

A METHOD FOR RATING THE SEVERITY OF RUNWAY INCURSIONS

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Abstract

Risk is a function of the probability of an event and the severity of the consequences of that event. Any discussion of issues of risk in surface operations must include a valid and reliable measure of the severity of the outcome of runway incursions. This paper describes an automated method for rating the severity of the outcome of runway incursions. This model was developed using the same criteria and decisions that experts currently use to determine the severity of an incursion. The model assigns a severity rating based on the information contained in the preliminary report of the incident. This includes: the geometry of the situation that resulted in the incursion and the closest proximity (horizontal or vertical), visibility, type aircraft, and whether or not (and characteristics of) the avoidance maneuver. The initial validation was conducted by comparing the model's assessment of 307 runway incursions to the assessment conducted by a panel of subject matter experts in the FAA Runway Safety Office. In 92% of the incidents, the model matched the group's ratings (of three levels of severity). Patterns of discrepancies are well defined and discussed. Ongoing validation efforts are also described. Finally, possible applications to losses of standard separation in the air are explored.

Introduction

At the Eleventh Air Navigation Conference in Montreal (September 2003) the International Civil Aviation Organization (ICAO) was challenged to "urgently progress the development of a formal definition for 'runway incursion' as a prerequisite for further actions to be taken in this domain." Also expressed was a need to develop a standardized

runway incursion severity categorization taxonomy. Information on runway incursions is not readily comparable across countries, in part, due to the differences in the definition of runway incursion. The United States' Federal Aviation Administration (FAA) has defined a runway incursion as: "Any occurrence in the airport runway environment [with an operating control tower] involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of separation with an aircraft taking off, intending to take off, landing, or intending to land." [1]. The definition of a runway incursion that was adopted by ICAO as of 25 November 2004 (and that will be used by the United States in the future) is "Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and takeoff of the aircraft."

An international standard for the definition of a runway incursion is the foundation for being able to share data across aviation authorities. Another critical step toward being able to analyze runway incursion data, either within a state or across states, is a standardized method for categorizing the severity of runway incursions. The validity of any analysis that speaks to (such as the causes of) "serious incidents" compared to less serious incidents is routed in a reliable and valid method of determining the severity of such incidents. Such a method for determining severity is also necessary for risk assessments (of procedures, equipment, etc). Since "risk" is a function of the probability of an event and the severity of the consequences of the event, a valid and reliable measure of the severity of the outcome of a runway incursion is essential for measuring the risk of surface operations.

FAA Runway Incursion Severity Categories

For years, the FAA had used the total number of runway incursions per year as a safety metric. Within the last several years, this measure was refined to differentiate between the incursions that came close to resulting in a collision and those that met the definition of an incursion, but had little or no chance of a collision. The FAA's Office of Runway Safety and Operational Services currently rates the severity of individual runway incursions as "A," "B," "C," or "D." These categories, designed to represent the risk of collision are defined as follows:

- Category "A" incursions are those in which a collision is narrowly avoided,
- Category "B" incursions are those in which "separation decreases and there is a significant potential for collision,
- Category "C" incursions are those in which separation decreases but there is ample time or distance to avoid a potential collision,
- Category "D" incursions have little or no chance of collision, but meet the definition of a runway incursion.

There are five operational dimensions that are used to guide the categorization. These are: available reaction time, the need for evasive or corrective action, environmental conditions, aircraft or vehicle speed, and proximity. Each category is qualitatively defined (such as evasive action was: not necessary, advisable, essential, or critical).

Note: The above four categories of severity are different from those specified by the International Civil Aviation Organization. FAA is currently working with Eurocontrol, Air Services Australia, and ICAO to develop standardized and well-defined categories for the severity of runway incursions. It is anticipated that these categories will match the current FAA definitions of "A," "B," and "C." That is, a category "A" will represent a runway incursion in which a collision was narrowly avoided, a "B" was an incursion that had significant potential for collision and a "C" involved ample time or distance to avoid a collision. Therefore, once the two schemes are harmonized, the current FAA category of "D" would logically be combined with the category "C."

