METEOROLOGICAL WARNINGS STUDY GROUP (METWSG)

FOURTH MEETING

Montréal, 15 to 18 May 2012

Agenda Item 6: Wind shear, turbulence and tsunami warnings

WIND SHEAR INFORMATION

(Presented by P.W. Chan, co-rapporteur of ad hoc group B)

SUMMARY

This paper examines the current provisions of wind shear information, a sample of current practices by States and Regions, and a summary of the safety assessment process needed for changes in the provision of wind shear information to pilots.

1. INTRODUCTION

1.1 The group will recall that an ad hoc group had been established by Action Agreed 2/6 to consider the need for adding the terms "expected" and reported" to the phraseologies used for wind shear alerts which arose from the suggestion of Hong Kong ATC and pilots. Diverging views were expressed at the third meeting of Meteorological Warnings Study Group (METWSG/3) regarding the benefits and any associated risks of implementing additional terms in the wind shear alert. As a result, the group agreed that the user needs should be more rigorously assessed and that the ad hoc group be tasked with assessing user needs for phraseology in wind shear alerts and for the wind shear provisions in Annex 3 — *Meteorological Service for International Air Navigation* . The group also agreed that risk assessment considerations for any changes should be borne in mind together with any training needs related to future changes in the associated provisions.

1.2 METWSG/3 formulated the following Agreed Action 3/14:

Agreed Action 3/14 — User assessment of wind shear provisions in Annex 3 and PANS-ATM (Doc 4444)

That an ad hoc group (B) consisting of Carole, Colin, Herbert, Juan, Ndiwa, PW (co-rapporteur) and Steve (co-rapporteur) be established with the purpose of further assessing the current and the future use of wind shear provisions contained in Annex 3 and Doc 4444, in particular by:

a) analyzing current practices and understanding the usage of the existing services;

b) evaluating issues associated with any proposed changes in the light of safety risk management and training that would be required both by ANSP and airlines, and

c) providing a report on the findings by 15 January 2012 for consideration at the METWSG/4 Meeting.

1.3 The operational requirements for observing and reporting wind shear were first developed in 1979 then later revised in 1983. That statement of operational requirements is stated in Appendix 1 to the *Manual on Low-Level Wind Shear* (Doc 9817), and posted as Appendix A to this Study Note (SN).

1.4 This paper examines the current provisions of wind shear information, a sample of current practices by States and Regions, and a summary of the safety assessment process needed for changes in the provision of wind shear information to pilots.

2. WIND SHEAR PROVISION IN ANNEX 3 AND DOC 4444

2.1 Provisions in Annex 3

2.1.1 Standards and Recommended Practices (SARPs) for observing and reporting wind shear are contained in Annex 3, Chapters 4 and 5, along with the associated technical specifications in Annex 3, Appendices 3 and 4. SARPs for the provision of warning and alerts are contained in Annex 3, Chapter 7, along with the associated technical specifications in Appendix 6. Guidance on wind shear is contained in Doc 9817.

2.1.2 Wind shear alerts are expected to complement wind shear warnings and together are intended to enhance situational awareness of wind shear.

Wind shear warnings:

> (7.4.1)[1] Wind shear warnings shall be prepared by the meteorological office designated by the meteorological authority concerned for aerodromes where wind shear is considered a factor, in accordance with local arrangements with the appropriate ATS unit and operators concerned. Wind shear warnings shall give concise information on the observed or expected existence of wind shear which could adversely affect aircraft on the approach path or take-off path or during circling approach between runway level and 500 m (1 600 ft) above that level and aircraft on the runway during the landing roll or take-off run. Where local topography has been shown to produce significant wind shears at heights in excess of 500 m (1 600 ft) above runway level, then 500 m (1 600 ft) shall not be considered restrictive.

Wind shear alerts:

> (7.4.3) At aerodromes where wind shear is detected by automated, ground-based, wind shear remote-sensing or detection equipment, wind shear alerts generated by these systems shall be issued. Wind shear alerts shall give concise, up-to-date information related to the observed existence of wind shear involving a headwind/tailwind change of 7.5 m/s (15 kt) or more which could adversely affect aircraft on the final approach path or initial take-off path and aircraft on the runway during the landing roll or take-off run.

2.2 **PANS-ATM (Doc 4444)**

2.3 The *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) is complementary to the SARPs contained in Annex 2 — *Rules of the Air* and in Annex 11 — *Air Traffic Services*. Doc 4444 provides procedures which are mainly directed to air traffic services (ATS) personnel, but flight crew are expected to be familiar with those procedures.

2.3.1 Doc 4444 mentions the phrase "wind shear" but does not contain or reference the phrases "wind shear alert" or "wind shear warnings". Doc 4444 does not include "wind shear alerts" amongst the listing of alerting phraseologies (12.6.1)[2]. The alerting phraseologies are provided for "low-altitude warning" and "terrain alert".

2.3.1.1 Doc 4444 states (6.6.4) that at the commencement of the final approach, "the latest information, if any, wind shear and/or turbulence on the final approach area" shall be transmitted to the aircraft. Doc 4444 states (7.4.1.2.2) that occurrence, or expected occurrence of wind shear (amongst other meteorological conditions) be given to the aircraft prior to take-off. It also states (6.4.1) that significant changes in the meteorological conditions (then lists wind shear in the note) in the take-off or climb-out area be transmitted to the aircraft (unless already provided).

2.3.1.2 Doc 4444 also refers to wind shear in the criteria for suspending certain parallel approaches (6.7.3.3) as well as runway-in-use selections (7.2.6).

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[1] Paragraph numbers in the parenthesis refer to those sections and paragraphs in the referenced document, e.g., Annex 3, Annex 6, and Doc 4444.

