AERODROME METEOROLOGICAL OBSERVATION AND FORECAST STUDY GROUP (AMOFSG)

TENTH MEETING

Montréal, 17 to 19 June 2013

Agenda Item 5: Aerodrome observations

THE PROVISION OF CROSSWIND AND TAILWIND INFORMATION

(Presented by Colin Hord)

SUMMARY

This Study Note presents additional information relating to the provision of crosswind and tailwind information, supporting the activities of WG/1 tasked with providing a more appropriate calculation of crosswind and tailwind components.

1. INTRODUCTION

1.1 An outcome of ninth meeting of the Aerodrome Meteorological Observation and Forecast Study Group (AMOFSG/9) proposed that a p aper or statement be developed for the Air Traffic Management Requirements & Performance Panel (ATMRPP) to alert this group to issues involved in the generation of suitable crosswind and tailwind data (AMOFSG/9 SoD,para 3.1.19 refers). The report provided by AMOFSG/9 WG/1 described existing and potential future algorithms to support this work, and highlighted a number of options, each with their own advantages and disadvantages.

1.2 This paper is designed to provide additional input into the ATMRPP and support WG/1 (Guidance and/or provisions to enable a more appropriate calculation of crosswind and tailwind components).

1.3 As described by AMOFSG previously, the generation of representative crosswind and tailwind components based upon wind reports in local routine and special reports and in METAR **and SPECI, is limited** by:

a) the operationally desired accuracy for wind, and

b) the allowable parameters in which reported wind direction, speed and gust information is provided.

1.4 Air traffic services (ATS) units make operational decisions relating to runway selection on the latest wind data provided in local routine and special reports. This paper highlights the limitations of such wind data when making these operational decisions, and offers a potential solution.

2. IMPACT OF CROSSWINDS AND TAILWINDS ON AIRCRAFT AND AIRPORT PERFORMANCE

2.1 Accurate crosswind and tailwind information is an important parameter for both pilots and Air Traffic Control units. For example, the International Federation of Air Line Pilots' Associations (IFALPA) Aircraft Design & Operation Committee Meeting of 9 to 11 November 2009 highlighted that the accident rate of aircraft increases exponentially with crosswind components over 20 kts, and supports the use of derived wind reports for crosswinds.

2.2 Tailwinds on landing can increase landing distances, especially in wet conditions, leading to overruns. Crosswinds increase the risk of landing veers (which again may be exacerbated by runway contamination). Few airports have cross runways to mitigate against excessive crosswind.

2.3 Two papers have been reviewed in connection with this issue:

"Safety aspects of aircraft operations in crosswind" issued by the National Aerospace Laboratory (NLR) and written by G.W.H van Es, P.J. van der Geest and T. M.H. Nieuwpoort. (May 2001)
http://www.nlr-atsi.nl/downloads/safety-aspects-of-aircraft-operations-in-cross.pdf

"Crosswind Certification – How does it affect you" issued by the National Aerospace Laboratory (NLR) and written by G.W.H van Es. (May 2006).
http://www.nlr-atsi.nl/downloads/crosswind-certification-how-does-it-affect-you.pdf

2.4 Some statistics:

a) adverse wind conditions (i.e. strong crosswinds and tailwinds) are involved in 33 per cent of approach-and-landing accidents.

b) crosswind in association with runway condition is a circumstantial factor in nearly 70 per cent of runway excursion events.

c) 85 per cent of crosswind incidents and accidents occur at landing.

(Source: Flight Safety Foundation Flight Safety Digest Volume 17 & 18 – November 1998 / February 1999).

2.5 Recent studies carried out at Heathrow airport show that “high headwind” and ‘high crosswinds’ occur at Heathrow on a regular basis. These events have proven to impact punctuality as aircraft spacing on approach may be increased. The impact on punctuality is similar to the effects of low visibility, snow and thunderstorms. The resulting delays also impact airline operator’s schedules, which may impact general flow and other airports. On some occasions, aircraft will need to divert.

3. LIMITATIONS OF WIND DATA PROVIDED

3.1 The limitations of wind data provided are based on 2 main factors:

a) the operationally desired accuracy for wind, and

b) the criteria for updating wind data to ATC.

