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ATC CONTROL AND COMMUNICATIONS PROBLEMS: AN OVERVIEW OF RECENT ASRS DATA

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INTRODUCTION AND MOTIVATION

> *"I was distracted by the following factors...I had to constantly help a terminal controller who was working my A-side. I had to ensure the terminal controller working the radar trainee followed my non-radar instructions. I had equipment out of service...the position was overloaded and unable to split sector because of staffing."* (ASRS Record 49392)

In the wake of the 1981 controllers' strike, the aviation industry has demonstrated sustained interest in air traffic problems arising from the rapid rebuilding of the controller work force—especially in ATC workload problems. Safety analysts of NASA's Aviation Safety Reporting System (ASRS) believe that the ASRS has seen a growth in reporting of ATC workload and communications problems during the past several years, reinforcing industry interest and concern. We undertook a research study to verify these analyst impressions, and compiled a substantial number of relevant reports to serve as a study data set.

OBJECTIVES AND SCOPE

This paper is limited to preliminary discussion of a portion of the data collected for the larger study. Our aims here are as follows:

- To examine possible correlation between controller experience level and incident occurrences
- To identify the types of safety incidents occurring in the data set
- To describe the most frequently occurring controller errors in the high workload situations described by these data
- To identify the specific workload and environmental factors associated with these errors
- To describe the ways in which pilot errors may have preceded or predisposed controller errors
- To assess the implications of these findings in regard to current ATC procedures/policies

APPROACH

Description of Data

All ASRS database records received over a 31-month period (January 1986-September 1988) were examined for association with such factors as controller workload, traffic volume, frequency congestion, ATC communications, and facility management policy. A total of 340 relevant incident reports were selected as a data set for the study. They represent a small portion of the total report intake during this period. Controller reporters submitted 42 percent of the reports, while pilot and flight crew members submitted 58 percent.

Study data are subject to certain statistical qualifications. All ASRS data, including those in this study, are submitted voluntarily and may reflect reporting biases; they constitute a non-random sample population of aviation incidents and events. Further, study data have been selected so as to include as many controller reports as possible. We consider this desirable for two reasons:

- In the ASRS database, controller reports are the best source for information concerning workload demands and other ATC problems, although pilot reports may be helpful in this regard if the reporting pilot(s) are experienced observers.

- The ASRS database contains many fewer controller reports than pilot reports (post-strike controller submissions to the ASRS constitute less than five percent of total database holdings). Thus potential controller inputs are limited during report retrieval unless additional reports are specifically solicited.

The selection criteria described above created a fair balance between pilot and controller reporters in this data set.

Method

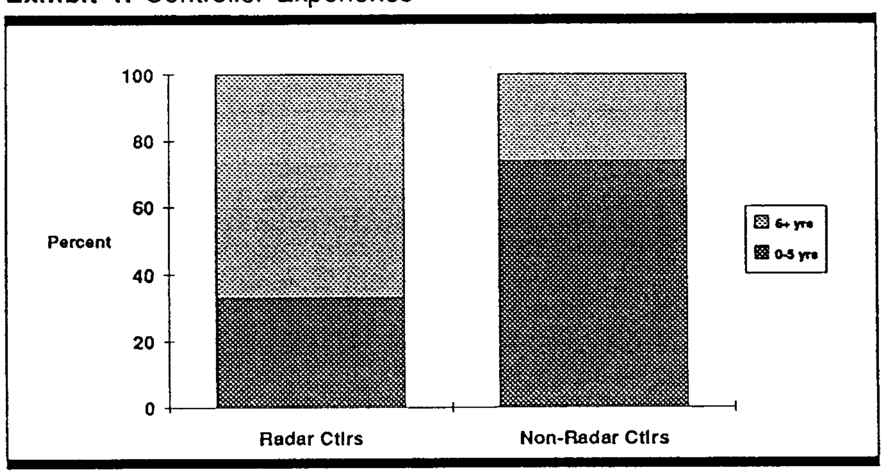
The authors have participated in the generation and review of several ASRS research studies, and have read and analyzed thousands of ASRS reports. They represent experienced pilot and controller viewpoints.

Early in the analysis process, we chose the "standardized narrative" to code data. This is a technique for extracting "soft" anecdotal information, in which each incident report is re-formatted into a set of carefully constructed sentences. This method improves the consistency of coding among data analysts, and aids in correlation analysis.

FINDINGS AND DISCUSSION

Controller Experience

Exhibit 1. Controller Experience



We were particularly interested in the experience levels of controllers involved in incidents, if this information was reported. In a majority of cases it was not. Over half of reporters were pilots, and not all controllers reported their experience. However, within the subset of controller reports where these data were available, we found that two-thirds of radar controllers reported experience in the range of six to twenty-one (or more) years, while the remaining one third reported experience of five years or less. With non-radar controllers, these general proportions were reversed. Three-fourths of non-radar controllers reported experience of five years or less, while one-fourth had six or more years of experience. Exhibit 1 shows these comparisons.

These data may have several interpretations. The predominance of experienced controllers among those reporting radar experience may simply indicate that experienced controllers are more likely to be familiar with the ASRS program, and thus more likely than developmental controllers to report safety incidents. However, this finding also suggests that experienced controllers—often assumed to be less vulnerable than developmentals to adverse workload pressures—may in fact be susceptible to these adverse influences.

The finding that a majority of non-radar controllers fell in the one to five year experience range was expected for two reasons: 1) on average it requires from three to five years to become a Full Performance Level (FPL) radar controller; 2) this experience range also includes some Terminal controllers who do not use radar.

Types of Safety Incidents

The safety incidents occurring in the data set were classified using conventional ASRS "anomaly" descriptors. *Airborne conflicts* were the most frequently reported anomaly in the study data set. They represented more than a third of all citations, reflecting the high proportion of controller reports in this study set. *Altitude deviations* were the next most frequent occurrence, followed by *runway incursions* and *erroneous penetration of airspace*. These study distributions are not characteristic of the ASRS database as a whole, in that altitude deviations account for more than 60 percent of total database anomalies.

Controller Performance Errors

We recorded and grouped controller errors according to shared attributes, and then associated these non-exclusive groupings with either of two broad concepts: control or communications.

Control Errors

Most control errors were errors of omission: the controller did not (or forgot to) perform a function as expected or needed. The three leading control errors involved *monitoring*, *timeliness*, and *coordination*. It is intuitively obvious that there is considerable overlapping among these categories.

Monitoring. One of a controller's most important functions is to perform systematic checks of the positions, altitudes, and flight paths of aircraft under positive control—to "keep the big picture." In this data set, *monitoring failures were most likely to involve an aircraft's flight path.* If monitoring lapses were not detected and corrected, they often contributed to later timeliness errors. Heavy traffic, associated with a complex traffic mix, appeared to be associated with most monitoring errors.

Timeliness. Timeliness refers to a controller's sequencing of instructions or actions with respect to the flight phase or condition of aircraft being controlled. Examples of incidents in this category were a controller's failure to give a frequency change; to issue a timely climb/-descent clearance, crossing restriction, or traffic advisory; to correct a pilot navigation error, altitude deviation, or clearance readback in a timely manner; or otherwise to act in an opportune manner.

Two timeliness errors occurred with significantly higher frequency than others: *failure to give timely climb/descent clearances*; and *failure to correct flight crew navigation errors or altitude deviations*. Again, heavy traffic volume and frequency congestion were associated with such omissions. Staffing shortages were also implicated in some reports.

Coordination. Coordination is the harmonious interaction of air traffic personnel and facilities to achieve a safe and expeditious traffic flow across airspace or movement area jurisdictional boundaries. The majority of coordination incidents in this study involved ineffective or improperly executed handoffs, pointouts, or APREQs ("approval requests"). *The most frequently occurring coordination error was failure to coordinate a handoff, or give a pointout, to an adjacent sector.* Airborne conflicts often resulted from coordination failures. One controller narrative echoed a theme common to many such reports: "This is becoming a frequent occurrence mainly because there are too many airplanes for the number of controllers available."

Communications Errors

The majority of communications errors were errors of commission where the controller made a procedural or verbal mistake. The leading communications errors involved *clearance composition*, *ATC phraseology*, and *readback/hearback*.

Clearance Composition. Clearance composition includes the order and sequence of a controller's instructions, as well as clearance content. These errors figured in a significant number of reports. The majority involved *a wrong heading or altitude assignment*, or *inappropriate or misleading instructions* that resulted in runway incursions or other ground incidents. Other clearance composition errors included issuance of clearances to the wrong aircraft, inconsistent instructions within a short time frame, or a series of non-standard vectors without explanation. Reporters' narratives singled out several contributing factors in these incidents: heavy traffic causing controller overload; similar aircraft call signs; and coordination difficulties.

Phraseology and Delivery Technique. Phraseology refers to a controller's choice of words in issuing instructions; delivery technique consists of a controller's enunciation, speech rate, and other factors influencing the way a clearance is heard. *Non-standard terminology in clearances* was identified as a problem in more than ten percent of all study reports. In this connection, some narratives mentioned poor controller radio technique as a problem needing remedial attention. *Too rapid issuance of instructions* ("speed feed") was the most common delivery technique problem cited. Congested frequencies and blocked transmissions appeared to underlie many such incidents.

Readback/Hearback. The ATC Procedures Handbook states that controllers are to ensure that a flight crew's readback is correct: "...If incorrect or incomplete, make corrections as appropriate." Preliminary data in this study confirm what is already a well-documented problem in air traffic control: *controllers often fail to correct erroneous flight crew readbacks.* Frequency congestion, blocked transmissions, and controller overload were the main causes reporters attributed to ATC hearback failures in this study set.

Factors Predisposing Controller Performance Errors

One of our main objectives was to identify the specific environmental factors predisposing controller performance errors. *Large numbers of aircraft*, *frequency congestion*, and *combined position/sector operations* were the factors most often cited in reporters' narratives. Almost one-third of all study narratives directly referenced controller overload or traffic saturation, lending subjective support to these findings. Exhibit 2 presents the top ten controller predisposing factors, in order of their numerical significance.

Exhibit 2. Workload Factors Affecting Controller Performance

1) Large numbers of aircraft
2) Frequency congestion
3) Combined positions/sectors
4) Need to resolve a conflict
5) Inclement weather
6) Sector/corridor design
7) Similar call signs
8) Giving/receiving training
9) Scope/data block clutter
10) Long working hours

In addition to the factors cited above, pilot performance errors also served to predispose controller errors. In particular, pilots' failure to clarify confusing instructions and adhere to clearances appeared to contribute downstream to a number of controller monitoring and timeliness errors. Pilot performance errors will be discussed in the section that follows.

Two of the predisposing factors shown—*combined position/sector operations*, and *controller training activities*—are of particular interest for their implications regarding current levels of

ATC staffing. In spite of the FAA's efforts to bring the controller work force to pre-strike levels, staffing may still be a problem in some facilities, as evidenced by the relatively large number of controller reporters in this study who stated that combined position/sector operations contributed to incident occurrences. This finding is reinforced by the concurrence of controller training activities with heavy traffic conditions in a number of safety incidents. Use of developmentals to control traffic that is congested and complex may also indicate staffing shortages and overloading of training personnel.

Pilot Performance Errors and Predisposing Factors

Although our main focus was on the errors and problems of air traffic controllers, the large number of pilot reports in the data set prompted us to track flight crew performance errors and their predisposing factors, as well. Our motivation was to determine what correlation, if any, existed between pilot and controller errors.

In a majority of those reports where information was available on both pilots and controllers, we discovered performance errors on the parts of both. The most common of the pilot errors were *confusion over altitude assignment*, *failure to clarify confusing instructions*, and *failure to adhere to a heading assignment*.

The three leading factors predisposing pilot errors were *frequency congestion* (and associated blocked transmissions), *radio communications*, and *traffic watch*. Two of these factors—frequency congestion and traffic watch—correspond to leading controller predisposing factors.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

The major findings in this study concern controller experience, workload factors that predispose controller performance errors, and ATC facility staffing.

- **The data suggest that a substantial number of controllers are handling too much traffic, or traffic mixes that are too complex, and further indicate that accumulating more controller experience may not solve these problems.**

This is the study's key finding. Other findings are as follows:

- There is no reliable correlation between controller experience level and operational errors or deviations in these data
- Evidence indicates that experienced controllers—often assumed to be less vulnerable than developmentals to adverse workload pressures—may in fact be susceptible to these adverse influences
- Heavy traffic and frequency congestion were the main factors associated with ATC control and communications errors in this study
- Combined position/sector operations were a contributing factor in a significant number of incidents, indicating that staffing levels in some ATC facilities may be inadequate
- Controller training activities were a contributing factor to incident occurrences when conducted during peak traffic periods
- These data support findings in other studies that controllers' failure to correct erroneous flight crew readbacks is a persistent problem in air traffic control.

Recommendations

Based on the above findings, the authors offer the following recommendations concerning ATC procedures and policies:

1) The following efforts on the part of the FAA may prove beneficial in correcting the periodic imbalances that appear to exist in the ATC system between controller capability and the volume of traffic to be moved:

   - Continue to hire and train new controllers

   - Implement more stringent traffic management procedures and new control technologies as soon as feasible.

2) The Air Traffic Training Handbook (3120.4G) currently specifies that controller training situations "should become progressively more complex," and that trainees be exposed to "actual or simulated conditions" which could be encountered after attaining full performance status, including heavy traffic. These general provisions might be strengthened by implementation of the following suggestions:

   - Within facilities, develop graduated formulas that clearly establish the number of OJT and simulation training hours for specific levels of traffic (light, moderate, and heavy)

   - Assign trainees to sectors/positions where their OJT/simulation training is consistent with established traffic volume and workload maximums for those positions.

3) Further controller training in the following areas may decrease performance errors:

   - Correct phraseology and enunciation

   - Prescribed procedures for handling similar call signs

   - Timeliness in control decisions and actions

   - Monitoring and correction of clearance readbacks

4) This study suggests that pilots, as well as controllers, need to be held accountable by the FAA for communications that result in system errors.