[2] Paragraph numbers in the parenthesis refer to those sections and paragraphs in the referenced document, e.g., Doc 4444.

3. CURRENT PRACTICES

3.1 United States

3.1.1 The United States (US) provides wind shear alerts. Appendix B of this SN contains the detailed description of the wind shear systems and procedures in the US.

3.1.2 The US does not provide wind shear warnings. It believes that the wind shear alerts are timelier and provide a greater level of safety. The performance [Probability of Detection (POD) and Probability of False Alarms (PFA)] of the wind shear alerts from the Terminal Doppler Weather Radar (TDWR) and Integrated Terminal Weather System (ITWS) are as follows:

TDWR - 90% POD and 10 % PFA,
ITWS - 95% POD and 5 % PFA

3.1.3 US practices require forecasts of non-convective low-level wind shear within 2,000 feet of the ground to be included the aerodrome forecast (in meteorological code form) (TAF). Differences have been filed with ICAO for both the wind shear warning and the inclusion of wind shear in the TAF.

3.1.4 US aviation regulations for air carriers and operators, known as FAR Part 121, require turbine-powered aircraft to be equipped with airborne wind shear warning system and/or a wind shear detection system. Specifically, FAR 121.358 states:

> (a) *Airplanes manufactured after January 2, 1991.* No person may operate a turbine-powered airplane manufactured after January 2, 1991, unless it is equipped with either an approved airborne wind shear warning and flight guidance system, an approved airborne detection and avoidance system, or an approved combination of these systems.
>
> (b) *Airplanes manufactured before January 3, 1991.* Except as provided in paragraph (c) of this section, after January 2, 1991, no person may operate a turbine-powered airplane manufactured before January 3, 1991 unless it meets one of the following requirements as applicable.
>
> (1) The makes/models/series listed below must be equipped with either an approved airborne wind shear warning and flight guidance system, an approved airborne detection and avoidance system, or an approved combination of these systems: (FAR 121.358 then continues to list the various aircraft).

3.2 Hong Kong, China

3.2.1 Doc 9817, Appendix 4, provides detailed information and description of wind shear alerting in Hong Kong, China. Wind shear alerts are provided by a Wind shear and Turbulence Warning System (WTWS), which integrates the alerts provided by the various meteorological instruments, such as the ground-based anemometers and weather buoys, mountain-top anemometer, TDWR, and Doppler light detection and ranging (LIDAR) systems. These alerts, together with pilot reports (PIREPs), if any, are passed by air traffic control (ATC) to aircraft on commencement of final approach, following ICAO Doc 4444.

3.2.2 Wind shear warnings are also issued by the aviation weather forecasters on automatic terminal information service (ATIS). The aviation weather forecasters would examine the prevailing and the forecast meteorological conditions to assess the chance of the occurrence of wind shear in the next half an hour or longer. Reference would also be made to the pilot reports of wind shear (if exist), and wind shear alerts given by the meteorological instruments. The wind shear warning would be indicated as “forecast” if it is purely a forecast without support by pilot report, and indicated as “forecast and reported” if it is supported by pilot report(s).

3.3 **CAR/SAM Regions**

3.3.1 Most of the meteorological services in the Caribbean/South American (CAR/SAM) Regions do not have the equipment to detect wind shear events. A few meteorological services have meteorological Doppler radar, but they have not received specialized training for its use in wind shear detection. One State has planned to acquire a low-level wind shear alert system (LLWAS). Many Caribbean meteorological services have established specific procedures to alert the pilots and the controllers about the possible presence of wind shear when thunderstorms are producing gusty winds near the threshold of the runway, including the suggestion of ceasing flight operations at the airport. Some States in both Regions have produced technical instructions for pilots, controllers and meteorological aeronautical staff on how to proceed in case of detection of wind shear and using the criteria of LOSS or GAIN to identify and quantify the phenomena. One meteorological service considers that it is not enough to use of the terms GAIN or LOSS and is planning a workshop with all involved in the matter to discuss the way to act.

3.3.2 Some meteorological services have identified the causes that produce the wind shear and have clear procedures in place when certain synoptic metrological conditions are present and affect a specific geographical area.

3.3.3 It was noted, as a result of the sample survey done of the meteorological services in both Regions, that even though ICAO has several technical regulations and manuals on wind shear, there is a lack of training for the personnel involved in this matter, not only those involved directly with the service, but also the managers of the service.

3.4 **Other**

3.4.1 The World Meteorological Organization (WMO) continues to encourage Members providing meteorological services to international air navigation to monitor any occurrence of low level wind shear, caused both by convective events and terrain-induced wind shear. In close collaboration with the Hong Kong Observatory (Hong Kong, China) a set of posters was developed and made available to all interested service providers, pointing out the different causes of wind shear.

3.4.2 The new Expert Team on MSTA and Aviation Exchange Models (ET-M&M) is addressing all aspects of weather impact on the wider terminal area and busy airspace, including low-level wind shear and convection. The Team is cooperating closely with the relevant ICAO groups in developing appropriate SARPs and associated Guidance for these phenomena.WMO further assists Members who have identified a need to provide Wind Shear Alerts and Warnings on the most suitable approach. The recommended steps include an in-depth analysis based on past pilot reports and incident reports on the most common nature of events (convective, topographic, moist/dry microbursts, etc). This is followed by local consultation with user communities (ATM, operators, pilots) on the urgency and nature of the phenomena encountered, and a consultation with internal or external experts, including ICAO and WMO Secretariat and Expert Teams on the most suitable and affordable technology to be installed for warning and mitigation of the associated risks. The next step is a business proposal involving stakeholders and funding sources (State/Ministry, Cost recovery, Funding Agencies) for the testing and implementation of a suitable system (ranging from simple LLWAS, to Doppler Radar and LIDAR systems) which must include in-depth training of the personnel involved with the system.

