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TERMINAL CONTROL AREA DESIGN AND AIR TRAFFIC LOADINGS

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16. Abstract

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Application of the response probability density function technique to predicting the level of safety and collision risk for terminal control area (TCA) design and air traffic loadings

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Summary

The response probability density function (pdf) technique adapted here from reference number [1,2] uses the pdf's of the variables governing both the air traffic loadings or stress and the terminal airspace design configurations sensitivity or strengths. This technique is proposed as a method which may be used to predict the relative level of safety and collision risk for TCA design configurations and air traffic loadings. For the first time, a strong relationship was found between near midair collision reports and midair collisions for annual operations within the fifty states. Operations, airport and airspace area were found to relate to these criteria of safety and provide useful interactive predictor equations of the actual near midair collision reports and midair collision occuring annually within the fifty states.

Introduction

The safe and effective performance of many systems is predicated on the ability of the designer to predict the useful load range in which the systems material characteristics and geometry affect the sensitivity or strengths of the system. To determine the range of applicability, a factor of safety is usually introduced.

This factor of safety is employed to account for the unknown or random elements which can affect the ability of the systems material characteristics and geometry to withstand its expected loads. Examination of real-life, real-time systems shows that both the stresses to which the systems material characteristics are subjected and their inherent strength to withstand them are random variables, often with large variances.

So the effective factor of safety N_e, the strength **s** divided by the stress **e** for any given system examined is also a random variable. Thus, the proper design question is "What is the probability that a load having a certain statistical variation will cause a material having strength that varies in another statistical manner to fail?"

In order to answer this question, one must determine the statistical properties of both the applied loads and the strengths of the materials themselves. In particular, if the loadings and the material properties give rise to an effective factor of safety with a lognormal pdf (log has a normal pdf), then the probability of failure can be easily determined. The present analysis extends the general response technique (1) to the TCA viewed as a system whereby the air traffic (system loads) and the TCA design (system strength) each are the product of several factors. This response pdf technique is then applied to determine the relative TCA collision risk probability and level of safety for alternative TCA designs and traffic loads.

1. Application of the response pdf Technique to the TCA viewed as a Response System in order to predict the level of safety and collision risk for various TCA designs and traffic loadings.

Consider the TCA system to have a certain strength or sensitivity (s) and a given excitation or load (e). The response (R) of the system is of the form

$$R = s/e \tag{1}$$

with s and e statistically independent of one another. In the preliminary example which follows, the sensitivity or strength s represents the TCA design variable of area, the excitation or load e is the number of operations variable, and the response R is an effective factor of safety of the TCA system. Let the sensitivity s of the TCA system be the product of n statistically independent factors Sj, i=1,2...,n. Similarly, assume that the excitation of the TCA system e is the product of m statistically independent factors e_i,i=1,2...,m. The goal of future R and D work is to test and verify that the strength and stress in the TCA collision risk/safety system can both be expressed as products of this form. Thus,

$$e = \prod_{i=1}^{m} e_i, \tag{2}$$

$$s = \prod_{j=1}^{n} s_j. \tag{3}$$

The TCA system response function or the effective level of safety N_e, therefore, is

$$R = \prod_{j=1}^{n} s_j \Big/ \prod_{i=1}^{m} e_i \; . \qquad (4)$$

Taking the logarithm of Eq. 4 yields

$$\log_{10} R = \sum_{j=1}^{n} \log_{10} s_j - \sum_{i=1}^{m} \log_{10} e_i \; . \qquad (5)$$

If it can be shown to a reasonably good approximation that the logarithm of each random variable e_i similar to the number of operations in the TCA per unit of time and s_j similar to the area of the TCA is normally distributed, then the pdf of the response is lognormal. With statistical independence of the random variables, R will tend to be lognormal from the central limit theorem with (m+n) moderately large. For the case of small (m+n) demonstrated here, however, it is necessary to check the pdf of each factor.

The expected (mean) value E of the logarithm of the TCA system response R, or its effective level of safety N_e is simply

$$E\{\log_{10}R\} = \sum_{j=1}^{n} E\{\log_{10}s_j\} - \sum_{i=1}^{m} E\{\log_{10}e_i\} \qquad (6)$$

and the total TCA system variance (Var) is

$$\mathrm{Var}\{\log_{10}R\} = \sum_{i=1}^{m} \mathrm{Var}\{\log_{10}e_i\} + \sum_{j=1}^{n} \mathrm{Var}\{\log_{10}s_j\}. \qquad (7)$$

To find the resulting probability for the normal pdf of the $\log_{10}R$, the normalized Gaussian variable z with unit variance is introduced:

$$z = E\{\log_{10}R\} / [\mathrm{Var}(\log_{10}R)]^{1/2}. \qquad (8)$$

If R is considered to be the effective factor of safety N_e, then when $\log_{10} R = 0$, the TCA system load, e is equal to the TCA systems design strength's. Hence, negative values of N_e correspond to instances when the effective factor of safety is less than one (see Fig. 1).

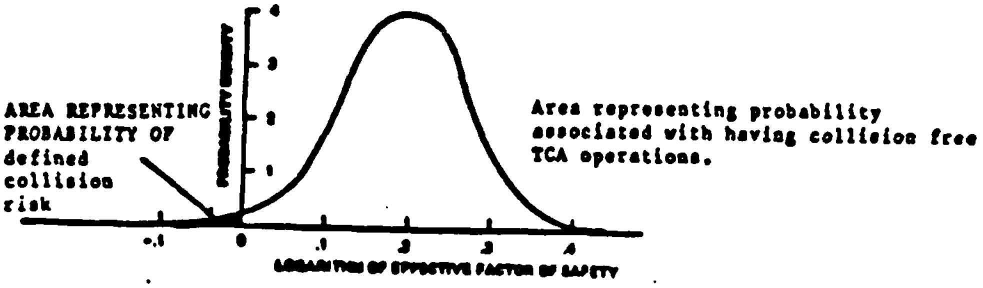


FIG. 1. Area representing probability of collision free TCA operations and associated level of defined collision risk.

Consequently, the area to the left of zero is the probability that the TCA load (for example, the number of operations/time plus, other to be determined load variables in the TCA) has exceeded the TCA systems design configuration strength (for example the TCA area + other to be determined strength variables of the TCA) and that overload or failure of some type, such as a defined risk of collision (one or more NMAC reports/time), has occurred.

This proposed technique will be used in future TCA analytic Research and Development, R&D studies to determine the effective level of safety associated with various terminal air traffic loads and alternative TCA design configurations.

To further develop the TCA model, there is a need to list and operationably define the many independent variables associated with TCA system design strength, s and TCA system load, excitation, stress, e.

All of the TCA system variables for s and e must have a logical, observable, demonstrable effect on NMAC, collision risk and the level of safety N_e of the operational TCA system.

