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on

ATC CONTINGENCY OPERATIONS IN THE EN-ROUTE FLIGHT REGIME

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by

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SUMMARY

Air traffic control operations were examined to learn what factors of controller performance should be given consideration in the design and development of future automation systems enhancing ATC. ASRS reports, the source material for the study, were selected from relatively current (within one year of present) groupings of contingency or unusual operations affecting controllers in Centers.

Analysis of the final study data set reports indicated that the retrieved reports appeared to be reasonably representative of operations in Centers. Contingencies were of two types: those constraining airspace usage or traffic flow (i.e., weather) and those related to system and equipment usage (i.e., radar/radio status). Examination of controller response to contingencies and workload pressures showed differing effects on controller allocations of effort among the three primary functions of planning, monitoring, and information transfer. It appears that automation advancements oriented towards aiding the controller in performing monitoring tasks may offer the most substantial safety benefit.

INTRODUCTION

The Federal Aviation Administration (FAA) has underway major programs to improve the safety, efficiency, and productivity of the future National

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Airspace System. The more significant of these are the Discrete Address Beacon System (DABS) that will permit direct, digital communication between ground and aircraft; the Automatic Traffic Advisory and Resolution Service (ATARS), an independent, ground based, collision avoidance system compatible with DABS; and Automated En-route ATC (AERA).

One justification for DABS is that digital communication between the ground and air will be more timely and less subject to ambiguity and misunderstanding. Also, aircrew would have available for reference hard copy of the controller's complete clearance. Studies of aircrew performance[1] indicate that substantial safety benefits may be realized by DABS usage. ATARS and AERA are justified on the basis of safety and productivity. Significant unanswered questions exist regarding their usage and the role of the air traffic controller in an automated ATC environment.

The study reported here examines air traffic control operations for the purpose of ascertaining what benefits and what liabilities, based on controller performance, should be given consideration in the design and development of future automation systems like those mentioned above. Source material for the study was drawn from the NASA Aviation Safety Reporting System (ASRS).

APPROACH

Since AERA specifically and ATARS more generally are associated with en-route ATC, a search of the NASA ASRS data base was conducted to yield safety reports pertaining to en-route ATC operations. The NASA ASRS is a voluntary, confidential safety reporting program available to pilots, controllers, and others using the National aviation system. Safety reports submitted to ASRS are analyzed, coded, and entered into a computer data base. Based on the use of appropriate descriptors, keywords, etc., safety reports may be retrieved for further research and analysis of specific subjects. Complete descriptions of ASRS have been reported elsewhere[2, 3].

Safety reports used in this study, were selected on the basis of satisfying the following criteria: (1) the report was submitted to ASRS by a controller within the previous year, and (2) a contingency or unusual operation of some form was involved or conflict alert was activated. The purpose in selecting only controller reports, as opposed to flight crew or other, was to assure a description of ATC operations from the controller's perspective. The condition that safety reports be submitted within the previous year was to minimize the influence, if any, of system or procedural factors that might be found in the ASRS data base (extending back to 1976) that are no longer significant. Contingency operations for the purpose of this study were defined as situations over which the controller has limited control or which might require off-nominal control tactics. In consultation with ASRS staff specialists in ATC operations the contingency factors of weather, equipment limitations or outages, special routings, and special use airspace were selected as descriptors to conduct the data base search.

This study is not concerned with whether or not a system error or system deviation occurred nor whether a situation in which less than standard separation existed. However if a reporter noted that conflict alert was ativated, that report was selected for study in the event that contingencies of a form not otherwise anticipated were revealed.

RESULTS AND DISCUSSION

Database Search and Preliminary Analysis

Using the descriptors mentioned in the previous section, 241 individual safety reports were obtained for study. The reports covered the period August, 1979 through July, 1980. They were all submitted by controllers from Air Route Traffic Control Centers (ARTCC). The reports were examined to identify instances of multiple reports of the same incident or occurrence. This examination revealed that 159 unique occurrences were reported.

