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~~Vertical~~ Separation Program, Phase I: Plan for Testing the Methodology to Collect Data on Total Vertical Navigational Performance

Brian Colamosca

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16. Abstract

As part of the study to reduce vertical separation above 29,000 feet (FL290) to 1,000 feet, a methodology for the data collection was developed. This paper is a description of that methodology, an enunciation of the various participating organizations and a brief statement about their expected contribution. Since this effort is exploratory, the proposed methodology is extensive in nature and thus the details of analysis and requirements for the extension of the data collection for completing the whole program will most likely be modified and adopted as this first phase comes to a conclusion.

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1.0 INTRODUCTION.

Presently, any two aircraft operating in United States airspace at or above Flight Level 290 (FL290, signifying 29,000 feet pressure altitude) must have planned 2,000-foot vertical spacing if their intended flight paths, in the horizontal plane, contemporaneously place them closer together than 5 nautical miles (nmi). Below FL290, 1,000-foot spacing is required. Established jet routes, defined between FL180 and FL450, are organized so that permissible altitudes occur in 1,000-foot increments between FL180 and FL290 and in 2,000-foot increments at higher altitudes. These vertical separation practices have been the established standards since the advent of substantial numbers of civil turbojet transport aircraft in the mid-1950's.

Economic and operational considerations strongly suggest that substantial benefits would obtain if the Vertical Separation Standard between FL290 and FL450 were reduced to 1,000 feet. The Federal Aviation Administration (FAA) is currently analyzing the feasibility of this reduction. This test plan describes a procedure for evaluating the suitability of a key step in this analysis.

1.1 BACKGROUND.

A 1,000-foot vertical separation standard will be judged feasible if such spacing does not compromise safety, the savings in fuel and operational efficiencies in the air traffic control (ATC) system being taken as demonstrably evident. In turn, safety will be judged uncompromised if the risk of midair collision is not increased intolerably through reduction of the Vertical Separation Standard. The FAA plan for judging the feasibility of a 1,000-foot Vertical Separation Standard thus consists of a process for assembling all the decisionmaking elements necessary to judge whether the risk of midair collision, due to the loss of planned 1,000-foot vertical spacing, is consonant with safe system operation. Necessary information consists of aircraft navigational performance, traffic packing densities, ATC operational procedures, and system environmental factors such as atmospheric turbulence.

Aircraft navigational performance in both the horizontal and vertical planes will affect the decision to reduce separation. Estimating such performance in the horizontal plane can be done using radar-derived aircraft position measurements. Such is not the case in the vertical plane. No radar-based measurement of an aircraft's vertical position is operationally available to air traffic control. Instead, an aircraft's own estimate of its pressure altitude, rounded to the nearest whole 100-foot increment, is transmitted in response to ATC system sensor interrogations which normally occur every 10 to 12 seconds. For traffic at jet route altitudes, this response contains an octal number identification code assigned by ATC from a list of 4,096 possibilities, the encoded pressure altitude, and other pertinent information. Because of various ways of mechanizing this automatic reporting process, the octal identification number is referred to as Mode 3/A information and the transponded pressure altitude as Mode C.

The FAA Technical Center has developed a plan to obtain measurements of an aircraft's vertical position necessary to assess system vertical navigational performance. The plan aims to provide estimates of both where individual aircraft should be in the vertical plane (in order to comply perfectly with ATC flight level assignments) and where, in fact, they are. Thus, it should be possible to estimate vertical position-keeping errors. In the horizontal plane, ATC-assigned aircraft position at any time can be expressed as a point on a great circle segment between two latitude-longitude fixes. Individual jet routes are uniquely defined in the horizontal plane by sequences of great circle segments between such fixes which very often correspond to the locations of radio navigation aids. In the vertical plane, however, the locations of flight levels are not rigidly fixed at specific geometric heights above mean sea level. Rather, the pressure altitudes defining the flight levels correspond to surfaces of constant pressure, or isobars, the geometric heights of which in a given area vary both throughout the day and as a function of the time of year. These diurnal and seasonal variations are further compounded by both differences in the geometric height of an isobaric surface within a volume of airspace at a given time and also changes in the height of a point on the surface over time. These spatial and temporal variations are due to such factors as atmospheric gravity/shear waves and instabilities, while diurnal and seasonal effects are likely due to temperature changes and longer-term climatic effects.

The magnitudes of variability in the geometric height of isobars induced by these effects are not easily measured. As a result, the FAA's plan for estimating vertical navigational performance, while thoroughly reviewed by the most competent experts available, does consist, in part, of techniques which have not previously been tested for the accuracies required to produce vertical navigational performance estimates suitable for the decisionmaking process. Thus, the FAA's plan to collect vertical navigational performance is staged in two phases. In Phase I, the FAA's currently proposed methodological approach to collecting vertical navigational performance data will be evaluated, refined and, hopefully, demonstrated to be adequate. In Phase II, the resulting methodology of Phase I will be employed to collect performance data which will adequately reflect the seasonal, geographical, and other effects thought to possibly alter vertical navigational performance. It is the data from this latter phase which will form the bulk of the vertical navigational performance sample to be used in deciding whether vertical separation should be reduced to 1,000 feet at and above FL290.