By way of general introduction to the operational definition of the TCA concept and some of the major TCA system variables, the following excerpts from reference 13 are very useful:

> "The TCA consists of controlled airspace extending upward from the surface or higher to specified altitudes within which all aircraft are subject to the operating rules and pilot and equipment requirements specified in FAR Part 91.
>
> The TCA concept was developed to reduce the mid-air collision potential in the congested airspace surrounding large air transportation hubs. These high density terminal areas present complex air traffic conditions resulting from a mix of large turbine-powered air carrier aircraft with other aircraft of varying performance characteristics. This type activity is incompatible with random, unknown transient aircraft proceeding through the area in the vicinity of airports at altitudes conflicting with arriving and departing flight paths. Even under good weather conditions, sole reliance on "see and avoid" for collision avoidance is impractical and a proven causal factor in near midair collision incidents."

"The risk of a midair collision in a given segment of airspace is directly related to the number of aircraft therein, and of those aircraft to the proportion that are relying solely upon seeing and avoiding other aircraft, as well as to the weather conditions, the operating characteristics of the aircraft, the dispersal of aircraft within the given airspace, and whether the aircraft are climbing, descending, or in level flight.

The regulatory requirements of TCA airspace afford the greatest protection for the greatest number of people by providing ATC with an increased capability to provide aircraft separation service within the airspace, thereby, minimizing the hazardous mix of controlled and uncontrolled aircraft. The criteria for considering a given terminal area as a TCA candidate is based on factors, or combinations of factors, that include the number of people and aircraft in the airspace, the area's potential for midair collision because of traffic density, and the type or nature of operations being conducted. Accordingly, guidelines have been established to identify TCA locations based on two basic elements--the number of enplaned passengers and the number of aircraft operations.

Safety factors, traffic counts, complexity, and projected growth shall be taken into consideration when evaluating a site for TCA actions. The following criteria are applicable for a site to be considered as a new TCA candidate or for upgrading to a Group I TCA.

a. Group I:

(1) 3,500,000 annual enplaned passengers from terminal area hub (satellite and primary airports).

(2) 300,000 annual instrument operations at the primary airport of which 60 percent must be air carrier.

b. Group II:

(1) 650,000 annual enplaned passengers from terminal area hub.

(2) 150,000 annual instrument operations at the primary airport.

(Note: Passengers and operations should include commuter, air taxi, and intra-state air carrier categories).

Regarding the configuration of a TCA:

a. General Design. Simplification of the TCA airspace configuration is a prime requisite. Vertical and lateral limits should be standardized and, to the extent practicable, be designed to retain all published instrument procedures once their flight track enters the TCA. The number of subareas shall be kept to a minimum."

" b. Lateral Limits. TCA airspace should initially be designed as a circular configuration centered on the primary airport, preferably at the VORTAC site if located on the primary airport. However, analysis of the terminal area operations may necessitate tailoring the airspace in a different manner depending upon the operational needs at the primary airport and the underlying satellite airports. The outer limits of the TCA should be predicated on a 300-foot per nautical mile climb and normally extend to approximately 20-25 NM from the primary airport. However, the outer limits must be determined by individual site operational, safety, and airspace requirements. Wherever possible, VHF Omnidirectional Range radials and distance measuring equipment arcs shall be used to define the boundaries of a TCA and its subareas. It is important, however, that prominent visual landmarks also be considered as aids to the VFR traffic desiring to remain clear of the area.

c. Vertical Limits. The ceiling of the TCA should be designated as low as possible depending on safety. The center of the TCA or that portion of the area covering the primary airport is normally designated to include altitudes from the surface to the ceiling. A 5 to 7 NM radius area for this purpose is generally sufficient. Beyond the designated TCA core, the floor is raised by additional designated areas as dictated by operational considerations including requirements for satellite airports within the overall planned TCA. Normally, the controlling factor in determining TCA floors is the rate of climb capability of departing aircraft. This capability varies widely between different types of aircraft under various conditions. Therefore, consideration should be given to the lower performance turbine-powered aircraft operating under adverse conditions. For planning purposes, the base of the TCA should be designed for the lowest climb rate of the turbojet aircraft that operate from the airport, normally, a 300-foot per NM rate of climb should be used.

d. VFR Corridors. The establishment of VFR corridors through the TCA is site sensitive in that their appropriateness depends on the operational requirements of individual locations. Generally, VFR corridors are believed to be only an alternative for access through TCA's in support of the general premise of the public's right to freedom of transit through the airspace. VFR operations over/around a TCA may be more palatable to the VFR user than being confined to a tunnel with less flexibility to maneuver. Frugal planning, such as simplicity of TCA design and designation of only essential airspace, should minimize any operational need for VFR corridors.

" e. Satellite Airports. When establishing a TCA floor, consider the adverse effect on satellite airport operations as well as operations at the primary airport. When airspace directly over a satellite airport is not required, appropriate airspace surrounding the airport should be excluded from the TCA. Special published traffic patterns and/or procedures may be required from the satellite airport.

Air Traffic has the responsibility to coordinate all efforts concerning implementation of the TCA program.

a. Regional Directors prepare all documents and provide staff studies for each location to determine justification for either withdrawing or proceeding with a notice of proposed rule making, NPRM. This applies to new TCA sites and modifications to existing TCA sites. This responsibility includes completion of all companion actions associated with the proposed site; i.e., studies, reports, analyses, etc.

b. To ensure that all regions apply a uniform approach to arrive at individual conclusions, a staff study which results in a conclusion to proceed or withdraw the location from further consideration shall be completed for each TCA proposal. Among other things, the staff study should contain:

(1) A description of the terminal area being studied including:

(a) VFR traffic flow in and through the area.

(b) IFR traffic flow in the affected en route structure including transition routes.

(c) IFR traffic flows in conjuction with runway configurations/SIAP's, SID's, STAR's and preferential arrival and departure routes.

(d) Names of airports and numbers and types of operations for each.

(e) General description of area traffic operations.

(2) Complete analysis of options and issues, such as:

(a) Lowest feasible top altitude that TCA operations can be safely conducted based on traffic flow, airport, and navigation aid locations.

(b) Major proposals submitted by user groups and an analysis of each.

(c) TRSA versus TCA, advantages and disadvantages of both.

(d) Near midair collisions analysis."

" (e) Impact on air traffic and air navigation facilities (new or modified control positions required, if any, and new or relocation of navigational aids including communication equipment).

(f) Withdrawal of the TCA proposal versus implementation. Candidate locations may be withdrawn when commensurate levels of safety can be sustained without ATC and or operational considerations do not justify such establishment.

(3) Economic assessment.

(4) Environmental considerations.

(5) Conclusions:

(a) Explanation of the conclusion reached based on the analysis of the options and issues.

(b) The need to enhance safety shall be the key factor in evaluating issues and options and should be reflected in the conclusion."

This source provides a list of candidate operational system variables to be examined. It is then necessary to analyze them and establish the degree of relationship of all major independent variables with NMAC reports i.e., collision risk and the level of safety.

