



Runway incursion prevention systems: A review of runway incursion avoidance and alerting system approaches

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ABSTRACT

Runway incursions are events where two or more vehicles use the same runway, resulting in a conflicting situation. Avoiding runway incursions has been a top ten priority for the National Transportation Safety Board (NTSB) for over a decade. Therefore, this article provides a review of currently deployed technological responses and those currently under development. The outline is as follows: In Section 1, an introduction to runway incursions and the increasing significance of the threat is given, followed by a brief description of possible technological solutions in Section 2. Section 3 introduces the results of currently developed runway incursion prevention systems, while Section 4 is a description of the performance of the systems. The review concludes with a brief discussion and an outlook on essential future work.

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1. Introduction

Runway incursions are occurrences at an aerodrome that involve the incorrect presence of an aircraft, a ground vehicle, or a person on the protected area designated for the landing and take-off of aircraft. The growing traffic volume has kept avoiding runway incursions on the National Transportation Safety Board (NTSB) “Most Wanted” list for safety improvements for over a decade [1]. In the past, runway incursions have led to accidents with significant loss of life. The worst runway incursion accident was at Tenerife, Canary Islands, Spain, in 1997, where two Boeings 747 collided. Recent incidents [2,3] show that runway incursions are still a problem. Although the number of runway incursions that result in an accident is small, the number of runway incursions has not significantly declined over the last decade. Statistics and results from simulation studies strongly indicate that the number of runway incursions increases much more rapidly than the traffic volume. Depending on the airport topography, an increase of 20% traffic volume may result in a 140% increase of runway incursion potential for a single runway [4]. This section introduces a definition of runway incursions and some statistics.

1.1. Definition of runway incursions

The International Civil Aviation Organization (ICAO) definition that has been adopted by the Federal Aviation Administration (FAA) in 2007 [5] of a runway incursion is the following [6]:

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 take-off of aircraft.

Runway incursions are classified in relation to the severity of the incident, with classifications A–E, as shown in Table 1. The most relevant classifications for Runway Incursion Prevention and Alerting Systems (RIPAS) are A and B, where time is critical. Classifications C and D should also be detected by RIPAS but do not require immediate action.

1.2. Causes for runway incursions

The FAA and ICAO both classify runway incursions according to the following types of causes that lead to the incursion: “Pilot Deviations” (PD), “Operational Errors/Deviations” (OE), and “Vehicle/Pedestrian Deviation” (VPD).

1.2.1. Pilot deviations

Pilot deviations are actions of a pilot that violate any Federal Aviation Regulation. For example, a pilot deviation occurs when a pilot crosses a taxiway hold line, entering a runway for which the aircraft has not been authorized by an air traffic controller (ATCO) to enter. For a detailed description of such a case, see the reports [2,3] of the NTSB and the German Federal Bureau of Aircraft Accidents Investigation (BFU).

1.2.2. Operational errors/deviations

Operational errors/deviations are actions of ATCOs that result in either less than the minimum separation between two or more aircraft and vehicles or an aircraft landing or departing on a runway that is closed to the aircraft. For example, an ATCO could commission an aircraft to land on a runway that is already in use. The report in [7] provides good insight into such a situation.

1.2.3. Vehicle/pedestrian deviations

Vehicle/pedestrian deviations include pedestrians, vehicles, or other objects that interfere with aircraft operations by movements that have not been authorized by air traffic control (ATC) and or APRON controllers. A serious runway incursion occurs when, for example, service technicians enter a runway unauthorized, a taxiing Boeing 747 nearly causes a collision, or when a service car left on the runway collides with a landing aircraft.

1.3. The role of general aviation

General aviation (GA) accounts for the majority of runway incursion incidents, including those that involve air carrier

Table 1
ICAO severity classification scheme [6].

Severity classification	Description
A	A serious incident in which a collision is narrowly avoided.
B	An incident in which separation decreases and there is significant potential for collision which may result in a time-critical corrective/evasive response.
C	An incident characterized by ample time and/or distance to avoid a collision.
D	An incident that meets the definition of runway incursion, such as the incorrect presence of a single vehicle, person or aircraft on the protected area on a surface designated for the landing and take-off of aircraft but with no immediate safety consequences.
E	Insufficient information or inconclusive or conflicting evidence precludes a severity assessment.

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