International Civil Aviation Organization

FOURTEENTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP OF APANPIRG (CNS/MET SG/14)

Jakarta, Indonesia, 19 – 22 July 2010

Agenda Item 14: **Regional MET support to ATM**

(2) Exchange of information on Met. Support for operation at aerodromes, terminal areas and en-route

USE OF DOPPLER WEATHER RADAR FOR LOW LEVEL WIND SHEAR WARNING AND THE NECESSITY OF INPUT / FEEDBACK FROM AIR CREWS

(Presented by India)

SUMMARY

This paper presents the prevalence of low level wind shear (LLWS) for a reasonably long duration over Chennai airport as observed by Doppler Weather Radar and the need for inflight report / de-briefing about LLWS.

This paper relates to:

Strategic Objectives:
A. Safety – Enhance global civil aviation safety
D. Efficiency – Enhance the efficiency of aviation operations

Global Plan Initiatives:
GPI-18 Aeronautical information
GPI-19 Meteorological Systems

1. Introduction/Background

1.1 India Meteorological Department (IMD) has a net work of five 10 cm Doppler Weather Radars (DWR) along its east coast adjoining Bay of Bengal. Eight more DWRs are being inducted in interior locations and along western coast adjoining Arabian sea during the current year. Chennai S-band DWR functioning from 20th February 2002 serves also as a Terminal DWR (TDWR) for Chennai airport.

1.2 With a very limited cases reported by air crews during 2002-2003, a suitable strategy for issuing LLWS warning has been devised which needs validation with a large data sample for making into operational use.

2. Discussion

2.1 Instances of moderate to severe LLWS in the approach path and over Chennai airport have been noticed based on DWR observations. While some of them, which were active for a short duration, were not at all reported, hardly one or two incidents have been reported by aircrews when the LLWS was active for more than 10 hours.

2.2 As wind shear cannot be satisfactorily observed from the ground and the aircraft observations represent the only available evidence (Para 5.6 of Chapter 5 of Annex 3, 2007) to alert all incoming aircrafts, it is necessary that LLWS experienced by the air crews be reported to ATC concerned and to the Meteorological office for alerting subsequent incoming aircrafts. Hence, reporting of wind shear by the air crew has a good bearing on air safety.

3. Other issue/topic (if any)

3.1 The case of reporting winds experienced at a few levels (say 1000 ft, 1800 ft etc.) at the time of landing for fine tuning the algorithm developed based on Chennai DWR observations and for ~~i~~ssuing LLWS warnings / alerts was taken up by IMD with airlines in many Regional operations committee (ROC) meetings organised by the Airports Authority of India (AAI), Chennai. However, the outcome is not encouraging.

3.2 Similar attempts made at Heathrow airport during 1977-1979 (to pass on winds at low altitudes and to give feedback on LLWS warning / alert issued by the Met. office) have been proved successful to make the LLWS alert strategy operational.

3.3 Reporting of LLWS experienced or otherwise (cessation) by the air crews should be encouraged on air safety point of view as well as to de-warn LLWS warning (as mentioned vide Para 7.4 of Chapter 7 & Para 4.1.2 of Appendix 4, Annex 3, 2007). The feedback is all the more necessary for fine tuning the algorithm developed based on DWR observations.

3.4 More over, reporting of turbulence at upper atmosphere / high altitudes based on eddy dissipation rate (EDR) related turbulence index (TI) as mentioned under Para 2.6.2 of Appendix 4 of Annex3, 2007 should also be encouraged for the purpose of preparation /alteration of SIGWX charts.

4. Action required by the Meeting

4.1 To take a note of the fact that in contrary to the general belief that the wind shear is short lived, there are cases when low level wind shear was found to be active for more than 10 hours over a tropical airport. Reporting and confirming the prevalence of LLWS as well the cessation of the same by all departing and incoming aircrafts will help the ATS concerned to give a better service.

4.2 To discuss and to finalise the action to be taken to encourage aircrews to report the presence / absence of LLWS over an airport to the appropriate ATS concerned.

4.3 To discuss and to take suitable action for reporting the intensity of turbulence experienced by the air crews at high altitudes based on turbulence Index as derived from the eddy dissipation rate.

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CNS/MET SG/14 – WP/24
Attachment

ATTACHMENTS (extracts from a few Papers published on LLWS related issues)

(1) Mausam, 55, 1 (January 2004), 103-118 551.509.316 : 551.557.4 (548.1)