It is, also, necessary to define and exercise criteria for showing a casual connection especially when there is a statistically significant mathematical relationship between any variable and collision risk.

Each of the system variables must be analyzed, quantified and their statistical nature i.e., the population, the frequency and magnitude of their occurrence in the TCA system established. The aim of this intermediate step is to establish a probability density function for each TCA system strength, s variable and stress, e variable, which is found to be related to NMAC reports.

After this search and identification of the appropriate s and e variables, the model may be exercised following the procedures outlined here and in reference 2. Results can be compared with available real-world data. Based on the outcome of this comparison the model may be revised and tested.

Testing of results as well as initial development of various hypothetical TCA operational system variables may be accomplished using computers and observing fast-time computer simulation of hypothetical TCA systems in operation.

Therefore, a necessary first step is to examine candidate system stress and strength variables and determine their relationship, if any, to near midair collision (NMAC) reports.

The ultimate goal of this in-house research is to determine and better understand the basic relationships between operational variables in the national airspace system and safety criteria which occur rarely (i.e. 1 time in 70,000 events to 1 time in over 2 million events). The initial criterion selected to measure the level of safety was near midair collisions reports and finally actual midair collisions which have occurred in the fifty states during the 1983 to 1988 time period. This view of the system provided a big picture and the opportunity for the first time to determine the relationship between these two important criteria for establishing the level of safety which is affected when the system design is changed. The usefulness of the operational variables, for future R&D regarding alternative design changes, was tested by 'predicting' the near midair collision reports and the midair collisions and comparing results with actual experienced reports and collisions occurring within the fifty states.

An important first variable to check is the one discussed in the aerospace handbook as being directly related to safety. That variable is the number of operations.

A preliminary look at the rank ordered data regarding the number of total operations and the number of reported NMAC reports for a year is shown in figure 2 for the fifty states.

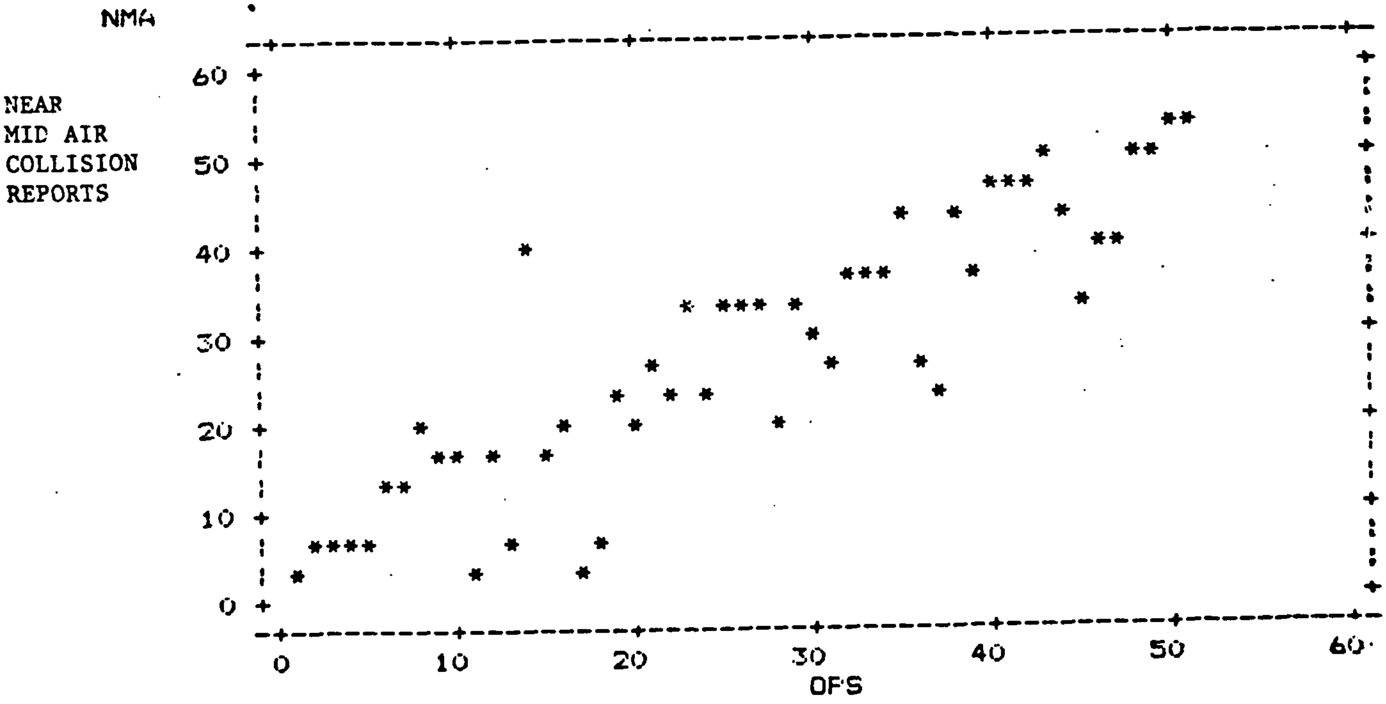


FIG. 2. Plot of NMAC Reports and Total Operations (RANKED) for the fifty states

The raw data of NMAC reports and number of operations yielded a Pearson r correlation coefficient of 0.963. This is a surprisingly high degree of statistical relationship between NMAC reports and the total number of operations per state per year. The square of the Pearson r 0.963 is an estimate of the amount of common variance between NMAC reports and total number of operations. That figure is 0.927. Therefore, the number of operations accounts for greater than 92% of the common variance for operations and NMAC reports. This relationship will of course be examined further using refined local area data as it becomes available. If it holds up, and there is a confirmed steady relationship, it provides as an important clue. It could be reasoned that if the model is indeed NMAC (number of reports) = OPS (i.e., the total number of operations) times a constant for the airport control areas where the reports occur; then, it follows that NMAC reports will decline as number of operations decline. The total number of operations per year however, is increasing with a 42 percent increase anticipated between 1982 and 2000, with itinerant operations outside the airport local operating area increasing 66 percent.

It is interesting to examine the language of the airspace handbook regarding the relationship of the number of instrument flight rule (IFR) and visual flight rule (VFR) operations which are pinpointed as the real problem, i.e., "see and be seen" uncontrolled VFR flight versus controlled IFR flight. Further examinations of historical information is warranted to determine the ratio of VFR operations to the total operations per state or other area per year. Most important is an examination of the annual number of VFR operations within the fifty states that are associated with annual NMAC reports as well as for controlled IFR traffic. Can it be shown that there is historically a disproportionate percentage of the total NMAC reports involving "see and be seen" uncontrolled VFR flights? If so, this poses a system problem in that VFR NMAC reports may not be directly associated with the TCA design characteristics or the TCA system strength variables, s.

