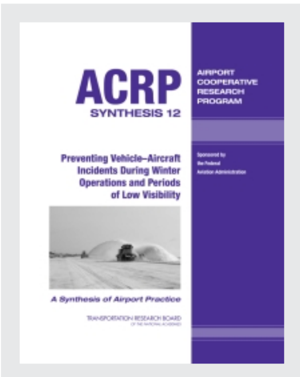

Preventing Vehicle-Aircraft Incidents During Winter Operations and Periods of Low Visibility

DETAILS

70 pages | | PAPERBACK
ISBN 978-0-309-09818-2 | DOI 10.17226/14199

AUTHORS

Stephen M Quilty; Transportation Research Board

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP SYNTHESIS 12

Preventing Vehicle–Aircraft Incidents During Winter Operations and Periods of Low Visibility

A Synthesis of Airport Practice

CONSULTANT
STEPHEN M. QUILTY
SMQ Airport Services
Lutz, Florida

SUBJECT AREA
Aviation

Research Sponsored by the Federal Aviation Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2008
www.TRB.org

AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

ACRP SYNTHESIS 12

Project 11-03, Topic S04-02
ISSN 1935-9187
ISBN 978-0-309-09818-2
Library of Congress Control Number 2008907271

NOTICE

The project that is the subject of this report was a part of the Airport Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, or the Federal Aviation Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The Transportation Research Board of the National Academies, the National Research Council, and the Federal Aviation Administration (sponsor of the Airport Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

Published reports of the

AIRPORT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academys p urposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

FOREWORD

Airport administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the airport industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire airport community, the Airport Cooperative Research Program authorized the Transportation Research Board to undertake a continuing project. This project, ACRP Project 11-03, "Synthesis of Information Related to Airport Practices," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an ACRP report series, *Synthesis of Airport Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Gail Staba
Senior Program Officer
Transportation
Research Board

This synthesis study is intended to inform airport operators about factors affecting safe winter operations and the prevention of runway incursions by airport snow removal equipment operators. The information contained in this report can be of value to airport operators in their efforts to provide a safer operating environment when engaged in snow and ice removal operations during normal and low visibility conditions.

Information used in this study was acquired through a review of the literature and interviews with airport operators and industry experts.

Stephen M. Quilty, SMQ Airport Services, Lutz, Florida, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

PREVENTING VEHICLE–AIRCRAFT INCIDENTS DURING WINTER OPERATIONS AND PERIODS OF LOW VISIBILITY

SUMMARY

This study sought qualitative information on factors affecting safe winter operations and the prevention of runway incursions by airport snow removal equipment operators. The information contained in this report can be of value to airport operators in their efforts to provide a safer operating environment when engaged in snow and ice removal operations during normal and low visibility conditions.

The objective of the report is to provide a compendium of existing practices, procedures, training, and systems that airport operators use to reduce the risk of vehicle–aircraft incidents and incursions during winter operations and periods of low visibility. The synthesis considered commercial service and general aviation airports that have either a full-time, part-time, or no operating air traffic control tower (ATCT). Thirty-six airports participated in the study and represent a balanced mix of large-hub, medium-hub, small-hub, non-hub, and general aviation airports across the nation.

Specific areas researched or reviewed for the report were as follows:

- Communication protocols and systems currently in use between winter operation vehicles, air traffic control facilities (both the ATCT and approach control), and between winter operation vehicles and aircraft at airports without an operating ATCT;
- Winter operational protocols at airports such as closing of runways, avoiding encroachment of auxiliary runways or taxiways, conducting winter operations between aircraft operations, and ensuring all winter operation vehicles are clear of a runway or a particular area;
- Human performance factors that affect the situational awareness of personnel while conducting winter operations, such as fatigue, sense of urgency in operations, distractions in the cabin area, and vehicle design features;
- Equipment and vehicle design factors that affect the situational awareness of employees during winter operations and low visibility conditions;
- Training or training systems provided to airfield vehicle operators for winter and low visibility operations; and
- Availability of technology and commercial displays or warning systems that are, or can be, used to prevent vehicle–aircraft incidents.

Runway incursions are a major area of concern to the FAA, airports, aircraft operators, and the general public. There is an increased risk and opportunity for an incident or accident to occur between snow removal vehicles and aircraft during winter operations because there is an increase in the number of vehicles being exposed to aircraft. This increased risk and resulting errors are highlighted in the report through examples reported to the FAA and the Aviation Safety Reporting System (ASRS). The examples in this synthesis of practice provide numerous and varied ways in which errors can manifest themselves. Airport operator defenses against errors are also provided, including examples of procedures and methods various airports use to manage snow and ice events and to prevent runway incursions. This synthesis includes a synopsis of past, present, and future technology both in use and being considered for implementation.

Information presented in this report is intended to be the first step in bringing the level of research and study into winter operations to a level commensurate with its importance in airport system safety. It is intended to raise the level of awareness of airport operators, government regulators, industry providers, and others to the need for continued research and investment into this high-risk area. An accident involving snow removal equipment and an aircraft has the potential to result in catastrophic loss of life, injury, equipment damage, and financial and socioeconomic disruption. As an educational tool, this study's intent was to present airport operators with winter operation practices and procedures that may enhance the safety of their own operations.

Issues arising from the study include the need for better research into the impact of operator fatigue during winter operations at airports and how to better manage fatigue; enhanced training and education within airport organizations; better methods for disseminating airport operating conditions and information to pilots; better procedure manuals at all airports for incorporating best practices for winter operations or low visibility operations; increased operator understanding of the nature of errors that occur during winter operations through better reporting of incidents and risks; greater opportunities for airports to acquire vehicles and newer technology; research into specific vehicle and cabin design parameters; and implementation of a safety management system as a means for better evaluating decisions associated with operating procedures, staffing levels, coordination with others, and managing the pressures associated with snow and ice control and low visibility conditions.

CHAPTER ONE

INTRODUCTION

Winter operations pose a unique hazard or risk for airports because snow removal vehicles and equipment are authorized to conduct operations on the movement areas of an airport, including active runways. Often, limited visibility caused by blowing or piled snow hampers the ability of vehicle operators to see and avoid aircraft or other vehicles. Reduced visibility also decreases the advantage of having an air traffic control tower (ATCT), since tower personnel cannot see exactly where vehicles or aircraft are positioned, unless the ATCT has new technology to assist the controller. Otherwise, communication protocols and recognized standard operating procedures (SOPs) must be practiced. In either case, technology and SOPs can be negated if a vehicle operator is fatigued, experiences a loss of situational awareness (SA), or otherwise makes an error in operation.

This study sought qualitative information on factors affecting safe winter operations by airport snow removal and equipment operators. The information contained in this synthesis can be of value to airport operators in their efforts to provide a safer operating environment when engaged in snow and ice removal operations during conditions of normal and low visibility. An emphasis of the study is on preventing or mitigating the factors that lead to runway incursions and aircraft and/or vehicle conflicts on the airport.

OBJECTIVE OF SYNTHESIS

The objective of this synthesis is to provide a compendium of existing practices, procedures, training, and systems that airport operators use to reduce the risk of vehicle–aircraft incidents and incursions during winter operations and periods of low visibility. A low visibility operation is defined in *Advisory Circular 120-57A, Surface Movement Guidance and Control Systems*, as the movement of aircraft or vehicles on the airport's paved surfaces when visibility is reported to be less than 1,200 feet runway visual range (RVR) (*1*). The synthesis considered commercial service and general aviation airports that have either a full-time, part-time, or no operating ATCT.

Specific areas researched or reviewed under the synthesis study were:

- Communication protocols and systems currently in use between winter operation vehicles, aircraft, and air traffic control facilities (both the ATCT and approach control), and between winter operation vehicles and aircraft at airports without an operating ATCT.
- Winter operational protocols at airports, such as closing of runways, avoiding encroachment of auxiliary runways or taxiways, conducting winter operations between aircraft operations, and assuring that all winter operation vehicles are clear of a runway or a particular area.
- Human performance factors that affect the SA of personnel while conducting winter operations, such as fatigue, sense of urgency in operations, distractions in the cabin area, and vehicle design features.
- Equipment and vehicle design factors that affect the SA of employees during winter operations and low visibility conditions.
- The training or training systems provided to airfield vehicle operators for winter and low visibility operations.
- The availability of technology and displays or warning systems that are used, or are being evaluated for use, to prevent vehicle–aircraft incidents.

A concern associated with airport operations that has received increased research and scrutiny over the years has been runway incursions. The FAA has established dedicated programs and organizational offices comprised of teams, committees, and individuals to address the safety issue. Although runway incursion efforts have been focused on preventing vehicles from entering or encroaching on an active runway or operational area, snow removal equipment must operate on those same active areas. The problem then becomes how to ensure that such vehicles are off of the movement or operational area when an aircraft operation is being conducted. Such assurance is especially true when low visibility hampers the ability of air traffic control personnel or vehicle operators from seeing aircraft operating on the pavement surfaces where snow removal operations are in progress.

DEFINITION OF INCURSION

A basic understanding of runway incursions and surface incidents will help to explain why winter operations are a major safety concern of airports.

Runway incursions or surface incidents are a major concern affecting safe operations of the Nation's airports because they present a collision hazard. The NTSB has identified the prevention of runway incursions as one of the "Most Wanted" safety issues to be addressed in aviation (*2*). Both the FAA and the International Civil Aviation Organization (ICAO) have implemented measures to combat and reduce runway incursions and/or surface incidents.

Prior to October 2, 2007, a runway incursion was defined by the FAA as

> Any occurrence at an airport 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 (*3*, p. A-9).

On October 2, 2007, the FAA announced a change to the definition of an incursion (*4*). In standardizing this definition worldwide, the FAA adopted the definition used by the ICAO. Thus, a runway incursion is now defined as

> 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 (*5*, p. L-1).

The adoption of the ICAO definition will require the FAA to reclassify certain events that previously have been defined as a "surface incident." The FAA definition of a surface incident is

> Any event where unauthorized or unapproved movement occurs in the movement area that affects or could affect safety of flight (*3*, p. A-10).

The primary difference between the older FAA definition of runway incursion and the newer ICAO definition is that ICAO defines an incursion to include any unauthorized intrusion onto a runway, regardless of whether a potential conflict with an aircraft exists or not. For the FAA, an incident not involving a potential conflict with an aircraft—such as an unauthorized vehicle crossing a runway while no aircraft are in the vicinity—was previously defined as a "surface incident" and not a runway incursion. A comparison of the two categories is identified in Figure 1.

Class A or B incursions are considered serious enough to have posed a significant risk of collision, while class C or D incursions are classified as not having posed an immediate major threat. Class E is not used in the United States as of yet. For additional assessment purposes, the FAA groups incursion or incidents events into one of three categories: (1) operational

FAA		ICAO	
Class	**Description**	**Class**	**Description**
A	Separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision.	**Accident**	Refer to ICAO Annex 13 definition of an accident.
		A	A serious incident in which a collision was narrowly avoided
B	Separation decreases and there is a significant potential for a collision.	**B**	An incident in which separation decreases and there is a significant potential for collision, which may result in a time critical corrective/evasive response to avoid a collision.
C	Separation decreases, but there is ample time and distance to avoid a potential collision.	**C**	An incident characterized by ample time and/or distance to avoid a collision.
D	Little or no chance of a collision but meets the definition of a runway incursion.		
Other SI	An event during which unauthorized or unapproved movement 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. (This subset includes only non-conflict events)	**D**	Incident that meets the definition of runway incursion such as incorrect presence of a single vehicle/person/aircraft on the protected area of a surface designated for the landing and take-off of aircraft but with no immediate safety consequences.
		Not Defined	(FAA non-conflict SI include more than just ICAO class "D" events.)
ID	Insufficient Data: inconclusive or conflicting evidence precludes severity assessment.	**E**	Insufficient information: inconclusive or conflicting evidence precludes severity assessment.

FIGURE 1 Comparison of the old FAA and the new ICAO incursion classifications. (*Source:* FAA.)

error, (2) pilot deviation (PD), or vehicle/pedestrian deviation (V/PD).

An operational error is a human error involving an ATCT controller, of which there are more than 8,000 in the United States. A PD is a human error involving a licensed pilot, of which there are more than 675,000 in the United States. A V/PD is a human error involving a vehicle operator or pedestrian that results in an entry onto the movement area that has not been authorized by an ATCT controller.

The change in definition will have implications on how vehicle incidents are recorded and on the number of incidents recorded. The number is expected to increase because previously identified surface incidents will now be recorded as incursions. The new method of recording data reflects how any incident is a potential hazard that could manifest itself later as an incursion or an accident if the timing is different.

BACKGROUND ON INCURSIONS

Much emphasis has been placed on runway incursions over the past decade, in part because of the significant possibility for loss of life and property. The most recent U.S. statistics covering the FAA fiscal year ending September 30, 2007, show there were 24 serious runway incursions (using the old FAA definition) (*6*). The incursion data reported by the FAA represent those tracked at airports having staffed ATCT (*7*). The 24 reported incursions occurred in relation to approximately 61 million operations. Even though 24 incursions can be considered a small number, just one incursion can have catastrophic results.

A drawback to identifying the true number of incursions or incidents is that they are normally only recorded at airports that have operating control towers, of which there are 397 overseeing more than 61 million aircraft operations. Not recorded are the number of incursions or incidents that may have occurred at airports without an ATCT operating or during periods the ATCT was closed, of which there are a total of 3,364 public use airports in the National Plan of Integrated Airports System and an additional 1,906 public use airports that are not included in that National Plan (*8*). The reported incursions and incidents may not be a true representation of the severity of the problem.

Information on runway incursions is important from an airport safety management standpoint. Airport operators need to know the potential risks associated with an activity so that they can determine the proper measures to manage the risk. During winter snow removal operations, the risk of incursions can increase significantly. Risk is assessed by identifying: (1) the probability that an event could occur, (2) the severity of its potential outcome, and (3) its exposure level, which is the number of opportunities for the event to occur (*9*).

Risk increases during winter operations because snow removal equipment is authorized to be on the airfield in larger numbers than other equipment during normal operations; more individuals who are not normally accustomed to regularly operating on the airport are at the controls of the equipment; and low visibility or obstructed conditions make it difficult for controllers, pilots, and vehicle operators to see each other.

The FAA has established a voluntary program called the Runway Incursion Information Evaluation Program (RIIEP). The program seeks to gather more in-depth runway safety data on runway surface incidents and runway incursions and seeks to understand the specific pilot or mechanic activities or operating conditions that resulted in them (*10*). The primary means of gathering the data is through in-depth interviews of pilots and maintenance technicians involved in these incidents. Analysis of the data is used to implement risk-reduction programs, produce guidance, and augment technologies. To date, this program has not been extended to incidents other than those involving pilots and mechanics.

The FAA has also established Runway Safety Action Teams as part of a national program, These teams are composed of individuals who have a vested interest in safe operations at a particular airport, such as airport management, air traffic control management, airline management, pilot groups, tenant groups, and others.

REGULATIONS

Under 14 Code of Federal Regulations (CFR) Part 139, airports desiring to be served by air carrier operations must acquire an airport operating certificate from the FAA (*11*). The certificate is issued only after the airport sponsor has developed an airport certification manual (ACM) that describes how the organization will comply with the federal safety regulations.

Four sections of the regulations are pertinent to this synthesis study: (1) Section 139.303 Personnel, (2) Section 139.313 Snow and Ice Control, (3) Section 139.329 Pedestrians and Ground Vehicles, and (4) Section 139.339 Airport Condition Reporting.

Under Section 139.303 Personnel, airport management has the responsibility to provide sufficient and qualified personnel to comply with the requirements of its ACM and Part 139; equip personnel with sufficient resources; and train all personnel who have access to the movement areas and safety areas. In particular, training is to address airport familiarization; procedures for access to, and operation in, movement areas and safety areas; airport radio communications; and other duties required under the ACM.

Section 139.313 Snow and Ice Control requires airport management, located at airports where snow and icing conditions normally occur, to prepare, maintain, and carry out a snow and ice control plan (SICP). The SICP contains instructions and procedures for the prompt removal or control of snow and ice, the positioning of snow off the movement area surfaces, the selection and application of authorized materials for snow and ice control, the timely commencement of snow and ice control operations, and the prompt notification to all air carriers and users of the airport whenever less than satisfactory conditions exist for safe operation by their aircraft.

Section 139.329 Pedestrians and Ground Vehicles requires an airport operator to limit access to movement areas and safety areas to only those pedestrians and ground vehicles necessary for airport operations; establish and implement procedures for the safe and orderly access to, and operation in, movement areas and safety areas by pedestrians and ground vehicles; ensure that those having access are under positive control of ATCT if in operation, or provide adequate procedures to control pedestrians and ground vehicles when ATCT services are not available; and maintain records of personnel training and accidents or incidents at the airport.

Section 139.339 Airport Condition Reporting requires an airport operator to collect and disseminate airport condition information to air carriers using the notice to airmen (NOTAM) system and other systems and procedures, as authorized by the FAA. It further requires the airport operator to prepare and keep a record of the dissemination of each airport condition report to air carrier operators.

In support of an airport operator's obligations to comply with the regulations, guidance material is provided through FAA Advisory Circulars (AC). Advisory circulars contain methods and procedures for compliance that are acceptable to the Administrator of the FAA. Three primary ACs that support the regulations and provide guidance to the airport operator are: (1) *AC 150/5200-30, Airport Winter Safety and Operations* (*12*), (2) *AC 150/5210-20 Ground Vehicle Operations on Airports* (*3*); and (3) *AC 150/5200-28 Notices to Airmen* (*NOTAMs*) *for Airport Operators* (*13*).

Although airports serving scheduled air carrier operations are required to have an SICP as part of their ACM, there are more than 4,500 other commercial service, cargo, or general aviation airports that are not required to have such a plan. The authority of the FAA to regulate airports is predicated on the airport being served by an air carrier operator. The remaining airports fall under the purview of their respective state or local governments, which may or may not require snow plans.

VEHICLE/PEDESTRIAN DEVIATIONS

It is not clear that there is a higher risk of vehicle and/or aircraft incidents at airports without an operating control tower, because no reliable or mandatory reporting and tracking system exists to date. Winter operations at airports present an increased risk and opportunity for an incident or accident to occur for the simple reason that a greater number of vehicles than normal are on the movement areas of the airport. Any time a vehicle operator drives onto an airport movement area, the exposure of that vehicle to potential aircraft is present. A winter season with numerous snow events will increase the number of vehicles being exposed to aircraft, thus the risk of an incident or accident can increase unless additional preventive measures are taken.

For example, for the period of October 2006 to February 2007, the FAA Great Lakes Region recorded 20 vehicle deviations on airports. Nine of the deviations involved snow removal equipment, with six of the nine categorized as runway incursions (*14*). Although any surface incident could result in an accident, runway incursions cause the greatest risk of a collision having a catastrophic outcome.

The increased risk caused by the additional snow removal vehicles and the length of operational exposure time is further compounded by the nature of airport operations and the limitations of humans conducting those operations. Snow removal and low visibility conditions present hazards not normally experienced in daily airport operations. Winter weather conditions create cold, blustery environmental conditions that can be difficult to manage or withstand over long periods. Because snow events can last from one hour to several days, the impact they can have on humans can result in fatigue, vertigo, disorientation, confusion, and other serious ramifications. Low visibility conditions can result from winds, drifting and blowing snow, or from fog. All these conditions can result in operators not being able to determine hold line locations when working on taxiway intersections that lead to the runway, or recognizing their exact location. As a result, snow removal operators may easily cross over a hold short line or not follow air traffic instructions resulting in a runway incursion.

To emphasize the nature of the problem nationally, a list of V/PDs involving snow removal equipment for the period of October 2006 to April 2007 is provided here (B. Castellano, FAA Division of Airport Safety, Washington, D.C., personal communication, Sep. 2007). The summary reports of V/PDs are presented as entered into the FAA database [note: reports listed under Section 2 as surface incidents may well be identified as incursions under the new incursion definition].

Vehicle/Pedestrian Deviations Classified as Runway Incursions

A. 12/6/06 V/PD Non-Hub Airport. Airport vehicle, Truck 39, had previously been authorized to make one turn around on Runway 31 at Taxiway Charlie. Local/Ground Control observed this operation to be complete and Truck 39 was clear of the safety area on Taxiway C. A Cessna C172, cleared to land on Runway 31 was crossing the approach end when Local Control observed Truck 39 crossing Taxiway C hold lines and instructed the vehicle driver to stop. Truck 39 stopped prior to runway edge. The C172 landed and reached taxi speed 800 ft from Taxiway C.

B. 1/13/07 V/PD Medium-Hub Airport. Sander 62 was instructed and read back instructions to hold short of Runway 5 at Taxiway D. Subsequently, Sander 62 crossed Runway 5 at D as a Continental Express EMBRAER E145 was on landing roll Runway 5. The E145 was abeam Taxiway M as the vehicle cleared the runway. Closest proximity reported was 2,000 ft horizontal.

C. 1/18/07 V/PD Small-Hub Airport. Maintenance M17, an airport snow plow, was instructed by Ground Control to hold short of Runway 18 on Runway 9. Driver of M17 read back "hold short Runway 18 on Runway 27." An Atlantic Southeast CRJ2 was cleared for takeoff on Runway 18 and was turning the corner at approach end when Maintenance M17 crossed Runway 18 at Charlie eastbound. Local Control immediately canceled the CFJ2's takeoff clearance. The pilot of ASA had observed the vehicle and did not roll. Closest proximity reported was 600 ft horizontal.

D. 2/1/07 V/PD General Aviation Airport. Plow 4, a snow removal vehicle, entered the departure end of Runway 6 as a Piper PA31 was on departure roll Runway 6. Due to the Piper's takeoff speed, pilot was advised of the vehicle. Ground Control instructed Plow 4 to immediately clear the runway. Plow 4 cleared the runway into the grass area at departure end as the PA31 lifted off approximately 1,500 ft away.

E. 2/2/07 V/PD Large-Hub Airport. A snow plow entered Runway 26 between Taxiway R4 and R6 on the Aircraft Rescue and Fire Fighting (ARFF) access road. It proceeded northbound and conflicted with a United B733 which was landing. The B733 was approximately 1,283 ft from the snowplow at the time and at an estimated speed of 94 knots. The snowplow exited on the north side of the runway with the B733 approximately 700 ft away at an estimated 56 knots.

F. 2/6/07 V/PD Small-Hub Airport. PLOW 36 and 3 brooms, conducting snow removal on Runway 9R/27L, had exited the runway and were told to hold short of Runway 27L. PLOW 36 operator read back the hold short instruction. Local Control (LC) then issued takeoff clearance on Runway 9R to a Learjet LR35. PLOW 36 reentered Runway 9R at Taxiway B-4 (midfield) heading northbound then made a 180 and exited the runway. The brooms remained holding short. The Lear overflew PLOW 36 by 50 ft.

G. 2/13/07 V/PD Medium-Hub Airport. CITY 81 and company, plowing on Runway 19R, were instructed to hold short of Runway 7R. CITY 81 read back hold short instructions. A snowplow then crossed Runway 7R and was in the intersection of 7R/19R when a Continental Express EMBRAER E145, was rolling out on Runway 7R. The E145 exited at Taxiway R, a normal exit point, as the snowplow cleared 7R/19R intersection. Closest proximity reported was 2,000 ft horizontal, the distance from taxiway R to the 7R/19R intersection.

H. 2/14/07 V/PD General Aviation Airport. SNOW 6, an airport snowplow, was working on the edges of Runway 5 and then exited the runway at the departure end onto Taxiway Alpha. SNOW 6 proceeded to remove snow on the taxiway then reentered Runway 5 without authorization. A Gulfstream GLF4 performing a Runway 5 full-length departure was just rotating near midfield when SNOW 6 entered the departure end of the runway. Closest horizontal distance at that point was 3,000 ft and the GLF4 passed overhead of the departure end above 300 ft vertical in a climb.

I. 3/17/07 V/PD Small-Hub Airport. Plow 74, an airport vehicle, crossed Runway 29 hold short line at taxiway C without authorization and conflicted with a Jet Blue EMBRAER E190 that was cleared for takeoff on Runway 29 full length. Plow 74 stopped prior to the edge of the runway and did not enter. The E190 had not yet rolled when takeoff clearance was immediately canceled. Closest proximity reported was 2,000 ft horizontal.

Vehicle/Pedestrian Deviations Classified as Surface Incidents

A. 12/3/06 V/PD Small-Hub Airport. Snow removal was in progress with two airport units authorized on the runway. A third unit, Unit 24 snow broom, entered the approach end of Runway 8 without clearance. No conflicts reported. Unit 24 then called ATCT for approval and was instructed to continue clearing the runway.

B. 1/18/07 V/PD General Aviation Airport. Airport 10, a snow removal vehicle, entered Runways 3 and 1 without authorization. No conflicts reported.

C. 1/24/07 V/PD Non-Hub Airport. Broom 1, an airport utility vehicle, was instructed to exit Runway 35 and remain clear. Broom 1 acknowledges then reports clear and holding short of Runway 35. Local Control clears an AMR American Eagle EMBRAER E145, on a visual approach, to land on Runway 35. Local Control then observes Broom 1 on Runway 35 near the intersection of Runway 35 and Taxiway C. Local Control instructs Broom 1 to exit the runway. Broom 1 complies and exits 35 at the Runway 23 intersection. The E145 is approximately 4 to 5 mi final when vehicle clears and the E145 is continued inbound for landing.

D. 1/26/07 V/PD Medium-Hub Airport. Local Control cleared Sand 2 (airport vehicle) to cross Runway 7R and to hold short of 7L. Sand 2 acknowledged and Local Control requested driver to read back hold short instructions. Sand 2 read back hold short instructions then continued across Runway 7L at Taxiway G. No conflicts reported.

E. 1/31/07 V/PD Medium-Hub Airport. Loader 77, an airport vehicle, called Ground Control from the east side requesting to clear snow on the access road up to Runway 31. Due to this access road intersecting Runway 31 inside the runway safety area (RSA) for

Runway 25L, Ground Control instructed Loader 77 to hold short of Runway 25L at all times and to advise if they needed to get into the clear zone for 25L. Loader 77 acknowledged this and read back the hold short instructions for 25L. Subsequently, Ground Control observed Loader 77 turning around on the very end of Runway 31, which is inside the RSA. Ground Control instructed Loader 77 to exit the RSA due to traffic on final for 25L. Loader 77 exited the RSA when arrival reached 2 mile final. No loss of separation reported.

F. 2/12/07 V/PD Large-Hub Airport. A snow plow vehicle was sanding a perimeter road west of Runway 22L. When making a 180-degree turnaround, the vehicle proceeded to cross the hold short line for Runway 22L. Local Control observed the snow plow and issued a go around to a Northwest Airlink CRJ2 that was on 1-mi final for Runway 22L. No loss of separation reported.

G. 2/17/07 V/PD Small-Hub Airport. Snow removal in progress for Runway 8 with 3 vehicles authorized to operate on the runway. Local Control then observed a fourth vehicle, Unit 26, on the runway at the west end without clearance.

H. 2/17/07 V/PD Non-Hub Airport. Snow removal was in progress for Runway 10. Airport 12 was instructed to exit Runway 10 and report off. Approximately 2 min later Airport 12 reported all vehicles clear of Runway 10. One vehicle at C2 intersection for Runway 10 moved onto the runway without authorization. A Continental Express E145 at outer marker and beyond 1 mi for Runway 10 was issued missed approach instructions to avoid loss of separation. Airport 12 was notified and had the vehicle clear the runway.

I. 4/5/07 V/PD Small-Hub Airport. Sweeper 11, an airport vehicle, requested to proceed onto Taxiway A between the hold line for Runway 03 and the runway. Ground Control instructed Sweeper 11 to cross hold line for Runway 03 but hold short of the runway. Sweeper 11 read back the instructions then proceeded to cross Runway 03. No conflicts reported.

J. 4/17/07 V/PD Small-Hub Airport. A vehicle (basket lift) entered Runway 36R at Taxiway E2 without authorization. No conflicts reported. The driver stated he was taking a shortcut and did not see the runway signs.

Attempting to quantify the root causes of the above incidents is difficult. The descriptions do not provide the level of detail that allow for in-depth analysis. There are multiple factors involved and they occur at different categories of airports and by different vehicles. This report seeks to better identify some of the factors involved.

RESEARCH METHODOLOGY

A qualitative approach was used in the accumulation of information for this report. The data were gathered by means of a questionnaire, telephone interviews (where necessary), e-mail correspondence, and a review of published studies and general literature.

The first step in the development of this report was to conduct a literature review. The following sources of information were investigated:

- Transportation Research Information Services (TRIS) database,
- AAAE and affiliated chapters,
- FAA national and regional offices,
- Personnel from several airports in the United States,
- Internet searches using various search engines, and
- Snow equipment organizations.

Additional material suggested by TRB project committee also was reviewed. The bibliographies from the researched literature were reviewed for any further sources that could be included in the analysis. Also considered during the review were more than 50 snow removal plans submitted to the FAA by various airports.

The second step in the development of this synthesis study was to conduct a survey of airports to seek qualitative information about their operations and experiences. The nature of the investigation into practices and procedures precluded the use of a closed-end questionnaire. The information being sought required a description of the activities being conducted at an airport. For this reason, an open-ended questionnaire was deemed more appropriate for collecting data on how the airports conduct their snow removal operations.

The questionnaire used for the survey (Appendix A) was pre-tested at a training workshop at the 41st International Aviation Snow Symposium, held annually by the Northeast Chapter of the AAAE (NEC/AAAE). Attendees of the workshop were primarily individuals involved in snow removal operations from across the country.

As a result of the pre-test and suggestions from panel committee members, the questionnaire was refined and disseminated to airports both electronically and by mail. Targeted specifically was a cross section of airports that fell into the following categories: large-hub, medium-hub, small-hub, non-hub, and general aviation. Thirty-six responses to the questionnaire were received. The categories into which the airports fell were: large-hub (6), medium-hub (4), small-hub (8), non-hub and commercial service (10), and general aviation (8). Several of the airports had cargo and/or military operations conducted on their airport. Further categorizing the responses, 20 were from airports with full-time ATCTs, 12 from part-time ATCTs, and 4 from airports without ATCTs. A list of airports from which responses were collected is provided in Appendix B.

Further targeted for the survey were airports that had received the Balchen/Post award from previous NEC/AAAE

Snow Symposium meetings. The Balchen/Post award is determined by a committee made up of industrywide aviation professionals who seek to acknowledge those airports that demonstrate responsive winter operations. Additional questionnaires were sent out electronically to representatives of the following AAAE committees: Small Commercial Service Airports; General Aviation; Operations, Safety, and Planning; and the Technical Services. Data were collected and synthesized over the period from April to October 2007.

Upon receipt of the completed questionnaires, the data were grouped by questions and topic area. Clarification of responses was sought as needed through direct communication with the responder. As part of the questionnaire, airports were asked to submit examples of their snow removal plans, separate winter operations procedure or policy manuals, and letters of agreement (LOAs) that existed with air traffic control towers. These documents were reviewed for information related to the synthesis study.

The third step in the development of this report was to research the technology associated with winter operations, runway incursions, snow equipment, and driver training. This entailed contacting companies engaged in runway incursion prevention, snow equipment manufacturing, and driver training simulators.

CONCLUSIONS FROM LITERATURE REVIEW

The literature on runway incursions is fairly extensive, having received emphasis from the NTSB and the FAA. FAA and other aviation stakeholders have taken steps to address runway and ramp safety, but the lack of coordination and leadership, technology challenges, the lack of data, and human factors-related issues have impeded progress (*10*). The lack of data and human factors issues is pertinent to this report. The review of literature found that previously published information on the topic of preventing incursions of snow removal vehicles was minimal, receiving only cursory mention in articles that focused more on snow removal equipment or on snow removal plans.

Published research or articles on roadway snow removal operations were much more extensive and refined. Research from the highway sector was reviewed and included in this report where it was assessed that the results and information could have application to airports. Areas such as accident prevention, vehicle design and lighting, and human factors are such areas.

Research on highway human factors has been well studied, and several studies are cited for inclusion in this report. In particular, a search on the effects of fatigue in snow removal operations resulted in numerous articles that were transportation-related but not specific to snow removal operations at airports. Because of the human factors implication of fatigue, the search results covered topics such as technologies for monitoring and preventing driver fatigue (*15, 16*); health and wellness factors (*17*); physiological, personality, and behavior aspects (*15, 18*); sleep loss factors (*19*); vigilance monitoring (*20*); duty time (*21*); ergonomics and other design considerations (*22, 23*); and management practices (*24*). All these factors were identified by the airport survey respondents as affecting their operations.

For extensive information on fatigue and fatigue management, both NASA (http://human-factors.arc.nasa.gov/zteam) and the Australian National Transport Commission (http://www.ntc.gov.au) have conducted significant research into fatigue in the transportation and aviation industry, as has the FAA (http://www.faa.gov) and the FMCSA (http://www.fmcsa.dot.gov). The results of the literature search in these areas are provided in subsequent chapters of this report, in particular chapter five.