How Runway Incursions Are Categorized In the United States

The procedure currently used by the FAA to assign a rating of severity to runway incursions is to present the incident to an in-house group of subject matter experts. This group was selected to capture expertise from the following operational areas: Air Traffic, Flight Standards, Airports, and Safety. The details of the event are reviewed with the airport diagram and ratings are solicited from each participant. When the ratings are not unanimous, the event is discussed until consensus is reached.

Incursions are typically categorized with respect to severity within a week or two after the event. The rating process begins with the review of the airport diagram and all of the available details of the incursion, such as weather (ceiling and visibility), time of day, aircraft type, and the narrative description of the event. A critical starting point of the discussion is the closest proximity, that is, how close the two aircraft or aircraft and vehicle came in space. In general, the closer the two objects came, the more likely a collision, and the higher the severity rating. However, the resultant closest proximity may or may not adequately represent the risk inherent in the incursion, depending on other circumstances. For example, if an extraordinary avoidance maneuver was executed by a pilot (such as a last minute go-around or landing and stopping the aircraft in a fraction of the required landing distance), then such information would increase the event's severity rating because it is more likely that the same set of circumstances would result in a closer proximity than in greater separation (compared to the proximity reported for the incident).

The advantage of the process of assigning a rating by group consensus is that it capitalizes on several critical areas of expertise, namely, aircraft performance, flight deck procedures, and air traffic control (ATC) operations. This collective expertise allows for more precise estimates of the potential for a collision, based on all recorded circumstances of the incursion. Furthermore, the group process allows for debate and discussion of issues that not all members of the group might have considered.

While the group decision process has its advantages, it also has obvious limitations. Several sources of variability in the ratings were identified by observing the process and interviewing the participants. The two most notable were personal criteria for risk acceptance (that is, some individuals were generally more conservative than others), and

shift of the group's criteria over time. In the group process, ratings assigned by individual raters often differed by a category or more (i.e., one person assigned an "A" and another a "B"). Individuals also differed on the relative importance (weighting) of individual factors in the weighting. Several of the raters perceived a shift in the group's criterion (to lower ratings) over time. That is, an event rated as a "B" today could have been rated as an "A" two years ago; one rated as a "B" two years ago, might now be rated as a "C," etc.

In order to gain insight into the decision processes that go into judging severity, an exercise was conducted by a group who had been assigning ratings to runway incursions since the inception of the ABCD classification. This exercise was conducted in two parts. First, the group was asked to assign a rating to the incidents as described, using the normal rating process. All but one of the incidents were presented as hypothetical, but were actually based on previous runway incursions. The descriptions of runway incursions (i.e., narratives plus information regarding day/night and visibility) were extracted from the runway safety database. Specific locations were excluded, but the key physical characteristics of the airport (e.g., distance from an intersection to the end of the runway) were preserved. In one case, a detail was changed to be less emotionally charged; the description of a pedestrian involved in a violation was changed to "a pedestrian" from "a six-year old child." Included in the discussion was that any pedestrian on the runway must be assumed to be unpredictable.

Of the 10 incidents, only one of them was expected to generate a higher rating than it had originally received because the original rating seemed unreasonably low. An incursion in which a Cessna pulled out in front of a landing Cessna and resulted in a vertical separation of 35 feet had been rated as a "B." As expected, the same event was rated as an "A" in this exercise. Of the remaining nine cases, three of them maintained the original rating. The other six reports (including the one in which the term "six-year old child" was replaced with "pedestrian") were downgraded in severity. The cases in which the ratings remained the same were all "Bs." In the six events in which the rating changed to a lower one, two went from "As" to "Bs," two went from "Bs" to "Cs." The latter included one incursion that was presented as—and remembered as—a complex incursion at Los Angeles airport (LAX). One incursion's rating went from a "C" to a "D," and one went from an "A" to a "C." The

description of the incursion for which the rating went from an "A" to a "C" was subsequently examined in more detail. While the description of the event as presented to the group was no different from the description that was originally used to assign the "A," one of the group members recalled having subsequent information regarding the pilot braking action that was not included in the report. Such additional information, which is considered in the rating, but not in the original report, was not routinely documented at the time (and was not documented in this case).