A preliminary look at the relationship between VFR and annual IFR operations in the fifty states and near mid air collision reports and mid air collision has disclosed no significant differences as correlations of 0.83 and 0.90 were found for IFR and VFR related to annual near mid air collision reports and 0.80 and 0.87 related to annual mid air collisions.

This relationship with the criteria of safety was explored further by examining the correlation between the mid air collisions reports and whether the aircraft were VFR, IFR, unknown or combinations of these variables. Again there was less than 4 percent common variance between the VFR and IFR aircraft and both criteria of safety, NMAC's and MAC's.

One of the prime characteristics of a control area to be examined is its physical size and geometry. For example, the number of square miles involved in each area of consideration should affect the density of airspace operations i.e., the number of aircraft, instantaneous airborne count (IAC) per square mile.

A preliminary look is possible using the area of each state and annual operations. The question posed is as follows: Is there a significant relationship between the size of the area of operations and NMAC reports for these areas?

A low positive relationship was found between annual NMAC reports for 1986 within the fifty states and the airspace of the state involved (i.e., the number of square miles). The Pearson r is 0.329 for the state data, accounting for 11 percent of the common variance between area in square miles and NMAC reports.

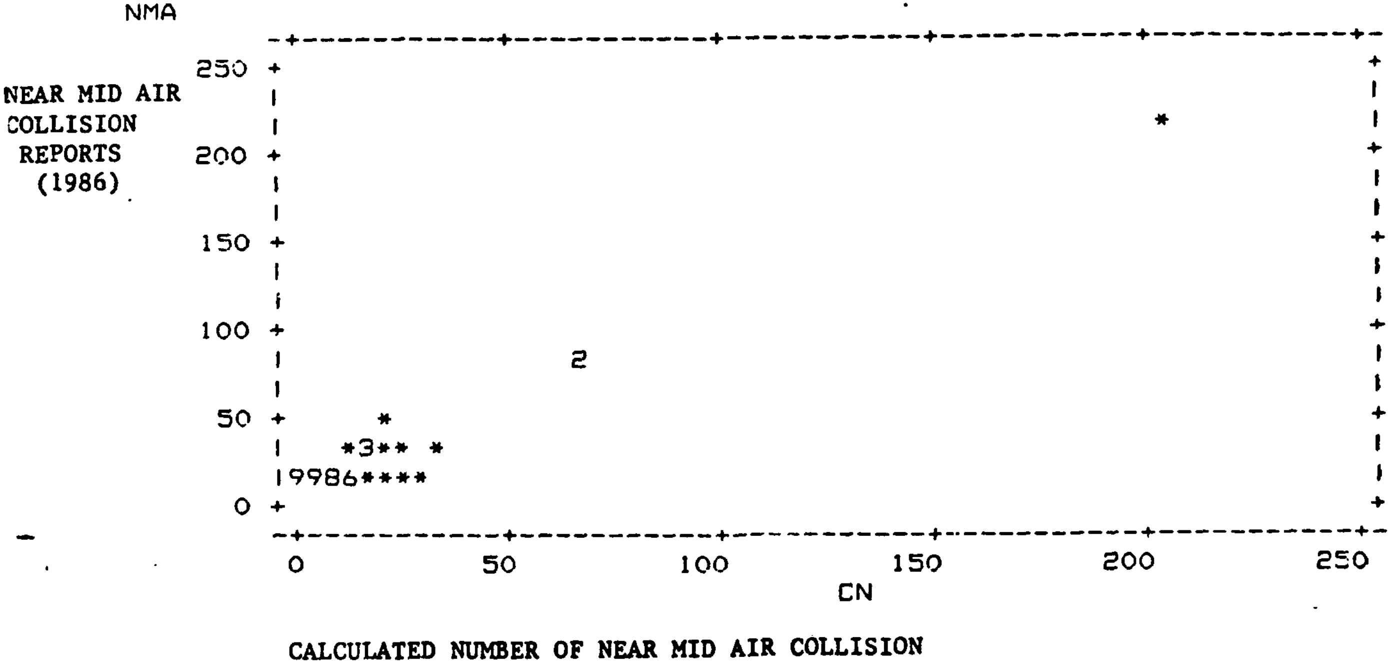
These are interesting preliminary results considering the large areas involved i.e., state area versus, plans to examine in future R&D work, more specific data regarding TCA areas and volumes (square and 3D airspace miles) and density of operations (IAC) and corresponding analyses of NMAC reports and the number of IFR and VFR airport (TCA) operations as well as total operations.

The relationship between the number of FAA towered airports within the fifty states and the criteria of safety was also examined. It was found that there was a low positive correlation between the number of airports in the fifty states and the annual number of 1987 near midair collision reports of 0.54. The correlation with midair collisions was 0.37. These correlations account for 29 and 12 percent of the common variance between the number of airports and the criteria of safety.

Although the relationships, with the criteria of safety, for area and airports were lower than the high correlation found for the number of operations, a useful relationship exists between the combined interaction among these three important airspace system operational variables and the criteria of safety. Therefore, predictor equations were found and used to predict outcomes and compare with actual experienced events and examine the results (i.e. predicted numbers versus actual near midair collision reports and midair collisions.

These results are presented graphically in figures 3, 4, 5, and 6. Each graph is followed by a Pearson correlation matrix which quantifies the relationship shown in each graph. All graphs and statistics were accomplished using reference 16. Additional analyses will be completed in the near future using different methods to verify the relationships found here. These results are published to paint a picture of broad relationships found which provide leads to be followed in later work in TCA design studies.

FIG.3--THE RELATIONSHIP BETWEEN NEAR MID AIR COLLISION REPORTS (1986) AND THE CALCULATED NUMBER USING THE PREDICTOR EQUATION WITH OPERATIONS, AIRPORTS AND SQUARE MILES (1986).



```
PEARSON CORRELATION MATRIX

                     NMA            CN

      NMA      1.000000000
       CN      0.980286582 1.000000000
```

FIG.4--THE RELATIONSHIP BETWEEN NEAR MID AIR COLLISIONS REPORTS (1987) AND THE CALCULATED NUMBER USING THE PREDICTOR EQUATION WITH OPERATIONS, AIRPORTS AND SQUARE MILES (1987)

```
      NMA87
                   -+----------+----------+----------+----------+----------+-
              300 +                                                          +
NEAR MID AIR      I                                                          I
COLLISION         I                                               *          I
 REPORTS      250 +                                                          +
(1987)            I                                                          I
                  I                                                          I
              200 +                                                          +
                  I                                                          I
                  I                                                          I
              150 +                                                          +
                  I                                                          I
                  I                                                          I
              100 +              **                                          +
                  I                                                          I
                  I                                                          I
               50 +     * 2                                                  +
                  I **2233                                                   I
                  I3958                                                      I
                0 +2                                                         +
                   -+----------+----------+----------+----------+----------+-
                    0         50         100        150        200        250
                                            PRN87
```

