Performance of Wind Shear Detection Systems Installed at the Hong Kong International Airport

Royal Observatory
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1. Introduction

A low level wind shear detection system (LLWSDS) developed by the Royal Observatory has been installed and operated on an experimental basis at the Hong Kong International Airport (HKIA) since September 1979. It comprises 5 ground-based anemometers linked to a microcomputer which computes and displays the wind shear along the final approaches to the airport in real-time. The 5 anemometers are located at the two ends of the runway (SE and NW), Lei Yue Mun (LYM), Yau Yat Chuen (YYC) and Kowloon Tsai (KLT). A full description of the system was given in the paper "Low-level Wind Shear Detection System at Hong Kong International Airport" by K.S. Tsui (Reference 5). When the system was first installed, 2-minute mean winds were used for the calculation of the wind shear, and the threshold for warning significant wind shear was chosen to be 8 knots per 100 feet change in altitude in accordance with ICAO recommendation.

Since the installation of the above system, pilots were requested through the automatic terminal information service (ATIS) to report low level winds and wind shear on landing or take-off at the HKIA so that the effectiveness of the system for low level wind shear detection could be assessed. Based on these aircraft reports, a report on the effectiveness of the LLWSDS in wind shear detection was prepared by the Royal Observatory (Reference 5) and presented at the Hong Kong Wind Shear Committee meeting in April 1981. In the report, it was noted that although there were insufficient aircraft reports to enable a confident judgement to be made on the effectiveness of the system, detailed analysis of some failure cases did reveal that there were some deficiencies in the system which were related to the non-representativeness of the wind measured by the anemometers. As a remedy it was proposed that the averaging period for winds used for calculation of the wind shear be reduced from 2 minutes to 30 seconds, so that it would be closer to the response time of an aircraft to wind changes. This proposal was accepted by the Wind Shear Committee and was implemented in June 1981. The effect of this change in averaging period was analysed by the Royal Observatory a few months later (Reference 6), and it was found that there had been no significant improvement on the wind shear detection capability of the system.

The LLWSDS was replaced by the Wind Analyser System (WAS) in January 1984. The new system, also developed by the Royal Observatory, is nearly identical to the LLWSDS, but generates additional aerodrome wind information required by Air Traffic Control.

Meanwhile, a Doppler acoustic radar system was acquired by the Royal Observatory in 1981 for the Chek Lap Kok replacement airport studies. The system comprises two Doppler acoustic radars (DAR) linked to a central station. At the Wind Shear Committee meeting in August 1982, a proposal was made by the Royal Observatory to employ DARs at HKIA to monitor low level wind shear in real-time. When the Chek Lap Kok project was shelved in 1983, one of the two DARs acquired for the project was deployed to the ILS Middle Marker Station at Lei Yue Mun (LYM), and it was put into operation in January 1984.

The DAR at LYM is 55 m above mean sea level, and approximately 1.8 nautical miles from the R31 threshold. Using the Doppler technique, it measures the wind direction and wind speed at 30 m height intervals from 60 m to 480 m above ground level. The averaging period for wind measurement is 10 minutes, which, limited by the original design of the system, cannot be reduced without compromising the accuracy of the data. There is also a propeller anemometer attached to the DAR to measure the wind at the 10 m level. The wind data generated by the DAR are transmitted to a minicomputer at the Royal Observatory, which computes the vertical wind shear along the runway direction at 30-m intervals from 60 m to 300 m above ground level. The wind and wind shear data are then transmitted to a colour graphic terminal in the Airport Meteorological Office (AMO) on which the latest 5 hours of wind and wind shear data are displayed in the form of a time-height section.

Subsequent to the Wind Shear Committee meeting in January 1984, Aeronautical Information Circular 06/84 was issued on 24 February 1984 requesting pilots' co-operation in supplying information on wind shear encountered and flight deck wind data to the AMO so that the effectiveness of the WAS and DAR for wind shear detection could be assessed. Brief descriptions of the operational aspects of both systems were given in the AIC.

During the 12-month period from March 1984 to February 1985, a total of 353 aircraft reports were received at the AMO. By ultilizing these reports, comparisons between aircraft winds and those collected by the DAR at the corresponding levels and with winds recorded at YYC and LYM were made. Verification of wind shear data generated by both systems against aircraft reports was also carried out. The results are presented in this report.

2. Basic Data Used in the Present Study

The 353 aircraft reports received during the period March 1984 to Feb 1985 were ultilized in the verification. In 104 reports it was mentioned that wind shear was encountered during take-off or landing at the HKIA while in 221 reports it was mentioned that no wind shear at all was encountered during take-off or landing. In the remaining 28 reports, there was no information on wind shear. Of the 353 reports received 270 contained low-level wind readings at 800', 600' and 400' levels. Monthly frequency of these reports is shown in Table 1 below.