Although many areas of aviation and flight operations have been studied and researched (e.g., extensive human factor research has focused on pilots and mechanics; aircraft design human factor research has focused on aircraft cabin layout; research into cognitive learning has resulted in more effective training regimens; and weather research has resulted in new systems for detection of significant events), little research has been conducted into the area of airport operations, and in particular, those associated with winter operations. Yet winter operations and low visibility conditions represent an increased risk component for airport operations and further result in the escalation of risk elsewhere in the aviation system.

As previously mentioned, the issue of runway incursion has received focused attention from the FAA and other government regulators internationally. The FAA has established an Office of Runway Safety (http://www.faa.gov/runwaysafety/) for that purpose. Various reports from the website were reviewed for information related to winter operations. Preventing incursions takes a coordinated effort of pilots, air traffic controllers, and airport operators to resolve. Many of the actions taken for preventing incursions also apply to snow removal operations. Results from the FAA studies indicate the majority of incursions are the result of pilot error, with controller error being second, and vehicle/pedestrian error being third. Snow removal equipment operator error is grouped into the last category. In addressing the issue of runway incursion and how to reduce the number of deviations, the FAA has developed guidance through various brochures, procedures, and manuals (Figure 2).

Chapter ten provides a synopsis of technology that has been considered in the past, is currently in use, or is being considered for use at airports to prevent incursions. The technology and systems identified represent a broad range of advanced technology and cost that is intended to address runway incursions in general. The systems include facility-based controller notification through the use of surface-movement obstacle detection equipment; ground-based flight crew notification

FIGURE 2 Various FAA sources of safety material. (*Source:* FAA.)

technology through ground tracking of aircraft and vehicles; and in-cabin aircraft and vehicle positioning equipment that provides pilots and vehicle operators with real-time position information on the airfield. The primary drawback to the implementation of advanced technology in the prevention of incursions is related to cost.

A review was conducted of approximately 95 airport snow plans submitted by Part 139 airports as part of their ACM. Although an airport's ground vehicle operating procedures (required under Part 139) may address winter operating conditions, the snow plans reviewed were not detailed enough to provide actual guidance for many of the decisions that must be made during a snow event; nor did they detail the method for vehicle operation. In essence, the plans only address the standards expected to be obtained and not the "how to." The lack of standardization or procedures in this area of the ACM is an area for further evaluation.

One non-hub airport with a part-time ATCT identified the following in its approved snow plan:

> A. During non-tower operations, runways will be closed during snow removal activities. Operations personnel will advise the air carriers of such closures and issue the appropriate NOTAMs.
> B. During tower operations, it may be necessary to close the main air carrier runway depending upon precipitation type, depth, weather conditions, and other factors. In such situations:
>   i. Airport management will determine the length of time required for runway closure:
>   ii. Other runways/taxiways may be closed for reasons of accumulated snow depth, excessive windrow height, snow removal operations, etc.

The example is typical of the SICPs submitted and reviewed for this report. Lacking is additional guidance or procedures for personnel responsible for implementing the plan. Statement A (non-tower operations) is straightforward in closing the runway. Statement B (tower in operation) provides flexibility. However, neither gives guidance about how to assess the conditions, in what manner the conditions should be addressed, when the activity is to occur, or how decisions will be made. Some airports have bridged this gap by generating separate written snow policies, methods, or procedures outside of the regulatory framework of Part 139. This is accomplished due to liability concerns for a violation of the regulation under the ACM if a particular procedure is not followed. Of the SICPs examined, fewer than 10 were determined to have separate procedures established. Most airports relied on and utilized the experience and knowledge of existing personnel for bridging the gap.

None of the SICPs reviewed for this report discussed runway incursion prevention issues associated with driver fatigue and distraction. Fatigue was mentioned in an ancillary policy and procedure manual developed by one airport.

Some of the questionnaire responses provide insight into competing goals as a possible root cause of winter incursions and unsafe situations during winter operations. For instance, air traffic system performance is measured, in part, by the availability of the air transportation system to accept the aviation demand, which includes the availability of a runway to accept an aircraft operation. An example of the pressures to keep the runway open is contained in one non-hub airport's approved snow plan:

> It is the intent of this program that airport personnel shall work closely with the ATCT when performing snow removal activities to keep runway closings to a minimum.

Closing a runway for snow removal, which advances the goals of airport operational safety, competes with the goal of availability. Competing goals create pressures on airport snow removal crews. A more in-depth analysis of competing goals and the pressures that snow removal operators experience is presented in chapter seven.

The literature search determined that much research about snow and ice removal has been accomplished on the road and highway systems, but not on the airport system. Much of the research points toward design and human factors issues as primary factors affecting driver operation. This is echoed in the survey responses. Even though highway operations and airport operations differ, this study sought to identify equipment, practices, and techniques that produce benefits to the airport system. An investigation into technology that addresses the runway incursion issue seeks to create a defense barrier against potential error. However, the cost of implementation and because new technology can create new error possibilities has made airport operations more complicated.

One source of unique information on winter operational experiences was found in the ACI–NA's annual survey on airport winter operations and services across North American airports (*25*). For 2006, it included a wide range of airfield operational issues including operational experiences, runway incursion prevention plans to eliminate perceived hazards, and experience in implementing and auditing ICAO Annex 14-recommended safety management systems (SMS).

SUMMARY

Chapter one introduces how winter operations pose a unique hazard or risk for airports because snow removal vehicles and equipment are authorized to conduct operations on the movement areas of an airport, including active runways. It outlines the purpose of the study and the research methodology that was used, including a literature search, questionnaire distribution, and a review of airport snow plans. The objective of the synthesis is to provide a compendium of existing practices, procedures, training, and systems that airport operators use to reduce the risk of vehicle–aircraft incidents and incursions during winter operations and periods of low visibility.

Within this chapter, background information is provided on runway incursions and the risks associated with such events. It further explains current regulations in place under 14 CFR Part 139 to address the issue. Provided are specific examples of runway incursion reports that occurred over one winter season. The reports highlight the varied nature of the incursion problem and introduce some of the factors causing them.

The next chapter provides a brief synopsis of the factors affecting collision risks that was culled from the literature search and the responses to the questionnaire.

CHAPTER TWO

FACTORS AFFECTING COLLISION RISKS

A runway incursion is more likely to occur at controlled airports when the exact location of an aircraft or vehicle on the airport surface is unknown or contrary to an ATCT instruction. ATCT controllers are constantly reminded of their need to monitor the location and progression of the aircraft and vehicles operating on the airport surface, in accordance with instructions issued, to provide assurance of separation. At uncontrolled airports, a safety hazard or runway incursion is more likely to occur when proper procedures are not followed by pilots or by ground operators.

One study that sought to identify the factors associated with incursions or surface incidents focused on ATCT controllers. It identified the most common factor for errors (27%) was the controller "forgetting" something. Forgetting about an aircraft (e.g., holding in position or on approach) contributed to 15% of the errors; 5% were related to the controller forgetting that a runway was closed; and 3% of the errors were the controller forgetting about a vehicle on the runway. The remaining 4% involved the controller forgetting something else, such as a local procedure (*26*).

A case example from the FAA follows:

> In daylight IMC, with Runway Visual Range reported at 3,000 ft, a B737 captain—just after touch down—observed the amber rotating beacon on a vehicle about 1,000 ft. ahead on the runway. The captain made an immediate "go-around" and missed the eight vehicles by an estimated 10 feet. What happened? While the aircraft was about 15 miles SW of the airport and being vectored for a runway 36 Cat II approach, the local controller had given the ground controller permission for snow removal equipment to proceed north on runway 36 and to exit runway 36 at the intersection of Runway 27L. The aircraft reported at the outer marker and was cleared to land with no further conversation between controllers about the status of the snow removal equipment. (*27*, p. 32)

Forgetfulness is not the sole domain of ATCT controllers, as airport maintenance and operations personnel can be just as forgetful, perhaps not of equipment on the airfield, but where they are located and of procedures or requirements that must be followed. Vehicle operators have a responsibility to maneuver their vehicles on taxiways and runways in accordance with ATCT instructions. As a cause of errors, loss of SA is discussed further in chapter six.

The FAA Office of Runway Safety has identified throughout its literature common factors for why incursions occur. The following are some of the contributing factors that have been identified:

- Failure to follow established standardized procedures,
- Failure to understand the implications of one's actions or inactions,
- Lack of training and practice to internalize procedures,
- Loss of SA,
- Failure to ask for help when confused,
- Failure to use the airport diagram, and
- Unfamiliarity with the airport.

When the questionnaire asked airport operators what factors they had experienced or thought would increase the risk of collision, the response was wide ranging and inclusive. The most common factors identified by survey respondents were poor communication, poor visibility, and fatigue. The factors identified represent the varying nature of airport operations at different categories of airports. The following chapters provide a synopsis of the type of factors identified in the survey responses, and they are grouped accordingly.

COMMUNICATION

Airport operator responses to the questionnaire cited multiple times that poor communication was a primary factor affecting the risk of collision. Poor communication included failed or miscommunication with the ATCT and other crew members, lack of communication of the snow plan or of ATC traffic advisories, and confusion about radio communications. Contributing to poor communication are radio-related factors that could have a basis in human factors, communication techniques and processes, or equipment operation. They include monitoring or using an incorrect radio frequency or the wrong radio, inoperative radio equipment, dead batteries, frequency congestion, failure to switch frequencies, or noise. The dissemination, or lack thereof, of safety-related information through the NOTAM system was also cited as a contributor to poor communication. Dissemination of safety-related information, proper communication protocol, and operator distraction is discussed in more detail in chapter three of this report.

ENVIRONMENT

Classified under environmental conditions are factors encountered during winter operations such as changing weather and extreme conditions (wind chill, wind gusts, blowing snow and whiteout conditions, heavy versus light snow), night operations, pavement surface conditions (presence of ice, glycol resulting in poor traction), and airfield congestion (vehicles and aircraft). The factor cited the most as increasing the possible risk of collision during winter operations was poor visibility. This includes fog, freezing rain, or blowing snow conditions, and reduced visibility due to snowbanks and obscuration of markings, signs, and lights. Addressing issues associated with visibility restrictions and winter conditions is discussed in chapter four.

HUMAN PERFORMANCE

The second most cited factor affecting possible risk of collision during winter operations was fatigue—not just of the vehicle operators—but of ATCT controllers and others. However, fatigue is a symptom having many different contributing factors. Pressure from air traffic controllers, pilots, and tenants to open or keep open operating surfaces, complacency from working long hours, sleep deprivation, sensory overload, distraction and lack of SA, too much radio chatter, operator inattention, repetitiveness of activity, operator attitude, physiological needs, vehicle ergonomics, and human error all are human factors that can grouped into the human performance category. Chapter five of this report provides a synopsis of the effects of fatigue during winter operations, with the information being limited to that of a primer on the contribution that fatigue can have on possible error and incursion-producing effects, and not an exhaustive presentation of its effects.

SITUATIONAL AWARENESS

SA has many definitions (*28*). Basically, it is a continuous process of attentiveness and surveillance that results in an accurate perception of the factors and conditions affecting an individual and his or her environment during a defined period of time. Essentially, SA refers to an individual's assumptions about how they feel, where they are located, the condition of their equipment, the abilities they have, what they thought they heard or meant to say, and myriad other factors that affect the outcome of any situation. SA was cited as a factor numerous times in survey responses. However, it becomes more apparent when one reads accident or V/PD reports that either a loss of SA or not having SA at all was a major factor in the event. SA is discussed in more detail in chapter six.

TIME PRESSURES

Frequently mentioned as a collision risk factor were pressures associated with maintaining operations. This includes not having adequate time to complete a trip down the runway, inadequate notice to get off a runway, length of time to gain access to a runway for snow removal, aircraft being authorized to taxi into position for takeoff while snow crews were performing final cleanup operations, tenants constantly calling inquiring when the surfaces will be open, aircraft running behind schedule, and organizational pressures to serve the customer by keeping the airfield and terminal areas open. Pressures associated with opening a runway or maintaining runway operations are discussed in chapter seven.

PERSONNEL, VEHICLES, AND EQUIPMENT RESOURCES

The survey respondents identified not having enough vehicles, equipment, or personnel as factors. Having vehicles and equipment that were operational throughout the winter event also was a concern, even though airports certificated under 14 CFR Part 139 are required to have programs to ensure vehicle readiness. The speed of vehicles, the heightened visibility through lighting and marking of vehicles, and the type and placement of brooms and plows were cited as potential collision risk factors. Equipment factors also refer to the airfield facilities, such as proper signage and lighting being available and operational. The design of vehicles was implicated in the questionnaire responses by reference to a particular design factor, such as comfortable seats, lighting, control layout, heating, and wiper blade action. Vehicle design is addressed more specifically in chapter eight.

OPERATIONAL FACTORS

Survey respondents identified factors that, while they could fall under some of the other categories, are best grouped under the heading of operational factors. This includes equipment not normally on runways or other operating surfaces during aircraft operations, non-routine vehicle and aircraft traffic patterns causing congestion, operations being conducted without ATCT assistance, changes in airfield configuration due to wind changes or snow blockage of movement areas, and the utilization of new or inexperienced employees or contractors.

Operational factors also include failure to follow standard procedures, an oft-cited factor in the survey responses. As previously discussed, airports serving air carrier operations are required to have snow plans approved by the FAA as part of the certification manual. It is a best practice for airports to update the SICP as part of their pre- and post-winter reviews. Less than adequate or failure to follow snow plans, ground vehicle operating procedures, or vehicle operator training programs can lead to winter operation incidents. Additionally, winter operation incidents can be created by inadequate or nonexistent procedures associated with NOTAM issuance and posting, incomplete self-inspections, lack of proper supervision, poor or slow response to conditions, vehicles not staying together, personnel not watching for other vehicles or aircraft, and inadequate information about approaching winter conditions. Chapter nine delves more into how airports manage these operational factors.

SUMMARY

Chapter two provides an introduction into the factors affecting the risk of collision during airport winter operations. According to the literature, the more common possibility for a safety hazard or runway incursion to exist occurs when the exact location of an aircraft or vehicle on the airport surface is unknown or is contrary to an ATCT instruction; when either controllers, pilots, or vehicle operators forget about a critical safety activity; or when proper procedures are not otherwise followed by controllers, pilots, or ground operators.

Chapter two further presents an outline of the remaining chapters of the report. Presented in chapters three to nine are more detailed analyses and explanations of the research on the factors affecting collision risks during airport winter operations.

CHAPTER THREE

COMMUNICATION

One key to safe airport operation during the winter season or in low visibility conditions at an airport with or without an operating control tower is the use of proper and correct communication. Proper and correct communication enhances SA and provides the means for carrying out an airport's snow plan in a timely and effective manner.

Because of its importance, the FAA has established communication protocols and regulations for both aircraft and vehicles operating on and in the vicinity of an airport. The communication protocols, phraseology, and words are spelled out in various FAA publications, namely regulations, orders, advisory circulars, and other guidance material.

RADIO COMMUNICATION PROTOCOLS

Radio communication protocols are spelled out in *Advisory Circular 150/5210-20, Ground Vehicle Operations on Airports* (*3*) or in the *Aeronautical Information Manual* (*AIM*): *Official Guide to Basic Flight Information and ATC Procedures* (*29*).

At airports with an operating control tower, permission must be requested and a clearance given prior to driving on a movement area. Any vehicle driving on the movement areas (runways and taxiways) of an airport must be in contact with the ATCT or be capable of monitoring and transmitting on the common traffic advisory frequency (CTAF) if ATCT is not in operation or does not exist. Movement areas at airports having an ATCT are defined in a memorandum of understanding (MOU) or LOA and described in the airport's ACM. Vehicle operators must always monitor the appropriate radio frequency when in the movement areas. A vehicle that is equipped with a radio may escort vehicles without radios, which is common during snow removal operations at many airports.

At airports without an operating control tower, airport ground vehicles equipped with radios should monitor the CTAF. The CTAF is assigned for the purpose of carrying out airport advisory practices while operating to or from an airport without an operating control tower. The CTAF may be a unicom, multicom, flight service station (FSS), or ATCT frequency and is identified in appropriate aeronautical publications. Unicom and multicom are nongovernmental air/ground radio communication stations that can provide airport information at public use airports where there is no ATCT or FSS.

Both CTAF and unicom frequencies have users make self-announcements of their position or intentions using standard terminology and phraseology. To "self-announce" refers to a procedure whereby pilots or vehicle operators broadcast their position or intended flight activity or ground operation on the designated CTAF.

A common method of crew coordination and communication at small to large airports is the use of a crew team concept. The concept involves a group of snow removal equipment that function together under the command of a lead supervisory vehicle or operator. In this instance, ATCT communication is with only the command vehicle and the equipment operators are, in essence, under escort. This communication protocol reduces the burden of the ATCT controller to monitor all vehicles and places the responsibility onto the airport snow supervisor. Individual LOAs and an airport's ACM will govern this type of communication protocol. Communication procedures and protocol are essential in these circumstances for ensuring all vehicles remain with the lead vehicle and follow its lead. Under 14 CFR Part 139.303, individuals operating on the movement areas of the airport should receive training in the different communication rules and operating impact that applies. The different requirements can be found in the FAA's *Aeronautical Information Manual* (*29*).

A distinction exists in aircraft operations if pilots are operating under instrument flight rules or visual flight rules. When the weather conditions create cloud ceilings below 1,000 feet above the ground level (AGL) or the horizontal visibility drops below 3 mi, instrument meteorological conditions (IMC) exist. When the cloud ceiling is more than 1,000 ft AGL and the visibility is greater than 3 mi, visual meteorological conditions (VMC) exist. VMC allows for either instrument or visual flight operating rules to be used by pilots.

The radio communication protocols to be used when conducting airport operations are listed here and are abstracted from the FAA's AIM, advisory circulars, and technical orders, and provide standard guidance for airport vehicle operators and pilots.

Approaches to an Airport with an Operating Control Tower

A pilot intending to make an approach should contact the tower for approval. This request should be made prior to starting the final approach or is handed off to the ATCT from Air Route Traffic Control Center (ARTCC). The final approach generally begins 10 nautical mi from the runway. The ATCT is to then communicate with snow removal equipment on either tower (local) control or ground control, as spelled out in local procedures, as to any action to be taken.

Approaches to an Airport Without an Operating Control Tower

A pilot intending to make an approach to an airport will be advised by ARTCC to change to the airport advisory frequency when direct communications with ATC are no longer required. Normally, such change would be made prior to leaving the final approach fix inbound (non-precision approach) or the outer marker or fix used in lieu of the outer marker inbound (precision approach), which is approximately 10 nautical mi from the runway. The pilot is to then use self-announcement procedures on unicom, multicom, or CTAF, as appropriate. Further announcements may be made by pilots as to their position on approach, or if performing a circle-to-land maneuver, their position in the traffic pattern. On landing, they are to report leaving the runway. It is incumbent on vehicle drivers to monitor the assigned frequency for their airport and respond with safety-related information only, such as their position or their intentions.

A practice implemented and recommended at some airports is to publish a remark in the airport's *FAA Form 5010 Master Record* identifying that snow removal operations are in progress during the winter months; that vehicle operators will be monitoring CTAF; and that landing and departing aircraft should announce their intentions on CTAF when ATCT is closed. The information placed on the *5010* is then replicated in the *Airport Facility Directory,* which all pilots are to reference prior to operating on, from, or into an airport.

Operating on an Airport with an Operating Control Tower

Airports with an operating ATCT will have spelled out in a LOA or MOU those areas that will be under ATCT operational control during the hours ATCT is in operation as well as those where they cannot provide ATC service due to visibility limits or other reasons. Airfield signage, pavement markings, local bulletins, airport diagrams, and operator training programs provide information on the operational areas. Vehicle operators and pilots have a responsibility to contact the ATCT prior to entering an airport movement area.

An ATCT authorization must be obtained prior to accessing a movement area during the hours an ATCT is in operation. Airport vehicles must comply with ATCT instructions while on the movement areas and further seek authorization for operations outside of what the ATCT had originally allowed.

Always state your position on the airport when calling the tower for vehicle movement instructions. Normal radio procedure is to use the following protocol:

- Identify who you are calling.
- Identify who you are.
- Wait for a response from ground control.
- Respond to ground control's acknowledgment with who you are, where you are, and what your intentions are.
- Wait for a response.
- Acknowledge the instructions, repeating back any hold short instructions.
- Proceed in compliance with the instructions.

Advisory Circular 120-57A, Surface Movement Guidance and Control System, commonly known as SMGCS (pronounced "smiggs"), requires a low visibility taxi and operating plan approved by the FAA for any airport that has takeoff or landing operations in visibility conditions less than 1,200 ft runway visual range (RVR) (*1*). These plans, which affect aircrew and vehicle operators, may incorporate additional lighting, markings, signage, and procedures to control airport surface traffic. Low visibility is addressed at two levels: operations less than 1,200 ft RVR but higher than 600 ft RVR, and operations 600 ft or less RVR.

Operating on an Airport Without an Operating Control Tower

A vehicle operator intending to operate on the runways and taxiways should so advise others by issuing a NOTAM, or use self-announce procedures and communicate position and intentions on unicom, multicom, or CTAF, as appropriate. Terminal Radar Control (TRACON) centers and ARTCC do not necessarily have on-airport traffic and runway-in-use information available to them. The key to communicating at an airport without an operating control tower is the selection of the correct common frequency. It is incumbent on airport vehicle operators to monitor the assigned airport frequency and communicate or self-announce position and intentions whether aircraft are present or not.

Self-announcements should follow the following format: (1) state the airport name, (2) identify your vehicle and position, (3) identify your intentions, and (4) restate the airport name. At an uncontrolled airport, some aircraft may not have radios or those that do may not have adequate time to announce their activity after being released by the ATC Center. Operations at airports without operating control towers require the highest degree of vigilance on the part of vehicle operators to see and avoid aircraft while operating on the airport, especially the runways. Drivers should stay alert at all times, anticipate the unexpected, use the published CTAF frequency, and follow standard or recommended airport operating practices. The use of the appropriate CTAF, combined with visual alertness and application of good operating practices, will enhance the safety of airport operations. Radio transmissions from ground vehicles should be confined to safety-related matters.

Advisory Circular 150/5200-30, Winter Operations on Airports, provides the recommendation that the overlying air traffic control frequency should be monitored along with the local frequency by the airport's snow control center or snow vehicles at all non-towered airports and at airports where the ATCT has less than 24-hour operations (*12*). This procedure should apply even if a NOTAM has been issued closing the runway for snow-clearing operations.

Most airports attempt to follow these procedures with some variation. This is primarily due to the different operating characteristics of airports, along with factors such as the experience of the crews, the pressure of keeping the airport open, and the capabilities of the equipment.

OPERATOR DISTRACTION

Operator distraction is a concern for runway safety because any distraction can cause an operator to miss an ATCT communication, not see or recognize visual clues such as pavement markings or signs, or otherwise interfere with an operator's cognitive thinking processes. For instance, research exists that demonstrates that the use of a cell phone while driving does impair one's cognitive and visual processes (*30*). Conducting a cell phone conversation can block out other thought processes or prevent a visual image from being recognized.

Cell phones are issued at some airports to a vehicle operator for use only in emergency situations (i.e., radio failure) or for communicating with operations or maintenance. At an uncontrolled airport, the lead plow operator may have a cell phone to receive FSS and ATC Center calls and for filing NOTAMs. However, good practice is to vacate the movement or safety area when calling FSS or others. It is not recommended to have the phone to receive or make normal business or personal calls while engaged in plowing operations.

An overwhelming majority of respondents to the questionnaire indicated that the use of cell phones, CDs, AM/FM radios, iPods, or similar devices is not allowed while operating on the airfield. The primary reason cited for disallowing the use of such devices was that in having to listen to the several radio frequencies (ATCT, operations or maintenance, emergency, public works, etc.), another audio device in the vehicle cabin is a major distraction. For the few airports that indicated they allow cell phones in the vehicles, specific policies were generally developed to identify the circumstances and conditions under which they could be used.

However, operational notes were made by survey respondents that can be of benefit to others. Regarding the practice of having to listen to several different frequencies, one airport operator placed the speakers in the cab in this manner: left side was the speaker for the radio tuned to approach control; a center speaker immediately behind the operator was tuned to ground control; a third speaker to the right side monitored airport operations. The placement of the speakers allows for directionality of the radio communication and reduces some confusion of which radio communication is being received.

To combat driver fatigue, a few operators indicated they use AM/FM music radios to help keep them awake. As discussed previously, driver fatigue is a major issue that is better managed through means that address the root cause and do not contribute to driver distraction.

The advisory circular on winter operations and safety suggests that consideration should be given to providing vehicle operators with headphones to minimize ambient noise disruption from vehicular noise. The use of headphones, especially active noise cancellation (ANC) or active noise reduction (ANR) type, is thought to help reduce the fatiguing affect of vehicle and environmental noise and enhance radio communication. Survey respondents indicated the use of headphones or earphones is not a common practice, in part due to their being uncomfortable after long periods of time, and primarily because the vehicle operators want to be able to "hear" the vehicle engine and related equipment. Experienced vehicle operators are attuned to the sounds of their equipment and the environment as part of their overall SA. Headphones, several respondents stated, detract from that awareness. However, hearing loss can be mitigated through the use of headphones and communication can be enhanced through the elimination of ambient noise. The disparity between whether headphones enhance or detract from vehicle operations is a topic for research and evaluation.

During the course of this study, one air traffic controller noted that an error he has to be attuned to is that of responding to a person's voice rather than to a vehicle call sign. For instance, due to a long-time familiarity with airport operations and personnel, the controller may know that Operator A is usually assigned Plow 11. But Operator A switches vehicles with Operator B in Plow 12 as a way to mitigate fatigue. Both Plow 11 and Plow 12 are on the airfield, and the controller, familiar with Operator A's voice, directs Plow 11 to exit a runway believing Operator A is inside, except that it is actually Plow 12 that requires direction.

As stated by one survey respondent

> Vehicle operators have misunderstood ATC clearances and have taken a clearance intended for another vehicle. Operators have "heard what they want to hear" and not what was actually said—complacency.

Vigilance and adherence to standard call signs on the part of both vehicle operators and controllers is important to prevent this type of error. The FAA has revised *Advisory Circular 150/5210-5, Painting, Marking, and Lighting of Vehicles*

Used on Airports to require vehicles purchased under the AIP to have reflective tape along the sides of all vehicles and to have large numbers on the sides and hood, as part of the effort to reduce errors associated with vehicle recognition (*31*). It is best practice to make all vehicles operating on the movement and non-movement areas as highly visible as possible. Reflective tape and vehicle identification numbering is one such method.

AIRPORT CONDITION REPORTING PROTOCOLS

Under Section 139.339 of 14 CFR Part 139, an airport operator is required to collect and disseminate airport condition information to air carrier operators using the NOTAM system and other systems and procedures, as authorized by the FAA. The NOTAM system is the mechanism by which time-critical aeronautical information affecting safe operation in the aviation system is to be disseminated to those needing the information.

The advisory circular on winter operations states that snow-related NOTAMs must be given in a timely manner because of their critical importance for safe operations (*11*). It also states that NOTAMs should adhere to the format and abbreviations found in *AC 150/5200-28, Notices to Airmen* (*NOTAMs*) *for Airport Operators* (*13*), *and FAA Order 7930.2, Notices to Airmen* (*NOTAMs*) (*32*), and *FAA Order 7340.1, Contractions* (*33*).

It has long been recognized that the NOTAM system has limitations and has not responded well to the growth of the aviation industry and technology. In the past, a concern of airports has been about the process by which NOTAMs are issued in a timely manner and are further disseminated. This is especially so during the winter season where a major snowstorm affecting many airports results in numerous NOTAMs entering the system. Anecdotal reports from vehicle operators as part of this report investigation mention the lack of timely notification of airport conditions as factors. The reasons cited by the operators for delay ranged from airport operators on the field not able to get back to the office to file them, to FSS not able to enter them in the system due to a major snow event placing high demand on the system, to a total communication breakdown by all parties involved.

The FAA has been slowly working toward improving the system. In April of 2007, the FAA turned over the operation of FSS to a private contractor. As with any changeover of the size and magnitude of FSS services, this was not without problems. Two of the areas negatively affected by the transition were the length of time it took to access a briefer specialist in order to issue a NOTAM and the number of calls that were dropped from the system. Further changes continue to be made to the NOTAM system to make it more efficient.

In October 2007, the FAA started the process to consolidate, streamline, and simplify NOTAM entry, quality assurance, and distribution. *FAA Order 7930.2K Change 2* places on FSS specialists the responsibility for classifying, formatting, disseminating, and monitoring the currency of NOTAMs (*32*). FSS specialists also are responsible for editing the content of all NOTAM data received from airports to conform to the NOTAM system requirements. This latter requirement was often a source of communication breakdown between airports and the flying or airport user public. An airport, knowing the conditions and describing them, would often have them modified to meet the FSS requirements, thereby not conveying the intended condition. This source of possible error is about to change.

As of January 28, 2008, the FAA has reclassified its system of identifying NOTAMs to include key words that describe more clearly where and what type of activity is occurring. This information is then made available systemwide. Prior to January 28, 2008, NOTAMs not related to a runway or navigation aid were generally classified in the NOTAM (L) or local category. The two classifications previously affecting airport snow removal and operations were NOTAM (D) or distant, and the NOTAM (L). NOTAM (D) information is disseminated for all navigational facilities that are part of the National Airspace System, and all public use airports, seaplane bases, and heliports listed in the *Airport/Facility Directory*. A complete file of all NOTAM (D) information is maintained in a computer database at the Weather Message Switching Center located in Atlanta, Georgia. Air traffic facilities and FSSs with Service A capability have access to the entire WMSC database of NOTAMs. These NOTAMs remain available for the duration of their validity, until published in the *Airport/Facility Directory*, or are rescinded. Once published or rescinded, the NOTAM data are deleted from the system.

NOTAM (L) information had included such data as taxiway closures, personnel and equipment near or crossing runways, and airport lighting aids that do not affect instrument approach criteria, such as visual approach slope indicators or precision approach path indicators. NOTAM (L) information was distributed only within the local FSS area and was not attached to the hourly weather reports. A pilot seeking NOTAM (L) information for an airport outside the local FSS areas had to specifically request the information from the FSS that was responsible for the airport concerned. Under the new standards, airports submitting NOTAMs, including ramp and taxiway snow data and other similar winter NOTAM activity, are now automatically listed under the NOTAM (D) category in accordance with *FAA Notice N JO 7930.85* and placed in the national database (*34*). This is a result of the FAA's adoption of the ICAO definition for an airport movement area, which includes taxiways, ramps, aprons, and lighting.

The change to the ICAO standard allows for immediate national dissemination and access of all airport NOTAMs, thereby increasing a user's awareness of winter operations activity on an airport. The (L) classification has been removed and effectively no longer exists. NOTAM information still will be required to be distributed through the FSS under existing airport procedures. However, that is expected to change in the future as well. It is anticipated that by fall of 2009, airport operators will be bypassing FSS and directly entering NOTAMs electronically into the system themselves.

With rare exceptions, it is the sole responsibility of airport management to open and close runways and other surfaces on an airport. The ATCT does not have the authority or the responsibility to open or close a runway, or other surface on an airport, unless agreed to in a LOA with the airport operator. Normally, the commencement of snow removal activity requires 30-min advance notice to the FSS and the operating ATCT. This allows adequate time for FSS to get the information into the system, allows the ATCT to revise its automated terminal information system (ATIS) and factor in arriving aircraft, and allows for aircraft operators and fixed-base operators (FBOs) to adjust their operations.

The primary method for notification of airport conditions is the use of the NOTAM system along with other FAA-approved methods that are identified in an airport's ACM. Airports with scheduled air carrier activity must inform the air carriers, and airports with operating control towers must inform air traffic control. Non-tower airports are required to inform FSS. Airports are allowed to utilize other supplemental methods, if approved by the FAA.

There is no requirement for airports to inform TRACONs or ARTCCs of NOTAMs as those facilities should receive the information as a result of filing a NOTAM with FSS. The process of going through several channels was cited by a number of airports in the survey as an area for communication breakdown. A safety issue raised by more than one non-towered airport in the survey was that an aircraft made an approach or attempted an operation at their airport with neither the pilot, TRACON, or ARTCC aware of the activity on the non-towered airport.

All ATCT, TRACONS, and ARTCC have a systems information area (SIA) screen available for accessing basic information about airports. The SIA is a separate monitor off to the side of a controller's position that allows a controller to query information about an airport, such as NOTAM information or information from the automated weather observations systems or the automated surface observations systems. This is of value at TRACON and ARTCC facilities where multiple airports, including non-tower airports, are under their jurisdiction. The extent to which the SIA is utilized varies with the facility and the amount of time a controller has to access the information on the screen. Pilots still have the responsibility to self announce on CTAF once released by the controller some distance from the airport.

As part of the radio communication protocol of IFR operation, a pilot making an instrument approach to an airport may not have the opportunity to switch frequencies to contact the FSS and receive updated reports of airport conditions. If requested by the pilot, TRACON or ARTCC can assist by checking the SIA, but only if (1) time permits, (2) it doesn't interfere with a controller's primary mission of maintaining aircraft separation, and (3) the FSS has entered the information in a timely manner. At busy TRACONs and ARTCCs, this can be difficult. Therefore, a pilot may not know about snow removal activities on an airport or other important airfield conditions. It is also why snow crews must exercise extreme vigilance when on a runway. It was noted by two airports that as part of their notification process, they have a direct line to the TRACON or ARTCC facility data entry position desk. This would be a good practice to implement at any airport.