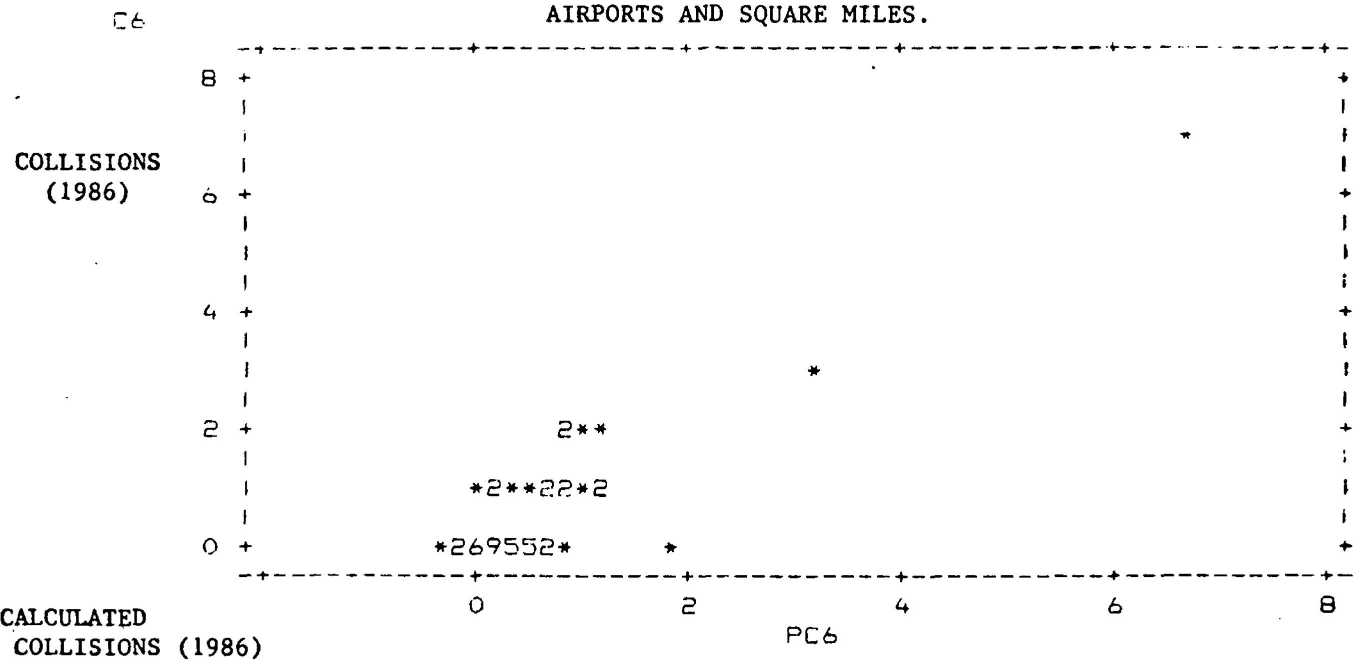
CALCULATED NUMBER OF NEAR MID AIR COLLISION REPORTS (1987)

```
PEARSON CORRELATION MATRIX

                          NMA87         PRN87

         NMA87            1.000
         PRN87            0.989         1.000
```

FIG. 5--THE RELATIONSHIP BETWEEN COLLISONS (1986) AND CALCULATED COLLISIONS USING THE PREDICTOR EQUATION WITH OPERATIONS, AIRPORTS AND SQUARE MILES.

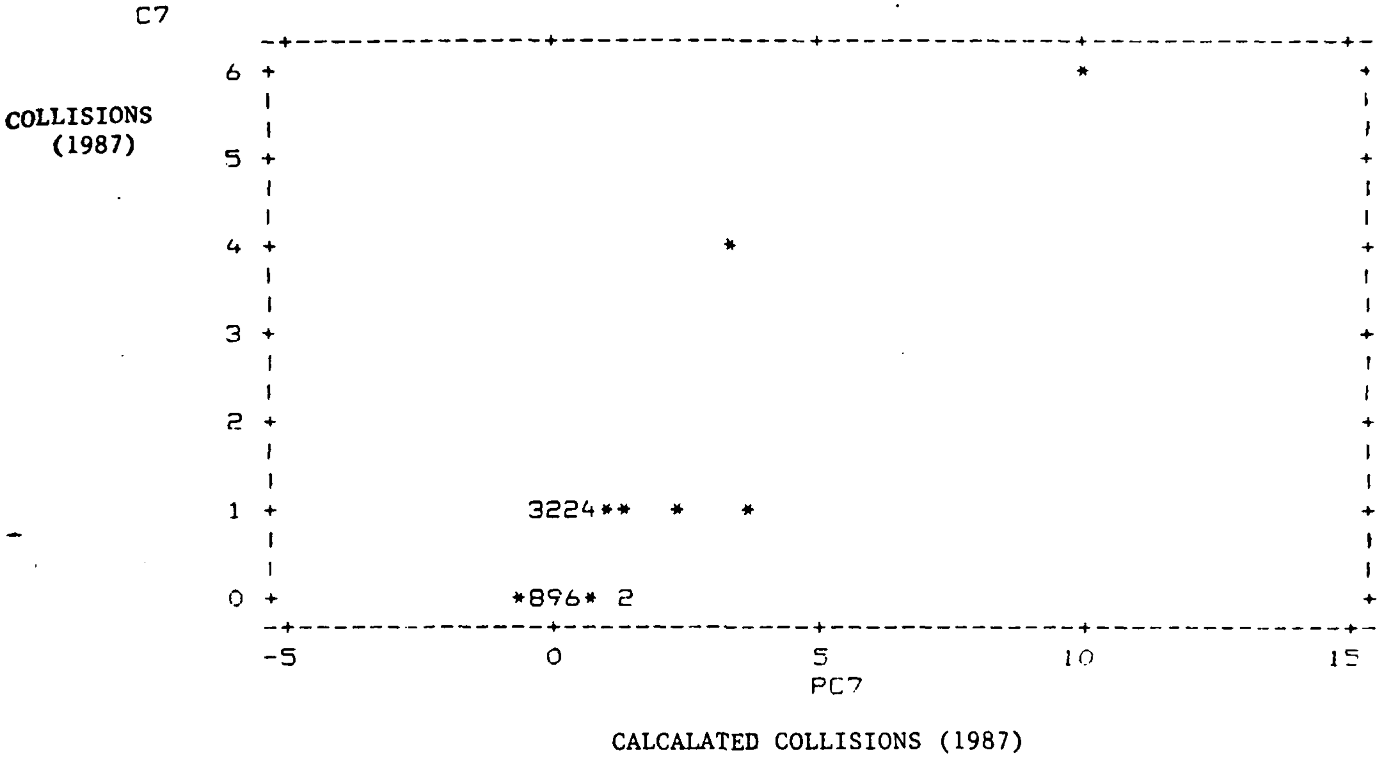


```
PEARSON CORRELATION MATRIX


                      C6            PC6

       C6            1.000
       PC6           0.895         1.000
```