In the second half of the exercise, the raters were asked to record (on paper with no discussion) whether a specific change in one of the factors (e.g., if it was night/IMC instead of day/VMC, or if the closest proximity was 100 feet instead of 500 feet) would have changed the rating (and if so, how). For this portion of the exercise, raters were not restricted to the ABCD classification, but were allowed to assign intermittent values (such as A- and B+). This was done to examine whether different raters would assess the effect of a specific factor in the same way. The results showed that changes in any single factor did not consistently affect the ratings. Some changes affected some participant's ratings, but not others'. Participants also weighted variables differently. When there was a change in some of the participant's ratings, the direction of the changes (i.e., up or down) were more consistent than the magnitude of the change assigned.

It is important to note that this exercise was never intended to be a study of inter-rater reliability. Rather, it was intended to provide insight into the factors used by the participants to assign a severity rating and how these factors interact. A proper assessment of the inter-rater reliability would have included a large number of randomly selected events (and a significant investment of the group's time). For this exercise, a small set of events was included for extensive discussion (in a two-hour period). Furthermore, most of the events were specifically chosen as ones in which the ratings originally assigned by the group were significantly different from ratings of similar incidents. Therefore, the ratings to be assigned in this exercise were expected to be different from the ones originally assigned to the same incidents. The FAA had long recognized that a standard method of identifying, weighting, and documenting the factors that contribute to the severity ratings of runway incursions was needed. Flaws inherent in the consensus procedure used to assign severity ratings to runway incursions made the ratings difficult to defend and impossible to replicate.

Since only the rating was recorded (and not the logic that led to the rating), it is impossible to trace an individual rating to the rationale for the rating.

Inconsistent and incomplete reporting of critical information also hinders replication of past ratings. For example, one report in the database may indicate that closest horizontal proximity was 100 feet; another may indicate that closest horizontal proximity was 100-499 feet. To help ensure that all reports contain information necessary to assess the severity and help determine causal factors of incursions, efforts are underway to standardize the information recorded in the reports.

Model for Rating the Severity of Runway Incursions

Ratings of the severity of events must be based on observable and recorded events, be reliable, have internal consistency, and external validity. The goal of the automated system for rating the severity of runway incursions was to model the expertise of the group (in terms of the knowledge base and decision processes), in a consistent (and thus reliable) fashion.

The definition of “severity of a runway incursion” used here refers to the outcome of the incursion in terms of the closest proximity (horizontal or vertical) that an aircraft came, or might easily have come, to collision with another aircraft, vehicle, or object on the runway. Currently, the severity of a runway incursion is defined independently of the number of people involved in any actual or potential collision, and independently of any event that occurs after the time of closest proximity (such as availability of rescue equipment and personnel).

The foundation for the rating of the severity of the outcome of the incursion is the closest proximity, that is, how close the two aircraft or aircraft and vehicle came in vertical and horizontal space. The role of the model is to determine whether the resultant closest proximity adequately represents the risk inherent in the incursion. Factors that influence the probability of a collision include: aircraft dimensions and performance characteristics, visibility, the geometry of the conflict, and operator (controller, pilot, or vehicle driver) responses. The role of the factors is to increase the severity rating beyond that which is suggested solely by closest proximity in situations in which closest proximity alone is insufficient to describe the risk. That is, an examination of the critical factors determines whether the same outcome could reasonably be expected to occur again, given the same situation.