Table 1 Aircraft reports received at the Airport Meteorological Office during the period March 1984 - February 1985

Month	Total no. of reports	No. of reports with information on wind shear			No. of reports with low-level wind readouts			Others
		31A/13D	13A/31D	Total	31A/13D	13A/31D	Total	
Mar 84	30	9	17	26	7	9	16	8
Apr 84	42	18	21	39	14	16	30	6
May 84	32	9	22	31	9	20	29	0
Jun 84	42	14	16	30	22	12	34	3
Jul 84	34	25	5	30	23	4	27	1
Aug 84	52	35	13	48	30	12	42	1
Sep 84	23	10	12	22	8	7	15	0
Oct 84	30	20	6	26	16	7	23	0
Nov 84	22	16	6	22	11	4	15	3
Dec 84	20	13	4	17	12	4	16	3
Jan 85	16	11	4	15	12	4	16	0
Feb 85	10	4	6	10	4	3	7	0
Total	353	193	132	325	168	102	270	25

Note * : There were some reports with information on turbulence but without any information on wind shear or low level wind readouts.

Data recorded at the time corresponding to the times of aircraft reports were extracted from the respective data files of the WAS and DAR for use in the verification. Since the DAR was vulnerable to interference by noise, manual quality control of the DAR data was performed to screen out those data which appeared doubtful in the light of other meteorological data.

3. Comparisons of Wind Measurements

There were 168 reports containing low-level wind information at 800', 600' and 400' from aircraft on 31A/13D and 102 reports from aircraft on 13A/31D during the selected 12-month period. These are considered to be sufficient for useful comparisons to be made with data obtained from the ground-based anemometers and the DAR. As both the WAS and DAR use the longitudinal component of the wind, ie the component along the direction of the flight path, to calculate the wind shear, only this component instead of the wind vector was used in the comparisons.

Correlation of the longitudinal component of the wind reported by aircraft with those measured by the WAS and DAR yields the following groups of regression equations (Table 2 to 5).

Table 2 Relationship between the longitudinal component of the wind reported by aircraft on 31A/13D and that measured by the anemometer at LYM

Level	Linear regression equation	Correlation coefficient	Number of cases
600'	Y = 0.88 X + 2.05	0.70	151
400'	Y = 0.73 X + 2.06	0.69	152

Level of significance better than 0.1%

where Y = longitudinal component of wind (knots) reported by aircraft

X = longitudinal component of wind (knots) measured by anemometer at LYM

Table 3 Relationship between the longitudinal component of the wind reported by aircraft on 13A/31D and that measured by the anemometer at YYC

Level	Linear regression equation	Correlation coefficient	Number of cases
600'	Y = 1.33 X + 2.36	0.73	94
400'	Y = 1.20 X + 1.50	0.69	95

Level of significance better than 0.1%

where Y = longitudinal component of wind (knots) reported by aircraft

X = longitudinal component of wind (knots) measured by anemometer at YYC

Table 4 Relationship between the longitudinal component of the wind reported by aircraft on 31A/13D and that measured by the DAR

Level	Linear regression equation	Correlation coefficient	Number of samples
800'	$Y = 0.89 X + 2.36$	0.74	141
600'	$Y = 0.92 X + 2.31$	0.70	144
400'	$Y = 1.00 X + 2.99$	0.66	144

Level of significance better than 0.1%

where Y = longitudinal component of wind (knots) reported by aircraft

X = longitudinal component of wind (knots) measured by DAR

Table 5 Relationship between the longitudinal component of the wind reported by aircraft on 13A/31D and that measured by the DAR

Level	Linear regression equation	Correlation coefficient	Number of cases
800'	$Y = 0.97 X - 2.07$	0.69	96
600'	$Y = 0.70 X - 3.46$	0.46	97
400'	$Y = 0.68 X - 3.96$	0.41	99

Level of significance better than 0.1%

where Y = longitudinal component of wind (knots) reported by aircraft

X = longitudinal component of wind (knots) measured by DAR

Results of correlation presented in Table 2 show that the longitudinal component of the wind recorded by the anemometer at LYM was greater than that reported by aircraft at higher levels (400' and 600'). This may in part be attributed to the funnel effect caused by the Lei Yue Mun Pass on the air flow. The effect was more pronounced at lower levels where winds were more likely to be deviated towards the direction of the flight path oriented along the Pass from southeast to northwest. According to results shown in Table 3, it was interesting to find that, on average, the longitudinal component of the wind recorded at YYC was about 75% of that reported by aircraft at 600' and 84% of that reported at 400' whilst a similar study (Chen 1980) using YYC anemometer records and AIDS data provided by Swiss Air revealed that the longitudinal component of the wind measured by the anemometer was only slightly lower than that experienced by aircraft overflying the area.