1.2 PURPOSE.

The objective of this document is to outline the goals and procedures of Phase I of the FAA's plan to collect vertical navigational performance data to aid in deciding whether to implement a 1,000-foot Vertical Separation Standard at and above FL290. Additional purposes are to identify the organizations and facilities involved in the test, to describe the types and quantity of data to be collected in the evaluation process, and to publish a tentative schedule for pertinent activities.

2.0 OVERVIEW OF DATA COLLECTION METHODOLOGY.

This section discusses the intended plan for collecting vertical navigational performance data. The plan is presented in the indicative mood; the conditional nature of portions of the plan, especially regarding accuracies, should be evident to the reader. The plan involves coordinated activities of an air route traffic control center (ARTCC) and an instrumentation range consisting of a precision three-dimensional radar and associated data recording and reduction support. Section 3.0 presents the specifics for testing this procedure, making explicit the ARTCC and range involved and highlighting those areas of the procedure requiring operational evaluation and demonstration of accuracy.

A pictorial synopsis of the FAA plan to collect vertical navigational performance data is shown in figure 1. Determining the geometric height of flight levels at and above FL290 will be accomplished using a specially dedicated aircraft equipped with state-of-the-art equipment for measuring local static pressure. The aircraft will fly a jet route segment which will be tracked with a very accurate three-dimensional precision radar, thus permitting a mapping or survey of the relationship between pressure altitude and geometric height for flight levels between 290 and some upper limit determined by the aircraft's performance capabilities. Real-time precision tracking of the pressure survey aircraft on the jet route segment being mapped will give a good first approximation of the flight level-height relationship. Post-flight processing of the very accurate pressure measurements made aboard the aircraft will permit differential corrections to the survey sufficient to permit mapping pressure altitude and geometric height with a standard deviation of 50 feet between the true and computed values. The aircraft at FL370 and associated measuring symbology in figure 1 illustrates the atmospheric surveying portion of the FAA plan.

With the relationship between flight level and geometric height established, the vertical navigational errors of itinerant aircraft operating on the jet route segments can be estimated. Flights planned to fly in level cruise through the surveyed area will be identified at the ARTCC controlling the airspace and their positions passed to the instrumentation range so that they can be tracked by precision radar. The total vertical navigational error estimated for each flight will then be the difference between the aircraft's geometric height, as to which the aircraft is assigned, it flies its assigned flight level, and the geometric height of the flight level as determined by the survey aircraft mapping process. The error will be estimated over that extent of the jet route segment which is considered accurately surveyed. This interval will be a minimum of roughly three minutes in order to permit observation of anticipated aircraft dynamics, such as the phugoid effect associated with piloting aircraft. In addition to precision radar tracking, the Mode-C pressure altitude transponded to the ARTCC by each observed flight will be recorded. This will be useful in determining how much of any total vertical error, as defined above, is due to the flight's observable deviation