FIG.6 _THE RELATIONSHIP BETWEEN COLLISIONS (1987) AND THE CALCULATED COLLISIONS USING THE PREDICTOR EQUATION WITH OPERATIONS, AIRPORTS, AND SQUARE MILES (1987)



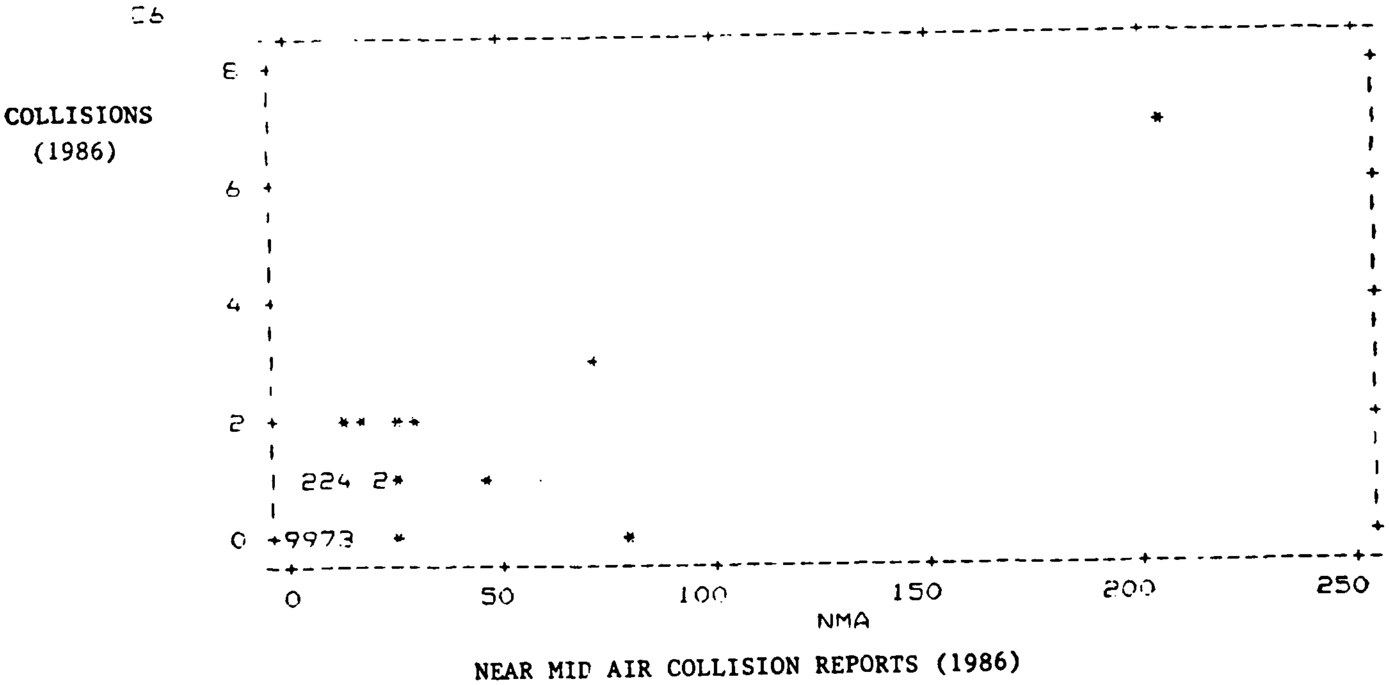
```
PEARSON CORRELATION MATRIX


                     C7           PC7

     C7            1.000
     PC7           0.865         1.000
```

The most interesting findings are presented graphically in figures 7 through 12 which show and establish, for the first time, that annual near mid air collision reports for the fifty states are strongly and significantly related to mid air collisions occurring annually within the fifty states.

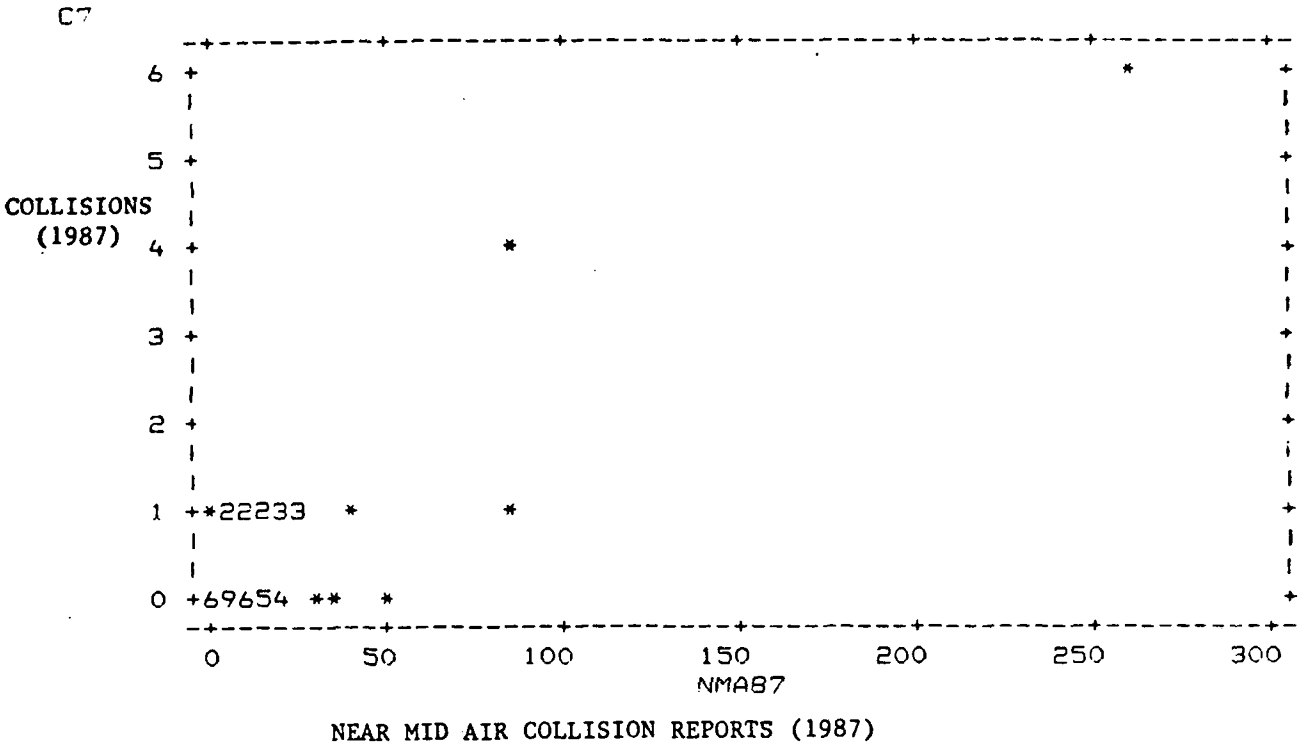
FIG.7 --THE RELATIONSHIP BETWEEN COLLISIONS (1986) AND NEAR MID AIR COLLISION REPORTS (1986)