On nowcasting wind shear induced turbulence over Chennai air field

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ABSTRACT. *With the newly installed Doppler Weather Radar at Cyclone Detection Radar station, Chennai during October 2001, it has been made possible to analyse the meteorological conditions conducive for the wind shear induced turbulence experienced by the pilots in the approach runway at the time of landing and take-off. The radar has been put into operation w.e.f February 21, 2002. Wind shears reported during February – October 2002, have been critically analysed in this study. The three dimensional shear (3DS), a combination of radial, azimuthal and elevation shears, gives a first hand information atleast half an hour before the occurrence of shear induced moderate turbulence when its value exceeds 16mps/km. The 3DS of more than 20mps/km is normally associated with turbulence experienced by the pilots. With the availability of sophisticated and vast computing power, it is now possible to delineate the layer at which the shear is active within 3-5 minutes from the receipt of the radar measured volume data by quickly computing elevation / vertical / radial / azimuthal shear etc. However, to arrive at a meaningful conclusion on the threshold values of shears that are conducive for wind shear induced turbulence and to make use of this information to alert the pilots, feed back from the pilots to build a detailed data base is absolutely inevitable. Monitoring of passage of sea breeze front may also be useful to issue wind shear warnings. The time tested Richardson number has also been verified for its 'outlook predictability' of the shear induced turbulence around the airport, though it can not pinpoint the exact location and the time at which turbulence is active. It is hoped that with precise, accurate and timely in-flight report about the wind shear experienced by the pilots and based on the experience gained in analyzing such information, it will be possible to issue probable 'wind shear alert / warning' in the near future.*

Key words – Doppler Weather Radar, Wind shear, Turbulence, Richardson number, Aviation, Three dimensional shear, Elevation shear, Vertical shear, Radial shear, sea breeze.

Lack of feed back from air crews

5.3 Though 3DS threshold value (> 16mps/km) can be operationally utilised only after studying a number of wind shear occurrences, it is being considered on trial basis for alerting the pilots at the time of take-off and landing operations upto 0.8 km with a view to get feedback from them, similar to the attempts made at Heathrow airport during 1979, to assess the efficacy of the method proposed in this study. The success of issuing the wind shear alert vests with feedback from the air crews. On a number of days, the pilots and flight dispatchers have been briefed about the possibility of wind shear and stressed the need for getting a positive or negative feedback from them. But the response is very bleak. The airline agencies have been frequently and periodically reminded through various channels / modes of communication to accord importance in giving their feedback about the occurrence or non-occurrence of wind shear. It is hoped that the feedback from air crews will be improved in the near future. Till such time a sizeable data base of wind shear cases is built and analysed for the worthiness of the 3DS threshold derived in this study, it is desirable to continue the exercise of briefing the pilots on the possibility of wind shear and to get their feedback positively to assess the efficacy of 3DS.

(2) MAUSAM, 60, 3 (July 2009), 325-342 551.501.75 : 551.554 : 551.508.855

An account of low level wind shear over Chennai airport - Part II : Turbulence and eddy dissipation

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ABSTRACT. In-flight reports on Low Level Wind Shear (LLWS) received from aircrafts are used to issue wind shear alerts for all subsequent landing aircrafts as per standing guidelines of International Civil Aviation Organisation (ICAO). In this paper, winds reported by aircrafts at 1000 and 1800 ft. are used to validate the wind estimated from DWR measured radial wind data employing standard algorithms. Turbulence indices and parameters have been computed independently using conventional (RS/RW) upper air data, aircraft measured winds and DWR estimated winds and compared these with wind shear induced turbulence reported by aircrews. Mean power law (wind escalation law) profiles in the boundary layer have been arrived at for unstable and stable atmospheric conditions. Three dimensional shear (3DS) upto 600 m a.g.l. has been worked out from DWR measured radial velocity data and compared with wind shear computed from RS/RW and aircraft measured winds and DWR estimated winds. It is found that 3DS values of more than 16 * 10-3 s-1 predict well the occurrence of moderate turbulence. Contrary to the general belief that wind shear is a short lived phenomenon which may last for a few minutes only, it has been observed that incidences of LLWS and induced moderate turbulence lasting more than 10 hrs are not at all uncommon over Chennai aircraft.

Key words - Chennai airport, Low level wind shear, Richardson number, Three dimensional shear, Eddy dissipation rate, Turbulence index, Doppler weather radar, METAR.

6.3 Wind Shear on 15th March 2006

An interesting case of wind shear induced turbulence was from 14:19 UTC on 15th March 2006 which continued upto early morning of 16th. Indian Airlines aircrafts at 10:38 UTC and 16:31 UTC on 15th and 00:29 UTC on 16th reported winds at 1000 ft and 1800 ft. Wind shear on these time periods were more than the moderate turbulence threshold described earlier. DWR estimated winds at 10:30 and 16:30 UTC also confirmed the presence of wind shear. The 3DS product has been displayed as a panoramic view in Fig. 7 from 14:19 UTC / 15th to 00:19 UTC / 16th. DWR revealed the presence of moderate turbulence over Chennai airport but none of the aircrafts reported turbulence but for the above three wind reports and that too just for complying with the recommendations of ROC meetings as stated earlier in this paper in section 4. It may be stated here that there were as many as 62 landing operations during the time interval stated above. A later discussion with operations people and with some of the aircrews of different airlines confirmed that there was moderate to severe turbulence but all the pilots were habituated with this sort of turbulence on some days over Chennai and their concentration was to have a safe landing and subsequent take-off operations from Chennai airfield in limited time span and hence there was no time even to de-brief.