1) ICAO Annex 3 — *Meteorological Service for International Air Navigation* , Att A defines the operationally desirable accuracy for wind as follows:

Mean surface wind Direction: ± 10°
Speed: ± 0.5 m/s (1 kt) up to 5 m/s (10 kt)
± 10% above 5 m/s (10 kt)

2) the criteria for updating the local report with a special report for wind is defined in Annex 3, Appendix 3 Para 2.3 as follows:

2.3.1 The list of criteria for the issuance of local special reports shall include the following:
...
e) those values which constitute criteria for SPECI.

2.3.2 Where required in accordance with Chapter 4, 4.4.2 b), SPECI shall be issued whenever changes in accordance with the following criteria occur:

a) when the mean surface wind **direction has changed by 60° or more** from that given in the latest report, the mean speed before and/or after the change being 5 m/s (10 kt) or more;

b) when the **mean surface wind speed has changed by 5 m/s (10 kt) or more** from that given in the latest report; and

c) when the **variation from the mean surface wind speed (gusts) has changed by 5 m/s (10 kt) or more** from that at the time of the latest report, the mean speed before and/or after the change being 7.5 m/s (15 kt) or more;

This means that wind direction, speed & gust data provided in local reports and which are used as a basis for the generation of crosswind and tailwind components, may actually denote a relatively large range of values, all of which have downstream impacts on the actual crosswind or tailwind component at any particular time. A two-minute wind report provided by ATC on landing carries a similar potential range of values as shown in Para 5.

3.2 The paper "Safety aspects of aircraft operations in crosswind" issued by the National Aerospace Laboratory, NLR concluded "that crosswind operations in general are surrounded with substantial uncertainty, warranting substantial margins relative to theoretical limitations when operating in crosswind conditions".

3.3. In consideration of the requirement to provide information relevant to crosswind and tailwind thresholds, ICAO Annex 3 recommends that a SPECI be issued to indicate when the runway tailwind and crosswind components have changed through values representing the main operating limits for typical aircraft operating at the aerodrome (App 3, para 2.3.3 refers). By reference to para 2.3.1.e, such requirements extend to local special reports as well.

> 2.3.3 **Recommendation.—** *Where required in accordance with Chapter 4, 4.4.2 b), SPECI should be issued whenever changes in accordance with the following criteria occur:*
>
> *a) when the wind changes through values of operational significance. The threshold values should be established by the meteorological authority in consultation with the appropriate ATS authority and operators concerned, taking into account changes in the wind which would:*
> *1) require a change in runway(s) in use; and*
> *2)* ***indicate that the runway tailwind and crosswind components have changed through values representing the main operating limits for typical aircraft operating at the aerodrome****;*

Whilst this attempts to address a specific need, the variation of direction, mean speed and gusts that are possible when a local special report has been issued means that the information provided continues to carry a wide range of potential but realistic outcomes for airlines and ATC Units.

4. CROSSWIND AND HEADWIND/TAILWIND COMPONENT ALGORITHM

4.1 There is no prescribed algorithm defined to derive crosswind and tailwind components, though a typical algorithm may be as follows:

Headwind/tailwind:
Wind strength x cos (wind direction - runway direction).
(A positive value denotes a headwind, and a negative value denotes a tailwind)

Crosswind:
Wind strength x sin (wind direction - runway direction)
(A positive value crosswind is from the right, and a negative value crosswind is from the left)

5. EXAMPLES

Variations in wind are attributable to temporary fluctuations (deviations) in the mean wind reported. The following examples demonstrate the valid range of wind direction and speed possible by the provision of specific wind data provided to air traffic control (ATC).

The application of the rules from 3(ii) above (local special criteria) give the range before another special report is required. It should be appreciated that the data provided at the time of the observation is likely to be accurate for that anemometer location! Of course the particular crosswind/tailwind component may lie anywhere within this range of values.

5.1 22015G26KT

Direction range: 170 to 270°
Mean speed range: 6 to 24 kts
Gust range: 17 to 35 kts

Runway in use: RW19

	17006KT	17024G35KT	**22015G26KT**	27006KT	27024G35KT
Headwind/Tailwind	06	23 / G33	**13 / G23**	01	04 / G06
Crosswind (from L, from R)	02	08 / G12	**08 / G13**	06	24 / G34

In this example, the mean **headwind** could be anywhere between **1 kt and 23 kt**, with gusts anywhere between **6 kt to 33 kt**.

