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BASIC ARTS III METERING AND SPACING PROGRAM

NAFEC TEST AND EVALUATION

by

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ABSTRACT

This report discusses the operational evaluation of the current version of the ARTS III Metering and Spacing (M&S) program integrated into the ARTS III operational program (Version AØ.15) with the conflict alert function. Test objectives were to determine the program's operational suitability and its compatibility with the conflict alert function. Data was also collected for input to a contractor's statistical analysis of program performance. Results indicate that this version of the M&S program was not operationally suitable. However, the conflict alert function continued to perform satisfactorily when M&S actions occurred.

PURPOSE

This report discusses the operational evaluation of the current version of the ARTS III Metering and Spacing (M&S) program integrated into the ARTS III operational program (Version AØ.15) with the conflict alert function. Test objectives were to determine the program's operational suitability and its compatibility with the conflict alert function.

BACKGROUND

The ARTS III Metering and Spacing (M&S) program is an evolutionary effort to provide the air traffic controller with automated assistance in the sequencing and spacing of arrival aircraft in a terminal control area. The M&S concept underwent test and evaluation (T&E) at NAFEC from October 1978 through December 1979. Test activities were not continuous due to a shift in project emphasis from the proposed Denver field appraisal to a NAFEC T&E, followed by a change in the Denver terminal approach control geometry plus numerous M&S program changes. This report summarizes the results of the last 38 test periods conducted from September 1979 to December 1979. During these tests, a "frozen" version of M&S (i.e., computer program unchanged throughout testing) was integrated into the latest ARTS III operational program (Version AØ.15) which included the conflict alert function. Both the operational suitability of M&S and its effect on the conflict alert function were determined from the results. Operational discrepancies which must be resolved in any redesign of the M&S program were identified. Test and evaluation were conducted as prescribed in the "ARTS III Basic Metering and Spacing Test Plan, Operational Suitability and Conflict Alert Compatibility," NAFEC, September 1979.

TEST METHOD

Terminal arrival operations at the Denver, Colorado, ARTS III facility were simulated for a single runway utilizing the NAFEC ARTS III System to perform data processing, display, and target generation functions. An ARTS III test target generator (TTG) scenario, based upon data recorded during Denver peak traffic hours, provided a continuous traffic flow (without natural gaps) at the rate of 41 aircraft per hour and generated both flight data and simulated target reports. Once the TTG scenario was activated, simulated targets were introduced into the environment and, under control of the M&S program, a landing schedule and sequence were established. NAFEC air traffic control specialists (ATCS) exercised control of simulated targets, either accepting or rejecting M&S generated speed, heading, and altitude commands. If the command was accepted by the controller, then through a feed-back loop, the simulated target reacted to the M&S command to achieve the landing schedule and sequence. If the ATCS rejected the command (overrode the computer), he substituted his control instructions via simulated radio to the TTG operators acting as pilots. The pilot/TTG operators would then, via TTG keyboard entries, fly the targets as instructed by the controller.

Two landing configurations were utilized, Geometries E and F. Geometry E (Figure 1) was a trombone approach to runway 26L with a fixed downwind leg. Geometry F (Figure 2) was an optimized geometry providing a variable (fan) downwind to runway 26L. Both geometries were based on the Denver four-fix approach patterns, and were tested with varying wind conditions. This sequence of tests was designed to exercise the M&S program using a heavy density of arrival aircraft. Departure traffic and missed approaches were not part of this evaluation since the use of an all-arrival environment satisfied the test objective.

The M&S program's suitability and compatibility with the conflict alert function were evaluated by the subject controllers who exercised the system. Pertinent data were recorded in daily test logs. Controller debriefings and other meetings also contributed to the findings recorded later in this document. Additionally, data were collected and provided to a contractor (Sterling Systems, Inc.) who was responsible for a statistical system performance analysis. Data were collected automatically via a data recording program and manually by chronological recordings of pertinent facts and observations in test logs during each period.

OPERATIONAL ASSESSMENT

The introduction of M&S into the ARTS III operational program caused no adverse effect on the conflict alert function. This was the consensus of subject controllers based on their observations during the T&E.

The operational potential of the M&S program was recognized by the participating controllers. However, it was their consensus that this version of the program was not operationally suitable for the following reasons:

1. The automatic resequencing actions were not always satisfactory. One type of automatic resequencing can occur if both aircraft are in the base area on downwind legs and the following aircraft can be resequenced without creating an excessive time or distance interval between the aircraft. This logic should be expanded to cover the case of the preceding aircraft on its downwind leg and the following aircraft arriving from a fix where a downwind leg is not required.