Those individuals or agencies requiring notification of snow removal activities are normally listed in an airport's ACM under either the snow and ice control section or the airport condition reporting section. Non-certificated airports are encouraged to have a similar listing. The list usually includes the following: ARFF, FSS, ATCT, air carriers (airport operations or central dispatch), cargo operators, FBOs, flight schools, emergency response command centers, city/county offices, and the general community.

The information may be transmitted by various methods including hand delivery, telephone, facsimile, e-mail, air band radios, ATIS, Internet, intranet, and commercial radio networks such as Aeronautical Radio, Inc. and Systems Atlanta, Inc., which are integrated communication systems that tie users together with a common electronic interface. Other systems are being developed by different airports. Two airports in the survey have systems that utilize wireless devices inside the operations or maintenance vehicles to communicate to the airport's intranet system.

An informational transmission procedure that sums up the process for one airport with a full-time ATCT is as follows:

> A memorandum of understanding (MOU) with the tower puts all snow removal activities on a separate ATC channel whenever possible. The procedure for closing the runway requires the Airport Duty Manager to notify the airlines and ATC that we are going to close the runway at a certain time, when the time comes they will verify with ATC that the runway is closed, they will then contact the Airport Personnel involved with snow removal on company radios that the runway is closed, they will in turn repeat the runway closure information back to the Duty Manager. All personnel on the runway remain on the same company frequency as the Duty Manager in addition to the ATC frequency in use for snow removal at the time. To reopen the runway, the Duty Manager will inspect the runway to insure there is no FOD or vehicles on the runway and advise the Airport Control Center that the runway is open and active. The Control Center will then announce on all company channels that the runway is open and active. At that time the Duty Manager will open the runway with ATC.

Improper communication protocols have been the source of many errors affecting aviation safety. Specifically, radio communication and the communication of NOTAM information are causes of runway incursion errors during winter snow and ice operations. Proper radio communication procedures have their basis in proper training and enforcement of standard radio protocols; that is, under the purview and responsibility of the airport operator. Proper communication also has a basis in proper equipment and procedures for those vehicles being escorted or under the jurisdiction of a team leader concept. This also is under the purview and responsibility of the airport operator.

The FAA has made inroads in resolving the NOTAM dissemination issue but it will take time for the process to be completed. Therefore, snow removal operators must forever be vigilant to the possibility that aircraft operators did not receive the vital safety information, and make plans accordingly through constant monitoring and proper safety practices. Those safety actions at uncontrolled airports can include: monitoring approach control frequencies, plowing in the direction of aircraft approaches and departures, having vehicle lights turned on, informing tenants through a separate notification method, placing a lighted “X” on the runway, and having an individual not actively engaged in snow removal monitor flight activity.

SUMMARY

Chapter three discusses in detail how poor communication has been the source of errors affecting aviation safety, with improper radio communication and NOTAM dissemination increasing the collision risk factor during winter operations. The chapter identifies FAA’s established communication protocols and regulations for both aircraft and vehicles operating on and in the vicinity of an airport. Using proper radio communication procedures, monitoring and transmitting on the proper radio frequency, staying visually alert and anticipating the unexpected, confining radio transmissions to safety-related matters, and having direct contact with ATCT centers will all enhance operational safety on airports.

The chapter also discusses changes being made in the NOTAM dissemination process to better communicate safety information in a timely and broad basis, and how the use of cell phones and other audio devices can be a collision risk factor by distracting the driver.

CHAPTER FOUR

ENVIRONMENT

Survey participants were asked to identify the kind of problems they have encountered at airports relative to reduced visibility, seeing where they are on the airport, or the difficulties in navigating on the airfield when engaged in snowplowing, brooming, deicing, or other winter operations. They were then asked to identify how they solved the problems. Their responses, as noted here, provide insight into the varied operations of different categories of airports that have varied organizational structures and resources.

VISIBILITY

All snow events present some measure of degradation in visibility and SA. Blowing snow, whiteout and blizzard conditions, blowing sand, heavy fog and precipitation, equipment blocking line of sight, and vehicle blind spots were factors cited by operators as affecting visibility. Outside the vehicle, the accumulation of snow or snow banks obscuring signs and lighting are major issues.

The speed of vehicles was cited as an issue by several airports because it resulted in both accidents and incursions. The time pressure to get the movement area cleared prompted the drivers to push their limits and the limits of their vehicles. Unfortunately, higher speeds decrease driver reaction time and increase braking distances, which increase the collision risk factor on the airport.

The use of runway and taxiway lights generated contradictory statements from operators as to which was the best method. One large-hub airport always works with their runway lights at high settings so they can better see the airfield signs that are connected to that circuit. However, a driver from a small-hub airport commented that the runway lights are always very bright, even on the dim setting, making it hard to cut the edge very close because of the glare and disorientation in the peripheral vision. One non-hub airport operator requests that the runway lighting be turned down, but not off, so that drivers are not blinded by the intensity of the airfield lighting. In contrast, the procedure at another airport is to turn off the runway lights as a means to eliminate confusion to pilots and reduce the risk of aircraft use. However, the lack of runway edge lights compounded the lack of visual cues for the snow crew. To illustrate how limited visibility and poor lighting can be confusing, one operator described a situation where a driver lost track of which side of the runway light he was oriented toward and ended up driving into the safety area.

Having a Category II/III instrument approach with centerline lighting and touchdown zone lighting makes it easier for a vehicle operator to discern the borders of the runway and one's position on the runway; however, most airports do not have such capability. Finding either the runway centerline for a beginning snow run or the sides of the runway or taxiway is a problem during winter operations because the pavement markings and lighting may be obscured. Using the obstruction lights on the localizer for a position reference on the runway was a trick one operator used. Another operator used obstruction lights on buildings or other fixtures as a reference.

MANAGING ENVIRONMENTAL CONDITIONS

There were a number of suggestions made by survey respondents regarding the most effective way to manage or address the problems brought on by wintry conditions or low visibility. To help with visual orientation, snow sticks mounted to edge lights are a common practice. Installing radius stakes around taxiway curves before winter season helped on several airports. One airport put reflective tape on the ends of signs as a way to help see where the signs are and for enhancing situational positioning. However, locating signs or edge lights proves difficult when, as another operator pointed out, the snow is so deep you cannot see either signs or lights. One airport operator commented on the benefit of runway guard lights, which is an available technology mentioned in chapter ten:

> Above ground runway guard lights (RGL or commonly called wig-wag lights) should be mandatory at all runway/taxiway intersections. In-ground lighting and surface markings are often obscured during snow/ice events. Compacted snow and ice can render those aids unusable for days following an event.

Several operators said the key to not having an incident, incursion, or collision with another vehicle is simply to slow down the operation as visibility declines. Maintaining proper distance from other vehicles was important and lighting on the rear of vehicles helped that purpose. This is supported in the literature search (*35*).

> We lead our snow teams with our most experienced operations staff. Most of the staff have over 20+ years working on the airfield, and they always know where they are. We also have the latest equipment with our runway snow teams. These vehicles are lit up like a winter holiday, and are easily seen in poor visibility conditions. They also have the best deicing capabilities like heated windshields, etc.

If the visibility gets too poor, several airports stated their policy is to stop snow removal operations until conditions improve. "Pull the operators off in low visibility—manage the risk," was the lament of one operator. When encountering a whiteout condition, one airport's practice is to stop and stay in position until it has passed. This requires good communication with other vehicles and with the ATCT, if in operation. In this case, the vehicle operators would all call in their positions to the designated supervisor or to the ATCT for runway evacuation instructions. If occurring at an uncontrolled airport, the risks must be evaluated beforehand as to what actions will be taken. For example, the point at which one airport ceased snow operations was the visibility reaching a trigger point of 300 ft RVR; for another, operations stopped when visibility was one-eighth of a mile (approximately 600 ft RVR).

The nature of wintry conditions makes it difficult for operators to see where they are located on a surface. It also makes it difficult to judge their distance from other vehicles or even the presence of other vehicles. Determining the best methods or procedures for working in these conditions is difficult because of the various operating capabilities and characteristics of the airport and its employees. The operational variability means that each airport needs to evaluate in more depth its exposure to risk. The implementation of an SMS can help in this evaluation and provide guidance for each operator. An SMS is a formal, top-down, business-like approach to managing safety risk. It includes systematic procedures, practices, and policies for the management of safety (including safety risk management, safety policy, safety assurance, and safety promotion) (*36*).

SUMMARY

Chapter four discusses the effect of winter environmental conditions on collision risk factors such as driver visibility and the absence of visual cues for snow removal efforts. The speed of vehicles was deemed to be a collision risk factor because higher speeds decrease driver reaction time and increase braking distances. Suggestions are made for the use of snow sticks and reflective tape to assist in recognizing positional placement. Consensus did not exist on whether runway lights should be on bright, low, or off when conducting winter operations. There were various comments received supporting each arrangement. Nor was there agreement on what to do during poor visibility conditions; that is, whether to stop in position on the runway or to pull all the vehicles off the operation until conditions improved. Because of the variability of operations at airports, it is suggested that each airport implement an SMS to evaluate their procedures in more depth. An SMS is one avenue for accomplishing proper evaluation, as is pre- and post-season review of the SICP.

CHAPTER FIVE

HUMAN PERFORMANCE

Human factors involves gathering information about human abilities, limitations, and other characteristics, and applying it to tools, machines, systems, tasks, jobs, and environments to produce safe, comfortable, and effective human use (*9*). In aviation, human factors is dedicated to better understanding how humans can more safely and efficiently be integrated with the technology. That understanding is then translated into design, training, policies, or procedures to help humans perform better.

One of the primary human performance factor topics mentioned in the survey and associated with increasing the possibility of error and risk during snow removal operations was the issue of fatigue.

FATIGUE

Fatigue is widely recognized as a core safety issue in the air transportation industry. It is on the NTSB's list of most-wanted safety improvements in aviation (*2*). And while the NTSB aviation recommendations are directed more toward pilots and mechanics, the recognition of fatigue in other safety-related areas of aviation are of no less importance or impact. This is evidenced by the number of times respondents mentioned fatigue in the survey and in the examples they provided.

Fatigue refers to one's inability to maintain sufficient alertness in a job. In general, fatigue results from inadequate rest over a period of time, which leads to the physical and mental impairment of an individual. The literature search revealed that numerous studies on fatigue have been conducted in the aviation field, but the overwhelming majority has been directed toward flight crew members and aircraft maintenance employees. Fatigue has not been readily studied within airport operations and, in particular, snow removal operations. And while the air transport industry has been required by the FAA and ICAO to establish fatigue management practices in their operations, those working on the airfield have not been subject to such regulation.

Snow removal crews, in particular, are vulnerable to the effects of fatigue due to the long hours of operation, the nature of the environment the operators work in, and the time of day during which many snow events occur. An example of the long hours is illustrated in one non-hub airport's snow plan:

> The airport will have a maintenance crew and an Operations Supervisor on duty during winter months (November 1st through April 1st) from 4:00 a.m. until the arrival of the last air carrier flight each day. If needed, personnel shall work through the night to continue snow removal operations as warranted.

The FAA has recognized the impact of fatigue on airfield operations and has mentioned it in *AC 150/5210-20, Ground Vehicle Operations on Airports* (*3*) and AC *150/5200-30, Airport Winter Safety and Operations* (*12*) as a collision risk factor to be considered by airport management in their operational plans.

An individual engaged in winter operations can experience one of two types of fatigue: acute or chronic. Acute is short term and is experienced as a direct consequence of some activity, such as strenuous exercise or intense mental concentration, which often occurs during winter storm operations. Acute fatigue would be experienced during and after a typical winter storm requiring the operator to engage in winter operations for one day. Chronic fatigue (a.k.a, cumulative fatigue) is a cumulative state of tiredness and decreased alertness, and is directly related to the physiological need for sleep. Chronic fatigue is more severe and longer-term than acute fatigue. Chronic fatigue develops when an individual camps out at the airport and works continuously over the length of a major storm for several days without adequate rest or recovery. The risk of an error or mistake increases with the degree of fatigue experienced.

Recognizing when one is fatigued and taking action to counter it are two important components of a safe operating system. Research has determined that vehicle operators are aware they are fatigued, in part because they actively fight sleep by opening the vehicle window, turning up the radio, frequently moving around in the seat, drinking coffee, etc. (*37*). Recognizing symptoms of fatigue then becomes an SA issue that all vehicle operators and airport organizations need to address in their training and operations.

FATIGUE AS AN ISSUE

At its core, fatigue is caused by a lack of restorative sleep. The evidence from various studies suggests that there are three broad factors that can contribute to a lack of restorative sleep: (1) the time of day work takes place, (2) the length of time spent at work and in work-related duties (such as driving to and from work), and (3) the amount and quality of rest obtained prior to and after a work period (*37*).

Typically, combinations of these factors contribute to the risk of fatigue. For example, a person operating a vehicle at night, after extended hours on the job and with a lack of quality sleep prior to work, would be facing a significantly higher operational or accident risk than someone exposed to only one of the fatigue factors. Merely limiting the hours of work through regulation or by directive does not adequately address the problem of fatigue. Factors such as time of day, the amount of prior rest, and the timing of rest breaks are central to managing fatigue.

The National Road Transport Commission of Australia has developed a Fatigue Management Scheme module that, although focusing on truck and heavy vehicle operators, has implications for airport snow removal operators as well (*38*). To qualify for the Fatigue Management Scheme certification, operators and drivers must identify and manage fatigue risk factors such as trip scheduling, driver availability, time working, lifestyle, quality of rest, and driver health standards.

A key feature of the Australian regulations is the inclusion of a "chain of responsibility" provision. This refers to the notion that airport organizations, from front-line supervisors to executive management, have responsibility for preventing incidents and accidents by implementing fatigue-related countermeasures. This is very similar to current FAA efforts to implement SMS at airports. The organization has as much responsibility as does the individual employee, if not more so, for alleviating fatigue and stress factors among its employees.

In reviewing the snow plans of the airports, it became apparent that such fatigue countermeasures were not part of an airport operator's SICP or training regime, nor were they even mentioned. A review of separate policy and procedure manuals for several airports did mention fatigue, but they did not go into detail as to how to mitigate it. There was no guidance given for shift duty time, adequate rest time, off-duty-related activities, physiological health factors, or other similar causes of fatigue.

FATIGUE FACTORS AND CAUSES

When asked to list the factors that they had experienced or thought contributed to driver fatigue or impairment, survey respondents identified factors that could be grouped into the following general areas: long work hours without breaks, irregular time, stress, boredom, environmental conditions, vehicle design and ergonomics, personal health, and staffing.

Long work hours with no breaks was the main factor that many of the respondents to the questionnaire said contributed to the buildup of fatigue, or which resulted in driver impairment. Unfortunately, working double shifts seems to be the norm in the industry in light of the unpredictability of when snow events occur and the need to finish the job before anyone can go home. This has implications associated with staffing levels.

Surprisingly, staffing levels were not cited as a prominent factor by respondents, but certainly staffing levels have a lot to do with "seat time." There seems to be an acceptance within airport organizations that staffing levels are set and employees are expected to get the job done no matter how long it takes. Long hours without breaks were commonly cited, more so at smaller airports than larger ones. Larger airports appear to be able to rotate individuals, thereby being able to give breaks. And even if given a break, several respondents noted how difficult it was to actually rest, in part because of the nature of the operation (need to stay on top of the snow event or to get the airport open), the individual being "wired" from too much stimulant (caffeine, high activity, etc.), or no place to rest (breaks taken out on the field, in the cold, or in the vehicle).

Contributing to the fatigue experienced while at an airport, several respondents cited how one spends their time *before* the snow event as a major factor affecting their abilities. Many respondents recognized the need for rest beforehand but cited the irregular and unpredictable timing of a snow event as impacting their need for rest. For instance, if they had little rest in the days prior to a snow event, or if they get a call while sleeping, or if having been sent home early to rest for the predicted snow event only to not be able to rest because it was out of sync with their circadian rhythm, the sleep disruption combined with stress creates additional burdens affecting their performance and decision making.

Although long working hours was the primary factor cited, one respondent noted that long working hours might not be so bad if the task of snow removal wasn't so boring at times. Idle sitting time waiting for an aircraft operation to be completed prods the body to rest. From that rest the body must be jolted into action when time comes to resume operations. One respondent noted how different the transition was from highway plowing to airport plowing. On the highway, the variability and obstacles kept him attuned and concentrating on the task. At the airport, the monotony and repetition of going up and down the runway made it easy to become complacent.

Fatigue can impair a driver's decision making and performance. So can stress—a factor that often contributes to mental and physical fatigue. Stress emanates from the need to keep the runway open, to not cause harm or damage, to get things done quickly, to satisfy other's demands (bosses, airlines, tenants, landside operations), and by aircraft wanting to operate on the movement areas. But according to the survey respondents, those are not the only sources of stress. They also cited home life, job satisfaction, and the drive to work itself (the need to get to work in worsening snow conditions) as factors.

Stress, of course, affects a person's performance. A little stress is beneficial in maintaining alertness. Too much stress, however, and a person becomes overwhelmed, ineffective, and starts to make errors. Stress is the body's reaction to a change that requires a physical, mental, or emotional adjustment or response. To better manage stress, research indicates that one must take care of the physical, mental, and emotional components of stress (*38*). Factors such as age, proper nutrition, and taking medications were mentioned by respondents to the questionnaire as having an affect on one's ability to manage stress. Several individuals made note of the eyestrain caused by blowing snow and bright lights as a major factor contributing to fatigue.

Blowing snow and brighter than normal lights constitute part of the operating environment the drivers encountered during winter operations. Because snow plows can operate at speeds up to 40 mph during snow removal, the need to see as far forward as possible requires lights that will illuminate as far as possible, which means more powerful and brighter lights than normal vehicle headlamps. Together, the bright vehicle lights and runway lights set at high settings contribute to driver fatigue. Vehicle engine and wind noise, climate control fans blowing, and the chatter of various aviation radio frequencies, all contribute to environmental factors causing fatigue. When one adds the alternating cold and heat of the outside and inside cabin environments into the situation, one can understand why those factors were cited by respondents as contributing to fatigue and driver impairment.

Snow equipment manufacturers have only recently attempted to address in their vehicle designs some of the environmental factors stated earlier, as well as some of the ergonomic factors that have plagued drivers in the past. Quite a few respondents mentioned vehicle design parameters as impacting their performance. It was clear by the survey response that some airports are still using old equipment, in that respondents cited the following as affecting their abilities: controls were not laid out well, the seats were uncomfortable, the condition of the cabin was old and worn, there wasn't room to move around in the cab, some vehicles still had manual transmissions requiring constant shifting, and the vehicles experienced frequent breakdowns. Vehicle design parameters are discussed in greater detail in chapter eight.

FATIGUE MITIGATION AND MANAGEMENT

Given that there are many different factors causing fatigue, they can be grouped into common attributes, as can the responses for mitigating or managing them. The groupings are best described as the following: limit duty time, provide sleep or rest facilities, provide food and drink, provide frequent or adequate breaks, rotate assignments, consider ergonomic factors, and other.

Limit Duty Time

Limiting duty time was the most frequently mentioned suggestion for mitigating fatigue. The length of duty time varied among airports. A maximum of 12 h of duty time was mentioned by several respondents. General aviation and non-hub airports, where the norm is to have but one daily shift of maintenance operations, would be most likely to utilize that length of time. Beyond 12 h of duty time, fatigue becomes a factor for professional drivers (*24*). At larger airports, where multiple shifts are staffed, the suggestions were to limit the employees to one normal shift or to no more than 10 h, and/or to stagger the staffing over several shifts. Several airports cited policies of 4 to 6 h on and 4 to 6 h off.

Sending one shift home early in anticipation of a later recall is practiced by several airports. However, the assumption is that shift personnel being released early will go home and get some rest. A drawback to the procedure is that often the individuals are not able to get rest due to family activity, circadian rhythm functions, or other circumstances, so they return to work fatigued, provided the roadway conditions allow them to return. The duty time limitations can be implemented more easily if the airport provides rest and food facilities for its employees at the airport.

Provide Sleep or Rest Facilities

During major winter storms, it is not uncommon for airport employees to remain at the airport for days. Several small and non-hub airports indicated they have sleeping quarters or cots set up in the maintenance facility. However, a good rest environment was deemed just as important to the operators. At primarily medium-to-large-sized airports, resources exist to secure lodging for their personnel at local hotels, which several do.

Provide Food and Drink

Survey respondents indicated the provision of food was deemed an important factor in combating the symptoms of fatigue, and it also has been identified by the FAA in its research. The FAA has noted in its fatigue countermeasure brochure that eating frequently and wisely to prevent low blood sugar reduces the effects of fatigue (*15*).

Some airports provide food or have it catered as a way to ensure proper nutrition for their employees. It also serves as a way to reduce the amount of time away from snow removal operations. Other airports will provide a snack pack for employees to take with them in the vehicle. Making sure the coffee pot is in good working condition is vital at many airports, though several respondents specifically mentioned the caffeine-potent "energy drinks" as an alternative. In a preliminary study, a specially formulated energy drink was found to have a consistent effect on sleepiness, lane keeping, and speed choice in traffic (*39*).

Although caffeine can increase vigilance and decrease the feeling of fatigue, it can also postpone sleep (whether desirable or not), impair the quality of the sleep that one gets, and can increase one's heart rate and blood pressure. Too much caffeine and operators will have difficulty recovering from long hours of work because their rest or sleep time will not be very restful. For restful sleep, the recommendation is for caffeine to be avoided for 6 h before going to sleep. A snow plow driver may find this difficult to do when completing a 12-h shift and having to return the next day.

Caffeine normally has its peak effect 1 to 3 h after being consumed. Individuals who regularly use caffeine develop a tolerance to it and eventually need more caffeine to feel the same effect. This makes it more difficult to use caffeine "strategically," because a lesser effect will occur when it is needed the most. Individuals who do not regularly consume caffeine will be more sensitive to its effects and, therefore, will find it easier to use caffeine strategically. Sensitivity to caffeine also changes with age so that as one gets older, one tends to get more of a "lift" from the same amount of caffeine.

Provide Frequent or Adequate Breaks

Based on the comments received in the survey, long hours are the expected norm during winter operations, especially at smaller airports that have fewer employees than larger airports. The comments received suggest that airport organizations do not typically plan increases in the number of employees during winter operations. Instead, they view the snow event as an anomaly that is to be managed using normal staffing levels and budgets. A normal solution to inadequate number of personnel is to increase existing employee hours but try to give them more frequent rest breaks. A second solution is to enlist building maintenance or other non-airfield personnel. That activity can increase the risks of a vehicle–aircraft incident, however, because the individual's experience and training in airfield operations may have lapsed. A best practice would be for airport management to have an integrated training regime to keep individuals current in airfield operations.

Frequent breaks were cited by a majority of responders as the way to mitigate the effects of fatigue factors. After getting adequate rest, the FAA has identified that standing up, stretching, and walking around as much as possible is a prime method for countering the effects of fatigue. Associated with taking frequent breaks is the suggestion made by many survey respondents to break up the monotony of snow removal operations by rotating assignments or jobs.

Rotate Assignments

Rotating employees between plows, blowers, sweepers, and other assignments combats fatigue by allowing the use of different motor skills and mental processes. The use of different skills and processes counters the boredom cited as a major cause of fatigue. Rotation every 4 h was the conventional wisdom expressed by respondents.

Consider Ergonomic Factors

Previously noted as a fatigue factor was the design and/or ergonomics of the vehicles used in winter operations. It is no surprise that a solution to that issue is to have newer vehicles with better seats, increased comfort, reduced noise levels, and better ergonomic layout of controls.

Other

Under the last broad area of survey response are a number of technologies and suggestions that point toward both the organization and the individual for managing the fatigue factors associated with winter operations. The simple act of rolling the window down to get cold air, or keeping the plows going and not stopping, using radio chatter and humor to keep spirits up, and talking to oneself to remain focused, all point toward the motivational aspects of combating fatigue. One respondent suggested as a motivator to remind every one of the overtime pay they would receive.

Although self-motivation can be a deterrent to fatigue, organizational efforts to manage fatigue are more effective. Having supervisors closely monitor the efforts of the snow removal crews for signs of fatigue; upper management support of policies to provide duty limits, adequate breaks, job rotation, sleeping quarters and food; or reducing stress and managing expectations of personnel through budget expenditures and well-planned options for bringing in support personnel are all examples of how an airport can indirectly reduce gaps that exist in the risk factors involved in winter operations. A well-thought-out SMS can create an organization that will support such efforts.

The following case examples of fatigue are from the questionnaire responses.

- At one large-hub airport, the approach to mitigating fatigue factors is as follows:

> Personnel are on duty around-the-clock during a snow event. Bunk, locker rooms, and shower facilities are provided. Crew scheduling was based on previous US DOT over-the-road regulations. During extended events, the full crew is broken into half or thirds to facilitate rest periods. Personnel are on the clock when they are sleeping. At airport insistence, equipment manufacturers have allowed vehicle operators to have input into the design of new operator cabs that feature improved ergonomics, better climate control, improved visibility, and user-friendly controls. The lack of cup holders was one of the largest operator complaints. We encourage operators to communicate to a manager that they are becoming fatigued. Breaks will be scheduled with no consequences to the individual. Five-minute cat naps (proven to alleviate short-term fatigue) are allowed in a vehicle, as long as that vehicle is parked in a safe location.

- Another large-hub airport takes the following approach:

> The airport operates two separate teams that work six (6)-hr shifts. The shifts start and stop 0600, 1200, 1800, and 0000 hrs.

> The basic rule is to switch at these times unless vehicle movement started within an hour of one of the start-stop times. This is the operator's time to eat, sleep, and shower. The Authority has kitchen staff that prepares breakfast and lunch. Meal times are 0500-0730 hrs for breakfast. Lunch is from 1100–1330 hrs. These times allow for both teams to eat if they choose to. Dinner is at the Marriott located on the airport property.

- A small-hub airport shares its lessons as follows:

> In the past, we used to have the same crews here to work a snow removal operation for as long as it took. There were times when the crew spent numerous days on airport property without getting home. Now, we have attempted over the past few years to split our crews into separate work crews during different times of the day. Due to our decreased amount of traffic here, after 2300 each day, we attempt to ensure that we have one of our main runways cleared and clean for any arrivals/departures between 2300 and 0400. We either give some of the workforce time to get some sleep who are here on site, or have a fresh group of personnel who have been home resting get underway with a full field snow removal cleanup starting at approximately 0400 for the morning aircraft operations. This, too, has worked out well for us.

- From a non-hub airport, their approach is as follows:

> This year we are going to have 2 crews so we can have someone on the field at all times. They will be on 7-hr shifts. First crew will be on duty while the other crew is on break to eat, shower, and sleep (they are paid for the whole time).

- Another non-hub airport took the following approach:

> We keep water on the field to keep the drivers hydrated, we try to give drivers mental breaks between each runway plow operation, and when possible we try to swap out our plow drivers. We also have a lot of discussion on the radio from the supervisors to keep staff engaged and on track.

The FAA has produced a report (*27*) that details some of the factors affecting fatigue in aviation operations. In that brochure some of the myths and truisms that apply to fatigue are presented. Those factors have the following effects (*27*, pp. A5–A6):

> ALCOHOL
> Drinking alcoholic beverages may help you to fall asleep faster, but it will make the quality of sleep that you get worse than it would have been if you had no alcohol.
>
> LIGHT, HEAT, and NOISE
> Sleep in a cool, dark, quiet place. Constant "white noise" (like the hums produced by air conditioners and fans) help to cover up other noises, making them less likely to disturb your sleep.
>
> PAIN RELIEVERS
> Some pain relievers can also interfere with getting enough sleep. In one study, people who were in no pain and given aspirin or ibuprofen (e.g., Advil®, Motrin®) before bed, woke up more often and spent more time awake during the night than when they took acetaminophen (e.g., Tylenol®) or a placebo.
>
> SMOKING
> Nicotine is a stimulant and cigarette smoking can interfere with sleep.
>
> CAFFEINE
> Everyone knows that drinking coffee near bedtime can make it difficult to get to sleep. What you may not know is that caffeine can also disrupt sleep even in people who fall asleep easily after consuming caffeine. For a better night's sleep, avoid caffeine for six hours before bedtime.
>
> TIPS FOR MAINTAINING ALERTNESS ON THE JOB:
> Now that you know how to get a good night's (or day's) sleep, here are some other tips to help ward off fatigue and keep you alert:
>
> - Stand up, stretch, and walk around as much as possible.
> - Eat frequently and wisely to prevent low blood sugar.
> - Spend break time under bright lights.
> - Wearing sunglasses changes the appearance of colors on a display and can increase your chances of mistaking one color for another.
> - Certain medications can affect your color vision. For example, Viagra® (sildenafil) can affect the ability to tell the difference between green and blue.

This information is presented because many respondents to this synthesis study thought differently about the effects of these factors.

There are also a number of fatigue management technologies that are becoming available to help maintain operator alertness and performance levels by detecting operator fatigue and interfacing with the operator and/or supervisor to prevent accidents and incidents (*17, 40*). Examples of such technology are eye-gaze detection systems, head-nod detectors, vehicle monitoring systems, in-seat vibration systems, physiology/behavioral devices, and mental reaction time tests. Use of fatigue management technologies in the airport setting was not indicated by any of the respondents to the questionnaire.

Human factors have long been recognized for its role in producing errors. For winter operations, fatigue is a major human factor that needs to be better addressed in the training efforts of airport organizations. Recognizing the symptoms of fatigue is an SA issue that all vehicle operators and airport organizations need to address in their training and operations.

SUMMARY

Chapter five discusses how fatigue is widely recognized as a core safety issue in the air transportation industry, with it being on the NTSB's most-wanted list for safety improvements in aviation. However, fatigue has not been readily studied within airport operations and, in particular, snow removal operations. The review of airport snow plans indicated that fatigue countermeasures were not part of an airport operator's SICP or training regime, nor were they even mentioned. Recognizing when one is fatigued and taking action to counter it are two important components of a safe operating system. The chapter provides a basic understanding of fatigue and stress and ways to manage each.

When survey participants were asked to list the factors that contributed to driver fatigue or impairment, the factors cited could be grouped into the following general areas: long work hours without breaks, irregular time, stress, boredom, environmental conditions, vehicle design and ergonomics, personal health, and staffing. Stress and its causes are discussed as a factor affecting human performance. Stress was found to emanate from such things as the need to keep the runway open, to not cause harm or damage, to get things done quickly, to satisfy other's demands, and to satisfy demands by aircraft wanting to operate on the movement areas. Other sources of stress that were cited were home life, job satisfaction, and the drive to work itself. Stress adds to the fatigue factor.

The literature identified factors such as time of day, the amount of prior rest, and the timing of rest breaks as being central to managing fatigue. Respondents identified limiting duty time, providing sleep or rest facilities, providing food and drink, providing frequent or adequate breaks, rotating assignments, and paying attention to ergonomic conditions as all being means to enhance human performance. Properly managing fatigue and stress requires both individual and organizational efforts. In this chapter, lessons are shared from airports as to how they address the collision risk factor of human performance at their airports.

CHAPTER SIX

SITUATIONAL AWARENESS

Highlighted in a brochure from the FAA Great Lakes Region were three actions that an individual driver can take to help prevent incursions or incidents on the airport during snow removal activities (*41*): (1) maintain SA, (2) improve communication, and (3) follow proper procedures.

In a later bulletin, the Great Lakes Region reported during the 2006 to 2007 winter season that 20 vehicle deviations had occurred on airports in the region, of which 9 involved snow removal equipment (*41*). Six of those were classified as runway incursions that resulted in a conflict with an arriving or departing aircraft. The brochure went on to state the following:

> We see one common denominator in nearly all incidents involving snow removal equipment. Please do not underestimate the importance of maintaining situational awareness while operating on the airfield at all times. Weather conditions, fatigue, and other factors play a role in detracting from optimum vehicle operator performance.

Many of the collision risk factors mentioned in chapter two can be addressed by thorough and proper employee indoctrination and training. And while this training generally does occur, the effectiveness of such training varies widely from airport to airport. The introduction of human factors involves knowledge of those factors that affect a person's SA.

> Generally, the ability of a driver to operate a vehicle safely is based on the perception of a situation, level of alertness, the amount of information available, and the ability to assimilate the available information (*42*).

INTRODUCTION

SA was previously explained as being a continuous process of attentiveness and surveillance that results in an accurate perception of the factors and conditions affecting an individual and his or her environment during a defined period of time (*28*).

Two important factors contribute to SA. First is what a driver or operator assumes to be true about the situation he or she is experiencing or facing based on the facts he or she has available at any given time. This is known as the theory of the situation.

Second is the set of skills and experience a person will utilize to address his or her theory of the situation. This is known as the theory of practice. If an individual's theory of the situation is aligned with reality, then a driver is more inclined to make good decisions about what actions to take. If an individual then has the set of skills and abilities to properly take action based on the assumptions (theory of practice), then a safe outcome is more probable.

A review of V/PD reports compiled by the FAA for FY2007 and reports culled from the NASA Aviation Safety Reporting System (ASRS) database (see Appendix C) provide insight on how a lack of SA can contribute to an accident or incident.