The intent of the rating is to represent the risk incurred; factors such as visibility, available response time, avoidance maneuvers executed and the conditions under they were executed allows a characterization of that risk. For example, suppose two aircraft had landed on intersecting runways and stopped 500 feet from each other. In perfect visibility and without severe braking executed by either pilot, the outcome that the aircraft would come no closer than 500 feet has a higher chance of reoccurring than in poor visibility (where there is degraded information for all parties) or with extreme avoidance maneuvers having been executed. Similarly, if available response time for one of the pilots was extremely short (e.g., less than 5 seconds), then more variability would be expected to be seen in the outcome of the pilot’s responses (and hence, the severity of the outcome) than if the available response time was long. Therefore, each factor that adds to the variability of the outcome of the incursion is considered in the rating and then more conservative rating is applied. This means that each relevant factor has the potential to make the rating of severity higher than it would have been if it were defined solely by the closest proximity. It should be noted that this is not the same as basing the rating on the worst possible, or worst credible, outcome of the scenario. The model does not rate the severity of the incursion based on everything that could have gone wrong, rather, it looks at the critical sources of variability within the scenario, assigns a weight to each factor (and to each element within the factor) that contributes to the variability, and generates a rating based on the assigned weights of the factors and the elements within each factor. While it may be helpful to think of the weights as scaling the “severity” level of the factor (for example, a pilot’s acceptance of clearance intended for another aircraft is more serious than a partially-blocked transmission) they actually represent the level of variability that the factor introduces into the severity of the outcome.

The model starts with a set of situations or “scenarios” that broadly subsume all types of runway incursions (with the exception of those involving helicopters or pedestrians). These scenarios define the parties involved (e.g., two aircraft or an aircraft and a vehicle), the action of the parties at the point of the incursion (landing, taking off, crossed the hold short line, etc.). The model starts with closest proximity (horizontal or vertical) and then identifies a set of weighted factors for each scenario. Each scenario has a specific set of factors associated with it.

Relevant factors can include:

- a. Visibility
- b. Type of aircraft (weight and/or performance characteristics)
- c. Characteristics of avoidance maneuver executed (including time available for pilot response)
- d. Runway characteristics and conditions (width, braking action reported)
- e. Degree to which the situation was controlled or uncontrolled (e.g., type of pilot/controller errors involved, whether all parties were on frequency, whether the controller was aware of all of the parties involved).

Subsumed within each factor are elements. Elements within the factor of visibility are levels of RVR (runway visual range), reported ceiling height and visibility, and day/night. The factor of runway characteristics include the width the runway in situations in which an aircraft on the runway conflicts with an aircraft or vehicle approaching it from the side. This factor also includes the runway conditions (dry, wet, braking action reported as poor or fair) in scenarios that involve avoidance maneuvers in which braking action is a relevant factor (e.g., hard braking action, aborted takeoff). There are several elements within the factor "controlled/uncontrolled." One element concerns communication issues such as aircraft not on the correct frequency, partially- or totally-blocked transmission, pilot accepting another aircraft's clearance, readback/hearback error, etc. The other elements map to a lack of awareness on the part of the controller (e.g., the controller forgot about an aircraft) or pilot (e.g., pilot landed on the wrong runway).

Within the model, each scenario has a rating table associated with it. These tables specify, for various values of horizontal or vertical proximity: a severity rating for overall best case and worst case, and ratings for each factor at worst case when all other factors are best case. Each individual factor has associated with it a scale from zero to ten. A value of zero means there is no influence of that factor to make the severity of the given incursion greater than what is evident from the closest proximity alone. A value of ten means there is maximum influence of that factor to make the severity of the given incursion greater than what is evident from the closest proximity alone with other conditions normal. When all factors are ideal, i.e.,

good visibility, aircraft are small (and hence, relatively slow, lightweight and highly maneuverable), no pilot-controller communication anomalies, and no avoidance maneuvers, then all factor values are zero. When this is the case, the severity of the runway incursion is adequately represented by the given closest horizontal or vertical proximity. If, on the other hand, all factor values are tens, then the situation is such that the resulting proximity of aircraft (or aircraft and other object) could easily have been much worse and is represented by "worst case" severity rating for that scenario at the resulting proximity. The greater each factor rating, the greater the expected variability of closest proximity for recurring runway incursions under the same conditions. A detailed discussion of the mathematics behind the model is available in Sheridan, 2004 [2].

Model Validation

The model was initially validated by comparing the results of the ratings produced by the model to the ratings produced by the group for 307 of the (Fiscal Year) 2003 runway incursions involving conflicts or potential conflicts between aircraft and between aircraft and vehicles. Of these 307 incidents, the model's ratings matched the group's category letter in 67% of the cases. An example of such a match are incidents in which the group ratings were "Cs" and the model rated the same events as either "C+," "C," or "C-." (Recall that the group's ratings are confined to categories: A, B, C, and D, whereas the model assigns ratings of: D+, D, C-, C, C+, B-, B, B+, A-, and A.)

