Chapter 8

SERVICE AREA: Terminal Wind and Temperature Hazards

1. Problem Description The terminal area, which includes not only the runways and taxiways but also the approach and departure routes and adjacent holding areas in the skies around the airport, can be an extremely busy and complex place. During periods of peak traffic, pilots must be continually aware of their surroundings, including other traffic and changing weather conditions, in order to maintain safety of flight. Weather hazards within the terminal area are dangerous because encountering them so near to the ground can require more altitude to recover than is available. Wind hazards — wake vortices, unexpected crosswinds, wind shear, microbursts, downbursts, turbulence, and gust fronts — are the most generally recognized hazards in the terminal area. The effects of these hazards on airborne aircraft can include:

- unexpected motions in all directions, which can lead to flight crew and passenger injury,
- loss of aircraft control, and
- airspeed fluctuations that may induce aerodynamic stall.

The presence of adverse low-level wind conditions can, of course, impact efficiency by reducing capacity at an airport and causing delays and diversions.

In addition, variations in ambient temperatures in the terminal area can lead to changes in takeoff and flight characteristics in aircraft. Failure to account for these variations can cause:

- aborted takeoffs, and
- inability to remain airborne once the aircraft is out of ground effect. (See box, page 8-2.)

2. Objectives The goal of the Terminal Wind and Temperature Hazard Service Area is to provide the timely and accurate low-level wind and temperature information needed to significantly reduce, if not eliminate, wind and temperature-related accidents in the terminal area. In order to reach this goal, the *National Aviation Weather Initiatives* establishes these objectives:

- reduction in the rate of low-level wind and density altitude-related accidents and incidents for general aviation aircraft,
- reduction in the rate of wind shear- and microburst-related accidents and incidents for all types of aircraft, and
- improvements in the capabilities for observing and forecasting wind shear/microburst events and movement of wake vortices.

3. Operational Decision Makers The range of decision makers described in Chapter 2 applies to the terminal wind and temperature hazard service area.

4. Current Operations Concept

4.1 Preflight Operations. During preflight the pilot gathers all available weather information, as described in Chapter 2. He or she must understand the current density altitude (see box, page 8-3) of the terminal area to make sure that appropriate power and control surface settings are used during takeoff. In addition, the pilot must consider information from all available airport sensors, such as LLWAS and TDWR, to assess the potential for encountering hazardous wind conditions. If conditions conducive to wind shear events are forecast or appear present, the pilot must also review emergency procedures prior to takeoff in case these conditions are encountered once airborne.

4.2 Airborne Operations. Pilots on climbout or on approach to landing need to be especially aware of changing weather conditions and other traffic in the area. The guidance just mentioned about reviewing emergency procedures for possible encounters with adverse wind conditions is especially applicable to pilots on approach. Pilots must be aware of the possibility of encountering wake vortices as well as other wind hazards generated by changing weather conditions.

Air Traffic Control personnel also need to be aware of wind hazards in the terminal area. Maintaining prescribed separations to prevent wake vortex encounters is a necessity, but controllers must also be aware that in some instances wakes can persist longer than expected or drift downward into the paths of aircraft positioned behind and below others. Flight operations personnel must be prepared to adjust capacity and change active runways as adverse conditions persist or move through the terminal area.

An airplane or helicopter flying near the ground (within 30 feet or so) gains extra lift from a cushion of air trapped between itself and the ground. This extra lift is called ground effect. During takeoff, an airplane can actually sustain flight in ground effect, yet not have sufficient lift or engine power to climb higher. Aircraft operating manuals take this characteristic into consideration when presenting safe takeoff performance parameters.

A few very unusual aircraft fly in ground effect for their whole flight. The Russian Orlonyok Wing-in-Ground Effect (WIG) vehicle shown below has an estimated payload of 15-28 tons and a speed of 250 mph.

5. Needed Service Improvements In the ideal situation, pilots would always be cognizant of hazardous wind and temperature conditions that exist when they are within any terminal environment. They should have both the knowledge of present weather conditions and the skill in dealing with the potential threats to safety those conditions represent. A number of improvements can bring this operational scenario closer to reality.

5.1 Production of Weather Information. Weather observation networks within the terminal area must provide sufficient resolution in space and time to allow identification of rapidly moving gust fronts and severe turbulent cells that can produce downbursts. Atmospheric conditions that determine the path of wake vortices, such as winds, temperatures, and stability, must be observed and measured. Current sensor and processor technologies under development offer the potential to provide significant amounts of low-level wind information. Development of algorithms for processing this sensor data will allow more accurate and timely products to describe what can be a rapidly changing environment. Commercially available, Federal Aviation Administration-certified wind shear sensors are slowly being installed in the commercial airliner fleet. These devices will reduce wind shear-related accidents as more aircraft are equipped.