Experience has shown that during the initial operational phase of a new system, feedback from forecasters and users and cooperation between the different stakeholders is paramount to adapt any system to local conditions and operating practices, thus minimizing false alarm rates and maximising probability of detection of severe events.

4. OTHER PROVISIONS AND SYSTEMS

4.1 Wind Shear - Annex 6

4.1.1 In addition to the provision of wind shear information by the ATS and meteorological office as in Annex 3 and PANS-ATM (discussed in section 2 of this paper), there are requirements for certain aircraft as stated in ICAO Annex 6 — *Operation of Aircraft* , Chapter 6 (Aeroplane instruments, equipment and flight documents). Annex 6 states in (6.21), Turbo-jet aeroplanes — forward-looking wind shear warning system:

> (6.21.1) **Recommendation.—** *All turbo-jet aeroplanes of a maximum certificated take-off mass in excess of 5,700 kg or authorized to carry more than nine passengers should be equipped with a forward-looking wind shear warning system.*
>
> (6.21.2) **Recommendation.—** *A forward-looking wind shear warning system should be capable of providing the pilot with a timely aural and visual warning of wind shear ahead of the aircraft, and the information required to permit the pilot to safely commence and continue a missed approach or go-around or to execute an escape manoeuvre if necessary. The system should also provide an indication to the pilot when the limits specified for the certification of automatic landing equipment are being approached, when such equipment is in use.*

4.2 Predictive wind shear and reactive wind shear systems

4.2.1 Boeing and Airbus offer two kinds of aircraft wind shear systems for their aircraft. These two systems are called predictive wind shear (PWS) and reactive wind shear Systems (RWS). PWS increases alerting time over that provided by the RWS. According to the Airbus *Flight Operations Briefing Notes - Adverse Weather Operation - Wind shear Awareness*[3]

> An optional WIND SHEAR warning is available on most aircraft models.
>
> The wind shear warning is based on the assessment of current aircraft performance (flight parameters and accelerations). The wind shear warning is generated whenever the energy level of the aircraft falls below a predetermined threshold.
>
> The wind shear warning system associated to the speed reference system (SRS) mode of the flight guidance constitute the reactive wind shear systems (RWS), since both components react instantaneously to the current variations of aircraft parameters.

[3] The Flight Operations Briefing Note was produced by Airbus and Flight Safety Foundation. For the complete document see: http://www.airbus.com/fileadmin/media_gallery/files/safety_library_items/AirbusSafetyLib_-FLT_OPS-ADV_WX-SEQ02.pdf

4.2.2 To complement the reactive wind shear system and provide an early warning of potential wind shear activity, some weather radars feature the capability to detect wind shear areas ahead of the aircraft.

4.2.3 This equipment is referred to as a predictive wind shear system (PWS). PWS provides typically a one-minute advance warning. PWS generates three levels of wind shear alert, depending on:

- The distance and angular position between the aircraft and the wind shear
- The altitude of the aircraft
- The flight phase.

5. SAFETY RISK MANAGEMENT AND TRAINING

5.1 Safety Risk Management (SRM)

According to ICAO *Safety Management Manual (SMM)* (Doc 9859) Second Edition – 2009, a safety assessment must be made for changes such as the proposed phraseology change. The SMM states in subparagraph 9.8.1,

> "Hazards may inadvertently be introduced into an operation whenever change occurs. Safety management practices require that hazards that are a by-product of change be systematically and proactively identified and those strategies to manage the safety risks of the consequences of hazards be developed, implemented and subsequently evaluated."
>
> The SMM further states in subparagraph 9.8.4
>
> "A formal management of change process should then identify changes within the organization which may affect established processes, procedures, products and services. Prior to implementing changes, a formal management of change process should describe the arrangements to ensure safety performance."

5.1.1 METWSG/3 SN/16 from provided the following list of potential issues that would need to be evaluated by each air navigation service provider (ANSP) following their safety management system (SMS) process:

5.1.1.1 Corroborating an automated wind shear alert with a pilot report (PIREP) manually in real-time. This would require a controller to match a PIREP with the corresponding automated alert location and associate it with the next automated update. This is a distraction from the controller's current duties. Also, it is not logical to use the PIREP to continually verify automated alerts until the next update of the ATIS. That said, many ATC already have the practice to relay the PIREP to pilots in addition to any wind shear alert. Thus, the proposed practice of adding "REPORTED" would actually simplify the process and reduce radio communication. Moreover the PIREP could be forwarded to MET Office for association with the next wind shear alert, thus easing the work load of the controller from keeping the PIREP log for relaying to subsequent aircraft.

5.1.1.2 Controllers verifying real-time automated wind shear alerts: The controller would have the responsibility of real-time verification of the automated wind shear alerts. This is a distraction from the controller's current duties. This is particularly undesirable during adverse weather conditions, high traffic volumes and/or complex operations with multiple runways in use. But as mentioned in para. 5.1.2.1, for ATCs that already have the practice to relay PIREP reports, the proposed practice would actually simplify the process and workload, especially where the PIREPs are forwarded to meteorological (MET) office for association purpose.

5.1.1.3 Introducing the human element affects negatively the accuracy and reliability of the current automated process. The accuracy and reliability then becomes uncertain for the pilot and the controller. On the other hand, the PIREP serves as additional information for the wind shear alert, and the alert would gain further confidence if it is supported by a PIREP.