Noting that the anemometers at LYM and YYC were 73 m (239') and 64 m (210') respectively above sea level, it should not be difficult to see that the longitudinal component of the wind did not vary linearly with height between the anemometer level and the 600' level. Hence, care should be taken when comparing magnitudes of vertical wind shear computed for different height intervals.

From Table 4, it can be seen that the longitudinal component of the wind measured by the DAR agreed quite well with those reported by aircraft over-flying the DAR (ie on 31A/13D). On the other hand, the results of correlation given in Table 5 shows that the degree of agreement was considerably less between the longitudinal component of the wind measured by the DAR and that reported by aircraft on the opposite flight path (ie 13A/31D). This reflects that there was considerable variation of the low level wind in the horizontal direction, which could be due to orography and presence of smaller scale meteorological features such as sea breeze fronts and thunderstorm gust fronts. The fact that the agreement decreases with height from 800' to 400' suggests that the air flow nearer to ground level was more disturbed by orography and the small scale meteorological features than higher up.

4. Assessment of the Wind Shear Detection Capability of the WAS

Refering to Table 1, there were altogether 325 aircraft reports with information on wind shear encountered during landing or take-off. Of these, 221 reports asserted that no wind shear at all was experienced. Of the remaining 104 reports in which it was mentioned that wind shear was encountered, 56 reports were from aircraft on 13A/31D, and the remaining 48 reports from aircraft on 31A/13D. On examination of individual reports, it was found that 19 of them could not be used for the verification (13 reports due to wind shear experienced at an altitude out of range of the WAS, 5 reports due to type or level of shear not given and 1 report due to faulty operation of the WAS). In the remaining 84 reports, only 30 (23 for 13A/31D, 7 for 31A/13D) described the wind shear as significant (ie strong or severe as opposed to light or moderate). Table 6 below shows the number of occasions for the three classes of intensity : (i) significant (strong or severe) (ii) less intense (light or moderate) or unknown (ie unreported) intensity and (iii) no wind shear.

Table 6 Occasions of wind shear of specified intensity reported by aircraft for the period March 1984 - February 1985

31A/13D				13A/31D			
Sig.	Less intense	No.	Total	Sig.	Less intense	No.	Total
7	31	145	183	23	22	76	121

As was done in the verification exercise in 1981 (Reference 5) the following criteria were adopted for defining the performance of the WAS in detection of significant wind shear :

(a) Success (S) - an aircraft reported the presence of significant wind shear on approach or departure whilst the WAS also indicated significant wind shear (8 knots per 100' or greater) of the same type (sinking of lifting) at the same time.

(b) Marginal success (MS) - the wind shear experienced by the aircraft was of the same type (sinking or lifting) as that indicated by the WAS, but the magnitude measured by the latter was less than 8 knots per 100'.

(c) Failure (F) - the type (sinking or lifting) of wind shear experienced by the aircraft was opposite to that indicated by the WAS.

Results of verification for the 30 cases of significant wind shear were given in Table 7 below.

Table 7 Verification of significant wind shears reported by aircraft against the wind shear measured by the WAS during the period March 1984 - February 1985

Detection threshold for significant wind shear : 8 knots per 100'

Runway	31A/13D			13A/31D			
	S	MS	F	S	MS	F	
Type of shear							Total
Sinking	1	5	0	9	5	2	22
Lifting	0	0	1	0	2	5	8
Total	1	5	1	9	7	7	30

From the results shown in Table 7, it can be seen that occurrences of significant lifting shear were considerably less than those of significant sinking shear in the time period concerned (8 against 22). The WAS appeared to perform quite well in the detection of significant sinking shear on 13A/31D but poorly in the detection of significant lifting shear for the same approach/departure path. For 31A/13D, the WAS might still be slightly more effective in detecting significant sinking wind shears than lifting shears but the number of samples in this case was too small for a confident conclusion to be made.

For less intense (or unknown intensity) wind shear, the result of verification are given in Table 8, with the criteria of success and failure defined as follows :

(a) Success (S) - an aircraft reported the presence of light or moderate wind shear on approach or departure whilst the WAS also indicated wind shear less than 8 knots per 100' of the same type (sinking of lifting) at the same time.

(b) Marginal success (MS) - either (i) an aircraft reported light or moderate wind shear whilst the WAS indicated that a wind shear equal or exceeding 8 knots per 100' of the same type (sinking or lifting), or (ii) there was no description of the intensity or level of occurrence of the wind shear experienced in the aircraft report but the type (sinking or lifting) of wind shear reported was the same as that indicated by the WAS, irrespective of the magnitude measured by the latter.