The mean **crosswind** could be anywhere between **8 kt (from the left) and 24 kt (from the right)**, with gusts anywhere between **12 kt (from the left) and 34 kt (from the right).**

5.2 11012G25KT

Direction range: 060 to 160 degs
Mean speed range: 3 to 21 kts
Gust range: 16 to 34 kts

Runway in use: RW19

	06003KT	06021G34KT	**11012G25KT**	16003KT	16021G34KT
Headwind/Tailwind	02	13 / G22	**02 / G04**	03	18 / G29
Crosswind (from L, from R)	02	16 / G26	**12 / G25**	02	11 / G17

In this example, the mean **headwind** could be anywhere between **18 kt** to a **tailwind of 13 kt**, with gusts anywhere between a **headwind of 29 kt** to a **tailwind of 22 kt**.

The mean **crosswind** could be anywhere between **2 kt to 16 kt (from the left)**, with gusts anywhere between **17 kt to 26 kt (from the left).**

General note:
Beyond this there is of course the tolerable limits of operationally desirable accuracy of wind, which adds a further degree of variability to the results. The range of potential values could also be a larger due to rounding (additional ±10˚ for wind direction and ± ~10 per cent for wind speed)

6. AIRCRAFT & AIRPORT OPERATIONAL LIMITS

6.1 Airports

6.1.1 As well as aircraft, airports have operational crosswind and tailwind limits. These may be affected by factors such a runway preference and noise abatement procedures (further details in **Appendix A**). The values vary but crosswind limits are normally 15-25 kts and tailwinds are normally no more than 10 kts.

6.1.2 Setting crosswind and tailwind thresholds are a matter for individual airline operators. However the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) provides the mandate for the provision of crosswind and tailwind information for arriving aircraft:

> 6.6.4 At the commencement of final approach, the following information shall be transmitted to aircraft:
> a) significant changes in the mean surface wind direction and speed;
> *Note.— Significant changes are specified in Annex 3, Chapter 4. However, if the controller possesses wind information in the form of components, the significant changes are:*
> *— Mean headwind component: 19 km/h (10 kt)*
> *— Mean tailwind component: 4 km/h (2 kt)*
> *— Mean crosswind component: 9 km/h (5 kt)*

and:

Chapter 7

> 7.2.6 Noise abatement shall not be a determining factor in runway nomination under the following circumstances:
> ...
> e) when the crosswind component, including gusts, exceeds 28 km/h (15 kt), or the tailwind component, including gusts, exceeds 9 km/h (5 kt).

6.2 Aircraft & Airlines

a) ***Airbus*** have procedures for operations in crosswind conditions. These require strict adherence to applicable crosswind limitations or maximum recommended crosswind values, particularly when operating on wet or contaminated runways.

Their limitations are summarised as follows:

Reported Braking Action (Index)	Reported Runway Friction Coefficient	Equivalent Runway Condition	Maximum Recommended Crosswind
Good (5)	0.40 and above	*Note 1*	Max demonstrated
Good / Medium (4)	0.36 to 0.39	*Note 1*	30 kt
Medium (3)	0.30 to 0.35	*Note 2* and *Note 3*	25 kt
Medium / Poor (2)	0.26 to 0.29	*Note 2* and *Note 3*	20 kt
Poor (1)	0.25 and below	*Note 3* and *Note 4*	15 kt
Unreliable (9)	Unreliable	*Note 4* and *Note 5*	5 kt

Table 1

Maximum Recommended Crosswind - Typical

Note 1: *Dry or wet runway without risk of hydroplaning.*
Note 2: *Runway covered with slush.*
Note 3: *Runway covered with dry snow.*
Note 4: *Runway covered with standing water, with risk of hydroplaning, or with wet snow.*
Note 5: *Runway with high risk of hydroplaning.*

Airbus note that a 'failure to recognize changes in landing data over time (i.e. wind direction shift, wind velocity or gust increase)' are often a factor in crosswind-landing incidents and accidents, and that pilots should 'be alert to detect changes in ATIS and tower messages (i.e. wind direction shift, velocity and/or gust increase).

b) ***Flybe*** have similar limits defined in their Ops manual. The table below provides details of both crosswind and tailwind operating maxima for their aircraft.