2. The controller's rejection of an M&S command inhibited the display of the command but was not fed back to the M&S program. The M&S program assumed that the aircraft would conform with the last command even if that command was rejected. Thus, rejection of speed reduction commands was ignored by the program. This would often cause aircraft to be early at the M&S final scheduling gate prior to the outer marker. As a result, the required separation on final approach was then derogated.

3. Because the M&S program is constrained by the limits of arrival airspace as defined in the site adaptable data base, it was not as flexible

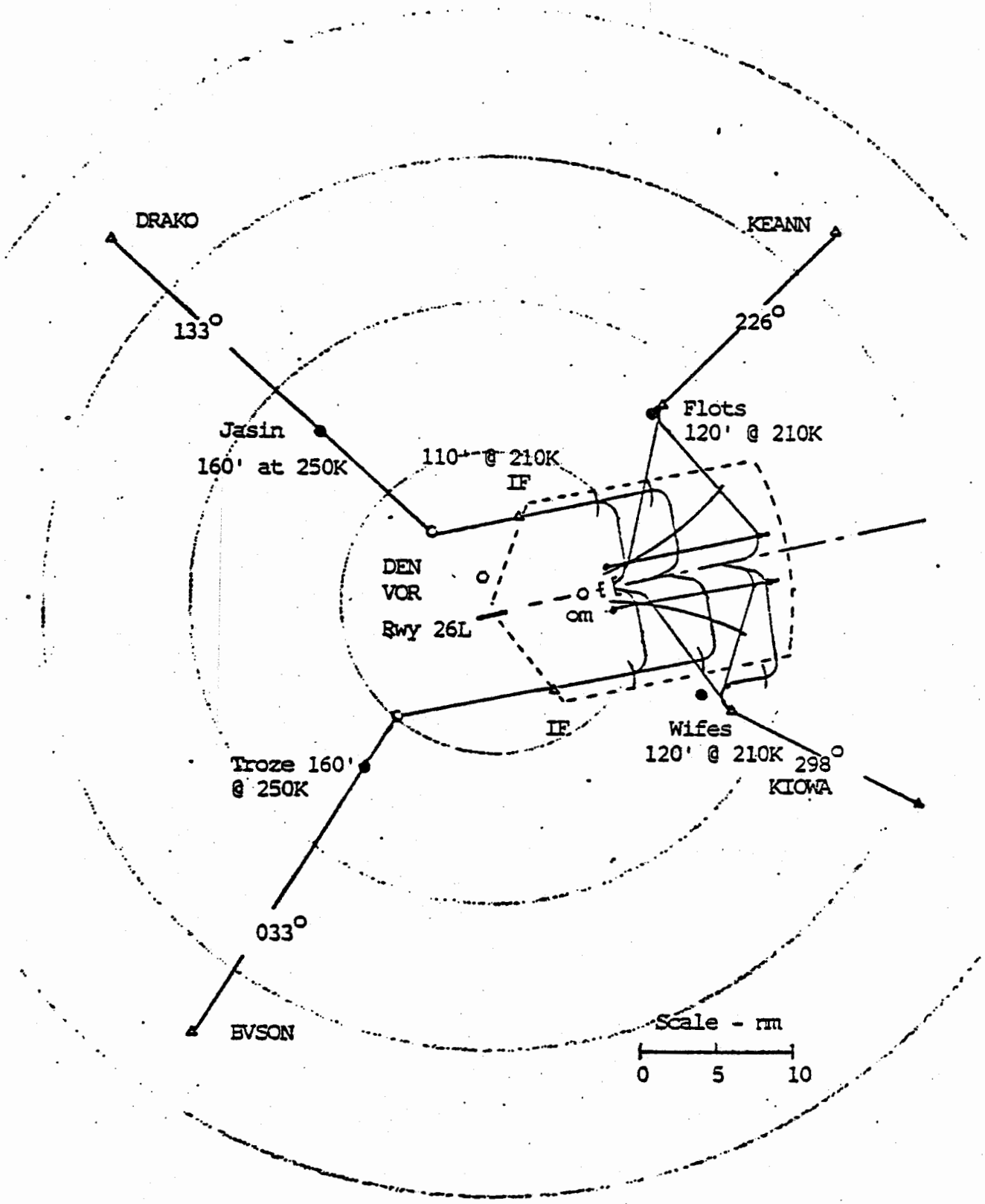

Figure 1. Geometry E - Current Denver Approach

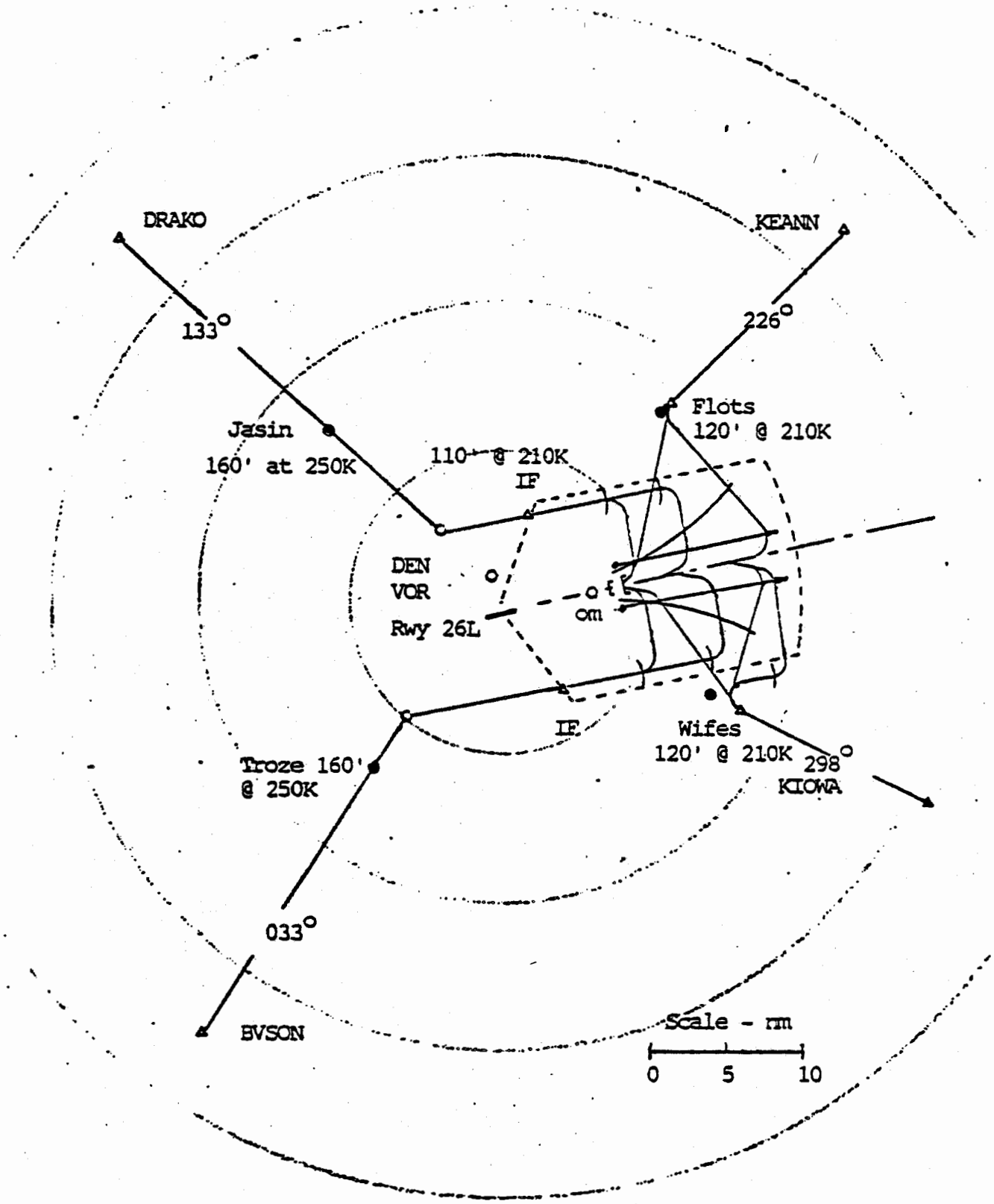

Figure 2. Geometry F - Optimized Approach

as a controller who can, through coordination with adjacent control areas, use path shortening vectors when conditions permit. Whenever the controller attempted to do this during these tests, the program was unaware of the controller's intent and resisted the change.

4. When a low performance aircraft followed a high performance aircraft, M&S control technique to achieve the required standard 6-mile separation, was unsatisfactory. After the final approach course intercept, vertical separation had to be maintained by the controller until longitudinal separation was achieved by aircraft speed differential. This occurred because the M&S program is designated to guarantee standard separation from the following aircraft only after the aircraft reaches the M&S final approach gate and thereafter to touchdown. Prior to the gate, the controller is expected to provide the required separation.

5. The limits of the approach control descent area were often violated. This zone extended approximately 20 miles east of the airport. Due to imprecise metering, aircraft were often turned on final approach outside of this area.

6. The M&S program turned aircraft onto the final approach course from opposite directions, at the same altitude, on headon courses. This problem was compounded by the failure of the command generation logic to use the knowledge of the exercise of the command reject keyboard function, causing additional controller workload and precipitating greater M&S program resistance to the intent of the controller (i.e., different from M&S's intent). This was in direct contrast to the intent of the command rejection function. A feedback to the command generation function should be provided to aid the controller and the program.

7. Aircraft were automatically removed from M&S control when, due to loss of target information, tracking was temporarily suspended and the data block placed in the ARTS III tabular coast/suspend display list.

8. The M&S program would issue unnecessary speed reduction commands to 180 knots and 210 knots when aircraft were 40 miles from the airport. Aircraft are not normally reduced to these speeds in a terminal environment this far from the airport unless the airspace is saturated.

9. The simultaneous display of M&S speed, heading, and altitude commands was unacceptable. Altitude and speed commands should be issued separately since most pilots have difficulty complying with simultaneous altitude descent and speed reduction.

10. M&S heading commands of less than 10° difference, and an excessive number of heading changes were received after the aircraft had been turned onto the downwind leg. Display of these useless headings, after the aircraft was established on downwind leg, was undesirable and increased controller workload.

11. M&S speed reduction and heading commands were received during the automatic handoff from the feeder fix controller to the final controller. These commands required extra coordination between the controllers.

12. M&S separation alerts were displayed even though all M&S commands were issued properly. This caused the controller to question the reliability of M&S commands since one part of the M&S program logic directed a specific control action and another warned that, as a result of this directed action, the predicted separation on final would be less than the legal minimums specified in FAA Order 7110.65.

13. The display of Direct Course Error (DICE), the early or late readout for the aircraft at the next fix, was not reliable. This information was utilized by the final approach controller to anticipate the display of commands and to adjust speed on final approach.

14. The M&S program control technique for VFR pop-ups was unsatisfactory. VFR pop-ups were given priority over previously scheduled aircraft instead of being fitted into the landing sequence on a first-come, first-served basis.

CONCLUSIONS

It was the consensus of the ATCS' who comprised the M&S project team during the 38 test periods that:

1. The M&S program had no adverse effect on the conflict alert function contained in the ARTS III AØ.15 program, but the M&S philosophy of not providing legal separation prior to the M&S gate was observed to generate commands for conflict encounters when aircraft were turned onto their base legs headon at a common altitude.

2. The M&S program does have the potential to provide assistance to the controller in determining optimum landing sequence, final approach course intercept heading and the time of issuance of the heading, but not with the operational discrepancies noted within this document.

3. The M&S program was not as flexible as the present radar control system (e.g., radar vectors to shorten flight paths have to be adapted in the M&S data base which cannot be dynamically modified).

4. The final approach landing sequence established by the M&S program and the automatic resequence function, as designed, did not always produce an optimum sequence. The logic should be expanded to include situations cited in this report.

5. The controller could not issue all M&S commands when separation alerts on final approach would result from these commands.

6. The display of M&S commands during transfer of control responsibility or during handoff situations, increased coordination between controllers.

7. It was not acceptable to turn aircraft onto the final approach course from opposite directions at the same altitude on headon courses.

8. Unless the operational discrepancies are resolved, an implementable version of the M&S program will not be attained.

RECOMMENDATIONS

It is recommended that:

1. The operational discrepancies resulting from the NAFEC T&E of the M&S program, as indicated in the above Conclusions, be resolved in any redesign of the M&S program.

2. Future test and evaluation of any M&S program include a more realistic terminal environment with departure traffic, missed approaches, and parallel runway geometries.

ACKNOWLEDGEMENT

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Sources of further information regarding this report are the author and Mr. Philip Karsten, ANA-210, Acting NAFEC Program Manager.

Note: Effective May 29, 1980, NAFEC was renamed the FAA Technical Center.

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APPENDIX A

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