(c) Failure (F) - the type (sinking or lifting) of wind shear reported by the aircraft was opposite to that indicated by the WAS.

Table 8 Verification of less intense (or unknown intensity) wind shears reported by aircraft against the wind shear measured by the WAS during the period March 1984 - February 1985

Runway	31A/13D			13A/31D			
	S	MS	F	S	MS	F	
Type of shear							Total
Sinking	7	3	8	8	5	3	34
Lifting	10	2	2	3	2	1	20
Total	17	5	10	11	7	4	54

For less intense (or unknown intensity) wind shear, the total number of cases of lifting shear was comparable to that of sinking shear. The WAS appeared to perform quite well in detecting the type of wind shear (ie sinking of lifting) except sinking shear on 31A/13D.

For reference, the performance of the WAS in each case of encountered significant wind shear were listed in Appendix 1 while those for less intense (or unknown intensity) wind shears were given in Appendix 2.

Theoretically, the ability of the WAS in detecting significant wind shear may be enhanced if the threshold of detection were set at a value lower than 8 knots per 100'. The effect would be for some MS scores in Table 7 to be changed to S scores. This is acceptable only if it does not at the same time significantly increase the rate of false alarms, ie warning significant wind shear while the wind shear is only moderate, light of negligible. It would therefore be useful to see what was the magnitude of the wind shear measured by the WAS for every case when it was reported by the aircraft that there was no shear or the shear was only light or moderate. Table 9 below shows the frequency distribution of the wind shear values calculated by the WAS for these 'insignificant' wind shear occasions.

Table 9 Frequency distribution of values of wind shear measured by the WAS at the times when aircraft reported that either no shear was encountered or the wind shear encountered was only light or moderate during approach or departure.

Magnitude of shear measured (kn/100')	>8	8	7	6	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-8<	Total
Runway	(lifting effect)											(sinking effect)								
31A/13D	-	-	-	1	4	6	9	21	37	27	28	22	10	6	1	-	1	-	-	173
13A/31D	1	1	-	1	3	4	11	11	13	15	11	5	6	6	4	1	-	-	-	93
Total	1	1	-	2	7	10	20	32	50	42	39	27	16	12	5	1	1	-	-	266

By lowering the detection threshold for significant wind shear to 7 knots per 100' would increase the percentage of false alarm by 3/266 = 1.1%. However, this change in threshold would only cause one MS score for sinking wind shear on 31A/13D in Table 7 to be upgraded to a S score. Since this improvement in detection capability for significant wind shear is not that appreciable, there is little advantage in lowering the detection threshold from 8 knots per 100'.

From Table 6, the percentage frequency of occurrence of significant wind shear on 31A/13D was 7/183 = 3.7%, while that on 13A/31D was 23/121 = 19.0%. The rather large percentage for 13A/31D was likely to be due to the curve on the flight path near YYC. In fact, it was found that on many occasions significant wind shear was encountered by aircraft during IGS approach to R13, particularly at the time immediately before it was established for the straight section of the final approach. As the aircraft turned for the final touch-down, the wind component along the flight path changed significantly although the wind might actually be uniform both in direction and speed with height over the area. It had been shown that uniform winds from NNE (030 degrees) or SSW (210 degrees) of 17 knots at both YYC and NW would suffice to cause the WAS (formerly LLWSDS) to alert the presence of significant wind shear on 13A/31D (Reference 2). The effect on aircraft due to turning in a uniform air flow is equivalent to that of natural wind shear. The WAS should be effective in detecting this type of "procedure-induced" wind shear, which might explain the high score in Table 7 in the detection of significant sinking shear on 13A/31D. This was once again demonstrated by the fact that during the passage of Typhoon Tess in early September 1985, many aircraft on R13 approach confirmed the presence of significant sinking shear warned by the WAS as they turned in strong easterlies (head wind component decreased sharply at the turn), and significant lifting shear at the same location when the wind later became southeasterly (head wind component increased sharply at the turn).

The capability of the WAS in detecting the presence of wind shear caused by approaching thunderstorms (the outflows from which are responsible for the formation of the gust fronts) and by the passage of cold fronts was well documented (Reference 1). As aircraft reports were quite sparse and it only took a very short time for a gust front or a cold front to pass through either approaches, no aircraft report on wind shear during the times of occurrence of either of these events was available in the 12-month period concerned for investigation.