Flybe Ops Manual Part B4	LIMITATIONS WIND LIMITATIONS	SECTION 1 Chapter 11 Page 27

11.0 WIND LIMITATIONS

11.1 Maximum Crosswind Components

Aircraft Configuration	Runway Conditions				
	Dry	Wet	Compacted Snow	Contaminated	Ice and Wet Ice Braking action Poor
Take-off	32kt	32kt	20kt	14kt	0
Landing	32kt	32kt	20kt	14kt	0
Cat II -auto-pilot coupled	18kt *	18kt *	18kt *	14kt	0

- This is the Cat II system limitation rather than the runway condition limitation.

11.2 Maximum Tailwind

Aircraft Configuration	Runway Conditions			
	Dry	Wet	Contaminated	Ice and Wet Ice Braking Action Poor
Take-off	10	10	10	0
Landing	10	10	10	0
CAT II	10	10	10	0

11.3 Maximum Headwind (CAT II)
For autopilot coupled CAT II Approaches the maximum headwind component is 24kt.

Table 2: Flybe operating crosswind and tailwind maxima

c) for ***Embraer*** aircraft, the maximum tailwind component for take-off and landing is 10 kts.

Embraer aerodynamic analysis has resulted in the maximum recommended crosswinds for take-off and landing given in *Table 3* below. These limits include gusts.

Maximum Crosswinds	
Runway State	**Maximum Crosswind (knots)**
Dry	38
Wet	31
Contaminated with compacted snow	20
Contaminated with standing water / slush	18
Contaminated with wet / dry snow	18
Contaminated with wet ice (non-melting)	12

Table 3: Embraer aircraft operating crosswind and tailwind maxima

Due to the possibility of compressor stall, static take off with cross winds in excess of 25 kts is not recommended.

d) the operating limits for a number of aircraft are numerous and summarised at ***Annex B***. Limits may also be affected by factors such as low visibility and pilot experience.

7. EFFECTS OF WIND DATA PROVIDED ON OPERATIONAL LIMITS

7.1 Applying the operational requirements of *PANS ATM Ch7* to the 2 specific examples used in this Paper, the crosswind component does not exceed 15 k ts (the threshold for noise abatement) according to the *reported* wind, but could do within the range of values that the reported wind caters for. Additionally, the crosswind and tailwind components can vary by values in excess of the ‘significant changes defined in PANS ATM, para 6.6.4.

7.2 Applying the potential values to typical aircraft and airport limits, most aircraft face a risk of operating aircraft beyond the airport’s operating maxima.

7.3 Applying the case of Example 1 (22015G26KT) used in this Paper to the Airbus, Flybe and Embraer limits, this report as provided would have been well within their crosswind limits. However, at the extent of the tolerable range for this report (24G34KTS), the crosswind limit would have been exceeded for all braking conditions (all excluding dry in the case of Embraer).

7.4 Applying the case of Example 2 (11012G25KT) used in this paper to the maximum tailwind component for take-off and landing stated by Flybe and Embraer, their 10 k t tailwind component limit would have been exceeded at points within the allowable range for this report (max tailwind - 13G22KT).

8. OUTCOMES/CONCLUSIONS

8.1 Natural variations in wind flow make it difficult to totally eradicate the potential for excessive crosswind or tailwinds.

8.2 Current Standards and Recommended Practices (SARPs) permit a large range of tolerance before an additional special report is required to the extent that it is possible to exceed crosswind/tailwind maxima for airlines. Tightening the criteria for local special reports for airports where crosswind and tailwind data is routinely provided, would allow for an earlier detection of relevant changes and would maintain the current wind report within closer parameters. Both these effects would mitigate the exposure to unexpected crosswind and tailwind conditions. However this would necessarily increase the number of ATIS updates which has been shown to be undesirable.

