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TEST AND EVALUATION OF A CONFLICT ALERT CAPABILITY FOR THE NAS ENROUTE SYSTEM

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16. Abstract

A series of tests of a conflict alert capability was conducted over a period of 4 months to evaluate the operational suitability of a system which alerts radar controllers to potential violation of radar separation standards. These tests were conducted in a beacon only high-altitude airspace environment with simulated digital target data. This report describes these tests and the results obtained.

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PREFACE

This report reflects the results of an effort at the National Aviation Facilities Experimental Center to test and evaluate the National Airspace System Enroute Stage A Model 3d1 system with a ground based collision prevention capability.

The operational program tape used throughout testing was developed for the A3d1.1 system and discrepancies recorded were limited to the conflict alert function and/or design. Results, conclusions, and recommendations contained in this report are operationally oriented and they do not consider program size and processing time requirements as a function of the overall system, nor implementation-associated factors.

LIST OF ABBREVIATIONS

ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
CA	Conflict Alert
CDC	Computer Display Channel
DCC	Display Channel Complex
DSF	Digital Simulation Facility
FL	Flight Level
NAFEC	National Aviation Facilities Experimental Center
NAS	National Airspace System
PAM	Peripheral Adapter Module
SAR	System Analysis Recording
SEPH	Altitude Separation Parameter
SEPR	Planar Separation Parameter
SSF	System Support Facility
UDS	Universal Data Set
WRNT	Warning Time Parameter
ZJX	Jacksonville, Florida, Air Route Traffic Control Center

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INTRODUCTION

PURPOSE.

The purpose of this activity was to test and evaluate the operational suitability of conflict alert (CA), a ground based collision prevention automation aid, developed for the Model 3d program of the National Airspace System (NAS).

This report discusses the method used and results obtained of the test and evaluation of the NAS Enroute Stage A Model 3dl with a CA capability conducted in the System Support Facility (SSF) at the National Aviation Facilities Experimental Center (NAFEC).

BACKGROUND.

A CA function, which provides radar controllers with a displayed alert for potential violation of radar separation standards among tracked aircraft was successfully integrated into the NAS Enroute Model 1 system. Preliminary tests of this CA function were conducted by the Federal Aviation Administration (FAA), Systems Research and Development Service, and MITRE Corporation, at the Jacksonville (ZJX), Florida, Air Route Traffic Control Center (ARTCC) from October 4, 1972, to November 30, 1972. The ZJX tests were conducted in order to validate the CA functional design, assess the man/machine design, assess the procedural implications, and to validate processing time. Testing included 16 hours of flight tests using two FAA test aircraft in 60 encounter situations (head-on, crossing, in-trail, climbing, and descending). Results showed that all conflict situations were detected and no false alarms were generated. Excepting encounters of very short duration, adequate warning of conflict was provided.

Based on the results and recommendations from the Jacksonville testing, integration of an improved CA algorithm with the NAS Model 3dl system was initiated. Successful program shakedown and comparative analysis (Model 1 and Model 3dl) testing preceded the system test and evaluation of the CA function.

This test activity was conducted between May 16, and September 13, 1973.

DISCUSSION

GENERAL.

Based on a test plan prepared by the MITRE Corporation, a NAFEC Test Team conducted tests in the SSF to verify the CA design by assessing, in a simulated high-altitude environment the detection capability of the algorithm and the operational suitability of the CA function.

The algorithm is designed to detect potential conflicts by projecting a volume of airspace constructed about each tracked aircraft along its velocity vector from its present position to a position some predetermined time in the future. The volume of airspace, defined by two parameters, planar separation parameter (SEPR), and altitude separation parameter (SEPH), is cylindrical with the diameter a function of SEPR and altitude a function of SEPH. The projection is made each computation cycle (two tracking subscans). Each track is projected for an interval of time, warning time parameter (WRNT), and a CA is declared for any pair of tracks determined to have less than the established radar separation minimums (based on the placement of the projected cylinders) during that time interval.

For each test session, one of three types of tests (detailed under Methodology) was utilized, however, parameters SEPR (4.8 miles), SEPH (1,000 feet) and WRNT (2 minutes) were constant throughout. The setting of the SEPH at 1,000 feet provide for 1,000 feet separation below flight level (FL) 290 and 2,000 feet above FL 290. All tests involved participation of NAFEC controllers, digital simulation facility (DSF) personnel, and personnel from MITRE Corporation and NAFEC to perform observer duties and test analysis.