Post-mortem analyses were carried out for the failure cases of Table 7 and Table 8 in the present verification study. The shortcomings of the WAS (formerly LLWSDS) described in Reference 5, viz the assumption that winds change linearly along the flight path between two anemometer locations, the inability to detect the presence of low level jets (in a loose sense), the non-representativeness of YYC winds in sea breeze situation and the sub-standard exposure of the anemometers in some wind directions, etc. have been found to be responsible for most of the failure cases.

5. Assessment of the Wind Shear Detection Capability of the DAR

It has already been shown in Section 3 of this report that the longitudinal components of the wind measured by the DAR at the 800', 600' and 400' levels agreed quite well with those reported by aircraft overflying the DAR on 31A/13D but less well with those reported by aircraft on 13A/31D. Hence the verification will be done for 31A/13D only.

Since the DAR was situated 55 m above sea level and the attached anemometer was 10 m above ground, the lowest level for which wind data were available from the DAR was 65 m (203') above sea level. As aircraft were flying at about 750' when they pass LYM, only those wind data obtained by the DAR below 800' were used in the verification. Since the DAR computed one wind shear value for every 30 m height interval (except the lowest interval which was 60 m - 10 m = 50 m), wind shear values for several height intervals might be used in verification of a single aircraft report if the wind shear experienced by the aircraft extended over a height interval greater than 30 m.

Magnitudes of longitudinal wind shear measured by the DAR in the 12-month period March 1984 to February 1985 sometimes exceeded 8 knot per 100'. However, examination of individual cases revealed that most of the large wind shear values were due to malfunctioning of the ground-based anemometer or noise interference from heavy precipitation, thunder or human activities. Some large wind shear values were considered to be genuine and caused by thunderstorm outflows. Unfortunately, on none of these occasions was an aircraft report available.

The magnitudes of the longitudinal wind shear measured by the DAR at the times of occurrence of significant wind shear as reported by aircraft were on the other hand all quite small, ranging only from 0 to 3 knots per 100' and mostly less than 2 knots per 100' (in fact 2 occasions with wind shear magnitude equal to 3 knots per 100', 3 occasions with shear magnitude equal to 2 knots per 100' and 12' occasions with shear magnitude equal to or less 1 knot per 100'). This was not very surprising because by the nature of wind fluctuation the wind averaged over a long period (10 minutes in the case of the DAR) were likely to be more steady than if the wind were averaged over a shorter period such as 30 seconds in the case of the WAS. Since the accuracy of wind shear measurement of the DAR was of the order of 1 knot per 100', it would not be realistic to set a threshold, say 1 knot per 100', in the DAR for automatic detection of significant wind shear. It would however be useful to examine if the DAR was able to determine correctly the type of wind shear (sinking or lifting). The following criteria for the performance of the DAR in detecting the type of wind shear were adopted, and the results of the verification for those occasions when wind shear was reported by aircraft within the height range 200' to 800' were presented in Table 10.

(a) Marginal success (MS) - the wind shear experienced by the aircraft at a height or layer within the range 200' to 800' was of the same type (sinking or lifting) as that indicated by the DAR.

(b) Failure (F) - all cases when an aircraft reported occurrence of wind shear and the DAR failed to indicate shear of the same type for the corresponding level or layer at that time.

Table 10 Result of verification of wind shear reported by aircraft on 31A/13D against the wind shear data generated by the DAR for the period March 1984 - February 1985

Intensity of shear as reported	Significant		Less Intense (or unknown magnitude)		Total
Type of shear	MS	F	MS	F	
Sinking	10	6	12	4	32
Lifting	2	-	8	2	12
Total	12	6	20	6	44

It can be seen that the DAR was generally effective in detecting the type of wind shear (sinking or lifting) on 31A/13D.

Although a simple threshold value could not be used in the case of the DAR for automatic detection of significant wind shear, the wind and wind shear data generated by the DAR have been found by aviation forecasters to be very useful in assessing the wind shear condition in the vicinity of the airport. The graphical display of DAR wind and wind shear data in the AMO have given them a two dimensional (height and time) picture of the air flow in the vicinity of the flight path which could not be obtained otherwise. This picture, when interpreted with other meteorological data, helped them to appreciate the mechanisms which gave rise to wind shear and therefore enabled them to exercise better judgement in issuing wind shear warnings.

Experience gained since the installation of the DAR at the present site have also revealed that the DAR data have other meteorological applications besides wind shear monitoring. So far, aviation forecasters have found the frequently updated low level wind display very useful for :

(a) forecasting changes, both in direction and speed, of the aerodrome winds with a higher degree of confidence since changes in the surface flow were on many occasions preceded by changes in the upper flow, particularly during onset of monsoon winds and passage of a marked surface front,

(b) monitoring the formation, intensification and decay of sea breeze circulations on sunny days which had a direct bearing on the variation of surface visibility not due to precipitation, and

(c) in providing respresentative low level wind readings to pilots, ATS units and helicopter operators when required.