5.2 Weather Product Generation and Delivery. Analysis and forecast products that decision makers rely on must provide information that can be rapidly digested and understood. Graphics and text products can be of great use to aircraft operations and service providers for planning purposes and for alerting aircraft in the terminal area of hazardous conditions. However, audible alarms are essential to pilots of business and general aviation aircraft on approach paths, because they do not have time to digest displays or messages before they encounter dangerous conditions.

> *Density altitude* is one of several measures of altitude used by aircraft. The simplest of early altimeters measured only the pressure of the atmosphere and displayed it on a cockpit gauge in terms of “feet”. This is called the *pressure altitude*. The more advanced modern altimeters measure both air pressure and temperature, calculate the air’s density, and display the effective altitude on a cockpit gauge in feet. This is called the *density altitude;* it is more meaningful to aircraft performance than pressure altitude. For example, flight a few hundred feet above the floor of a desert can be at a density altitude of several thousand feet because of the high air temperatures.
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> Aircraft operating at high density altitudes must take into account longer takeoff rolls, reduced rate of climb, and reduced maneuvering capabilities. These factors are important for aircraft operating in desert or mountainous environments or when taking off or landing in especially hot weather, particularly if the aircraft is at or near maximum gross weight.
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> The crash of a Cessna 177B in Cheyenne, WY in 1996 was the center of considerable media attention. The NTSB accident summary stated in part: “Probable cause: the pilot-in-command’s improper decision to take off into deteriorating weather conditions...when the airplane was overweight and when the density altitude was higher than he was accustomed to...” (NTSB SEA96MA079).

5.3 Pilot Training. Pilots of all classes of aircraft need refresher training in dealing with high density altitudes, wind shear, and other wind hazards, as well as recovery techniques following upset. Terminal area hazard training programs, such as the highly effective FAA windshear package developed in the 1980's, need to be developed or modified as necessary and provided as supplements to other training methods.

6. Terminal Wind and Temperature Hazards Initiatives On pages 8-5 and 8-6 are the initiatives which have been identified for this service area.

Number	Terminal Wind and Temperature Initiatives	Relative Ranking*	Cooperating Organizations
1	Develop and implement terminal wind and temperature products, such as microburst and low-level wind shear information integrated into a single display which requires little or no interpretation or analysis, that are applicable for use by pilots, ATC service providers, airline operations centers, and other users.	★★★★	NOAA/NWS, Industry**, FAA, NASA
2	Develop and implement ground-to-air Flight Information Service capabilities to disseminate terminal wind hazard observations, within 1-2 minutes of observation, and forecast products, within 15 minutes of product generation, throughout the National Airspace System, i.e, to the cockpit, to airline operations centers, and to ATC service providers.	★★★★	FAA, NASA, DoD, Industry
3	Develop and implement a multi-functional color cockpit display which includes terminal wind hazards along with terrain and traffic hazards.	★★★★	NASA, Industry
4	Increase the types and number of aircraft capable of automatic reporting of terminal wind hazards.	★★★★	NASA, Industry
5	Improve current ground-based communications systems to readily disseminate hazardous and operationally significant wind condition reports and products affecting terminal operations.	★★★	FAA, NASA
6	Develop capabilities for providing terminal wind and temperature hazard information directly to decision support systems.	★★★	FAA
7	Develop and implement aircraft-mounted, forward-looking technologies for detecting microburst, wind shear, and wake vortex events.	★★	Industry, FAA, NASA
8	Expand the number of airports at which microburst and low-level wind shear services are available based on increased operations load at particular airports and the emergence of more cost-effective technologies.	★★	FAA, Industry

9	Improve the forecasts of surface temperature, as well as associated procedures for the calculation of density altitude, for increased awareness of operational ramifications.	★★	NOAA/NWS, DoD
10	Develop and implement forecasting (for 1 hour or greater) and modeling techniques that will improve hazardous and operationally significant surface wind condition products (including resolution and accuracy in time and space) affecting terminal operations.	★	NOAA/NWS, DoD, FAA
11	Develop and implement forecasting (for up to 1 hour) and modeling techniques that will improve hazardous and operationally significant surface wind condition products (including resolution and accuracy in time and space) affecting terminal operations.	★	NOAA/NWS, DoD, FAA

Terminal Wind and Temperature Initiatives

* The relative rankings assigned to the initiatives are based on a qualitatively calculated benefit/cost ratio. It's possible that a high-benefit initiative which is costly to implement may rank lower than a medium- or low-benefit initiative which is medium or low in cost to implement. All these initiatives are considered to have a positive benefit to aviation; however, when benefits and costs are considered, some rank relatively higher than others. Details can be provided upon request. Four stars (★★★★) is the highest ranking.

** The term "Industry" in this context refers to private organizations (e.g., airlines, manufacturers, associations) which may represent both users and providers of weather information.