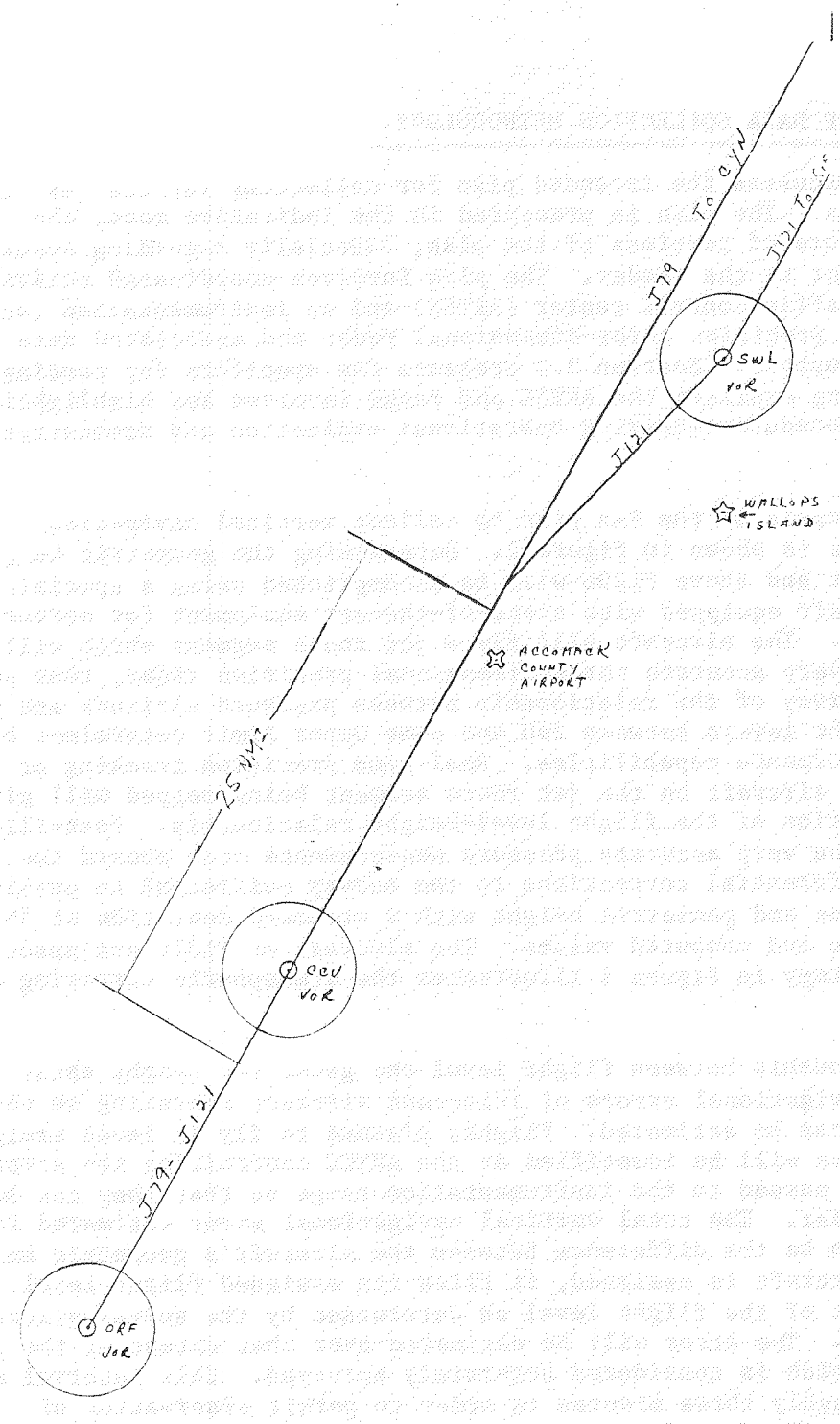

FIGURE 1. DATA COLLECTION AREA

from assigned altitude and how much is due to sources not normally known to the crew, such as faults in measuring pressure or converting the measured pressure to information useful in flying the aircraft.

The Mode-C track of an aircraft will normally be of much longer duration than its precision radar track, since deviations from assigned altitude may well have periodicities considerably in excess of three minutes. All ATC-aircraft voice communications for the tracking period will also be recorded. Mode-C tracks will be saved on a radar data recorder (RDR) designed by the FAA Technical Center for such specialized data collections. In a modified form, the RDR will not only record an aircraft's Mode-C track but also use this information to compute and transmit an initial position fix for precision radar acquisition of the candidate aircraft. The aircraft at FL330 and associated tracking and recording symbology of figure 1 illustrates the determination and recording of vertical navigational performance in the FAA plan.

Atmospheric surveys will take place at specific times during a day. Because of the expected diurnal movement of isobars, as well as anticipated spatial and temporal variabilities, it will be necessary to estimate the geometric height of flight levels between surveys. This will be done using simple mathematical models parameterized by the survey measurements, meteorological observations of atmospheric changes between surveys (as shown in figure 1), established patterns of isobar movement and, insofar as possible, observations of the geometric height of itinerant aircraft with known vertical position-keeping abilities.

An investigation of each especially large observed vertical navigational error will be conducted. The aircraft operator will be contacted to determine if any operational or equipment factors are explanatory. Where practical, special testing of the aircraft's altimetry system will be conducted if other means for explaining the error's cause prove fruitless. A reasonable threshhold for triggering this special investigative mode is an error of 300 feet or more from assigned flight level, which cannot be adequately explained by the Mode-C or voice comunications information pertinent to examination of an assigned altitude deviation.

Having examined the plan for collecting vertical navigational performance macroscopically, it is now useful to list some details of each of the plan's component activities.

2.1 ARTCC FUNCTIONS AND DATA.

An FAA Technical Center air traffic control specialist will be stationed at the ARTCC and will be solely responsible for data collection activities at the center. This will help to ensure that no additional workload will be levied on the ARTCC's controller staff because of data collection activities. There will also be Technical Center representation at the instrumentation range

for the purpose of coordinating activities between that location and the ARTCC. The Technical Center air traffic control specialist stationed at the ARTCC observing traffic on the jet route segment of interest fills several roles:

a. Conduit for channeling information about survey aircraft and tracking plans to the ARTCC's air traffic management staff, providing details of the intended next day's activities of the aircraft, and the expected next day's status of facilities at the precision tracking range as well as near real-time variations from present day's planned activities.

b. Initiator of process leading to precision tracking of itinerant users of jet route segments.

c. Guarantor that the tracked sample of itinerant aircraft represents a broad spectrum of users, aircraft types, altitude choices and flight directions by logging sample elements incrementally and choosing new entrants in accordance with the desired characteristics.