5.1.1.4 Reduced value of alerts due to inconsistent use of the term "REPORTED". – Inconsistent use of "REPORTED" could result in reduced value of the wind shear alert. That said, considering the high POD and low FAR of the automatic wind shear detection systems as detailed in para. 3.1.2 above, the PIREPs should have reasonable consistency about the occurrence of low level wind shear.

5.1.1.5 Uncertainty of time if using the term "EXPECTED". Use of the term "EXPECTED" is ambiguous and could lead to reduced value in wind shear alerts and de-sensitizing the pilot to the information being conveyed. It begs the questions "when?" and "for how long?" As the information is passed to the pilots upon commencement of final approach or upon take-off, there should be little/no ambiguity in "when" and "where" the wind shear is expected especially as the location is given.

5.1.1.6 Increased variability of wind shear phraseology internationally. Changing the phraseology could lead to differences around the world. This could lead to distraction or confusion of international flight crews who are conditioned to comply with standard procedures. Thus the option to use the terms "EXPECTED" and "REPORTED", if agreed, should be documented in Doc 4444 and the local practice be promulgated in the Aeronautical Information Publication (AIP).

5.1.2 These issues must be evaluated by each ANSP following their SMS process. The outcome for each would include mitigations that each ANSP would have to implement. At a minimum, this would include training for pilots and controllers.

5.1.3 Lastly, while each ANSP is required to conduct a safety risk assessment many States do not have this process established. Also, there is the assumption that if ICAO implements a change to the SARPs States may be left to believe that on the contrary that a safety risk may not be required because why would ICAO establish a new SARP without prior coordination and consultation that the change poses no safety risk. The SMS is an independent process of establishing a SARP usually after the fact. Experts who endorse a proposed change to the SARPS need to be cognizant of the potential that the SARP might not pass a safety risk assessment without implementation of mitigation factors to reduce the risk. Also, each operator would be required to review their internal safety risk management plan to determine what actions would be required.

5.2 **Training for ANSP and airlines.**

5.2.1 As noted in paragraph 3.4.3, wind shear training is an issue for some CAR/SAM States.

5.2.2 As noted in paragraph 4.1.3, training for pilots and controllers would be a required outcome of the SMS.

5.2.3 Given the number of severe runway excursions in convective situations occurred during the last decade, where wind shear and water-loading of runways may have contributed to a significant number of accidents, a review of the basic wind shear training offered to pilots and ANSP may be worth considering. The current practice of invariably increasing speed and descent angle in wind-shear prone situations may require a thorough review in the light of several such accidents where changing conditions (negative > positive shear) may have contributed to over-runs and excursions).

5.2.4 The cost and resources required to develop and publish the training material, and conduct the necessary training are not known at this time. It is noted that training would be required for any changes to the SARPS, and it is not specific to the introduction of new wind shear alert phraseology.

6. RECOMMENDATION

6.1 Action 3/14, part a), asked the ad hoc group B to make an assessment of existing wind shear services, which is presented in Section 3 of this SN.

6.2 Action 3/14, part b), asked the ad hoc group B to evaluate the issues associated with any proposed changes in the light of safety risk management and training that would be required both by ANSP and airlines. Adding the terms "reported" and "expected" to wind shear terminology will require State's ANSPs to conduct a safety risk assessment to assess and mitigate any issues with the introduction and implementation of these changes. Part of this mitigation will be training for the ANSP and the airlines.

6.3 Recall that the original purpose of adding the terms "reported" and "expected" was to give the pilot confidence in the wind shear alert. It is noted that confidence is available to the pilot with forward-looking wind shear warning systems in airplanes in rainy weather. Yet, forward-looking wind shear systems may not give a good signal in non-rainy weather conditions and even in the US, predictive systems are available on approximately 63 per cent of the air carrier only.

6.4 There are large differences in the maturity of the ground-based automatic wind shear alerting systems and percentage of equipped aircraft between airports. Noting that optional phrases may be used in Doc 4444, the group is invited to consider the following draft action:

> **Draft Agreed Action 4/xx– Provision of wind shear information**
>
> Table 12.3.1.7 of Doc 4444 be extended to include the terminology "EXPECTED" and "REPORTED" as optional items in PANS-ATM (Doc 4444).

6.5 The adoption of the terminology should first be agreed with the appropriate ATS unit and operators concerned subject to the passing of safety risk assessment as necessary.

7. ACTION BY THE GROUP

7.1 The group is invited to:

a) note the information in this paper; and.

consider the recommendation provided.

APPENDIX A

Appendix 1 to Doc 9817 - *Manual on Low-level Wind Shear*

STATEMENT OF OPERATIONAL REQUIREMENTS

(Foreword refers)

1. INFORMATION PROVIDED TO THE PILOT

1.1 There is an operational requirement for information on low-level wind shear and turbulence (from any cause) to be provided to the pilot in such a manner as to enable the pilot to counter their effects and maintain safe control of the aircraft.

1.2 Pending further development of reliable operational airborne and ground equipment, this information should be based on reports from aircraft and/or ground-based meteorological observations or on the assessment of the current weather situation.

2. GROUND-BASED EQUIPMENT

There is an operational requirement for ground-based equipment from which to derive the following information that shall be provided to the pilot prior to take-off or the commencement of the initial approach:

a) significant changes in surface wind along the runway; and

b) significant changes in the wind along the take-off and final approach paths extended to 500 m (1 600 ft) above runway level with particular emphasis on the layer between runway level and a height of 150 m (500 ft).

Note.— Five-hundred m (1 600 ft) should not be considered restrictive where local conditions require increases above this height.

3. AIRBORNE EQUIPMENT

There is an operational requirement for airborne equipment that can detect the presence of significant low-level wind shear and turbulence irrespective of its cause and can:

a) provide the pilot with a timely warning and the information necessary to safely maintain the desired flight path or the action to take to avoid it; and

b) indicate that the limits specified for certification of automatic landing equipment are being approached.