6. Conclusions and Recommendations

In comparing the longitudinal component of the wind reported by aircraft with that measured by the anemometer of the WAS at YYC or LYM over which the aircraft flew, it was found that the longitudinal component of the wind reported by aircraft was well correlated with that measured by the anemometer at LYM or YYC. The magnitude of the longitudinal component of the wind measured by the anemometer at LYM was, on average, greater by about 20% than those computed from aircraft winds for higher levels. This was likely to be due to the funnel effect of the Lei Yue Mun Pass on the wind flows. The magnitude of the longitudinal component of the wind measured by the anemometer at YYC was, on average, about 84% of that recorded at 400' and 75% of that recorded at 600' by overflying aircraft. For either approach/departure routes, the wind did not vary linearly with height.

The longitudinal component of wind reported by aircraft on 31A/13D was found to agree quite well with that measured at the corresponding level by the DAR at LYM. The agreement was not so good when wind measured by the DAR was compared with the wind reported by aircraft on 13A/31D. This shows that there was considerable variation of the wind in the horizontal direction. To obtain wind information for 13A/31D would required an additional DAR under that approach/departure route.

Verification of wind shear reported by aircraft against that measured by the WAS shows that the system was quite effective in detecting significant wind shear on 13A/31D but not so well on 31A/13D. Its better performance on 13A/31D was likely to be due to its ability to detect the wind shear effect caused by the curve on the flight path on 13A/31D in some wind conditions. From results of previous studies, it was also known that the system was also capable of detecting wind shears caused by the outflows from thunderstorms in close proximity of the airport and those associated with the passage of marked cold fronts.

Post-mortem analyses carried out for failure cases revealed once more the inherent shortcomings of the WAS, viz the assumption that winds change linearly with height along the flight path, the inability to detect the presence of low level jets (in a loose sense), the non-representativeness of YYC winds in sea breeze situations and the sub-standard exposure of the anemometers in some wind directions. Considering the general topography around the airport, it is unlikely that relocation of any of the anemometer would lessen these shortcomings significantly.

The magnitudes of wind shear computed by the DAR could not effectively indicate the presence of significant wind shear which were caused by the fluctuation of winds over a time scale much shorter than the averaging period used for the calculation of the wind and wind shear (ie 10-minutes). Due to the design of the DAR, it is not possible to shorten the averaging period for the wind and wind shear measurement without compromising the accuracy of the date. Nevertheless, the 10-minute mean winds measured by the DAR and the derived wind shear were found to be useful to aviation forecasters in assessing the wind shear condition on 31A/13D. Furthermore, experience gained in the past 18 months shows that the DAR data have other useful applications in aviation weather forecasting. So far, aviation forecasters have already found the DAR data useful for predicting the changes of the aerodrome wind and the variation of surface visibility in sea breeze situations and for providing low level wind information to pilots, ATS units and helicopter operators. It is therefore recommended that the operation of the DAR at Lei Yue Mun be continued. But noting that the correct interpretation of the DAR data requires meteorological reasoning and assimilation of other meteorological data, it is not recommended that the DAR data be displayed anywhere outside the AMO.

The reliability of the results of verifications depends quite a lot on the number of aircraft reports received. Although more aircraft reports would make the statistics more impressive, it is not considered likely that a longer period of data (say one more year of data) would alter significantly the findings in this report. Since it involves additional workload on the part of pilots to report low level wind and wind shear, it is proposed that the current intensified effort to request pilots to report low level wind while landing or taking off at the HKIA be discontinued, and the co-operation of pilots and airlines in the past few years be duly acknowledged. Pilots will of course continue to report low level wind shear encountered to the Met Office and/or ATC in accordance with ICAO procedures.

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Results of Verification on Significant Wind Shear Encountered by Aircraft During Take-off and Landing at HKIA for the Period March 1984 - February 1985