The functions performed to fulfill these roles, then, are:

a. Frequent communications with the Technical Center personnel at the precision instrumentation range for purposes of planning and modifying daily test activities concerning survey flight and tracking.

b. Real-time montioring of traffic flight planned to fly the route segment of interest for purposes of choosing flights to track.

c. Direct real-time voice communication with the tracking facility in order to provide initial positions of itinerant flights for precision radar acquisition.

d. Maintenance in real-time of a log detaching pertinent identifying information for all flights tracked.

e. Maintenance in real-time of survey form designed to ensure that the sample of flights adequately reflects the desired range of relevant characteristics.

The data to be compiled at the ARTCC will consist of:

a. Logs fully identifying aircraft tracked during the test.

b. Any important operation factors noted during the test, such as the ease or difficulty of survey flight integration into the ATC environment, pertinent weather phenomena, or significant events involving tracked flights.

c. ATC air-ground voice communications for the test period.

d. The Mode-C return for all tracked aircraft.

e. Recording/noting any aircraft with an altitude bust (i.e. 300 foot or more off assigned altitude).

2.2 PRECISION TRACKING RANGE FUNCTIONS AND DATA.

Technical Center personnel assigned to the precision tracking range will not have any responsibility for data collection at that site. Such duties will be carried out solely by the range's test director, radar crews, and support staffs. Rather, the role of the Technical Center will be one of coordination and planning, with the intent of ensuring that the types and quantity of data collected at the instrumentation range will satisfy test objectives. Contributions made by Center personnel will thus be in the following areas:

a. Coordinating with the Technical Center air traffic control specialist assigned to the ARTCC concerning the planning of future survey flights and tracking activities based on the projected availibility of instrumentation range prescision radars and associated support facilities, and modifying plans in real-time as necessitated by range equipment complement changes.

b. Meshing pressure survey aircraft activities with the availability of precision range facilities.

The principal function of the instrumentation range during Phase I is to provide accurate, frequent, aircraft-independent measurements of survey and itinerant flights in the three spatial dimensions. An additional function of the range is to provide local standard meterological data pertinent to the time intervals when tracking is being carried out.

Data gathered at the instrumentation range will thus consist of:

a. Records identifying aircraft tracked and ancilliary information appropriate to correlate these records with those copied at the ARTCC for same aircraft.

b. Time-ordered, computer processable, smoothed three-dimensional tracks of survey and itinerant aircaft flights.

c. Meterological records pertinent to the test times in any format conveniently available.

2.3 SURVEY AIRCRAFT FUNCTIONS AND DATA.

A member of the Technical Center staff will maintain contact with the director of pressure survey aircraft operations for purposes of coordinating the plane's contributions to the overall effort. Functions which the aircraft will perform are:

a. Pressure surveying the centerline of the jet route segment of interest from FL290 to FL410. In the event that such a thorough survey is impossible, due to ATC operational or test time constraints, flying either some of the flight levels on centerline or doing the survey in a nearby area will be substituted.

b. Gathering data on the spatial and temporal variability of the relationship between pressure altitude and geometric height.

The latter type of information will be used to model the atmosphere between pressure surveys and to gain insight into the general behavior of isobaric heights. Data to be gathered by the pressure survey aircraft will, essentially, by that required to define the locations of flight levels in terms of pressure altitudes. Thus, frequent samples of total pressure, static pressure, total temperature, and atmospheric density will be necessary.

From these, accurate estimates of the pressure altitude at any point can be computed from the hydrostatic equation suitably parameterized. In order to have quicklook estimates of the isobar geometric height relation at a given time, which do not depend on the availability of a precision radar, the pressure survey aircraft should also collect frequent estimates of its latitude, longitude, geometric height, and pressure altitude.

2.4 FOLLOW-UP OF LARGER OBSERVED NAVIGATIONAL PERFORMANCE ERRORS.

The geometric height of the pressure survey aircraft will be plotted in real time at the precision radar site as it maps flight levels. As itinerant flights proceed along the surveyed segment, their geometric heights will likewise be plotted. Whenever the Technical Center observer at the site notes that the difference between the heights of one of these flights and the reference surveyed height exceeds 300 feet, a special procedure will be followed. First, the Technical Center air traffic control specialist at the ARTCC will be asked to determine if the aircraft is showing a Mode-C transponded difference from its assigned flight level. If such is not the case, the flight may be exhibiting an error due to undetected altimetry problems. The Technical Center air traffic control specialist will, if possible, coordinate a query of the flight by the responsible ARTCC control position for purposes of asking the crew which systems are being used to maintain altitude and if they note non-nominal operation of any equipment. In the event that assigned altitude deviation does not appear to be the cause of the larger error, the Technical Center observer will initiate a post flight investigation of the aircraft in order to help in explaining the deviation. The investigation will include contacting the aircraft operator for discussions and review of maintenance records as well as special testing where warranted.