A similar long duration wind shear incidence of more than 10 hrs was earlier observed over Chennai airport on 23/24 May 2006 (Suresh, 2008, personal communication) wherein only one aircraft (M/s Air India) reported the observation of turbulence. These cases were brought to the notice of air line operators and the necessity of in-flight / debriefing report on wind shear / turbulence was once again stressed. The necessity of feedback / in-flight report or de-briefing is inevitable to fine tune the 3DS threshold already arrived at by Suresh(2004) based on some eight

incidences of reported wind shears and also to validate future incidences. However, aircrews are repeatedly intimating that in view of limited time available to them between two operations (in view of heavy competition in the aviation industry during the present days), they are unable to report to ATC due to their primary concentration on safe landing and take-off operations. Nonetheless, pending the reception of vast data base for fine tuning the 3DS value, the current 3DS threshold (viz., $16 * 10^{-3}$ s^{-1}) may be used by the forecasters to issue low level wind shear alert over Chennai airport as its predictability is quite good.

7. Summary and conclusions

In the absence of full fledged / efficient low level wind shear(LLWS) alert system, the in-flight reports by aircrews serve as a vital database to issue wind shear alerts. Aircrews have been impressed upon that the in-flight report on LLWS will be quite beneficial for the aviation community and they were periodically requested to pass on this vital information to air traffic controllers at the earliest possible time on observing these phenomenon. They were briefed about similar attempts made at Heathrow airport (Roach, 1981) and subsequent tangible benefits.

(3) MAUSAM, 61, 1 (January 2010), 19-34 551.508.59 : 551.501.75

An account of low level wind shear over Chennai airport –

Part I : Observation and forecasting aspects

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ABSTRACT. Low level wind shear (LLWS) is an aviation hazard. LLWS cases reported by the air crews over Chennai airport from 1987 to 2007 (barring 1992 and 1993 during which period no report is readily available for analysis) have been analysed threadbare. The most favourable time / period of occurrence of LLWS have been documented which has prophylactic value to issue LLWS alert in current weather reports. Richardson number and turbulence index (TI) have been computed for the reported cases of LLWS and the efficacies of these thermodynamical indices have been documented. There were cases of active moderate / severe LLWS cases lasting even beyond 10 hrs duration in contrary to the general belief that LLWS is a short lived phenomenon. The urgency / necessity of having a sizeable LLWS database to devise a suitable warning strategy have been highlighted.

Key words – Chennai airport, low level wind shear, Richardson number, Turbulence index, Doppler Weather Radar, METAR, Three dimensional shear.

5.2. *Necessity of feedback from air crews*

This particular case of wind shear on 23/24 May 2006 suggests that wind shear can be active even for nearly ten hours. Under this sort of long duration active wind shear conditions, the current practice of using the reported wind shear as a supplementary information in current weather reports (METAR) for the next two hours may not be sufficient in the context of air safety. information about cessation of wind shear condition is received from the air crews, there is no alternative method than to continue the existing practice. The necessity of feedback from air crews was highlighted through various forums (Suresh, 2004). The current case has been presented to air crews and operational staff members of various airlines operating from Chennai airport during 2006 and 2007 and they were impressed upon the consequences of wind shear related accidents that had been documented elsewhere (Fujita, 1980 and 1990; ICAO, 1983 and 2004). In order to devise a suitable LLWS warning strategy, it was pointed out to them the absolute inevitability of sizeable database on LLWS experienced by the air crews. Whence such a database is made available to the Met. office, analysis based on surface and upper air meteorological data and DWR information can be effective to identify warning threshold(s). Hence, the airline agencies have been kept informed about a similar attempt made at Heathrow airport in the year 1977 (Roach, 1981) prior to the introduction of LLWS warning method from Heathrow airport during 1980s. Aircrews operating from Chennai airport were requested to pass on in-flight reports without fail. Despite these efforts during 2006-2008, the response is not encouraging. However, constant pursuing with airlines is still being made to get a sizeable database.

6. Summary and conclusions :

(*i*) Maximum number of low level wind shear (LLWS) cases have been reported over Chennai airport during 1200-1800 UTC and the most favourable period for LLWS is May – June and December. Minimum frequency of LLWS was reported during November when steady northeasterly winds prevail over Chennai.

(*ii*) Richardson number detects 71% of the reported LLWS cases over Chennai. Maximum predictability is during 1200-1800 UTC during which period maximum number of LLWS cases were reported by the aircrews.

(*iii*) Thermally induced and shear induced turbulence were detected in almost 50% in each category.

(*iv*) 45.2% of reported LLWS cases were in the layer upto 090 m a.g.l. Very fine resolution upper level data is needed in the lowest portion of boundary layer (surface / mixed layer) to predict the LLWS.

(*v*) Predictability through Turbulence Index (TI), *viz*., TI > 3*10-6 rad s-1 °K m-2 and *Ri* < 0.6 has 61.5% efficiency in predicting LLWS cases reported over Chennai.

(*vi*) In contrast to the general belief that wind shear is a short lived phenomenon, there are cases at which LLWS was active for more than 10hrs over Chennai airport.

(*vii*) It is absolutely inevitable to have sizeable database of LLWS incidences reported by the aircrews to devise a suitable LLWS warning strategy.

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