Following are two examples from the ASRS database where SA may have played a role (*43*):

> As our airplane accelerated towards V1 speed, both cockpit crew members noticed the snow removal vehicle on what appeared to be a collision course with our aircraft and continuing towards the runway at a rapid pace with no obvious signs of stopping before entering the runway. At some point very close to our V1 speed, the driver of the snow removal vehicle appeared to very abruptly stop at a very close distance from the edge of the runway just as we passed by him. We were able to continue our takeoff past him uneventfully. The snow removal vehicle driver was not exercising due caution and safely operating his vehicle given the slippery taxiway conditions. [ACN 540191]

> We were able to visually confirm that the runway of landing was clear of snow removal equipment. We also noticed equipment removing snow on the crossing Runway 15/33. I mentioned to the captain that a snow plow was moving rapidly on Runway 33, from our left toward our landing runway (Runway 28). As we descended, we discussed that if we had to go around what the process would be. With our plan in place, as we reached 200 ft AGL, the plow proceeded to cross onto our runway. Upon entering our runway, he made a turn that looked as if he realized his mistake, but turned out to be him setting up for his u-turn to go back onto Runway 33. . . . We made a visual pattern back around and landed without further incident. Tower asked equipment people if they had been on the runway. We did not hear the reply. It pays to keep your eyes open, situational awareness up, and be ready with a plan if things go awry! [ACN 496828]

Loss of SA and improper communication are not issues just for vehicle operators; it applies to ATCT controllers as well. In a review of past studies, the MITRE Center for Advanced Aviation System Development, the Runway Incursion Joint Safety Analysis Team, and the Volpe National Transportation Systems Center determined an overwhelming number of both pilot and controller errors can be classified into the category of "loss of situational awareness" (*44*). Specifically, when tower controllers are involved in an operational error, it is typically due to one or more of the following (*45*):

- Forgetting about an aircraft, a closed runway, a vehicle on the runway, or a clearance that the controller issued;
- Miscalculation of the impending separation;
- Communication error: hear-back errors (i.e., failing to catch a read-back error);
- Misidentifying an aircraft or its location (and issuing an instruction to the "wrong" aircraft); and
- Incomplete or inadequate coordination among controllers.

For these reasons, vehicle drivers need to improve their own SA because they may be affected by others who may not have SA. Some general suggestions from the FAA for maintaining SA and improving communication follow (*41*):

- Review current airport surface conditions before starting snow removal operations.
- Know where you are on the airport and where you are going at all times.
- Keep airport/taxi diagrams readily available during snow removal operations.
- Be on the alert for aircraft, vehicle, and pedestrian activity.
- Make proper contact and communication with the control tower, if open.
- Monitor and announce position and intention over the CTAF or be under the control of a radio-equipped vehicle, if there is no tower or it is closed.
- Work out a method of signaling to clear the runway, etc., ahead of time.
- Listen before you transmit. Monitor radio communications to establish a "mental picture" of airport activity, if able.
- Think before keying your transmitter. Keep communications with the controller clear and concise.
- Never assume. Make certain you understand all instructions.

Read back runway hold-short instructions and clearances verbatim.

- Follow proper procedures.
- Install a compass vertical card, digital compass, or regular compass in the vehicle.
- Install GPS handheld displays in the vehicle.

SOPs provide a structure that helps to decrease the probability of human error and attempts to capture errors before they result in a runway incursion. By applying SOPs to surface operations, vehicle operators can reduce the probability of a runway incursion by increasing and maintaining SA within the safety of procedures previously agreed to and made clear to all.

Proven and effective procedures are imperative for safe ground operations. Several identified by the FAA follow (*41*):

- Limit conversations when on runways; avoid unnecessary communication.
- Be vigilant, especially when on or near runways.
- Be aware of current airport surface conditions.
- If lost, notify ATC immediately. If in doubt, ask!
- Make your equipment visible by appropriate use of lights.
- Ensure your vehicle's radio operates properly and use radio headsets and noise-canceling microphones as needed.
- Use good judgment, should radio failure occur.
- Never stop on an active runway unless coordinated with ATCT.

IMPROVING SITUATIONAL AWARENESS

One of the recommendations from *AC 150/5200-30, Airport Winter Safety and Operations*, for helping to prevent runway incursion after the runway reopens is to ensure that taxiway directional signs, runway holding position signs, and other light fixtures have been cleared of snow blockage and are legible and distinguishable to drivers and pilots (*12*). These actions improve SA because an operator can interpret his location on the airfield better.

The following suggestions are actions derived from *Advisory Circular 120-74A, Parts 91, 121, 125, and 135, Flightcrew Procedures During Taxi Operations* that can be applied to airport vehicle operators (*46*). To help improve SA, it is important for a vehicle operator to

- Understand and follow ATC instructions and clearances;
- Have an airport diagram available for use;
- Know and use all of the visual aids available at the airport, such as the signs, markings, and lighting;
- Monitor ATC instructions or clearances issued to other aircraft;
- Make a mental or physical note of the position of aircraft traffic and be especially aware of the elapsed time from ATC communication to any expected aircraft operation;
- Prior to entering or crossing any runway, scan the runway, taxiway, apron, and/or final approaches for other aircraft or vehicles;
- Use a "continuous loop" process for actively monitoring and updating their progress and location during snow removal or low visibility operations. This includes knowing the vehicle's present location and mentally calculating the next location on the route that will require increased attention (e.g., a turn onto a taxiway, an intersecting runway, or any other transition points). As the "continuous loop" is updated, operators should verbally share relevant information with other operators in the group; and
- Write down ATCT instructions, especially if you will be operating in an area for an extended time, or mark it on an airport layout drawing.

Other suggestions for consideration in mitigating or reducing incursions are provided by survey respondents as follows:

- "Make the call signs for vehicles on your airport unique from each other. Instead of having Operations 1, 2, 3, etc.; Plow 1, 2, 3, etc.; and Blower 1, 2, 3, etc.; have Operations 11, 12, 13, etc.; Plow 21, 22, 23, etc.; and Blower 31, 32, 33, etc."
- "To enhance a vehicle's presence when on a runway, turn on driving lights day or night, similar to what large aircraft operators do when commencing their takeoff roll or landing."
- "After each snow event, have a debriefing with members of the snow committee, or at least the ATCT tower chief to discuss lessons learned. Keep written minutes for referral."
- "Install tunable radios that have at least a two-frequency quick switch (flip-flop) capability."
- "Sound deaden the vehicle cabs. Provide headphones if necessary."
- "Place FAA-provided airfield signs and marking placards in vehicles."
- "Place an airport layout diagram in the cab."
- "Provide a writing instrument and pad in easy reach for writing down ATCT instructions."
- "Mark vehicle exteriors with large identification numbers."
- "Issue NOTAMs and inform FSS, TRACON, or CENTER of changes."
- "If radio communication is lost between ATCT personnel and the equipment operators, ATCT personnel should rapidly flash the runway lights on and off as a signal for the operator to clear the runway."
- "Repeat all instructions with ATCT."
- "Have one person monitor runway intersections."
- "Limit area of operations [to one section or one taxiway or one runway or one apron area]."
- "Limit operator hours."
- "[When plowing a runway/taxiway intersection] Clear snow up to the next taxiway [rather than just to the hold line to prevent turnarounds from entering the runway safety area]."
- "Specifically ask ATCT for turnarounds from a connector taxiway onto the runway to clear the hold line area."
- "[For non-towered airport] All drivers should monitor CTAF or assigned frequency [while only one crew member communicates with aircraft]. Crew leader makes assignments and tracks progress. Crew leader verifies all clear, reports the same to aircraft, and directs staff on/off the runway."
- "Place compasses in the vehicles [to enhance SA]."
- "Have operators not accustomed to operating regularly on the movement area or the AOA drive more frequently year around [training]."
- "Require through NOTAM a 10-min notification for prior permission to land [if airport does not have an ATCT]."
- "Maintenance supervisor in the lead vehicle of the snow crew activates a blue light on his vehicle to warn the snow crews of a pending aircraft operation."

SUMMARY

Chapter six addresses the importance of SA as a collision risk factor. Not having SA increases the possibility for an incursion incident. An overwhelming number of both pilot and controller errors can be classified into the category of "loss of situational awareness." This chapter presents suggestions to increase one's SA from the literature, FAA guidance material, and responses from the questionnaire. The application of SOPs provide a structure that helps to decrease the probability of human error and runway incursion by increasing and maintaining SA. The chapter emphasizes that training and indoctrination into the principles of SA can lead to safe outcomes.

CHAPTER SEVEN

PRESSURES TO KEEP THE RUNWAY OPEN

The challenge of keeping the runway open during winter operations is cited as one of the main factors of stress on equipment operators and management. Stress contributes to fatigue, which contributes to increased errors and the possibility of incursions. This synthesis study sought to identify some of the factors that create pressure and a sense of urgency for equipment operators. One respondent summed up the pressures at his very busy general aviation airport in the following way:

> One of the main factors is the length of the storm. If staff has been plowing longer than 10–12 hours, there is a sense of urgency to finish snow removal because fatigue begins to set in. Other factors that can contribute are holidays and the staff's resulting desire to get home. If plowing occurs overnight, there is often a desire to finish as much area as possible before traffic picks up the next morning. There can also be pressure from tenants to have runways, taxiways and ramp areas cleared before their scheduled departure. Even the Tower Controllers can pressure the staff to complete snow removal. Any time the main runway is closed (which is the only runway with an ILS [instrument landing system]) for any reason (such as contaminant, a disabled aircraft, etc.), there is tremendous internal and external pressure to do whatever necessary to get the runway open quickly and safely.

TIME PRESSURES

A review of other survey responses highlight common themes behind the sense of urgency:

Customer Service Pressures

- "Pressure by airline and tenants to remove snow from their operations."
- "Aircraft taking delays or canceling flights. Demands by air carriers for better airfield conditions when you are doing the best for the situation that is present."
- "Corporate pilot expectations."
- "While airline schedules are reduced in a snowstorm, there is more pressure to run more flights. The faster that runways can be cleared, the more traffic can be accommodated. With aircraft at 85% load factors, we try very hard to keep our runways open so more of our customers can get to their destinations. When we don't meet our goals, aircraft often hold and possibly divert, costing airlines money and customer inconvenience."
- "Other tenants' pressure, customer service mission in general. (How soon can you be done? How many staff members are working now?)"

Authority Figure Pressures

- "ATCT asking about runway conditions and when things will be clear of snow and usable."
- "Managers asking how come it isn't done yet, saying they would have had it open already, even though equipment is broken down."
- "Management decision to keep airport open when surrounding destination airports are closed."
- "Aircraft waiting to take off or land."
- "Charter flight arrivals/departures."
- "Airport, airline, and ATCT pressure to not close and then to reopen quickly (numerous and repeated calls to snow removal commanders)."
- "There have been times when conditions on the runway are poor due to snow or ice accumulation, but staff was unable to plow the runway immediately because of the ATCT's need to land 'just one more aircraft.' It puts the Snowboss in a difficult position to either allow an operation when the runway conditions are poor, or make the decision to close the runway at the risk of antagonizing the ATCT and landing aircraft."

Economic Pressure

- "We constantly work to maintain and expand air service at our non-hub facility. Every flight delay and cancellation can have a negative multiplier effect on future air service. This is always forefront in our minds when we shut down for snow removal."
- "Winter operations is an irregular or emergency operation. For us, we operate with one runway versus our normal two parallel and we take air traffic delays as a result. The urgency is to restore the airport to normal operating conditions as quickly and safely as possible."
- "Impact of runway closures to the national ATC system."
- "As a one runway airport, during the ski season with occasionally 150 GA jet operations, we receive considerable pressure as to how soon we will be open. Our major problem is a heavy snow shower or squall and very, very shortly after the sun is out and now everyone is trying to come in or leave."

Air Carrier Pressure

- "For our large-hub airport it is the inbound international arrivals—Airport Ops knows what is on the horizon and it is up to the snow team to have the runway ready when the airplane arrives."

- "Our non-hub airport has only one primary runway. When it is closed it affects a lot of people. Bare and dry is the safest condition on an airport and we want to get there as soon as we can."

Safety and Personal Pressure

The following pressures reflect a portion of the actual pressures experienced during any one snow event:

- Pending Lifeflight departures or organ donor flights,
- Being called in late followed by broken equipment, and
- The desire to reduce the impact to aircraft operations.

The pressures come from many sources because of the different goals that each source seeks as an outcome. Snow removal stands in the way of achieving those individual or company goals. For instance, airlines seek on-time performance, corporate operators seek business meetings, FBOs seek fuel sales, flight schools seek billable aircraft hours, charter operators seek contractual fulfillment, municipalities seek community pride or economic impact, terminal tenants seek passenger business, employees seek job retention or family goals. All of these competing goals center on having the runway open and available for use. Reducing pressures on employees can be somewhat difficult as the following survey respondent implies:

> I don't believe they [pressures] can be reduced. It is in the nature of the business that time is money and all the pavement areas need to be cleared. That everyone who asks about it has a good reason for asking about it.

MANAGING PRESSURES

The sense of urgency and the accompanying stress and fatigue is difficult to specifically identify as a cause of runway incursions or unsafe operations. An NTSB investigation would normally cite those factors as being contributory rather than primary. The question of how to manage or mitigate the pressures was sought in the synthesis survey by asking, "how can the internal and external pressures associated with resolving or completing winter snow removal operations be reduced or minimized?" Responses can be grouped into four key areas: preparation, management of expectations, adequate resources, and proper communication.

Preparation

- "I don't feel the pressure can really ever be reduced or minimized. As an airport operator, we have an obligation to work in a quick and effective manner to keep our travelers flying. This also has to be conducted with safety in mind at all times. Preparation is key."
- "The key approach is to establish priorities for which areas of the airport to plow and stick with it."
- "Although we strive for minimal delays and disruptions in operations when in winter operations at our medium-hub airport, it is expected that there will be delays. This helps. However through comprehensive training and planning efforts throughout the year, we are able to mitigate those delays and disruptions."

Management of Expectations

- "Maintaining accurate levels of expectations regarding timelines for the reestablishment of airport operations."
- "Education to corporate pilots, FBOs, etc., of what operators (snow removal) are up against."
- "Personnel and equipment have certain maximum levels of productivity. Educate the persons outside those directly involved that clearing the runway is not a 15-min operation."
- "Pressure is a GOOD thing. It keeps us sharp and operating at our best. If it took us 2 days after a snowstorm to open an airport we wouldn't be helping any of our customers. People expect that weather should not affect them in this space age. We try to accommodate that expectation. Besides, we NEVER compromise on safety. We just work smarter and faster."
- "We are inadequately equipped and staffed for snow removal. Nevertheless we are expected to deal quickly with snow. Either expectations must change or resources must be improved. Neither is likely to occur."

Adequate Resources

- "Improve forecasting and real-time weather data."
- "A wireless airfield so operations can update information without having to go back to the office."
- "Sufficient and higher capacity snow removal equipment."
- "Sufficient manpower."
- "More personnel and better equipment."
- "Replacement of old and inefficient equipment."
- "Additional equipment."
- "Additional operators."
- "Additionally, have an adequate number of personnel to have restful time off and breaks between weeks of work; having first-class equipment and good maintenance; having the right equipment for the job, instead of trying to do the work with inadequate equipment; and providing adequate storage facilities for the equipment, material, and personnel."
- "Having ample manpower to maximize use of top-of-the-line snow equipment in a timely fashion."

Proper Communication

- "Getting direction from operation department. [Knowing] what they want cleaned before going out in the field so you can bring the right equipment. Communication is the

key. If the team knows what they need to accomplish before they get out there, they take ownership of it."
- "Proper communications and updates with tenant businesses, ATCT, and FSS."
- "Solid communications—Involve local air traffic and local air carrier and/or airport users in every phase of snow removal from annual planning, individual event planning, actual operations, and a post-event review/critique. Establishing credible expectations (forecasting capacity) leading into an actual event is the best course of action in relieving internal and external pressures. Communicate to the users your performance goals and objectives, then exceed those expectations."
- "Our vehicle operators are in close contact with airline operations personnel, who inform us when an aircraft is airborne and its estimated time of arrival. Good communications and position report updates have pretty much eliminated the sense of urgency."

Given that there are many competing goals placed on snow removal operations and that there are four themes for mitigating the sense of urgency, it becomes incumbent on airport management to seek and promote a unifying purpose for addressing these needs. That unifying purpose, as one respondent said, is "to get everyone on the same page of safety."

- "Heavy emphasis on Safety, Safety, and more Safety."
- "From my observations, safety is paramount when working with the snow team."
- "Safety first. Someone running off and flaming out or worse will cause a closure of possibly a day or more, so having to wait until the runway surface is acceptable/safe takes little time in comparison."
- "We hold a winter operations conference at the beginning of our winter operations season with all of the air carriers and tenants. We hold a comprehensive review session to remind everyone of the airport's procedures for winter operations response. This has helped tremendously because when an event happens, the tenants are aware of the procedures and know what to expect."
- "Build a trust relationship with airport, airline, and ATC management that snow removal will be conducted as quickly as safety and conditions allow."
- "Snow removal operations usually shut down when visibility goes below 1/8 mi for safety considerations (highly unusual)."
- "Unsafe snow removal operations are not tolerated here at our medium-hub airport. In a situation where a snow squall may reduce visibility to zero, we have the crews stop in place until the visibility improves. This situation would never occur on an active runway, only on a NOTAM'd closed piece of airfield pavement."
- "Our procedures ensure that SAFETY is never compromised. While we try to work quickly, I can give you multiple examples of how we slowed down the operation to make sure we were safe and the airfield was operated in a safe condition. In 2005 we had a blizzard that dumped 7 in. of snow in an hour. We suspended operations which resulted in closing the airport. It took us 6 hrs to reopen with limited capability. But all our operators and passengers were safe."
- "At times you must defer to Mother Nature. Staff is instructed to make decisions on runway and/or airport status by always erring on the side of safety; they are to make decisions as if a loved-one is on the next arriving or departing aircraft."
- "Our crews take great pride in maintaining the facility. The previous "visual" perception that all pavement must be free of contaminant has been replaced with a "safety" culture, confirmed by surface friction readings."

The last comment reflects the growing emphasis on airports establishing a safety management system. Mentioned previously, an SMS strives to develop a culture at an airport that would mitigate the pressures and other risk factors common to winter operations.

SUMMARY

Chapter seven identifies some of the factors that create pressure and a sense of urgency for equipment operators, which can result in increasing the possibility of a runway incursion or collision risk. The pressures come from many sources because of the different and competing goals that each source seeks as an outcome. The chapter identifies as common themes behind the sense of urgency as being: customer service pressures, authority figure pressures, economic pressures, air carrier pressures, and safety and personal pressures. Examples from the responses of survey participants are provided. Also provided are responses to the question of how to manage or mitigate the pressures. Responses were grouped into four key areas: preparation, management of expectations, provision of adequate resources, and having proper communication. The sense of urgency is real for many airport operators and is considered a collision risk factor that needs to be addressed by airport management.

CHAPTER EIGHT

VEHICLE AND EQUIPMENT RESOURCES

Preventing runway incursions requires a multifaceted approach to addressing all the factors that affect a driver's ability to accurately identify where he or she may be located on the airport at any given time. The design of vehicles and equipment are factors to be examined in reducing the possibility of collision risk or incursion.

VEHICLE DESIGN

The design of a vehicle can have a major impact on a driver's ability to operate it safely. A primary factor for preventing collisions is the ability to see during winter or low visibility operations. Survey respondents cited blowing and swirling snow, night-time operations, frosted-up windows, and obscured markings and lights as common situations that decreased visibility. Environmental factors affecting visibility were previously addressed in chapter four. This chapter considers the design of vehicles and its impact on driver performance.

A strong opinion of respondents was that high-intensity discharge (HID) lights are the best for cutting through the blowing snow and projecting far down the runway or taxiway. One operator stated that the ability of HID to have a defined illumination was very beneficial, especially if angled down at about 30 degrees from eye level at the cab. The operator stated he only uses the HID lights when plowing because the light is "whiter" and not yellowish like other lights, especially when reflected by the snow. Halogen lights were preferred as the second choice of light. They are less expensive than HID lights, but not as focused in their illumination, and they require a higher lumen output to achieve the same level of illumination as HID lights (*47*). Regular vehicle lights or spotlights on vehicles were deemed by respondents to be not as effective as either HID or halogen lights.

Inadequate information exists on the use of light emitting diode (LED) lights in snow removal equipment or low visibility conditions, though research is advancing on its use in roadway vehicles. One airport identified that their use of LEDs in their rotating beacons were deemed superior to regular beacons. LED backup lights or rear-facing lights are available on some equipment and help prevent rear-end collisions. The accumulation of ice and snow on LED lights is of concern as LEDs do not generate the level of heat to melt ice as do other bulb types.

The placement of external vehicle lights has an impact on driver visibility; a location at eye level and angled downward is the preferred choice among respondents. The next choice was placement above the cab. This preference conflicts somewhat with a study accomplished in highway use, which stated that lights placed above the cab were not advantageous because they reflected too much light back into the operator's eyes (*48*). Lights mounted on top of a plow or sweeper are not perceived to be beneficial either because of the obscuration from blowback snow. High-visibility lighted (either by fiber or LED) or colored rods on the corners of sweepers and plows were deemed to help with SA for the driver as they could better determine the tracking of the attachment. Due to blowing snow or fog, one respondent said having a rear-facing fog spotlight on the back of the vehicle is important to prevent another vehicle from running into it. One non-hub airport has installed flashing red halogen lights for that same purpose. Another airport has factory-equipped LED lights. Normal vehicle brake or position lights were deemed inadequate for the purpose of providing adequate alert to a fast-approaching vehicle.

The type of lights to use and their placement on snow removal equipment are areas for more thorough study (*49, 50*). Providing small directional glare shields on lights was found to be beneficial. To further reduce glare, it has been found that having just a single spotlight mounted on the passenger side with the driver side spotlight turned off is advantageous (*47*).

If the vehicle lighting is proper, the next design item respondents frequently commented on were the windshields. The current design philosophy is to provide as much glass area as possible. For the front windshield, there are three basic designs: forward-sloped, flat, and reverse-sloped. Reversed-slope was respondents' preferred design during winter operations, because snow and ice accumulate less readily on it. To counter the accumulation, manufacturers have installed washing fluid deluge systems that flood the front and side windshields to remove snow and ice. These were found to be effective by airport users.

The deluge systems pumps heated windshield deicer fluid through a series of nozzles above the primary and side windows to rid the windows of accumulations and contaminants. One non-hub airport maintenance department sprays ice melter on the plow truck windshields with a 2-gal. garden sprayer when the wiper blades accumulate ice or slush. They place the sprayer in the cab so it is available while they are plowing.

Wiper blades are an important factor in keeping the windshield clean for clear visibility. However, the equipment manufacturers stated they provide only a heavy-duty winter blade that is often no different than what one can obtain for a private vehicle. As a result, ice and snow can still accumulate on them causing ineffective wiping action and viewing distortion. Older vehicles used to have ridges etched into the glass as a way to vibrate the blade to help it shed snow and ice. Several respondents implied that heated wiper blades were of value, but the most common request from respondents was for better wiper blades overall.

- "While following the brooms at such slow speeds (they are 10 mph tow-behinds), the windshield on the operations vehicle can get iced up to the point where the wipers don't do anything. The side windows of the broom's tow vehicles also get snow-covered."
- "While not one of the above-listed areas, it is helpful to check vehicle windshields before each snow season, especially when using sand. The pitted windshields should be replaced, as necessary, to provide better visibility for the next winter season."

Windows can be kept clear of frost, snow, or ice accumulation through the use of defroster systems, either electrical or hot air venting. The preference leans toward electrically heated windows and mirrors. Defroster systems can add to humidity buildup inside the cab as a result of the driver's breathing and body heat. Some airport operators have specified air conditioning units on snow removal equipment for eliminating moisture in the cabin. If not properly designed, defroster systems can contribute to driver fatigue through the generation of excessive noise or fluctuating cabin temperatures, and electric wires in the windshield can malfunction.

Good lighting and good defrosting are key components for increasing visibility. Another influential factor is the height of the cabin. Plows and sweepers generate swirling or blow-back snow over any attachments and onto the vehicle windshield. As one airport operator mentioned, being able to sit up high and look out and over the swirling snow makes a big difference in his ability to see where he is plowing and to see objects such as signs, markings, and aircraft. The popularity of vehicles with the cabins placed as far forward as possible and the engines mounted beneath or behind the cabin support this idea and have environmental noise reduction as an added benefit.

Associated with the generation of swirling or blow-back snow ("snow cloud" effect) is the design of the plow blade and deflectors, and the speed capability of the vehicle. All three affect the extent to which snow is blown up and over the blade or brooms and impedes forward visibility. A low-height mold board on a plow reduces the amount or height of swirling snow as compared to a high-straight mold board with a snow deflector, according to snow equipment drivers. But low-center mold boards are not useful at airports that routinely experience high volumes of snow. When used, snow deflectors with trap angles less than 50 degrees can eliminate much of the blow-back (*51*). Vehicle speed is another factor affecting the amount of swirling snow and resulting snow cloud around the vehicle. The slower the speed, the less the blow-back. Unfortunately, the slower the speed, the longer a vehicle remains on the movement areas as a potential hazard to aircraft.

The design of the cabin layout has an impact on driver fatigue and distractions. Equipment manufacturers are working to place controls in easy and comfortable reach of the operator. Mounting the controls on a console attached to the seat provides ergonomic benefits. Sound deadening material is being added in some vehicles to better reduce the decibel readings in the cabin. Because of the long periods of sitting, the comfort of the seat is of importance. Most seats installed in snow removal equipment are made of varying stiffness of foam, but air-inflated seat cushions are being researched as an alternative to reduce fatigue and increase comfort (*52*). Most newly purchased vehicles come equipped with air-adjustable mechanisms.

SNOW REMOVAL EQUIPMENT

Advisory Circular 150/5200-30, Airport Winter Safety and Operations, provides guidance in the number and type of vehicles and appliances for the airport size and operation (*12*). Sizing of the snow and ice control equipment fleet should be based on the total Priority 1 paved area that must be cleared of snow, slush, or ice within a recommended clearance time. Priority 1 paved areas amount to having cleared one primary runway, taxiway access and egress from that runway to the terminal, and any ARFF access routes. The equipment fleet recommended in the advisory circular is associated with eligibility for federal funding participation.

Formulas exist for determining the number of plows, brooms, and blowers to achieve the clearance time necessary for a particular runway or other paved surface areas (*53, 54*). The acquisition of larger capacity snow and ice removal equipment can help reduce the potential for incursion by having fewer exposed numbers of operations (*55*). However, financial considerations may preclude the ability of an airport to acquire more efficient or larger pieces of equipment. *Advisory Circular 150/5220-20, Airport Snow and Ice Control Equipment*, offers guidance on how to select the number and types of equipment necessary to meet recommended clearance times (*54*).

The design of vehicles and attachments, the layout and equipping of cabins, and the placement of lights all have an impact on the prevention of incursions. The impact has not been adequately evaluated to identify the best method or practice in the airport sector. Neither is it clear whether research is being applied to vehicle design as much as normal business practices are. One airport conveyed that it was tough to get the manufacturer of their snow removal equipment to accept ergonomic design changes to its vehicle since the production line was not set up to accommodate such a request.

SUMMARY

Chapter eight addresses how the design of vehicles and attachments, the layout and equipping of cabins, and the placement of lights all have an impact on the prevention of incursions. HID lights were identified as the best lamp type, and the placement of lights at eye level angled downward was deemed to be most effective, though the latter is an area needing more study. How to enhance visibility from the cabin is provided through respondent suggestions. The current design philosophy is to provide as much glass area as possible and to fluid deluge systems, good wiper blades, and an effective defroster system. Another influential factor helping to reduce the risk of collision by enhancing visibility is the height of the cabin and the ability to sit up high and look out and over the swirling snow. Further factors described in the chapter are the design of the plow blade and deflectors and the speed capability of the vehicle.

CHAPTER NINE

OPERATIONAL FACTORS

Survey respondents were asked to identify the kind of problems they have encountered at airports relative to reduced visibility, seeing where they are on the airport, or the difficulties in navigating on the airfield when engaged in snow plowing, brooming, deicing, or other winter operations. They were then asked to identify how they solved the problems. Their responses as noted here provide insight into the varied operations of different-sized airports and their organizational structure and resources.

The synthesis questionnaire asked about the use of outside contractors for snow removal operations. A few replied that they did use contractors and, if they were used, they were restricted primarily to landside purposes only (the plowing of access roads, parking lots, etc.). However, the larger airports may allow or require their tenants to be responsible for snow removal on their leased areas for which the airlines or FBO may contract with snow removal contractors needing access to the airfield. This can pose a problem of access control and safety.

The few airports that did use contractors on the airfield side generally restricted them to the ramps and other non-movement areas. These operations can cause an incursion or incident. To assist in preventing such occurrences, a number of methods and techniques are used. Proper training of contractor personnel in pavement markings, signage, and operational constraints is key. A good practice is to include contractors in the preseason and post-snow event briefings. Several airports made it a point to close the area being worked on through the NOTAM system. One airport outlines its ramp area in red lights to distinguish it from the blue lights associated with taxiways. A number of airports provide a dedicated operations or maintenance employee to oversee the contractor operation. The airport monitors or escorts will park at the boundary of the movement and non-movement areas to act as a physical reminder of the demarcation.

As mentioned in previous chapters, all snow events present some measure of degradation in visibility and SA. Blowing snow, whiteout and blizzard conditions, blowing sand, heavy fog and precipitation, equipment blocking line of sight, and vehicle blind spots were all factors cited by operators as affecting visibility. Outside the vehicle, the accumulation of snow or snow banks obscuring signs and lighting is a major issue.

Several airports reported that excessive vehicle speed was a cause of an accident and incursion on their airport. An interview with the driver of one incident indicated that he was going fast because of the pressure to get the movement area cleared for a scheduled flight. Higher vehicle speeds decrease driver reaction time and increase braking distances, which accounts for one incident where the driver entered a runway from an intersecting runway because he was going so fast as to not brake in time. Different airport operators said the key to not having an incident, incursion, or collision with another vehicle is to simply slow down the operation as visibility decreases. Maintaining proper distance from other vehicles was important and adding lighting on the rear of vehicles has helped.

If the visibility gets too poor, several airports stated that their policy is to stop snow removal operations until conditions improve. Others had specific limits for stopping, such as at 300 or 600 ft RVR. When encountering a whiteout or passing squall condition, one airport's practice is to stop and stay in position until it has passed. This requires good communication with other vehicles and with ATCT, if in operation.

- "Pull the operators off in low visibility—manage the risk."
- "We lead our snow teams with our most experienced operations staff. Most of these staff have over 20+ years working on the airfield, and they always know where they are. We also have the latest equipment with our runway snow teams. These vehicles are lit up like a winter holiday, and are easily seen in poor visibility conditions. They also have the best deicing capabilities like heated windshields, etc."

AVOIDING OR PREVENTING INCURSIONS

A survey question asked about the practices, procedures, methods, or techniques used at the airport for avoiding or preventing the incursion of vehicles on active and/or crosswind runways. The responses to the question are related somewhat to the category and staffing of the airport, but more so to its philosophy of operation. Either the airport philosophy centered on maintaining an active runway for aircraft operations during snow removal activity, or closing the runway for snow and ice removal activity. The different philosophies represent different approaches to managing risk and the different benefits that may be derived from that choice.

The most frequent procedure mentioned by respondents was close coordination between the snow crews and ATCT or pilots, primarily through the use of one point of contact. Typical responses were as follows:

- "One person in charge."
- "Single command vehicle for ATCT communication."
- "Groups of vehicles under one call sign."
- "A dedicated Ops Manager works directly with the runway snow team. The Ops Manager is in direct contact with the tower at all times; the snow team moves with close coordination with the tower."
- "Snowboss is responsible for advising drivers when aircraft are taxiing and their current location and heading."

Another common response from airports with an ATCT was for all vehicles to monitor ground frequency. This comment came from airports that used the team approach to snow removal, where the team lead vehicle had responsibility for communicating with ATCT and the other vehicles just listened. One airport without an ATCT indicated it had one vehicle operator monitor approach control, another operator monitor CTAF, a third monitor unicom, while all vehicles monitor a common second maintenance radio frequency to share information. However, not all airports have sufficient staff and well-equipped vehicles (usually general aviation and small commercial service airports). Relying on equipment or personnel from supporting departments may present a problem due to lack of airport operational familiarity and training.

Several airports made it clear that they always close a runway when conducting winter snow removal operations on it. Although the category of airport that practiced this philosophy varied from non-hub to large-hub airports, it was more likely that this practice was employed at medium- to large-hub airports because they could continue aircraft operations on one runway while focusing their resources on the other runways. The economics of the decision involved in closing a runway requires balancing the heavy demands for continuous operation with the efficiency of clearing a runway and taxiway system.