Month	Date/Time (GMT)	Flt. No.	Runway	Details of Wind Shear Encountered	Verification WAS	Remarks
Mar	04/0508	CX 503	13A	Signifiant lifting shear Rwy 13 final	MS	
	07/0650	CX 501	13A	7 knots sinking shear during landing	S	
	21/1405	CX 451	13A	Significant sinking shear at 400'	MS	
	26/1434	FT 9077	13A	Significant sinking shear at 200' (10-20 knots)	MS	
Apr	03/1035	QF 27	13A	Significant lifting shear between LT and outer marker	-	Height out of range of WAS
	04/0510	KLM 887	31A	Very Significant sinking shear 1000'-400'	MS	
	04/0513	MH 10	31A	Significant sinking shear between 400' and 200', lifting before touchdown	MS	Lifting shear by WAS
	23/0950	QF 27	13A	Significant sinking shear at 300' on short final	MS	
May	24/1147	QF 27	13A	Significant lifting late approach and final (noticeable wind direction variation during turn on final)	F	
	25/0250	PA 006	13A	10-15 knots sinking shear below 1000'	S	
	25/0635	MH 14	13A	Significant lifting shear at 200'	F	
	25/0725	MH 11	13A	Significant sinking shear 800'-100'	S	
	25/1059	QF 77	13A	Bumpy and significant wind shear at 1800'	-	Height out of range of WAS
	25/1351	CX 712	13A	Significant sinking shear 400' abeam checker board	S	
	31/0652	CX 750	13A	Significant sinking shear at 500' near checker board	F	
Jun	01/0730	MH 14	31A	Significant sinking shear on approach from TH at 800'	-	Height out of range of WAS
	04/0631	MH 12	13A	Significant wind shear encountered at 1000'	-	Height out of range of WAS
	19/0603	CX 511	13A	Significant lifting 1000'-CB, significant sinking CB-50' AGL	F	
Jul	08/0418	CI 831	13A	Significant lifting shear netrween 700' and 500'	MS	
	13/1119	PA 021	31A	10 knots sinking shear at 800'	-	Height out of range of WAS
Aug	17/2235	LH 686	31A	Significant wind shear 2000'-1200' (type of shear not given)	-	
	18/0535	CX 503	13A	Significant sinking shear on short final	MS	
	18/0624	MH 61	13A	Significant sinking wind shear on final	S	
	18/1007	BR 382	13A	Significant sinking shear from 200' to threshold	S	
	18/1342	CX 301	13A	Significant lifting shear at 300'	F	
	20/0604	MH 61	13A	Significant sinking shear 500'-100'	S	
	20/0624	CX 521	13A	Significant sinking shear at 200'	S	
	20/1302	CX 902	13A	Significant lifting shear abeam checker board	F	
	21/0053	SQ 1	31A	Significant sinking shear at 200'	S	
	21/0712	CX 720	31A	Significant sinking shear below 800'	MS	
	22/0438	CX 503	31A	Significant lifting shear at 100'	F	
Sep	26/0505	MH 10	13A	Significant lifting shear at RW	F	
	27/0049	CX 200	13A	Significant sinking shear from 600'	S	
Oct	20/0710	MH 61	31A	Significant sinking shear 500' to touchdown	MS	
Feb	10/0400	BA 26	13A	7 knots sinking shear on final	MS	
	18/0555	CX 008	31A	Significant sinking shear 100' to touchdown	MS	

Results of Vertificatiion for Less Intense (or Unknown Magnitude) Wind Shear Encountered by Aircraft
During Take-off and Landing at HKIA for the Period March 1984 - February 1985