4. TRAINING

There is an operational requirement for pilots to be trained to counter the effects of low-level wind shear and turbulence. All relevant information on the subject, together with recommended flight techniques, flight profile data and performance information relevant to the particular type of aircraft, should be given.

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APPENDIX B

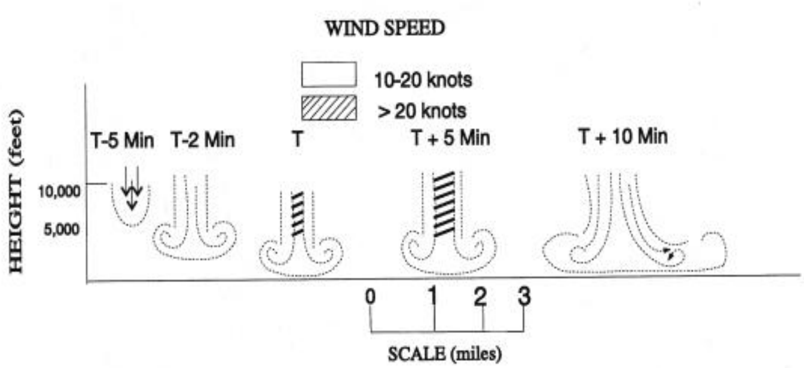
Wind Shear Systems in the United States

Note: The information in this appendix is taken directly from the US FAA's Aeronautical Information Manual, Chapter 7, Safety of Flight.

7-1-26. Microbursts

a. Relatively recent meteorological studies have confirmed the existence of microburst phenomenon. Microbursts are small scale intense downdrafts which, on reaching the surface, spread outward in all directions from the downdraft center. This causes the presence of both vertical and horizontal wind shears that can be extremely hazardous to all types and categories of aircraft, especially at low altitudes. Due to their small size, short life span, and the fact that they can occur over areas without surface precipitation, microbursts are not easily detectable using conventional weather radar or wind shear alert systems.

b. Parent clouds producing microburst activity can be any of the low or middle layer convective cloud types. Note, however, that microbursts commonly occur within the heavy rain portion of thunderstorms, and in much weaker, benign appearing convective cells that have little or no precipitation reaching the ground.



Vertical cross section of the evolution of a microburst wind field. T is the time of initial divergence at the surface. The shading refers to the vector wind speeds. Figure adapted from Wilson et al., 1984, Microburst Wind Structure and Evaluation of Doppler Radar for Wind Shear Detection, DOT/FAA Report No. DOT/FAA/PM-84/29, National Technical Information Service, Springfield, VA 37 pp.

FIG 7-1-14
Evolution of a Microburst

c. The life cycle of a microburst as it descends in a convective rain shaft is seen in FIG 7-1-14. An important consideration for pilots is the fact that the microburst intensifies for about 5 minutes after it strikes the ground.

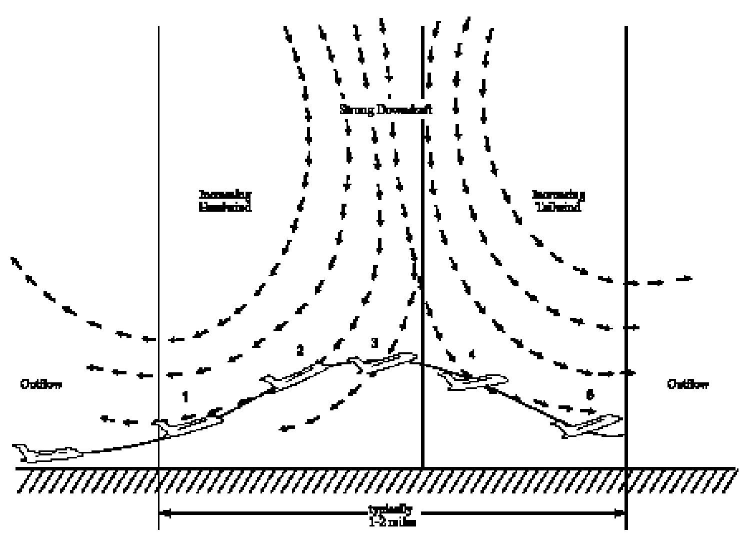
d. Characteristics of microbursts include:

1. Size. The microburst downdraft is typically less than 1 mile in diameter as it descends from the cloud base to about 1,000-3,000 feet above the ground. In the transition zone near the ground, the downdraft changes to a horizontal outflow that can extend to approximately 2 $^{1}/_{2}$ miles in diameter.

2. Intensity. The downdrafts can be as strong as 6,000 feet per minute. Horizontal winds near the surface can be as strong as 45 knots resulting in a 90 knot shear (headwind to tailwind change for a traversing aircraft) across the microburst. These strong horizontal winds occur within a few hundred feet of the ground.

3. Visual Signs. Microbursts can be found almost anywhere that there is convective activity. They may be embedded in heavy rain associated with a thunderstorm or in light rain in benign appearing virga. When there is little or no precipitation at the surface accompanying the microburst, a ring of blowing dust may be the only visual clue of its existence.

4. Duration. An individual microburst will seldom last longer than 15 minutes from the time it strikes the ground until dissipation. The horizontal winds continue to increase during the first 5 minutes with the maximum intensity winds lasting approximately 2-4 minutes. Sometimes microbursts are concentrated into a line structure, and under these conditions, activity may continue for as long as an hour. Once microburst activity starts, multiple microbursts in the same general area are not uncommon and should be expected.