3.0 TEST FORMATS, PROCEDURES, SCHEDULES, AND EXPECTED OUTPUT.

The Phase I test will be conducted from July 12 to August 12, 1983. Precision tracking facilities will be provided by the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center, at the Wallops Flight Facility, Wallops Island, Virginia. Air Traffic monitoring and identification of flights for tracking will be done at the Washington Air Route Traffic Control Center, Leesburg, Virginia. The pressure survey aircraft will be a North America 265 Series 60 Sabreliner owned and operated by the National Center for Atmospheric Research (NCAR), Boulder, Colorado. Details of the high quality research capabilities of this aircaft are available in NCAR Bulletin 3, 6 and 9 (references 1, 2, and 3). The FAA Technical Center will receive support in conducting on-site data collection activities from ARINC Research Corporation, Annapolis, Maryland. In particular, responsibility for gathering details pertinent to the explanation of larger apparent vertical navigational errors will be borne by ARINC Research Corporation.

The names and locations of key individuals in the Phase I test are given in Appendix A.

Testing will proceed between 0800 and 1630 on normal workdays during the planned period unless test conditions dictate otherwise (test schedule and goals are covered later). Inavailability of any of one of the following facilities will cause a day's testing to be cancelled:

a. NCAR Sabreliner.

b. At least one Wallops C-band precision radar and support elements.

c. Necessary restricted or military warning area airspace.

d. Washington ARTCC tracking and display functions.

Item d above is an unlikely event for an extended time in view of the necessity to control air traffic. Thus, items a through c are expected to be the principal reasons for cancelling a day's testing. The NCAR project manager on-site at NASA/Wallops will have sole responsibility for determining the availability of the Sabreliner. The NASA/Wallops Test Director will decide on a daily basis about the status of items b and c.

The NASA/Wallops Test Director will exercise overall judgement concerning whether a day's testing will or will not proceed and will also modify a day's schedule in light of local operational considerations and other demands upon Wallop's Facilities. The FAA Technical Center test coordinator at Wallops will be responsiblle for deciding whether a day's modified testing schedule is

feasible in light of necessary coordinations with the Washington Air Route Traffic Control Center and the FAA Technical Center and so inform the NASA/Wallops Test Director.

3.1 PHASE I TEST OBJECTIVES.

The chief overall goal of the Phase I test is to demonstrate the feasibility of the FAA's proposed methodology for collecting vertical navigational performance data to support decisionmaking about a 1,000-foot vertical separation standard. Feasibility will be demonstrated when all facets of the plan have been carried out and required accuracies achieved. The main accuracy requirements are two: (1) relating pressure altitude to geometric height on the route segment of interest at any time with an accuracy of 50 feet or less, and (2) measuring the geometric height of itinerant aircraft with an accuracy of 50 feet or less. Achieving these accuracies will require considerable knowledge of atmospheric statics and dynamics, as well as substantial empirical evidence about precision radar performance. As a byproduct of meeting these accuracy requirements, the data collection development would produce a sample of vertical navigational perfomance. This sample is a secondary goal of Phase I.

The specific objectives of the test can now be stated in terms of the primary and secondary goals of Phase I:

a. Demonstrate accuracies of pressure survey procedure using the NCAR Sabreliner.

b. Determine the necessary frequency and extent of surveys.

c. Accurately estimate mesoscale atmospheric dynamics.

d. Examine methods for monitoring changes in pressure levels, such as mathematical models or the pressure altitude, geometric height profiles of aircraft thought to be especially accurate vertical navigators.

e. Observe the effects of different atmospheric conditions.

f. Identify and follow up apparent larger vertical navigational errors.

g. Gather an initial sample of vertical navigational performance.

3.2 TEST AREA AND CONSTRAINTS.

The route segment which will be pressure surveyed and on which itinerant traffic will be monitored, is part of jet routes 79 and 121 (J79/J121) starting roughly 40 nautical miles north of the Norfolk (ORF) VOR and continuing northward for about 25 nautical miles, as is shown in figure 1. During the

nominal test day period of 0800 to 1630, itinerant traffic volume is quite heavy from about 0930 to 1130 and again from about 1330 through 1630. At other times during the test day, traffic volume is only light to moderate. Military warning areas and restricted airspace areas exist to the east and west of the route segment centerline, with proper ATC separation from those to the east an especial concern at the northern end of the segment. Traffic on J79-J121 is about 80 percent scheduled air carrier flights, with the remainder nearly all high-performance business general aviation aircraft.

3.3 SPECIFICS OF FACILITIES INVOLVED IN DATA COLLECTION.

The Technical Center's air traffic control specialist assigned to the Washington Air Route Traffic Control Center for the test will monitor high altitude sector 34 on a specially dedicated planned video display (PVO), which has responsibility for that portion of J79-J121 traffic of interest. Since it encompasses considerable airspace to the north and south of the segment, the Technical Center's air traffic control specialist will monitor only Sector 34 during the test and only voice communications from that sector will be recorded for possible later use. Since the Technical Center receives digitized radar target reports from the Plaines, Virginia and Trevose, Pennsylvania air traffic control en route radars as a matter of course, the radar data recorder to be used in the test will be located in the Technical Center's Technical and Administrative Building.