The largest categorical difference between the group's and model's ratings were between "Cs" and "Ds." In general, the model classified most of these incidents as "Ds," while the group categorized most of them as "Cs." Interviews with the group revealed two relevant issues. First, the group rarely assigned a "D" to any event that involved two aircraft on the same runway at the same time, no matter how far apart the aircraft were. In one such incident, (rated "C" by the group and "D" by the model), the closest proximity was 7500 feet. Also revealing was the fact that the group said that they spent most of their time deciding whether an event was a "C" or a "D." In general, it was easier to come to consensus on the more serious events.

As previously mentioned, the categories of "C" and "D" are planned to be merged into one category to harmonize with ICAO's three levels of severity for events with a probability of collision. Therefore, the

differences in ratings between “Cs” and “Ds” are not a concern. When the categories of C and D are combined, only 15 (5%) of the 307 instances involved discrepancies of one category or more. For example, one incursion received a rating of “D+” from the model and a “B” from the group. Without telling the group of the model’s rating (or reminding them of the rating that they had assigned nine months previously), the group was asked to re-rate the incident. When given the same details of the incursion as originally presented, half of the group said, “C” and half said “D.” Therefore, the model’s rating of “D+” was validated.

Most of the other cases in which the ratings were categorically different involved unusual incidents in which pilots intentionally taxied toward the traffic on the same runway. Such actions were not envisioned when the model was developed. Since the ratings produced by the model are based on closest proximity and do not discriminate between intentional and unintentional actions, the model assigned a higher severity rating than the group. For example, in one such incident, two small aircraft landed on the same runway, opposite direction. While approximately 3000 feet apart, the two aircraft slowed to taxi speed and intentionally veered to the right to pass each other. At the moment they passed, they came within 50 feet. The model’s rating of “A” was based on the proximity of 50 feet, which was the only recorded closest proximity value contained in the report. The group’s assessment of that incident was a “C.”

Therefore, for the model to be used in such instances, the input must include the closest proximity achieved *unintentionally*. Any reduction in proximity that was realized after both vehicles were under control as a result of intentional actions is irrelevant to the severity of the outcome (and, hence the risk of the situation that created the incursion).

There is one area in which the model’s ratings present as philosophically different from the group’s severity categorization—landovers. A “landover” or “flyover” involves an aircraft or vehicle holding on the runway. An aircraft attempts to land on the same runway and either lands over the traffic or aborts the landing and flies over the traffic. In the recent past, the group has consistently rated such incidents in which the aircraft cleared the traffic by 300 feet vertical as “Bs” (significant potential for collision). The model assigns a rating of “C” (ample time or distance to avoid a collision). Whether such incidents merit a severity classification of “B” or “C” will need to be determined by the Office of Safety

and Operational Services. If it is determined that such events should be classified as “Bs,” the criteria in the model used to assign the ratings in this situation can easily be changed. To date, this is the only situation that has been identified that may warrant a change in the model.

With the remaining discrepancies, we found the model’s rating to be more defensible than those assigned by the group. The most dramatic of these events, involved an aircraft cleared to takeoff on a runway that was closed due to men and equipment on the runway. Upon rotation, the aircraft collided with the plastic cones that had been placed 3,000 feet from the men and equipment. (Note: There is no requirement to place cones or other physical indications of men and equipment on the runway.) The model rated the severity of this incident a “D+” meaning “little risk of collision,” based on a closest proximity (between the aircraft and the men and equipment) of 3,000 feet. The group, however, rated it an “A” based on the collision with the cones.

All incidents in which there was a discrepancy of one letter grade or more (e.g., if the model’s rating was a “B” and the group’s rating was a “C”) will be reviewed with the group. In cases in which the group does not agree with the model’s assessment (such as those involving landovers), senior FAA staff within the Office of Runway Safety (who are not involved in the rating process) will decide whether they concur with the ratings produced by the model or with those produced by the group. This information will be used to determine what refinements to the model are needed.