A microburst encounter during takeoff. The airplane first encounters a headwind and experiences increasing performance (1), this is followed in short succession by a decreasing headwind component (2), a downdraft (3), and finally a strong tailwind (4), where 2 through 5 all result in decreasing performance of the airplane. Position (5) represents an extreme situation just prior to impact. Figure courtesy of Walter Frost, FWG Associates, Inc., Tullahoma, Tennessee.

FIG 7-1-15
Microburst Encounter During Takeoff

e. Microburst wind shear may create a severe hazard for aircraft within 1,000 feet of the ground, particularly during the approach to landing and landing and take-off phases. The impact of a microburst on aircraft which have the unfortunate experience of penetrating one is characterized in FIG 7-1-15. The aircraft may encounter a headwind (performance increasing) followed by a downdraft and tailwind (both performance decreasing), possibly resulting in terrain impact.

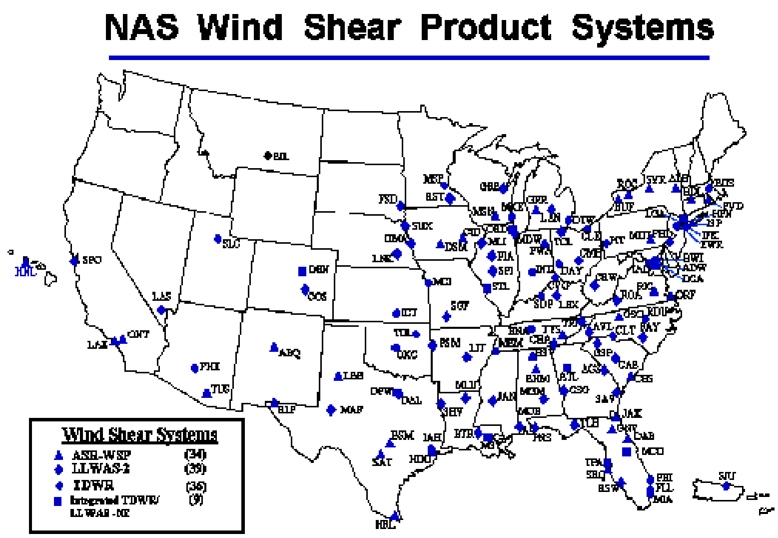


FIG 7-1-16
NAS Wind Shear Product Systems

f. Detection of Microbursts, Wind Shear and Gust Fronts.

1. FAA's Integrated Wind Shear Detection Plan.

(a) The FAA currently employs an integrated plan for wind shear detection that will significantly improve both the safety and capacity of the majority of the airports currently served by the air carriers. This plan integrates several programs, such as the Integrated Terminal Weather System (ITWS), Terminal Doppler Weather Radar (TDWR), Weather System Processor (WSP), and Low Level Wind Shear Alert Systems (LLWAS) into a single strategic concept that significantly improves the aviation weather information in the terminal area. (See FIG 7-1-16.)

(b) The wind shear/microburst information and warnings are displayed on the ribbon display terminals (RBDT) located in the tower cabs. They are identical (and standardized) in the LLWAS, TDWR and WSP systems, and so designed that the controller does not need to interpret the data, but simply read the displayed information to the pilot. The RBDTs are constantly monitored by the controller to ensure the rapid and timely dissemination of any hazardous event(s) to the pilot.

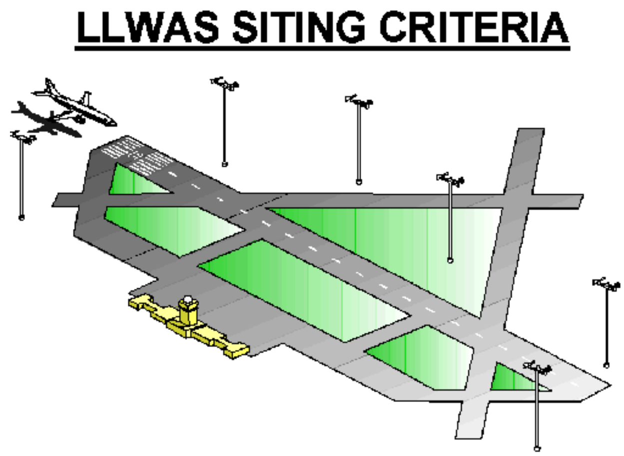


FIG 7-1-17
LLWAS Siting Criteria

(c) The early detection of a wind shear/micro-burst event, and the subsequent warning(s) issued to an aircraft on approach or departure, will alert the pilot/crew to the potential of, and to be prepared for, a situation that could become very dangerous! Without these warnings, the aircraft may NOT be able to climb out of, or safely transition, the event, resulting in a catastrophe. The air carriers, working with the FAA, have developed specialized training programs using their simulators to train and prepare their pilots on the demanding aircraft procedures required to escape these very dangerous wind shear and/or microburst encounters.

2. Low Level Wind Shear Alert System (LLWAS).

(a) The LLWAS provides wind data and software processes to detect the presence of hazardous wind shear and microbursts in the vicinity of an airport. Wind sensors, mounted on poles sometimes as high as 150 feet, are (ideally) located 2,000 - 3,500 feet, but not more than 5,000 feet, from the centerline of the runway. (See FIG 7-1-17.)

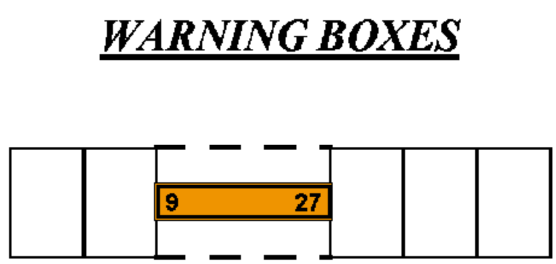


FIG 7-1-18 **Warning Boxes**

(b) LLWAS was fielded in 1988 at 110 airports across the nation. Many of these systems have been replaced by new TDWR and WSP technology. Eventually all LLWAS systems will be phased out; however, 39 airports will be upgraded to the LLWAS-NE (Network Expansion) system, which employs the very latest software and sensor technology. The new LLWAS-NE systems will not only provide the controller with wind shear warnings and alerts, including wind shear/microburst detection at the airport wind sensor location, but will also provide the location of the hazards relative to the airport runway(s). It will also have the flexibility and capability to grow with the airport as new runways are built. As many as 32 sensors, strategically located around the airport and in relationship to its runway configuration, can be accommodated by the LLWAS-NE network.

3. Terminal Doppler Weather Radar (TDWR).

(a) TDWRs are being deployed at 45 locations across the US. Optimum locations for TDWRs are 8 to 12 miles off of the airport proper, and designed to look at the airspace around and over the airport to detect microbursts, gust fronts, wind shifts and precipitation intensities. TDWR products advise the controller of wind shear and microburst events impacting all runways and the areas $^1/_2$ mile on either side of the extended centerline of the runways out to 3 miles on final approach and 2 miles out on departure.(FIG 7-1-18 is a theoretical view of the warning boxes, including the runway, that the software uses in determining the location(s) of wind shear or microbursts). These warnings are displayed (as depicted in the examples in subparagraph 5) on the RBDT.

(b) It is very important to understand what TDWR does NOT DO:

(1) It **DOES NOT** warn of wind shear outside of the alert boxes (on the arrival and departure ends of the runways);
(2) It **DOES NOT** detect wind shear that is NOT a microburst or a gust front;
(3) It **DOES NOT** detect gusty or cross wind conditions; and
(4) It **DOES NOT** detect turbulence.

However, research and development is continuing on these systems. Future improvements may include such areas as storm motion (movement), improved gust front detection, storm growth and decay, microburst prediction, and turbulence detection.

(c) TDWR also provides a geographical situation display (GSD) for supervisors and traffic management specialists for planning purposes. The GSD displays (in color) 6 levels of weather (precipitation), gust fronts and predicted storm movement(s). This data is used by the tower supervisor(s), traffic management specialists and controllers to plan for runway changes and arrival/departure route changes in order to both reduce aircraft delays and increase airport capacity.

4. Weather System Processor (WSP).

(a) The WSP provides the controller, supervisor, traffic management specialist, and ultimately the pilot, with the same products as the terminal doppler weather radar (TDWR) at a fraction of the cost of a TDWR. This is accomplished by utilizing new technologies to access the weather channel capabilities of the existing ASR-9 radar located on or near the airport, thus eliminating the requirements for a separate radar location, land acquisition, support facilities and the associated communication landlines and expenses.

(b) The WSP utilizes the same RBDT display as the TDWR and LLWAS, and, just like TDWR, also has a GSD for planning purposes by supervisors, traffic management specialists and controllers. The WSP GSD emulates the TDWR display, i.e., it also depicts 6 levels of precipitation, gust fronts and predicted storm movement, and like the TDWR GSD, is used to plan for runway changes and arrival/departure route changes in order to reduce aircraft delays and to increase airport capacity.

(c) This system is currently under development and is operating in a developmental test status at the Albuquerque, New Mexico, airport. When fielded, the WSP is expected to be installed at 34 airports across the nation, substantially increasing the safety of the American flying public.

5. Operational aspects of LLWAS, TDWR and WSP.

To demonstrate how this data is used by both the controller and the pilot, 3 ribbon display examples and their explanations are presented:

(a) MICROBURST ALERTS

EXAMPLE-
This is what the controller sees on his/her ribbon display in the tower cab.

27A MBA 35K- 2MF 250 20

NOTE-(See FIG 7-1-19 to see how the TDWR/WSP determines the microburst location).

This is what the controller will say when issuing the alert.

PHRASEOLOGY-
RUNWAY 27 ARRIVAL, MICROBURST ALERT, 35 KT LOSS 2 MILE FINAL, THRESHOLD WIND 250 AT 20.

In plain language, the controller is telling the pilot that on approach to runway 27, there is a microburst alert on the approach lane to the runway, and to anticipate or expect a 35 knot loss of airspeed at approximately 2 miles out on final approach (where it will first encounter the phenomena). With that information, the aircrew is forewarned, and should be prepared to apply wind shear/microburst escape procedures should they decide to continue the approach. Additionally, the surface winds at the airport for landing runway 27 are reported as 250 degrees at 20 knots.

NOTE-*Threshold wind is at pilot's request or as deemed appropriate by the controller.*

REFERENCE-*FAA Order JO 7110.65, Air Traffic Control, Low Level Wind Shear/Microburst Advisories, Paragraph 3-1-8b2(a).*

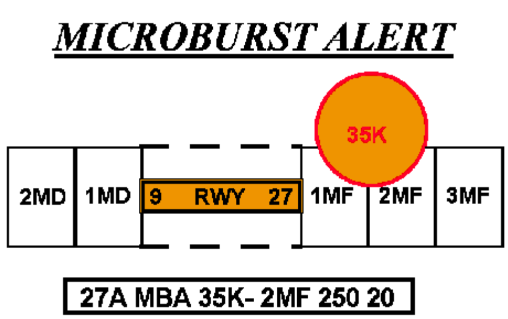


FIG 7-1-19
MICROBURST ALERT

(b) WIND SHEAR ALERTS

EXAMPLE-
This is what the controller sees on his/her ribbon display in the tower cab.