Month	Date/Time (GMT)	Flt. No.	Runway	Details of Wind Shear Encountered	Verification WAS	Remarks
Mar	03/0555	PA 6	13D	Wind shear 200'-300'	-	Magnitude and type not given
	04/1448	TG 602	13A	Moderate sinking shear on final	S	
	06/0633	CX 521	13A	Moderate sinking shear on final	S	
Apr	03/1005	TG 606	13A	Sinking wind shear between LT and outer marker	-	Height out of range of WAS
	07/1155	CX 710	13A	Sinking wind shear experienced on final	MS	Intensity of shear not given
	07/2258	AI 308	13A	Light lifting wind shear on final	S	
	14/0626	MH 61	13A	Light sinking wind shear between 300' and 100'	S	
	17/0711	MH 11	13A	Light wind shear at 4500' near LT	-	Height out of range of WAS
	30/0648	CX 710	13A	Moderate sinking shear at 300'	S	
	30/1003	QF 27	13A	Light lifting shear at 200'	-	WAS unservicable
May	05/0500	MH 10	31A	Light sinking wind shear just before threshold Rwy 31	S	
	23/0500	CX 700	13A	Light sinking wind shear below 600'	S	
	24/0610	CI 817	13A	Light sinking wind shear on landing	S	
	24/0700	MH 15	13A	Light sinking wind shear at 400'	F	
	24/1100	SQ 2	13A	Light to moderate sinking wind shear at 500'	S	
	24/1300	CX 411	13A	Sinking wind shear below 300'	MS	
	30/0458	MH 10	31A	Light sinking shear 500' to touchdown	F	
Jun	01/0635	CX 900	31A	Minor wind shear encountered	-	Height and type of shear not given
	01/0645	MH 11	31A	Light sinking shear at 500'	F	
	04/0640	CX 521	31A	Light sinking shear 150'-200' on short final	MS	
	05/0504	MH 10	31A	Light lifting shear 1.5 n miles final at 500'	S	
	13/0506	MH 10	31A	light to moderate lifting shear on final approach	S	
	15/0952	LH 664	31A	Lifting/sinking in the gap 900'-750'	-	Height out of range of WAS
	10/1319	CX 712	31A	Sinking wind shear in approach (intensity not given)	MS	
	19/1325	CX 712	13A	Light wind shear	-	Magnitude and type not given
	24/0624	CX 521	31A	Light lifting wind shear between 250' and 100'	S	
	25/0340	PA 6	13A	Wind shear and turbulence experienced at 1000'	-	Height out of range of WAS
	25/1000	QF 27	13A	Light sinking wind shear between 200' and ground	F	
Jul	09/1256	NW 17	13A	Light sinking wind shear at 1000'	-	Height out of range of WAS
	09/1258	CX 902	13A	Lifting wind shear from IGS to 50' (intensity not given)	MS	
	13/0950	LH 664	31A	Light lifting wind shear between 800' and 300'	S	
	21/1251	CX 100	31A	Sinking wind shear on approach (level not given)	MS	
	23/0119	LH 640	31A	Light sinking wind shear at 400'	S	
Aug	11/1303	CX 505	13A	Light liftiing wind shear at 500'	F	
	15/0700	CX 720	31A	Light lifting wind shear 300'-500'	S	
	16/1007	BR 382	31A	Sinking shear followed by lifting shear below 300'	MS	Lifting shear by WAS
	17/2239	SQ 1	31A	Sinking shear at 500' (intensity not given)	F	
	21/0515	MH 10	31A	Light to moderate sinking shear 2000' to minimum	S	
	22/0439	CX 700	31A	Light lifting wind shear 300'-100'	F	
	25/0555	KL 885	31A	Lifting wind shear while landing at Rwy 31	S	
	30/0622	MH 12	31A	Light wind shear last 200'to touchdown	-	Type of shear not given

Sep	05/0611	MH 10	13A	Light lifting wind shear 1 n mile on final 13 at 300'	S	
	21/0130	CX 713	13A	Surface -100' lifting, 100'-300' sinking (intensity not given)	MS	Sinking shear by WAS
	23/2351	SQ 1	31A	Light sinking shear below 500'	F	
	24/1334	JL 001	13A	Sinking wind shear and turbulence below 200' (intensity not given)	MS	
	25/0532	MH 10	13A	Light lifting wind shear on final turn at 300'	S	
	26/0028	CX 200	13A	sinking wind shear at checker board, lifting wind shear in final approach	MS	Sinking shear by WAS
	26/1130	TG 607	13D	Moderate lifting wind shear on take-off	S	
	26/1132	CI 832	13D	Moderate lifting wind shear on take-off	S	
	27/0002	SQ 1	13A	Moderate sinking wind shear at 300'	S	
Oct	20/0511	MH 10	31A	Light sinking wind shear 2 n miles from 31 threshold	-	Height out of range of WAS
	20/1021	SQ 2	31A	Sinking wind shear on final (intensity not given)	MS	
	20/1024	CI 827	31A	Light sinking shear on final	S	
	20/1027	LH 668	31A	Light sinking shear on final	S	
	25/0655	CX 710	13A	Lifting shear on final	F	
	26/1240	EG 231	31A	Light lifting shear on final	S	
	27/0500	MH 10	31A	Light lifting shear between 1000' and 500'	S	
	28/0355	CX 401	31A	Light sinking shear at 200'	F	
	28/0634	CX 501	31A	Light sinking shear at 2 n miles Rwy 31 ILS	-	Height out of range of WAS
Nov	08/1338	CP 401	31A	Light sinking wind shear on final	F	
	08/1340	CX 712	31A	Light sinking wind shear on final	F	
	20/0919	LH 682	31A	Light lifting wind shear at 200'	S	
	21/1014	LH 664	31A	Lifting wind shear on final 100'-200' (imtenstiy not given)	F	
	24/1318	CX 505	31A	Light sinking shear 200'-100'	S	
Dec	28/0724	MH 11	31A	Light sinking shear after TH to short final	S	
	28/0952	LH 664	31A	Light lifting shear prior to touchdown at 100'	S	
Feb	13/0700	CX 421	13A	Light sinking shear just before landing	F	
	24/0705	CX FLTs	13A	Moderate wind shear encountered (type of shear not given)	-	

Extract on Low Level Wind Shear and its Measurement
from Report on Aerodrome Meteorological Measurements,
CIMO-IX/Doc.15, prepared for the Ninth Session of
the WMO Commission for Instruments and Methods of Observation,
Ottawa, 15 - 26 July, 1985