Twenty three test sessions, each of 2-1/2 hours duration, were conducted between May 16 and September 13, 1973, of which 16 were successful from a data collection viewpoint and seven were unsuccessful due to either computer or DSF failures. Appendix A contains a summary of all test sessions conducted.

ENVIRONMENT.

All test sessions were conducted in the SSF, a laboratory model developed at NAFEC for enroute system testing (figure 1). The SSF is divided into two 12-sector laboratories each one differing only in the display channel used to drive the displays. These include the computer display channel (CDC) and the 9020E display channel complex (DCC). Tests could be and were conducted using either configuration.

The NAS program data base varied depending on the laboratory used for testing. For the CDC laboratory, the A3dK455Y or A3dK555Y system tapes with CDC version 33F7 was utilized. When the DCC laboratory was used, the program data base was the A3dK355Y system tape with DCC version 105Y.

Sectorization was identical in both laboratories and was based on a hypothetical geography called a universal data set (UDS). Included in each laboratory were seven low, three high, one ultrahigh, and one oceanic sector. Commonly used by both laboratories were five ghost sectors which took the place of all external facilities (automated radar terminal system (ARTS) towers; phase I, NAS on-line, and manual centers).

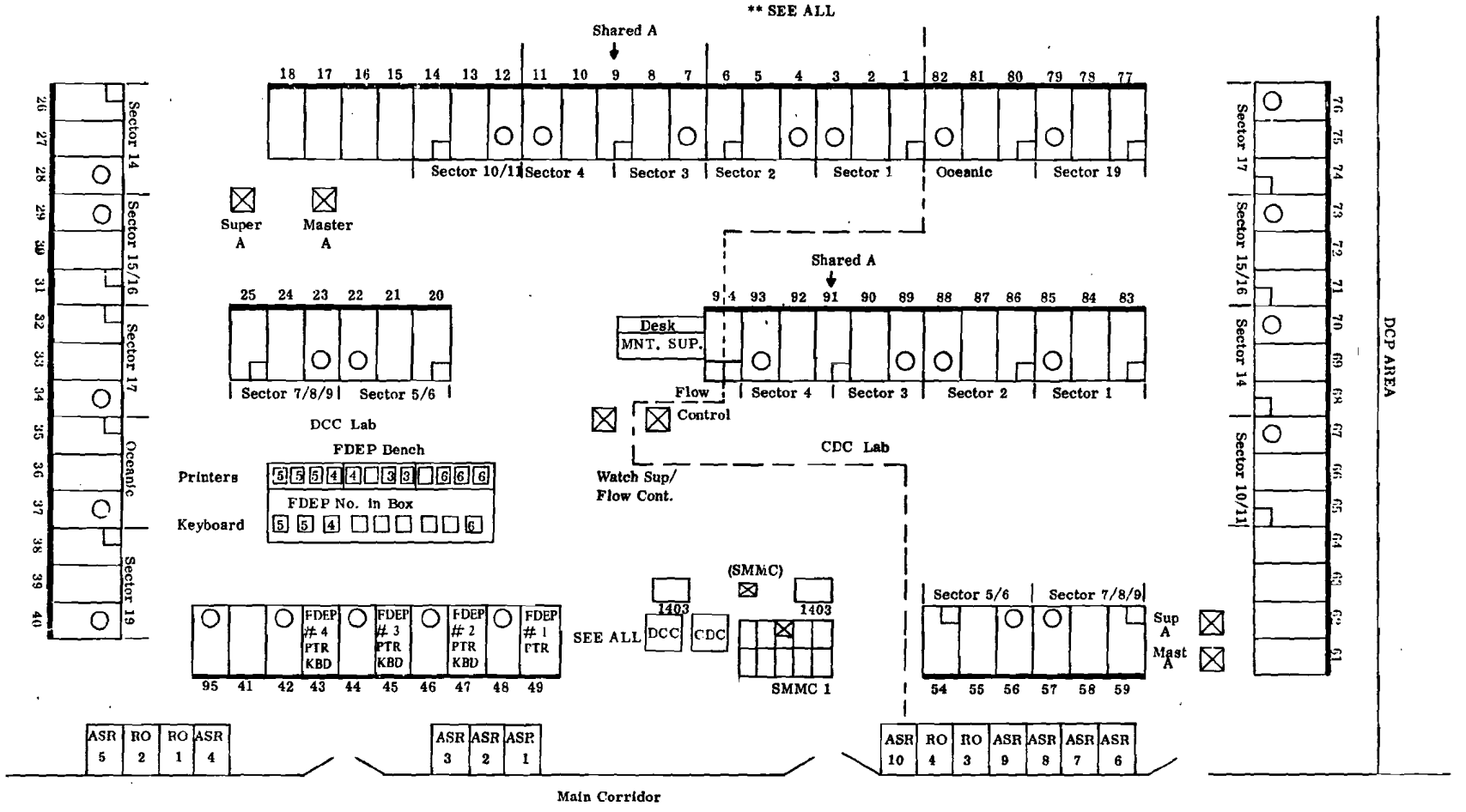
Simulated radar inputs to the SSF were provided by the DSF. Three traffic samples were used during testing including one each of light, moderate and heavy density. Some additional detail on traffic samples can be found under Methodology.

SECTOR	FSP ADDR	CUE ADDR. A POS	CUE ADDR. D POS	R CONS ADDR.	SECTOR	FSP ADDR	CUE ADDR. A POS	CUE ADDR. D POS	R CONS ADDR.
1	4F	34	04	1	10/11	50	21	01	7
2	9F	24	14	2	14	51	31	11	8
3	EF*	35*	05	3	15/16	A1	32	02	9
4	EF*	35*	15	4	17	F1	22	12	10
5/6	A0	30	00	5	19	A2	33	03	11
7/8/9	F0	20	10	6	Oceanic	52	23	13	
Flo Cont.	F2	-	-		Maint.	F4	-	-	12**

*Shared A

Position	IOT Address
Supervisory A	3E
Master A	3D
SMMC	DE
Watch Sup/ Flow Cont.	8E

Device (s)	Adapted As
FDEP #1 & 2	Man. Center
FDEP #3 & 6	Twr. Tracon
FDEP #4 & 5	Twr. Tracon
RO #1, 2, 3, 4	Phase 1 Out
ASR #4, 5, 9, 10	Phase 1 In (Sim loop)
ASR #1, 6	Area B
ASR #2, 7	Mil B
ASR #3, 8	Air Line B



NOTE: FDEP's number 3 and 4 have equipment located both on the console and on the FDEP bench.

FIGURE 1. SSF LABORATORY CONFIGUREATION

METHODOLOGY

To test and evaluate the Model 3d1 program with a CA capability, three types of tests were conducted. Each type of test had a specific objective and the test method varied somewhat. The following description details each type of test as to objective and method:

TYPE 1 - PRECISE ENCOUNTERS.

OBJECTIVE. To obtain data which contrasts automatic with manual conflict detection performance.

METHOD. The DSF provided target movement on preplanned flight paths which included crossover, head-on, and converging encounters between pairs of aircraft. Approximately 147 pairs were tracked during a 2 hour test period. Controllers were asked not to take any control actions to ensure separation but to advise the observer if he believed a conflict would exist, the action he would take to resolve the conflict, and an estimate as to what the distance between each aircraft in the encounter would be at their closest approach. Not all encounters were actual conflicts (separation ranged from zero to 16 miles). The information recorded by the observer provides a quantitative basis for contrasting the manual conflict detection (controller) with the automatic conflict detection (CA algorithm).

TYPE 2 - CONFLICT ALERT WARNING ONLY.

OBJECTIVE. To evaluate the performance of the CA function with respect to its detection capability and the adequacy of warning provided.

METHOD. A traffic sample of moderate density (approximately 80 tracked targets at the peak) was used for all type 2 tests. The DSF provided the target movement for a broad class of preplanned encounters in addition to background traffic which included aircraft departures climbing into the high-altitude airspace, aircraft flying coded routes, aircraft transversing the UDS geography via airways, and point-to-point (direct) routes. The encounters were similar to those used in type 1 tests. Controllers were asked not to take any control actions to resolve potential conflicts until a conflict alert was generated. Controllers were asked to advise the observer: (1) if they would have taken action earlier or later than the time the alert was issued, (2) if a hazardous situation went undetected, or (3) if they would have taken no action at all even though the alert was issued. This information was recorded on the observers log.

TYPE 3 - CONFLICT ALERT BACKUP.

OBJECTIVE. To validate the performance of the CA function as a backup tool.

METHOD. Traffic samples of moderate and heavy density were used for type 3 tests. The moderate sample had approximately 80 tracked targets at the peak while the heavy sample had approximately 150 tracked targets at the peak. Preplanned encounters were included in the moderate traffic samples while the heavy samples did not. The DSF provided the target movement for both densities. Controllers were asked to perform all normal air traffic control (ATC) duties and to advise the observer of any alerts or lack of alerts. The objective was to obtain information pertaining to the number of false alerts, alerts issued too soon or too late, or not at all, or areas where the algorithm failed to function as designed. During the running of the heavy density traffic samples, weather contours were displayed with controllers being asked to vector aircraft around the weather cells, workload permitting. Intent here was to put a heavy load on both the controller and system to obtain information as to whether the CA program had any impact (response time, distraction, etc.) during this type of operation.

DATA COLLECTION.

Data collection was identical for the three type of tests. Manual data consisted of observer logs, debriefing sessions, and questionnaires. Appendix B (Conflict Alert Questionnaire) shows the total of the responses of 16 NAFEC controllers to the questionnaire which was issued during the last two test sessions. Data reduction and analysis printouts, including CA analysis and track distribution summary, were obtained from the automatic data collected on the system analysis recordings (SAR).

RESULTS

Results are based on: (1) Controller responses to questionnaires, (2) debriefing sessions that followed each test session, (3) test observer logs, and (4) analysis of the printouts of the automatic data collected. The major emphasis in conducting the CA testing was placed on assessing the operational suitability of the CA function. In addition, the displayed information (blinking data blocks and a list display), alerting the controller to a potential conflict, was also evaluated.

Throughout testing, controller response to the CA concept was favorable. The majority of controllers who were exposed to the CA package agreed that the function should be incorporated into the NAS Enroute Stage A Model 3d program as a backup tool. The displayed information was considered adequate although several controllers indicated a desire to have altitude information in addition to aircraft identifications included in the list display. However, the need to have a list displayed when only two aircraft were in a potential conflict situation within the same sector was questioned by participating controllers.

During several test sessions, the blink rate of the data blocks was varied. Rates of two per second, four per second, and six per second were used in order to determine the optimum setting. For maximum readability of the flashing data block, clarity, and attention getting, the rate of four per second was deemed to be the optimum.

The timing of the appearance of the displayed information (blinking data blocks and list) was considered adequate with the WRNT set at 2 minutes. Controller opinion was split on whether the blinking data blocks and the list display erased fast enough once a potential conflict seemed by the controller to be resolved. Suggestions from those who answered in the negative included a switch action or track ball action to stop the blinking and erase the list.

Isolated cases of late alert warnings were observed and reported during several test sessions. Based on controller and observer comments, the late alerts occurred when aircraft were either turned into each other by vectoring or changed flight direction based on filed flight plan. It was determined that the late alert was not a fault of the CA algorithm itself, but the lag in the A3d tracker program. This lag is apparent in display of the data block vector line (projecting flight direction into the future) when it tries to catch up to the actual heading of a turning aircraft. There was no attempt during testing to experiment with various tracking and smoothing parameters in order to correct this problem. It was also determined that false alerts could occur due to the same tracker program lag. That is, aircraft could be vectored away from other aircraft or change direction according to filed flight plan, yet this lag in projecting future position could cause an alert although the aircraft were presently separated and would be in the future. Another cause of

late or false alerts was attributed to the failure of controllers to update flight plan altitude information and not to the CA function. Controllers agreed that false alerts could be distracting but the few that were observed during testing did not derogate the desirability of the CA function or concept.

CONCLUSIONS

From analysis of all the data collected, it is concluded that:

1. The CA program as designed and tested is operationally suitable when integrated with the NAS Enroute Model 3d1 program.

2. Improvements in the NAS tracker program, specifically the areas pertaining to track azimuth and track position prediction, would help to prevent or minimize the occurrences of late or false alerts and missed conflict detections.

3. Late or false alerts can be expected if flight plan altitude information in the computer is not kept up-to-date by the controller.