27A WSA 20K- 3MF 200 15

NOTE-*(See FIG 7-1-20 to see how the TDWR/WSP determines the wind shear location).*

This is what the controller will say when issuing the alert.

PHRASEOLOGY-
RUNWAY 27 ARRIVAL, WIND SHEAR ALERT, 20 KT LOSS 3 MILE FINAL, THRESHOLD WIND 200 AT 15.

In plain language, the controller is advising the aircraft arriving on runway 27 that at about 3 miles out they can expect to encounter a wind shear condition that will decrease their airspeed by 20 knots and possibly encounter turbulence. Additionally, the airport surface winds for landing runway 27 are reported as 200 degrees at 15 knots.

NOTE-*Threshold wind is at pilot's request or as deemed appropriate by the controller.*

REFERENCE-
FAA Order JO 7110.65, Air Traffic Control, Low Level Wind Shear/Microburst Advisories, Paragraph 3-1-8b2(a).

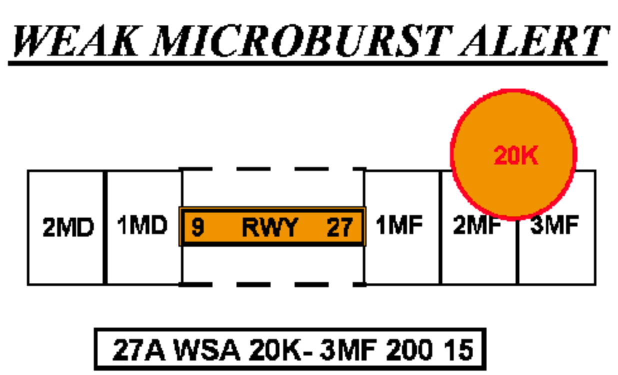


FIG 7-1-20
Weak Microburst Alert

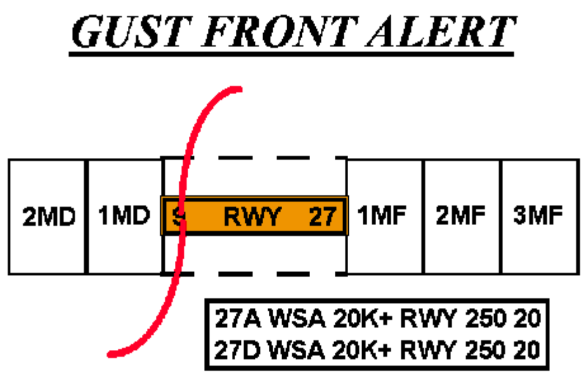


FIG 7-1-21
GUST FRONT ALERT

(c) MULTIPLE WIND SHEAR ALERTS

EXAMPLE-
This is what the controller sees on his/her ribbon display in the tower cab.

27A WSA 20K+ RWY 250 20
27D WSA 20K+ RWY 250 20

NOTE-*(See FIG 7-1-21 to see how the TDWR/WSP determines the gust front/wind shear location.)*

This is what the controller will say when issuing the alert.

PHRASEOLOGY-
MULTIPLE WIND SHEAR ALERTS. RUNWAY 27 ARRIVAL, WIND SHEAR ALERT, 20 KT GAIN ON RUNWAY; RUNWAY 27 DEPARTURE, WIND SHEAR ALERT, 20 KT GAIN ON RUNWAY, WIND 250 AT 20.

EXAMPLE-
In this example, the controller is advising arriving and departing aircraft that they could encounter a wind shear condition right on the runway due to a gust front (significant change of wind direction) with the possibility of a 20 knot gain in airspeed associated with the gust front. Additionally, the airport surface winds (for the runway in use) are reported as 250 degrees at 20 knots.

REFERENCE-*FAA Order JO 7110.65, Air Traffic Control, Low Level Wind Shear/Microburst Advisories, Paragraph 3-1-8b2(d).*

6. The Terminal Weather Information for Pilots System (TWIP).

(a) With the increase in the quantity and quality of terminal weather information available through TDWR, the next step is to provide this information directly to pilots rather than relying on voice communications from ATC. The National Airspace System has long been in need of a means of delivering terminal weather information to the cockpit more efficiently in terms of both speed and accuracy to enhance pilot awareness of weather hazards and reduce air traffic controller workload. With the TWIP capability, terminal weather information, both alphanumerically and graphically, is now available directly to the cockpit on a test basis at 9 locations.

(b) TWIP products are generated using weather data from the TDWR or the Integrated Terminal Weather System (ITWS) testbed. TWIP products are generated and stored in the form of text and character graphic messages. Software has been developed to allow TDWR or ITWS to format the data and send the TWIP products to a database resident at Aeronautical Radio, Inc. (ARINC). These products can then be accessed by pilots using the ARINC Aircraft Communications Addressing and Reporting System (ACARS) data link services. Airline dispatchers can also access this database and send messages to specific aircraft whenever wind shear activity begins or ends at an airport.

(c) TWIP products include descriptions and character graphics of microburst alerts, wind shear alerts, significant precipitation, convective activity within 30 NM surrounding the terminal area, and expected weather that will impact airport operations. During inclement weather, i.e., whenever a predetermined level of precipitation or wind shear is detected within 15 miles of the terminal area, TWIP products are updated once each minute for text messages and once every five minutes for character graphic messages. During good weather (below the predetermined precipitation or wind shear parameters) each message is updated every 10 minutes. These products are intended to improve the situational awareness of the pilot/flight crew, and to aid in flight planning prior to arriving or departing the terminal area. It is important to understand that, in the context of TWIP, the predetermined levels for inclement versus good weather has nothing to do with the criteria for VFR/MVFR/IFR/LIFR; it only deals with precipitation, wind shears and microbursts.

— END —