For example, issuing a local special report for the following 'significant' changes reduce the chance of aircraft encountering excessive crosswinds or tailwinds:

a) the mean surface wind direction has changed by **30°** or more, rather than 60°**,** and

b) when the mean surface wind speed has changed by **5** kt or more from that given in the latest report (rather than 10 kt); and

c) when the variation from the mean surface wind speed (gusts) has changed by **5** kt or more (rather than 10 kt).

Taking the 2 examples provided in this paper and comparing the range of outcomes for the current special report criteria against the criteria above, provides the following results:

Example 1:

22015G26KT

Direction range:	170 to 270°
Mean speed range:	6 to 24 kts
Gust range:	17 to 35 kts
Runway in use:	RW19

	17006 KT	17024 G35KT	**22015 G26KT**	27006 KT	27024 G35KT
Headwind/ Tailwind	06	23 / G33	**13 / G23**	01	04 / G6
Crosswind (from L, from R)	02	08 / G12	**08 / G13**	06	24 / G34

22015G26KT

Direction range:	200 to 240°
Mean speed range:	11 to 19 kts
Gust range:	22 to 30 kts
Runway in use:	RW19

	20011 KT	20019 G30KT	**22015 G26KT**	24011 KT	24019 G30KT
Headwind/ Tailwind	11	19 / G30	**13 / G23**	07	12 / G19
Crosswind (from L, from R)	02	03 / G05	**08 / G13**	08	15 / G23

Tightening the special criteria reduces the maximum expected cross wind from the left from 08 / G12 to 03 / G05, and from the right from 24 / G34 to 15 / G23

Example 2:
11012G25KT

Direction range: 060 to 160 degs
Mean speed range: 3 to 21 kts
Gust range: 16 to 34 kts

Runway in use: RW19

	06003 KT	06021 G34KT	**11012 G25KT**	16003 KT	16021 G34KT
Headwind/ Tailwind	02	13 / G22	**02 / G4**	03	18 / G29
Crosswind (from L, from R)	02	16 / G26	**12 / G25**	02	11 / G17

1012G25KT

Direction range: 090 to 130 degs
Mean speed range: 8 to 16 kts
Gust range: 21 to 29 kts

Runway in use: RW19

	09008 KT	09016 G29KT	**11012 G25KT**	13008 KT	13016 G29KT
Headwind/ Tailwind	01	03 / G05	**02 / G4**	04	08 / G14
Crosswind (from L, from R)	08	16 / G29	**12 / G25**	07	14 / G25

Tightening the special criteria does not reduce the maximum expected cross wind from the left. However, the maximum expected tail wind is reduced from 13 / G22 to 03 / G5.

Whilst the special criteria could be tightened, this would lead to more updated reports, and how best to communicate this to the pilot in high workload environments is a challenge.

8.3 In the Netherlands the averaged crosswind components are available to ATC for all possible runways as separate database items next to local reports. Airports could be encouraged to maintain a separate data base to provide the range of cross/tailwind values for any particular reported mean wind provided in the local reports.

8.4 This is clearly an important and complex issue that requires further exploration it is suggested that this topic is raised at the Met Divisional Meeting scheduled for July 2014.

9. ACTION BY THE GROUP

9.1 The group is invited to:

a) note the contents of this paper;

b) discuss the potential of the mitigating actions considered at Para 8 of this paper;

c) discuss whether the provision of actual crosswind for the runway should be provided to the pilot in addition to the wind direction and wind speed, thereby avoiding any miscalculation;

d) discuss the viability of including gust information in the calculation of crosswind and tailwind; and

e) consider raising this as a topic for further discussion at the MET Divisional Meeting 2014.

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APPENDIX

NOISE ABATEMENT PROCEDURES

A-2

PROPOSED AMENDMENT TO THE

PROCEDURES FOR AIR NAVIGATION SERVICES

AIR TRAFFIC MANAGEMENT

. . .

Chapter 7

PROCEDURES FOR AERODROME CONTROL SERVICE

. . .

7.2 SELECTION OF RUNWAY-IN-USE

. . .