PEARSON CORRELATION MATRIX

	C6	NMA
C6	1.000	
NMA	0.839	1.000

FIG. 8--THE RELATIONSHIP BETWEEN COLLISIONS (1987) AND NEAR MIP AIR COLLISION REPORTS (1987)



```
PEARSON CORRELATION MATRIX

                          C7          NMA87

          C7              1.00000000
       NMA87              0.84460353 1.00000000
```

FIG. 9--THE RELATIONSHIP BETWEEN COLLISIONS (1986 AND 1987) AND NEAR MID AIR COLLISION REPORTS (1986 AND 1987)

**COLLISIONS
1986
AND
1987**

```
C67
        -+----------+----------+----------+----------+----------+-
     20 +                                                        +
        I                                                        I
        I                                                        I
        I                                                        I
     15 +                                                        +
        I                                                   *    I
        I                                                        I
        I                                                        I
     10 +                                                        +
        I                                                        I
        I                                                        I
        I                                                        I
      5 +                 **                                     +
        I    *2                                                  I
        I    2 * *                                               I
        I*3433 **  *                                             I
      0 +4954*                                                   +
        -+----------+----------+----------+----------+----------+-
         0         100        200        300        400        500
                                    N67
```

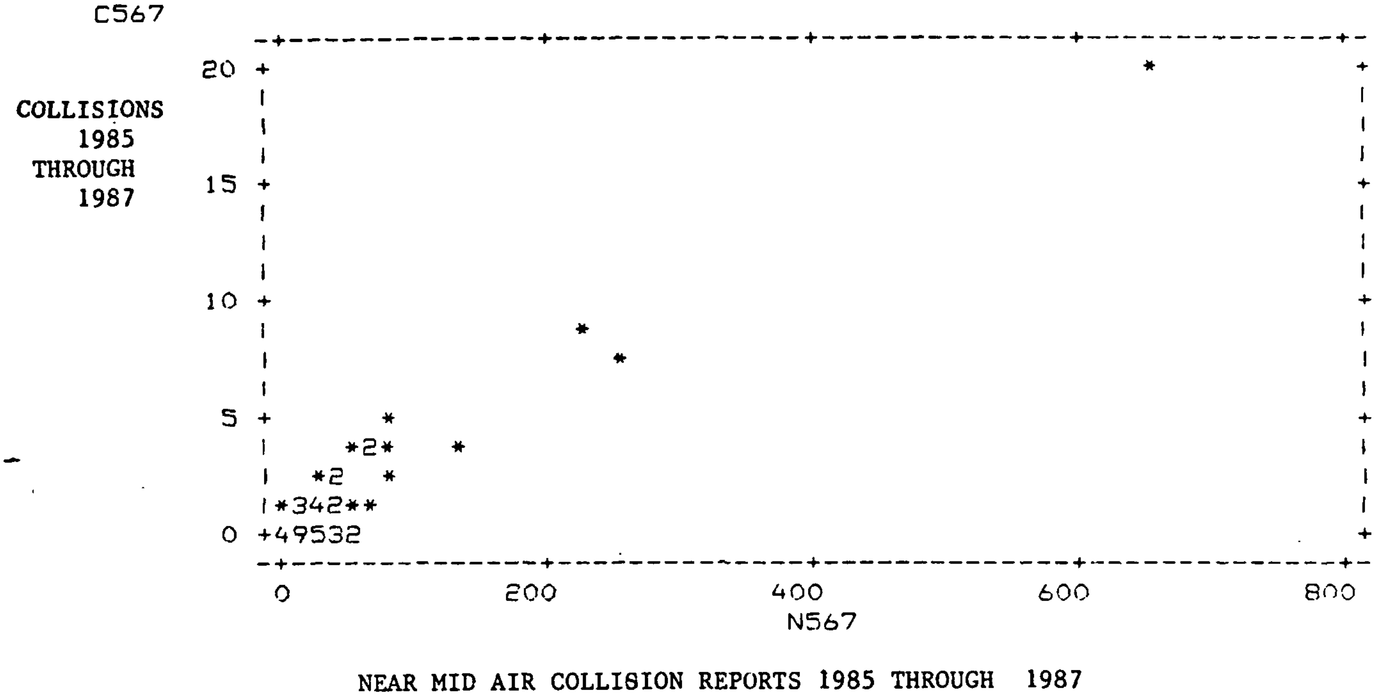
NEAR MID AIR COLLISIONS 1986 AND 1987

```
PEARSON CORRELATION MATRIX


                        C67          N67

          C67          1.000
          N67          0.940        1.000
```

FIG. 10--THE RELATIONSHIP BETWEEN COLLISIONS 1985 THROUGH 1987 AND NEAR MID AIR COLLISION REPORTS 1985 THROUGH 1987

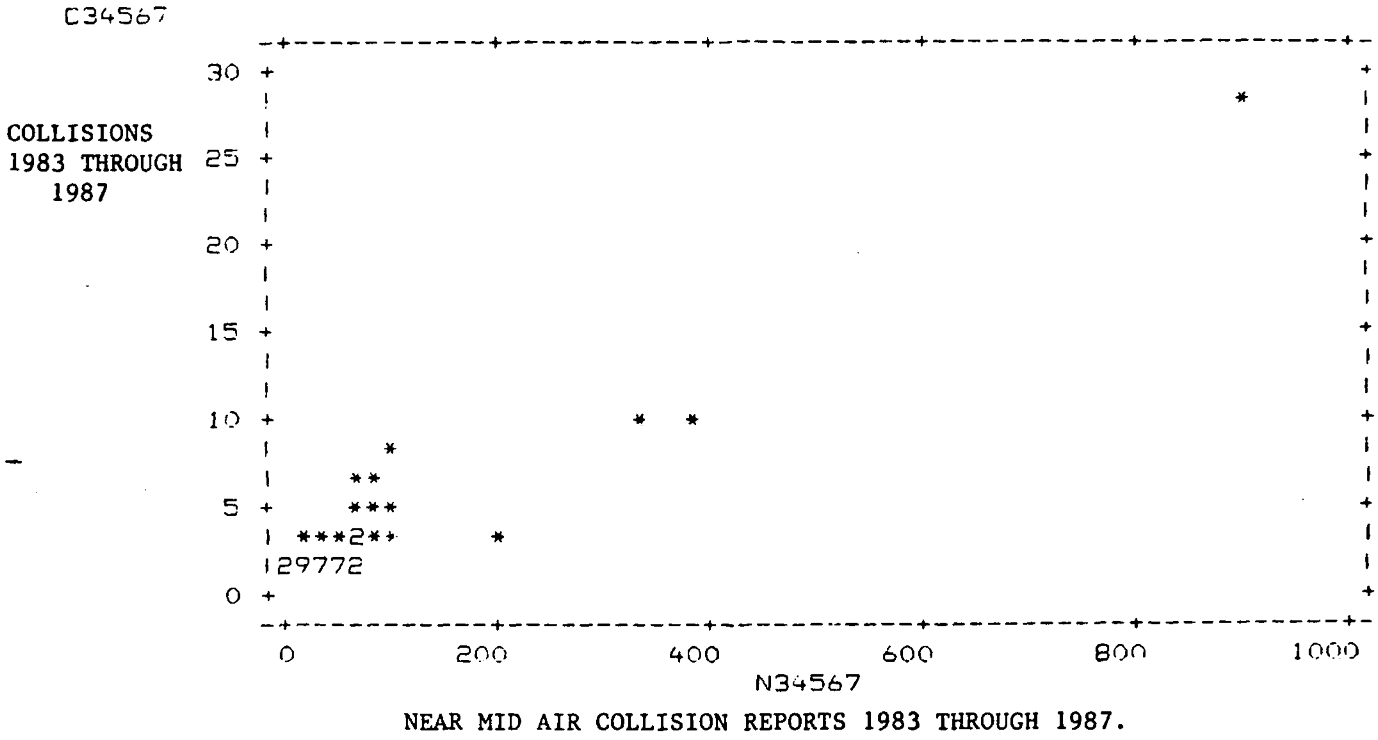


```
PEARSON CORRELATION MATRIX


                      C567        N567

      C567            1.000
      N567            0.967       1.000
```