The NASA/Wallops test director has scheduled participation of an AN/FPQ-6 and two AN/FPS-16 precision tracking radars in the test. Use of the units (designated by Wallops as radars 5, 3, and 18) will be on an "as available" basis, dependent on equipment status and priorities. Because of require pre- and post-tracking calibrations and maintenance checks, any of the precision tracking radars will be available only from 0930 to 1530 during a normal workday.

The NCAR Sabreliner has an extensive array of sensors and recording equipment designed for atmospheric research and a Litton LTN-51 inertial navigation system (INS). Given the necessity to accurately map atmospheric statics and predict atmospheric dynamics, these systems will be employed in charting information from two basic flight profiles. The first will be a pressure survey of the route segment of interest from flight levels 290 to 410, as is shown in figure 2.

This pressure survey will be conducted on or nearby and parallel to the route centerline of the segment of interest. The second flight profile will be a constant-altitude rosette, nominally centered at or near Accomack County Airport, as is shown in figure 3. This figure shows restricted area R4006 which is to the west of the route segment. The pattern, intended to gather data for modelling spatial and temporal variations of gravity/shear waves, will be flown

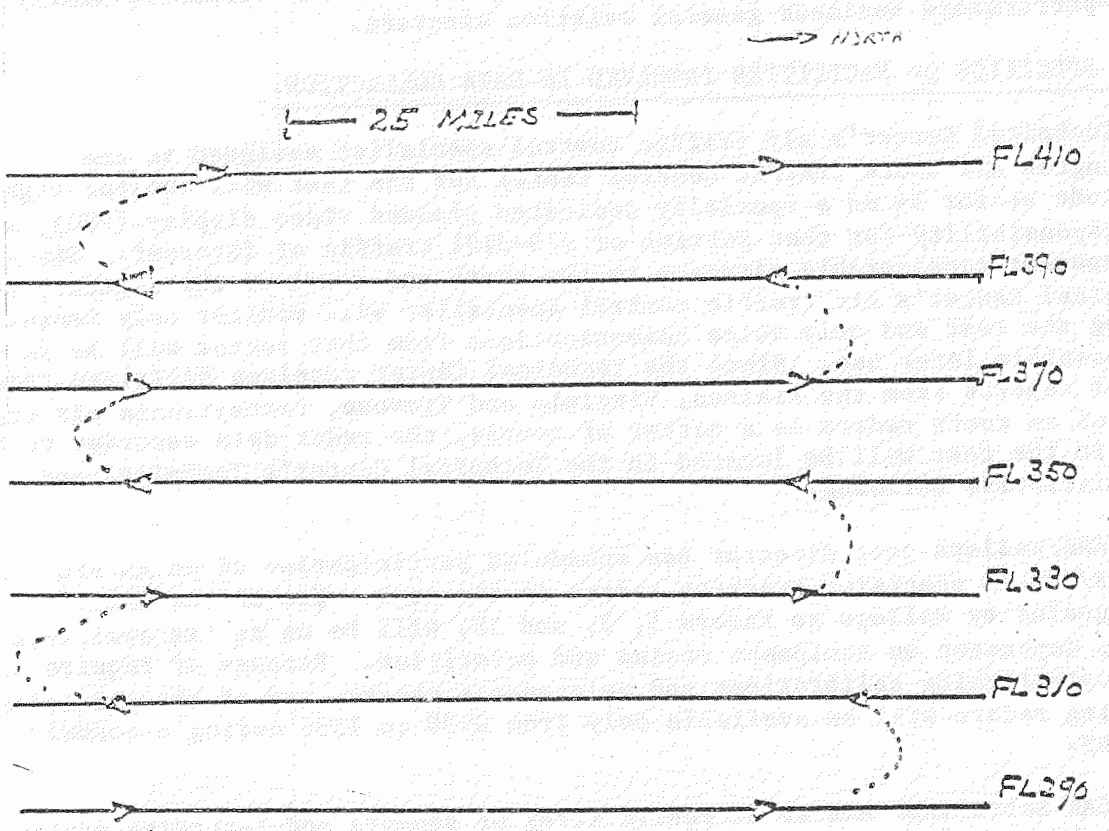

FIGURE 2. VERTICAL VIEW OF SURVEY AIRCRAFT FLIGHT PROFILE

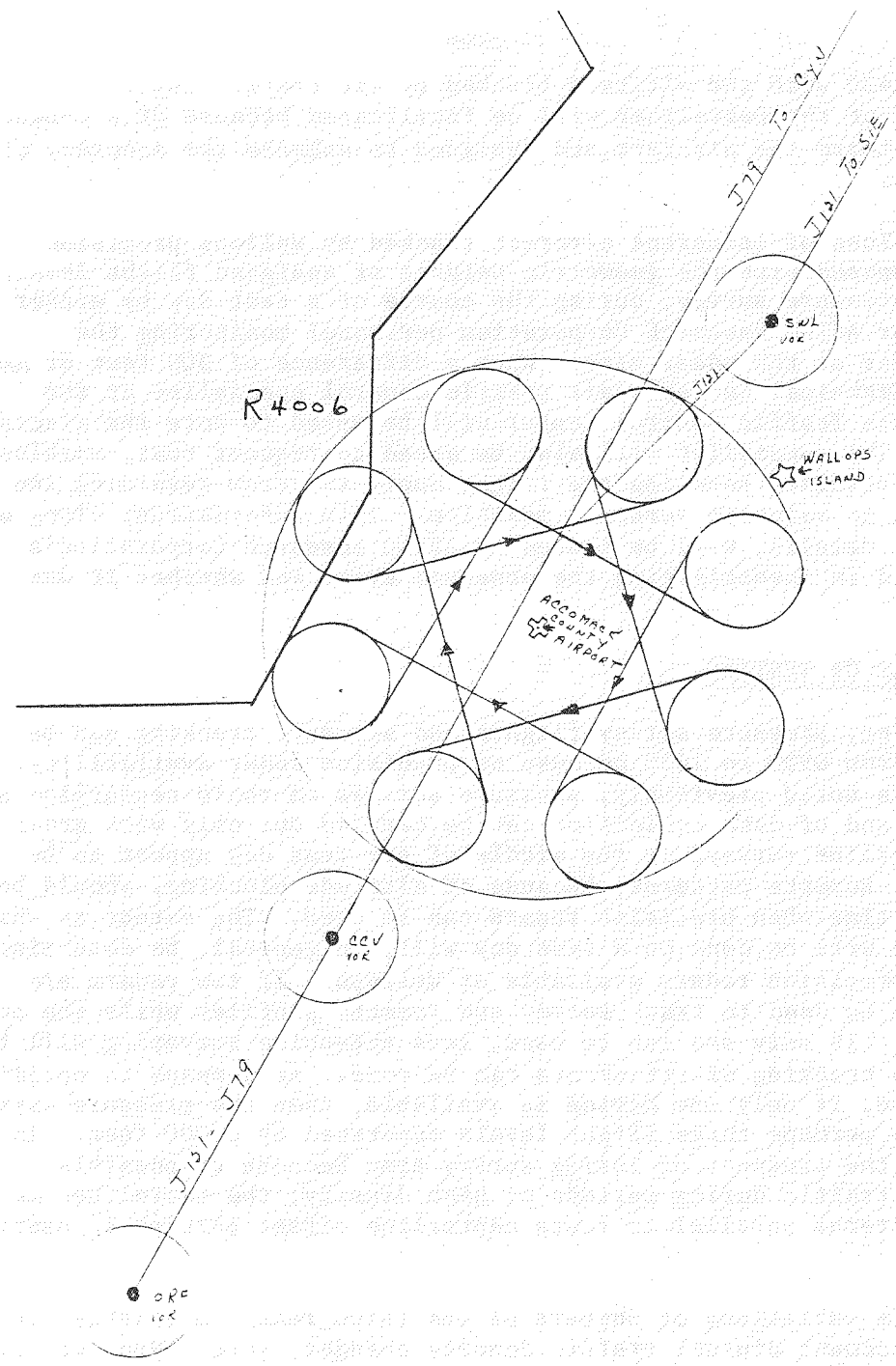

FIGURE 3. ROSETTE SURVEY PATTERN

either FL280 or FL430 with the altitude blocked by air traffic control. Precision tracking of the Sabreliner will be facilitated because of a C-band beacon installed aboard the aircraft and designed to enhance the accuracy of the Wallops radars.