Insert new paragraph 7.2.7 as follows:

7.2.7 Notwithstanding the requirements in paragraph 7.2.6 above, noise abatement can be a determining factor in runway nomination under the following circumstances:

a) when the crosswind component, including gusts, does not exceed 10 m/s (20 kt), or the tailwind component including gusts does not exceed 3.5 m/s (7 kt), and the following requirements are met:

i) a wind measurement system for the touchdown and take-off area is installed that incorporates both wind measuring sensors with a dedicated data processing system, which provides the following reporting accuracy to the aircraft:

1) mean surface wind direction: ± 10 deg;

2) mean surface wind speed: ± 0.5 m/s (1 kt) up to 5 m/s (10 kt) and ± 10% above 5 m/s (10 kt); and

3) variations from the mean surface wind: ± 1 m/s (2 kt), in terms of longitudinal and lateral components.

ii) a continuous safety risk assessment procedure is in place that monitors and compares reported winds from the aircraft flight data with data derived from the wind measurement system in a) i) above;

iii) precision approach guidance is available for the runway in use;

iv) the current landing area wind is reported by ATC to aeroplanes on final approach;

v) the current "take-off area" wind is reported to aeroplanes as part of the take-off clearance;

vi) aeroplanes are advised, when variations from the mean wind speed (gusts) exceed 2.5 m/s (5 kt);

vii) reported braking action remains "good"; and

viii) at aerodromes with multiple runways, the wind information for each separate runway in use is included in the information provided by the automatic terminal information service (ATIS).

Manufacturer	Model	Demonstrated Crosswind knots	Manufacturer	Model	Demonstrated Crosswind knots	Manufacturer	Model	Demonstrated Crosswind knots
Aerospatiale	ATR-42	45 (Takeoff)	British Aerospace	BAe146-100	25 (Takeoff)	Douglas	DC-10-10/30	29
Aerospatiale	ATR-42	38 (Landing)	British Aerospace	BAe146-100	30 (Landing)	Douglas	DC-10-40	23.5
Aerospatiale	ATR-72	35	British Aerospace	BAe146-200	30 (Takeoff)	Douglas	MD-11	35
Airbus	A300-600	32	British Aerospace	BAe146-200	35 (Landing)	Douglas	MD-80	28
Airbus	A310-200/300	28	British Aerospace	Jetstream 4100	35	Douglas	MD-87	28
Airbus	A320-100/200	29 (Takeoff)	Canadair	CL-65 RJ	24	Douglas	MD-90	30
Airbus	A320-100/200	33 (Landing)	Canadair	CL-600/601/604	24	Embraer	EMB-120	30
Airbus	A321	27 (Takeoff)	Cessna	500	25	Embraer	EMB-145	30
Airbus	A321	28 (Landing)	Cessna	550	23	Fokker	F28-all series	30
Airbus	A330-300	17 (Takeoff)	Cessna	560	20	Fokker	F100	30
Airbus	A330-300	22 (Landing)	Cessna	650	25	Fokker	F70	35
Airbus	A340-200/300	27	Cessna	750	21	Fokker	F50	33
Boeing	707-300B ADV/C	33	Dassault	Falcon 20	23.5	Fokker	F27-all series	25
Boeing	727-100/200	29	Dassault	Falcon 50	24.7	Gulfstream	II	24.5
Boeing	737-100/200	29	Dassault	Falcon 900	30	Gulfstream	III	21
Boeing	737-300/400/500	35	Dassault	Falcon 2000	35	Gulfstream	IV	24
Boeing	747-100/200	28	deHavilland	DHC-8-100/200/300	36	Learjet	24	26
Boeing	747 SP	34 (Takeoff)	Dornier	Do 328-100	21	Learjet	25	33
Boeing	747 SP	32 (Landing)	Douglas	DC-8-61	17	Learjet	31	30
Boeing	747-400	30	Douglas	DC-8-62	32	Learjet	35/36	26.5
Boeing	757-200	30	Douglas	DC-8-63	23.5	Learjet	55	27
Boeing	767-200	29	Douglas	DC-8-71/72/73	28	Learjet	60	29
Boeing	767-300	33	Douglas	DC-9-30/34/40	36	Lockheed	L1011-1	33
Boeing	777-200	38	Douglas	DC-9-50	28	Lockheed	L1011-500	28
						SAAB	340	35

Source: Faa and manufacturers

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