FIG.11--THE RELATIONSHIP BETWEEN COLLISIONS 1983 THROUGH 1987 AND NEAR MID AIR COLLISION REPORTS 1983 THROUGH 1987

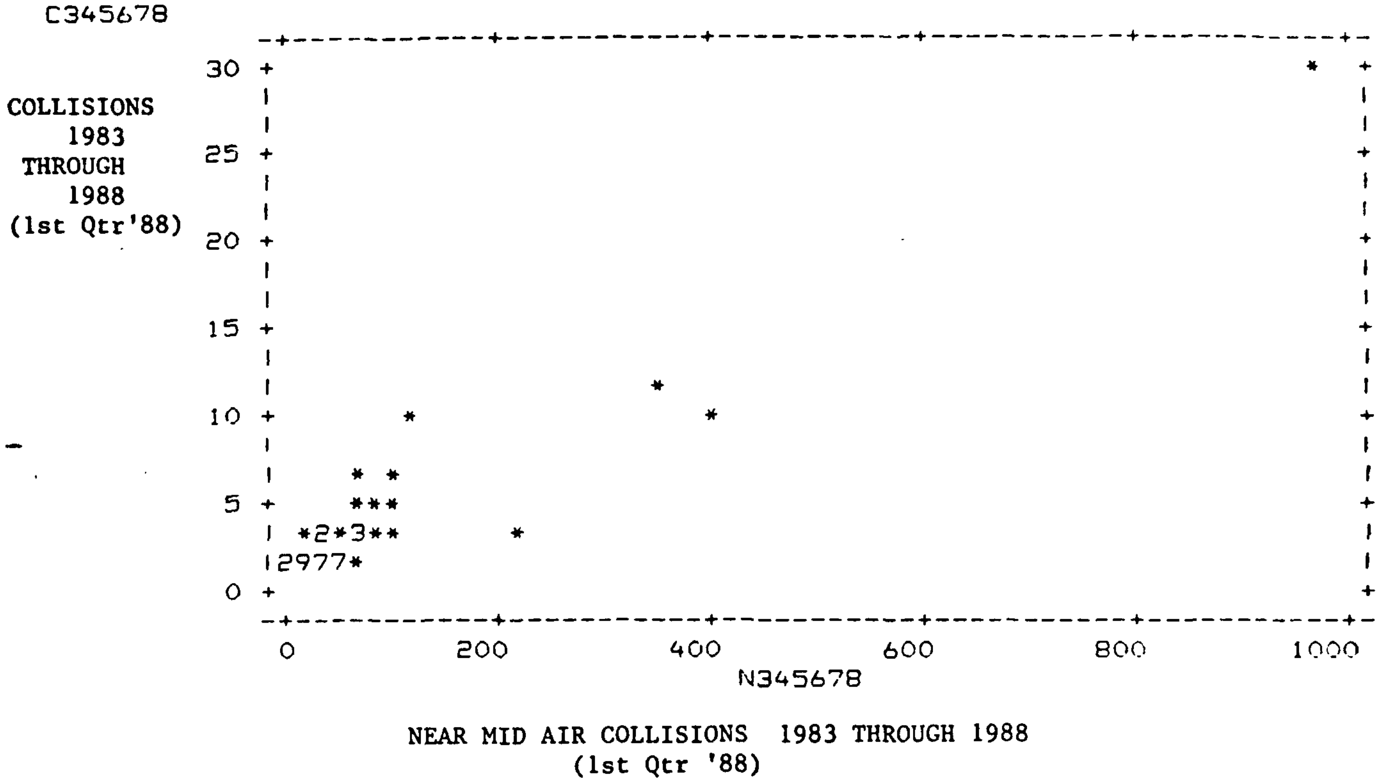


```
PEARSON CORRELATION MATRIX

                      C34567        N34567

      C34567           1.000
      N34567           0.943         1.000
```

FIG. 12--THE RELATIONSHIP BETWEEN COLLISIONS 1983 THROUGH 1988
AND NEAR MID AIR COLLISIONS 1983 THROUGH 1988.
(FIRST QUARTER '88)



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PEARSON CORRELATION MATRIX


                     C345678      N345678

C345678                1.000
N345678                0.944        1.000
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This finding provides an extremely useful criterion of safety. That is near midair collision reports which will be useful measures to be used in the search for operational variables which strengthen the design of the national airspace system and its component parts. The usefulness stems from the finding that these reports occur approximately 1 in 70,000 operations as opposed to collisions which occur approximately 1 in over 2 million operations. As they are shown to be highly related, the criterion occurring 30 times or more often has the greater utility in determining the level of safety in the smaller components of the national airspace system when changes in the design are made. For example, before and after comparisons of TCA design may be examined using changes in the number of near midair collision reports as a real criterion or measure of the level of safety attained. This is because it has been shown here that near midair collision reports correlate highly with midair collisions, which although perhaps the ultimate criterion of the safety level achieved, occur rarely.

This preliminary analysis provides an example of the additional R&D work needed and planned to be carried out during 1989 and 1990. The goal is to determine and quantify the relationship of other unknown but equally important airspace system stress and strength variables in the National Airspace System design and establish their significant relationship to safety criteria: NMAC reports, midair collisions and other yet to be discovered criteria. The ultimate goal is to verify the utility of this proposed model and other mathematical models using real time and fast time computer simulations that calculate or demonstrate the overall level of safety achieved and collision risk probabilities.

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