The vertical positions of itinerant aircraft tracked by Wallops precision radars will be compared with the geometric heights of assigned flight levels, as determined by pressure survey, during the course of a test day by either Technical Center or ARINC Research Corporation personnel monitoring the vertical bed plotter at the radar site. When a difference of 300 feet or more is observed, the Technical Center's air traffic control specialist at the Washington Air Route Traffic Control Center will be asked to note the aircraft's Mode C response. The specialist will also be asked to request that, workload permitting, the controller handling the flight query the crew regarding the systems being used to maintain vertical position. This information, along with all other relevant details, will be passed to ARINC Research Corporation's headquarters to aid in investigating the observed event and whether it was indeed an error.

3.4 DAILY SCHEDULE OF TESTING.

Practically speaking, pressure survey flights and aircraft tracking can be carried out only from 0930 to 1630 because of precision radar availability. Given traffic peaks noted previously, pressure surveys on route centerline at the beginning and end of data collection can be carried out only with great difficulty. Centerline surveys in the middle of the test day appear to be quite achievable. Rosette patterns, because of altitude blocking, should be achievable at any time when precision radars can be used. The extent to which pressure surveying will be done on a test day will, in general, be determined by the number of precision radars available at Wallops. If two radars are available, one can be used to track survey and rosette profiles while the other tracks itinerants. If only one can be used, less extensive surveying will be tried so that some tracking of itinerants can be done. As a means to optimize precision radar use, if only one device is available, then the pressure survey will be limited to perhaps three flight levels separated by 6,000 feet. In order to minimize the prospect of losing survey time because of possible interference with traffic during periods of high density, the Sabreliner may fly its profile patterns parallel to route centerline offset perhaps 10 nautical miles to the east.