Eleven of the occurrences related to operations at the Anchorage ARTCC and one to the Honolulu ARTCC. As these Center's extensive use of non-radar separation is atypical of the Center operations in the 48 contiguous States, they were excluded from the study. As future automation efforts are related to radar environments, an analysis of non-radar procedures was incompatible with the purpose of this study.

The distribution of the remaining 147 occurrences by ARTCC is shown in Table 1. Also shown is the total activity by Center for October, 1977 through September, 1978[4]. A regression analysis of these data yielded a correlation coefficient of 0.478. This is significant (probability less than 0.05) suggesting to some degree a consistent relationship between total ARTCC activity and occurrences reported to ASRS.

A recent study of the FAA System Effectiveness Information System (SEIS) by Kinney, Spahn, and Amato[5] provides information about the number of system errors occurring over the period 1974-1976. In Table 2 the distribution of system errors at Centers by FAA Region is presented in relation to the occurrences used in this study.

A regression analysis performed on the data shown in Table 2 produced a correlation coefficient of 0.914. This is highly significant (probability less than 0.001). Even though this study was designed without consideration of its representativeness to the ARTCC environment, the significant relationships between total aircraft handled and system errors are remarkable. The occurrences used here should be viewed as substantively relating to ARTCC operations.

The preliminary analysis also revealed that in 12 instances insufficient information was provided in the safety report to permit complete analysis. Accordingly, 135 occurrences formed the basis for the remainder of the study. Each of these occurrences was examined in detail to identify the contingency and other factors involved.

Contingency Factors

The contingency factors identified as having some bearing on the reported occurrences fell into two broad categories. One category related to

TABLE 1. ARTCC OPERATIONS AND REPORTED OCCURRENCES

Center	Operations[a]	Occurrences
Albuquerque	1,010,587	2
Atlanta	1,610,664	9
Boston	1,001,332	8
Chicago	1,982,189	7
Cleveland	1,879,024	12
Denver	923,701	10
Fort Worth	1,515,512	6
Houston	1,441,309	5
Indianapolis	1,517,993	12
Jacksonville	1,397,517	5
Kansas City	1,339,487	5
Los Angeles	1,389,269	13
Memphis	1,347,510	2
Miami	1,337,430	3
Minneapolis	1,241,627	6
New York	1,770,007	17
Oakland	1,120,442	12
Salt Lake City	656,746	2
Seattle	913,270	1
Washington, DC	1,557,139	10

a - Total Aircraft Handled

airspace and traffic flow constraints and the other related to system or equipment functions. Table 3 presents the contingency factor distribution by these two categories. Note that more than one factor could be cited in an occurrence or that none may be relevant. Of the 135 occurrences, 94 reflected the presence of a contingency situation that affected the controller's actions in some way.

TABLE 2. SYSTEM ERRORS AND REPORTED OCCURRENCES

FAA Region	System Errors[a]	Reported Occurrences
Central	16	5
Eastern	93	27
Great Lakes	161	37
New England	14	8
Northwest	11	1
Rock Mountain	28	12
Southern	125	19
Southwest	70	13
Western	91	25

a - Total for 1974-1976.

To illustrate the form of the above contingency factors in ARTCC operations a series of safety reports follow. The first involves controller error leading to Radar Data Processing (RDP) function and Special Use Airspace contingencies.

> "Com A was on an IFR flt plan ORL-CTY-MSY-DWH at FL180. I was working R30, Nepta Sector. All warning areas were inactive. I cut off the key that displayed the lines for the warning areas. At approx 21XXZ (17XX lcl) VPS apch called and wanted to know who was in his airspace, they did have a computer strip. When I cut off the special use key for the warning areas it also cut off some of VPS apch airspace to the south. I fell into my own trap by cutting off the key and not remembering the VPS apch cntl airspace extended further south than now displayed."

The following occurrence in which conflict alert was activated involves distractions associated with uncertainty about broadband/narrowband status and weather.

TABLE 3. CONTINGENCY FACTORS

Category	Citations
Airspace and traffic flow factors	62
Weather deviations	29
Weather	14
Special use airspace	16
Routings	13
Sector boundaries/status	4
System and equipment factors	48
Narrowband/broadband operation	8
Broadband operation	7
RDP functions	12
Communication functions	12
Aircraft system functions	4
Radar and radio coverage	2

"The data blocks on ACR Acft A and MLT Acft B started flashing conflict alert. A was turned south and B was turned south also. An attempt was made to stop A below B at FL210. This was not accomplished. Weather conditions involved a stationary cold front with up slope conditions. Tops varied between 17,000 and FL240 in the area. There were approximately 6 small aircraft on frequency. Some were experiencing icing conditions. The computer failed and recovered three times. We were not told whether to go broadband or stay narrowband. The interphase controller was distracted with change of route information and the necessity of making and taking of manual handoffs. The radar controller was trying to work a broadband and a narrowband situation at the same time."

The final example to illustrate contingency operations demonstrates a controller's problem when flight deviations due to weather and communication failure occur.

"While working heavy traffic when there were extremely turbulent thunderstorms in the sector, I had ACR A on a vector heading of 060 degrees so that the flight might go around an area of severe turbulence. The aircraft requested FL330 and I issued climb instructions to them. At the same time the sector immediately north of DET Hi handed off ACR B to me on an approximate heading of 180 degrees, this placed the two aircraft in a potential conflicting situation. After a period of about 10 seconds when the B had not called on my frequency, I asked the handoff man to get the transferring controller to switch the aircraft, they replied that B was NORDO. I therefore issued an immediate turn to A of 70 degrees, which placed him on vector heading of 350 degrees. I explained the situation to the A and he concurred. At this time the aircraft were approximately 12 O'Clock to each other and about 3 miles apart and A was FL334 and climbing."

Sector/Facility Boundaries

While examining the safety reports to determine the nature of the contingency factor and how it may affect controller performance, it was observed that many appeared to relate to situations occuring near the boundaries between air traffic control sectors or facilities. Table 4 presents the distribution of occurrences as to their position relative to sector/facility boundary and by the presence or absence of a contingency factor.

TABLE 4. DISTRIBUTION OF OCCURRENCES WITHIN SECTOR AIRSPACE

Occurrence Location	Contingency Factor Present		Total	Percent
	Yes	No		
At sector boundary	43	28	71	53
Within sector	38	26	64	47

A statistical test of the mutually independent sets shown in Table 4 reveals that no significant difference is found as a consequence of the presence of a contingency factor. The dominance of occurrences involving contingency factors was expected as the study was designed to yield that kind of occurrence. That 53 percent of the occurrences were situated geometrically near sector/facility boundaries was unexpected. ASRS safety report analysis and coding prior to computer entry establishes the presence of factors that either appear to enable or are associated with the reported occurrence. Returning to the original set of 241 safety reports comprising the data set used in this study as a point of reference, one finds that some 226 directly cited an ARTCC control enabling factor. Of these, there were only 55 notations (24.3 percent) suggesting between-sector/facility coordination issues. A proportional analysis of the 135 study occurrences would have yielded only 33 boundary related occurrences, not the 71 actually found.

One further opportunity to compare the unexpectedly large proportion of control problems found at the proximity of sector boundaries exists from the study by Kinney, Spahn, and Amato(5). In examining the FAA SEIS data base they found that 23.8 percent of the ARTCC system errors occurring during 1974-1976 involved intersector or interfacility coordination issues.

Air Traffic Control at Sector Boundaries

No immediate explanation for the observed discrepancy being available, further analysis concentrated on those occurrences taking place near sector boundaries. As the principal procedural mechanisms for handling aircraft movement transactions within the region of sector boundaries are handoffs and point outs, the 71 occurrences were examined to assess the character of these transactions. There were 39 in which either the handoff or point out was late or omitted, 30 in which the handoff or point out transaction was performed in accord with procedure, and 2 in which several sectors failed sequentially to detect that an aircraft was operating at variance with the posted flight plan.

The 39 incidents in which either the handoff or point out was omitted represented about 29 percent of the 135 occurrences comprising the total study set. This value is close to both ASRS and SEIS database proportions relating to sector/facility coordination. The following example illustrates the consequences of an omitted point out.

"I observed a target Acft A, entering O'Hare Tracon's airspace 45 miles south of the airport. The center controller did not point out A. I put an ARTS tag on the target and pointed him out to all controllers necessary. At that time, we did not know if the aircraft was VFR or IFR. My coordination was not in time for the south departure man at O'Hare Tracon. Acft B came less than 3 miles and 1000 of the unknown traffic 42 miles south of O'Hare, at 11,000 ft MSL. B did not see the other traffic."

The next example reveals, further, the controller's problems when a handoff transaction is late.

"ACR A was eastbound on J78 approx 40 west of ZUN at FL330. ACR B was NEbnd from PHX to GUP. ZAB sector 39 effected a handoff approx 5 to 10 miles from my boundary on B. At approx the same time I received a handoff from sector 92 on A, both acft were observed by me to be on collision courses and were approx 10 to 15 miles apart. After 2 attempts, I was able to issue and receive acknowledgement for A to turn right, heading 120 vectors for traffic. I then had to call sector 39 and have the controller send B to my frequency. After B came over, I turned him 30 deg to the right. Both acft passed each other with approx 3 miles separation. I believe the major factor leading to and causing this situation was the failure of both sectors 92 and 39 to effect a timely radar handoff and transfer of communications."

The essential features of these two examples, and others where point outs or handoffs are not performed in accord with procedure, are the same. The receiving controller has control over, at most, one of the aircraft, and limited time, if any, to effect a solution to an impending conflict.

The 30 incidents occurring near sector boundaries where appropriate handoff or point out procedures were used present a substantially more complex picture. The normal handoff, or point out, may take one of three forms, i.e., (1) approved as proposed, (2) approved with constraints reference other traffic, or (3) denied, or "unable"[(6)]. The latter case (there were seven in the subset) may present particular problems to the controller if he is already managing a complex traffic flow situation. The following example reveals how a controller's options are limited when faced with an "unable" and other factors.

ACRs-A and B enroute to JFK at FL330. B was north of J70 deviating due to a line of thunderstorms which extended from Dunkirk, NY south to Tidioute, PA. ACR-A was on J70 50 miles east of Jamestown, NY, VOR. B had just cleared the east side of the thunderstorm area, and was assigned a 150 deg heading to intercept J70 which would have put B 20 miles ahead of Acft A. At this time I made a computer handoff to NY sector No. 49 on both aircraft, as well as getting on the hotline to advise NY center of B's heading. NY answered the line by telling me to give B a right 360 deg turn, I then asked about ACR-A and NY advised descend ACR-A to FL290 and keep him coming. At this time my options were few. Due to thunderstorm activity I had traffic (C) at FL330 deviating north of J584 which put the aircraft about 15 miles south of ACR-A. I didn't want to turn A around and drive him back into the weather, so I descended ACR-A to FL290 and with B making a right 360 deg turn the two aircraft passed within a mile and 1000 ft of each other where 5 miles and 2000 ft are required. This situation arises quite often with NY when thunderstorms are in the area. My question is why must NY always wait until aircraft are almost on the center boundaries before deciding if they can accept an aircraft. If I would have had more of a warning this situation would not have occurred."

When considered as a whole, the 30 handoff/point out occurrences revealed a wide range of associated factors as shown in Table 5.

The first two categories relate directly to the contingency factors selected at the initiation of the study. The third category points up a class of contingencies effected by the way pilots control their aircraft and interact with the ATC system. The last category refers to those controller human factors affecting ATC . As these factors were prevalent here, and as there were 64 incidents occurring wholly within a sector's boundaries, a more detailed analysis of controller performance is presented in the following sections.

Controller Performance

As previously shown, some 64 occurrences described incidents taking place strictly within the confines of a controller's airspace. Even though the selection of these for inclusion in this study was based on the presence

TABLE 5. FACTORS ASSOCIATED WITH HANDOFF/POINTOUT OCCURRENCES

Airspace and Traffic Flow (Includes weather, special use airspace, navaid status, sector geometry)	16
Equipment Status (Includes radio, radar, and radar data processing)	10
Pilot Performances (Includes aircraft performance, clearance deviations, and pilot discretion)	13
Controller Performance (Includes coordination deviations, planning, monitoring, training, etc.)	26

of contingency factors, their analysis for the purpose of developing a qualitative description of controller performance appears warranted.

The approach taken was to analyze the occurrences from the perspective of the controller's job responsibilities. That is, the controller is responsible for planning the traffic flow in his sector and issuing clearances as necessary to assure separation; and he is responsible for monitoring traffic flow for assuring compliance with clearances and for detecting potential conflicts. In addition, the occurrences were analyzed to detect incidences of information transfer deficiencies since the controller is essentially unable to plan and monitor traffic movement if he has no knowledge of its presence. Finally, the occurences were examined to identify the kinds and frequency of discrete technical errors, e.g., computer entry errors, clearance delivery errors, etc.

The results of the above described analyses are presented in Tables 6 and 7.

As shown in Table 7, controller technical errors were infrequently reported. Consequently, other than to indicate the kinds that are present,

TABLE 6. CONTROLLER PERFORMANCE DEFICIENCIES

Category		Citations	Percent of Reports
Planning		27	42
Traffic flow (long term)	(11)		
Conflict resolution (short term)	(16)		
Monitoring		22	35
Vigilance	(18)		
Distractions	(4)		
Information Transfer		8	12
Unclassifiable		7	11
Totals		64	

TABLE 7. CONTROLLER TECHNICAL ERRORS

Type	Citation
Clearance Delivery	2
Strip Bay Usage	2
Computer Usage	3
Clearance Confirmation	4
Briefing of Relief	2

no further effort to assess their influence on controller performance was made in this study. A study of technical errors may be revealing, in its own right, to identify areas of procedural or equipment usage deficiencies.

Returning to Table 6, one observes that 42 percent involved planning deficiencies, 35 percent monitoring deficiencies, 12 percent information transfer deficiencies, and 11 percent could not be classified. The FAA system errors review process leads to the determination of a principal direct cause of a system error[5]. The most frequently cited causal factors are failures in attention, judgement, and communication. Assuming that judgement corresponds to planning, attention to monitoring, and communication to information transfer, a statistical test was performed to assess the relationship of the classification categories used here and the FAA categories. No statistically significant difference was observed, adding further support to the earlier observation that these occurrences appear substantively representative of ARTCC operations.

The eight information transfer occurrences noted in Table 6 involved failures among the controllers staffing a sector to make one another aware of all the traffic under the jurisdiction of the sector. Usually the error entailed the acceptance of a handoff by one controller without informing the other.

The 22 occurrences involving monitoring deficiencies are straightforward as to interpretation. Some involved the presence of distractions, such as discussions with the controller's supervisor or a trainee; in others the controller failed to maintain a complete awareness of the traffic flow in his sector. Later in this section a hypothesis relating to monitoring deficiencies will be put forth.

The most prevalent form of controller performance deficiency pertained to planning. It was observed that planning, or the strategies the controller adopts to manage traffic flow, took two forms. The first involved the initial consideration of an aircraft's subsequent movement through the sector airspace and the second involved traffic management in connection with resolving potential conflicts. The following examples illustrate respectively deficiencies in these two types of planning.

> "ACR-A was southwest bound climbing out of Omaha, NE Airport direct HLC VOR. ACR-B was descending to land at Omaha Airport routing LNK direct OMA VOR. The traffic at

the LNK sector was moderate with at least three other aircraft possible traffic for A and B. I planned for B to pass north of A, but they became head on traffic. The collision alert started to flash, but there wasn't enough time to react to it. I turned both aircraft 90 degrees left, but A ended up topping the B instead of lateral separation."

"I relieved A ctlr to go home about 2:30 p.m. The briefing included the potential confliction. The ACR B was about 25nm N of LOZ crossing J43 direct DAS. ACR A was on J42, both Wbnd. In this situation with ACR B being 25-40 kts faster the longer you wait to vector ACR A north behind ACR B the easier it is. I waited until about 3 min before conflict would occur and turned ACR A 15 deg right, after about 1 min I saw the vector was inadequate and turned him an additional 25 or 30 deg. ACR A asked where his tfc was, I stated 2:00 and 12 mi, ACR B. The ACR A said I don't think I want to get this close can we have a higher alt? I clrd ACR A to FL370 and then issued hdg 270 to ACR B (about 30 deg rt). The action was too little and too late. The aircraft passed between 1 and 2 mi apart with 800' alt. The error was a result of poor or untimely actions on my part."

During examination of the ASRS reports associated with this analysis of controller performance, it was observed that in many instances the reporter would describe the amount of traffic under his control. That is, he would indicate the traffic flow was moderate, moderate to heavy, heavy, or complex. On the assumption that the controller was conveying workload level, the decision was made to examine the controller performance factors in the presence of higher workload levels and also to examine the same factors in the presence of contingencies. A statistical test was first performed to test the hypothesis that workload would be mentioned if a contingency factor was present. The results of this analysis, shown in Table 8 refute the hypothesis although marginally.

The distribution of the controller performance factors in the presence of heavy workload is shown in Table 9. No significant differences are observed as a consequence of workload reported levels.

TABLE 8. WORKLOAD AND CONTINGENCY FACTORS

Workload Cited	Contingency Factor Present	
	Yes	No
Yes	19	7
No	19	19

$X^2 = 3.408 \qquad .05 < p < .1$

TABLE 9. WORKLOAD AND CONTROLLER PERFORMANCE

Workload Cited	Controller Performance Factor		
	Planning	Monitoring	Inf. Transfer
Yes	10	12	3
No	17	10	5

$X^2 = 1.66$, not significant

In Table 10, the distribution of controller performance factors as a function of contingency factors is shown. A very significant difference in controller performance is found as a consequence of the presence of a contingency.

The finding that contingency factors significantly influence controller performance, and workload does not, adds credence to the previous observation (Table 8) that workload and contingency factors are independent considerations as to their effect on controller performance.

TABLE 10. CONTINGENCY FACTORS AND CONTROLLER PERFORMANCE

Contingency Factor Present	Controller Performance Factor		
	Planning	Monitoring	Inf. Transfer
Yes	10	16	7
No	17	6	1

$X^2 = 8.53m\ p < .02$

Although the information presented in ASRS safety reports cannot in itself offer an explanation for the differences shown in Table 10, consideration of the controller's perception of himself might offer some insight. A recent study by Rose, Jenkins, and Hurst[7] indicates that as a group controllers tend towards strong, dominant, agressive, independent, self-confident personalities.

These personality traits suggest that controllers would prefer active, planning-related functions as opposed to passive, monitoring-related functions. Further, these trait related preferences are reinforced by virtue of the large number of aircraft to be handled as opposed to the very infrequent number of system errors.

A review of the findings presented above in light of the controller's personality traits appears warranted. First, that planning related errors occur more frequently can probably be explained on the basis that the controller does more planning than monitoring. This notion might also be expressed as, "If I plan well, why monitor?" Second, that planning errors occur relatively less frequently when contingency or higher workload conditions prevail probably suggests that the controller is putting forth greater effort to plan well than he does under nominal conditions.

The disproportionate number of monitoring errors occurring under contingency conditions suggests that more effort may be required to plan effectively than is appreciated. The planning effort may, under certain circumstances, be so compelling as to be a distraction intervening in the accomplishment of other duties.

Implications for ATC Automation

A recent literature review by Smith and Dieterly[8] reveals that few proven guidelines exist for the introduction and use of automation based on human performance considerations. They further report that as yet the technical community has not reached agreement about a definition of automation.

Without other reference then, the material developed and presented in the preceeding sections must be considered within the context of the FAA's institutional responsibilities. The FAA must provide for the safe, orderly and efficient flow of air traffic. Automation concepts that are at variance with a controller's abilities might be expected to be counterproductive to FAA expectations.

Current automation efforts relating to enhanced information transfer between aircraft and ATC, e.g., DABS, appear in light of the material developed in this study not to be at variance with a controller's performance abilities. There is however apparently a safety problem relating to information transfer between control sectors that is not being addressed in any known program.

The AERA program, recently described by Zellweger and Weathers[9], appears to be oriented towards automation of the planning and control functions of air traffic control. Although the information developed here indicates that planning errors are more frequent, that circumstance is influenced inversely as a consequence of special demands on the controller's planning abilities. The early adoption of automation techniques that directly assume a portion of the planning responsib'lities might be received negatively by the controller.

Zellweger and Weathers point out that attainment of completely automated planning and control would be realized only through an evolutionary process. Automatic aids for assistance in resolving short-term, potential conflict situations--the planning deficiency most frequently observed here--would appear to have direct safety benefits as well as to introduce planning oriented automation to the controller.

Automation to aid the controller in traffic monitoring would also appear to provide safety benefits as well as be readily accepted by the controller. That is, of the 135 occurrences in this study, the controller reporter noted that conflict alert was activated in 31 instances. In no instances did reporters indicate, or suggest, a negative attitude about conflict alert or its activation. There was, to the contrary, one suggestion that it might be improved for head-on traffic situations.

Several areas of deficiencies observed in this study might benefit from the use of automatic monitoring aids. One would detect aircraft deviations from flight plans or clearances. Another would detect potential omissions of handoffs or pointouts and cue controllers--remind them--of the need to take action.

As there are no known published reports describing the details of the ATARS concept, the information developed in this study can be used in only a general way to consider independent conflict resolution systems. The discussion proceeds on the assumption that the conflict resolution message results in an uncoordinated movement of air traffic.

The class of ARTCC control problems described here that relate directly to uncoordinated traffic movement involves those incidents occurring near sector boundaries where the pointout or handoff was omitted or late. The observation was made with respect to them that the controller had little time to resolve potential conflicts. If the independent resolution messages are extremely rare events, they may prove to be a significant safety factor. If, on the other hand, they occur too frequently, independent conflict resolution systems may be discounted by both controllers and pilots.

FINDINGS AND CONCLUSIONS

An ASRS study of ARTCC air traffic control operations was conducted to ascertain what benefits and what liabilities based on controller performance should be given consideration in the development of further automation for use in the en-route air traffic environment.

The occurrences selected for study were found to correlate significantly with the frequency and geographic distribution of total aircraft handled and system errors. When classified into controller performance deficiency categories of planning, monitoring, and information transfer, the occurrences were found to correspond with FAA system error causal factor categories of judgement, attention, and communication.

The study was designed to assess the specific effects of contingencies on controller performance. Contingencies found to be a factor include those that constrain airspace usage or traffic flow such as weather and special use airspace and those related to system and equipment usage such as radar and radio communication status.

The occurrences were found frequently to describe situations occurring within the proximity of control sector boundaries. The most frequently observed situations involved omitted, late, or denied handoffs or pointouts. Controller performance deficiencies were found to be related to failures in planning, monitoring and information transfer.

The presence of a contingency factor was found to affect significantly the distiibution of planning, monitoring, and information transfer failures. It was found that workload, based on reported traffic levels, did not significantly affect the distribution of performance failures.

Based on these findings, the following conclusions were reached:

1. The occurrences reported to ASRS and used in this study relate substantively to ARTCC operations and system errors.

2. Omitted, late, and denied handoffs and pointouts occur relatively frequently and efforts to reduce their occurrence would offer significant safety benefits.

3. Managing contingency situations has an important effect on controller performance adversely influencing his ability to monitor and transfer information.

4. Automation oriented towards aiding the controller in performance of his monitoring tasks would offer substantial safety benefits.

5. Independent conflict resolution systems that are not coordinated with the controller's traffic management tasks are not likely to be acceptable.

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