- Sample Large-Hub Airport Response: "The airport *always* closes runways for snow and ice control, even when taking sanders down the middle of the runway for a 5-min operation."
- Sample Medium-Hub Airport Response: "At our airport we only have equipment on a runway that isn't closed when we are applying sand to bring up the friction ratings. When we receive a pilot report that the braking action has deteriorated, we take a Field Maintenance supervisor's vehicle along with an Operation's vehicle out to the affected runway to accompany the sand trucks for their applications. Usually the Field Maintenance supervisor will lead the sand trucks and the operations vehicle will bring up the rear to ensure that all vehicles are clear of the runway after application, and to check to see if the friction values have improved. All coordination via radio transmissions are performed with the ATCT supervisor working with our crews on our airport's UHF frequency. This allows our snow removal crews to listen to one radio, avoiding VHF frequency, and ensures the supervisors and work force personnel are all on the same page with ATC."

Some airport operators choose to conduct snow removal operations on the runway without closing it (*56*). This type of airport operation was more prevalent at airports having only one primary runway that had to be kept open or airports having very little traffic such that snow removal crews could operate without interruption for long periods of time.

- Sample Response: "Coordinate with ATCT between arrivals, snow supervisor confirms with equipment operator that they are on the runway."

Conducting snow removal operations with an operating ATCT requires close coordination and excellent communication. Close coordination, which would be spelled out in an LOA, requires a good working relationship with ATCT personnel. Lacking a good and trusting relationship, either party may feel uncomfortable conducting winter operations while the runway is still open.

- Sample Medium-Hub Airport Response: "We have two parallel runways here that intersect with our crosswind runway. Whenever we have to cross any of the active runway intersections with our snow removal crews, the Operation's duty manager is the person that requests all crossings with the ATC supervisor. Again, Field Maintenance supervisor's vehicle is in the lead, and the Operation's vehicle brings up the rear, and reports to the ATC supervisor when all vehicles are clear of a particular intersection. This system has worked very well for us for many snow removal seasons."
- Sample Non-Hub Airport Response: "Close coordination with ATCT. Status review by snow removal team supervisor. Constant monitoring of ATCT frequency by all snow removal operators."
- Sample General Aviation Airport Response: "Conducting snow removal on the runway between operations is a frequent occurrence at our airport given the amount of traffic we experience (a busy GA airport). During snow removal, we typically have six Maintenance personnel on duty responsible for plowing, and one Operations person that acts as the 'Snowboss.' One of the main responsibilities of the Snowboss is to coordinate all movement of the plows on the movement area with the ATCT and act as a single point of contact between the ATCT and plows."

One airport specifically remarked in their survey response that they had experienced several situations during winter operations when ATCT forgot they were on the field and approved an aircraft operation for the area they were working in. Two non-hub airports, attempting to enhance SA, provided a poster-size layout of the airport, covered it with laminate, and placed it in the ATCT for use by the controllers. The idea is for the controller to use erasable markers to identify those areas where snow removal equipment is operating or where a movement area is closed. This acts as a quick visual reminder to the ATCT controller.

Two other large-hub airports enhance SA by stationing an operations manager in the ATCT to better facilitate communication with the equipment operators and tower personnel. This arrangement is somewhat unique in that many ATCT facilities do not allow anyone other than FAA employees in the tower cab. However, with the nature of operations at these particular airports, which is to routinely open and close airport sections and to have teams of snow removal vehicles engaged in winter operations, the practice proves to be valuable in increasing alertness, coordination, and communication.

ENSURING VEHICLES ARE CLEAR OF A RUNWAY

A question on the synthesis survey asked vehicle operators to describe some of the practices, procedures, methods, or techniques used at their airport for assuring all winter operation vehicles were clear of a runway or a particular area when opening the runway to air traffic.

- The typical response
  - Airport operations visually inspects to make sure vehicles are clear of runways.
  - Visual inspections by the person who's opening it.
- Sample Large-Hub Airport Response
  - "Smaller tightly controlled teams of drivers and equipment. Two crew leads for Maintenance personnel. On Runway and Taxiway, Onsite Ops Duty Manager coordinating opening/closures with FAA Tower. All vehicles have two-way radio communication with Leads and Ops personnel. Leads and Ops personnel have additional communication with FAA Tower."
  - "The airfield snow team has three sets of eyes and vehicles watching them, the Team Leader, the Operations Officer assigned to the team, and a follow-up vehicle that works very close with the team leader. The follow-up vehicle operator is watching how the team is cleaning the area as well as calls when the team is clear of runways and taxiways."
- Sample Medium-Hub Airport Response
  - "Our standard procedures are to close the crosswind runway during periods of snowfall. We also task our duty manager with the responsibility of doing a final inspection after snow vehicles are clear of the runway. This ensures that the pavement is in an acceptable condition and that all vehicles are clear of the runway and there is no debris on the pavement. Only after the inspection is complete and the runway certified is the pavement given back to the ATCT for use."
  - "All vehicles are accounted for before opening a runway by Maintenance leads and Ops Duty personnel on the runway."
- Sample Small-Hub Airport Response
  - "Third party (ops) does a final check to make sure snow removal equipment is clear."
  - "Operations is last to clear the runway after snow crews."
  - "Primary practice is for crew lead to have overall responsibility for tracking staff/equipment and reports when all clear. ATCT verifies, Ops verifies."
- Sample Non-Hub Airport Responses
  - "Written policy—vehicles work in company teams, each team leader is responsible to ensure his company is clear and to report clear to ground control."
  - "Previous experience at nontowered airport . . . all monitor CTAF (only one crew leader communicates with aircraft). Crew leader makes assignments and tracks progress. Crew leader verifies all clear and reports same to aircraft. Directs staff on/off the runway."
  - "If the ATCT is open, they clear vehicles over the frequency; if ATCT is closed, airport operations issues a NOTAM requiring 15 min prior permission for landing/takeoffs and controls all vehicles on CTAF."
  - "A dedicated Ops Manager works directly with the runway snow team. This Ops Manager is in direct contact with the tower at all times, the snow team moves in close coordination with the tower."
- Sample General Aviation Airport Response
  - "When ATCT needs equipment to clear the runway for an operation, the ATCT notifies the Snowboss via the tower frequency. The Snowboss then notifies all plows via an 800 mhz radio system. As each plow clears the runway, they report clear to the Snowboss via the 800 mhz radio. Once the Snowboss has noted all equipment clear of the runway, he or she advises the ATCT via the tower frequency."

Two airports indicated they conduct their winter operations as if they were emergency situations and they utilize an Incident Command System (ICS) similar to their emergency plan operation:

- "[We] work an Incident Command System for snow removal operations."
- "During a snow event, airport operations activates our snow desk which is an old ATC tower overlooking the eastside of our airfield. It will be manned 24/7 until the storm passes and proper removal is completed for safe traffic. Operations manager and/or officers oversee maintenance or outside contractors during process. We communicate on an assigned radio channel to monitor all movement and progress. Once a movement area is clear for traffic, ops will then coordinate with ATC for opening."

Some airport snow crews rely on each other, as follows:

- “Buddy system.”
- “Drivers assist each other by advising each other if they are too close to the edge of pavement, if pavement friction is poor, etc.”
- “Constant monitoring and communication on the radio assists to avoid an incursion. Each vehicle operator maintains his own responsibility to clear on and off the runway. The operators also try to remind each other.”
- “We have the ATCT dim the lights after an arrival/departure or we click it down manually. Also we have the drivers look out for one another; if they see someone starting to drift or go too far off the pavement they will check to make sure that person is okay and awake and make sure that person knows where he or she is.”
- “Looking out for one another (e.g., reminding of hold instructions).”

The questionnaire responses suggest that it is at the smaller non-hub and general aviation airports where the latter responses—looking out for one another—occur. This is due, in part, to fewer vehicles and drivers involved in the snow removal effort and the speed at which those vehicles operate. It may appear more efficient for the smaller crews to work somewhat independent of each other, rather than as one tightly controlled group.

DRIVER TRAINING

Training of vehicle operators was a positive factor emphasized by a number of airports as a solution to the problem of runway incursions. One part of the questionnaire asked respondents to identify what type of snow removal operations training is conducted at their airport. The responses were wide-ranging. Most airports referenced the requirement under 14 CFR Part 139 for operator training before gaining access to the movement and safety areas of the airport, which does not specifically reference snow removal operating conditions. As indicated by most responders, the type of training conducted consisted of primarily classroom instruction.

A common problem stated by operators as affecting operations is a driver’s lack of familiarity with the airport:

- “Personnel not completely trained in equipment operation, snow removal game plan procedure, which may vary by storm occurrence, time of day, etc.”
- “Ninety percent of our operators are plumbers, electricians, carpenters, office workers, and A/C mechanics that don’t have experience on the airfield layout and need to be directed to the area that needs to be cleaned.”

The solution rests with the airport through proper training. Sections 139.303(a) and (b) of 14 CFR Part 139 tie together the requirement for airport operators to provide sufficient, qualified staff and to equip those employees with adequate resources to comply with the regulations. Airports governed by Part 139 meet the requirement by providing the requisite training, though quality can fluctuate greatly between airports.

The requirements for ground vehicle operator training under Part 139.329 are targeted toward preventing or restricting vehicle access to the airport movement areas. Training requirements for those authorized to operate on the runways and taxiways consist of using proper radio communication, understanding signs and markings, and controlling access. *Advisory Circular 150/5210-20, Ground Vehicle Operations on Airports,* provides guidance to airport operators in developing training programs for safe ground vehicle operations and pedestrian control on the airside of an airport (*3*). The advisory circular does not go into detail on the special circumstances encountered during winter snow and ice operations. For all airports, certificated or not under Part 139, the FAA has issued *Advisory Circular 150/5200-30, Airport Winter Safety and Operations*, which provides guidance to airport operators as to how to establish an SICP that better addresses the need for training and procedures to prevent incursions (*12*).

An SICP is required of airports certificated under 14 CFR Part 139. Training of personnel engaged in snow removal operations is a required part of an SICP. In this regard, the airport is to assess whether they are staffed adequately with qualified personnel, have a training program that adequately tracks test records and development of those personnel, and ensures all storm crews have received training on the SICP and trained on new equipment. Additionally, as it relates to potential runway incursion activities, the SICP is to address how snow crews ensure markings, signs, and lighting systems are legible/visible after clearing operations, and establish procedures in case of airfield accidents involving snow clearing crews, aircraft, or other airport vehicles.

The airport SICP is to also provide specific procedures for those periods when the ATCT is closed, or for airports that do not have an ATCT (non-towered airport). Additionally, the SICP should contain specific procedures for the following:

- Unexpected situations, such as when whiteout conditions occur while snow-clearing crews occupy the runways.
- Addressing the possibility for a runway incursion after the runway reopens as a result of runway snow removal operations covering taxiway signs with plowed snow, covering taxiway or runway lights, blocking of pilot or vehicle operator line of sight, or similar operational considerations.
- Procedures requiring continuous coordination among the clearing crew and the snow control center (SCC) or FSS or ATCT facility to ensure the equipment operators on runways are aware of their surroundings.
- Training in proper radio communications and for when radio communication is lost between crews or when a single driver loses the radio signal.

Based on survey responses, the primary method of training personnel for snow removal operations is conducted as part of the normal ground vehicle operations training, which involves primarily classroom training. Targeted winter operations training is more likely to occur at airports with multi-crew teams. In training new or inexperienced vehicle operators, on-the-job or hands-on training is the more common method. The majority of training is conducted in-house.

Survey respondents identified the maintenance supervisor or airport operations director as a key individual providing the training. In developing the team concept, however, one airport cited that all members of the maintenance and operations staff are involved in the process. In conducting dry runs or hands-on training, pairing a new or inexperienced driver with a qualified veteran or experienced driver is a prevalent practice, followed by an assessment from the maintenance or operations director. Practice dry runs would occur in the fall prior to winter conditions and consist of driving in formation, working the ends and the intersections of runways and taxiways, making radio calls, and gaining familiarity with equipment controls and operation.

One airport identified the importance of conducting some of the on-the-job-training or dry run training at night, since that is when the majority of snow removal operations occur at that particular airport. Another airport requires the snow removal crews to read the snow plan, read the owner's manual for each piece of equipment, and get hands-on training from a foreman.

The following comment highlights a practice that several airports perform:

> New employees are given both classroom and hands-on training. [We] conduct an annual preseason review of snow removal operations. [We] review snow removal operations after an event. [We] conduct a post-season review of operations.

That is, they conduct orientation training, then a special winter preseason training and education session per their SICP, and reinforce all learning by having a debriefing session after each snow event.

Other organizational and motivational factors that result in a high performance operation are noted in the following statement from a survey respondent:

> Training, experience, and strict adherence to procedures and protocols improve performance. Crew members "graduate" to the runway snow removal team. One area to note is that there is very little staff turnover. Operators stay until retirement, which results in a very experienced work force. Loyalty is established by fair compensation, excellent equipment and facilities, and input into operational decisions. Equipment procurement and hiring is not encumbered with political undertones.

The U.S. Air Force provides an outline for training of snow crews in their *Air Force Instruction 32-1002, Snow and Ice Control* (*57*).

> Readying the Snow Team:
>
> 3. Training. Give higher priority to training after winters with below-average snowfall. Provide:
>   - 3.1. Formal classroom lectures, training films, and discussion periods.
>   - 3.2. Ensure operator hands-on training for all snow and ice control equipment. Perform practice runs with the equipment using typical operation scenarios. Substitute water for liquid deicers to reproduce realistic operations.
>   - 3.3. Furnish formal instruction on effective and efficient anti-icing and deicing with minimal chemical use. Instruction must cover chemical usage issues, including P2/BMPs, environmental impact, and impact on aircraft, weapon systems, and airfield infrastructure.
>   - 3.4. Tabletop exercises using miniature equipment on airdrome layouts to simulate operations and to reduce training costs.
>   - 3.5. Operator maintenance responsibilities, including fuel, fluid, supply locations, repair techniques, and heavy equipment maintenance reporting procedures.
>   - 3.6. Instruct the operators on communication procedures and right-of-way information.
>   - 3.7. Details of the SICP, emphasizing the order of priorities.
>   - 3.8. An airfield and base familiarization tour highlighting locations where problems are likely. Conduct a night tour for night shift employees.
>   - 3.9. Duty location, duty hours, duty uniform, shift schedules, and notification procedures.
>   - 3.10. Allow for periodic attendance at technology sharing seminars and workshops with other military bases and governmental agencies (i.e., the snow symposium in Buffalo, New York).
>   - 5.1. Implementing Lessons Learned. The Operations Flight Chief reviews the activity logs at the end of the snow season, determines the problems and successes, and incorporates improvements into the revision of the SICP. Use P2/BMPs proactively to minimize or eliminate problems. Begin preparing for the next snow removal season at the end of the current season.

Training of vehicle operators was a positive factor emphasized by a number of respondents as a solution to the problem of runway incursions.

DRIVER TRAINING TECHNOLOGY

The FAA has issued *Certalert 02-05, Driver Training Simulators,* in which they inform the airport community of the existence of driver-training simulators (*58*). Simulators allow for in-house training that otherwise would require actually operating on the movement areas. They have been found to be effective in developing behaviors that can be transferred to the actual vehicle operation (*59*). Current state-of-the-art vehicle simulator technology enables training in situation awareness, risk analysis and decision making, emergency reaction and avoidance procedures, and conscientious equipment operation. There are two types of simulators: mobile and stationary. Both have advantages and disadvantages.

Several airports have purchased full-scale driver simulation technology for use in training their employees. The simulators are used for the training of personnel with access to the movement areas of the airport. In particular, the simulator at Minneapolis–St. Paul International Airport uses computer-aided design drawings, geographic information systems data, and satellite and other images to create a virtual world of the airport and everything on the airfield. The technology used in the system is able to simulate many different conditions at the airport, including night, day, low visibility, snow, rain, fog, rough terrain, and other features to give trainees the most realistic conditions possible. Other large airports have acquired similar technology, primarily for instruction in ARFF capabilities, but they are adaptable to snow activity as well.

The cost of full-scale driving simulators point toward only limited use at those airports having the financial capability to acquire them, as costs can range from $200,000 to $800,000. For airports that do not have similar capability or do not want to make the investment in a customized driver training simulator, there are nonproprietary or generic systems that can be used to help develop basic driving skills, SA, and radio communication techniques. Several truck manufacturers have simulators, including portable ones, for training an operator on their equipment. Another option is to acquire customized airport-specific desktop computer or video projection capability. A number of medium- to small-hub airports in the United States utilize this type of technology. The FAA has coordinated research efforts to provide a low-cost option by funding the use of a PlayStation 2 video game as a platform for adapting software to reflect the Richmond International Airport in Virginia (*60*). Snow removal driver training through the use of simulation technology is evolving and is an area of further research, study, and development by the industry and the government.

SUMMARY

Chapter nine conveys survey respondent's replies as to how they resolved operational problems encountered at airports relative to reduced visibility, seeing where they are on the airport, or the difficulties in navigating on the airfield when engaged in snow plowing, brooming, deicing, or other winter operations. Their responses provided insight into the varied operations of different-sized airports and their organizational structure and resources. The variety is explained as being related to the philosophy of operation each airport had: either the airport philosophy centered on maintaining an active runway for aircraft operations during snow removal activity, or closing the runway for snow and ice removal activity. The different philosophies represent different approaches to managing risk and the different benefits that may be derived from that choice.

Some airport operators always close the runway while snow removal operations are being conducted, while other airports conduct snow and ice removal operations on an active runway in close coordination with ATCT. Close coordination is normally spelled out in an LOA, and requires a good working and trusting relationship with ATCT personnel.

Practices are described in this chapter as to how airport maintenance or operations departments can ensure all vehicles have exited the runway prior to allowing aircraft on it. The most common method was for an operation or maintenance supervisor to perform a runway sweep. Lastly, snow removal driver training is discussed along with new simulation technology that is available. This study determined that winter operations training of most airport employees is accomplished by airport supervisors.

CHAPTER TEN

PAST, CURRENT, AND FUTURE TECHNOLOGICAL DEVELOPMENTS

For years, the method used to avoid runway and airfield incidents during low visibility and winter operating conditions was based primarily on human communication, the alertness of operators and controllers, and written SOPs or regulations. The advancement of technology has created potential to better mitigate the effects of human and operational errors at airports, especially during winter operations.

A number of public and private technologies have been proposed and studied over the years. The technologies follow one of two paths for preventing incursions: one is detection and the other is avoidance. Detection relies on technology to detect a possible incursion and provide an alert to ATC, while avoidance technologies prompt an alert to an aircraft or vehicle operator to not enter a restricted area.

Runway safety technologies that have been considered, are being studied, or are being used for purposes of enhancing safety at airports follow:

- Airport surface detection equipment model 3 (ASDE-3),
- Airport movement area safety systems (AMASS),
- Airport surface detection equipment-X (ASDE-X),
- Airport target identification system (ATIDS),
- Automated dependent surveillance-broadcast (ADS-B),
- Runway status lights (RWSL),
- Low cost surface surveillance (LCSS),
- Loop detection technology (LOT),
- Final approach runway occupancy signal,
- Driver-enhanced vision systems (DEVS),
- Motion sensing systems, and
- Other technology.

The unique operating conditions of winter can create a challenge for the implementation of any incursion technology. Although certain technology is being utilized or implemented, it is not clear from the literature search the extent to which winter operational conditions were considered or evaluated as part of the testing. Any consideration of technology intended to help prevent incursions must take into consideration the effects of snow banks, blowing snow, or freezing precipitation, as well as operational conditions of numerous vehicles on the movement areas making quick starts, stops, and turns, and working in groups or singularly. Such conditions are clearly an area for further study and evaluation. Listed below are short summaries of the technology.

AIRPORT SURFACE DETECTION EQUIPMENT MODEL 3

Airport surface detection equipment (ASDE) is a ground-surveillance radar that depicts aircraft and airport vehicles and equipment on the airport surface. ASDE-3 is a ground-mapping radar that provides air traffic controllers with a video display of all vehicles and obstacles on an airport's runways and taxiways. It aids controllers in the orderly movement of aircraft and ground vehicles on the airport surface, especially during periods of low visibility such as rain, fog, and night operations. For ASDE-3 to prevent incursions or conflicts on the ground, a controller must monitor the screen.

AIRPORT MOVEMENT AREA SAFETY SYSTEM

In conjunction with ASDE-3, the installation of additional safety logic software will sound an alarm to warn controllers of a potential collision or incursion. The software addition is called airport movement area safety system (AMASS). AMASS extends and enhances the capability of the ASDE-3 radar by providing automated alerts and warnings to potential runway incursions and other hazards, thereby assisting the controller's vigilance. The visual and aural prompts require controllers to respond to situations that potentially compromise safety.

AIRPORT SURFACE DETECTION EQUIPMENT-X

An enhanced version of airport surface detection equipment, called "ASDE-X," is intended to address small- to medium-sized airports. It is a less-expensive ground radar and warning system than ASDE-3 radar and AMASS. ASDE-X integrates a combination of surface movement radar and transponder multi-lateration sensor antennas placed around an airport to detect and show aircraft and vehicle positions on an ATC tower display. The system detects and alerts controllers to potential aircraft and vehicle collision situations through advanced conflict detection and alerting technology. An ASDE-X displays an identification tag next to every radar target depicted on a ground controller's display.

AIRPORT TARGET IDENTIFICATION SYSTEM

An airport target identification system (ATIDS) provides controllers with aircraft and vehicle identification and position on the airport movement area and in selected ramp and gate areas as a means to augment existing ASDE/AMASS systems. It has become part of the Runway Incursion Reduction Program.

LOW COST SURFACE SURVEILLANCE

Low cost surface surveillance (LCSS) systems are vehicle-tracking systems that utilize global positioning system (GPS), microwave technology, or changes in the earth's magnetic field. They are beginning to make inroads into aviation operations. Some are an extension of existing ground fleet vehicle management systems while others are expansion of the GPS revolution (*61, 62*).

AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST

Automatic dependent surveillance-broadcast (ADS-B) is a cooperative surveillance system that uses satellite technology, vehicle and aircraft avionics, and a flexible ground infrastructure to more accurately and quickly transmit information between aircraft and air traffic control. "Automatic" means that the system is always on and requires no operator intervention. "Dependent" means it depends on an accurate global navigation satellite system (GNSS) signal for position data. "Surveillance" reflects its radar-like observational capabilities and services. Broadcast means the system continuously broadcasts aircraft position and other data to any aircraft, vehicle, or ground station equipped to receive ADS-B. With ADS-B, aircraft and vehicles will be able to receive data about each other's whereabouts directly, rather than through ATC intercession. It will display in the cockpit or cabin the location of aircraft and vehicles on and in the vicinity of an airport.

RUNWAY STATUS LIGHTS

The runway status lights (RWSL) system is a series of lights (hold position, runway and taxiway lead-on centerline, and elevated runway guard lights) that inform controllers, pilots, and vehicle operators whether or not a runway is clear (*63, 64*). Used in conjunction with ASDE-3 and ASDE-X, RWSL safety logic software assesses any possible conflicts with other surface traffic. Red in-pavement runway entrance lights are illuminated if the runway is unsafe for entry or crossing, and red in-pavement runway centerline hold lights are illuminated if the runway is unsafe for arrival or departure. The vehicle or aircraft operator then responds to the signal.

GLOBAL POSITIONING SYSTEM VEHICLE TRACKING

GPS satellite vehicle tracking systems, also known as automatic vehicle locators (AVL), have been utilized in highway traffic management systems for several years. Several companies have adapted it to airports (*65, 66*). On-board processors mounted to each vehicle help track their location. The vehicles communicate over a radio or cellular digital packet data system to a base station where a computer monitors fleet activity and processes captured data for post-analysis. Each may be clicked on to see precisely which vehicle is at which location, what it is doing, and how it is performing. All data are recorded and can be played back on the computer.

GPS also allows for vehicles to be monitored through means of a web browser cartography program such as Google Earth or Mapquest. The computer monitor can be located in the operations office, the ATCT, or even the vehicles themselves. The monitored vehicles then appear as small traversing dots on the screen. Other GPS tracking systems are passive in that a simple GPS receiver is displayed over an airport's geographical information system layout of the airport (*67*).

LOOP TECHNOLOGY

Loop technology (LOT) is a common method for detecting objects as they pass over a given position by creating an inductive electrical charge in a wire or sensors embedded in the pavement. LOT is used throughout the nation for roadway vehicle traffic monitoring and control. LOT has the potential to be used in a stand-alone mode or as a supplemental sensor input to an ASDE radar surface surveillance system. It can also be conveyed to the vehicle operator as an in-cabin warning monitor (*68*).

FINAL APPROACH RUNWAY OCCUPANCY SIGNAL

Final approach runway occupancy signal is a pilot notification system that provides warning to aircraft pilots on final approach when vehicles or other aircraft are actively on the runway through inductive loop sensors embedded in the runway and taxiway surfaces to track aircraft and vehicles entering and exiting the monitored zones. When any monitored zone on the runway is occupied by a stationary or slow-moving target, such as a snow plow, a signal is provided to pilots on approach to landing by flashing the precision approach path indicator lights as a visual indication to pilots on approach (*69*). The monitoring system can use LOT, multilateration, or similar technology to detect the presence of equipment, vehicles, or aircraft.

DRIVER-ENHANCED VISION SYSTEMS

DEVS can consist of night vision enhancement devices and night vision imaging systems that can provide drivers with some ability to see at night for enhanced operations (*70, 71*). Night vision goggles are a main component of night vision imaging systems. Interior and exterior cabin lighting, cabin control layout, and vehicle windows are secondary components. Based on survey responses, night vision enhancement devices and night vision imaging systems are not currently being used at airports in snowplowing operations and its potential utility is unclear.

Enhanced vision systems typically use imaging sensors to penetrate weather phenomena such as darkness, fog, haze, rain, or snow; the resulting enhanced scene, a sensor image, is presented on a head-up display (*72*). The display is normally projected onto the windshield or through a separate display. The use of head-up displays in snow removal vehicles may be an issue, however, as their use demands an undue amount of attention and makes them prone to such adverse effects as distortion, luminance contrast differences, dark adaptation inhibition, and object misrepresentation (*73, 74*).

MICROWAVE MOTION SENSORS

Microwave motion sensors consist of microwave transmitters located at the hold lines of runways or wherever vehicles need to be monitored. The transmitters can selectively detect incoming or outgoing traffic and send a signal to an enunciator located in the ATCT or elsewhere. A receiver device in a vehicle could play a prerecorded voice warning, or transmit an audio or light warning to the driver in response to each of the signals sent by the microwave transmitters. The microwave transmitters are impervious to weather conditions (*75, 76*).

GROUND MARKER SYSTEM

A ground marker system is designed to transmit locally a voice message to the cockpit of an airplane or the cabin of a vehicle to alert the operator of his or her position on the airport surface. The system is activated when an aircraft or vehicle is detected by inductive loops in the pavement. An in-cab vehicle warning system using wireless communication supported by dedicated short-range communications is also being investigated. Dedicated short-range communications is the technology used on toll highways for recognizing vehicles. As applied to airports, dedicated short-range communications data can be transmitted from a runway edge monitor or taxiway sensor to a vehicle in-cab alerting system (rather than to the marker system used for arriving aircraft) to warn the driver that it is not safe to enter a runway or other airport surface (*76*).

LASER LIGHT HOLD LINES

A laser enhancement program functions by projecting a bright light across the first solid line of the hold position markings thereby emphasizing the hold position markings. The laser and optic assembly device straddles the end of a hold line and projects a line or shaped beam of laser light along the surface. When shown in adverse weather conditions such as rain, snow, or fog, it creates a low profile three-dimensional line that is far more noticeable than traditional low visibility lighting aids. The technology has the capability to project lines in red and yellow laser illuminations. In areas that are subject to snow accumulations that can cover up painted markings, the laser lines could convey the location, layout, color, and importance of these markings (*76, 77*).

ADDRESSABLE MESSAGE BOARDS

A 2002 demonstration project installed addressable electronic signs that could display programmed advisory messages on an LED display at taxiway/runway intersections or other areas of interest. Its intent is to supplement standard hold position signs, address problematic areas on an airport, or convey SA information to ground operators (*76*).

IN-GROUND LIGHT EMITTING DIODE

The in-ground LED is a commercial transportation-grade LED light strip encased in a linear strip of clear plastic and placed along hold lines. The intent of the in-ground LED light strips is to accentuate runway and taxiway signage and markings (i.e., hold-short lines) that may become obscured during low light and low visibility weather conditions (*76*). Although functional in low visibility situations, it is not clear how they would function in snow removal situations.

RUNWAY GUARD LIGHTS

Runway guard lights (RGL) are currently required by the FAA for airports that have an approved SMGCS plan for conducting operations during low visibility conditions or at airports that have an operational need. The RGLs enhance the standard visual cues, signs, and markings used to mark the location of the holding position. Because RGLs are an international standard and are visible in both day and night operations, RGLs provide added surface safety during all weather conditions.

ENHANCED RUNWAY LEAD-ON LIGHTS

Effective February 1, 2007, *Advisory Circular 150/5340-30C, Design and Installation Details for Airport Visual Aids*, changed runway lead-on light standards to include a modified color pattern of taxiway centerline lead-on lights (*78*). The modification requires alternating yellow and green lights from the hold-short line to and from the runway to indicate a runway environment. On the taxiway, the centerline lights are green up to the hold-short line.

ENHANCED TAXIWAY SURFACE MARKINGS

Advisory Circular 150/5340-1, Standards for Airport Markings, was issued in April 2005, requiring airfield markings standards to change to enhance markings effective June 30, 2008, for airports with 1.5 million or more annual passenger enplanements (*79*). In August 2007, FAA initiated an industrywide call to action that recommended all 14 CFR Part 139 airports install enhanced taxiway and hold-short markings, regardless of the number of passenger enplanements. To support the call to action, the FAA has since issued *Change 1* to the *Advisory Circular* requiring the enhanced markings at all 14 CFR Part 139 airports (*80*). The use of surface-painted holding position signs is required for airports having multiple runways, taxiway widths greater than 200 ft, or as determined by other operational need.

SUMMARY

The previous chapters three through nine expounded on the factors that contributed to the possibility of increased collision risk or runway incursion. Chapter ten highlights the advancement of technology as potential means to mitigate the effects of human and operational errors at airports. The chapter provides a synopsis of past technology that had been explored but not adopted, existing technology that is in use, and promising future technology that can address several of the factors identified in this report. The technology follows one of two paths for preventing incursions: technology designed for detection and technology designed for avoidance. Although various technologies are being considered, one obstacle to overcome is the feasibility of usage during winter operations, which places a unique operating condition on each technology. This is an area for further research and study.

CHAPTER ELEVEN

CONCLUSIONS

Runway incursions are a major area of concern to the FAA, airport, and aircraft operations, and to the general public. This report provides qualitative and anecdotal information on factors affecting safe winter operations and the prevention of runway incursions by airport snow removal and equipment operators. Through a literature review and a questionnaire distributed to airport personnel, data were collected to address the study's main points of focus as follows:

- Communication protocols and systems currently in use,
- Winter operational protocols in use,
- Human factors that affect personnel,
- Equipment and vehicle design factors that play a role in prevention,
- Training or training systems used by airports, and
- The availability of commercial displays or warning systems to prevent incursions.

Throughout the report, examples from incident reports and from survey respondents are included to help highlight the problems and solutions that airport operators experience during winter operations. Both practical and theoretical guidance on managing collision risk factors are provided. The collision risk factors are grouped and discussed under the headings of: Communication, Environment, Human Performance, Situational Awareness, Time Pressures, Vehicles and Equipment Resources, Operational Factors. Lastly, technology investigated, used, or proposed to help mitigate the effects of human error and help reduce the possibility of a serious runway incursion are described.

The study found that unsatisfactory communication continues to be a factor contributing to runway incursions by individuals engaged in snow removal operations. Communication refers to both the radio communication requirements of the FAA, the methods for coordination between the parties engaged in winter operations, and the dissemination of safety information to others. Although the FAA has standard procedures for radio communication, the study found that errors by all parties involved continue to result in runway incursions. The methods for coordination were found to vary among airports, in part due to the size of an airport's operations, the available resources, and the emphasis airport management placed on proper coordination. Methods that work at large airports may not apply to smaller airports, or vice versa. Also, the dissemination of safety-related information, primarily through the notice to airmen (NOTAM) system, was targeted as being unsatisfactory by many survey respondents. The FAA implemented new NOTAM procedures effective January 28, 2008, as a first step toward resolving the unsatisfactory concerns.

The survey responses and discussion with airport operators point to an effort by airport organizations to do the best they can given the resources they have. Every airport did take snow and ice control activity seriously and recognized the increased risk of an incident or runway incursion. Additional resources of equipment, personnel, technology, and money are possible solutions, but the report highlights that organizational procedures (or the lack of them), competing pressures, and human performance factors are issues seeking attention as well.

The methods airport operators use for marshaling their resources during winter operations varied among airports. Conducting snow removal operations with small groups of equipment with one lead was deemed a good practice at larger airports. Whether an airport closed a runway for snow removal operations or accommodated aircraft operations depended on many competing factors. These factors could be more thoroughly evaluated through implementation of a safety management system.

Winter operations require sustained human performance over both intense short and long periods of a snow event. Fatigue is a major factor affecting the decision making and risk management of individuals. The study found that fatigue was frequently reported as the cause of mistakes on the airfield. Contributing to fatigue was stress as a result of factors both within and external to the workplace. Both the individual and airport management have a responsibility to address the effects of fatigue and stress as factors contributing to runway incursions. None of the snow and ice control plans reviewed for this report discussed runway incursion prevention issues associated with driver fatigue and distraction, though it was mentioned in an ancillary policy and procedure manuals developed by one airport.