In view of possible variations of numbers of precision radars available and also taking into account diurnal traffic density changes, three types of test days will be defined at the outset of Phase I:

Type I Day

Starting at 0930, a full pressure survey offset 10 nautical miles from centerline, followed by a rosette at FL430 and landing.

Starting at 1230, a full pressure survey on route centerline, followed by a rossette at FL430, followed by a limited survey from FL410 offset 10 nautical miles from centerline, followed by a rosette at FL280 and landing.

Type II Day

Starting at 0930, a limited pressure survey starting from FL290, 10 nautical miles offset from centerline, and landing.

Starting at 1230, a full survey on centerline and landing. At 1500, a limited survey starting at FL290 and landing.

Type III Day

Starting at 0930, a limited survey starting at FL290 and landing.

Starting at 1230, a limited survey from FL290 and landing.

The Type I day assumes the availability of two precision tracking radars; Types II and II require one precision radar.

Exceptions to this daily schedule will be a day at the beginning and at the end of the data collection to mutually calibrate aircraft and radar systems and three or so days later in the data collection period to examine late afternoon traffic or non-nominal weather conditions such as thunderstorms. Because of the heavy press of requests for use of Wallops facilities and unpredictability of military use of adjacent airspace, as segment of days of the week to type days if not practical.

Appendix B details the daily duties and schedules of the various Technical Center personnel involved in the Phase I test.

REFERENCES

1. Bulletin No. 3, The NCAR Sabreliner: Overview and Summary of Capabilities, The National Center for Atmospheric Research, Research Aviation Facility, Boulder, Colorado.

2. Bulletin No. 6, Flight Planning: The NCAR Sabreliner, The National Center for Atmospheric Research, Research Aviation Facility, Boulder, Colorado.

3. Bulletin No. 9, Description of Standard Output Data Products From NCAR Research Facility Aircraft, The National Center for Atmospheric Research, Research Aviation Facility, Boulder, Colorado.

APPENDIX A

ORGANIZATIONS AND KEY PERSONNEL

Principal contacts and Federal Telecommunication System (FTS) or commercial (COMML) telephone numbers. Principal contacts for the organizations involve in the Phase I Vertical Separation Program test of July 12 to August 1983 are:

Raymond D. Atkins, Test Director
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APPENDIX B

PHASE I TEST DAILY COMMUNICATIONS AND EVENTS INVOLVING TECHNICAL CENTER PERSONNEL

The following schedule and communications requirements will guide the Technical Center Vertical Separation Program personnel involved in the Phase I test. In the following schedule, the Technical Center air traffic control specialist at the Washington Air Route Traffic Control Center is referred to as the "Tech Center ATCS," the Technical Center test coordinator at Wallops Flight Faciity as the "Tech Center Coordinator," and the Technical Center Test Monitor at the Technical Center's Technical and Administrative Building (T/A Bldg.) as the "Tech Center Monitor."

Time	Location	Event
0800	Tech Center T/A Bldg.	Tech Center Test Monitor mounts RDR tape for day.
0800	Washington ARTCC	Tech Center ATCS mounts voice tape for day; checks ARTCC status.
0800	Wallops Flight Facility	Tech Center Coordinator reviews status of equipment and planned activities with Wallops Test Director and NCAR Project Manager.
0830	Washington ARTCC/ Wallops Flight Facility	Tech Center ATCS and Tech Center Coordinator review day's planned activities and coordinate any late changes.
0845	Washington ARTCC	Tech Center ATCS reviews any changes to planned daily activities with ARTCC staff.
0845	Wallops Flight Facility	Tech Center Coordinator reviews any changes arising from Washington ARTCC problems.
0900	Tech Center T/A Bldg. Wallops Flight Facility	Tech Center Coordinator and Tech Center Monitor discuss Mode-C traces of previous day's tracked flights; note aircraft for follow-up to ARINC Research Corporation.
0930	Washington ARTCC Wallops Flight Facility	Morning test tracking begins.
1130	Washington ARTCC Wallops Flight Facility	Morning test tracking ends.

Time	Location	Event
1230	Washington ARTCC Wallops Flight Facility	Afternoon test tracking begins
1530	Washington ARTCC Wallops Flight Facility	Afternoon test tracking begins
1545	Washington ARTCC Tech Center	Tech Center ATCS passes ACIDS and beacon ID's of tracked aircraft to Tech Center Monitor.
1545	Wallops Flight Facility	Tech Center Coordinator discusses plans next day's flying and tracking with Wallops Test Director and NCAR Project Manager
1600	Wallops Flight Facility Washington ARTCC	Tech Center Coordinator passes details of planned next day's activities to Tech Center ATCS who passes on significant events to ARTCC air traffic management
1600	Tech Center T/A Bldg.	Tech Center Monitor removes and labels RDR tapes, submits tapes for overnight processing by VORKLI/WES
1615	Washington ARTCC	Voice tape removed, labeled.

An overview of this communication process and attendant data collected is presented in the attached figure.