The validation process continues with the following efforts. Another year’s worth of runway incursion data is expected to be run through the model and compared to the group’s assessment by May 2005. As of October 1, 2004, validation of the model has included incursions being rated in real time by a third party using the model and then compared to the group’s ratings. Finally, Air Services Australia and Eurocontrol also have copies of the program and have been asked to provide validation feedback. The automated rating method will be refined as needed and as improvements in the data recorded in runway incursion reports are realized. No rating system for the severity of the outcome of runway incursions can be completely objective; however, by establishing consensual a priori criteria and rules for translating factual data and quantitative estimates into ratings, and implementing the translation by computer, the method can be more objective and internally

consistent. Global use of such a system could help improve risk management worldwide and encourage global solutions to a global problem.

Other Applications

Currently, the FAA categorizes a “severity index” to categorize the severity of errors of air traffic controllers (but not of pilots) that result in a loss of standard separation (except those that result in runway incursions). This index is defined as a “method to determine the gravity, or degree that the separation standard was violated, for operational errors that occur in-flight” [3] and categorizes controller operational errors into three categories of severity: low, moderate, and high.

The index is based on a formula that considers the vertical and horizontal separation of the aircraft as a function of the required separation (50%) the flight paths of the aircraft, i.e., whether the aircraft were approaching head-on, at an angle or in a tail-chase/over-take scenario (20%), closure rate (10%) and whether or not the event was controlled by air traffic control (20%). Thus, 80% of the rating is situation and outcome dependent. Only 20% is assigned to the actions taken by ATC to resolve the conflict. This factor is referred to as “controlled/uncontrolled.” A controlled event is defined as “an operational error where the employee was aware of the impending conflict and takes corrective action to increase the separation” (ibid). An uncontrolled event is defined as “an operational error where the employee was unaware of the conflict takes no corrective action and/or became aware of the conflict but did not have enough time to effectively mitigate the loss of separation” (ibid). An uncontrolled event rates the maximum penalty (20 out of 20).

Therefore, the present severity index used to assess the severity of controller errors that result in loss of standard separation combines the severity of the outcome with the quality of air traffic services provided. The concept of rating the severity of the outcome of an event independently of the degree of fault attributable to any and all parties could also be applied to losses of standard separation in the air. Under such a scheme, the severity of the outcome, i.e., the probability of a collision, would be assessed independently of the severity of the human error. This would allow, for example, an assessment of the quality of air traffic service provided in an incident that is independent of the outcome of the event. For example, there are egregious controller errors that result in little loss of separation, due to pilot action or

chance. There are also common and inevitable human errors (such as failing to detect a readback error when the readback is only slightly different from the clearance issued) that may result in a near collision due to factors beyond the control of air traffic. Such a scheme would differentiate between these extreme type of events and gradations of outcome severity and quality of air traffic service provided.

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References

1. Federal Aviation Administration, *Runway Safety Report*, Washington, DC, August 2004.
2. Sheridan, T., “An Interpolation Method for Rating the Severity of Runway Incursions,” presented at the Symposium on Human Performance, Situation Awareness, and Automation, Daytona Beach, 23-25 March 2004.
3. Federal Aviation Administration, 7210.65C Par 6-1-1, Washington, DC.

Disclaimer

The views presented in this paper are solely those of the authors’ and do not represent the official views of the Federal Aviation Administration, or the Department of Transportation.

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Runway incursions, modeling expert judgment, outcome severity, risk, runway safety, performance metrics

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Daniel J. Hannon received a Ph. D. in experimental psychology from Brown University in 1991 and completed a post-doctoral fellowship in cognitive neuroscience at Syracuse University in 1992. He has worked as an engineering psychologist for U.S. Department of Transportation Volpe Center since 1993, working primarily in the areas of flight deck and ATC human factors. He is currently the manager of the Runway Safety Human Factors program.

Thomas Sheridan is a senior transportation fellow at the Department of Transportation's Volpe Center and Ford Professor of Engineering and

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