The importance of situational awareness (SA) while operating on the airfield was an important ingredient for reducing collision risk factors. Loss of SA was found in the literature to be a major cause of controller, pilot, and ground vehicle operator errors. A safe operating environment is achieved when snow crews and air traffic controllers coordinate effectively and work closely to that end. A letter of agreement is a starting point, but it may also require a trusting relationship with air traffic control tower personnel. Adherence to well-established standard operating procedures is important in that regard, and this report provides information on procedures in place at different-sized airports.

Lastly, both past, present, and future technology is presented that has been studied by the FAA, implemented in some cases, and still being considered in others, and which further helps to act as a defensive mechanism for addressing human error as a cause of runway incursions. The hope is that technology can reduce the impacts on the weak links of the coordination and communication necessary between controllers, pilots, and ground vehicle operators. The technology, however, also needs to be affordable to the smaller airports and stand up to the harsh conditions of winter operations.

Specific issues arising from this report and which are areas for further investigation or research are as follows:

- Provide for specific research and training opportunity into the impact of fatigue during winter operations at airports and how to better address or manage it.
- Study enhancing the training and education of personnel within airport organizations into the principles of fatigue, stress, and SA.
- Study better methods for disseminating airport operating conditions and related safety information to pilots, especially at uncontrolled airports.
- Study more uniform procedures and practices for inclusion in an airport's snow and ice control plan or separate procedure manual.
- Study expanding the Runway Incursion Information and Evaluation Program to include airport operators, as a means for better understanding the nature of errors that occur during winter operations.
- Study revising the vehicle purchasing parameters to encourage the acquisition of safety-related devices and more powerful vehicles to maximize visibility, minimize driver fatigue, and reduce the time spent on the runway.
- Research and investigate more fully the advantages and disadvantages of headphone use, types of vehicle lighting and their arrangement on the vehicles, and better ergonomic controls and cabin environments specific to airport equipment.
- Study safety management systems as a means for better evaluating decisions associated with operating procedures, staffing levels, coordination with others, and managing the pressures associated with snow and ice control and low visibility conditions.
- Investigate, conduct, and better report research on the capabilities of incursion technology during winter operations.

REFERENCES

1. *Advisory Circular 120-57A, Surface Movement Guidance and Control Systems*, Federal Aviation Administration, Washington, D.C., Dec. 19, 1996.
2. "NTSB Most Wanted Transportation Safety Improvements: Aviation Issue Areas," National Transportation Safety Board, Washington, D.C., 2007 [Online]. Available: http://www.ntsb.gov/recs/mostwanted/aviation_issues.htm [Jan. 1, 2008].
3. *Advisory Circular 150/5210-20, Ground Vehicle Operations on Airports*, Federal Aviation Administration, Washington, D.C., Apr. 26, 2004.
4. *Airport Certification Bulletin 08-01: Definition of Runway Incursion*, FAA Great Lakes Region, Des Plaines, Ill., Oct. 2, 2007 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/regional_guidance/great_lakes/airports_resources/certification_bulletins/media/08-01.pdf [Jan. 1, 2008].
5. *Manual for Preventing Runway Incursions (Doc. 9870), First Edition,* International Civil Aviation Organization, Montreal, Canada, 2006 [Online]. Available: http://web.nbaa.org/public/ops/safety/icao_pri07.pdf [Jan. 1, 2008].
6. "FAA Exceeds Annual Goal for Reducing the Most Serious Runway Incursions" (FAA Press Release), Washington, D.C., Oct. 31, 2007 [Online]. Available https://www.faa.gov/news/press_releases/news_story.cfm?newsId=9932 [Jan. 1, 2008].
7. "Fact Sheet" (FAA Press Release), Washington, D.C., Dec. 4, 2007 [Online]. Available: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8410 [Jan. 1, 2008].
8. *National Plan of Integrated Airport System 2007–2011: Report to Congress*, Federal Aviation Administration, Washington, D.C., Sep. 29, 2006 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/planning_capacity/ [Jan. 1, 2008].
9. Reason, J., *Managing the Risks of Organizational Accidents*, Ashgate, Burlington, Vt., 2002.
10. Runway Incursion Information Evaluation Program (RIIEP), *Federal Register*, Vol. 71, No. 197, Oct. 12, 2006, pp. 60226–60228. *Aviation Runway and Ramp Safety: Sustained Efforts to Address Leadership, Technology, and Other Challenges Needed to Reduce Accidents and Incidents*, (GAO-08029), U.S. Government Printing Office, Washington, D.C., Nov. 2007.
11. 14 Code of Federal Regulations, Part 139, *Certification and Operations: Land Airports Serving Certain Air Carriers*, January 1, 2004, U.S. Government Printing Office [Online]. Available: http://www.access.gpo.gov/nara/cfr/waisidx_04/14cfr139_04.html [Jan. 1, 2008].
12. *Advisory Circular 150/5200-30, Airport Winter Safety and Operations*, Federal Aviation Administration, Washington, D.C., Sep. 5, 2007.
13. *Advisory Circular 150/5200-28, Notices to Airmen (NOTAMs) for Airport Operators*, Federal Aviation Administration, Washington, D.C., July 24, 2006.
14. *Airport Certification Information Bulletin 07-05,* FAA Great Lakes Airport Certification Division, Des Plaines, Ill. Feb. 22, 2007 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/regional_guidance/great_lakes/airports_resources/certification_bulletins/media/07-05.pdf [Jan. 1, 2008].
15. Edwards, D.J., B. Sirois, T. Dawson, A. Aguirre, B. Davis, and U. Trutschel, "Evaluation of Fatigue Management Technologies Using Weighted Feature Matrix Method," *Proceedings of the 4th International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, Stevenson, Wash., July 9–12, 2007 [Online]. Available: http://ppc.uiowa.edu/driving-assessment/2007/proceedings.htm [Jan. 1, 2008].
16. Heitmann, A., R. Guttkuhn, A. Aguirre, U. Trutschel, and M. Moore-Ede, "Technologies for the Monitoring and Prevention of Driver Fatigue," *Proceedings from Driving Assessment 2001: The 1st International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design,* Aspen, Colo., Aug. 14–17, 2001, pp. 81–86. [Online]. Available: http://ppc.uiowa.edu/driving-assessment/2001/ [Jan. 1, 2008].
17. Orris, P., S. Buchanan, A. Smiley, D. Davis, D. Dinges, and G. Bergoffen, *CTBSSP Synthesis of Safety Practice 9: Literature Review on Health and Fatigue Issues Associated with Commercial Motor Vehicle Driver Hours of Work*, Transportation Research Board, National Research Council, Washington, D.C., 2005 [Online]. Available: http://onlinepubs.trb.org/onlinepubs/ctbssp/ctbssp_syn_9.pdf [Jan. 1, 2008].
18. Wilson, G.F., J.A. Caldwell, and C.A. Russell, "Performance and Psychophysiological Measures of Fatigue Effects on Aviation Related Tasks of Varying Difficulty," *International Journal of Aviation Psychology*, Vol. 17, No. 2, 2007, pp. 219–247.
19. Van Hemel, S.B. and W.C. Rogers, "Survey of Truck Drivers' Knowledge and Beliefs Regarding Driver Fatigue," In *Transportation Research Record 1640* (Paper No. 98-0297), 1998, pp. 65–73 [Online]. Available: http://commerce.metapress.com/content/a4301661h8323200/fulltext.pdf [Jan. 1, 2008].
20. Desai, A.V. and M.A. Haque, "Vigilance Monitoring for Operator Safety: A Simulation Study on Highway Driving," *Journal of Safety Research*, Vol. 37, No. 2, 2006, pp. 139–147.
21. Williamson, A., A. Feyer, and R. Friswell, "The Impact of Work Practices on Fatigue in Long Distance Truck Drivers," *Accident Analysis & Prevention,* Vol. 28, No. 6, 1996, pp. 709–771.

22. Boggs, C., "Field Study to Evaluate Driver Fatigue Performance in Air-Inflated Truck Seat Cushions: Objective Results," *International Journal of Heavy Vehicle Systems*, Vol. 14, No. 3, 2007, pp. 227–253.
23. Ball, D., S. Versluis, R.A. Hendrickson, J. Pittenger, B. Frank, A. Stewart, and D. Murray, *Factors in Decisions to Make, Purchase, and Use On-board Safety Technologies* (Report FMCSA-MCRT-06-003), Federal Motor Carrier Safety Administration, Washington, D.C., Dec. 2005 [Online]. Available: http://www.fmcsa.dot.gov/facts-research/research-technology/report/factors-in-decisions.htm [Jan. 1, 2008].
24. *Beyond the Midnight Oil: An Inquiry into Managing Fatigue in Transport* (Report to House of Representatives Standing Committee on Communication, Transport and the Arts), The Parliament of the Commonwealth of Australia, Canberra, Australia, Oct. 2000 [Online]. Available: http://www.aph.gov.au/house/committee/cita/manfatigue/mfcontents.htm [Jan. 1, 2008].
25. *North American Airports Council International Snow Book & Airport Operations Survey 2006*, PPS Publications, Atlanta, Ga.
26. Cardosi, K. and A. Yost, *Controller and Pilot Error in Airport Operations: A Review of Previous Research and Analysis of Safety Data*, Report DOT-VNTSC-FAA-00-21, Federal Aviation Administration, Washington, D.C., Jan. 2001 [Online]. Available: http://ntlsearch.bts.gov/tris/record/tris/00948891.html [Jan. 1, 2008].
27. Cardosi, K., *Runway Safety: It's Everybody's Business* (Brochure DOT/FAA/AR-01/66), FAA Office of Aviation Research, Washington, D.C., July 2001 [Online]. Available: http://www.faa.gov/RunwaySAFETY/pdf/handbook.pdf [Jan. 1, 2008].
28. Uhlarik, J. and D.A. Comerford, *A Review of Situational Awareness Literature Relevant to Pilot Surveillance Functions* (Report DOT/FAA/AM-02/3), FAA Office of Aeromedical Research Washington, D.C., Mar. 2002 [Online]. Available: http://www.hf.faa.gov/docs/508/docs/cami/0203.pdf [Jan. 1, 2008].
29. *Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures*, Change 3, Federal Aviation Administration, Washington, D.C., Aug. 30, 2007, [Online]. Available: http://www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/AIM/ [Jan. 1, 2008].
30. Strayer, D.L., F.A. Drews, R.W. Albert, and W.A. Johnston, "Cell Phone Induced Perceptual Impairments During Simulated Driving," *Proceedings from Driving Assessment 2001: The 1st International Driving Symposium on Human Factors in Driving Assessment, Training and Vehicle Design,* Aspen, Colo., Aug. 14-17, 2001 [Online]. Available: http://ppc.uiowa.edu/driving-assessment/2001 [Jan. 1, 2008].
31. *Advisory Circular 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on Airports*, Federal Aviation Administration, Washington, D.C., July 11, 1986.
32. *FAA Order 7930.2, Notices to Airmen* (*NOTAMs*), Federal Aviation Administration, Washington, D.C., Feb. 16, 2006 [Online]. Available: http://www.faa.gov/airports_airtraffic/air_traffic/publications/ [Jan. 1, 2008].
33. *FAA Order 7340.1, Contractions*, Federal Aviation Administration, Washington, D.C., Mar. 15, 2007 [Online]. Available: http://www.faa.gov/airports_airtraffic/air_traffic/publications/atpubs/CNT/CNTHME.HTM [Jan. 1, 2008].
34. *FAA Notice N JO 7930.85*, Federal Aviation Administration, Washington, D.C., Jan. 28, 2008 [Online]. Available: http://www.faa.gov/airports_airtraffic/air_traffic/publications/ [Jan. 1, 2008].
35. Bullough, J. and M.S. Rea, "Simple Model of Forward Visibility for Snowplow Operators Through Snow and Fog at Night Journal," *Transportation Research Record 1585*, 1997, pp. 19–24 [Online]. Available: http://commerce.metapress.com/content/e63030368201261g/fulltext.pdf [Jan. 1, 2008].
36. *Advisory Circular 150/5200-37, Introduction to Safety Management Systems* (*SMS*) *for Airport Operators*, Federal Aviation Administration, Washington, D.C., Feb. 28, 2007.
37. Horne, J.A. and L.A. Reyner, "Falling Asleep at the Wheel," In *CTBSSP Synthesis of Safety Practice 9: Literature Review on Health and Fatigue Issues Associated with Commercial Motor Vehicle Driver Hours of Work*, Transportation Research Board, National Research Council, Washington, D.C., 1995, p. 106 [Online]. Available: http://onlinepubs.trb.org/onlinepubs/ctbssp/ctbssp_syn_9.pdf [Jan. 1, 2008].
38. *Setting Standards for Knowledge and Awareness About Fatigue Management in the Heavy Vehicle Industry: Policy Position Paper*, National Transport Commission, Melbourne, Australia, Sep. 2007, [Online]. Available: http://www.ntc.gov.au/filemedia/Reports/SettingStdsKnowAwarFatMngtSept07.pdf [Jan. 1, 2008].
39. Parkes, A.M., B.F. Sexton, and S. Burton, "An Evaluation of the Effects of a Functional Energy Drink on Post-lunch and Early Evening Driving Performance," *Proceedings from Driving Assessment 2001: The 1st International Driving Symposium on Human Factors in Driving Assessment, Training and Vehicle Design*, Aspen, Colo., Aug. 14-17, 2001 [Online]. Available http://ppc.uiowa.edu/driving-assessment/2001/ [Jan. 1, 2008].
40. Dinges, D.F., G. Maislin, G.P. Krueger, R. Brewster, and R.J. Carroll, *Pilot Test of Fatigue Management Technologies—Final Report* (Report No. FMCSA-RT-05-002), Federal Motor Carrier Safety Administration, Washington, D.C., Apr. 2005 [Online]. Available: http://www.fmcsa.dot.gov/facts-research/research-technology/publications/pilot-test/pilottest-fmt-finalreport.htm#tc [Jan. 1, 2008].
41. "Reducing Runway Incursions—Focus: Snow Removal," FAA Great Lakes Region Certification Office, Des Plaines, Ill., Nov. 2002 [Online]. Available: http://www.faa.gov/runwaysafety/ace/brochures/2.pdf [Jan. 1, 2008].

42. Migletz, J. and J. Graham, "Driver Needs, Retroreflectivity Requirements, and Information Through Word and Symbol Markings," In *NCHRP Synthesis 306: Long-Term Pavement Marking Practices,* Chapter 3, 2002, p. 13 [Online]. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_306_22-37.pdf [Jan. 1, 2008].
43. Aviation Safety Reporting System Query, Oct. 2007 [Online]. Available: http://asrs.arc.nasa.gov/.
44. "Runway Safety Blueprint 2002–2004," Federal Aviation Administration, Washington, D.C., July 2002 [Online]. Available: http://www.faa.gov/RunwaySAFETY/pdf/blueprint1.pdf [Jan. 1, 2008].
45. Cardosi, K.M., "Runway Safety," In *Human Factors Impacts in Air Traffic Management*, Ashgate, Burlington, Vt., 2005, pp. 43–70.
46. *Advisory Circular 120-74A, Parts 91, 121, 125, and 135 Flightcrew Procedures During Taxi Operations*, Appendix 2, Federal Aviation Administration, Washington, D.C., Sep. 26, 2003.
47. Bullough, J.D., Z. Fu, and J. VanDerlofske, "Discomfort and Disability Glare from Halogen and HID Headlamp Systems," Presented at SAE 2002 World Congress, Detroit, Mich., Mar. 4–7, 2002 [Online]. Available: http://www.lrc.rpi.edu/programs/transportation/vehicle.asp?section=13.1 [Jan. 2008].
48. Bajorski, P., S. Dhar, and D. Sandhu, "Forward-Lighting Configurations for Snowplows," In *Transportation Research Record 1533*, Transportation Research Board, National Research Council, Washington, D.C., 1996, p. 59 [Online]. Available: http://www.lrc.rpi.edu/programs/transportation/TLA/pdf/TLA-2004-01.pdf [Jan. 1, 2008].
49. Rea, M.S. and B.E. Thompson, *NCHRP Research Results Digest 250: Improved Visibility for Snowplowing Operations*, Transportation Research Board, National Research Council, Washington, D.C., 2000 [Online]. Available: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_250.pdf [Jan. 2008].
50. Bullough, J.D. and J. VanDerlofske, *Vehicle Forward Lighting: Optimizing for Visibility and Comfort: A Transportation Lighting Alliance Scoping Study*, Report TLA 2004-01, Transportation Lighting Alliance, Troy, N.Y., Jan. 2004.
51. Thompson, B.E. and H.K. Nakhla, "Visibility Improvements with Overplow Deflectors During High Speed Snowplowing," *Journal of Cold Regions Engineering,* Vol. 16, No. 3, 2002, pp. 102–118.
52. Boggs, C., "Field Study to Evaluate Driver Fatigue Performance in Air-Inflated Truck Seat Cushions: Objective Results," *International Journal of Heavy Vehicle Systems*, Vol. 14, No. 3, 2007, pp. 227–253, Oct. 2004 [Online]. Available: http://www.sae.org/technical/papers/2005-01-1008 [Jan. 1, 2008].
53. Flagg, F.J., *Runway Snow Removal by Blade, Broom and Blower*, Unpublished thesis, American Association of Airport Executives, Alexandria, Va., n.d.
54. *Advisory Circular 150/5220-20, Airport Snow and Ice Control Equipment*, Federal Aviation Administration, Washington, D.C., June 30, 1992.
55. "Cleveland's Stepped-up Snow Control," *Airport Magazine*, Vol. 19, No. 1, 2007, pp. 36–41.
56. Eaton, M. and J. Groves, "Snow Removal Challenges Regional Airport Crews," *Roads & Bridges*, Vol. 28, No. 6, 1990, pp. 30–31.
57. *Snow and Ice Control* (Air Force Instruction 32-1002), Apr. 23, 2007, pp. 16 and 25 [Online]. Available: http://www.e-publishing.af.mil/shared/media/epubs/AFI32-1002_90SWSUP_I.pdf [Jan. 1, 2008].
58. *Driver Training Simulators* (Certalert 02-05), FAA Airport Safety and Operations Division, Washington, D.C., Aug. 26, 2005 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/airport_safety/certalerts/ [Jan. 1, 2008].
59. Masciocchi, C.M., V.J. Dark, and D. Parkhurst, *Evaluation of Virtual Reality Snowplow Simulator Training: Final Report* (CTRE Project 06-245), Iowa State University Center for Transportation Research and Education, Ames, Iowa, Jan. 2007 [Online]. Available: http://www.ctre.iastate.edu/reports/snowplow_simulator_final.pdf [Jan. 1, 2008].
60. "Aviation News Bestavia.com" [Online]. Available: http://www.bestavia.com/eng/index.php?option=com_content&task=view&id=377&Itemid=37 [Jan. 1, 2008].
61. Transtech Airport Solutions, "The Intelligent Airport" [Online]. Available: http://www.transtech-solutions.com/products/asm/airport.html [Jan. 1, 2008].
62. Hartmann, U., *Intelligent Surveillance and Management Functions for Airfield Applications Based on Low Cost Magnetic Field Detectors*, Saarbrucken, Germany, Mar. 2006 [Online]. Available: http://www.ismael-project.net/ [Jan. 1, 2008].
63. *Runway Safety Report: Runway Incursion Trends and Initiatives at Towered Airports in the United States, FY 2003 through FY 2006,* FAA Air Traffic Organization, Washington, D.C., Sep. 2007 [Online]. Available: http://www.faa.gov/runwaysafety/ [Jan. 1, 2008].
64. *FAA's Implementation of Runway Status Lights* (Report AV-2008-021), U.S. Department of Transportation OIG, Washington, D.C., Jan. 14, 2008 [Online]. Available: http://www.oig.dot.gov/StreamFile?file=/data/pdfdocs/WEB_Final_RWSL.pdf [Jan. 15, 2008].
65. Airport International, Companies supplying vehicle tracking. [Online]. Available: http://www.airport-int. com/products-and-services/vehicle-tracking/ [Jan. 1, 2008].
66. Advantage Tracking Systems [Online]. Available: http://www.advantagetracking.net/ [Jan. 1, 2008].
67. Cudmore, P., "GPS/GIS Solutions for Improving Airfield Inspections, Reporting, Maintenance and Safety," *Presented at the 2007 FAA Worldwide Airport Technology Transfer Conference,* Atlantic City, N.J., Apr. 2007 [Online]. Available: http://www.airporttech.tc.faa.gov/naptf/att07/2007/Papers/P07059%20Cudmore.pdf [Jan. 1, 2008].
68. Edwards, V. and C. Evers, "Loop Technology (LOT) as an Alternative Surface Surveillance System," *Proceedings of the AIAA 17th Digital Avionics Systems Conference*, Bellevue, Wash., Oct. 31–Nov. 7, 1998,

Vol. 2, pp. F33/1-8 [Online]. Available: http://www.erabeyondradar.com/documents/white-papers/CNS/LOOP%20TECHNOLOGY%20(LOT)%20AS%20AN%20 ALTERNATIVE%20SURFACE%20Surveillance%20System.pdf [Jan. 1, 2008].

69. Helleberg, J.R., *Flashing Precision Approach Path Indicator Modeling and Simulation Final Report* (Report MTR-04x0000051), MITRE Corporation Center for Advanced Aviation System Development, McLean, Va., 2004 [Online]. Available: http://www.mitre.org/work/tech_papers/tech_papers_05/05_ 0213/05_0213.pdf [Jan. 1, 2008].
70. Hollnagel, E. and J.E. Källhammer, "Effects of a Night Visual Enhancement System (NVES) on Driving: Results from a Simulator Study," *Proceedings of the Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, Park City, Utah, July 21–24, 2003 [Online]. Available: http://ppc.uiowa.edu/driving-assessment/2003/Summaries/Downloads/Final_Papers/PDF/34_Hollnagelformat.pdf [Jan. 1, 2008].
71. *Advisory Circular 150/5210-19, Driver's Enhanced Vision System* (*DEVS*), Federal Aviation Administration, Washington, D.C., Dec. 23, 1996.
72. *Advisory Circular 23-26, Synthetic Vision and Pathway Depictions on the Primary Flight Display*, Federal Aviation Administration, Washington, D.C., Dec. 22, 2005.
73. Harder, K.A., J. Bloomfield, B.J. Chihak, C. Shankwitz, and M. Donath, *Evaluation Report Volume 1: System Performance and Human Factors* (MN/RC-2004-07), Minnesota Department of Transportation, St. Paul, Nov. 2003 [Online]. Available: http://www.lrrb.org/pdf/200407.pdf [Jan. 1, 2008].
74. Caird, J.K., W.J. Horrey, and C.J. Edwards, "Effects of Conformal and Nonconformal Vision Enhancement Systems on Older-Driver Performance," *Transportation Research Record 1759*, 2001, pp. 38–45 [Online]. Available: http://trb.metapress.com/content/y28637330j72715n/fulltext.pdf [Jan. 1, 2008].
75. Smithey, D., *Runway Incursion Detection and Warning System*, United States Patent No. 6,486,825, Nov. 26, 2002.
76. FAA Assessment Action Team, "Runway Incursion Airport Assessment Report," Presented at Sarasota–Bradenton International Airport, Sarasota, Fla. Aug. 1, 2002 [Online]. Available: http://www.faa.gov/runwaysafety/pdf/rireport.pdf [Jan. 1, 2008].
77. *Laser Technology Will Make It Easier for Pilots to See Runway Markings* (Press Release), FAA Alaskan Region, Anchorage, Ak., Mar. 19, 2004 [Online]. Available: http://www.faa.gov/news/press_releases/news_story.cfm?newsId=6377 [Jan. 1, 2008].
78. *Advisory Circular 150/5340-30C, Design and Installation Details for Airport Visual Aids,* Federal Aviation Administration, Washington, D.C., Sep. 9, 2007.
79. *Advisory Circular 150/5340-1 Standards for Airport Markings*, Federal Aviation Administration, Washington, D.C., Apr. 29, 2005.
80. *Change 1 to AC 150/5340-1J, Standards for Airport Markings*, Federal Aviation Administration, Washington, D.C., Mar. 31, 2008.

BIBLIOGRAPHY

Arthur, H., "Snow Removal 2000," *Airport Magazine*, Vol. 12, No. 4, 2000.

Arthur, H., "Large Hub Winter Operations: Revolution or Evolution?" *Airport Magazine*, Vol. 13, No. 4, 2001.

Blackburn, R.R., K.M. Bauer, D.E. Amsler, D.E. Boselly, and A.D. McElroy, *NCHRP Report 526*: *Snow and Ice Control: Guidelines for Materials and Methods*, Transportation Research Board, National Research Council, Washington, D.C., 2002.

Croft, J., "Two Birds with One Stone," *Airport Magazine*, Vol. 17, No. 2, pp. 34–36, 2005.

Croft, J. and S. Broderick, "Big Jobs for Small Tools," *Airport Magazine*, Vol. 18, No. 1, 2006, pp. 38–43.

Effects of Operating Practices on Commercial Driver Alertness, Publication No. FHWA-MCRT-99-008, Federal Highway Administration, Office of Motor Carrier and Highway Safety, Washington, D.C., 1999.

Eklund, N.H., M.S. Rea, and J. Bullough, "Survey of Snowplow Operators About Forward Lighting and Visibility During Nighttime Operations," *Transportation Research Record 1585*, No. 25, 1997, pp. 25–29 [Online]. Available: http://commerce.metapress.com/content/npux05470232030v/fulltext.pdf [Jan. 1, 2008].

"Equipment Plays a Key Role in Airport Snow Removal," *Public Works Journal*, Vol. 129, No. 13, 1998, pp. 22–24.

Evaluation of the FAA Runway Safety Program, Report #2002-20, Federal Aviation Administration, Washington, D.C., Sep. 30, 2002 [Online]. Available: http://www.faa.gov/evalsupport/reports/runwayeval.pdf [Jan. 1, 2008].

FAA Order 5200.10, Procedures for Conducting Investigations of Vehicle/Pedestrian Deviations, Federal Aviation Administration, Washington, D.C., Apr. 28, 2004 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/resources/publications/orders/media/Safety_5200_10.pdf [Jan. 1, 2008].

FAA Order 7050.1, Runway Safety Program, Federal Aviation Administration, Washington, D.C., Nov. 1, 2002 [Online]. Available: http://www.faa.gov/aso/Docs/7050_1.pdf [Jan. 1, 2008].

Hartman, D., "The Lights Will Be On," *International Airport Review*, Vol. 10, No. 3, 2006, pp. 37–40.

Jones, D.R., "Runway Incursion Prevention System Simulation Evaluation," Proceedings 21st Digital Avionics Systems Conference, Oct. 27–31, 2002, Irvine, Calif. [Online]. Available: http://ntlsearch.bts.gov/tris/record/tris/00940439.html [Jan. 1, 2008].

Kuemmel, D.A., *NCHRP Research Results Digest Number 238: Report on the 1998 Scanning Review of European Winter Service Technology*, Transportation Research Board, National Research Council, Washington, D.C., April 1998.

Kurner, D., "Runway Safety Updates," Presented at the FAA Western-Pacific Region 3rd Annual Airports Conference, Lawndale, Calif., Mar. 26–29, 2007 [Online]. Available: http://www.faa.gov/airports_airtraffic/airports/regional_guidance/western_pacific/airports_news_events/2007_conference/media/may23/Kurner_Diggons-OfficeofRunwaySafetyUpdates.pdf [Jan. 1, 2008].

Kvidera, M., "Let It Snow—Dulles Airport Is Ready," *Public Works Journal*, Vol. 134, No. 10, 2003, pp. 52–55.

Masciocchi, C., V. Dark, and D. Parkhurst, *Evaluation of Virtual Reality Snowplow Simulator Training: A Literature Review* (CTRE Project 06-245), Iowa State University CTRE, Ames, Sep. 2006 [Online]. Available: http://www.ctre.iastate.edu/research/detail.cfm?projectID=1160763489 [Jan. 1, 2008].

McCormick, C., "That's Snowbusiness . . . : The Business of Getting Ready for Old Man Winter," *Airports International*, Vol. 40, No. 1, Jan. 2001, pp. 30–31.

McCormick, C., "Clearing the Runway: Multi-function Snow-Clearance Equipment Is Getting Good Grades at Newark Liberty International Airport," *Airports International Magazine*, Vol. 36, No. 8, 2003, pp. 19–20.

"O'Hare Snow Removal: Getting the Most from the Least," *Airport Services Management*, Vol. 18, No. 9, 1978, p. 29.

"Runway Incursions: A Call to Action" (White Paper), Mar. 2007, Airline Pilots Association, Washington, D.C. [Online]. Available: http://www.alpa.org/DesktopModules/ALPA_Documents/ALPA_DocumentsView.aspx?itemid=7474&ModuleId=1316&Tabid=256 [Jan. 1, 2008].

Signal, L., D. Ratieta, and P. Gander, *Fatigue Management in the New Zealand Aviation Industry*, Report B2004/0048, Australian Transport Safety Bureau, Canberra, Australia, Apr. 2006 [Online]. Available: http://www.atsb.gov.au/publications/2006/pdf/grant_20040048.pdf [Jan. 1, 2008].

"Snow and Ice Control Aid Safe Airport Operations," *MCOA Newsletter*, AirTAP Briefings, Spring 2002, University of Minnesota Center for Transportation Studies, Minneapolis.

"Snow Plan—ANC," *Airports International Magazine*, Vol. 38, No. 1, Jan. 2005.

"Snow Removal: 1978," *Airport Services Management*, Vol. 18, No. 2, 1978, pp. 15–17.

Sub-Committee on Runway Incursions—Final Report (National Civil Aviation Safety Committee, TP 13795E), Sep. 14, 2000, Transport Canada, Ottawa, Quebec.

Tolton, E., "Winter in Toronto," *International Airport Review*, Vol. 9, No. 3, 2005, pp. 19–22.

The Snowfighter's Handbook: A Practical Guide for Snow and Ice Control, SALT Institute, Alexandria, Va., 1999 [Online]. Available: http://www.saltinstitute.org/snowfighting/1-intro.html [Jan. 1, 2008].

Wade, A.R., M.L. Cook, and T.J. Rosenthal, "Low Cost PC Simulation Technology Applied to Novice Driver

Training," *Proceedings from Driving Assessment 2001: The 1st International Driving Symposium on Human Factors in Driving Assessment, Training and Vehicle Design*, Aspen, Colo., Aug. 14-17, 2001, [Online]. Available: http://ppc.uiowa.edu/driving-assessment/2001/ [Jan. 1, 2008].

Wright, J., "The Use of a Computer Generated Virtual reality Driver Training Simulator for Airport Personnel," Presented at the 2002 FAA Technology Conference, Atlantic City, N.J., May 2002 [Online]. Available: http://www.airporttech.tc.faa.gov/naptf/att07/2002%20TRACK%20S.pdf/S24.pdf [Jan. 1, 2008].

ACRONYMS

AC	Advisory Circular
ACM	Airport Certification Manual
ADS-B	Automated Dependent Surveillance-Broadcast
A/FD	Airport/Facility Directory
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AMASS	Airport Movement Area Safety Systems
ANC	Active Noise Cancellation
ANR	Active Noise Reduction
AOA	Aircraft/Airport Operating Area
ARFF	Aircraft Rescue and Fire Fighting
ARINC	Aeronautical Radio, Inc.
ASDE-3	Airport Surface Detection Equipment Model 3
ASDE-X	Airport Surface Detection Equipment
ASRS	Aviation Safety Reporting System
ASOS	Automated Surface Observation System
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATIDS	Airport Target Identification System
ATIS	Automated Terminal Information System
AVL	Automatic Vehicle Locators
AWOS	Automated Weather Observation Surface
CDPD	Cellular Digital Packet Data
CFR	Code of Federal Regulations
CTAF	Common Traffic Advisory Frequency
DEVS	Driver-Enhanced Vision Systems
DSRC	Dedicated Short Range Communications
EVS	Enhanced Vision System
FAROS	Final Approach Runway Occupancy Signal
FBO	Fixed-Base Operator
FLIR	Forward Looking Infra-Red
FMS	Fatigue Management Scheme
FMT	Fatigue Management Technologies
FOD	Foreign Object Debris/Foreign Object Damage
FSS	Flight Service Station
GA	General Aviation
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HID	High Intensity Discharge
HUD	Head-Up Display
ICAO	International Civil Aviation Organization
ICAS	Incursion Collision Avoidance System
ICS	Incident Command System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LCSS	Low Cost Surface Surveillance
LED	Light Emitting Diode
LOA	Letter of Agreement
LOT	Loop Detection Technology
MOU	Memorandum of Understanding
MWS	Millimeter Wave Sensor
NAS	National Airspace System
NEC/AAAE	Northeast Chapter/American Association of Airport Executives
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airports System
NVED	Night Vision Enhancement Device
NVIS	Night Vision Imaging System
OE	Operational Error
OIS	Optical Identification Sensor
OJT	On-the-Job-Training
PANS-ATM	Procedures for Air Navigation Services—Air Traffic Management
PAPI	Precision Approach Path Indicator
Part 139	Federal Regulation Governing the Certification of Airports
PD	Pilot Deviation
RGL	Runway Guard Light
RIIEP	Runway Incursion Information Evaluation Program
RIJSAT	Runway Incursion Joint Situational Awareness Team
RIRP	Runway Incursion Reduction Program
RSAT	Runway Safety Action Team
RVR	Runway Visual Range
SA	Situational Awareness
SAI	Systems Atlanta, Inc.
SIA	Systems Information Area
SICP	Snow and Ice Control Plan
SMS	Safety Management System
SMGCS	Surface Movement Guidance and Control System
SOP	Standard Operating Procedure
SV	Synthetic Vision
TIS-B	Traffic Information Service-Broadcast
TRACON	Terminal Radar Control
TRIS	Transportation Research Information Services
VASI	Visual Approach Slope Indiciator
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
V/PD	Vehicle/Pedestrian Deviation
WMSC	Weather Message Switching Center

APPENDIX A

Survey Instrument

AIRPORT COOPERATIVE RESEARCH PROGRAM S04-02
Preventing Vehicle/Aircraft Incidents During Winter Operations

NAME: _________________ DATE: _________________
AIRPORT: _________________ PHONE OR EMAIL: _________________

1. Snow removal and ice control operations on an airport represent a time when there is an increased risk for a collision between an aircraft and vehicles involved in winter operations.

