal from an aircraft was observed, the results were listed as no indications. There is no means of determining from the information available whether replies were missed or poor because of faulty ground equipment, transponder failure, or improper use of the system by a pilot or controller. This inability to properly evaluate data is another reason why a device such as a remote test transponder installation is needed. Such a device would enable a controller to quickly check the operability of the entire ground facility of a beacon system.