4. The data block blink rate of four per second is the optimum setting for legibility of the flashing data block, and attention getting.

5. The list display is not necessary when only two aircraft within the same sector are involved in a potential conflict situation.

6. When displayed, the tabular conflict list data showing aircraft identity of pairs in conflict is adequate.

RECOMMENDATIONS

Predicated on the results and the conclusions derived from these tests of a CA capability, the following overall recommendations are presented:

1. The CA function be incorporated into the NAS Enroute Stage A Model 3d programs for initial use in the positive control airspace after assuring that it will function with the A3d2 system. This will provide an immediate ATC enhancement and should be implemented in a way as to provide the basis for extension of the capability to the full airspace rapidly upon completion of full airspace testing.

2. Refine the CA program design so it is more time responsive to erasure of blinking data blocks and list displays once potential conflicts are resolved.

3. Suppress the CA list display when only two aircraft are involved in a potential conflict situation within the same controlling sector. Display the list if more than two aircraft are involved or if the aircraft involved are in two different controlling sectors.

APPENDIX A

TEST SESSION SUMMARY

Test No.	Date Conducted	Type Test	SSF Lab.	No. ATCS	No. DSF Pilot	Test Successful	Remarks
1	5-16-73	2	CDC	16	24	no	DSF problems
2	5-23-73	2	DCC	16	24	no	9020E cable problems
3	6-1-73	2	CDC	16	24	yes	
4	6-4-73	1	DCC	16	20	yes	
5	6-15-73	2	DCC	16	24	no	DSF aborts
6	6-22-73	2	DCC	16	24	no	Failure of PAM 2
7	6-25-73	2	CDC	16	24	yes	
8	7-2-73	2	DCC	16	24	yes	
9	7-9-73	1	DCC	16	20	yes	
10	7-12-73	3	DCC	16	24	no	9020E failure
11	7-18-73	1	CDC	16	20	yes	
12	7-23-73	1	CDC	16	20	yes	
13	7-30-73	1	CDC	16	20	no	9020E problems
14	8-1-73	1	CDC	16	20	no	CDC, DSF problems
15	8-6-73	3	CDC	16	24	yes	
16	8-17-73	2	DCC	16	24	yes	
17	8-20-73	2	DCC	14	24	yes	
18	8-24-73	2	DCC	14	24	yes	
19	8-27-73	3	CDC	16	24	yes	
20	8-31-73	3	DCC	16	24	yes	
21	9-5-73	3	CDC	16	24	yes	
22	9-6-73	3	DCC	16*	24	yes	
23	9-13-73	3	DCC	16*	24	yes	

*Each controller responded to questionnaire issued after each of these test sessions.

APPENDIX B

CONFLICT ALERT QUESTIONNAIRE

The purpose of this questionnaire is to obtain your views concerning the data display and operational usefulness of the conflict alert program which is being developed for possible implementation into the NAS program.

You are requested to carefully consider each question before selecting an answer and to add comments where appropriate. Your cooperation will be appreciated.

1. Does the conflict alert program, as designed, do the job you expected it to do?

   Yes 30

   No 2 (If No, please explain under general comments)

2. Do you think the conflict alert display will improve the safety margin in ATC operations?

   Yes 29

   No 3

3. Does the displayed data provide sufficient information for immediate use in providing separation?

   Yes 29

   No 3

4. The blink rate of the conflict alert display is approximately 4 per second. Do you consider this to be:

   Too fast 8

   Too slow 1

   Just right 23

5. Is the timing of the appearance of the conflict alert display:

Too early 5

Too late 3

Just right 24

6. Does the conflict alert display erase rapidly enough after the conflict has been resolved?

Yes 14

No 18

7. What would you change about the data display if you were designing the program?

Add altitude (1 controller), omit list completely (3 controllers) timing of erase (1 controller).

8. Should there be an option of having conflict alert operational or non-operational in the NAS program on a sector by sector basis?

Yes 22

No 10

9. Do you consider the list display necessary when only two targets are involved on the display?

Yes 8

No 24

10. Do you consider it desirable for the conflict alert list display to blink?

Yes 3

No 29

11. What priority would you give to implementation of the conflict alert feature into the NAS program?

High	7
Low	8
Moderate	17

General Comments: