CONTROLLER AND PILOT ERROR IN SURFACE OPERATIONS

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Abstract

This paper presents the results of an examination of controller and pilot errors in surface operations. Several different types of reports were analyzed, including: FAA reports of operational errors of controllers in air traffic control towers, FAA reports of pilot deviations, NTSB reports of accidents and incidents, and reports submitted by pilots and controllers to the Aviation Safety Reporting System (ASRS). All of these reports were analyzed for the following: type of pilot and controller error, factors contributing to, or coincident with, the error, and what could be done in the tower to help prevent these errors and increase the safety of surface operations. Controller errors were predominately attributable to a lapse in controller memory, an error in judgment of separation, failure to ensure that the runway was clear, and inadequate coordination between controllers. While the objective data on pilot errors is scarce, pilot errors were subjectively attributed to inadequate airport signage and markings and errors in communication between pilots and controllers. The paper concludes with recommendations for improving the safety of surface operations and for improving the quality of data related to pilot and controller errors.

Introduction

Runway incursions[1] and other surface incidents[2] are significant threats to aviation safety and efficiency. While the number of reported near mid-air collisions (NMAC) has remained relatively steady since 1995, the number of reported runway incursions has steadily increased (FAA, November 1999). Some of this increase might be due to an increased awareness of the problem and increased willingness to report incursions; however, it is clear that runway incursions require intervention.

It is no surprise that "nearly all runway incursions are caused by human error" (FAA, 1998 Airport Surface Operations Safety Action Plan, p. 1). While the opportunities for equipment malfunctions to cause such problems are relatively rare, the opportunities for human error are abundant. The proximity and number of aircraft in the terminal environment, combined with the complexity of operations and the requirement for split-second timing, conspire to make the airport surface and proximal airspace extremely unforgiving of pilot and controller errors. Previous studies (Steinbacher, 1991; Bales, Gilligan, and King, 1989; NTSB, 1986) have shown that the experience level of the controller, complexity of the traffic, or weather were not significant contributing factors to runway incursions. The overwhelming consensus of such studies is that the two most significant categories of controller errors was a failure of the controller's memory and inadequate controller-controller coordination. In all of these studies, the most common contributing factor was that the controllers had forgotten something significant, e.g., the presence of aircraft on a runway, the closure of a

[1] A runway incursion is defined as "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing or intending to land" (FAA, November 1999, p. G-4).

[2] A surface incident is defined as "any event where unauthorized or unapproved movements occurs within the movement area or an occurrence in the movement area associated with the operation of an aircraft that affects or could affect the safety of flight" (Ibid., p. G-4).

runway, or a clearance that he/she had issued. The second most common factor was a lack of, or incomplete, coordination between controllers. A final issue identified was the supervisor was either not in the tower cab, working at least one control position, or engaged in activities other than directly supervising staff (Steinbacher, 1991; Bales, Gilligan, and King, 1989).

In a National Transportation Safety Board (NTSB) special investigation of runway incursions (NTSB, 1896), the incursions classified by the FAA as due to pilot error were all attributable to a pilot entering, crossing, or taking off from a runway without a clearance. In "several" of these instances, runway and taxiway signs were "missing or inadequate." In "at least two [of the nine] instances, pilots did not comply with controller clearances which the pilots had acknowledged receiving" (p. 2). These runway incursions "usually involved either communication problems, such as misunderstanding clearances, or inadvertent entry of a runway because of disorientation" (p. 12).

Method

Several different types of reports were analyzed in this study. These included 256 Federal Aviation Administration reports of operational errors of controllers in air traffic control towers, 67 FAA reports of pilot deviations, 42 reports of accidents and incidents investigated by the National Transportation Safety Board; these reports are filed by investigators and were the most current in the FAA National Aviation Safety Data Analysis Center's (NASDAC) data base as of November 15, 1999. Also analyzed were 400 reports submitted by pilots and controllers to the Aviation Safety Reporting System (ASRS); these reports contain self-reports of errors or other incidents or safety concerns. All of these reports were analyzed for the following: type of pilot and controller error, and factors contributing to, or coincident with, the error.

Results

Tower Operational Errors And Deviations. FAA reports of 256 tower operational errors and deviations from the busiest towers in the U.S. (what was then Levels 3, 4, and 5). These reports were of incidents that occurred between January 1997 and June 1999. The FAA reports of operational errors and deviations are form-filled reports with areas for a narrative and comments. While this work did analyze the causal factors as identified by the FAA investigator, the form was found to be lacking in several critical areas. For this reason, the reports were analyzed independently for causal and contributing factors. The only two factors analyzed solely from the FAA form-filled part of the report were the rating of the complexity of the traffic at the time of the incident and the weather. With respect to complexity, only 30 percent of the reports specified that the complexity was above average or complex. Thirty-two percent of the reports specified an average level of complexity, 20 percent below average and 25 percent as easy. Weather was listed as a factor in only 8 percent of the reports.

The most common contributing factor, occurring in 27 percent of the operational errors and deviations examined, was the controller "forgetting" something. In 15 percent of the reports, the controller had forgotten about an aircraft (such as one that had been cleared to land or one holding at the end of a runway). In 3 percent of the operational errors and deviations examined, the controller forgot that there was a vehicle on the runway. In an additional 5 percent of the cases, the controller forgot that the runway was closed. Other memory failures accounted for an additional 4 percent of the incidents examined.

The second most common element found in this analysis of operational errors and deviation was a communication error between pilots and controllers; miscommunication was found to be a factor in 19 percent of the incidents.

A failure of one controller to relay needed information to another controller or a failure to obtain approval for a specific operation (such as a failure to coordinate a runway crossing) was noted in 18 percent of the reports in this analysis.

The absence of a supervisor (who was not working a control position) was noted in 11 percent of the operational errors and deviations examined. However, it is important to note that this factor was not able to be consistently coded because many of the reports do not explicitly contain this information. The reports may say that the supervisor was "unaware" that an error

was developing; however, many did not specifically state whether or not the supervisor was in the tower cab at the time. In many cases, it was the supervisor (or controller-in-charge) that prevented a bad situation from getting much worse.

There were four factors that suggest the need for further research to determine their effect, if any, on controller error: peripheral duties imposed by traffic management duties, Land and Hold Short Operations (LAHSO), effects of working combined positions, and intersection takeoffs. In each case, the degree to which these factors contribute to the complexity of the controller's task and the risk of a runway incursion or accident need to be investigated.

FAA Reports of Pilot Error. All of the 67 FAA records of pilot deviations in tower airspace contained in the NASDAC data base as of November 1999 were examined. Of these, only six percent described runway incursions, and none of them contained enough detail to be able to provide insight as to why the events happened.

Final Reports of Aviation Accidents and Incidents Investigated by the National Transportation Safety Board (NTSB)

As of November 15, 1999, there were 42 final reports in the NASDAC data base of accidents and incidents in airspace controlled by air traffic control towers. These reports covered the period of December 1983 to July 1995. Of these, 22 were unique reports of surface accidents and incidents not related to aircraft mechanical failures. By far the largest common factor, occurring in 70 percent of these reports, was the controller's failure to verify that the runway was clear before allowing an aircraft to takeoff or land. In some of these cases, the pilots reported that their aircraft were clear of the runway, when in fact it was not; in one case, a fleet of vehicles reported clear when they were not. Twenty-two percent of the 22 incidents and accidents involved miscommunications between pilots and controllers; in 13 percent of these cases, an aircraft accepted a clearance intended for another aircraft. Thirteen percent involved a "memory lapse" on the part of the controller - forgetting that he/she had cleared an aircraft to land, takeoff, or position and hold on the runway. Only one case involved a controller that was working combined position. Only one report mentioned that the supervisor was working a control position at the time of the incident. Two of the reports cite poor airport markings (in one of these cases a sign had blown over).

While previous research (Steinbacher, 1991; Bales, Gilligan, and King, 1989; NTSB, 1986) did not find that weather or visibility was a significant contributing factor to runway incursions, the present data suggest that visibility might be a significant factor in surface incidents that result in accidents. Of the six accidents, only one occurred in visual meteorological conditions (VMC) during the day. Two occurred in instrument meteorological conditions (IMC) during the day. Two occurred in VMC at night (this includes one with fog). One accident occurred in VMC at dusk. Of the 16 incidents, eight occurred in VMC during the day (this includes one with haze and another with rain and haze). Five occurred during VMC at night (one with haze and one with snow). Two incidents occurred during IMC at night and one occurred during IMC during the day.

Reports Submitted to the Aviation Safety Reporting System (ASRS)

The Aviation Safety Reporting System is a wealth of information submitted by pilots and controllers regarding specific events and concerns. Self-reports of errors typically present a candid portrayal of causal factors that the person may or may not wish to relay to the investigative authority. One hundred reports of "runway transgressions" submitted by pilots were examined to determine causal factors from a pilots' view (and whether improvements in tower capabilities could prevent or ameliorate such errors). In an effort to determine the causal factors of tower controller errors as well as the general concerns of tower controllers, the most recent 300 ASRS reports submitted by tower controllers were examined. Of these, some were duplicates and others did not contain enough information to merit analysis. This left 271 reports on which the following results are based.

Controller Concerns. Of the 271 reports examined, 32 percent were reports of controller concerns. Thirty-eight percent of these reports concerned weather information (ASOS [Automated Surface Observation System] inaccuracies, the need for wind information or

low-level wind shear indication). An additional 34 percent of these reports were regarding radar outages, malfunction, or cited the need for surface radar at that facility. Twenty-three percent of the controller concerns were regarding local procedures, local "problem traffic" (such as training centers or high speed military traffic) and reports of problems with local letters of agreement (LOA) or reports of controllers at other facilities failing to comply with LOAs. The remaining controller concerns contained in these reports concerned LAHSO (land and hold short operations), and miscellaneous issues (such as air quality in the tower) each comprising less than four percent of the reports of controller concerns.

Controller Reports of Pilot and Controller Error**.** Thirty-two percent of the reports submitted by tower controllers contained descriptions of pilot error and miscellaneous incidents; however, most offered no insights as to why the event occurred. Twenty-eight percent of the reports submitted by controllers describe errors that they themselves committed. The most common type of error reported involved memory lapses. Instances in which the controller forgot about an aircraft, that a runway was closed, or that a clearance had been issued accounted for 29 percent of all of the self-reports of controller errors. Sixty-two percent of these errors resulted in runway incursions. Additionally, two aircraft were cleared to land on a closed runway. While not all respondents reported factors that contributed to these errors, the most common contributing factor reported was that the controller was working combined positions; this was cited in 32 percent of the 22 errors involving memory lapses.

There were 24 reports involving instances in which the controller made a judgment error in predicting separation. Fourteen of these involved separation in the air; 13 of these errors resulted in a loss of standard separation and one resulted in a near mid-air collision (NMAC). Four of these reports specified that the controller was working combined position at the time of the incident. An additional 10 reports of controller judgment errors involved separation on the ground (nine resulting in runway incursions); none of these reported that the controller was working combined positions at the time of the incident.

Twenty-four percent of the controller errors involved poor coordination between controllers. Thirty-three percent of these instances resulted in NMACs, and seven percent resulted in runway incursions (the remainder resulted in a loss or possible loss of standard separation). In 22 percent of these cases, the reporter cited a poor position relief briefing as a primary cause of the lack of coordination (e.g., the controller was not informed of an aircraft).

The reports involving self-reports of tower controller errors contained a similar breakdown of the type of controller errors as the operational error data. The errors fell into three distinct categories: memory lapses, controller-controller coordination, and judgment errors in predicting separation. Most reports did not identify particular causal factors; however, 16 percent stated that the reporter was working combined positions at the time, 6 percent identified a poor position relief briefing as contributing to the error, 4 percent identified fatigue as a contributing factor, and 4 percent mentioned controller-pilot communication errors (one report involving a blocked communication).

Reports Submitted by Pilots. The 100 most recent reports filed to ASRS that resulted in a runway transgression were examined. "Runway transgression" is defined by ASRS as the "erroneous or improper occupation of a runway or its immediate environs by an aircraft or other vehicle so as to pose a potential collision hazard to other aircraft using the runway, even if no such aircraft were actually present". Seventy-five of these reports were of incidents that occurred in controlled domestic airspace and not to aircraft equipment failure or concerns specific to a particular location. Forty-two (56 percent) of the remaining 75 reports involved crossing the "hold short" line. These instances resulted in 12 runway incursions (six aborted take-offs and six "go-arounds"). Most (57 percent) of these errors were attributed to the pilot not being able to see the hold short line or otherwise poor markings. There were 15 incidents in which a pilot taxied onto a runway without authorization; an additional 12 instances in which a pilot taxied to, taxied onto, or took-off from the wrong runway; and an additional six incidents in which a pilot crossed a runway without authorization. Forty-two percent of these 75 reports cited the need for better airport markings and 30 percent were attributable to controller-pilot communication

errors (36 percent of these communication errors involved aircraft accepting another aircraft's clearance). The final four reports did not fit into any category.

In summary, there were 75 pilot incidents contained in the data; 33 runway incursions and 42 other surface incidents. Forty-seven percent of these incidents were directly attributed to poor airport markings and signage by the reporter, and 33 percent involved miscommunications between pilots and controllers.

Conclusions and Recommendations

The most recent reports of controller operational errors and the self-reports of errors from controllers and pilots suggest the following recommendations:

- Improved Surveillance and Monitoring Equipment for Controllers. Not all air traffic control towers have surface radar. Those towers have only pilot position reports to verify an aircraft position. Those towers with surface radar would also benefit from timely and accurate alerts of potential conflicts.

- Acting Supervisor in the Tower Cab (Not Working a Control Position). Having a supervisor or controller-in-charge to provide an "extra set of eyes" appears to be an effective safety net.

- Support for Controller Memory of Critical Information (e.g., memory aids). Simple memory aids, such as posting of closed runways, are not consistently used.

- Improved Means of Communication Between Pilots and Controllers. Communication errors between pilots and controllers is a common factor in accidents and incidents. More effective means of communication, such as a broader use of data link, are needed to prevent an aircraft accepting another aircraft's clearance and help to relieve frequency congestion.

- Improved Airport Markings and Signage. Particularly more conspicuous "hold short" markings are needed to help prevent pilot's getting lost.

- Mechanism to Ensure that the Runway is Clear Before a Clearance Issued to an Aircraft to Take-Off or Land. While controller training is the first line of defense, this task could be aided by a system (for pilots and/or controllers) that displays whether or not the runway is occupied.

- Increased Aircraft Conspicuity. Additional lights are needed to make aircraft more conspicuous both to controllers and to pilots on the ground and on approach.

- Cockpit Standard Operating Procedures. Cockpit SOPs for ground operations are needed to help ensure that: non-essential tasks are completed during relatively low workload and non-critical phases of operation, and that (both) pilots are aware of the location of their aircraft on the airport surface, the location of all critical elements in the airport environment (e.g., hold short points, intersecting runways, aircraft on approach, etc.) and their ATC clearance.

- Revised Methods for Investigating and Recording Pilot and Controller Errors in Surface Operations. The forms used for investigating controller operational errors should be revised to ensure that they capture the key types of error (e.g., forgetting) and coincident factors. The reports of pilot deviations filed by the FAA contain no useful information as to what contributed to the error or how the error could have been prevented; the forms and procedures used to investigate and record pilot errors need to be dramatically revised to capture the type of error and contributing factors. An attempt should be made in all reports of pilot and controller error to shift the emphasis from "fault-finding" to identifying ways in which the error could be prevented.

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Author's Biography

Kim Cardosi received a Ph.D. from Brown University in Experimental Psychology in 1985 and a private pilot's certificate in 1990. She has conducted extensive research in controller-pilot communications and has supported many FAA programs. Kim currently supports the FAA's Office of the Chief Scientific Advisor for Human Factors, the FAA's Runway Safety Program, and the NASA-Ames Research Center. Kim is the manager of the ATC human factors program at the Volpe Center, part of the Department of Transportation's Research and Special Programs' Administration and serves on the Board of Directors of the Air Traffic Control Association.