Q1A: List the factors that you have experienced or think increase the risk of collision:

Q1B: Are you aware of the number of runway incursions nationally related to snow removal operations within the last year July 1, 2006 to June 30, 2007?
Yes _____ No _____ How many do you think? _____

Q1C: Does your airport have a
_____ full-time ATCT; _____ part-time ATCT; _____ no ATCT
_____ a non-precision or GPS instrument approach to a runway

Q1D: Name and contact number for ATC manager: __________________________

2. While sometimes it is possible to close a runway while winter operations are conducted on it, at other times it is necessary to conduct winter operations on the runway between aircraft arrivals and/or departures.

Q2A: How do you avoid or prevent the incursion of vehicles on active and/or crosswind runways, and assure all winter operation vehicles are clear of a runway or a particular area when opening to air traffic?

Q2B: To whom do you communicate with about the opening and closing of runways/taxiways or other operational requirements during winter operations?

Q2C: How (what means or procedures) do you communicate with others about the opening and closings of runways?

3. Winter operations often occur over several consecutive hours that can result in driver fatigue.

Q3A: List the factors that you have experienced or think contribute to driver fatigue or impairment:

Q3B: What have you done or what methods, techniques, or procedures have you and your personnel used or found to be helpful in reducing the effect of fatigue from long snow removal operations during day and/or night operations?

Q3C: Can you give an example of when the effects of fatigue at your airport or another airport have affected safe winter operations?

4. There is often a sense of urgency and time pressure during the winter operations to restore the airport to normal as quickly as possible.

Q4A: List the factors or situations that you have experienced or think contribute to the sense of urgency to complete snow removal operations.

Q4B: From your perspective, how can the internal and external pressures associated with resolving or completing winter snow removal operations be reduced or minimized?

Q4C: Can you give an example of when the effects of time pressure or urgency at your airport resulted in an unsafe operation during snow removal or low visibility conditions?

5. Winter operations are often conducted during periods of reduced visibility due to weather and/or darkness. Visual cues that drivers normally use to navigate on airport runways and taxiways may be obscured or take on a different appearance.

Q5A: What are problems that you or your personnel have experienced while engaged in snow plowing, brooming, deicing, fog or other winter operation that have caused reduced visibility, seeing where you are, or difficulty in traversing the runways, taxiways, and ramps?

Q5B: How did you solve the problems in Q5A? Please describe what works: practices, procedures, equipment, etc.

Q5C: Does your airport use a commercial or other type of system to track the location of winter operation vehicles or provide an alert that a vehicle is entering a prohibited area (GPS, ASDE-X, manual chart, FLIR, other)? Please describe.

Q5D: What airfield equipment, fixture, or vehicle design item could be or has been valuable to you in enhancing visibility during winter operations (type of lights, wipers, deflectors, blades, reflectors, flags, FLIR, DEVs, etc.)?

Q5E: Do you contract out any of the snow removal operations at your airport?
Yes _____ No _____ If yes, what area of the airport are they assigned to operate on?

How do you prevent contract personnel who are assigned to winter operation duties in non-movement areas (apron/ramp) from entering movement areas (runways/taxiways)?

6. Communication breakdowns between vehicle operators, air traffic controllers, and/or pilots can result in a vehicle being on the runway when an aircraft is arriving or departing.

Q6A: Has this ever occurred at your airport?
_____ Yes _____ No If yes, can you briefly describe the situation(s)?

Q6B: Have you or your personnel experienced an unsafe communication breakdown with ATCT, FSS, Approach, TRACON, or Unicom/CTAF?
_____ Yes _____ No If yes, can you briefly describe the situation(s)?

Q6C: How do you enhance communication or prevent miscommunication between:
a) Winter operation vehicles and air traffic control (both ATCT and approach control)?
b) Winter operation vehicles and aircraft (especially at airports without an ATCT)?

Q6D: Does your airport have any prohibitions on the use of cell phones or listening to AM/FM radios, CDs, etc., while engaged in snow and ice removal operations?
Yes _____ No _____
If yes, please provide a copy of the policy or explain the prohibition.
If no, have there been any problems or issues associated with their use?

Q6E: What type of snow removal operations training is conducted at your airport?

Q6F: Who conducts snow removal training at your airport and what does it consist of?

7. One purpose of this study is to identify airports that have effective winter operations and communication protocols. Can you recommend and identify any other airports that you think have good operations or procedures?

8. Has your airport ever won the Balchen/Post award for snow removal operations?
_____ Yes _____ No When? _________

Thank you!! Return with this survey(s) a copy of your snow plan and/or procedures and any ATCT LOA's to: Stephen Quilty, A.A.E. 620 Kirkshire Drive, Perrysburg, OH 43551-2934
Email: squilty@bgsu.edu

APPENDIX B

Airport Respondents

Airport Name	Identifier	Category	ATCT
Dulles International Airport, VA	IAD	Large Hub	T-F
Reagan National Airport, VA	DCA	Large Hub	T-F
Salt Lake City International Airport, UT	SLC	Large Hub	T-F
Minneapolis–St. Paul International Airport, MN	MSP	Large Hub	T-F
Seattle–Tacoma Intl. Airport, WA	SEA	Large Hub	T-F
Newark Liberty International Airport, NJ	EWK	Large Hub	T-F
Raleigh–Durham Airport, NC	RDU	Medium Hub	T-F
Pittsburgh International Airport, PA	PIT	Medium Hub	T-F
St. Louis International Airport, MO	STL	Medium Hub	T-F
Buffalo International Airport, NY	BUF	Medium Hub	T-F
Burlington International Airport, VT	BTV	Small Hub	T-F
Juneau International Airport, AK	JNU	Small Hub	T-F
Lehigh Valley International Airport, PA	ABE	Small Hub	T-F
Victoria International Airport, BC, Canada	CYYJ	Small Hub	T-F
Syracuse International Airport, NY	SYR	Small Hub	T-F
Rochester International Airport, NY	ROC	Small Hub	T-F
Albany International Airport, NY	ALB	Small Hub	T-F
Knoxville McGhee Tyson Airport, TN	TYS	Small Hub	T-F
Erie Municipal Airport, PA	ERI	Non-Hub	T-P
Barkley Regional Airport, KY	PAH	Non-Hub	T-P
Grand Forks Regional Airport, ND	GFK	Non-Hub	T-P
Redding Municipal Airport, CA	RDD	Non-Hub	T-P
Capital Regional Airport, MI	LAN	Non-Hub	T-F
Portsmouth/Pease International Airport, NH	PSM	Non-Hub	T-P
Lebanon Municipal Airport, NH	LEB	Non-Hub	T-P
Eagle County Regional, CO	EGE	Non-Hub	T-P
Ely Municipal Airport, NV	ELY	Commercial Svc.	N
Hagerstown Regional Airport, MD	HGR	Commercial Svc.	T-P
Yreka Rohrer Field, CA	1O5	General Aviation	N
Beverly Municipal Airport, MA	BVY	General Aviation	T-P
Norwood Municipal Airport, MA	OWD	General Aviation	T-P
Quonset State Airport, RI	OQU	General Aviation	T-P
Chicago Executive Airport, IL	PWK	General Aviation	T-P
Centennial Airport, Englewood, CO	APA	General Aviation	T-F
Chester County Airport, Coatesville, PA	MQS	General Aviation	N
Truckee–Tahoe Airport, Truckee, CA	TRK	General Aviation	N

Notes:
T-F = Tower full-time (20)
T-P = Tower part-time (12)
N = No tower (4)

APPENDIX C

Reports from the Aviation Safety Reporting System (ASRS)

Full-time ATCT. Large-hub.

AFTER BEING CLRED FOR TKOF AT RWY 4, STARTED NORMAL TKOF WITH CONFIGN OF FLAPS 3 DEGS FOR CONTAMINATED RWY. JUST AFTER V1 AND VR STARTED NORMAL ROTATION AND NOTICED FLASHING YELLOW LIGHTS OUT OF FRONT WINDSCREEN RIGHT IN FRONT OF ME. ABOUT TIME MAIN GEAR WAS OFF COULD SEE THAT IT WAS A SNOW PLOW. THEN I NOTICED 2 OTHER VEHICLES ON THE NEW RWY. WHEN THE NOSE OF ACFT WAS TOO HIGH TO SEE FIRST VEHICLE, AND WE WERE ABOUT TO OVERFLY, I COULD SEE 1 VEHICLE THAT APPEARED TO BE ON RWY ALSO AND THE THIRD VEHICLE APPEARED TO BE JUST CLR OF RWY. XING HT WAS APPROX 50-75 FT.

++

Full-time ATCT. Small-hub.
MD80. SNOW PLOW ALMOST ENTERED RWY AS THE CREW ACCELERATED PAST V1.

SAFETY OF FLT—DANGEROUS OP OF SNOW REMOVAL TRUCK. SAFETY OF FLT. DANGEROUS OP OF SNOW REMOVAL VEHICLE. TWR CLRED US ‘POS AND HOLD’ ON RWY 10 TO WAIT FOR SNOW REMOVAL VEHICLES TO FINISH A RUN OF REMOVING SNOW FROM THE RWY. THE 3 SNOW PLOWS WERE PROCEEDING TOWARDS THE DEP END OF RWY 10 (TOWARDS THE E). WHEN THEY HAD COMPLETED THEIR WORK, ALL 3 VEHICLES EXITED THE RWY AT THE END. AFTER CONFIRMING WITH THE VEHICLE DRIVERS ON THE TWR RADIO FREQ THAT THEY WERE ALL CLR OF RWY 10, TWR THEN CLRED US FOR TKOF ON RWY 10. DURING THE FIRST PART OF OUR TKOF ROLL, ONE OF THE SNOW PLOW TRUCKS HAD PROCEEDED W ON TXWY A AND THEN MADE A TURN TOWARDS RWY 10 ONTO TXWY M (PRESSUMABLY TO PROCEED TO THE APCH END OF RWY 33 VIA TXWY M IN ORDER TO MEET ONE OF THE OTHER SNOW PLOWS TO PLOW SNOW FROM RWY 33). AS OUR AIRPLANE ACCELERATED TOWARDS V1 SPD, BOTH COCKPIT CREW MEMBERS NOTICED THE SNOW REMOVAL VEHICLE ON WHAT APPEARED TO BE A COLLISION COURSE WITH OUR ACFT AND CONTINUING TOWARDS THE RWY AT A RAPID PACE WITH NO OBVIOUS SIGNS OF STOPPING BEFORE ENTERING THE RWY. AT SOME POINT VERY CLOSE TO OUR V1 SPD, THE DRIVER OF THE SNOW REMOVAL VEHICLE APPEARED TO VERY ABRUPTLY STOP AT A VERY CLOSE DISTANCE FROM THE EDGE OF THE RWY JUST AS WE PASSED BY HIM. WE WERE ABLE TO CONTINUE OUR TKOF PAST HIM UNEVENTFULLY. THE SNOW REMOVAL VEHICLE DRIVER WAS NOT EXERCISING DUE CAUTION AND SAFELY OPERATING HIS VEHICLE GIVEN THE SLIPPERY TXWY CONDITIONS. HIS VEHICLE COULD VERY EASILY HAVE SKIDDED AS HE TRIED TO STOP AND COULD HAVE ENTERED THE RWY JUST IN FRONT OF OUR ACFT JUST AS WE WERE ACCELERATING TO ROTATION SPD. HIS ACTIONS CAUSED BOTH PLTS IN OUR CREW TO FOCUS ON HIM AND THE POTENTIAL FOR COLLISION, AND GREATLY DISTR US FROM OUR PRIMARY DUTIES OF MONITORING OUR ACFT DURING THE MOST CRITICAL MOMENTS OF OUR TKOF.

++

Non-towered. Non-hub.

SNOW PLOW ON SIDE OF RWY END DURING DO-328 LNDG ROLLOUT. NO CONFLICT. HOWEVER, VEHICLE PRESENCE NOT DISSEMINATED VIA ARTCC CTLR, OR ACKNOWLEDGED BY ARPT CTAF ADVISORY FREQ WHEN FLC BROADCAST THEIR LOCATION AND INTENTIONS PRIOR TO LNDG.

++

Part-time ATCT. Non-hub.

ON FEB/XA/01, CAPT AND I WERE FLYING FLT A LITTLE AFTER XA00. I WAS THE PF UNTIL THE LNDG PHASE. OUTSIDE THE IAF, RECEIVED THE ATIS AND DID NOT STATE ANYTHING ABOUT

PLOWING IN EFFECT, WHEN HE READ ME THE ATIS. VISIBILITY WAS ABOUT 2 MI WITH LIGHT SNOW. WE SET UP FOR THE LOC BACK COURSE RWY 17. AT THE FAF, CAPT MADE THE TFC RPT ON CTAF, THAT WE WERE INTXN INBOUND, ANYONE PLEASE ADVISE, AND NO ONE RESPONDED. I FLEW THE APCH DOWN TO THE MDA, THEN CAPT TOOK THE PLANE OVER FOR THE LNDG BECAUSE THE BRAKING ACTION WAS RPTED AS POOR. WHILE LNDG AND IN THE ROLLOUT PHASE, THE CAPT AND I NOTICED SOME DIM FLASHING LIGHTS WAY DOWN AT THE FAR END OF THE RWY AND OFF TO THE L-HAND SIDE. WE BOTH THOUGHT THAT MAYBE IT WAS JUST SOME CONSTRUCTION SIGNS OFF TO THE SIDE OF THE RWY AT THE FAR END. WE BOTH DID NOT FEEL THREATENED OR IN ANY DANGER AT ANY TIME, SO WE CONTINUED THE ROLLOUT. UPON ROLLOUT WHILE APCHING OUR TURNOFF, WE BOTH REALIZED THAT IT WAS A PLOW THAT WAS ON THE SIDE OF THE RWY AT THE FAR END. THERE WAS NOTHING ON THE ATIS OF PLOWING AND ZAU WAS NOT INFORMED OF SNOW PLOWING IN EFFECT.

++

Full-time ATCT. Large-hub.
JUST AIRBORNE FROM RWY 4, ACR RPTS TO TWR EQUIP ON RWY DEP END.

AFTER BEING CLRED FOR TKOF AT RWY 4, STARTED NORMAL TKOF WITH CONFIGN OF FLAPS 3 DEGS FOR CONTAMINATED RWY. JUST AFTER V1 AND VR STARTED NORMAL ROTATION AND NOTICED FLASHING YELLOW LIGHTS OUT OF FRONT WINDSCREEN RIGHT IN FRONT OF ME. ABOUT TIME MAIN GEAR WAS OFF COULD SEE THAT IT WAS A SNOW PLOW. THEN I NOTICED 2 OTHER VEHICLES ON THE NEW RWY. WHEN THE NOSE OF ACFT WAS TOO HIGH TO SEE FIRST VEHICLE, AND WE WERE ABOUT TO OVERFLY, I COULD SEE 1 VEHICLE THAT APPEARED TO BE ON RWY ALSO AND THE THIRD VEHICLE APPEARED TO BE JUST CLR OF RWY. XING HT WAS APPROX 50-75 FT. RPTED TO TWR THAT VEHICLES WERE OVERFLOWN ON RWY. TWR THEN STATED OVER RADIO, ‘WHO ARE THE VEHICLES ON MY RWY?’ WE WERE THEN HANDED OFF TO DEP CTL.

++

Non-towered. General aviation.
ACFT X TAKES EVASIVE ACTION AND EXECUTED A GAR TO AVOID A SNOW PLOW THAT BLUNDERS ON THE ACTIVE RWY.

THE ARPT USES A CITY AND UNICOM RADIO WHEN SNOW PLOWS ARE ON THE ARPT GROUNDS. ACFT RADIO AND PERSONNEL CALL THE CITY AND ADVISED THEM OF THE INBOUND ACFT. I AM THE RAMP SUPERVISOR THERE AND WAS NEEDED AT THE HANGER TO PULL AN ACFT OUT. WHEN I WAS DONE WITH THE JOB THE DRIVER OF THE SNOWPLOW CAME OVER AND INFORMED ME OF A NEAR MISS WITH AN ACFT. I WENT IN THE FBO, WHERE MY BOSS WAS SUPPOSED TO BE MONITORING THE RADIO IN MY ABSENCE, AND SHE WAS ON THE PHONE OBLIVIOUS TO THE SIT. I WENT AND TALKED TO THE PLTS OF THE EMB-120 AND THEY INFORMED ME THAT THE SNOWPLOW EXITED THE RWY AND THEN BACKED UP ONTO THE ACTIVE WHILE THEY WERE LNDG. THE PLT INITIATED A GAR AND MISSED THE PLOW BY AN ESTIMATED 5 FT. WHEN I WENT BACK IN THE OFFICE AND TALKED TO MY BOSS SHE WAS AWARE OF THE PROB AND TRIED TO TRANSFER BLAME TO ME SAYING THAT THE RADIO WAS TURNED DOWN (IT WAS STILL TURNED ‘WAY UP’ I COULD HEAR IT 20 FT AWAY THROUGH A DOOR). THE RADIO FOR THE CITY WAS ALSO TURNED UP AND PRIOR TO GOING OUT I BLATANTLY TOLD MY BOSS TO MONITOR THE RADIO, AS IS COMMON PRACTICE. NO ONE WAS INJURED HOWEVER THE EMB120 TOOK EVASIVE ACTION AND INITIATED A GAR TO MISS THE VEHICLE. CITY PLOWS ARE NOT EQUIPPED WITH AN AVIATION RADIO AND WHEN MY BOSS WAS ASKED ABOUT THIS SHE SAID ‘IT DOESN’T DO ANY GOOD BECAUSE THEY DON’T UNDERSTAND AVIATION JARGON.’ THIS ISN’T THE FIRST TIME THIS HAS HAPPENED HOWEVER THIS IS THE CLOSEST WE HAVE COME TO AN ACCIDENT AND IT IS OBVIOUS THAT THE CURRENT STANDARDS OF ADVISING ACFT AND SNOW PLOWS DOES NOT WORK. THIS IS DEFERRED BY MY BOSS BY HER STATING THAT IF WE WOULD MONITOR THE RADIO CLOSER IT WOULD NOT BE AN ISSUE. AS THIS SHOWS, EVEN WHEN THE RADIO IS ‘MONITORED’ THERE IS STILL A PROBLEM. NO NOTAM WAS FILED ABOUT PLOWS AND EQUIP ON THE RWYS. CALLBACK

CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: RPTR HAD NOTHING NEW TO ADD TO HIS ORIGINAL RPT.

++

Full-time ATCT. Non-hub.
A DH8 CREW MADE A GAR WHEN A VEHICLE WAS DISCOVERED ON THE RWY.

UPON CONTACT WITH THE TWR CTLR, WHILE FLYING THE ILS RWY 28, WE WERE INFORMED THAT THERE WERE MEN AND EQUIP ON THE RWY (RWY 28) AND A LNDG CLRNC WAS NOT GIVEN. A FEW MINS LATER, LNDG CLRNC WAS GIVEN. APPROX 500 FT AGL, WE BECAME VISUAL AS WE DEPARTED THE PASSING SNOW SHOWER. WE WERE ABLE TO VISUALLY CONFIRM THAT THE RWY OF LNDG WAS CLR OF SNOW REMOVAL EQUIP. WE ALSO NOTICED EQUIP REMOVING SNOW ON THE XING RWY 15/33. I MENTIONED TO THE CAPT THAT A SNOW PLOW WAS MOVING RAPIDLY ON RWY 33, FROM OUR L TOWARD OUR LNDG RWY (RWY 28). AS WE DSNDED, WE REPLIED THAT IF WE HAD TO GO AROUND WHAT THE PROC WOULD BE. WITH OUR PLAN IN PLACE, AS WE REACHED 200 FT AGL, THE PLOW PROCEEDED TO CROSS ONTO OUR RWY. UPON ENTERING OUR RWY, HE MADE A TURN THAT LOOKED AS IF HE REALIZED HIS MISTAKE, BUT TURNED OUT TO BE HIM SETTING UP FOR HIS U-TURN TO GO BACK ONTO RWY 33. AS WE REACHED 100 FT AGL, THE CAPT LEVELED OFF AND STARTED ADDING PWR AS WE WATCHED TO SEE WHAT THE PLOW WOULD DO. AFTER HIS INITIAL TURN TO THE L, HE TURNED BACK R, PROCEEDING ACROSS OUR RWY CTR-LINE IN HIS U-TURN. AT THIS POINT WE WERE ADDING PWR AND PERFORMING THE GAR. WE RPTED TO TWR ‘GOING AROUND, SNOW PLOW ON RWY.’ WE MADE A VISUAL PATTERN BACK AROUND AND LANDED WITHOUT FURTHER INCIDENT. TWR ASKED EQUIP PEOPLE IF THEY HAD BEEN ON THE RWY. WE DID NOT HEAR THE REPLY. IT PAYS TO KEEP YOUR EYES OPEN, SITUATIONAL AWARENESS UP, AND BE READY WITH A PLAN IF THINGS GO AWRY!

++

Full-time ATCT. Med-hub.
A320 CREW SHORTLY AFTER ROTATION, IN A LOW VISIBILITY CONDITION, SAW VEHICLES ON THE RWY.

TAXI FOR TKOF IN RESTR VISIBILITY FOR DEP ON RWY 4. GND CTL AND TWR WERE COMBINED ON 1 FREQ. AN ACR X ACFT WAS WAITING FOR TKOF. JUST AFTER BEGINNING OUR TAXI FROM GATE, WE HEARD WHAT SOUNDED LIKE A SNOW PLOW ASK IF HE COULD HAVE THE RWY BACK AFTER ACR X DEPARTED. TWR SAID YES. WE CALLED THE TWR TO REMIND THEM THAT WE WERE TAXIING OUT SO THEY WOULD KEEP THE RWY OPEN LONG ENOUGH FOR US TO DEPART. THE FO THEN CONTACTED DISPATCH TO UPDATE THEM ON FIELD CONDITIONS. I HEARD A VEHICLE REQUEST CLRNC TO CROSS THE RWY, WHICH WAS GRANTED. TWR TOLD US TO CALL WHEN #1 FOR TKOF. WE DID—ABOUT 3-5 MINS AFTER I HEARD THE VEHICLE ASK FOR XING CLRNC. WE THEN GOT CLRNC TO TAXI INTO POS AND TOLD TO CALL WHEN READY. WE CALLED READY AND WERE CLRED FOR TKOF. JUST AFTER ROTATION WE SAW VEHICLES XING OUR RWY AT ABOUT TXWY P OR TXWY G. WE FLEW OVER THEM AT 50-75 FT (CEILING 100 FT). I RPTED THIS TO TWR. THE CTLR ASKED THE VEHICLES WHAT THEY WERE DOING ON HIS RWY. I THINK EITHER THE CTLR ASSUMED THEY HAD ALREADY CROSSED (THEY SHOULD HAVE BEEN CLR SEVERAL MINS EARLIER) AND I ALSO THINK THE SNOW PLOWS THOUGHT ACR X WAS THE ONLY DEP AND THEY COULD HAVE THE RWY BACK. APPARENTLY, ONLY 1 CAR HAD AN ATC RADIO AND THE OTHER PLOWS AND VEHICLE FOLLOWED HIM, OR THEY JUST CROSSED WITHOUT CLRNC. THEY SHOULD HAVE HEARD OUR TKOF CLRNC. THEY KNEW WE WERE TAXIING BECAUSE THEY HAD TO GIVE WAY TO US AT TXWY E.

++

Non-towered. Non-hub.
AN SF340 FLC LANDS THEIR ACFT ON A SNOW AND ICE COVERED RWY WHILE IT IS OCCUPIED BY A SNOW PLOW.

I WAS ON THE 3RD DAY OF A 4 DAY TRIP. I HAD TO RPT THAT DAY AT AB00. I WAS ON THE 4TH AND LAST LEG OF THE TRIP, IN IMC WITH CLR ICE BUILDING UP ON MY AIRPLANE WITH THE AUTOPLT INOP. THE CTR CTLR TURNED US IN HIGH AND TIGHT FOR THE APCH AND THE RWY WAS SNOW AND ICE COVERED WITH

WHITEOUT CONDITIONS. ZBW ON 124.75 CLRED FLT FOR THE ILS RWY 1 APCH. WE WERE AT 3200 FT MSL AT 1-2 MI FROM THE FAF. WE WERE VECTORED HIGH ON THE GS SO WE INCREASED OUR RATE OF DSCNT TO INTERCEPT THE GS. THE AUTOPLT WAS MEL'ED INOP, SO I HAD TO HAND FLY THE APCH USING ONLY THE FLT DIRECTOR. AT 3200 FT TO 1000 FT WE WERE ENCOUNTERING FREEZING RAIN AND PICKING UP CLR ICE ON THE ACFT. AFTER THE APCH CTLR (ZBW) CLRED US FOR THE APCH, HE NEVER SWITCHED US TO CTAF ON 122.8. WE, THE CREW, ALSO FORGOT TO GO TO THE CTAF. AFTER LNDG ON RWY 1, THE FO AND I SAW A PLOW TRUCK APPROX 3/4 MI DOWN THE RWY ON THE L-HAND SIDE PLOWING SNOW DRIVING AWAY FROM US. I MANAGED TO STOP THE ACFT APPROX 1500 FT BEHIND THE PLOW TRUCK AND EXITED THE RWY AT TXWY C AND PULLED UP THE CTAF AND ANNOUNCED ON THE RADIO THAT FLT WAS CLRING RWY 1. BY THE TIME WE SAW THE TRUCK WE HAD ALREADY LANDED ON THE RWY AND FELT THAT DOING A GAR ON A SNOW AND ICE COVERED RWY AND GOING BACK UP INTO FREEZING RAIN WOULD BE A LOT MORE DANGEROUS THAN JUST STOPPING BEHIND THE PLOW TRUCK WHICH WAS DRIVING AWAY FROM US ANYWAY.

++

Part-time ATCT. Non-hub.
THE FLC OF A TWIN JET CPR ACFT LANDED ON A RWY THAT WAS OCCUPIED BY A SNOW PLOW.

WE WERE CLRED TO LAND AFTER EXECUTING A LOC BACK COURSE TO RWY 21. OUR LNDG CLRNC WAS ISSUED 5 MI FROM THE THRESHOLD OF THE RWY. WHILE ON THE LNDG ROLLOUT WITH BRAKES APPLIED, BOTH CREW MEMBERS NOTICED A SNOW PLOW TRUCK AT OUR 12 O'CLOCK POS FACING OUR OPPOSITE DIRECTION ON THE ACTIVE RWY APPROX 3000 FT FROM OUR ACFT. THE SNOW PLOW IMMEDIATELY EXITED THE RWY TO THE R IN ORDER TO AVOID OUR ROLLOUT. WE CONTINUED OUR BRAKING AND STOPPED APPROX 1000 FT PRIOR TO THE PLOW'S LOCATION. A DETERMINATION WAS MADE DURING A MEETING BTWN CREW AND ARPT MGMNT, THAT TWR PERSON ON DUTY CLRED THE PLOW ONTO THE ACTIVE RWY 21. HOWEVER, THEN CLRED US TO LAND AND NEVER NOTIFIED THE PLOW DRIVER TO EXIT THE RWY. SINCE OUR LNDG CLRNC WAS ISSUED TO US 5 MI OUT, THERE WAS MORE THAN A SUFFICIENT AMOUNT OF TIME TO CLR THE PLOW OFF THE RWY. THE CONTRIBUTING FACTOR TO THIS OCCURRENCE WAS THE TWR CTLR'S LACK OF COM TO GND EQUIP PERSONNEL.

++

Part-time ATCT. Non-hub.
P180 LNDG OBSERVED SNOW PLOWS ON RWY DURING LNDG ROLL, NO INFO FROM ATC.

I WAS THE PF ON THE TRIP. WE DEPARTED XXXX AT XA32. WE WERE IN VMC. WHEN ATC GAVE US VECTORS FOR THE APCH, WE ENTERED IMC AT THAT TIME AND REMAINED IMC FOR THE REST OF THE APCH. THE CAPT ASKED FOR CLARIFICATION AND ATC CLRED US THEN TO THE VOR AND FROM THERE FOR THE ILS APCH. THE CAPT CONTACTED THE TWR AND WAS TOLD TO CALL A CERTAIN FIX INBOUND. I WAS CONCENTRATING ON THE INSTS AND FLYING THE AIRPLANE WHILE THE CAPT WAS CALLING OUT ALTS ABOVE DECISION HT. I WAS MENTALLY GOING OVER THE MISSED APCH PROC AND PREPARING MYSELF FOR THE APCH LNDG TRANSITION WHEN THE CAPT ACQUIRED VISUAL REF WITH THE RWY AT ABOUT 250 FT ABOVE DECISION HT AND ABOUT 1 1/4 MI FORWARD VISIBILITY. I LOOKED OUTSIDE AND ALSO SAW THE RWY. I THEN DISCONNECTED THE AUTOPLT AND LANDED. ONCE WE TOUCHED DOWN, I SAW 2 OBJECTS ON EITHER SIDE OF THE RWY AT A DISTANCE IN FRONT OF US. THE CAPT TOLD ME TO KEEP THE AIRPLANE STRAIGHT ON THE CTRLINE AND TO SLOWDOWN USING PROP REVERSE. WHEN WE PASSED THE OBJECTS, WHICH TURNED OUT TO BE SNOW PLOWS, THE ACFT HAD SLOWED DOWN CONSIDERABLY. IN MY OPINION, THERE WERE SEVERAL FACTORS CONTRIBUTING TO THE FAILURE BY THE CAPT/PNF TO RPT THE FIX INBOUND. IT WAS THE FIRST TRIP THE CREW MEMBERS FLEW TOGETHER. UP TO THE FAF, I CAN RECALL THE RADIO XMISSIONS QUITE CLRLY. THEREAFTER, I TUNED OUT THE RADIO SOMEWHAT AND ASSUMED THE CAPT/PNF RPTED THE FIX AND OBTAINED LNDG CLRNC. I WAS CONCENTRATING, DURING THE LAST SEGMENT OF THE APCH, PRIMARILY ON THE INSTS AND APCH PROGRESSION. THE CAPT MONITORED MY FLYING THE APCH CLOSELY SINCE IT WAS MY FIRST TIME AS PF WITH HIM, TAKING SOME ATTN AWAY FROM HIS DUTIES AS PNF. I ALSO THINK THERE WAS A LACK OF AWARENESS BY THE CTL TWR. WHY DIDN'T THE TWR INVESTIGATE/CALL US AFTER FAILING TO HEAR FROM US? THE TWR KNEW WE WERE ON THE APCH

INBOUND FOR LNDG. WHY WAS THE SNOW PLOW EQUIP ON THE RWY WHILE INST APCHS WERE IN PROGRESS? CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: RPTR ADVISED THAT THEY DID IN FACT LWOC. THE SNOW PLOWS, AT THE TIME THEY PASSED THEM, WERE OPERATING ON THE SIDE OF THE RWY AND NOT ON THE RWY SURFACE. WHEN THEY PARKED THE ACFT, THEY WERE MET BY A SHERIFF'S DEPUTY WHO STATED THEY HAD LWOC AND THAT HE WAS THERE BOTH TO GATHER INFO REGARDING A POTENTIAL VIOLATION AS WELL AS TO 'PROTECT THEM FROM THE SNOW PLOW OPERATORS—WHO ARE KIND OF HOT HEADS AND WERE UPSET WITH THE CREW.' THE DEPUTY REVIEWED THEIR FLT BAGS, CHARTS AND PLATES, AND TOOK DOWN PERSONAL INFO. THE CAPT HAS SUBSEQUENTLY RECEIVED A 'LETTER OF INVESTIGATION' FROM THE FAA. RPTR EMPHASIZED HE FELT THE ATCT LCL CTLR WAS LAX IN NOT MONITORING THEIR ARR MORE CLOSELY AND FOR NEVER ADVISING THEM REGARDING THE PLOWING IN PROGRESS. HE FURTHER SPECULATES THAT THE OP OF SNOW PLOWS ON OR IN THE VICINITY OF THE ILS ANTENNAS MIGHT WELL DISRUPT SIGNAL PROPAGATION AND IS LIKELY NOT AN AUTH ACTIVITY.

++

Part-time ATCT. Non-hub.
FLT CREW OF PIAGGIO P180 ON ILS APCH FORGETS TO RPT AT FIX INBND, AND LWOC IN IMC AND SNOW WITH SNOW PLOWS STILL ON RWY.

I HAD NEVER BEEN TO AIRPORT BEFORE. AS WE WERE APCHING, CTR ASKED US TO SLOW DOWN, THERE WAS A CHEROKEE ON THE APCH. WE COMPLIED. THE CHEROKEE GOT VERY DISORIENTED. THEY TOOK HIM BACK AROUND ON VECTORS TO RETRY THE ILS. I OFFERED TO DO SEVERAL 360 DEG TURNS TO GIVE HIM MORE SPACING. WE WERE STILL VMC AND I WOULD HAVE RATHER STAYED VMC THAN GO TO THE VOR AND HOLD IMC WITH RPTED ICING. APCH SAID OK. THE CHEROKEE GOT IN, AND WE WERE CLRED TO A FIX. I ASKED FOR CLARIFICATION, APCH CLRED US TO THE VOR AND CLRED US FOR THE APCH. (THERE WAS NO PT REQUIRED FROM THE VOR.) WE GOT ESTABLISHED, APCH HANDED US OFF TO TWR. I PICKED UP NEW ATIS WITH MUU RPTS (BRAKING ACTION). TWR SAID HE WOULD GET US A NEW MUU RPT, THEN ASKED US IF WE HAD THE RPT. I ANSWERED IN THE AFFIRMATIVE, WE HAD THE NEW BRAKING ACTION RPT. I WAS MONITORING FO. MY EXPERIENCE SHOWS NEW PLTS IN THE PIAGGIO TEND TO GET SLOW. VERY DANGEROUS IN THE P180. APCH SPD IS 140 KTS, TOUCHDOWN IS 120 KTS. I WAS INSIDE AND OUTSIDE, WATCHING FOR RWY AND MONITORING FO. WE GOT GND CONTACT ABOUT 500-600 FT AGL, BUT FORWARD VISIBILITY WAS 1 MI OR LESS THAN 1 MI. FINALLY SAW RWY/LIGHTS. WE TOUCHED DOWN AND I SAW OBJECTS ON BOTH SIDES OF RWY APPROX 1/2 WAY DOWN. I WAS NOT EXPECTING ANYTHING TO BE ON THE RWY. WE WERE NEVER TOLD SNOW REMOVAL EQUIP ON RWY. I MADE A JUDGEMENT CALL. I COULD SEE THERE WAS ROOM BTWN THE SNOW PLOWS FOR US WITH PLENTY OF ROOM ON EITHER SIDE. WE WERE SLOWED DOWN TO WHERE THE IAS WASN'T EVEN READING WHEN WE PASSED THE TRUCKS. I DIDN'T WANT TO TRY A TOUCH-AND-GO, AIRPORT IS APPROX 6600 FT MSL. WE PROBABLY WOULD NOT HAVE BEEN AIRBORNE BY THE TIME WE WERE BY THE PLOWS. OUR COURSE OF ACTION WAS THE SAFEST POSSIBLE IN THAT SIT. TWR TOLD US TO CONTACT HIM VIA PHONE. TWR PERSON AND I TALKED SEVERAL TIMES. HE TOLD ME HE HAD ONLY BEEN THERE 1 MONTH. HE TOLD US HE WAS THE ONLY ONE IN THE TWR. WHY WAS THERE NO SUPVR IN THE TWR? WHY DIDN'T HE TELL US THERE WAS EQUIP ON THE RWY? WHY AM I CLRED FOR AN APCH WHEN THERE IS EQUIP THAT CAN MAKE MY LOC READ ERRONEOUS IN IMC? DID HIS ATIS SAY SNOW REMOVAL WAS IN EFFECT?

++

Non-towered. Non-hub.
C208 PLT IS SURPRISED TO FIND 2 SNOW BLOWERS ON THE RWY FOLLOWING AN ILS APCH. ON GAR DISCOVERS HE HAD SELECTED THE WRONG CTAF FREQ. VEHICLES CLRED THE RWY TO ALLOW A SUCCESSFUL LNDG.

AT APPROX 35 MI FROM LNDG, I WAS ABLE TO PICK UP THE ASOS AND NOTIFIED ZDV THAT I WOULD BE REQUESTING THE ILS RWY 10 APCH TO THE AIRPORT. I BEGAN AT THIS TIME TO SET RADIOS FOR THE ILS AND REQUESTED VECTORS TO THE LOC FROM ATC. AT ABOUT 13 MI FROM AIRPORT, I WAS CLRED FROM CTR FREQ TO ADVISORY FREQ. AT THIS TIME I SELECTED THE FREQ I HAD PREVIOUSLY STORED WHEN

SETTING THE RADIOS FOR THE APCH. I MADE A POS CALL ON ADVISORY FREQ AND RECEIVED NO REPLY FROM UNICOM WHICH IS NOT TOO UNUSUAL. AT 7 MI, MADE ANOTHER POS RPT AND KEYED PLT CTL LIGHTING TO ‘HIGH.’ AT ABOUT 2 MI, BROKE OUT OF THE OVCST AND MADE A ‘SHORT FINAL’ POS RPT. IT WAS AFTER THIS I NOTICED A ROTARY SNOW BLOWER ON THE TXWY APCHING THE RWY AND IT APPEARED HE WAS GOING TO CONTINUE ONTO THE RWY OVERRUN AREA. I STOPPED MY DSCNT AND LOST SIGHT OF THE PLOW UNDER THE NOSE OF THE ACFT. AT THIS POINT, I NOTICED ANOTHER PLOW ON THE RWY ITSELF AND MADE THE DECISION THAT I WOULD BEGIN THE MISSED APCH. I BEGAN A CLB BUT DID NOT IMMEDIATELY BEGIN THE TURN TO THE VOR, SO I COULD EXAMINE THE RWY TO SEE IF THERE WAS SOME UNDISCLOSED HAZARD OR SITUATION TO BE AWARE OF DURING MY FOLLOWING APCH. NOT SEEING ANYTHING, I BEGAN MY TURN ON THE PUBLISHED MISSED APCH AND WENT TO SELECT THE CTR FREQ TO NOTIFY THEM OF THE MISSED APCH WHEN I NOTICED THAT I HAD SELECTED THE WRONG FREQ FOR CTAF 122.8 INSTEAD OF 123.0. I SET THE CORRECT FREQ AND CALLED AIPORT UNICOM TO ADVISE THEM OF THE SITUATION. THEY SAID THEY HAD ‘HEARD ME ON STEAMBOAT’S FREQ’ AND WERE CLRING THE RWY. WHEN THEY MADE THE CALL THAT ALL THE EQUIP WAS CLR, I WAS ON DOWNWIND AND HAD GOOD VISUAL CONTACT WITH THE RWY AND ELECTED TO LAND FROM THAT POINT. THE PRIMARY FACTOR IN THE SEQUENCE OF EVENTS WAS THE PLT’S SELECTION OF THE WRONG CTAF. BETTER AWARENESS OF THIS IS THE RESOLUTION. ADDITIONALLY ISSUANCE OF NOTAMS MAY HAVE REINFORCED THE NEED TO COMMUNICATE WITH UNICOM INSTEAD OF JUST MAKE STANDARD POS RPTS. ALSO A MEANS OF MONITORING ARTCC MIGHT GIVE ADDITIONAL ALERT OF INBOUND ACFT HELPING TO REDUCE THE CHANCE OF SIMILAR CONFLICT IN A FUTURE OCCURRENCE OF THIS TYPE.

++

Full-time ATCT. Large-Hub.
CTLR EXPERIENCES AMASS ALERT WITH NO VISUAL CONFLICTING TFC.

ACFT X ILS RWY 9L APCH TO VISUAL CONDITIONS. DEICER TEAM (DEICER 3) TO CROSS RWY 4 AND TO HOLD SHORT OF RWY 9L WITH ACKNOWLEDGMENT. THERE WAS AN AMASS ALERT THAT THE RWY WAS OCCUPIED. I SCANNED THE RWY, AND THE DEICING TEAM HAD STOPPED SHORT OF THE RWY. I THEN SCANNED THE REST OF THE RWY FOR OTHER VEHICLES AND ACFT, AND THE RWY WAS CLR. I THEN DECIDED TO ALLOW THE ACFT TO LAND.

++

Full-time ATCT. Large-Hub.
A CL65 FO RPTED BEING DISTR DURING TAXI AND ALLOWING HIS CAPT TO DEPART THE TXWY AND JOIN A ROADWAY.

WE WERE TALKING TO THE RAMP CTLR. HE CLRED US TO TAXI W ON TXWY A, WITH OUR DISCRETION, TO CUT OVER TO TXWY B ON TXWY A4 OR TXWY A3 BECAUSE OF SNOW AND SLUSH ON TXWYS. I WAS BUSY WITH CHKLISTS AND WAS HEADS DOWN. I LOOKED UP AND SAID ‘WE’RE COMING UP ON TXWY A4.’ THE CAPT SAID, ‘IT LOOKS GOOD. LET’S TAKE IT,’ AND HE TURNED US ONTO IT. WE TAXIED ABOUT 20 FT WHEN THE RAMP CTLR ADVISED US TO STOP, THAT WE WERE ON A VEHICLE ROAD. AT THE TIME OF THE TURN, THERE WAS NO TFC ON THE ROAD. WHEN WE REALIZED WHERE WE WERE, A BIG BUS STARTED TOWARDS US, THEN STOPPED. THE CTLR HAD THE BUS BACK UP AND HE CLRED US OVER TO TXWY B AND WE WERE ON OUR WAY. I APOLOGIZED AND HE SAID ‘NO PROB.’ THE VEHICLE ROAD WAS IN BETTER SHAPE THAN THE TXWYS. WE MISTOOK IT FOR A CLRED TXWY BECAUSE WE WANTED TO AVOID SNOW/SLUSH. WE JUST FLAT OUT SCREWED UP.

++

Full-time ATC. Medium-hub.
A B737-200 IS ALMOST HIT BY A BOX PLOW DURING ITS TXWY INCURSION WHILE REMOVING SNOW AT A HIGH SPD FROM THE RAMP AREA.

WX AT TIME OF INCIDENT: WIND 210 DEGS AT 10 KTS, GUSTING TO 25 KTS. VISIBILITY VARIABLE 1/2–3/4 MI, BLOWING SNOW AND MIST. AFTER PUSHBACK AND AFTER DEICING THE ACFT, WE RECEIVED

A TAXI CLRNC TO TAXI THE ACFT TO RWY 24L VIA TXWY K, HOLD SHORT OF RWY 24R AT TXWY C. WE ENTERED TXWY K DIRECTLY ABEAM GATE X AND WHILE TAXIING E ON THE TXWY, BOTH THE FO AND I OBSERVED A BOX PLOW THAT HAD STARTED ITS RUN FROM THE XA GATE AREA, MOVING S TOWARD TXWY K AT A HIGH RATE OF SPD. NEITHER I NOR THE FO WERE SURE OF THE PLOW OPERATOR'S INTENTIONS, SO I BEGAN TO SLOW THE ACFT SO AS TO AVOID A POTENTIAL PROB. HOWEVER, WITHIN JUST A FEW SECONDS, WE BOTH REALIZED THE PLOW OPERATOR DID NOT SEE US AND WAS CONTINUING ITS APCH TO TXWY K, STILL PROCEEDING AT A HIGH RATE OF SPD AS THOUGH THE INTENTION WAS TO GO THROUGH THE TXWY AND PUSH THE SNOW TO THE S SIDE OF THE TXWY AREA. AT THAT POINT, I APPLIED MAX BRAKING AND TURNED THE ACFT APPROX 25 DEGS TO THE R TO AVOID A COLLISION AND SLID TO A STOP WITHIN JUST A FEW FT OF THE S EDGE OF THE TXWY. OPERATOR ALSO APPLIED MAX BRAKING AND SLID TO A STOP APPROX 15 FT FROM THE L SIDE OF THE FORWARD ACFT FUSELAGE, ABEAM THE L-1 DOOR AND JUST OUTBOARD OF THE #1 ENG INLET. ONCE WE REALIZED THAT BOTH THE ACFT AND THE PLOW HAD STOPPED AND NO COLLISION HAD TAKEN PLACE, WE CONTACTED GND CTL AND INFORMED THEM OF THE NEAR COLLISION. AFTER CLRING THE AREA AND MAKING SURE WE HAD ENOUGH ROOM TO TURN THE ACFT TO THE L AND BACK TOWARD THE CTR OF TXWY K, WE ASKED FOR CLRNC TO CONTINUE OUR TAXI UP TO THE HOLDING POINT SHORT OF RWY 24R. THE PLOW OPERATOR BACKED THE PLOW UP AND RETURNED TO THE GATE AREA. AFTER OUR RETURN TO THE AIRPORT, LATER IN THE DAY, I CONTACTED THE PLOW OPERATOR'S SUPVR MR X AND DISCUSSED WITH HIM THE EVENTS THAT HAD TAKEN PLACE EARLIER THAT MORNING. HE EXPLAINED THAT THIS PLOW OPERATOR IS NOT ONE OF HIS REGULAR, FULL-TIME EMPLOYEES, BUT IS RATHER A PART-TIME WORKER WHO IS PERIODICALLY CALLED IN DURING PEAK WORKLOAD TIMES. IN ADDITION TO THE EVENTS JUST DESCRIBED AND WHILE TAXIING OUT FOR DEP AS FLT ABCD, WE WERE PROCEEDING N ON TXWY R FOR A DEP OFF RWY 14 WHEN ANOTHER INCIDENT OCCURRED. JUST NO F TXWY M, 2 ROAD GRADERS WERE ON THE TXWY AND BEGAN TURNING SBOUND TO GET BACK TO A ROAD THAT TRAVELS IN A SOUTHEASTERLY DIRECTION FROM THE TXWY. THOUGH THEY WERE STILL APPROX 150-200 YARDS AHEAD OF US, GND CTL HAD NOT NOTIFIED US THAT THE GRADERS WERE CLRED TO BE ON THE TXWY, AND I'M NOT AT ALL SURE THEY DID HAVE A CLRNC TO PROCEED ONTO THE TXWY. WE DID HAVE TO SLOW THE ACFT SOMEWHAT IN ORDER TO GIVE THEM TIME TO CLR. I WOULD NOT CATEGORIZE THIS AS A 'NEAR MISS,' BUT THE FACT REMAINS, THEY WERE SOMEWHERE THEY PROBABLY SHOULD NOT HAVE BEEN. I ONCE AGAIN CONTACTED GND CTL AND INFORMED THEM THAT THIS WAS THE SECOND TIME TODAY THAT WE HAD AN UNCOMFORTABLE EXPERIENCE WITH SNOW REMOVAL EQUIP. THEIR REPLY (ONCE AGAIN) WAS THAT THEY WOULD CONTACT THE AIRPORT OPERATOR AND INFORM THEM OF THE PROB. SNOW REMOVAL AT A MAJOR ARPT IS A VERY DIFFICULT JOB AND REQUIRES A TREMENDOUS AMOUNT OF COORD BTWN THE WORKERS AND GND AND/OR TWR CTL, BUT IT SEEMS THAT IN THIS CASE THOSE COMS HAD BROKEN DOWN.

++

Part-time ATCT. Non-hub.
ARPT OPS SUPVR ALLEGES KC135 GAR CAUSED BECAUSE OF NON XFER OF CTL TWR WITH MEN AND EQUIP ON RWY PROVIDING SNOW REMOVAL.

DURING SNOW OPS AT APPROX XA45, A KC-135, BASED AT THIS ARPT ALMOST LANDED ON A SNOW REMOVAL CREW ON RWY 5R WITHOUT HAVING THE PROPER ATC CLRNC TO LAND. THE PLT WAS TALKING TO A DIFFERENT AIRPORT ATC CTL. THE OTHER AIRPORT SWITCHED THE ACFT OVER TO OUR TWR, BUT THE PLT DID NOT CONTACT AIPORT TWR UNTIL HE SAW THE EQUIP ON THE RWY. AT THAT TIME HE SAID 'GOING AROUND,' THEN PULLED UP AND CIRCLED AROUND FOR ANOTHER APCH. IT WAS SNOWING AND THE VISIBILITY WAS APPROX 1 MI., THE ACFT WAS APPROX 300 FT OVER THE THRESHOLD BAR OF THE RWY. THE CTLR STATED THAT HE DID NOT KNOW THE ACFT WAS ON FINAL APCH BECAUSE THE ACFT DID NOT HAVE A T-TAG (ON THE RADAR SCOPE) AND NEVER CONTACTED HIS TWR FREQ. THE CTLR FOUND OUT THAT THE ACFT WAS ON FINAL APCH WHEN VEHICLES ON THE RWY INQUIRED ABOUT IT ON GND FREQ, AND BY THAT TIME THE ACFT HAD ALREADY BEGUN THE GAR. THERE WERE 2 PLOWS, 2 BROOMS AND 2 PICKUP TRUCKS ON THE RWY. THE LCL FSDO OFFICE WAS NOTIFIED AND A RPT WAS MADE WITH THE FAA. ALSO, WE HAVE HAD CONVERSATIONS WITH BOTH AIRPORTS' TWR CHIEFS. MY CONCERN IS

THAT THIS IS THE SECOND TIME IN 2 YRS THAT WE HAVE HAD THIS HAPPEN AND THIS MAY BE A SYS PROB AS WELL AS HUMAN ERROR.

++

Full-time ATCT. Large hub.
B12 HELI PLT AND ATCT LCL CTLR DIFFERED ON WHERE THE LNDG WAS TO TAKE PLACE.

DURING APCH TO LNDG ON TXWY, TWR CTLR ADVISED SNOW REMOVAL ON TXWY F (SAME TXWY I WAS LNDG ON) AND MEN AND EQUIP WORKING ON THE BARRIERS ON RWY 31. I THOUGHT I WAS INSTRUCTED TO AVOID MEN AND EQUIP ON THE RWY AND TXWY. I CROSSED THE RWY AT 90 DEG ANGLE WELL CLR OF THE MEN AND EQUIP AND 300-400 FT AGL. LANDED ON TXWY F 1000-3000 FT FROM NEAREST VEHICLE. TWR OPERATOR WAS SURPRISED. HE THOUGHT HE HAD RESTR ME FROM ANY FLT OVER THE RWY (14,500 FT LONG).

++

B737-300 WAS ALMOST HIT BY AN ARPT GND EQUIP SNOW REMOVAL TRUCK.
Full-time ATCT. Large hub.

AFTER LNDG ON RWY 21L, WE WERE TOLD TO FOLLOW THE ACR ON TXWY T AND TXWY K AND HOLD SHORT OF CLOSED RWY 9L. THIS IS A VERY LONG RTE AROUND THE NEW TERMINAL CONSTRUCTION. APCHING TXWY K, WE OBSERVED SEVERAL LARGE SNOW SCRAPER/BLOWERS WORKING NEAR THE AREA OF CLOSED RWY 21R AND TXWY Y. THEY WERE MOVING RAPIDLY AND IN A VERY IRREGULAR PATTERN, HITTING THE AREAS OF SNOW ON THE TXWYS. OUR TXWYS WERE CLR ON THE CTRLINE WITH A BAND OF SNOW ON THE R EDGE. NO SNOW WAS FALLING AND THE VISIBILITY WAS GOOD. WE WERE 1/4 MI BEHIND THE ACR AND 1/4 MI IN FRONT OF A COMPANY FLT THAT WITNESSED THE EVENT. AS WE APCHED TXWY K4, A SMALLER SNOW BLOWER WHO WAS WORKING ON TXWY Y MADE A TURN ONTO TXWY K4 AND WITHOUT STOPPING OR SLOWING DOWN CAME DIRECTLY AT US AT A HIGH RATE OF SPD AND OBLIVIOUS TO OUR MOVEMENT ON THE ACTIVE TXWY. MY FO YELLED ‘I DON’T THINK HE IS GOING TO STOP’—AND HE DID NOT. I TOOK EVASIVE ACTION TO THE R AND SLAMMED ON THE BRAKES. WE DID NOT DEPART THE TXWY, BUT GOT NEAR THE EDGE INTO THE SNOW. LUCKILY, THE VEHICLE WAS SMALL ENOUGH TO GO UNDER THE WINGTIP WITHOUT COLLIDING WITH US. WITHOUT OUR ACTION, WE BELIEVE HE WOULD HAVE IMPACTED US BTWN THE NOSE GEAR AND #1 ENG. AT THE GATE, I CALLED THE ARPT MGR WHO STARTED AN INVESTIGATION INTO THE EVENT. LOOKING BACK, I DO REMEMBER SEEING AN SUV TYPE TRUCK WITH THE SNOW PLOWS, BUT HE WAS DEFINITELY NOT IN CTL OF HIS EQUIP. THIS ARPT IS BY FAR THE MOST DANGEROUS ARPT FOR TAXI AND COMPLICATED INSTRUCTIONS IN OUR SYS.

++

Part-time ATCT. Non-hub.
RWY AT ARPT WAS OCCUPIED BY A SNOW SWEEPER WHEN A REGIONAL JET CHKED IN ON A 1 MI FINAL.

I WAS WORKING THE LCL CTL POS ON JAN/XA/01. VISIBILITY WAS RESTR DUE TO SNOW SHOWERS AND LOW CEILINGS. A VEHICLE WAS ON THE MAIN RWY (RWY 5/23) TRAVELING SWBOUND SWEEPING SNOW. THE VEHICLE WAS APPROX 1500 FT FROM THE APCH END OF RWY 23 WHEN ACR X, A REGIONAL JET, FIRST CHKED IN. I GLANCED UP AT THE BRITE RADAR DISPLAY IN THE TWR AND WAS SHOCKED TO SEE THE ACFT ON A 1 MI FINAL TO RWY 23 AT 500 FT AGL. I LOOKED DOWN AT THE VEHICLE AND HE WAS 1000 FT FROM THE CLOSEST TURNOFF AND IT WOULD HAVE BEEN IMPOSSIBLE FOR HIM TO CLR THE RWY IN TIME FOR ACR X TO LAND. ACR X WAS SENT AROUND, BUT THE ACFT’S MOMENTUM ALLOWED THE ACFT TO DSND DOWN TO 200-300 FT AGL. ACR X OVER FLEW THE VEHICLE AT A LOW ALT. A REVIEW OF THE VOICE TAPES INDICATED THAT ACR X WAS NEVER ADVISED TO CONTACT THE TWR BY APCH CTL. WHEN QUIZZED BY THE RADAR CTLR AFTER THE GAR THE PLT STATED HE SWITCHED OVER ON HIS OWN BECAUSE HE WAS ‘COMING UP ON SHORT FINAL.’ THIS SIT COULD HAVE BEEN TRAGIC IF ACR X HAD NOT SWITCHED FREQS ON HIS OWN. MORE OFTEN THAN NOT, PLTS LAND WITHOUT A LNDG CLRNC WHEN THEY ARE NOT SWITCHED TO THE TWR OR THEY FORGET TO CHANGE

FREQ. THE POS AND DIRECTION OF THE VEHICLE, ALONG WITH THE LOW VISIBILITY, WOULD HAVE MADE IT DIFFICULT TO SPOT DURING LNDG. WE WERE WORKING WITH THE 'NEW' STAFFING LEVELS TODAY WHEN ACR X CAME WITHIN FT OF HITTING A VEHICLE. THE 4 CTLRS WERE WORKING THE 4 REQUIRED POS (2 IN THE TWR AND 2 IN THE RADAR ROOM) AND THE SUPVR WAS AWAY FROM THE OP DOING PAPERWORK.

++

Full-time ATCT. Non-hub.
DAY CTLR CONCERNED WITH DAY ARPT SNOW REMOVAL VEHICLE RESTRS.

I WAS WORKING THE GND AND LCL CTL POS IN THE ATC TWR. SNOW REMOVAL OPS WERE ONGOING WITH SNOW AND FREEZING RAIN. RWY 6L WAS THE ACTIVE RWY AND THE ILS RWY 6L THE ONLY APCH AVAILABLE. BRAKING ACTION ON THE TXWYS WAS NIL. BRAKING ACTION ON THE RWY WAS POOR, DETERIORATING RAPIDLY TO NIL. WHEN SNOW REMOVAL IS IN PROGRESS, THE CITY DOES NOT CLOSE THE RWY. WE (ATC) WORK THE EQUIP ON AND OFF THE RWY BTWN ARRS AND DEPS. AT ONE POINT, I HAD 5 DIFFERENT GROUPS OF VEHICLES ON THE RWY. EACH GROUP WITH A DIFFERENT CALL SIGN. I HAD TO MAKE 5 DIFFERENT CALLS TO CLR THE VEHICLES OFF THE RWY AND 5 CALLS TO VERIFY CLR OF THE RWY. THIS IS A DANGEROUS AND UNSAFE CONDITION. THE RWY BRAKING ACTION IS DETERIORATING AS SNOW REMOVAL CANNOT TAKE PLACE WITH ACFT OPERATING ON THE RWY. I HAVE TO REMEMBER WHERE ALL THE TRUCKS ARE WHILE CONTINUING AIR OPS. THE ANSWER SEEMS SIMPLE. CLOSE THE RWY (MAYBE 20-30 MINS). CLR THE SNOW AND ICE, THEN REOPEN FOR OPS. IN MY 15 YRS EXPERIENCE AT DAYTON, THIS IS HOW IT HAS ALWAYS BEEN. I'M TIRED AND FRUSTRATED TO BE PLACED IN THIS SIT. WE ARE SACRIFICING THE SAFETY OF THE FLYING PUBLIC, PLTS, AND SNOW REMOVAL EQUIP OPERATORS.

++

Full-time ATCT. Large hub.
ACR B727 STRIKES GND VEHICLE DURING WINTER CONDITIONS ON RAMP.

DURING A LIGHT/MODERATE SNOWSTORM, OUR B727 WAS TAXIING TO OUR GATE. THE RAMP WASCOVERED WITH APPROX 2 INCHES OF SNOW. BRAKING AND MANEUVERABILITY WERE FAIR TO GOOD. WHILE ACFT WAS ON PARKING CTRLINE, THE L WINGTIP STRUCK A DEICING TRUCK PARKED NEARBY. MARSHALLERS AND WING WALKERS WERE PRESENT, BUT NOT ABLE TO TELL IF A CONFLICT WAS PRESENT UNTIL TOO LATE. THE SNOW COVERED THE SAFETY LINES SO NO ONE COULD TELL IF THE TRUCKS WERE IN THEIR PROPER POS. DAMAGE TO THE ACFT WAS SMALL, TRUCK WAS UNDAMAGED. I BELIEVE THAT THE INCLEMENT WX MAY HAVE AFFECTED THE GND PERSONNEL'S PERFORMANCE. I'M SURE THEY WANTED TO GET OUT OF THE COLD AND SNOW ASAP. IN ADDITION, THE MARSHALLER DIDN'T KEEP AN EYE ON THE WING WALKERS – SHE WAS WATCHING THE ACFT ALIGNMENT WITH THE TAXI CTRLINE. SUPPLEMENTAL INFO FROM ACN 461253: SOMEONE OTHER THAN THE MARSHALLER SIGNALED THE CAPT TO STOP, BUT THE MARSHALLER DID NOT GIVE THE STOP SIGNAL. IT APPEARED THAT THE SAFETY CONES WERE IMPROPERLY PLACED AND THE MARSHALLER SIMPLY WASN'T PAYING ATTN. SUPPLEMENTAL INFO FROM ACN 461669: THE MARSHALLER, WHEN ASKED WHY THEY DID NOT SEE THE WING WALKER'S STOP SIGN, SAID THEY WERE NOT WATCHING THE WING WALKERS. BETTER TRAINING MAY PREVENT THIS, PLUS KEEPING SAFETY LINES CLR OF SNOW WOULD HELP.

++

Full-time ATCT. Small hub.
FOREIGN OBJECT DAMAGE TO THE R ENG OF A B737 WHEN IT ENCOUNTERED A 3 FT PILE OF SNOW WHILE MANEUVERING TO AVOID SNOW REMOVAL EQUIP.

FOLLOWING A NORMAL APCH AND LNDG TO RWY 4, ACFT WAS TAXIED CLR OF THE END OF RWY TO THE GATE. SEVERAL GND/SNOW REMOVAL VEHICLES WERE OPERATING TO L OF ACFT SO WE MOVED TO THE R SIDE OF RAMP. BLUE TAXI EDGE LIGHTS WERE CLRLY VISIBLE TO THE R. ACFT TAXIED INTO APPROX

3 FT HIGH SNOW PILE AND BECAME STUCK. R ENG INGESTED SNOW, RESULTING IN FOD. CONTRIBUTING FACTORS WERE LOW VISIBILITY AND NO NOTICE OF PILED SNOW ON AN ACTIVE TXWY.

++

Part-time ATCT. Non-hub.
A SAAB 340 PLT LNDG AT CTAF RPTS OVERFLYING AND LNDG BEYOND AN ARPT MAINT VEHICLE THAT DID NOT EXIT THE RWY FOLLOWING SEVERAL CALLS.

THE LACK OF ATTN OF THE GND VEHICLE DRIVER TO HIS POS ON THE RWY (HOW FAR HE HAD TO GO TO BE CLR) AND TO HOW FAR OUT THE ACFT WAS ON APCH. LNDG AT AIRPORT, WE WERE TALKING ON CTAF GIVING POS RPTS AS NEEDED. GIVING A BASE LEG RPT, THE DOT SWEEPER DRIVER RESPONDED THAT HE WOULD BE CLR OF THE RWY. ARPT 'MOBILE ONE' ALSO STATED 'LIGHTS ARE ON, DECK IS CLR.' VISIBILITY THEN DROPPED DUE TO A SNOW SQUALL. UPON TURNING FINAL I NOTICED A VEHICLE ON THE RWY. 2 COMPANY ACFT WERE WAITING TO CROSS THE RWY. THEY HEARD OUR POS CALLOUTS AND HELD ON THE N SIDE OF THE RWY WAITING FOR US TO LAND. 1 ACFT SEEING US ON FINAL AND THE VEHICLE ON THE RWY CAUTIONED ME AND STARTED YELLING AT THE DRIVER. A GAR WAS NOT POSSIBLE DUE TO THE VERY LOW VISIBILITY OFF THE DEP END OF THE RWY. I DECIDED THE SAFEST THING TO DO WAS TO LAND BEYOND THE VEHICLE. I SIDE-STEPPED SLIGHTLY TO THE R AND OVERFLEW THE VEHICLE AND SAFELY LANDED. PLT WITNESSES RPTED THAT WHEN I TOUCHED DOWN THAT THE VEHICLE WAS CLR. IT IS NOT EVERY DAY THAT I OVERFLY A VEHICLE ON THE GND WHEN LNDG. IN FACT IT IS THE FIRST TIME. HAVE THE DOT DRIVERS BETTER UNDERSTAND WHERE THEY AND ACFT ARE IN RELATION TO EACH OTHER. THE CREW SHOULD ALSO ENSURE THAT THEY ARE CLR. IN THIS CASE BECAUSE THE VISIBILITY WENT DOWN I OPTED TO LAND AS THE SAFEST MEASURE.

++

APPENDIX D
Resource List

Advisory Circulars

AC 23-26	Synthetic Vision and Pathway Depictions on the Primary Flight Display
AC 120-57	Surface Movement Guidance and Control Systems (SMGCS)
AC 120-74	Parts 91, 121, 125, and 135 Flightcrew Procedures during Taxi Operations
AC 150/5200-28	Notices to Airmen (NOTAMs) for Airport Operators
AC 150/5200-30	Airport Winter Safety and Operations
AC 150/5210-5	Painting, Marking, and Lighting of Vehicles Used on Airports
AC 150/5210-19	Driver's Enhanced Vision System (DEVS)
AC 150/5210-20	Ground Vehicle Operations on Airports
AC 150/5220-20	Airport Snow and Ice Equipment
AC 150/5340-1J	Standards for Airport Markings
AC 150/5340-30	Design and Installation Details for Airport Visual Aids

Orders and Notices

Order 5280.5	Airport Certification Program Handbook
Order 7340.1	Contractions
Order 7930.2	Notices to Airmen (NOTAMs)
Order 7930.2K	Change 2 NOTAMs
Notice N JO 7930.85	NOTAMs

Useful Websites

AOPA Runway Safety	www.aopa.org/asf/runway_safety
Air Line Pilots Association Safety	www.alpa.org/runwaysafety
Australia Fatigue Management	www.ntc.gov.au
FAA ATO Safety	www.faa.gov/airports_airtraffic/airports/runway_safety
FAA Runway Safety	www.faa.gov/runwaysafety
Federal Aviation Administration	www.faa.gov
FMCSA Fatigue Management	www.fmcsa.dot.gov
NASA Fatigue Management	human-factors.arc.nasa.gov/zteam
NTSB Accident Reports	www.ntsb.org
Runway Incursion Evaluation	www.faa.gov/airports_airtraffic/airports/runway_safety/riiep/
Runway Status Lights System	www.rwsl.net/

Abbreviations used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation