AERODROME METEOROLOGICAL OBSERVING SYSTEMS STUDY GROUP (AMOSSG)

FOURTH MEETING

Montreal, 15 to 18 September 2003

SUMMARY OF DISCUSSIONS

1. HISTORICAL

1.1 The fourth meeting of the Aerodrome Meteorological Observing Systems Study Group (AMOSSG) was held at the International Civil Aviation Organization (ICAO) headquarters in Montreal, Canada, 15 to 18 September 2003.

1.2 The meeting was opened on behalf of the Director of the Air Navigation Bureau (ANB) of ICAO by Dr. Olli Turpeinen, Chief of the Meteorology Section of the ANB.

1.3 The names and addresses of the participants are listed in **Appendix A**. Bryan Boase (Australia) was elected chairman of the meeting. The meeting was served by the Secretary of the AMOSSG, Neil Halsey, Technical Officer in the Meteorology section of the ANB.

1.4 The meeting considered the following agenda items:

1) Opening of the meeting

2) Election of Chairman

3) Adoption of working arrangements

4) Adoption of the agenda

5) Aerodrome observation requirements

6) Capability of automatic observing equipment to meet aeronautical requirements

7) Aerodrome forecast requirements

8) Guidance material

9) Future work programme

10) Any other business

11) Closure of the meeting

1.5 A list of documentation issued for the meeting is given at **Appendix B** in this summary of discussions.

2. AGENDA ITEMS 1 TO 4: OPENING OF THE MEETING; ELECTION OF CHAIRMAN; ADOPTION OF WORKING ARRANGEMENTS; ADOPTION OF THE AGENDA

2.1 These items are covered under Section 1: Historical.

3. AGENDA ITEM 5: AERODROME OBSERVATION REQUIREMENTS

3.1 Amendment 73 to Annex 3 — *Meteorological Service for International Air Navigation*

3.1.1 The group recalled that much of its work over the previous two meetings had concerned the preparation of an update to Chapter 4 of Annex 3 which had been submitted to the MET Divisional Meeting (2002) as a part of the proposed Amendment 73 to Annex 3. This had been carried out in two parts:

a) draft provisions related to the introduction of prevailing visibility (some States had been concerned about the concept; therefore, as a separate item it could have been easily excluded from the Amendment if deemed to be necessary); and

b) draft provisions related to the rest of Chapter 4 of Annex 3.

3.1.2 The group was pleased to note that the MET Divisional Meeting (2002) in its Recommendation 2/1 had endorsed the proposals made by the group for amendments to Annex 3 including the introduction of the concept of prevailing visibility. However, two modifications had been made to the original proposal from the group. Firstly, it had been considered to be premature for an enabling clause to be placed in Annex 3 for the dissemination of METAR, SPECI and TAF in the BUFR code form. Secondly, the proposed change of the definition of "vicinity" had not been accepted by the meeting.

3.2 Harmonization of SPECI criteria with TAF change criteria

3.2.1 The group noted that the MET Divisional Meeting (2002) in its Recommendation 2/3 b) had invited ICAO, in consultation with the World Meteorological Organization (WMO) and user organizations to consider the need for harmonizing the criteria for issuance of SPECI and those for including change groups in TAF.

3.2.2 The criteria for issuance of SPECI are defined in Annex 3, paragraph 4.3.4. It was borne in mind that sub-paragraph d) specifies that certain thresholds for changes in the wind should be established by the meteorological authority in consultation with the appropriate ATS authority and operators concerned. The group also noted that Amendment 73 to Annex 3, should it be adopted by the ICAO Council, will make one change in that all references to "visibility" will be replaced by "prevailing visibility".

3.2.3 The criteria for including change groups in TAF are defined in Annex 3, paragraph 6.2.5. It was borne in mind that sub-paragraph h) specifies that additional change criteria can be based on local aerodrome operating minima, as agreed between the meteorological authority and the operators.

3.2.4 The group agreed that there is an operational need to harmonize these two sets of criteria and that the Secretary should develop a draft amendment to Annex 3 in time for the AMOSSG/5 Meeting. However, it was pointed out that it is the SPECI criteria that represent the operational requirements and that such a harmonization should involve an amendment of the TAF change criteria in order to match the SPECI.

3.3 **The use of, and definition of the term "vicinity"**

3.3.1 The group recalled that it had been proposed that the term "vicinity" should effectively be deemed to represent all points which lie between 8 km and 16 km from the aerodrome reference point.

3.3.2 At the MET Divisional Meeting (2002) there had been some concern expressed regarding the change to the definition of the term "vicinity", which had been proposed to be redefined in terms of the aerodrome reference point, in that the reference point of an aerodrome did not necessarily represent a suitable location for such a definition at all aerodromes. It had been considered that at some aerodromes the reference point was not situated at a central location within the perimeter of the aerodrome and consequently it was possible that areas 8 km from this point were still considered to be "at the aerodrome". Consequently, further consideration of this definition had been referred back to ICAO by the MET Divisional Meeting (2002), (Recommendation 2/3 e) refers). The Air Navigation Commission, when taking action on this recommendation, had requested that the group develop proposals in time for Amendment 74 to Annex 3.

3.3.3 Two suggested definitions of "vicinity" were presented to the group. Firstly, Kevin (United States) presented an explanation of the definition used for automatic observing systems in the United States ("that area adjacent to the aerodrome that extends from 8 km to not more than 16 km from the aerodrome reference point") and secondly, Dennis (Netherlands) made a proposal for a definition that took the size and shape of the aerodrome into account by defining the concept of an "aerodrome radius" and taking the vicinity as an area encompassing a further 8 km radius. After a lengthy discussion the group agreed that the most appropriate definition would be that used in the United States as was presented to the MET Divisional Meeting (2002) as this definition had the advantage of being very simple and therefore easy for pilots to understand and interpret. It was believed that this definition would be acceptable provided that clear guidance was available to enable human observers to make full use of the definition. To this end it was agreed that the secretary would include an explanation of the definition of the term "vicinity" in the next update of the *Manual of Aeronautical Meteorological Practice* (Doc 8896). Some concerns were raised regarding large aerodromes whereby a distance of 8 km could be considered to be within the aerodrome and it was agreed that the definition should be modified to use the term "approximately 8 km" in order to accommodate such situations. Some concern was also expressed about the difficulty in the observation of certain weather phenomena within the aerodrome and/or its vicinity due to local topography.

3.3.4 The group agreed that the Secretary should prepare a draft amendment to Annex 3 in time for the AMOSSG/5 Meeting taking into account the views expressed by the group.

3.4 **Migration plans for the use of table-driven code forms**

3.4.1 The MET Divisional Meeting (2002), in its Recommendation 2/5 had invited WMO to develop a migration plan concerning the use of table-driven code forms for the dissemination of METAR/SPECI and TAF.

3.4.2 The group noted that the WMO Congress had endorsed the timetable developed by the relevant Commission for Basic Systems (CBS) expert team. This timescale will introduce such codes in two phases. Firstly, that table-driven codes could be used, by those States that wish to do so, in parallel with the traditional alphanumeric codes from 2007 and that the table-driven codes would become fully operational from 2015. The first stage of this plan will necessitate the development of enabling provisions in Annex 3 as a part of Amendment 74. The group agreed that such draft provisions should be developed by the Secretary in time for the AMOSSG/5 Meeting.

3.4.3 The group also noted that an ICAO/WMO ad-hoc group had addressed, in May 2003, several technical issues related to the migration. That group had been assisted by experts in the operation of the aeronautical fixed telecommunication network (AFTN).

3.4.4 Firstly, the introduction of table-driven codes could cause difficulties in some AFTN switching centres, assuming that there will be a period of overlap resulting in the dissemination of such information in parallel with the alphanumeric code forms as some switching centres would not have the capacity to deal with the potential for additional data volumes. Furthermore, AFTN circuits are not able to carry digital codes which implies that the introduction of the BUFR code form needs to be coordinated with the introduction of circuits on which digital data can be disseminated. These circuits will have to be introduced on a regional basis and ultimately between regions. The two-way technology associated with the satellite distribution system for information relating to air navigation (SADIS) 2nd generation system was discussed by the meteorological sub-group (METG) of the European Air Navigation Planning Group (EANPG), as one possible carrier of digital codes, within the SADIS footprint.

3.4.5 Secondly, it had been suggested at the MET Divisional Meeting (2002) that the character form for the representation and exchange of data (CREX) code form could be used during the transition to table-driven codes. Potentially, this would have alleviated the problems concerning the use of digital codes on the AFTN. However, it was noted that the AFTN would also not be able to accommodate the CREX code form owing to the likely length of messages that would be required using this code. Therefore, the ad-hoc group had ruled out the potential use of the CREX code form for aeronautical meteorological codes during the migration.

3.5 Revision of present weather and recent weather requirements and the use of fully automatic observing systems during operational hours

3.5.1 The group recalled that at the AMOSSG/3 Meeting it had been concluded that no changes to the requirements for present weather or recent weather had been necessary at that time. However, the group had agreed that this review should remain on the work programme of the group for further consideration.

3.5.2 The requirement to re-address this task had been emphasized by the MET Divisional Meeting (2002) which, in its Recommendation 2/3 d) had invited ICAO, in consultation with WMO to re-evaluate the requirements for present weather and recent weather taking into account the capacity of automatic systems.

3.5.3 The MET Divisional Meeting (2002) in its Recommendation 2/3 c) had also invited ICAO, in consultation with WMO to study the expansion of the use of fully automatic observing systems to include operational hours including the new concept of “required level of meteorological services”.

3.5.4 The group agreed that in order to facilitate the use of fully automatic observing systems during operational hours, a careful review of the requirements for the reporting of present weather and recent weather would be necessary. It was agreed that a working group would consider these two issues in parallel. The tasks and working arrangements for the working group are contained in **Appendix C** to this report.

3.5.5 The group noted that whilst it was possible to reduce the requirements for the reporting of present weather and recent weather, it may not be possible to limit those requirements such that all of the required elements can be observed by fully automatic equipment.

3.5.6 In order to provide further assistance the group noted that two sets of criteria currently exist in the possible discrimination of international aerodromes which the working group could consider for proposals regarding the use of fully automatic observing systems during operational hours.

3.5.7 Firstly, the definitions of aerodromes with runways designated under the various categories given below for which there are already many examples of separate provisions given in a number of ICAO Annexes:

Non-instrument runway. A runway intended for the operation of aircraft using visual approach procedures.

Instrument runway. One of the following types of runways intended for the operation of aircraft using instrument approach procedures:

a) *Non-precision approach runway.* An instrument runway served by visual aids and a non-visual aid providing at least directional guidance adequate for a straight-in approach.

b) *Precision approach runway, category I.* An instrument runway served by ILS and/or MLS and visual aids intended for operations with a decision height now lower than 60 m (200 ft) and either a visibility not less than 800 m or a runway visual range not less than 550 m.

c) *Precision approach runway, category II.* An instrument runway served by ILS and/or MLS and visual aids intended for operations with a decision height lower than 60 m (200 ft) but not lower than 30 m (100 ft) and a runway visual range not less than 350 m.

d) *Precision approach runway, category III.* An instrument runway served by ILS and/or MLS to and along the surface of the runway and:

   1) intended for operations with a decision height lower than 30 m (100 ft), or no decision height and a runway visual range not less than 200 m;

   2) intended for operations with a decision height lower than 15 m (50 ft), or no decision height and a runway visual range less than 200 m but not less than 50 m; and

   3) intended for operations with no decision height and no runway visual range limitations.

3.5.8 Secondly, there are five categories or aerodromes available for each of the regional plans which are allocated to all international aerodromes (given below):

a) RS - international scheduled air transport, regular use;

b) RNS - international non-scheduled air transport, regular use;

c) RG - international general aviation, regular use;

d) AS - international scheduled air transport, alternate use, and

e) ANS - international non-scheduled air transport, alternate use.

3.5.9 The group noted that the categories listed above are simply used to inform users of the usage of the various aerodromes in States and that no implications are made regarding the technical capabilities that may exist at any particular aerodrome. It was noted that the criteria listed are already used in various provisions within ICAO but that alternative criteria could be considered by the working group, although international consensus would have to be reached concerning the criteria to be used. Furthermore, the group agreed that the working group could attempt to separate purely safety-related weather phenomena from those associated with efficiency and economic considerations. It was noted that the results of the work of the group should be passed to the secretary by the end of 2004 so that a draft amendment to Annex 3 could be produced in time for the AMOSSG/5 Meeting.

3.6 **The use of modern observing techniques including remote sensing**

3.6.1 The group recalled that it had been agreed at the AMOSSG/3 Meeting that a progress report would be provided by Michel (France) on the use of remote sensing techniques for the purpose of improving the generation of automatic aerodrome observations.

3.6.2 Further reports were noted by the group concerning progress made and the potential for remote sensing to provide useful information in the operational environment. The group noted that it was often difficult to use such information directly as inputs to the current aerodrome reports and that it could be used to provide complementary information after consideration of the operational needs of pilots and others involved in aerodrome operations. Brief summaries were given regarding the potential use of radar images, lightning networks, satellite images, wind profilers and lidar and it was noted that lidar data is used for wind shear monitoring in Hong Kong, China. It was suggested that such information could fall into three categories:

a) information used to assist in the production of standard meteorological reports;

b) information used to assist aerodrome operations but not as direct input to aerodrome meteorological reports, and

c) information that could be sent directly to an aircraft in flight.

3.6.3 The group agreed that the potential to use remote sensing to assist in the production of aerodrome meteorological reports was of primary interest to the AMOSSG. This would involve such systems that would be capable of providing direct input to METAR or local reports and would fully comply with the current requirements in Annex 3.

3.6.4 The group noted that it was likely that such techniques could also generate information in a format that would be more directly usable in an operational environment as demonstrated by the use of radar imagery to identify convective activity rather that the presence of CB or TCU clouds as presented by Denis (France), and also taking into account the use of such information by pilots from onboard meteorological radars. It was noted that such complementary products could be considered as potential requirements at future meetings of the group.

3.6.5 The group also noted that any potential products that could be used for uplink to aircraft in flight should be considered by the Meteorological Information Data Link Study Group (METLINKSG).

3.7 **The use of the term “CAVOK”**

3.7.1 The MET Divisional Meeting (2002) in its Recommendation 2/3 a) had invited ICAO, in consultation with WMO to re-evaluate the appropriateness of the use of the term “CAVOK” in meteorological reports and aerodrome forecasts taking into account the requirements of ATS units and users as well as the potential costs of any proposed changes. This had been as a result of suggestions that by using the term “CAVOK” the requirements of some users and States had not been met as cloud information had been required up to 7 600 m (25 000 ft).

3.7.2 The group noted that the Commission had felt that the term “CAVOK” had been in use for many years with no known incidents. Furthermore the Commission had agreed that the high costs involved for many States had cast doubt on the validity of pursuing the matter any further. As a consequence the Commission had agreed that work on this issue should **not** be pursued by this group any further.

3.8 **Update and presentation of cloud base height in ATS units**

3.8.1 The EANPG at its forty-fourth meeting, in its Conclusion 44/16 had identified the need for provisions in Annex 3 to cater for the update and presentation of cloud base height in air traffic services (ATS) units. The Commission had taken action on this conclusion by referring the issue to this group for resolution.

3.8.2 Amendment 72 to Annex 3 had upgraded paragraph 4.1.8 to a Standard which now requires that surface wind, runway visual range (RVR) and the height of cloud base shall be assessed or measured by an integrated automatic observing system at aerodromes with runways intended for Category II and III instrument approach and landing operations. Provisions already exist in Annex 3 for the display of such information relating to surface wind (Section 4.5) and RVR (Section 4.7) in ATS units whereas no provisions exist for the display of information relating to the height of cloud base.

3.8.3 The group agreed that there is a need to develop provisions in Annex 3 relating to the display of the height of cloud base in ATS units and that the Secretary should develop a draft amendment to Annex 3 in time for the AMOSSG/5 Meeting.

3.9 **The attainable accuracy of observation or measurement**

3.9.1 The Air Navigation Commission (ANC) had instructed the Secretariat to invite the World Meteorological Organization (WMO) to update the attainable accuracy of observation or measurement as given in Attachment B to Annex 3.

3.9.2 A report was presented by Saad (WMO) on the progress being made by WMO on this issue. Initial discussions had led to a set of proposed levels of accuracy that could be obtained although final approval was still awaited from the relevant WMO constituent bodies.

3.10 **The use of the descriptor “FZ”**

3.10.1 The group noted that some difficulties had been experienced by the fact that it is not permitted to differentiate between widespread fog and fog forming in patches, shallow fog and fog banks when the temperature is below 0E Celsius and the “FZ” descriptor is required. It had been noted that operations were limited on occasions when patches of freezing fog were being encoded as FZFG which would indicate that freezing fog was affecting the entire aerodrome.

3.10.2 The group agreed that Henry (IATA) should seek the views of IATA regarding the requirement for a potential change to Annex 3 that would allow the use of the descriptor “FZ” in conjunction with the descriptors “MI”, “PR” and “BC”. It was also agreed that IATA should include the possibility of combining the descriptor “FZ” with mist (“BR”). It was noted that such a change would increase the requirements for the reporting of present weather which should not be undertaken without a solid operational requirement although it was also stated that these particular proposals could be fulfilled by fully automatic observing equipment.

3.10.3 A further issue was raised regarding the reporting of fog and the assessment of visibility that should be used in order to determine whether fog should be reported. It was suggested that it was unclear whether meteorological optical range (MOR) should be used or the new concept of aeronautical visibility which took into account the runway lightning conditions. It was confirmed that it should be the aeronautical visibility that should govern whether fog is reported and the group agreed that the secretary make appropriate amendments to the *Manual of Runway Visual Range Observing and Reporting Practices* (Doc 9328) and to the *Manual of Aeronautical Meteorological Practice* (Doc 8896) to ensure that no confusion existed.

3.11 **The encoding of runway visual range (RVR)**

3.11.1 The group noted that the reporting scales for RVR in WMO No 306, *Manual on Codes* were not consistent with Annex 3. This had been due to an oversight following the Amendment 72 to Annex 3. The group agreed that WMO should be invited to align WMO No 306, *Manual on Codes* as appropriate.

3.12 **Agreed action by the group**

3.12.1 The group agreed that the following actions should be taken in time for the AMOSSG/5 Meeting;

a) the **secretary** to develop a draft amendment to Annex 3 in order to harmonize the TAF change criteria with SPECI criteria;

b) the **secretary** to develop a draft amendment to Annex 3 in order to provide a definition of an aerodrome vicinity based on the one used in the United States and to provide an explanation of the definition in the *Manual of Aeronautical Meteorological Practice* (Doc 8896);

c) the **secretary** to develop draft enabling provisions in Annex 3 for the dissemination of METAR/SPECI and TAF in the BUFR code form;

d) a **working group** to consider whether any changes should be made to the requirements for the reporting of present weather and/or recent weather and to establish a framework for the use of fully automatic observing systems during operational hours based on criteria such as the runway categories and based on those studies, and upon the completion of the work, to task the secretary to develop a draft amendment to Annex 3 to accommodate the use of fully automatic observing systems during operational hours, and

e) the **secretary** to develop a draft amendment to Annex 3 for the display of the height of cloud base in ATS units in time for the AMOSSG/5 Meeting.

f) **Henry** to arrange for IATA to assess the operational requirement for the use of the descriptor “FZ” in conjunction with “MI”, “PR”, “BC”, and “BR”;

g) the **secretary** to make appropriate amendments to the *Manual of Runway Visual Range Observing and Reporting Practices* (Doc 9328) and the *Manual of Aeronautical*

Meteorological Practice (Doc 8896) to clarify the reporting of fog using aeronautical visibility, and

h) **ICAO** to invite WMO to align the WMO No 306, *Manual on Codes* with Annex 3 concerning the reporting increments of RVR.

4. AGENDA ITEM 6: CAPABILITY OF AUTOMATIC OBSERVING EQUIPMENT TO MEET AERONAUTICAL REQUIREMENTS

4.1 Assessment of the capability of automatic weather stations to meet the future requirements

4.1.1 The group recalled that no new developments had been reported at the AMOSSG/3 Meeting and, as a consequence, no proposals had been made regarding Amendment 73 to Annex 3 in connection with the ability of fully automatic observing systems meeting the aeronautical requirements. It had been agreed that whilst substantial progress had been made in the area of automation, further effort would be required before fully automatic systems could be used in lieu of human observers.

4.1.2 A brief overview of the status that had been agreed at the AMOSSG/4 Meeting is given below:

Temperature, dew point temperature, wind, atmospheric pressure, runway visual range (RVR)

4.1.3 It was agreed that temperature, dew point temperature, wind, atmospheric pressure and RVR could be observed, or assessed using fully automatic equipment in order to meet the aeronautical requirements.

Visibility

4.1.4 It was agreed that visibility could be observed using fully automatic observing equipment so as to meet the current aeronautical requirements. However, the group noted that additional guidance was required in the proposed manual being developed by the Secretariat on the use of automatic observing systems in the light of draft Amendment 73 to Annex 3 which calls for the use of prevailing visibility in aerodrome reports.

Cloud amount and height of cloud base

4.1.5 The group agreed that cloud amount and the height of cloud base could be assessed by fully automatic equipment despite a limited number of problems under certain circumstances such as the onset or cessation of cloud sheets crossing an aerodrome. The group felt that these issues were being addressed and that they could be regarded as minor difficulties bearing in mind the traditional difficulties experienced by human observers in observing cloud during the hours of darkness. The group noted that some work was still required concerning the harmonization of the techniques used to develop algorithms for the automatic evaluation of cloud amount and the height of cloud base but that this work did not affect the ability of such systems to meet the aeronautical requirements.

4.1.6 The group recalled that the MET Divisional Meeting (2002) (Recommendation 2/4 refers) had invited WMO to study the possibility of producing standard algorithms for cloud amount as well as the height of cloud base. It was noted that an CIMO expert team of WMO had been given the task of investigating the harmonization of algorithms for evaluating cloud amount and that it had been estimated that results from the study would be available in two or three years. It was hoped that a similar study would be accepted by a CIMO expert team in the near future to investigate the algorithms for evaluating the height of cloud base. Whilst it was understood that the sentiment of this group would not affect the CIMO efforts, a number of members stated that they believed that the development of cloud amount and height of cloud base algorithms should be left to the suppliers of sensors and automatic meteorological observing systems. Despite the lack of standardized algorithms, many States have been using quite similar algorithms based on ceilometer data over a given period of time, to calculate cloud amount and the height of cloud base. The group reported the general satisfaction of users with such products, over recent years.

Cloud type (CB, TCU)

4.1.7 The group agreed that it was not possible to detect the presence of CB and/or TCU directly using fully automated equipment and that it was unlikely that such direct observation would be possible in the future. However, it was noted that consideration should be given to other methods such as the detection of convective activity using remote sensing (paragraph 3.6.4 refers). It was noted that automated reporting of lightning and convective activity may obviate the need to report CB and TCU in the future.

Present and recent weather

4.1.8 The group agreed that it was not currently possible to observe all of the present and recent weather phenomena.

Summary

4.1.9 The group agreed that progress was being made in the ability of automatic observing systems to meet the full aeronautical requirements for all meteorological elements except for present and recent weather. The introduction of remote sensing such as lightning detection and weather radar were noted to have been effective in addressing previous concerns. It was also noted that several States including Australia, Canada, Finland, France and the United States already use fully automatic observing systems during operational hours at some aerodromes, and these States use fully automatic observing systems to support aerodrome forecast (TAF) production. However, it was agreed that the Annex 3 requirements for present weather cannot currently be fully met by automation. As a result, the group cannot conclude that automation meets the aviation requirements until and unless present and recent weather requirements are revised in line with the capabilities of automation unless there are future technical developments in this area.

4.2 **Automatic weather station networks**

4.2.1 The group noted a report by Bryan indicating that in certain, often remote, areas there was a need for additional meteorological observations in order to meet the aeronautical requirements. It was noted that this would not necessarily mean that "full" observations were required at these additional sites. However, the strategic location of specific automatic sensors at a considerable distance from the aerodrome could assist in en route weather related decision-making and aviation weather watch functions.

4.3 **Agreed action by the group**

4.3.1 The group agreed that the following action should be taken in time for the AMOSSG/5 Meeting;

a) the **secretary** to merge the tasks considering "the automatic detection of cloud type" and assessing "the overall capabilities of automatic observing systems in meeting the aeronautical requirements" in the work programme of the group.

5. AGENDA ITEM 7: AERODROME FORECAST REQUIREMENTS

5.1 Review of the forecast accuracy requirements

5.1.1 The Air Navigation Commission had taken action on a proposal made by WMO to update the forecast accuracy requirements currently given in Attachment E to Annex 3.

5.1.2 The group noted that Amendment 73 to Annex 3, (still subject to adoption by the ICAO Council), will make minor editorial adjustments to the titles of Attachment E. However, the meteorological content of the attachment, which will become Attachment B, will remain unchanged through Amendment 73.

5.1.3 The group noted a report presented by Henry that indicated a draft amendment to Attachment E to Annex 3 which is at **Appendix D** to this report. It was pointed out that a request had been made by WMO to consider changing the format of this attachment in order to facilitate the TAF verification process that was being developed by WMO. It was not clear to the group how the format should be changed; therefore, it agreed that WMO should be invited to provide additional information on the format that would take the verification scheme into account and that a review of the attachment could then take place bearing in mind the figures for the desirable accuracy for forecasts that had been produced by IATA. The group also agreed that the elements concerning route forecasts and area forecasts should be sent to the World Area Forecast System Operations Group (WAFSOPSG) for its consideration.

5.2 The operational feasibility and desirability of requiring a greater accuracy in the first three hours of a TAF

5.2.1 The Commission had taken action on a proposal to study the operational feasibility and desirability of requiring a greater accuracy in the first three hours of a TAF. This matter had been referred to the group for consideration with the view that this could be achieved by, *inter alia* removing the use of the term "PROB" from the forecast during the first three hours or by introducing a more flexible update frequency.

5.2.2 After some discussion the group agreed that further clarification was required and that the members should seek the views of the operators in their respective States. It had been unclear whether is was the use of the PROB statement in general that was causing difficulty or whether it was the overuse of the PROB statement that had been noted in some States. The group agreed that the members would provide reports as necessary for the AMOSSG/5 Meeting.

5.3 Monitoring the development of techniques for forecasting runway visual range (RVR)

5.3.1 A longstanding task of the ICAO Secretariat is to monitor the development of techniques for forecasting RVR which had been originally formulated at the COM/MET/82 Divisional Meeting. This issue had been studied more recently by the MET/AOP PT in the EUR Region although it had concluded that no satisfactory techniques exist at present and the study had been held in abeyance pending any further progress made by States.

5.3.2 The group noted that no progress was known of beyond that being progressed in the EUR Region and agreed that any progress would continue to be monitored by the group. It was noted that RVR and visibility have a theoretical link due to their definitions. One point of concern was raised in that the requirement for forecasts of aeronautical visibility rather than MOR could cause confusion as the difference may not be obvious to a forecaster.

5.4 TAF validity periods

5.4.1 The group noted a report by Henry indicating that the increasing length of flights was leading to some difficulties when aerodrome forecast information was not available for the scheduled arrival time. This was leading to fuel penalties and an unnecessary cost burden on the airlines. A proposed solution was to issue 24-hour TAFs but with a lead time of 6 hours. However some members of the group felt that it would be more appropriate to issue a 30-hour forecast without including a lead time for the forecast.

5.4.2 It was noted that the production of a 30-hour TAF would cause some difficulties concerning both the coding of the validity time of the TAF and the time change groups within the TAF as these could give rise to ambiguity given that a particular time could appear twice within the validity period of the forecast. The group agreed that the secretary should provide a draft amendment to Annex 3, including changes to the TAF forecast template, in time for the AMOSSG/5 Meeting and that subsequently WMO should be invited to address the code changes that would be required. It was also noted that the precise issuance times for TAF are agreed through the regional air navigation agreements and that these should be adjusted accordingly.

5.5 Agreed action by the group

5.5.1 The group agreed that the following action should be taken in time for the AMOSSG/5 Meeting:

a) **Saad** to arrange for WMO to provide guidance on the format for Attachment E to Annex 3 that would accommodate the TAF verification scheme being developed by WMO;

b) the **secretary** to refer proposals for the updating of Attachment E to Annex 3 relating to en-route forecasts to the WAFSOPSG for consideration;

c) the **members** to provide reports on the use of the PROB and whether difficulties had been encountered through its overuse which would lead to a requirement to remove the use of PROB in the first 3 hours of TAF, and

d) the **secretary** to provide a draft amendment to Annex 3 to allow for the introduction of 30-hour TAF.

6. AGENDA ITEM 8: GUIDANCE MATERIAL

6.1 Following the MET Divisional Meeting (2002) arrangements had been made for a draft version of the new manual on the use of automatic observing systems to be developed by Michel.

6.2 The group was pleased to note the draft manual that had been produced by Michel and expressed their gratitude for his endeavours.

6.3 The group studied the general format and structure of the draft manual and agreed that, owing to the extensive nature of the document that it would be more appropriate to allow some time for the members of the group to provide detailed comments so that the secretary could incorporate any changes as appropriate. It was agreed that the secretary would circulate a soft copy of the draft manual to all members and advisors to the meeting and that replies would be given in red-line/strike-out format using either Word Perfect or Word by 30 October 2003. It was also agreed that whilst Michel had been able to provide examples of the methodology and algorithms used in certain cases it would be appropriate for other members of the group to submit similar material that could be included as appendices to the manual.

6.4 It was agreed that no detailed comments would be provided at the meeting. The draft manual is given as **Appendix E** to this report.

6.5 **Agreed action by the group**

6.5.1 The group agreed the following actions:

a) **all members** to review the draft manual on automatic observing systems and provide suggested amendments in red-line/strike-out format by 30 October 2003, and

b) the **secretary** to edit and compile the manual for circulation and final comment as soon as practicable.

7. AGENDA ITEM 9: FUTURE WORK PROGRAMME

7.1 The group recalled that the work programme had been updated following the MET Divisional Meeting (2002) and further updated the programme taking into account the discussions of the meeting.

7.2 The updated work programme is given at **Appendix F** to this summary of discussions.

8. AGENDA ITEM 10: ANY OTHER BUSINESS

8.1 The group noted that the EANPG at its forty-fourth meeting, in its Conclusion 44/17 had invited ICAO to study the need for guidance material concerning the calculation of cross wind and tail wind components for take-off and landing operations and in particular in cases where gusts are reported. The Commission had expressed the view that the straightforward calculation of these components had been routinely performed for many years (for mean winds) with no apparent difficulties. The Commission had therefore referred the issue of guidance material relating to such calculation in the situation where gusts are reported to the AMOSSG for consideration.

8.2 It was noted that the Operations Panel (OPSP) which was meeting concurrently with the AMOSSG had also discussed a similar issue and that proposals were in preparation for related issues to be referred to the AMOSSG for consideration. The group agreed that the secretary would keep the group informed regarding the outcome of the OPSP Meeting and that Dennis would prepare a study note as appropriate for the AMOSSG/5 Meeting.

8.3 The group agreed that there was a need for the group to continue its work owing to the extensive nature of the tasks being addressed. It was agreed that the next meeting of the group would take place during the second quarter of 2005 for planning purposes. The current ICAO policy is to hold all study group meeting at the ICAO headquarters in Montreal although a strong request was made by Bryan, and strongly supported by the group, to hold the meeting in Australia, citing himself as the only representative on the group from the southern hemisphere.

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APPENDIX A

LIST OF PARTICIPANTS

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APPENDIX B

LIST OF DOCUMENTATION

Doc No.	Number of pages	Presented by	Title	Agenda Item
SN 01	4	Secretary	Provisional agenda	4
SN 02	8	Secretary	Overview of past and expected progress with respect to aerodrome observation requirements	5
SN 03	3	Secretary	Overview of past and expected progress with respect to assessments of the capability of automatic observing equipment to meet aeronautical requirements	6
SN 04	2	Secretary	Overview of past and expected progress with respect to aerodrome forecast requirements	7
SN 05	72	Secretary	Draft version of a manual on the use of automatic observing systems	8
SN 06	4	Secretary	Updating the future work programme of the group	9
SN 07	4	P. Woveris	Operationally desirable accuracy of forecasts	7
SN 08	4	M. Leroy	Use of remote sensing techniques	5.1
SN 09	3	K. Browne	Provide a more accurate definition of “aerodrome” and “vicinity” for reporting of routine and special observations	5
SN 10	4	P. Woveris	TAF validity periods and issuance times	7
SN 11	4	D. Hart	Additional regulation with respect to the FM 15 METAR, FM 16 SPECI and FM 51 TAF code, regarding the descriptor “freezing” (FZ) in cases of fog (FG) at an aerodrome	5.1

Doc No.	Number of pages	Presented by	Title	Agenda Item
SN 12	**3**	**D. Hart**	**Harmonization between WMO and ICAO regulations, with respect to the FM 15 METAR and FM 16 SPECI code, regarding the encoding of runway visual range**	**5.1**
SN 13	**9**	**D. Hart**	**Definition of "aerodrome" and "vicinity"**	**5.1**
SN 14	**9**	**S. Benarafa**	**Capability of automatic observing equipment to meet aeronautical requirements**	**5**
SN 15	**3**	**B. Boase**	**Automatic weather station networks**	**6**
SN 16	**8**	**M. Leroy**	**Convective activity detection (TCU & CB) using radar imagery and its coding in auto METAR: preliminary assessment**	**5.3**
SN 17	**2**	**B. Okossi**	**Harmonization of SPECI criteria with TAF change criteria and removing the term "PROB" in the TAF during the first 3 hours**	**5.1** **7**
SN 18	**2**	**B. Boase**	**Operationally desirable accuracy of forecasts**	**7**
IP 01	**1**	**Secretary**	**Working arrangements for the meeting**	**3**

PART II — LIST OF DOCUMENTATION IN ORDER OF AGENDA ITEM

Agenda Item	Doc No.
3	IP 01
4	SN 01
5	SN 02, SN 08, SN 09, SN 11, SN 12, SN 13, SN 14, SN 16, SN 17
6	SN 03, SN 15
7	SN 04, SN 07, SN 10, SN 17, SN 18
8	SN 05
9	SN 06

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APPENDIX C

TASKS FOR THE WORKING GROUP ON AERODROME OBSERVATION REQUIREMENTS AND THE USE OF AUTOMATIC OBSERVING EQUIPMENT DURING OPERATIONAL HOURS

1. TASKS

a) to consider whether any changes should be made to the requirements for the reporting of present and/or recent weather bearing in mind the METAR is required to support flight-planning; and

b) to establish a framework for the use of fully automatic observing systems during operational hours based on criteria such as the runway categories.

Note 1.— Upon the completion of the work, the secretary will develop a draft amendment to Annex 3 to accommodate the use of fully automatic observing systems during operational hours.

Note 2.— The reporting requirements could be extended to cover all of the current observation requirements, which cannot currently be observed by fully automatic systems.

Note 3.— Any criteria for defining aerodrome categories must be agreed internationally.

2. WORKING ARRANGEMENTS

2.1 It is expected that the working group will work by correspondence and would complete its tasks by the end of December 2004.

2.2 The members of the working group will be Bryan (Australia), Bill (Canada), Cho-Ming (Hong Kong, China), Ossi (Finland), Michel (France), Dennis (Netherlands), Andy (United Kingdom), Steve (United States), Benoit (ASECNA) and Saad (WMO), and nominations will be sought from the International Air Transport Association (IATA) and International Federation of Air Line Pilots' Associations (IFALPA). The rapporteur for the group will be Steve who will be expected to coordinate the work of the group. The secretary will provide guidance as required.

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APPENDIX D

ATTACHMENT E TO ANNEX 3 — *METEOROLOGICAL SERVICE FOR INTERNATIONAL AIR NAVIGATION*

Note 1.— The guidance contained in this table relates to Chapter 6 — Forecasts, in particular to 6.1.1.

Note 2.— If the accuracy of the forecasts remains within the operationally desirable range shown in the second column, for the percentage of cases indicated in the third column, the effect of forecast errors is not considered serious in comparison with the effects of navigational errors and of other operational uncertainties.

Element to be forecast	*Operationally desirable accuracy of forecasts*	*Minimum percentage of cases within range*
	AERODROME FORECAST (TAF)	
Wind direction	± ~~3~~20°	80% of cases
Wind speed	± 9 km/h (5 kt) ~~up to 46 km/h (25 kt)~~ ~~± 20% above 46 km/h (25 kt)~~	80% of cases
Visibility	± 200 m up to ~~7~~800 m ± 30% between ~~7~~800 m and 10 km	80% of cases
Precipitation	Occurrence or non-occurrence	80% of cases
Cloud amount	~~± 2 oktas~~One category below 450 m (1 500 ft) Occurrence or non-occurrence of BKN or OVC between 450 m (1 500 ft) and 3 000 m (10 000 ft)	70% of cases
Cloud height	± 30 m (100 ft) up to ~~120~~300 m (~~4~~1 000 ft) ± 30% between ~~120~~300 m (~~4~~1 000 ft) and 3 000 m (10 000 ft)	70% of cases
Air temperature	± 1°C	70% of cases
	LANDING FORECAST	
Wind direction	± ~~3~~20°	90% of cases
Wind speed	± 9 km/h (5 kt) ~~up to 46 km/h (25 kt)~~ ~~± 20% above 46 km/h (25 kt)~~	90% of cases
Visibility	± 200 m up to ~~7~~800 m ± 30% between ~~7~~800 m and 10 km	90% of cases
Precipitation	Occurrence or non-occurrence	90% of cases
Cloud amount	~~± 2 oktas~~One category below 450 m (1 500 ft) ~~± 30% between 700 m and 10 km~~Occurence or non-occurrence of BKN or OVC between 450 m (1 500 ft) and 3 000 m (10 000 ft)	90% of cases
Cloud height	± 30 m (100 ft) up to ~~120~~300 m (~~4~~1 000 ft) ± 30% between ~~120~~300 m (~~4~~1 000 ft) and 3 000 m (10 000 ft)	90% of cases
	FORECAST FOR TAKE-OFF	
Wind direction	± ~~3~~20°	90% of cases
Wind speed	± 9 km/h (5 kt) up to 46 km/h (25 kt) ± 20% above 46 km/h (25 kt)	90% of cases
Air temperature	± 1°C	90% of cases
Pressure value (QNH)	± 1 hPa	90% of cases
	AREA, FLIGHT AND ROUTE FORECASTS	
Upper-air temperature	± ~~3~~2°C (Mean for 900 km~~/500 NM~~ (500 NM))	90% of cases
Relative humidity	± 30%	90% of cases

Upper wind	± 28 km/h (15 kt) ~~up to flight level 250~~ ~~± 37 km/h (20 kt) above flight level 250~~ (Modulus of vector difference for 900 km~~/500 NM~~(500 NM))	90% of cases
Significant en-route weather phenomena and cloud	Occurrence or non-occurrence	80% of cases
	Location: ± 100 km~~/60 NM~~ (60 NM)	70% of cases
	Vertical extent: ± 600 m~~/2 000 ft~~ (2 000 ft)	70% of cases
	Tropopause height: ± 300 m (1 000 ft)	80% of cases
	Max wind level: ± 300 m (1 000 ft)	80% of cases

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APPENDIX E

DRAFT AMOSSG MANUAL

Chapter 1

INTRODUCTION

1.1 This manual is a technical guide created to help design or update automatic measurement systems for airports and understand the characteristics and limits of such systems. The manual also deals with performance control and maintenance, as well as with maintaining the optimum operating conditions.

1.2 The chapters in this manual are organized according to parameter type and are presented in the same order as Annex 3, Chapter 4.

1.3 As far as possible, each chapter corresponding to a parameter type follows this structure:

Introduction and use:

— measurement methods;

— algorithms;

— parameter variability;

— sources of error;

— calibration and maintenance; and

— sensor locations.

1.4 Paragraphs in each chapter are basically elaborated according to the parameter and the information that is deemed to be useful. The objective of this manual is not to describe all possible measurement methods. Document No. 8 of the WMO, also called the "CIMO guide" (Commission for Instruments and Methods of Observation), describes these methods in detail and is regularly updated by the WMO. This manual therefore takes this guide into account, and describes only the aspects that are useful or specific to the field of aeronautical meteorology.

1.5 There also exists the "Manual of Runway Visual Range Observing and Reporting Practices" (Doc 9328), which describes all aspects related to RVR and, to a large extent, visibility. This manual therefore does not go into detail about elements already dealt with in Doc 9328.

1.6 The automatic observation of clouds and present weather is a new area of study and cannot yet meet all the needs expressed in Annex 3. Especially where software is concerned, the system architects are sometimes the only ones in this growing field with the relevant know-how. The algorithms are constantly evolving, making it difficult to standardize them at the present time. This manual therefore indicates the basic principles, and cannot be complete.

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Chapter 2

DEFINITIONS

Air temperature. The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.

Allard's law. An equation relating illuminance (E) produced by a point source of light of intensity (I) on a plane normal to the line of sight, at distance (x) from the source, in an atmosphere having a transmissivity (T).

Atmospheric pressure. Pressure (force per unit area) exerted by the atmosphere on any surface by virtue of its weight; it is equivalent to the weight of a vertical column of air extending above a surface of unit area to the outer limit of the atmosphere.

Ceilometer. Instrument for measuring the height of the base of a cloud layer, with or without a recording device.

Cloud amount. The fraction of the sky covered by the clouds of a certain genus, species, variety, layer, or combination of clouds.

Cloud base. The lowest level of a cloud or cloud layer.

Convective cloud. Cumuliform cloud which forms in an atmospheric layer made unstable by heating at the base or cooling at the top.

Dedicated display. A display connected to a sensor, designed to provide a direct visualization of the operational variables.

Dew-point temperature. Temperature to which a volume of air must be cooled at constant pressure and constant moisture in order to reach saturation; any further cooling causes condensation.

Disdrometer. Device used for catching the drops of liquid hydrometeors and for measuring the distribution of their diameters.

Extinction coefficient. The proportion of luminous flux lost by a collimated beam, emitted by a incandescent source at a colour temperature of 2 700 K, while travelling the length of a unit distance in the atmosphere (per metre, m-1).

Geographic Wind Direction. Direction from which the wind blows, measured clockwise from geographical north.

Koschmieder's law. A relationship between the apparent luminance contrast (Cx) of an object, seen against the horizon sky by a distant observer, and its inherent luminance contrast (C0), i.e. the luminance contrast that the object would have against the horizon when seen from very short range.

Light Detection and Ranging (LIDAR). Method for investigating atmospheric behaviour using pulsed light beams (laser).

Lightning detection network. Network of local lightning detectors transmitting in real time to a central computer, localizing lightning flashes by combining information received from each detector.

Luminance (photometric brightness) (L). The luminous intensity of any surface in a given direction per unit of projected area (candela per square metre, cd/m2).

Luminance intensity (I). The luminous flux per unit solid angle (candela, cd).

Magnetic wind direction. Direction from which the wind blows, measured clockwise from magnetic north.

Meteorological optical range (MOR). The length of the path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp, at a colour temperature of 2 700 K, to 0.05 of its original value, the luminous flux being evaluated by means of the photometric luminosity function of the International Commission on Illumination (CIE) (metre (m) or kilometre (km)).
Note – The relationship between meteorological optical range and extinction coefficient (at the contrast threshold of $\varepsilon = 0.05$) using Koschmieder's law is : MOR = $\text{In}(0.05)/\sigma \approx 3/\sigma$. MOR = visibility under certain conditions (see below).

Precipitation intensity. Amount of precipitation collected per unit time interval.

Present weather. Weather existing at a station at the time of observation; it is represented by a set of keyword.

Present weather sensor. Sensor measuring physical parameters of the atmosphere and calculating a limited set of present weather codes, always including present weather codes related to precipitation.

Prevailing visibility. The visibility value, observed in accordance with the definition of "visibility", which is reached or exceeded within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.
Note: — This value may be assessed by human observation and/or instrumented systems. When instruments are installed, they are used to obtain the best estimate of the prevailing visibility.

QFE. Pressure value at an elevation corresponding to the official elevation of the aerodrome.

QNH. Pressure value at which an aircraft altimeter is set so that it will indicate the official elevation of the aerodrome when the aircraft is on the ground at that location. QNH is calculated using the value for QFE and the pressure altitude relationship of the ICAO standard atmosphere.

Runway visual range (RVR). The range over which the pilot of an aircraft on the centre line on a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.

Scatter meter. An instrument for estimating extinction coefficient by measuring the flux scattered from a light beam by particles present in the atmosphere.

Sodar. Sound detection and ranging.

Surface wind. Wind blowing near the Earth's surface. It is measured, by convention, at a height of 10 m above ground in an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstruction.

Thermometer screen. Structure to protect certain instruments from radiation and weather while at the same time ensuring sufficient ventilation.

Transmissivity (or transmission coefficient) (T). The fraction of luminous flux which remains in a beam after traversing an optical path of a unit distance in the atmosphere (dimensionless).

Transmissometer. Instrument which indicates visibility by measuring the transmission or extinction of a beam of light over a fixed distance. (that takes a direct measurement of the transmittance between two points in space, i.e. over a specified path length or base line).

Transmittance (tb). Transmissivity within an optical path of a given length b in the atmosphere (dimensionless).

Visibility. Visibility for aeronautical purposes is the greater of :

a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; and

b) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.

Note: —The two distances have different values in air of a given extinction coefficient, and the latter b) varies with the background illumination. The former a) is represented by the meteorological optical range (MOR).

Visual threshold of illumination (Er). The smallest illumence required by the eye to make a small light source visible (lux, lx).

Weather radar. An adaptation of radar for meteorological purposes. The scattering of electromagnetic waves, at wavelengths of a few millimetres to several centimetres, by raindrops and cloud drops is used to determine the distance, size, shape, location, motion, phase (liquid and solid), as well as the intensity of the precipitation. Another application is in the detection of clear-air phenomena through scattering by insects, birds, etc. and fluctuation of the refractive index.

Wind profiler radar or sodar .Designed for measuring wind profiles.

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Chapter 3

WIND

3.1 INTRODUCTION

3.1.1 Wind has a direct impact on aircraft. The direction of prevailing winds determines the runway's centre line and direction of travel. Cross winds force the pilot to compensate for the drift.

3.1.2 An important characteristic of wind is its temporal and spatial variability, which hinders the pilot and can sometimes be dangerous. Temporal variability made it necessary to define multiple parameters related to wind: mean, minimum and maximum values. Spatial variability is mostly related to temporal variability, and can, for example, lead to a relative movement of gusts (like ripples on a body of water). It can also be related to terrain effects of the aerodrome or its surroundings, or to the presence of obstacles. This is why Annex 3 recommends that wind observations be representative of the touchdown zone (for arriving aircraft) and of conditions along the runway (for departing aircraft), which sometimes leads to the installation of multiple sensors.

3.1.3 The recommended measurement height (10 m) is a compromise between being high enough to avoid the effects of obstacles on the ground and an installation height that is practical and safe for aircraft. A height of 10 m is recommended by the WMO and makes various measurements comparable.

3.2 MEASUREMENT METHODS

3.2.1 A few methods for measuring wind by remote sensing still exist: lidar, wind profilers (SODAR, UHF radars). A lidar works only in clear atmospheric conditions. The airport's acoustic environment can have a negative impact on a SODAR. A UHF wind profiler radar cannot measure the lowest layers of wind. So some remote sensing systems have selective uses, linked to certain sites or needs (e.g, the windshear detection), but they are not used these days; they are also very expensive.

3.2.2 Wind measurements are therefore taken on site using anemometers. The most common are cup or propeller anemometers, whose rotating speed is relatively in sync with the wind speed; they are associated with wind vanes. The characteristics of such instruments are well defined in document WMO No. 8. For these instruments, the time constant is equal to the distance constant, a characteristic of the anemometer, divided by the wind speed. For a classic distance constant of 5 m, the time constant for a speed of 20 kt is 0.5 seconds. Extreme wind speed values calculated over 3 seconds, as recommended by the WMO, can therefore be measured without any problems with a cup or propeller anemometer.

3.2.3 There are also static hot-film sensors and ultrasonic sensors. There are more and more ultrasonic anemometers on the market; their advantage is that they do not have moving mechanical parts, but are more technically complex, and can de-ice themselves better than most rotating sensors. Ultrasonic sensors also have a short time constant and are able to provide many measurement samples per second. It is important to integrate these measurements over a 3-second period for speed and direction extremes to keep these extreme values from depending on the sampling rate of measurements.

3.3 ALGORITHMS

3.3.1 Mean speed values

3.3.1.1 There are several methods of calculating mean wind speed. At each instant, a wind vector is available and characterized by its speed and direction.

3.3.1.2 It is possible to calculate the mean wind vector over a given period by calculating the mean of the North/South and East/West components of each instantaneous wind vector, and extracting the speed and direction of this mean wind vector. This type of calculation might seem logical given the nature of the information (a vector), but it does have some disadvantages:

— it depends on the actual availability of direction. If a wind vane breaks down when using an anemometer, the “wind force” parameter is no longer available;

— mathematically, it can lead to a zero mean wind vector, although there are non-zero instantaneous wind vectors, as a result of a wind change. This case is however theoretical, especially since such a change in wind can result in a marked discontinuity if the wind speed is high enough. Nevertheless, a reduction in the mean wind vector is possible if there is a change in direction with light winds; and

— this is not the same method of calculation used in the past, when electronic equipment for calculating vectors did not exist. A temporal integration was done on the modulus of instantaneous wind with recorders.

3.3.1.3 It is also possible to calculate separately the mean wind speed using only the instantaneous speed by calculating the mean modulus of instantaneous wind vectors. This method has several advantages:

— it does not require the direction, and a breakdown of the wind vane does not result in the absence of calculated speed parameters;

— it is easier to implement; and

— it is closer to calculation techniques used in the past.

Its disadvantage is that it gives a mean wind vector that is different from the vector mean of instantaneous winds.

3.3.1.4 The ICAO and WMO have not yet provided recommendations on the calculation method, probably since both practices are used throughout the world and a vector calculation would cause problems in several areas. With modern systems, vector calculations are not a problem, especially since they are required for the mean direction. Differences in results between both calculations are minimal when there are few changes in wind direction, but differences are greater when there are significant changes in direction. If the speed is over 10 kt, there is marked discontinuity. If the speed is less than that, the differences (in absolute values) between both methods remain minimal.

3.3.2 Mean direction values

3.3.2.1 Similarly, the calculation can be vector or scalar (direct mean of directions), but the scalar mean of directions poses a major disadvantage in relation to the discontinuity of directions between 360° and 10°. Of course, the mean of directions varying between 360° and 10° must not be 180°. It is still possible to avoid this problem by introducing a drift in the directions, for example by considering a direction of 370° rather than 10°, but applying such a drift that depends on effectively measured directions, can be difficult and can cause errors in certain conditions. This method of calculation is therefore not recommended.

3.3.2.2 It is much better to perform a vector calculation, which can be done using two methods:

— by calculating the mean wind vector and its direction; and

— by calculating the mean wind vector using the instantaneous vectors of a unit modulus and the direction equal to the measured direction. This method of calculation is somewhat simpler than calculating the actual mean wind vector. Unless there are significant variations in wind speed, it gives equivalent results, while significant variations in wind speed produce marked discontinuity.

3.3.3 Calculating a mean value

3.3.3.1 Whether the calculation is vector or scalar, the term "mean" should be understood as an arithmetic mean over the given time period. The minimal calculation periodicity depends on the period. There are several periods.

3.3.4 Calculating extreme values

3.3.4.1 Annex 3 and the WMO recommend that extreme force and direction values be calculated over a 3-second period. The WMO recommends that these values be calculated using measurement samples available every 250 ms; however, it may be acceptable to calculate these values using measurement samples available at least every second. The calculation should be made as the primary samples become available (e.g. every 250 ms, or at least every second); it should not be made every 3 seconds over a 3-second period, since the calculation would then depend on the calculation time window for wind speed fluctuations, which can be faster than this 3-second period.

3.3.4.2 It is also important for the instantaneous measurement used to be representative of the entire period separating two measurements. If this period is 500 ms, the measurement should be representative of the wind during these 500 ms. This is usually the case with rotating anemometers, whose measurement system counts the number of turns in a given period, which may not be the case for sensors with a faster pace of measurement.

3.3.5 Calculating mean values over 2 and 10'

3.3.5.1 These mean values may be calculated only every minute, at the same pace local reports are updated. For local reports, the calculation period is 2'. For METAR/SPECI messages, the calculation period is usually 10', but it can be less in cases of marked discontinuity.

3.3.6 Marked discontinuity (MD) algorithm

3.3.6.1 Annex 3 defines an MD as follows: “A marked discontinuity occurs when there is an abrupt and sustained change in wind direction of 30° or more, with a wind speed of 20 km/h (10 kt) before or after the change, or a change in wind speed of 20 km/h (10 kt) or more, lasting at least 2 minutes”.

3.3.6.2 This definition may be used as follows:

a) to take into account a change in direction of 30°, the instantaneous directions should not be used directly, since rapid changes reach and often top 30°, without any actual change in wind direction;

b) an MD must be maintained for at least 2 minutes, so the mean wind must be used over 2 minutes (speed and direction);

c) to calculate ff2 and DD2, the mean speed and direction values over the last 2 minutes;

d) to calculate ff8 and DD8, the mean speed and direction values over 8 minutes, calculated 2 minutes before (meaning that it does not take into account the last 2 minutes). To limit calculations, it is also possible to use the mean values over 10 minutes, calculated 2 minutes before. The result will not differ much and the mean values over 10 minutes are usually calculated regularly;

e) to compare DD2 with DD8. If both mean directions differ by more than 30° and the mean wind before or after (ff2 or ff8) is above 10 kt, there is an MD;

f) compare ff2 with ff8. If the absolute difference is above 10 kt, there is an MD;

g) if an MD is detected, note the moment it occurs, in order to calculate the successive mean values. When the MD is detected, the last values calculated over 2 minutes must be used for the mean values. The following minute, the parameters will be calculated over a period of 3 minutes, then 4, until the normal 10-minute period is caught up with; and

h) after an MD and during the 8-minute “catching up” period that follows, deactivate the search for a new MD.

3.3.6.3 When an MD is detected, the representative mean wind period (first 2 minutes, increased progressively to 10 minutes) must also be used to find the extreme speed and direction values.

3.3.7 Minimum and maximum speeds

3.3.7.1 Extreme wind speed values must be calculated using values that represent a 3-second period, over an adapted period (usually 10 minutes, but also between 2 and 10 minutes after an MD). Extreme values can be calculated over successive 1-minute periods, then combined over the appropriate time period.

Maximum speed is included in local reports and in METAR/SPECI messages if the difference between the maximum and mean speed over 10 minutes (or a lesser time period after an MD) is above or equal to 10 kt, in which case the minimum speed is then also included in local reports.

3.3.8 Extreme wind directions

3.3.8.1 The sector of variability in 3-second mean directions is limited by the two extreme direction values calculated in the preceding 10 minutes (time increment) and can be defined every minute using 3-second mean directions calculated as the data come in. These directions are placed in a direction histogram with a resolution of 10°.

3.3.8.2 The sector can be found in two steps using the direction of the mean wind in the given 10 minutes. Step one looks for the first limit by scanning the histogram directions counter-clockwise. Step two looks for the second limit by scanning the histogram directions clockwise. In both steps, the desired limit is the direction of the histogram adjacent to a sector with two consecutive directions of zero value. If the occurrence of the condition that determines one or more limits is not met (sector of 360°) the sector is declared undetermined.

3.3.8.3 In usual conditions, this search is performed over a 10-minute period. After an MD, the search period is lowered to 2 minutes and then increases progressively to 10 minutes.

3.3.9 Geographic direction and magnetic direction

3.3.9.1 Wind directions coded in METAR/SPECI are given in relation to true north, as are those in local reports. However, local information given to pilots must be in reference to magnetic north. The difference between true north and magnetic north depends on the location. The difference is sometimes small compared to the 10° coding resolution, but it can reach up to 20 or 30° in some areas of the world. Any ambiguity about the significance of directions must therefore be avoided between the service providing the observations and the aeronautical user. It is especially important for the controller to avoid performing a mental conversion using a value displayed in geographic degrees. It may be preferable, with local agreement, to provide directions directly in relation to true north in local reports.

3.3.10 Changes in parameters

3.3.10.1 Wind is a parameter that is very variable in time (gusts) and space. If the aerodrome's topography can generate significant differences along the runway, several sensors should be installed, but they should not be close to obstacles that can affect measurements. Obstacles increase turbulence and can make wind direction more variable. The change criterion of 60° in direction is often exceeded artificially.

3.3.10.2 When there are gusts, wind speed can suddenly increase or decrease, which explains the importance of observing both the maximum and minimum speed values. How much the speed changes depends on weather conditions and a great deal on the roughness of the surrounding land; rough land produces greater changes. On average, the ratio of maximum wind to mean wind over 10 minutes is close to 1.45, and the ratio of minimum wind to mean wind is close to 0.7.

3.3.10.3 High wind variability could make it tempting to use instantaneous wind, giving the impression that reality is being represented more accurately; this is a false impression and instantaneous wind should not be used (Annex 11, 4.3.6.1).

3.3.10.4 Using instantaneous wind values is dangerous for the following reasons:

— instantaneous wind changes quickly. Between the time the display controller looks at the data and transmits the information to the pilot, instantaneous wind can change a great deal. Displaying extreme values (when justified) over the last

10 minutes gives a better indication of possible wind conditions around an aircraft; and

— instantaneous wind is measured where the sensor is located, not where a moving aircraft is located. In case of gusts at a speed of 30 kt (15 m/s) for example, a 20-second period is required for displacing an air mass over a distance of 300 metres; there is always a drift between the measurement and the actual wind around an aircraft.

3.4 SOURCES OF ERROR

3.4.1 Sensors

3.4.1.1 Bearings on mechanical sensors can wear down, increasing the starting threshold. Such an increase can cause problems during light winds, but light wind speeds do not affect operations. For greater wind speeds, an increase in the starting threshold does not cause many problems, since the torque exerted by the wind on cups or a propeller is proportional to the squared speed, so it quickly and greatly exceeds the resistance corresponding to the starting threshold: if the threshold is 2 m/s, for a speed of 10 m/s, the torque will be 25 times stronger. Nevertheless, wear can eventually lead to a blocking of the anemometer or wind vane.

3.4.1.2 One way to monitor the good condition of bearings is to check the starting threshold. This can be done in laboratory, making it necessary to change the on-site sensor. France uses a simple technique to monitor bearings: sheltered from the wind (in a vehicle or building), a pulse is given to the anemometer and the amount of time the rotation stops is measured. If the bearings are worn down, they will stop rotating for a shorter amount of time than those of a sensor that is in good condition. The minimum amount of time required for the bearings to be considered in good condition depends on the type of anemometer. This method is simple and dependable, and can also be used for a wind vane, by replacing the flag with cups (to limit aerodynamic braking and increase the inertia of the axis of rotation).

3.4.1.3 Static sensors can be monitored in a zero wind chamber (in which the sensors are sometimes packaged), available through the sensor manufacturers' catalogue.

3.4.2 Measurement environment

3.4.2.1 It is very important to install a sensor in the clearest location possible. The WMO recommends installing a wind measuring instrument at a distance equal to at least 10 times the height of surrounding obstacles. This rule is already a compromise between the desired clearance and realistic constraints. In fact, the desired clearance is between 20 to 30 times the height of surrounding obstacles, particularly if the obstacles are high.

3.4.2.2 For thin obstacles, a mast or antenna for example, the clearance distance should be at least 15 times the diameter of the obstacle.

3.4.2.3 Sensors must never be installed on the roof of a building, such as a control tower. It may seem practical at first, with a sensor located at an appropriate height, but the building itself affects the wind flow, which is accelerated at roof level or at the top of the building. For a sensor installed 2 or 3 m above a control tower, speed can by overestimated by 30 per cent. The overestimate will depend on the wind direction and the relative position of the sensor in relation to the edge of the roof.

3.4.3 Orientation of the sensor

3.4.3.1 A wind measurement sensor must be facing true north to indicate the direction correctly. The sensor's design plays a part in determining how easily it can be oriented north. The stability of the fastener must also be checked to keep the sensor from rotating over time.

3.4.3.2 For the sensors to be accessible, the fastening mast can often be folded down. The mast should have a mark, which must be positioned correctly towards the north. This can be checked with a magnetic compass aligned with the marker and installed in the same place as the sensor or wind vane. Without proper precautions, it is quite possible for alignment errors to exceed 10°.

3.4.4 Calibration and maintenance

3.4.4.1 For rotating anemometers, the response characteristics are essentially related to the characteristics of the cups or the propeller and wind vane flag. The bearings must be monitored regularly and changed if necessary. With bearings in good condition, visually monitoring the good condition of the cups or the propeller can be enough for the anemometer. An inexpensive way of making sure that these cups or propellers are in good condition is to make a preventive replacement of these elements at regular intervals (every 2 years for example).

3.4.4.2 It is also possible to use a motor whose rotation speed is known in order to train the axis of a rotating anemometer, which makes it possible to control the sensor's transducer.

3.4.4.3 For static anemometers, a check point is the zero wind chamber test. The stability of the characteristics of measurement ranges depends on the sensor's design. Verifying the sensor's response to the measurement ranges requires a windtunnel test. For sonic anemometers, the standard used is ISO 16622.

3.4.4.4 The orientation of the wind vane must be monitored regularly. If the mast bears a mark for orientation, and its design makes it possible to guarantee the stability of its orientation, a simple visual check can suffice. This of course requires the sensor to be designed in such a way as to guarantee that the direction indication is aligned with the mark on the sensor: The quality and stability of the orientation depend largely on the sensor's design.

3.4.5 Measurement locations

3.4.5.1 For local reports, wind observations must be representative of the touchdown zone for arriving aircraft and of the length of the runway for departing aircraft. Measurements cannot of course be taken on the runway, and it is important to follow the clearance rules (Annex 14, Volume I, Chapter 8 and Doc 9137). The minimum distance of a 10-m frangible mast in relation to the runway centre line is 90 m. The mast must be placed in this zone only if absolutely necessary. Normally, a 10-m mast should be at least 220 m from the runway centre line.**(include figure 5.2 Doc 9388 or equivalent figure from Annex 14 or Doc 9137?)**

3.4.5.2 Multiple wind measurements are recommended for aerodromes subject to changing weather conditions: terrain effects, land or sea breezes, widely-spaced aerodrome.

3.4.5.3 In METAR/SPECI messages, the wind measurement must be representative of the runway or runway complex. If only one wind measurement is taken at the airport, this measurement is used both for local reports and METAR/SPECI messages.

3.4.5.4 With multiple measurements, the measurement deemed the most representative of the site is used for METAR/SPECI messages. In practice, a measurement is selected while the measurement system is being designed. Measurements should not be selected that are too specific of a runway threshold and that would therefore be intended especially for this threshold, because of specific local conditions.

3.4.5.5 With multiple measurements, it is better for the measurement system to be reconfigured to use another measurement, in case the sensor used for METAR/SPECI messages breaks down.

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Chapter 4

VISIBILITY

4.1 Introduction and use

4.1.1 For obvious reasons, visibility is a crucial parameter for aeronautical operations. Low visibility can prevent a runway or an airport from operating. Visual aids (markings) and landing and takeoff instruments are specifically set up to limit these operational restrictions.

4.1.2 The RVR is the best assessment of what the pilot sees on the centre line of a runway. The visibility can also be seen as the best assessment of what the pilot sees outside this centre line. There can be differences between a visibility observation on the ground and what the pilot sees. The ceiling height is of course important for the pilot, who must adjust his/her level accordingly. We may also consider using slant visibility, but this notion has not been defined because it cannot be measured or observed. Two notions exist for visibility: contrast visibility and light source visibility. In the case of RVR, both notions are used in a clearly defined context.

4.1.3 For the WMO, visibility is the meteorological optical range (MOR), which corresponds to a contrast threshold of 0.05.

4.1.4 Visibility for aeronautical purposes was only recently defined objectively, as was RVR over 20 years ago. Prior to this definition, the MOR was sometimes used as a visibility parameter, since no other recommendations existed.

4.1.5 The definition of visibility for aeronautical purposes explicitly takes into account the existence of light sources in an airport's environment, with a value of 1000 candelas:

"Visibility for aeronautical purposes is the greater of:

a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background; and

b) the greatest distance at which lights in the vicinity of 1000 candelas can be seen and identified against an unlit background.

The two distances have different values in air of a given extinction coefficient, and the latter b) varies with the background illumination. The former a) is represented by the meteorological optical range (MOR)."

Note.— The two distances have different values in air of a given extinction coefficient, and the latter b) varies with the background illumination. The former a) is represented by the meteorological optical range (MOR)."

4.1.6 Visibility in a METAR/SPECI message must be representative of the aerodrome, which is a wide area over which significant changes in visibility can take place, so it was necessary to find a synthetic way of describing these changes. Amendment 73 of Annex 3 introduces the notion of prevailing visibility, defined as follows:

"The visibility value, observed in accordance with the definition of "visibility", which is reached or exceeded within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could compromise contiguous or non-contiguous sectors.

Note.— This value may be assessed by human observation and/or instrumented systems. When instruments are installed, they are used to obtain the best estimate of the prevailing visibility."

4.1.7 The RVR manual, Doc 9328, describes the atmospheric phenomena that reduce visibility, the different measurement instruments and the algorithms, so these will not be covered in detail here.

4.1.8 The distinctive characteristics of automatic visibility observations are linked to the possible spatial changes in visibility.

4.1.9 For aeronautical purposes, the measurement range for visibility is from 25 m to 10 km. Values greater than or equal to 10 km are indicated as 9999 (metres). A sensor must therefore be able to measure values above 10 km or indicate if the measurement is greater than or equal to 10 km.

4.1.10 The lower limit is actually linked to the resolution of 50 m required in reports. Measurement instruments often have a resolution smaller than 50 m in low values. Annex 3 specifies that visibility values should be rounded down to the nearest lower reporting step which means that a visibility value of 45 m will be reported as 0 m. This makes it possible to specify the lower limit of the measurement range, which is therefore 50 m or less (avoid the exact value of 50 m, which may cause coding ambiguities - 0 or 50 m - except if the sensor is capable of indicating "value below 50 m").

4.2 Measurement methods

4.2.1 Forward scatter meters are well adapted to the visibility measurement range.

4.2.2 Backward scatter meters are sensitive to the types of scattering particles (fog, dust, sand, rain, snow) and are to be avoided, except if they are able to identify the type of particles, to take these into account.

4.2.3 A transmissometer has a measurement range linked to its base (distance between the transmitter and receiver). This base is adapted to the RVR range (50 to 1500 or 2000 m), which is too short to measure visibilities up to 10 km. However, there are double-base transmissometers that make it possible to cover the measurement range of visibility.

4.2.4 There are also prototype systems that use a camera and automatically analyze an image by recognizing or not predefined marks. The advantage of this technique is that it could resemble a human observation, and possibly provide an overview, but it would have the disadvantage of referring to a reference point (described further on). Continuous functioning in widespread luminance ranges is a delicate matter when trying to avoid sun glare. At night, only the luminous marks can be used, so they must exist. At present, no such validated systems are used.

4.2.5 Not all sensors available on the market perform the same way. Chapter 9 of Doc 9328 describes a method used to test visibility measurement sensors.

4.2.6 Calculating aeronautical visibility also requires the background luminance, measured by a background luminance sensor. Doc 9328, Chapter 9.1.5, describes the sensor needed to calculate the RVR.

If it exists, it is possible to use the same sensor to calculate visibility. If the RVR is not required for the aerodrome, a background luminance sensor must be installed. It is often associated with a sensor (scatter meter) in order to use its electrical supply, often its support and sometimes its electronic components. Note that sensors now used for automatic visibility observations, as defined in Annex 3, also provide the RVR calculation parameters.

4.2.7 When the background luminance sensor is used to calculate visibility, it must be placed so as to avoid glare from direct light (especially from runway lights) and the sun. Under these circumstances, a single luminance measurement can be used for all visibility points measured by instruments. Nevertheless, in cases of multiple visibility measurements, it is recommended that a second background luminance sensor be installed to replace the first in case it breaks down.

4.3 Algorithms

4.3.1 Aeronautical visibility calculations are based on the laws of Koshmeider (contrast visibility) and Allard (visibility from light sources).

4.3.2 Calculation methods and formulas are detailed in Doc 9328 and apply to a range of 20 m to 10 km, with an intensity value set at 1000 candelas. The calculation is simpler than the RVR calculation, which must take into account multiple luminous intensities (lights along the edge and on the centre line of the runway) and transition areas related to the directivity of lights and the loss of luminous efficacy outside the optimal axis.

4.3.3 The calculation is given below. It involves many steps. It is first necessary to know or calculate the meteorological optical range (MOR). A sensor such as a scatter meter usually provides the MOR value directly. A sensor such as a transmissometer provides a transmittance value tb, which is a function of its basic length b and the extinction coefficient (σ). We have $t_b = e^{-sb}$ and MOR =3/σ, Hence MOR = -3.b/Ln(t_b).

4.3.4 Visibility is the greater of the following two values:

The MOR.
The distance from which light sources of 1000 cd can be seen, according to the law of Allard.

4.3.5 The law of Allard can be expressed several ways, depending on the parameters used. In this case, we know the MOR and want to calculate the visibility V.

Call ET, the visual threshold of illumination and I, the luminous intensity
With ET = I.e-$^{\sigma V}$/V^2 and by replacing s by 3/MOR, we get:
$V = -MOR/3 \;.\; Ln(E_T/I.V^2)$ (1)
For visibility, we must use I = 1000 cd.
The relationship between E_T and luminance B is described in Attachment D of Annex 3:

The relationship (1) does not make it possible to analytically calculate V. Several ways can be used to solve this, one of which is provided below:

Consider the sequence $V_n = MOR/3.\ Ln(E_T/I.V_{n-1}{}^2) = f(V_n{-}_1)$

If this sequence converges, it converges towards V, the visibility sought.

4.3.6 It can be demonstrated that if V_n is greater than V, then V_{n+1} will be less than V. The sequence V_n is close to the value of V.

If we take V_0 = MOR, and if V_1 is less than V_0, we can conclude that solution V to equation (1) is less than V_0 = MOR. In this case, the calculation is not necessary, since the visibility distance given by the law of Allard is less than the MOR. So the visibility is equal to the MOR, which is good since the sequence can diverge in such conditions. However, it is possible to show that if V_1 > MOR, given that V_0 = MOR, the sequence converges.

4.3.7 The iterative calculation of this sequence can then be performed until the difference between V_n and V_{n+1} is small in relation to the value of V_n. For example:

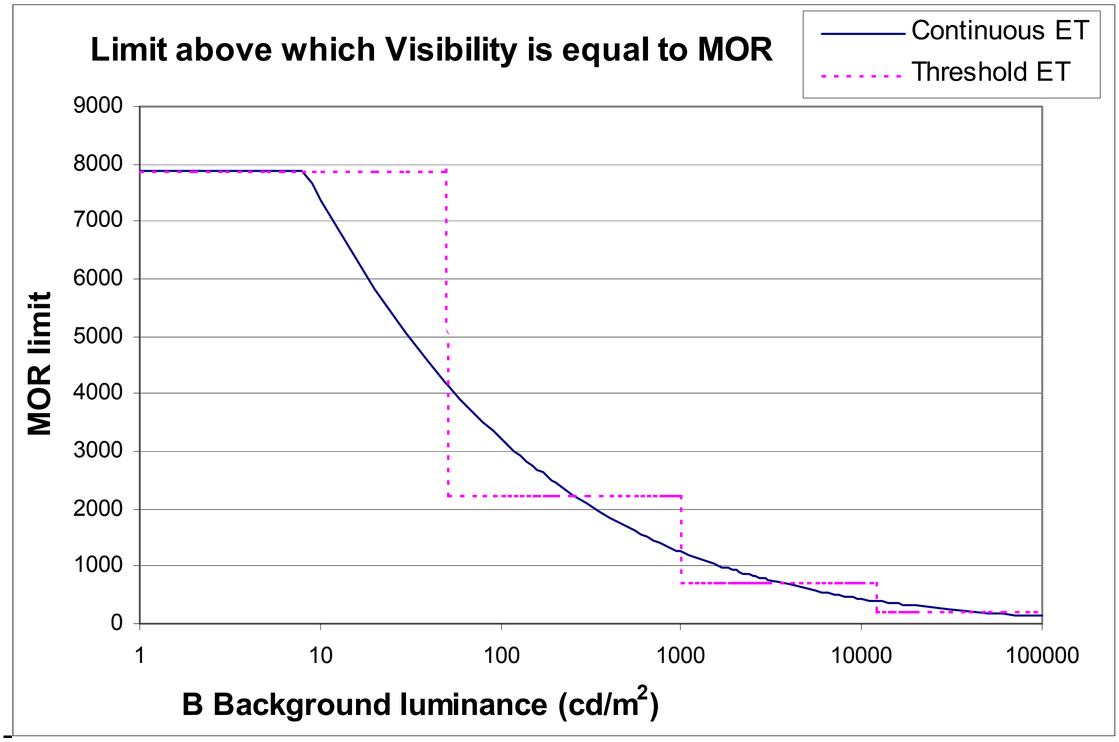
$abs(V{-}{-}_{n-} - V{-}_{n-1-})/V{-}_n < 0.01$

4.3.8 In practice, convergence may be slow. It can be very quickly accelerated using an intervening variable:

- Start with V_0 = MOR and calculate $V_1 = f(V_0)$. Calculate $V_{01} = (V_0 + 2*V_1)/3$
- Calculate $V_2 = f(V_{01})$, and $V_{12} = (V_{01} + 2*V_2)/3$
- Calculate $V_3 = f(V_{12})$ and $V_{23} = (V_{12} + 2*V_3)/3$
- The calculation can be continued so forth, but in practice, the value of V_{23} is very close to the required value of V and the calculation can be ended at the third iteration.

4.3.9 For each luminance value (and therefore for each associated E_T illuminance threshold), there is an MOR value over which visibility by light sources is less than the MOR and where the aeronautical visibility is therefore equal to the MOR. This limit is easy to calculate using equation (1). It is such that V = MOR, therefore $Ln(E_T/I.MOR^2) = -3$.

This limit is indicated by the chart and table below.



Condition	Illumination threshold steps	Background luminance	MOR limit-
Night-	8 x 10-$^{-7-}$	-£- 50	7889-
Intermediate-	10-$^{-5-}$	51 – 999	2231-
Normal day-	10-$^{-4-}$	1000 – 12000	706-
Bright day (sunlit fog)-	10-$^{-3-}$	> 12000	223-

4.4 Changes in visibility

4.4.1 Isolated measurements

4.4.1.1 All current visibility sensors directly or indirectly measure the extinction coefficient s, on a small atmospheric volume of a few litres with a scatter meter. Using a transmissometer, the atmosphere is sampled over a greater distance, the base of the transmissometer, which is a few dozen metres. In both cases the portion of the atmosphere used for the measurement is local to the sensor. Taking a MOR of several hundred metres or kilometres may seem unreasonable, since the atmosphere analyzed is not located kilometres away; the measurement is therefore representative of large visibility distances only if the visibility is homogenous, which is usually the case. The occurrence frequency of non-homogenous visibility can be taken from METAR messages containing visibility with an indication of direction (METAR coded before the introduction of prevailing visibility). This frequency is often below 1 per cent, which means that in over

99 per cent of cases, the human observer determined the visibility as homogenous.

4.4.1.2 With a scatter meter, the optical signal during high visibility is very low, but comparing many instruments has proven that certain sensors are capable of measuring high visibility (around 10 km or more) with good comparability and reproducibility.

4.4.1.3 However, for spatial variations in visibility, the indication provided by a sensor only represents where it is installed.

4.4.1.4 For local reports, it is recommended that the visibility be representative of the takeoff zone for departing aircraft and the approach and landing zone for arriving aircraft. Instruments located along the runway and runway thresholds are very well placed to be representative of these zones. So the local representation of instrumented measurements is an asset. A human observer does not have the same advantages during observations, when visibility is low and/or not homogenous, since he/she is rarely capable of seeing the runway and the approach and takeoff zones correctly.

4.4.2 Visibility in METAR/SPECI messages

4.4.2.1 In METAR/SPECI messages, it is recommended that visibility be representative of the aerodrome with a possible indication of changes in direction. The notion of prevailing visibility has recently been introduced.

4.4.2.2 The advantage of having a human observe visibility using the meteorological station as a reference point is that the observation is based on an overview that covers a large volume of the atmosphere. However, there are limitations related to how effectively objects or lights are seen. For example, if the meteorological station and observer are located in a foggy area with a visibility of 300 m, the observer does not see anything beyond those 300 m. Without instruments, he/she therefore cannot be aware of visibility conditions beyond 300m. The visibility representative of the whole aerodrome is therefore unknown.

4.4.2.3 Conversely, if a fog bank is located 2000 m from the observer, with a visible mark at 2000 m, the observer indicates, as he should, a visibility of 2000 m, even though visibility in the fog bank is much less (for example, 300 metres indicated by a sensor).-

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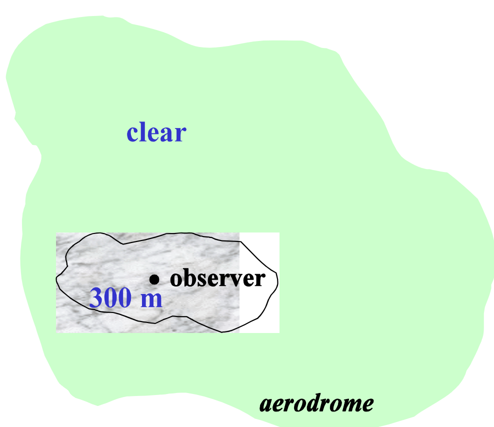

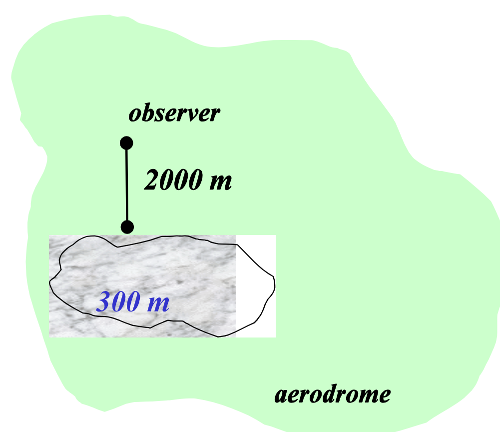

4.4.2.4 It is therefore important to understand that instrumented and human visibility observations are comparable only when the atmosphere is homogenous. When this is not the case, human observation and automatic observation each have their limits. A sensor unit installed on the site is a good solution. In fact, such a situation is taken into account in the definition of prevailing visibility. Measurements can then be combined to meet the requirements of this definition.

4.4.2.5 In practice, it is recommended that the minimal visibility be calculated using the available measurement sensors. With an automatic system, prevailing visibility is the visibility observed by at least half of the sensors installed. Direction indications can be recorded if the spatial distribution of sensors is adequate.

4.4.2.6 Prevailing visibility is reported in METAR/SPECI messages, accompanied by minimal visibility when it is less than 1500 m, and when it differs from the value of prevailing visibility by at least 50 per cent.

4.4.3 Sources of error

4.4.3.1 The spatial variability of visibility is the main source of error when visibility is not homogenous. In fact, this variability it must be considered each time comparisons between instruments or between instruments and human observations are made. Doc 9328, Chapter 9, describes a method of evaluating performances and a method of detecting spatial inhomogeneities by analyzing temporal variability.

4.4.3.2 Instruments must be calibrated regularly, according to the manufacturer's instructions. It is usually recommended to monitor instruments every 6 months and experience shows that settings remain stable over such a period. The calibration of a scatter meter is based on the use of a scattering plate, which is also calibrated. The calibration process relies on gold sensors, which are regularly compared to one or more transmissometers (on a specific test site or at the manufacturer's). This process is described in Doc 8328, Chapter 8.

4.4.3.3 It is important to avoid any unwanted optical reflection that causes, on a scatter meter, an increase in the signal scattered and therefore an MOR indication that is too low. This can be caused particularly by spider webs. Optical surfaces must therefore usually be maintained more often than they are calibrated. Many models monitor the contamination of their optical surfaces and are able to warn the acquisition system when their performance declines or their surface requires cleaning.

4.4.3.4 It is also important to avoid unwanted reflections from plant life. To do so, care must be taken to ensure that the surrounding land is clean and that there is no plant life to attract flying insects that could enter into the measurement volume. Another way of avoiding these problems is to set up the measurement volume high above the ground, which is in fact recommended (the measurement should be representative of a height of 2.5 metres).

4.4.3.5 The background luminance sensor used for calculating visibility must also be cleaned and calibrated regularly, according to the manufacturer's instructions. A measurement uncertainty of 10 per cent is considered acceptable.

4.4.3.6 Snow on the ground can also affect the measurement of the scattered signal, for it increases the continuous signal picked up by a scatter meter's receiver. In case of heavy accumulations of snow, the surface of the snow must not be too close to the scattering volume. It is important to remove the snow all around the sensor and/or install the sensor's measurement head high enough.

4.4.3.7 If there is snow on the ground, significant errors can take place if snow drifts or blows in the scattering volume. For sites subject to this, the measurement head should be raised.

4.4.3.8 Drifting and blowing snow can obstruct a scatter meter's optical heads. Instruments usually have a heating mechanism to avoid such blockage, but it may not provide enough heat in extreme conditions. It is therefore important to be careful and clear the optical heads of snow. The danger in such circumstances is that the obstruction of the optical path causes a reduction in the signal scattered and therefore an overestimate of the MOR. Certain sensors are designed to signal such circumstances.

4.4.4 Measurement locations

4.4.4.1 When only one sensor is installed, it should be in the area that is most representative of the aerodrome. In any case, the location must respect the manufacturer's clearance rules, and most importantly, must not be too close to buildings. If there are no specific constraints related to the airport's climate, it is best to choose a location that is easy to access for sensor maintenance and to connect it to the acquisition system; the meteorological enclosure can be a good solution.

4.4.4.2 When multiple sensors are installed, it is usually better to document the visibility conditions in the landing and takeoff zones. The locations of the runway thresholds, used for RVR measurements, are therefore well adapted. The location is described in Annex 3 and in Doc 9328, Chapter 5. In fact, the same sensors, especially scatter meters, can be used to determine the RVR and visibility.

4.4.4.3 If there is an area of the aerodrome that is particularly subject to unfavourable visibility conditions, such as a fog advection zone, it is recommended that a sensor be installed in that area.

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Chapter 5

RVR

5.1 Introduction

5.1.1 Document 9328, "Manual of Runway Visual Range Observing and Reporting Practices" was updated in 2000 and covers all aspects related to RVR. These elements will not be dealt with here.

5.1.2 Since Amendment 72 of Annex 3, scatter meters can be used to measure the extinction coefficient used to calculate RVR. Contrary to most transmissometers, a scatter meter can also cover the visibility measurement range. It is therefore natural and recommended to use the measurements from a scatter meter to calculate both RVR and visibility. This of course requires that the scatter meter be installed according to the regulations and recommendations of Annex 3.

5.2 RVR coding in METAR/SPECI messages

5.2.1 When RVR is coded in a METAR, Annex 3 recommends including only the value or values representative of the touchdown zone, that is, the landing threshold of the runway in use. Since the airport manager and not the meteorological service determines which runways are in use, the service must be made aware of which landing thresholds are in use. In a system that is fully automatic (or functioning during a period in fully automatic mode), the system does not know which threshold or thresholds are in use. In such cases, the RVR for each instrumented threshold is reported in METAR/AUTO messages when conditions requiring RVR data are met (visibility or RVR below 1500 m).

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Chapter 6

PRESENT WEATHER

6.1 INTRODUCTION AND USE

6.1.1 Present weather must be observed in both local reports and METAR/SPECI. Some weather conditions, such as freezing precipitation, are of great importance to the pilot and to aerodrome operations. Other conditions, such as light rain, are less important. Operations are sometimes only indirectly affected by present weather, for example when visibility is reduced or when there are gusts of wind; nonetheless, these are still reported. Conditions requiring special messages or SPECI are linked to freezing or heavy precipitation, thunderstorms and phenomena that reduce visibility, such as wind-blown snow and rising sand.

6.1.2 Automatic systems are not currently capable of reporting all types of present weather. Hence it is important to identify the types of present weather that are more dangerous for operations than others, in order to assess the acceptability of an automatic system. Unlike visibility, RVR or ceiling, there are no defined present weather thresholds that could lead to a downgrade of the runway or aerodrome.

6.1.3 The sensors used for the automatic observation of present weather are recent. There are several types, using different physical principles, so that improvements in performance and capacity can be planned.

6.1.4 Sensor diagnostics are generally not used directly, but are combined with other parameters to limit errors and increase their reliability and the types of present weather that can be reported (for example, a precipitation described as :"liquid", with an air temperature less than -0.5°C, is practically always a freezing precipitation). Hence the importance of the algorithms associated with present weather sensors.

6.1.5 Validating the performance of an automatic system is complex because a) the human observer, often considered a reference, is not infallible, and b) some phenomena are very rare, so it is difficult to adjust the sensor and to establish statistics on its performance. Fortunately, the most intense present weather phenomena are the easiest to identify and are often the most important where operations are concerned.

6.2 MEASUREMENT METHODS

6.2.1 There are many principles of measurement and instruments, while the number of suppliers is low. In 1993-1995, the WMO gathered all the present weather sensors available on the market internationally at the time and made a comparison. Since then, some new sensors have appeared and the internal algorithms of the instruments have evolved; still, the comparison provides a good illustration of the instruments' possibilities and limits.

6.2.2 The detection thresholds expressed in mm/h are given for some sensors. We remind the reader of the WMO indications for thresholds associated with light, moderate and heavy levels of intensity:

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Intensity	Drizzle	Rain	Snow-
Light	< 0.1 mm/h	< 2.5 mm/h	< 1.0 mm/h-
Moderate -	≥- 0.1 and < 0.5 mm/h	-≥- 2.5 and < 10 mm/h	-≥- 1.0 and < 5 mm/h-
Heavy	-≥- 0.5 mm/h	-≥- 10 mm/h	-≥- 5 mm/h-

6.2.3 Scintillation sensors

6.2.3.1 One manufacturer analyzes the scintillation frequency of an optical beam, through which the particles to detect or identify pass. The scintillation frequence depends on the size of the particles and the speed with which they are moving in the beam. So there exists a signature depending on the type of precipitation. This sensor, which was not designed to identify drizzle, is the one currently used in the United States in ASOS systems. It identifies rain and snow, but very light precipitation is often not determined. The detection threshold specified when the sensor was designed is 0.25 mm/h for liquid precipitation. The manufacturer's catalogue lists several sensors based on this principle and a complementary acoustic sensor (a sort of disdrometer) has been designed to add the identification of hail and ice pellets.

6.2.4 Optical sensors of the scatter meter type

6.2.4.1 Many manufacturers produce sensors of this type. These sensors measure the visibility and detect and identify certain categories of hydrometeors.

6.2.4.2 The sensor is a double scatter meter: forward scatter (classic for visibility) and rear lateral. It determines particle size and speed and establishes a distribution table of the number of particles by size and speed. The table is analyzed to determine the hydrometeor. Though the sensor is designed to detect drizzle, very weak precipitation is often not determined, while rain and snow recognition is quite good. The sensor indicates rain instead of snow during mixed precipitation, light snow flurries and wind-blown snow. This must generate a very different table from the one expected from the general theory.

6.2.4.3 Another manufacturer uses a scatter meter initially designed to measure visibility, to which it has added a precipitation detector. The low volume of optical scatter means that individual particles can be detected. Using the optical signal, the sensor calculates the intensity of precipitation. The precipitation detector with a capacitive grid reacts to the quantity of water and gives an intensity. The optical and capacitive intensities are related where liquid precipitation is concerned, while optical intensity is higher for solid precipitation (low water content). Temperature measurement aids the sensor and is also used to determine whether precipitation is freezing rain.

6.2.4.4 Theoretically, this sensor is capable of identifying many different types of hydrometeors: drizzle, rain, snow, hail, snow grains, ice crystals and mixed precipitation. Tests have shown good recognition of "classic" varieties like rain and snow and, to a lesser extent (50 per cent), drizzle, but a low recognition of some varieties like hail, recognized as heavy rain.

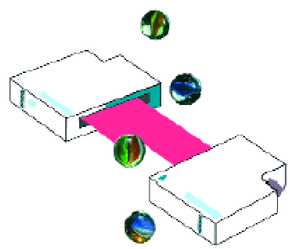
6.2.4.5 The sensitivity of this sensor has a threshold of approximately 0.05 mm/h. It identifies freezing precipitation by temperature analysis (liquid precipitation + negative temperature).The same manufacturer also markets two other sensors using the same principles, but with a more limited visibility range and fewer hydrometeoric varieties recognized.

6.2.5 Acoustic disdrometer

6.2.5.1 A disdrometer measures raindrop distribution by size. Each drop is identified by its impact on a horizontal surface, generating an electric pulse in proportion to its size. Distribution of the drops permits the identification of rain and drizzle but not the distinction between snow and drizzle, because the impacts of snowflakes are registered as small diameters. Hail and ice pellets generate large impacts.

6.2.6 Optical disdrometer

6.2.6.1 This disdrometer detects the size, number and fall speed of drops as they pass a light barrier. Each type of particle (drizzle, rain, snow, hail, etc.) has a signature in a two-dimensional table (size and speed), so that the type of precipitation can be recognized. There are at least two recent sensors of this type on the market.



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6.2.7 Microwave radar

6.2.7.1 Canada has developed a bistatic Xray radar sensor, pointing vertically. The signal emitted is reflected by particles and undergoes a Doppler shift according to the fall speed: weak for snow, stronger for rain. Signal intensity depends on the number and type of particles. So the sensor can distinguish rain and snow, but identifying drizzle is a more delicate matter.

6.2.8 Ice accretion sensor

6.2.8.1 This sensor detects the presence of a layer of ice or frost on a vibrating rod, the resonance frequency of which varies accordingly. The rod is heated once its frequency falls below a defined threshold. his sensor is used in practically all ASOS systems in the United States to detect ice in precipitation. It is also used to detect conditions of freezing drizzle, which eludes detection by the present weather optical sensor.

6.2.9 Temperature sensor

6.2.9.1 One development underway is the measurement of the thermal energy needed to melt solid precipitation. Such a sensor would permit the detection and identification of hail or small hail in certain circumstances: the necessity of melting a hydrometeor when the ambient temperature is above 5°C is a good indication of the presence of hail or small hail. The capacities of such a sensor have still to be proven.

6.2.10 Precipitation detectors

6.2.10.1 There are several models: optical (detection of particles passing through a light beam); grid (detection of water on a surface, modifying an electric resistance or capacity). These detectors cannot identify precipitation type, but they can be sufficient for sites not subject to certain types of hydrometeor. For example, it is not necessary to identify snow in tropical regions.

6.2.11 Lightning detectors

6.2.11.1 There are several sensors that detect lightning within a 50 km radius, using the magnetic and electrostatic signature of the lightning. By assessing the distance and direction of the lightning, these sensors can provide local information on thunderstorms and how far away they are. An alternative to a local sensor is a lightning network.

6.3 INSTRUMENTAL LIMITATIONS

6.3.1 The current limitations of present weather sensors have been deduced from WMO comparisons and various presentations at international conferences. They are as follows:

— for most sensors, the identification of rain and snow is correct in 90 per cent of cases, more where intensity is higher;

— only some sensors can identify drizzle, but performance is low (50 per cent of cases at best);

— no sensor really identifies hail;

— mixed precipitation is rarely reported. They are seen as either rain or snow;

— where intensities are very low (< 0.1 mm/h), precipitation type is not well identified. The code "undetermined precipitation" (UP) is often used and is preferable to an identification error;

— there is a compromise between the detection threshold and the rate of false alarms (detection of non-existent phenomena), and the most "sensitive" sensors are also sometimes subject to false alarms. So it is important to determine the most practical detection threshold. For aeronautical use, it is not really necessary to detect very weak intensities (e.g. < 0.1 mm/h), except for freezing precipitation, for which the WMO recommends a threshold of 0.02 mm/h;

— snow intensity is not always well reported; and

— optical systems are sensitive to pollution and require regular maintenance, especially if they are near the sea.

6.4 ALGORITHMS

6.4.1 The processing of the physical signals measured is done by the sensor itself. Detailed algorithms constitute manufacturer's know-how and are more or less documented, depending on the manufacturer. They sometimes use the temperature to correct or establish the diagnostic of present weather. That can serve a double purpose with the complementary algorithms of an external processing system, in which case it is important that the internal processing be known, so that the overall system functions well.

6.4.2 Potentially, the final diagnostic of present weather could be greatly improved with a combination of different sensors or parameters. The use of air temperature is the most obvious example, but there are other useful parameters or other inter-parametric correlations. Thus, supplementary, more "classical" sensors, such as temperature measurements, can be installed and used. Data combination algorithms permit the identification of complementary types of present weather or the correction of initial diagnostics sent by the present weather sensor. In this case, some algorithms can be specific to the sensor used and its known faults.

6.4.3 Many States and/or meteorological services develop and use such algorithms. It is not easy to gain an overview as few of these algorithms are clearly documented and sometimes they are regarded as having commercial value. So at present it is not possible either to "standardize" these algorithms, or to cite them.

6.4.4 A list of possibilities or practices is given below for information only; it is not in any particular order and is not exhaustive.

6.4.5 In France, studies have shown the usefulness of temperature measurement instruments (not protected by a shelter) placed at two levels above the ground, e.g. at +10 cm and +50 cm, called T_{+50} and T_{+10}. When there is no precipitation, these two temperatures are often different, because there is a temperature gradient above the ground: at night, with a clear sky, the ground is cooler, so T_{+10} is cooler than T_{+50}; by day, with a clear sky, the ground is warmer, so T_{+10} is warmer than T_{+50}. However, in the presence of fog or precipitation, these two temperatures are subject to the same atmospheric conditions, which minimize the differences in temperature that can exist between the two measurements. This fact can be used, but the absence of a temperature gradient does not mean that there is fog or precipitation. For the same reasons, the comparison with air temperature (T_{air}) is also useful.

6.4.6 Algorithms for detection

6.4.6.1 The following conditions normally lead to an absence of precipitation, so a wrong diagnostic from the sensor can be corrected.

— difference T_{air} - T_{+10} > 3°C over a 20-minute period ° no precipitation;

— difference T_{+50} - T_{+10} > 1.5 °C over a 20-minute period ° no precipitation;

— ($T_{+50} > T_{air} + 2$) and ($T_{+10} > T_{+50 + 2}$) day time ° no precipitation;

— no clouds detected above 4500 m (15000 ft) ° no precipitation;

— visibility > 40 km for 5 minutes ° no precipitation.

— relative humidity (RH) < 50 per cent o no precipitation;

— RH diminishes or the difference between T_{air} and dew point depression increases and visibility increases o no precipitation;

— sudden diminution of difference between T_{+50} and T_{+10} (outside sunrise and sunset) o start of precipitation or arrival or fog; and

— isothermia (constant temperature) of T_{+50} or T_{+10} at 0°C (or temperature very close to 0°C, considering uncertainty of measurement) o melting snow probable.

6.4.7 Algorithms for identification

— cases of snow with a T_{air} > 4°C are very rare;

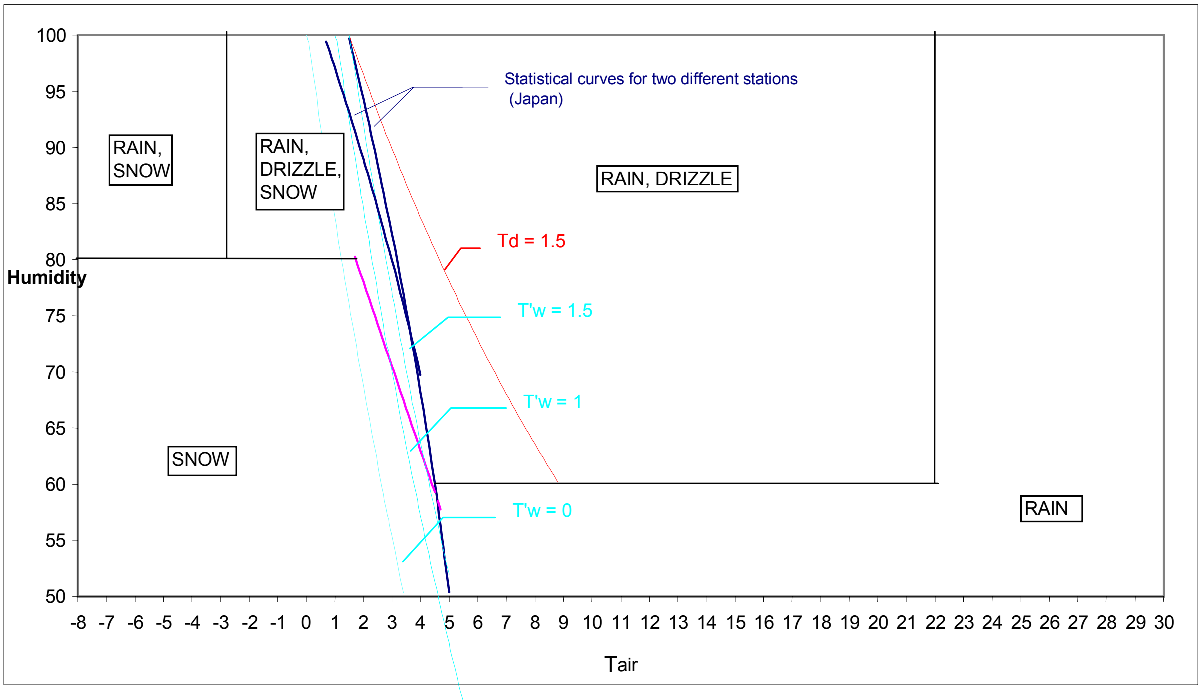
— when T_{air} < -5°C, there are no longer any liquid precipitation;

— cases of mixed rain and snow occur nearly always with T_{air} in the interval [-1°C, 5°C];

— isothermia (constant temperature) of T_{+50} or T_{+10} at 0°C (or te;perature very close to 0°C, considering uncertainty of measurement) o melting snow probable (and melting snow if a present weather sensor has diagnosed precipitation). Sometimes, hoar frost or freezing fog;

— wet-bulb temperature, noted as T_{wb}, presents a limit for rain and snow. Snow is not observed when T_{wb} > 1.5°C; and

— position in a T_{air} diagram, RH or a T_{wb} diagram, RH. There are zones where some varieties of hydrometeor are observed alone, and some zones where some varieties are not observed. Such diagrams alone are not enough to determine the type of hydrometeor, but they can help identify or correct the sensor's initial diagnostic. For example, at a negative temperature with an RH less than 80 per cent (T_{air} < 0°C and RH < 80 per cent), only snow is encountered. Drizzle is often accompanied by high RH (> 90 per cent).



-Example of diagram (T_{-air}, RH)

— visibility < 1000 m and cloud base height > 1500 m (5000 ft) ° snow type;

— drizzle occurs only when there are stratus, clouds whose base is lower than 500 m (1660 ft);

— precipitation detected and no clouds above 3000 m (10000 ft) ° rain;

— in the presence of drizzle, visibility is less than 10 km;

— with equal intensity (expressed in mm/h), snow causes a loss of visibility (or MOR) 4 to 10 times greater than rain. There are criteria that link visibility, intensity of precipitation and the type of precipitation.

6.5 POSSIBLE IDENTIFICATIONS

6.5.1 Detection threshold

6.5.1.1 Automatic systems can detect the hydrometeors, the detection threshold depending on the initial specifications of the system and sensors used. A defined detection threshold does not exist.

6.5.1.2 The initial specifications of the ASOS systems in the United States were around 0.25 mm/h. A recent WMO (CIMO) recommendation defines a 0.02 mm/h threshold as a lower limit used to indicate traces of precipitation (trace between 0.02 and 0.2 mm/h).

6.5.1.3 For aeronautical needs, the useful threshold limit has still to be defined. A 0.02 mm/h threshold is probably appropriate for freezing precipitation, but this very weak threshold is probably not useful in the other cases. And an intensity described as "weak" would cover a very wide dynamic range (0.02 mm/h to 2.5 mm/h), with a very variable operational importance. The term "weak" already implies that the phenomenon has a very weak influence, so an intensity of 0.02 mm/h perhaps has no effect. The disadvantage to an automatic system of a very weak detection threshold is the difficulty in identifying the hydrometeor in such conditions. The UP indication proves useful here. Experience with the first automatic systems installed seems to show that a 0.2 mm/h threshold could be acceptable, except for freezing precipitation, for which 0.02 mm/h would be recommended.

6.5.2 Identification of drizzle (DZ)

6.5.2.1 Some systems can distinguish drizzle from rain, but current sensors are reliable only to 50 per cent. This could be improved with complementary algorithms, but not to a great extent. Anyway, a proper distinction between drizzle and rain is not generally considered vital, and classification errors are not very serious for aeronautical operations.

6.5.2.2 Another difficulty in identifying drizzle is its detection, directly linked to the detection threshold discussed above. Drizzle droplets are very small, and hard to detect by some sensors.

6.5.3 Identification of rain and snow (RA, SN)

6.5.3.1 Many sensors accurately identify rain and snow, except where intensities are very weak (< 0.1 or 0.2 mm/h). If there is too much uncertainty or too much risk of error, it is better to use the UP code.

6.5.4 Identification of snow grains, ice pellets, ice crystals (SG, PL, IC)

6.5.4.1 Very few present weather sensors and hence very few automatic systems today are able to recognize these types of hydrometeors. Those that can (or claim to be able) are not very reliable. Also, comparisons show that the more types of hydrometeor a sensor can detect, the more confusion there is between the types. Before a system is designed or acquired, someone must decide how important it is to identify all these varieties, for if they are not identified individually, they will often be reported as snow.

6.5.5 Identification of hail and small hail and/or snow pellets (GR, GS)

6.5.5.1 Many manufacturers claim that their sensor can identify hail, but a WMO comparison of present weather sensors, and later studies, show that this is not the case. The hail is certainly detected, but it is identified as heavy rain. The optical and/or radar signals used are unable to produce an accurate identification. Special sensors would be needed. Some models are being developed, based on acoustic and thermal techniques, but pending their completion, prudence is advised where current systems for identifying GR and GS are concerned.

6.5.6 Identification of fog and mist, possibly also haze and smoke (FG, BR, HZ, FU)

6.5.6.1 Visibility sensors correctly indicate fog (visibility less than 1000 m) and mist (visibility between 1000 and 5000 m). Caution is advised, because the visibility to take into account is the visibility for aeronautical use defined in Chapter 1 of Annex 3. So the definition of fog and mist does not correspond precisely to the WMO definitions, which take visibility to be an MOR.

6.5.6.2 The presence of fog must be confirmed by a high RH of at least 95 per cent (95 per cent and not 100 per cent, to account for the uncertainty of the measurement), to avoid FG coding because of visibility reduced by heavy rain or, especially, snow. The presence of RA or SN in this case would be clearly identified because the intensity would facilitate identification by a present weather sensor.

6.5.6.3 The presence of mist must be confirmed by a high RH of at least 80 per cent (threshold to be verified). If the RH is lower, it is haze or dust haze, coded as HZ. Visibility can temporarily drop below 5000 m in case of precipitation or of smoke. A characteristic of mist or haze is its good temporal stability, at least over a 10- to 30-minute period. This might cause visibility to vary, but slowly and continuously, without major fluctuations. Major fluctuations indicate the presence of precipitation (also detectable for confirmation) or of smoke. A criterion for the stability of visibility is recommended for mist (BR or HZ). Conversely, when there is no precipitation and visibility fluctuates, smoke might well be present and can be reported. However, one must always be aware that the capacity of an automatic system to report very local phenomena like smoke is limited by selective visibility measurements. Smoke will not be seen unless it passes the sensor.

6.5.6.4 The representative visibility of the aerodrome should be used to identify fog or mist. If there are several scatter meters, multiple visibility measurements should be used to identify (localized) smoke or “bank” (BC) or “partial” (PR) fog.

6.5.7 Darkening or other phenomena (SA, DU, VA, PO, FC, DS, SS)

6.5.7.1 Current automatic systems cannot report these phenomena. For a duststorm (DS) or sandstorm (SS), a coding could be arranged using a combination of low visibility (e.g. < 1000 m), low RH (e.g. < 50 per cent) and high wind speed (e.g. average wind over ten minutes > 15 m/s). Studies could be done showing the correlation between these parameters and the occurrence of DS or SS, using data gathered on sites subject to these conditions.

6.5.8 Identification of a squall (SQ)

6.5.8.1 A squall is defined by a sudden increase in wind speed lasting at least one minute and sometimes several. It is often accompanied by a wind change and a sudden variation in atmospheric pressure. In practice, squalls can be detected by comparing the spot wind with the average wind over two minutes. One is looking for a certain increase (e.g. at least 8 m/s), which must keep up without fail for at least a minute: this notion is important because it prevents simple gusts from being confused with squalls. If several wind sensors are installed, the data from each should be analyzed to detect a squall.

6.6 ALGORITHMS FOR PRESENT WEATHER CHARACTERISTICS (TS, SH, FZ, ETC.)

6.6.1 TS

6.6.1.1 Thunderstorm presence can be determined by a local lightning detector or by using a lightning sensor network. The difficulty then is transmitting the information from the network to the local observation system at the aerodrome, but modern telecommunications are offering more and more possibilities.

6.6.1.2 The TS characteristic is coded when a thunderstorm is detected at an aerodrome, bracketed with an indication of precipitation, if present. Joint coding of TS and SH in the same group is not possible; priority should be given to TS over SH.

6.6.1.3 The VCTS coding is used when a thunderstorm is detected outside the aerodrome, but no further than 8 km beyond the perimeter. Objective distance assessment is possible with lightning detectors and networks.

6.6.2 SH

6.6.2.1 There is no objective or mathematical definition for showers. To determine a possible SH precipitation characteristic, it is necessary to analyze the intensity of precipitation over a given period, for example one hour. During this time, periods of precipitation must be isolated from periods without precipitation.

6.6.2.2 One way of doing this is to identify periods with precipitation intensities (measured every minute for example) above 0.2 mm/h, separated by an interruption (zero intensity) lasting at least five minutes. If there are at least two periods with precipitation over the last 60 minutes, SH can be indicated.

6.6.3 FZ

6.6.3.1 Freezing rain often occurs when the air temperature is below zero. Liquid precipitation is almost always freezing when $T_{air} < -0.5$ °C. This is a simple and relatively reliable way of identifying the freezing characteristic of precipitation, on condition that the precipitation was detected and properly identified as liquid. For very light precipitation, an icing sensor that reacts to a small amount of ice is required. Whether or not to install this sensor in an automatic system depends on the how often freezing phenomena appear, as well as how they affect operations.

6.6.4 BL

6.6.4.1 Many sensors analyze particles that pass through an analysis volume. Wind-blown snow can be confused with snow or another type of hydrometeor, since it is moving faster than usual. The sensor's behaviour depends on its design and physical principles. The United States has developed an algorithm to detect BLSN for ASOS systems.

6.6.5 DR MI

6.6.5.1 The sensitive part of present weather and/or visibility sensors is usually installed at a height greater than two metres. Low phenomena therefore cannot be detected, and these DR or MI characteristics are not usually available with an automatic system. This would require specific instruments (or sensors installed lower) that were not set up on automatic systems installed to date. Detection of DR and MI has not yet been deemed important enough to justify an investment in specific instruments.

6.6.6 BC and PR

6.6.6.1 These characteristics apply to fog. In the presence of fog banks, fog is not homogeneous and there is a local temporal variability in visibility. For example, it the visibility analysis at one point shows the presence of at least two visibility episodes below 1000 m, separated by at least five minutes, the characteristic BC is probable. If there are many visibility sensors at the airport, all available sensors can look for fog episodes to increase the probability of detecting fog banks.

6.6.6.2 The partial character (PR) can only be reported if there are many visibility sensors at the airport. The partial character can therefore be coded only if some of the sensors indicate stable visibility below 1000 m. Stability is necessary to distinguish this case of fog banks. This stability can be evaluated by the presence of no fog episodes or a single fog episode (over a one-hour period, for example) per sensor.

6.6.7 Intensity of precipitation

6.6.7.1 Three intensity levels are defined for hydrometeors and duststorms or sandstorms. Present weather sensors can measure the intensity of the hydrometeors they detect. This intensity is indicated by sensors in mm/h, and sometimes as light, moderate or heavy, which is only the result of an intensity test in mm/h in relation to thresholds integrated in the sensor. It is therefore better to use the intensity in mm/h directly, to establish the intensity level. Intensity often varies significantly in time, so it is necessary to filter information before determining the intensity level. A WMO work group proposed using the mean of the three maximum intensities over the last 10 minutes (intensities being available every minute).

6.6.7.2 Thresholds must then be used for light, moderate and heavy levels. WMO reference identifications are:

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-Intensity	Drizzle	Rain	Snow-
Light	< 0.1 mm/h	< 2.5 mm/h	< 1.0 mm/h-
Moderate	-^{3}- 0.1 and < 0.5 mm/h	-^{3}- 2.5 and < 10 mm/h	-^{3}- 1.0 and < 5 mm/h-
Heavy	-^{3}- 0.5 mm/h	-^{3}- 10 mm/h	-^{3}- 5 mm/h-

6.6.8 Vicinity (VC)

6.6.8.1 With an automatic system using local instruments at the aerodrome, the vicinity indication VC cannot be reported, except for a TS, when it can be identified by a lightning detection instrument capable of indicating its distance.

6.6.8.2 The only way of reporting the VC indication for other types of present weather to which this indication can apply would be to install additional sensors in the vicinity of the airport. Automatic systems are usually installed at small aerodromes (or outside the airport's operating hours) and have not yet justified an investment in sensors around the aerodrome.

6.6.9 Association of algorithms

6.6.9.1 All data combination algorithms are usually installed in a central computer of the observation system. The different combinations can be complex. There are several ways of combining the different algorithms: A "classic" approach with a series of tests leading to a diagnostic and coding. A combination of many individual algorithms to which weights are given, for cases where algorithms yield different diagnostics. A "fuzzy logic" approach is a technical solution to the problem.

6.7 VARIABILITY OF PARAMETERS

6.7.1 Most present weather phenomena do not vary significantly in time, over an interval of a few minutes (10 for example). In cases of low intensity, the system's internal algorithms also examine the diagnostics over the last few minutes to confirm or reject them (and possibly code UP in case of doubt).

6.7.2 However, precipitation intensities often vary significantly in time. It is recommended that the data be smoothed during the last 10 minutes. Temporal variations in intensity can also be used to determine the nature of downpours.

6.7.3 Apart from some phenomena such as fog, rain, hail, small hail and smoke, present weather is very often homogeneous at the airport and it is not necessary to install many sensors at different locations. Because of its operational significance, visibility is a specific case and can justify the installation of multiple sensors, which can be used to increase the detection reliability of fog and report on possible associated characteristics (BC, PR).

6.8 SOURCES OF ERROR

6.8.1 Since present weather is not a direct physical measurement, as are temperature or even visibility, there are multiple sources of error. The more intense a present weather phenomenon is, the better identified and detected it will be. The risk of classification error therefore increases when the intensity is very low.

6.8.2 Rain and snow are quite easy to identify, but some types of present weather are more difficult to identify. The fact that they are rare also makes it difficult to assess the systems' performances. It is easier to develop systems for common types of present weather.

6.8.3 The validation of an automatic system is a complex process since present weather phenomena are very difficult to simulate, making it necessary to wait until they appear on the site. Comparisons must therefore be made over long periods and reference measurements are required. At present, a human observer is the reference. During such comparisons, it is important to check that observations are performed simultaneously. At the start and end of precipitation, phases in which intensities are often very low, an automatic system and a human observer can provide different observations, reducing the static detection and identification scores, without proving an actual defect in the automatic system. One way of reducing these risks is to use a “clinical” human observation, performed right on time, like the automatic system. This requires a specific observation, which is very expensive in terms of human resources. If not, it is essential to evaluate the system's behaviour for each episode of present weather, taking into account the system's diagnostics (as well as the observer's) a few minutes before and after the observation.

6.8.4 There are several categories of present weather codes useful for aeronautical purposes in relation to the observation abilities of an automatic system:

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Possible and reliable coding	RA, SN, FG, BR, HZ Characteristics TS, FZ, VCTS Intensity levels-
Possible or foreseeable coding	SQ, DS, SS Characteristics SH, BC, PR-
Partial detection Coding sometimes possible	DZ, GR, GS, FU-
Coding not possible (in 2003)	SG, PL, IC, SA, DU, VA, PO, FC Often GR, GS Characteristic VC (except for TS)-

Not all automatic systems have the same observation reliability or abilities. A system's limitations are usually announced by ICAO through an official notification of difference. Difficulties arise if observation possibilities differ between aerodromes in the same State, because it is then more difficult to document and make users aware of the limitations of each system. The formatting of local reports and METAR/SPECI messages does not provide much opportunity to indicate observation limitations (the possibility exists for cloud type and cloud clover). It is therefore best to see to it that the observation abilities of an automatic system are harmonized within the same State.

6.8.5 For the installation of sensors, it is important to check that the vicinity is free of plants that could attract flying insects, which could enter into the measurement volume. One way of limiting this possibility is to install the measurement volume high above the ground. An adequate measurement height (2.5 metres for example) is recommended to avoid wind-blown particles or dust, and keep the sensor from being buried under snow.

6.9 CALIBRATION AND MAINTENANCE

6.9.1 Sensors must be maintained according to manufacturers' recommendations. Regular maintenance usually consists in cleaning the outside of sensors, especially optical sensors. Monitoring and/or calibration recommendations for optical sensors that use a back-scatter light analysis are usually the same as for scatter meters that measure visibility (see “Visibility” chapter).

6.9.2 One of the problems faced when calibrating present weather sensors is the difficulty of simulating hydrometeors. The stability of a sensor's characteristics depends on its design. One monitoring method is to make localized comparisons with a local observer throughout the life of the system, or to establish correlations or comparisons with neighbouring observation stations during well-established meteorological phenomena that cover a large area.

6.10 LOCATION OF MEASUREMENTS

6.10.1 Annex 3 specifies that present weather information should be representative of conditions at the aerodrome and in its vicinity, for certain phenomena. It also states that this information should be representative of takeoff zones in local reports designed for departing aircraft and of landing zones in local reports designed for arriving aircraft.

6.10.2 This should therefore lead to present weather observations that differ for a given point in time, when present weather is not homogeneous at an aerodrome. Nevertheless, local reports do not indicate the location of present weather observations and it must be rare for a human observer to report distinct present weather values for several areas within an airport. In reality, it is mostly the observation of visibility, RVR and clouds that is specific to a landing or takeoff zone.

6.10.3 In the case of an automatic observation, it is also acceptable for the observation to be made at a single point, chosen as the most representative of the aerodrome and/or usually located to provide easy access for installation, maintenance and data transmission, such as the meteorological enclosure, for example. For information on fog and mist, the automatic system must use all sensors available at the aerodrome.

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Chapter 7

CLOUDS

7.1 Introduction and use

7.1.1 Like visibility and RVR, the quantity of clouds as well as the type and height of cloud base greatly affect operations. Too low a cloud base can downgrade a runway or airport because it has a direct influence on the pilot's view of the runway.

7.1.2 Horizontal cloud extent, described by the four abbreviations FEW, SCT, BKN and OVC can also be troublesome. This is why cloud cover is reported.

7.1.3 Cumulonimbus (CB) or towering cumulus (TCU) are convective clouds potentially dangerous for aircraft, because of high vertical wind speeds associated with gusts in the vicinity and associated wind shear. These clouds can greatly affect landings and takeoffs, and so it is vital to report them.

7.1.4 Many airports have been using ceilometers for years. They make it possible to measure precisely the cloud base directly above the sensor. An analysis of successive measurements provides an evaluation of the cloud layers with the same regularity, day and night.

7.1.5 The automatic identification of CB and TCU clouds is still difficult, and sometimes even impossible. However, methods are being assessed in several countries.

7.2 Measurement methods

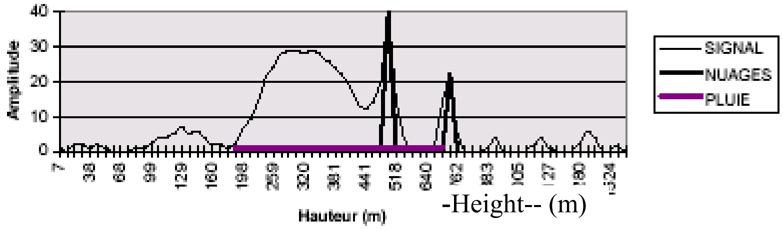
7.2.1 Cloud base height

7.2.1.1 The only automatic sensor currently used to measure the height of cloud base is called a ceilometer. All recent models use a laser diode as a light source.

7.2.1.2 A light pulse is directed upwards and part of the light power is reflected or back-scattered by the different layers of the atmosphere. A very fast electronic detector measures the return signal for different successive instants. Each instant corresponds to a distance equal to the time between emission of the light (pulse) and its reception, divided by the speed of light and again divided by two (emission and return). The system determines a back-scatter profile of the signal, which is how a LIDAR works.

7.2.1.3 The power from a light pulse is limited by technology, and especially by safety standards: light pulses must not be dangerous to the human eye. The power of the back-scattered signal is therefore very low and hardly different from background light. It is therefore necessary to multiply the number of laser pulses (usually 10,000) to increase the signal/noise ratio and to obtain a usable back-scatter profile. The technical details constitute manufacturer's know-how.

EXEMPL-EXAMPLE OF A BACK-SCATTER PROFILE



--SIGNAL
CLOUDS
RAIN

-Height-- (m)

--
-Example of a back-scatter profile with two cloud layers and a rain signal

— when there are no clouds, the back-scatter profile is "flat". The ceilometer detects the absence of clouds in the direction of the light pulses it emits;

— when there are clouds, the back-scatter profile increases heavily at the cloud base level. A strong signal variation in the back-scatter profile indicates the presence of a cloud base. The appearance of the back-scatter profile depends on the optical structure of the cloud base, which can be well defined (very white cloud) or diffuse (base not well defined). Since the profile is also established using multiple pulses spread out over a period of several seconds (up to 15 or 30), the height of the base above the ceilometer can also vary when clouds move horizontally. The interpretation of the back-scatter profile, indicated as a number representing the height of the cloud base, also constitutes manufacturer's know-how. This also explains why performances can vary between models from different manufacturers;

— in certain cases, a ceilometer is able to detect several cloud layers, assuming that the signal penetrated the first layer or that this layer was not on the light signal's path for part of its integration period, with the multiple pulses. With a market model, the detection frequency of a second cloud layer is 10 per cent. Such detection is therefore possible but not systematic;

— during precipitation, the back-scatter profile emits significant signals under clouds. The ceilometer is therefore able to detect the presence of something, which is not always identified as a cloud base if there is no net increase of the back-scattered signal. The indication given by the ceilometer depends on the model and its internal algorithms established by the manufacturer. The indication given is sometimes lower than the height of the cloud base, since the signal back-scattered by precipitation varies in time. Precipitation has an influence on observations especially when it rains heavily and/or snows. Note that under such circumstances, the visual assessment of the cloud base, even with lighting aids such as a nephoscope, is also extremely difficult. To limit the influence of precipitations, the pulse direction of certain ceilometers is slightly inclined from the vertical; and

— in the presence of fog, the back-scatter profile emits a significant signal at the lowest levels. The signal then diminishes quickly and becomes unavailable. In such circumstances, the ceilometer cannot indicate the height of a cloud base, which may not even exist; it indicates either a conventional value below "30 m", or a vertical visibility value.

7.2.1.4 The first ceilometers were designed solely for aeronautical purposes and had a measurement range of 30 or 50 m to 1500 m (100 or 150 ft to 5000 ft). More recent ceilometers have a wider measurement range, from 30 m or less to 7000 m or more. The better performance of instruments and improvements in the way signals are processed have resulted in increased efficiency; low and medium level clouds are more easily detected, and certain high clouds may be detected as well.

7.2.2 Cloud cover

7.2.2.1 The United States, with ASOS systems, has developed an algorithm that makes it possible to calculate the cloud amount by analyzing the indications of the height of cloud bases over the last 30 minutes. This method and its limits are described further on.

7.2.2.2 There are also prototype cloud cover sensors based on the use of one or more infrared radiometers pointed successively towards different areas of the sky to determine the radiative temperature. This temperature is low when the sky is clear and higher when clouds are present; the (radiative) temperature of clouds decreases with altitude. It is however necessary to take the ambient temperature or real temperature profile into account: a cloud at 0°C can be close to the ground or at 3000 m, depending on the season and location. Such sensors, still being developed in 2003, cannot precisely indicate the altitude of clouds. However, they have the capability of indicating cloud cover without the disadvantage of the algorithm associated with a ceilometer, which can "see" only clouds passing above the ceilometer. They could detect the arrival or extent of a cloud layer right above a ceilometer and therefore usefully complete the information it provides.

7.2.2.3 There are also sensors that "photograph" the image of the sky reflected on a hemispherical dome or through a fish-eye optic. Analyzing the image can make it possible to detect the presence of clouds and calculate their extent, but this method works only during daytime, in visible light. At night, it would be necessary to use infrared instruments looking directly at the sky. This resembles the previous method.

7.2.3 Identifying CB and TCU clouds

7.2.3.1 CB/TCU clouds are identified visually and sometimes acoustically. A cumulonimbus can be buried in a cloud mass, without being directly identifiable by a human observer. Lightning and/or thunder indicate the presence of CB clouds.

7.2.3.2 A weather precipitation radar detects the presence of precipitation (and sometimes even clouds), and quantifies the intensity of precipitation. Very convective cloud cells are clearly visible and result in high reflectivity levels. A proposal is being examined by the WMO to define CB and TCU clouds, or more precisely convective clouds that are bothersome or dangerous to aircraft, using reflectivity levels. A disadvantage of this method is that high levels of reflectivity can also exist during disturbance periods with heavy precipitation, without the presence of CB/TCU clouds. The combination of radar images with infrared satellite images can fine-tune the diagnostic seen by satellite, since CB and TCU clouds have a large vertical extent so the temperature at their tops is low.

7.2.3.3 Radar and satellite images are commonly used by meteorological forecasters. Products adapted to convective phenomena are starting to be available to aeronautical users in certain countries. Development is underway in many countries to extract information on convective clouds from radar and satellite images and integrate it into METAR/SPECI messages and local reports. There are however coding difficulties, which will be described in the following section on algorithms. An objective definition of the area around the airport, in which CB/TCU clouds must be indicated, is also necessary. This area should perhaps be related to the area where a thunderstorm might be detected (TS or VCTS). Since a definition does not exist at present, it is very possible for the presence of CB clouds to be indicated by a human observer when he sees lightning, even if far away (a distance of 100 km is possible).

7.2.3.4 There are local sensors and/or networks that detect lightning and that can indicate the presence of lightning in a defined area corresponding to the TS and VCTS zone. Lightning indicates the presence of CB clouds. Unfortunately, for automatic detection based on this method, there are many cases (two out of three according to a study in France) where CB clouds are reported in a METAR, when there is no lightning at an airport or in its vicinity. Lightning detection can be used to detect CB clouds, but this method is not enough to correctly report on the absence or presence of such clouds.

7.2.3.5 There are also electric-field sensors (field generators) whose wide variations can indicate that a thunderstorm is approaching, but there are no reliable automatic algorithms that link the electric field to the presence of CB storm clouds.

7.3 Algorithms

7.3.1 Determining cloud layers using a ceilometer

7.3.1.1 Many algorithms developed by meteorological authorities and/or system designers are used throughout the world to calculate cloud layers using a ceilometer. It is difficult to "standardize" algorithms precisely, but all algorithms use the same method of calculation, developed by the United States with ASOS systems. This method was widely published by the United States and is described below.

7.3.1.2 A ceilometer usually provides data every 15 or 30 seconds. Individual data on cloud base height (or lack of cloud base) are used over a period of 30 minutes. To accelerate detection of a recent change, the last ten minutes are taken into account with a double weight in the algorithm. The basic principle of the algorithm is that the clouds passing above the ceilometer give a good indication of the cloud cover. The 30-minute period is a compromise between an integration that is long enough to be representative and short enough not to introduce a smoothing and a late detection of a variation that is too significant. Some countries use a longer period of one hour (Canada).

7.3.1.3 Individual detections are classified in intervals of 30, 60 or 150 metres (100, 200 or 500 ft) depending on the altitude, and they form a set of classes with a width and number of impacts within the width. There are usually several classes with a non zero number of impacts after this process, and the number must be reduced. Classification is made according to height.

7.3.1.4 -The method consists in grouping the classes that are the “closest”, until five or fewer are left.

To do this, a "distance" D is calculated between adjacent classes equal to - $\frac{N_1 N_2 (H_1 - H_2)^2}{N_1 + N_2}$ -, with (N_i, H_i),

the number of impacts in class i and its corresponding height. This "distance" is smaller when H_1 and H_2 are close and when N_1 and/or N_2 are small.

-
The algorithm calculates the distances D between adjacent classes and looks for the minimum value. Both classes corresponding to the minimum distance are grouped in the new weight class $N_1 + N_2$ and height class - $\frac{N_1 H_1 + N_2 H_2}{N_1 + N_2}$ -. The height five classes.

7.3.1.5 This number (five) is greater than the number of cloud layers that can be reported in local reports and METAR/SPECI messages, so it must be reduced. Reduction could be done using the same method as before, but this could cause a grouping of two very distinct classes in terms of height and the creation of a "ficticious" secondary layer. The limit of five classes is therefore a compromise based on tests and the experience of the algorithm's designers.

7.3.1.6 A grouping is made using the five (or fewer) previous classes if the difference in height between two classes is less than a given threshold, according to the height of the lowest class. Differences are greater for "higher" classes.

7.3.1.7 The limits used by the ASOS algorithm are:

-
-

Lowest height	Difference between two heights-
H -£- 300 m (1000 ft)	-£- 90 m (300 ft)-
300 m < H -£- 900 m (1000 ft < H -£- 3000 ft)-	£- 120 m (400 ft)-
900 m < H -£- 1500 m (3000 ft < H -£- 5000 ft)-	£- 180 m (600 ft)-
1500 m < H -£- 2400 m (5000 ft < H -£- 8000 ft)-	£- 300 m (1000 ft)-
H > 2400 m (8000 ft)	-£- 480 m (1600 ft)-

-

When this last grouping has been done, there may be 0 to 5 layers. For each layer weighing Ni, the algorithm calculates a number of equivalent oktas using the total number N of valid pulses taken into- account, using the formula - $\frac{N_i \times 8}{N}$ -.

7.3.1.8 If the first layer carries N_1 (N_1 impacts) and the second layer carries N_2 (N_2 impacts), the weight taken into account to calculate the number of oktas in the second layer will be $N_1 + N_2$, to account for the "obstruction" of the first layer. This reasoning is continued for the following layers. The number of oktas for each layer successive in altitude is increasing. It is then indicated as FEW, SCT, BKN or OVC. The absence of clouds is usually indicated by SKC, if the range of the ceilometer enables it to detect all types of clouds. If not, NCD is indicated (Annex 3, Part II, Chapter 4.9).

7.3.1.9 Cloud layers calculated this way can then be integrated, in ascending order according to height, in local reports and METAR/SPECI AUTO messages, by applying the rules in Annex 3:

— first layer FEW, SCT, BKN or OVC;

— second layer SCT, BKN or OVC; and

— third layer BKN or OVC.

This last coding limits the layers to three.
The algorithm also deals with specific cases:

— if after grouping has been done there are only very small layers (below 6 per cent of impacts possible in the 30-minute period, taking into account the double weights of the last 10 minutes), the layers are omitted;

— if the ceilometer indicates "invisible sky" or vertical visibility values, a specific process is used. Since it is not possible to mix cloud layers and vertical visibility values, the algorithm favours vertical visibility values (with a minimum amount) and can provide a vertical visibility diagnostic (VV/// or VVnnn, depending on the ceilometer's ability to indicate a real vertical visibility value and its reliability), except if there are layers over four oktas; and

— additional visibility data from a scatter meter can also be used to code a "invisible sky" and/or vertical visibility only when visibility is low (below 1500 m for example).

Algorithms used can vary from one State to another in terms of grouping thresholds or methods, but the principle remains the same.

7.3.2 Determining cloud layers using many ceilometers

7.3.2.1 If the aerodrome has many ceilometers, cloud layers must be calculated for each and therefore for each end of the runway, and the result must be indicated in local reports. For METAR/SPECI messages, the observation must be representative of the aerodrome and its vicinity, so all ceilometers available must be used to increase the validity of the measurement. One way of doing this is to integrate the measurements of each ceilometer in an algorithm such as described above, which will handle a greater number of base measurements.

7.3.3 Detecting the presence of CB or TCU clouds

7.3.3.1 A ceilometer, the only automatic sensor currently capable of measuring the height of a cloud base, cannot identify CB or TCU clouds. This identification can therefore only be done from a secondary source of observation. If this source is a human observer, the observation system's central computer must make it possible to enter cloud layers or modify layers calculated automatically and add the indication CB or TCU to some of these layers.

7.3.3.2 If this source is an automatic system, the information available probably indicates the presence or absence of very convective clouds, or CB or TCU clouds, without indicating the associated height, and probably without indicating cloud amount. This is the case, for example, if the source is a radar image analysis or the identification of CB clouds resulting from the presence of lightning. In this case, it is difficult to give the indication CB or TCU to an existing cloud group or to associate it with a cloud amount and height. For automatic systems that are not capable of detecting the presence or absence of CB or TCU clouds, Annex 3 recommends appending the symbol "///" to each cloud group to inform the user.

7.3.3.3 If detection is possible, the method used to associate the CB/TCU indication with one or more groups must be defined. A possible solution is to add a new group of "//////CB" or "/////TCU" type clouds.

7.3.4 Variability of parameters

7.3.4.1 Spatial and temporal variability of cloud parameters greatly depend on the meteorological situation, and sometimes on the site.

7.3.4.2 When the sky is completely clear or completely overcast, there are no temporal and spatial changes. A single ceilometer on a site is more than enough and an algorithm to calculate cloud layers as described above yields excellent results, when compared to a human observer.

7.3.4.3 When the sky is partially covered by cumulus, temporal variability above a given point (such as where a ceilometer is installed) is high. In fact, this is the variability used by the algorithm to calculate the amount of cloud layers. Evaluated over a 30-minute period, spatial variability is usually low throughout the aerodrome, except if there are marked terrain effects on the site. This can be the case with terrain contours nearby or with airports located on the sea front, where clouds often present a clear line between the shore and the water.

7.3.4.4 There are cases where there can be significant differences in cloud amount or height above different points of the aerodrome: a disturbance, advection fog, terrain effects. These cases do not occur often, except at certain sites that can require specific instruments. Rare cases occur over a short period during a transition phase, which is why the algorithm gives a double weight to the last 10 minutes.

7.3.4.5 So, except in specific sites identifiable by their climate, an automatic observation based on a single ceilometer is often representative of the aerodrome. This does not take away from the importance of having a ceilometer at each end of the runway in use, for conditions where cloud amount is not homogeneous at the airport and in its vicinity: This condition can be rare, but is dangerous for the pilot.

7.4 Sources of error and limitations

7.4.1 Height of cloud base

7.4.1.1 A ceilometer is very precise when there are clouds with a well defined base or a homogenous cloud layer. In fact, no other instrument performs better. This makes it difficult to truly evaluate the uncertainty of measurements. Comparing different ceilometer models is a way of evaluating the uncertainty of measurements, without really knowing the true value when there are differences. Many ceilometers have been compared over the last few years, starting with a comparison by the WMO in 1988-89.

7.4.1.2 Uncertainty is greater in cases of diffuse cloud bases or heavy precipitation. In this case, the ceilometer sometimes indicates a vertical visibility that is often close to the height of a cloud base measured before or after.

7.4.1.3 With precipitation, if the indication is of a cloud base, the height indicated is usually less than the actual base. This can cause problems in the aerodrome's operation, but it is safer to underestimate this value.

7.4.1.4 The information given by a ceilometer is currently the best estimate of the true height of cloud bases.

7.4.2 Vertical visibility

7.4.2.1 Some ceilometers provide vertical visibility in certain circumstances (or similar to the profile of the back-scattered signal). The validity of the vertical visibility value is difficult to establish.

7.4.2.2 First, the notion of "vertical visibility" is not clearly defined, as is now horizontal visibility in Annex 3 (the greater of the MOR value and the value of visibility from light sources of 1000 cd). In the case of vertical visibility reported in place of the height of a cloud base, the vertical visibility value is often low (between 30 and 200 m) and the decision to take into account or not a light source to calculate visibility is particularly important. For such values, there exists approximately a factor of 3 between contrast visibility (MOR) and visibility from light sources.

7.4.2.3 Second, it is very difficult for a human observer to estimate vertical visibility; vertical marks are required but do not exist (except at the foot of a tower). An aircraft could be a mark, in front of the runway threshold, but it would be a moving mark that could not be anticipated (since vertical visibility changes slowly). If an observer "views" at a vertical tower, he usually does so on a slant and his assessment is therefore falsified.

7.4.2.4 Nevertheless, certain States use the digital vertical visibility data provided by a ceilometer as the best possible information to meet ICAO recommendations. Other States, such as France, prefer limiting themselves to an invisible sky indication, without a digital indication of vertical visibility (VV/// coding).

7.4.3 Cloud cover

7.4.3.1 The disadvantage of the algorithm to calculate cloud layers using measurements from a ceilometer is that it depends on clouds passing above it. Extreme cases of a stationary isolated cumulous will lead to an OVC indication, but this case is not likely. It is more likely that the cloud amount may be underestimated or overestimated by category (FEW-SCT, SCT-BKN, BKN-OVC). Experience shows a greater occurence of OVC clouds with an automatic algorithm than with an observer. For a human observer, any gap in a cloud cover means that BKN must be indicated instead of OVC. There is a lower probability of detecting a gap using a ceilometer. A human observer also has a tendency to overestimate cloud cover when the sky is half covered (SCT-BKN transition). This effect has been documented by the United States under the name packing effect, due to the fact that certain holes in cloud covers cannot be seen because of the slant visibility effect. This bias caused by human observations is more significant when the observer is located far from the approach area (extension of the runway threshold), which is usually the case. With a slant observation, it is difficult for the observer to correctly estimate cloud cover in this area: if he is located 4 km from the middle marker (or from an equivalent point), clouds with an altitude of 400 m are seen from at an angle of 6°!

Example of packing effect

7.4.3.2 The automatic algorithm generates significant errors in cases of an advection cloud layer, which cannot be seen until it rises above the ceilometer. There can therefore be a delay in detection, which is limited to 10 minutes because of the double weighting of recent measures, on condition of course that cloud layers rise above the ceilometer.

7.4.3.3 One way of reducing this limitation is to combine the data from ceilometers with a cloud layer sensor based on the infrared observation of the sky. Developments are underway for such a combination.

7.4.4 -Identifying CB-TCU clouds-

7.4.4.1 For an observer, the presence of CB clouds can be detected visually (shape of cloud) or deduced from the occurrence of lightning or thunder. A CB cloud buried in a cloud mass can be invisible to an observer and not be signalled. If lightning is visually detected, CB clouds very far away can be detected and reported (whereas they should not be, since they are not in the vicinity). A human observation has specific characteristics that differ from those of an automatic detection based on the analysis of a radar image.

7.4.4.2 A weather observer is also often aware of the meteorological situation using radar images, satellites, forecast models, etc. His expertise can therefore indicate the presence of CB clouds even if they cannot be seen directly from the meteorological station.

7.4.4.3 An automatic detection of CB clouds is essentially based on the surpassing of radar reflectivity thresholds (for example 44 dBz), associated with a recognition of location cells. It is therefore necessary to set a maximum distance between the "centre" of the airport and a cell to identify the presence of CB clouds at an airport and in its vicinity. The smaller the distance, the greater the level of CB clouds detected by a human observer and undetected by an automatic analysis will be. Vice-versa, if there is a large distance, the level of CB clouds detected by an automatic analysis and not signalled by an observer will be high. French studies show that a distance of 30 km seems to be a compromise that optimizes the comparability of human and automatic detection. One of these studies shows that 25 per cent of CB clouds reported by an observer (in a METAR) are not signalled by an automatic analysis. This can seem very significant, but the same study indicates that half of CB clouds signalled by an automatic analysis are not "seen" by the observer. Either the automatic analysis falsely indicates CB clouds for a given area of high reflectivity, or the observer is unable to see one or more CB clouds buried in a cloud mass, for example. Furthermore, the same study reveals that if the distance is increased, the amount of CB clouds "not detected" by the automatic analysis is lower, which seems to indicate that, in certain circumstances, the human observer probably reports CB clouds that are far away.

7.4.4.4 The level of uncertainty of CB cloud detection depends heavily on how a CB cloud observation is defined. If the definition is based on a radar reflectivity level, a radar image (if available) will provide the best possible estimate.

7.4.4.5 Reporting TCU clouds is more difficult because of how a towering cumulus is identified. For an observer, a TCU cloud can be identified only when seen directly. For an isolated TCU cloud, a human observation is easy (during the day!). For a TCU cloud buried in a cloud mass, the observation is much more difficult from the ground.

7.4.4.6 With an automatic analysis of a radar image, the presence of TCU clouds can be determined by reflectivity levels lower than those of CB clouds. A French study showed that a threshold of 33 dBz is strongly linked to the effective diversion of aircraft because of a convective activity and could be a useful threshold for identifying the presence of TCU clouds, but with a detection rate three times greater than that of a human observation. There is a risk of "falsely" signalling TCU clouds during heavy precipitation, which are not necessarily related to a convective activity. But must importantly, any phenomenon that can hinder the pilot, even if it is not a TCU cloud, must be signalled.

7.4.5 Calibration and maintenance

7.4.5.1 A ceilometer "times" the back-scattered return signal. The stability of distance measurements is therefore linked to the stability of an oscillator, which is a very stable electronic element.

7.4.5.2 It is possible to check a sensor's range finding by aiming horizontally at a wall, at a distance recognized by the sensor. Such verification is not useful on site.

7.4.5.3 The mechanical construction of the instrument guarantees that, except in cases of mechanical shock, the optical axes of emitting and receiving optical beams do not move.

7.4.5.4 Optical surfaces must remain clean and clear. A heating mechanism inside the sensor keeps them free from condensation. The protective glass must not be contaminated since this could cause parasitic signals. Simply cleaning the surface by hand is enough. In case of snowfall, the protective glass must remain free of snow.

7.4.5.5 The life of the laser used depends on the sensor, and often has a shorter life span than the sensor itself; a drop in power reduces the range.

7.4.5.6 Ceilometers on the market have these internal surveillance parameters: heating, contamination, laser power, etc. and signal the state of sensors when emitting messages. There are usually three states: normal, warning and error, which make it possible to warn the user (warning) before automatically identifying the measurement as invalid (error). It is therefore important for the acquisition system to be designed to handle this diagnostic and maintenance information.

7.4.6 Location of measurements

7.4.6.1 Annex 3 recommends that cloud observations for METAR/SPECI messages be representative of the aerodrome and its vicinity, and that local reports be representative of the approach zone. For the approach zone, the best location is that of the middle marker, or the position equal to 900 or 1200 m from the runway threshold.

7.4.6.2 Local reports are used in real time, whereas METAR/SPECI messages are used outside the aerodrome, for flight preparation. It is important to favour the use in real time, and therefore the location where the middle marker is installed (or the equivalent location). Using these ceilometers for METAR messages is perfectly acceptable.

7.4.6.3 The location of ceilometers remains a recommendation. Installing a ceilometer at this location can sometimes be very costly because of the lack of power and/or the data transmission cable. In this case, another location must be chosen, such as the runway threshold where other visibility sensors and sometimes RVR sensors are installed. The disadvantage is a difference in observation at a given point and time during the transition phases of the cloud cover, but this difference is often acceptable. Strictly applying the location recommendation could, in the worst case scenario, lead to an airport that is not instrumented or not as well instrumented owing to costs. This would result in a lower service level, so a compromise must be found for the location in order to maximize the service level, taking into account the resources available.

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Chapter 8

Air Temperature and Dew Point Temperature

8.1 INTRODUCTION AND USE

8.1.1 The air and dew point temperatures must be representative of all the runways although a single value for each parameter is used for the aerodrome. Consequently, the measurements must be taken in an area considered representative of the aerodrome that is not subject to specific fluctuations due to the surrounding environment. The measurements must be taken in an open and naturally ventilated area.

8.1.2 Air and dew point temperatures are basic meteorological parameters that are used and required for: determining current weather conditions, preparing meteorological forecasts, lift calculations, icing forecasts, passenger information, etc.

8.1.3 The desired degree of precision is of ±1°C, which, with a few precautions, is an attainable value.

8.2 MEASUREMENT METHODS

8.2.1 Measurements are easily automated and have been automated for several years. The sensors must be protected by a shelter or screen.

8.3 TEMPERATURE SENSORS

8.3.1 Numerous principles of physics, associated with various types of sensors, can be applied to the measurement of temperature. There is a standard sensor covering the range of air temperature measurements that is strongly recommended due to its numerous benefits: the Pt100 platinum resistance probe, whose most common value of resistance is of 100 ohms (Ω) at 0°C. Probes with a resistance of

1000 W at 0°C are also used on occasion. IEC 60751[1] Class A compliant probes have an uncertainty factor of less than 0.2°C in the typical measurement range (-40°C to +60°C).

8.3.2 As platinum is a corrosion-proof metal, platinum wire probes have excellent stability over time, particularly when the platinum wire is well protected. It is therefore preferable to use a probe with proper mechanical protection. Sensors with corrosion-proof metal casings are used in France; these render the sensors virtually indestructible, with the exception of mechanical attacks. Experience has shown excellent stability, i.e., reliable to within 0.2°C over a 20-year period.

8.4 RELATIVE HUMIDITY SENSORS

8.4.1 The most economic and widespread method for determining the dew point temperature consists of measuring the air temperature and its relative humidity. The dew point temperature is then calculated based on these two parameters. Consequently, it is important that these two measurements be taken within the same screen to reflect the values of the same air sample. The calculation principles and recommended formulas are described in detail in the document World Meteorological Organization #8 and are not repeated here.

8.4.2 The majority of relative humidity sensors in use are capacitive hygrometers: a layer of copper covered with an organic substance and a metallic layer (gold) thin enough to be porous to water vapour. The resulting electric capacity fluctuates in accordance with the dielectric constant of the organic layer, which depends on the relative humidity. Though there are many impedance variation hygrometers on the market, they do not all support saturation, which can lead to major measurement drifts. It is therefore essential to use a sensor specifically designed to handle the saturated conditions that frequently occur within instrument screens. Such sensors are available for meteorological use.

8.4.3 Contrary to the statements sometimes issued by manufacturers, hygrometer uncertainty is at best 3 per cent and it generally ranges from 5 per cent to 6 per cent over the entire temperature and relative humidity range. The uncertainty factor is greater in near-saturation conditions. The corresponding uncertainty factor for the dew point depends on the relative humidity and the temperature. Table n specifies the dew point uncertainty factor with a 5 per cent relative humidity uncertainty factor at different temperatures and relative humidity levels.

Air temperature	RH=20%	RH = 40%	RH = 60%	RH=80%	RH = 100%
-20° C	2.3	1.3	0.8	0.7	0.6
0° C	2.7	1.5	1	0.8	0.8
30° C	3.3	1.8	1.3	1	0.9

Table of dew point uncertainty factors, in °C, with a 5 per cent relative humidity (RH) uncertainty factor.

8.4.4 Relative humidity sensors must be regularly calibrated in a laboratory, which is typically done on an annual basis. Calibration costs are often in the same range as the acquisition cost of a hygrometer.

[1] International Electrotechnical Commission Standards' Industrial platinum resistance thermometers

8.5 DEW POINT TEMPERATURE SENSORS

8.5.1 There are several types of direct dew point measurement sensors. Some are chilled-mirror sensors: a mirror is cooled (using Peltier effect modules) until dew or frost appears on the mirror. The frost is optically detected when a light beam directed at the mirror becomes scattered. A temperature probe (typically a Pt100) then measures the temperature of the mirror. For continuous measurements, the mirror temperature is regulated in order to obtain the dew point threshold.

8.5.2 Chilled-mirror dew point temperature sensors are often laboratory models. However, there are models that have been adapted for continuous outdoor use that can handle mirror pollution problems caused by dust.

8.5.3 Other sensors take relative humidity measurements while heating the air to prevent saturation. This makes it possible to take relative humidity measurements within a narrower humidity and temperature range, which results in a lower measurement uncertainty factor. An air temperature reading is taken near the relative humidity sensor and the dew point temperature is then calculated.

8.5.4 The uncertainty factor of a direct dew point temperature measurement is in the area of 0.5 to 1°C.

8.6 INSTRUMENT SCREEN

8.6.1 Sensors must absolutely be protected by a screen. Without a screen, temperature measurement errors can be as high as 20°C. The screen must protect the sensors from the effects of solar and terrestrial radiation as well as precipitation while providing adequate ventilation for the sensors.

8.6.2 There are artificially ventilated screens and passive, naturally ventilated screens. Screens are never neutral; they always have an impact on measurements. Well-designed forced ventilation screens provide greater benefits than passive screens. ISO standard 17714 specifies the general screen characteristics and describes how they can be controlled.

8.6.3 Even with a screen, air temperature measurement errors can be as high as 2°C. With passive screens, these errors often occur in strong solar radiation conditions coupled with poor ventilation. As for relative humidity, major errors can occur towards the end of fog or frost conditions when the screen remains wet or frosted. In such extreme conditions, relative humidity readings can be off by as much as 50 per cent, i.e., several °C for the dew point temperature. As for air temperature, measurement uncertainties associated with the screen are generally significantly higher than uncertainties associated with the sensor (Pt100) and the acquisition system. However, the desired ±1°C accuracy is attainable with a well-designed screen.

8.7 PARAMETER VARIABILITY

8.7.1 For both air and dew point temperatures, the atmospheric signal is a combination of the slow variations associated with the diurnal cycle and the eventual passage of disturbances and the rapid variations associated with turbulence and precipitation.

8.7.2 The screen's thermal mass can cause a sensor lag in relation to the atmospheric signal, which, in turn, will generate temporary measurement errors of several degrees. As these errors generally occur during rapid, and therefore short, variation phases, they do not significantly hinder the user.

8.7.3 In convective situations, there are rapid relative humidity variations that can reach 10 per cent within one minute; these will correspond with dew point temperature variations of several °C within one minute. Such variations generally occur in positive temperature situations and have little operational impact. They can, however, seem surprising to the user.

8.8 MEASUREMENT LOCATIONS

8.8.1 Measurements must be taken in a location deemed representative of the aerodrome. Care should be taken to avoid implementation in areas where local factors could lead to measurements that are not adequately representative of the aerodrome: parking lots, proximity to buildings and areas subject to jet blast. Beyond local effects, spatial variability is generally minor and does not justify taking multiple specific measurements in takeoff and landing areas.

8.8.2 Air and dew point temperature measurements are taken within a meteorological enclosure when one is available. It is recommended that these measurements be taken in an open area over natural, short-cropped ground. The WMO recommends a measurement height of 1.25 m to 2 m. The effective measurement height depends on national meteorological practices, which explains the range of height values specified by the WMO. It is important to maintain a height of at least 1.25 m, as the temperature gradient in relation to height increases in closer proximity to the ground. This could lead to measurements that are not adequately representative of the air temperature.

8.8.3 In areas where snow can accumulate on the ground, a system to raise or lower the screen is required to maintain a relatively constant height above the snow cover. If no such system is available, then the installation height for the screen must be increased to prevent the screen from becoming buried under a layer of snow. In such circumstances, a height higher than 2 m is acceptable as the temperature gradient for heights of 1.5 m to 5 m is low and generally remains below 1EC.

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Chapter 9

Pressure

9.1 UTILITY OF PRESSURE MEASUREMENT

9.1.1 Pressure is measured at the altitude of the barometer installation. All altitudes refer to mean sea level (MSL). The altitude of the barometer is not known by the users , i.e. the pilots. The value measured by the barometer must be used to calculate the useful parameters: QNH and QFEs.

9.1.2 QFE is the pressure reduced to an official aerodrome altitude, using the most appropriate profile of the atmosphere, thus taking in account, if necessary, the air temperature at the aerodrome. When set to a QFE altimeter setting, a altimeter will indicate height above the QFE reference level, and 0 when landed. The reference level for the computation of QFE should be the (official) aerodrome elevation. For non-precision approach runways with thresholds 2 m (7 ft) or more below the aerodrome elevation, and for precision approach runways, additional QFEs should refer to the relevant threshold elevation.

9.1.3 QNH is the pressure reduced to mean sea level (MSL), using the standard ICAO profile of the atmosphere (Standard Atmosphere). QNH gives a “normalized” information of pressure, independent of the altitude of measurement. Altimeters using the same standard profile can deduce the plane altitude above a given point, knowing the QNH of this point. When set to a QNH altimeter setting, a pressure type altimeter will indicate altitude above sea level and the official aerodrome altitude when landed.

9.2 QNH and QFE CALCULATIONS

9.2.1 Pbar, the pressure measured by the barometer must be expressed with a resolution equal or lower than 0.1 hPa. Computation of QNH and QFE values must be done with a resolution equal or lower than 0.1 Pha. Final and operational values of QNH and QFE are rounded down to the nearest lower whole hectopascal.

9.2.2 QFE is calculated first, taking in account the altitude differences between the official level of the aerodrome and the effective altitude of the barometer. This calculation can use the ICAO Standard Atmosphere (ICAO Doc 7488/3), using the effective air temperature at the time of calculation. For small altitude differences, a fixed value of the air temperature (15°C) can be used. Table n shows dP = QFE - Pbar for a difference of -10 m between the official level of the aerodrome (Href) and the level of the barometer (Hz), for several values of the air temperature. For realistic values of Href - Hz, the difference dP is proportional to the difference (Href - Hz). It can be seen that the effect of a temperature difference of 30°C relatively to +15°C is about 0.12 hPa. For small values of Href - Hz (let say < 10 m), the effective air temperature can be validly neglected for the calculation of QFE. For higher values, use of the effective air temperature is recommended.

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T	Dp (hPa)-
15°C	1.19-
-15°C	1.33-
+45°C	1.08-

Table n

Additional QFEs for relevant threshold elevations are calculated with the same procedure (using Pbar and Hthreshold - Hz). QNH is calculated from QFE of the aerodrome (at altitude Href), using the ICAO Standard Atmospheric profile (ICAO Doc 7488/3).

First, calculation of the equivalent altitude H in ICAO standard atmosphere:

$$H = 44330.77 - 11880.32 \times QFE^{0.190263}$$

And then

$$QNH = 1013.25 \times \left(1 - 0.0065 \times \frac{(H - H_{ref})}{288.15}\right)^{5.25588}$$

(numeric values have been calculated and rounded from formulae and values of different parameters described in ICAO Doc 7488/3).

9.3 ERROR SOURCES FOR PRESSURE MEASUREMENTS

Several potential sources of error for pressure measurements are identified for giving guidance to minimize them.

9.4 CALIBRATION OF BAROMETER

9.4.1 A barometer is an accurate sensor used for measuring absolute values with a resolution and accuracy of the order 0,1 hPa around values closed to 1000 hPa. So, a barometer is an instrument which must have a relative accuracy close to 10-4 (0.1 hPa/1000 hPa). This implies precautions for the sensitive element and the associated electronic. To avoid to add additional sources of uncertainties, it is recommended to use a barometer with a numerical output, thus eliminating further errors in an analog/numeric conversion by the automatic system.

9.4.2 If the barometer is installed outdoors, the stated accuracy must be maintained for the whole range of outdoor temperatures. This may implied calibration at different temperatures. When taking in account of temperature effects, repeatability and metrological factors, the attainable accuracy of good barometers is about ±0.3 hPa. To maintain accuracy in time, the barometer must be regularly calibrated. The periodicity of calibration depends on the characteristics of the barometer. With the current models on the market, it is not necessary to have a calibration periodicity smaller than 1 year. Longer periods are possible for some models. Some designs have several (2 or 3) sensitive elements within the same case, giving redundant raw measurements which can be cross-checked to detect a drift of a sensitive element when compared to others.

9.4.3 It is recommended to calibrate the instrument in a metrology laboratory. Nevertheless, a field check or even a field calibration is possible using adequate instrumentation: a portable transfer reference barometer with a pressure generator. For example, France controls (without adjustment) the barometer in the field every year with such a system and calibrates (with a possible adjustment) the barometer in laboratory every two years.

9.4.4 Even if the barometer is used outdoors, thus subject to temperature variations, the calibration can be reasonably made only at the laboratory temperature (usually 23°C ±1°C), considering that a potential drift of the temperature compensation stays low and can be neglected.

9.5 DYNAMIC PRESSURE DUE TO WIND SPEED

9.5.1 Movement of the air causes dynamic variations of pressure. The order of magnitude of dynamic pressure effects is about 0,3 hPa for wind speeds of 10 m/s and 1 hPa for wind speed of 20 m/s.

9.5.2 Static heads have been developed for outside installations and are available from several manufacturers. These pressure ports organize a buffer air volume to minimize dynamic pressure effects, which are reduced by a factor of 2 or more. Such static heads are recommended for barometers installed outside in locations subjects to frequent high winds.

9.5.3 Inside a building, dynamic pressure effects can also occurred, but they are much lower than outside. They depends on the configuration of the building itself, the location and nature of the openings, the direction of wind speed. Thus, it is not possible to give simple rules for the barometer location inside a building, except that it may be better to locate it inside a room not having a direct opening with outside. But this cannot be a rule.

9.5.4 A way to check if dynamic pressure effects influence the measurement is to analyze the variability of pressure on a small scale of time (let say 10 minutes). Variations greater than 0,2 hPa above the linear variation of pressure is an indicator of dynamic pressure effects. For example, France uses algorithms to automatically signals high pressure variability, and sudden abnormal pressure changes.

9.6 LOCATION OF THE BAROMETER

9.6.1 Considering temperature influence on the sensor and dynamic pressure effects, it is recommended to install the barometer indoors, when possible.

9.6.2 It is said in the literature (WMO Doc 8, CIMO guide) to not install a barometer in an air conditioned building or, if installed in a climatized room, to use a pressure port connected outside (or to a non-climatized place).

9.6.3 Using a pressure port may also cause problems. If it is connected directly outside, it can generate dynamic pressure errors, as previously mentioned. This may require a buffer volume to minimize these errors. The pressure connection also requires a tube, which must always stay open. This tube has generally a small diameter and presents a risk of obturation by dust, insects, spiders, etc… If the tube is obturated, the effect is dramatic on the pressure measurement. Within a fixed volume, variations of pressure are directly linked to variations of pressure: the barometer is transformed in a thermometer! A variation of

1°C gives a variation of about 3 hPa. So, the good idea of using a tube presents a risk, leading to much higher errors than errors due to air conditioning.

9.6.4 In fact, over or under pressure due to air conditioning remains quite low, lower than 0,1 hPa. In “white rooms” where a volunteer over pressure in maintained inside to avoid input of external particles, the overpressure in about 0,1 hPa only. Therefore, the problem of air conditioning is more theorical than practical. It is obvious that it is better to avoid the installation of the barometer inside a “sealed” building, nevertheless it can be done. And then, it is better to not use a pressure port with a tube subject to the risk of obturation. This tube is generally forgotten and not checked.

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Chapter 10

SUPPLEMENTARY INFORMATION

10.1 Annex 3 recommends adding information to local reports and/or METAR/SPECI messages:

- — recent weather (all messages);
- — significant meteorological phenomena in approach zones and climb-out zones, along with their location (local messages);
- — wind shear (all messages); and
- — sea surface temperature and state of sea (METAR/SPECI).

10.2 With an automatic system, supplementary information can be added only if the system is capable of reporting it.

10.3 An automatic system that provides present weather can and should provide information on recent weather observed at the aerodrome since the last report or during the last hour. Among these recent weather values, many can be reported by an automatic system, especially those concerning precipitation (RERA, RESN, REDZ, RESHRA, RESHSN) and possibly freezing precipitation (REFZDZ, REFZRA) and thunderstorms (RETS). The methods, characteristics and limits of the automatic observation of present weather are described in the " Present Weather" chapter.

10.4 When an automatic system is installed on an aeronautical platform at sea (designed for helicopters), it is recommended that sea surface temperature, which can be measured automatically, be included in METAR/SPECI messages. It is also recommended that the state of the sea be included according to code table 3700 from the WMO Code Manual (No. 306, Vol. I.1, Part A). The state of the sea is related to the wave height and can be automatically reported only if a measurement sensor exists. Swell gauges are instruments that measure wave height and wave periods, so it is technically possible to indicate the state of the sea.

10.5 Some airports can be equipped with upper wind measurement systems (wind profiler) capable of detecting wind shear. In this case, wind shear information should always be included in local reports and METAR/SPECI messages. There are also systems that detect wind shear based on multiple wind measurements (usually 12 to 16) taken from the ground at the aerodrome. These systems require that the site be surveyed beforehand. They produce warnings and alarms and provide digital or graphic information on terminals. They are usually installed at large airports and are not entirely automated. Nevertheless, they are a potential source for detection and automatic coding of wind shears in additional information from local reports and METAR/SPECI messages.

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Chapter 11

Integrated Measurement Systems

11.1 CATEGORIES OF INTEGRATED MEASUREMENT SYSTEMS

11.1.1 Measurement systems can vary in complexity from simple systems composed of sensors and dedicated displays to systems that manage several runways or that are capable of automatically coding METAR/SPECI and local messages.

11.1.2 Indicators are sometimes directly linked to sensors, especially when dealing with wind or pressure values. The simplest measurement systems can consist of wind, pressure, air temperature and humidity measurements. Some indicators can calculate the locally required parameters (mean wind speed over 2 minutes and maximum and minimum values, QNH and QFE, dew point temperature). With such indicators, simple systems consisting of a sensor and its dedicated displays can be enough for local information, without requiring a central processing unit. However, these systems alone cannot provide visibility and/or ceiling indications. They may be considered adequate for small aerodromes, where the control tower officer provides the pilot with information, but they cannot automatically code METAR/SPECI messages.

11.1.3 Caution is necessary when installing such systems. In fact, using a minimal system sometimes leads to neglecting the measurement clearance rules (particularly for wind) or the quality of sensors and their calibration. Mechanical barometers with needle gauges are sometimes used, but their metrological performance is much lower than recommended. Yet atmospheric pressure is particularly important for small aerodromes that do not have instrumented landing systems (ILS). It is also common to see wind measurements taken directly from the roof of the control tower, in conditions generating significant measurement errors.

11.1.4 The integrated systems have a central computer that combine all measurements, performs the necessary calculations and broadcasts the information. The local broadcast of parameters is then done on the same line or terminal, which gathers all required information and displays it where it is needed. With such systems, there is no need to have dedicated displays for each sensor, unless stipulated by local agreements regarding the visual comfort or installation of fail safe visual imagery systems. When specific indicators are used, they are often associated with wind measurements, and sometimes to pressure values (QNH/QFE).

11.1.5 The display of local information is therefore very often centralized on the same terminal. Two main possibilities exist:

a) the terminal can be part of the meteorological measurement system. In this case, an image is generated by the central computer, on an alphanumeric console or sometimes on a graphic console, which may include an outline chart of the aerodrome; and

b) the display is not part of the meteorological measurement system, which regularly broadcasts local reports to an outside display unit. For example, the unit can be one of the aerodrome's specific computers that can possibly display other useful information besides meteorological information to the controller.

11.1.6 At present, in partly automatic systems, measurements of wind, pressure and air and dew point temperature are always taken automatically. It is also possible to have one or more visibility measurement sensors, one or more ceilometers, or one or more sensors for RVR. A computer makes it possible to monitor measurements and complement them with a visual observation: visibility, cloud cover, type of clouds and present weather. With these complementary human observations, the system's computer does METAR/SPECI coding, and formats local reports.

11.1.7 In fully automatic systems, METAR/SPECI coding is automatic and messages contain the word "AUTO". Local reports are also coded automatically. In 2003, automatic systems cannot provide all the information required by Annex 3, so the coding is partial. Not all automatic systems offer the same possibilities, which depend on the instruments and algorithms used. It is therefore necessary to inform the user about the system's capabilities and limitations (*Aeronautical Information Services Manual* (Doc 8126)). This information can help define several system classes capable of providing different service levels. For example, the USA, with the ASOS systems installed in the 90s, defined 4 service levels that could be improved by adding a human observer. It is also possible to define several categories of automatic systems, depending on their capabilities.

11.1.8 The simplest systems measure wind, pressure values, air and dew point temperature. Such systems can provide useful information for small aerodromes, but their observation limitations preclude a valid automatic coding of METAR/SPECI messages.

11.1.9 Other automatic systems also use a scatter meter for visibility, a ceilometer for cloud height base and for estimating cloud amount, and a sensor (or group of sensors) for present weather. This means they can provide the visibility, cloud layer and present weather parameters, but they are limited when it comes to representing visibility measured from a single point, the validity of cloud layers indicated by a ceilometer and different types of present weather that can be displayed. The capabilities and limitations are discussed in the following chapters. A great weakness is the fact that the presence of CB or TCU convective clouds cannot be observed. However, such systems are designed to code METAR/SPECI AUTO and local reports. They are used for small aerodromes, and sometimes in conjunction with a human observer, during specified times. Most ASOS systems in the USA are examples of such systems.

11.1.10 More complete automatic systems can use multiple sensors for visibility, sometimes several ceilometers for clouds, complementary sensors for present weather (local flash detectors or information from a lightning measurement network), and information from a weather radar to detect the presence of convection clouds. RVR calculations can also be made. With such systems, METAR/SPECI AUTO coding can resemble the coding required by Annex 3. The capabilities of complete systems depend on the sensors and algorithms used. There will be progress in the coming years, which may produce observations that are complete and reliable enough to no longer require the key word AUTO in METAR/SPECI code forms.

11.1.11 In any case, whatever the capabilities and limitations of a system, it is important not to forget paragraph 4.1.13 of Annex 3: "…, the specific value of any of the elements given in a report shall be understood by the recipient to be the best approximation of the actual conditions at the time of observation".

11.1.12 It is true that in some fields, an automatic system has fewer capabilities than a human observer. There is often more documentation on the limitations of an automatic system than the limitations of a system that uses a human observer, which is sometimes, by definition, considered perfect-but that is not always the case. Visibility is an example: an observer located in a foggy area (in a fog bank, for example), cannot identify the conditions of a runway threshold by himself/herself if he/she cannot see it.

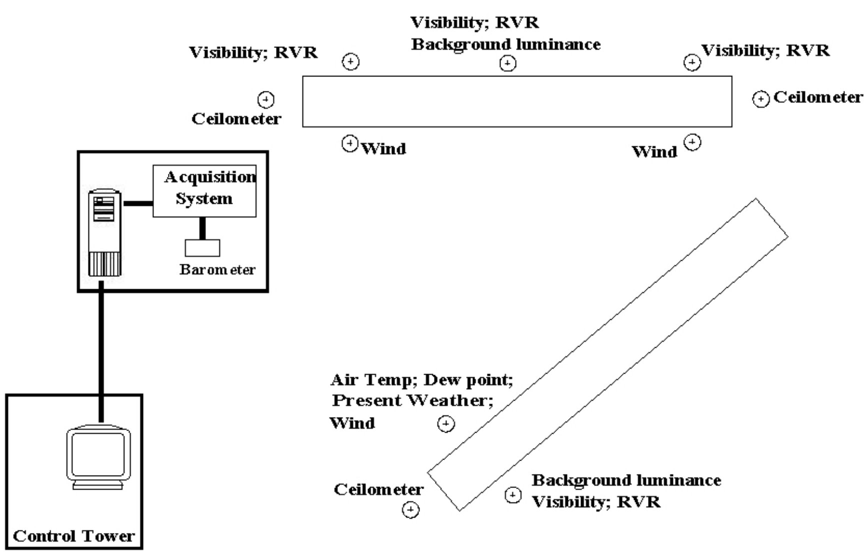
11.1.13 The information from an automatic system is sometimes more objective, since it is more clearly defined and reproducible than information from a human observer.

11.1.14 An automatic system and a human observer do not use the same observation methods, so they cannot always be compared directly. For example, analyzing signals from a ceilometer aimed vertically to determine cloud layers sometimes gives wrong results. This can also be the case, but for different reasons, with night-time human observations. It goes to show that the performance of an automatic system cannot be judged by comparing it directly to what a human observer would do, but rather by the overall quality of the service provided to the aeronautical user.

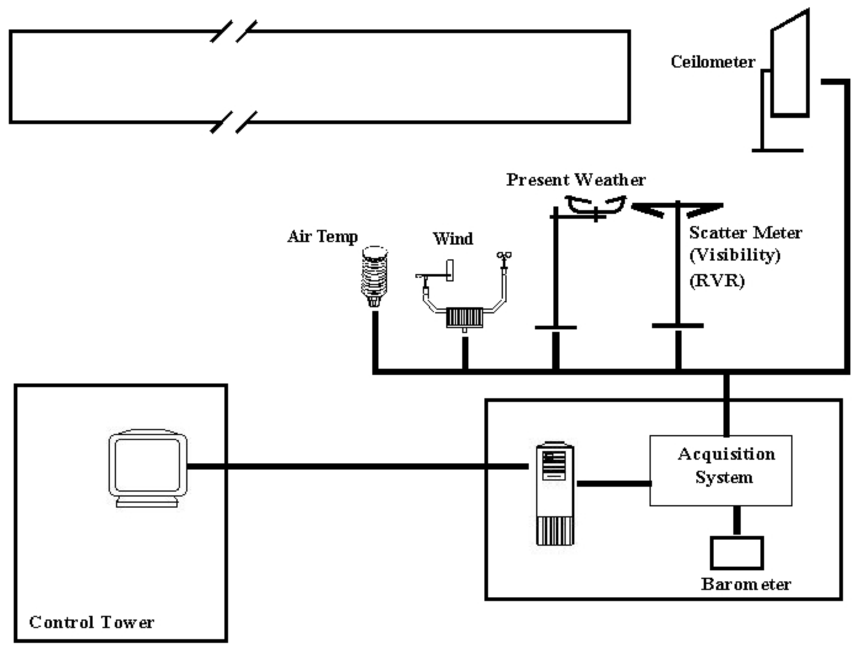
11.1.15 Examples of diagrams of various systems:

Simple system with pressure, T, Td, and wind sensors. ASOS-type auto system with wind, T, Td, pressure, scatter metre, telemeter and present weather.

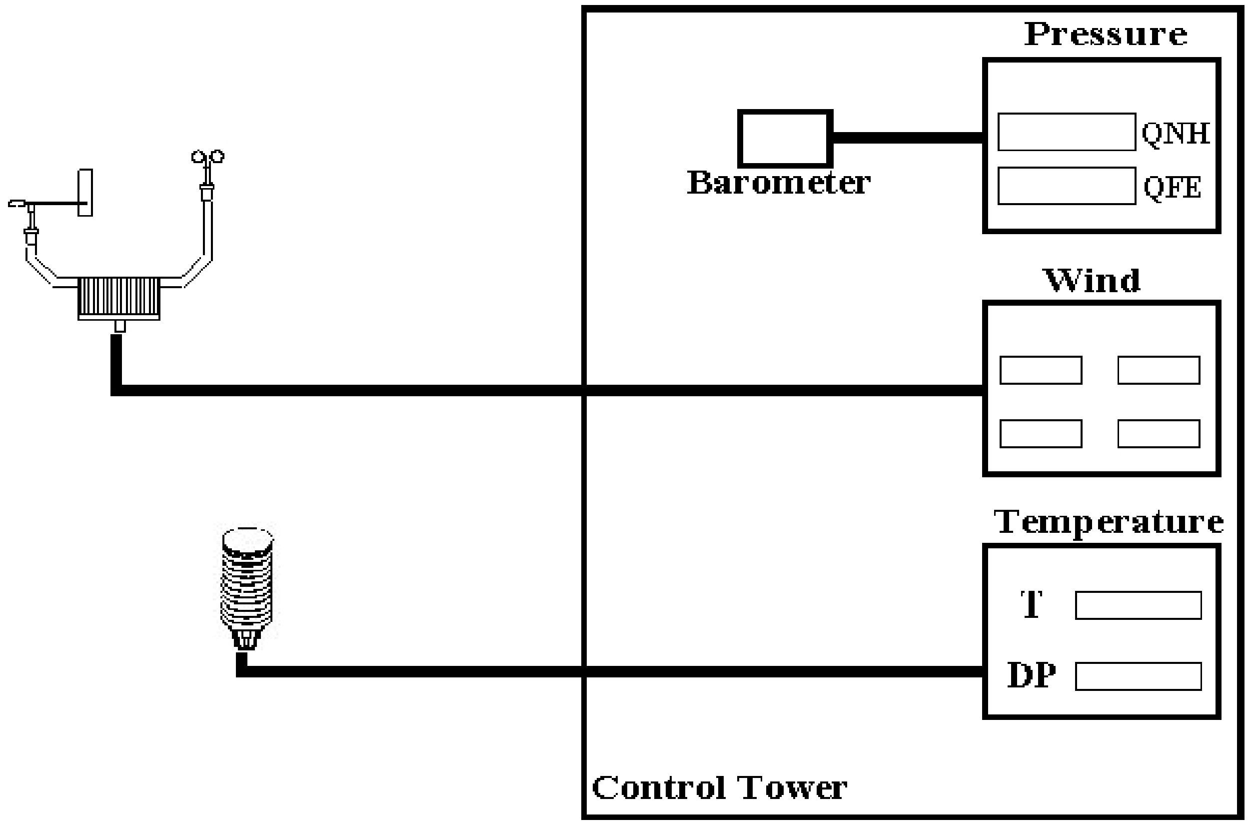
Complete system with wind, T, Td, pressure, several scatter metres for visibility and RNR, telemeter(s), present weather, outside lightning information and radar.



Complete system with wind, temperature, pressure, several scatter metres for visibility and RVR, ceilometer(s), present weather, and possibly external lightning information and radar.



ASOS-type automatic system, with wind, temperature, pressure, scatter metre, ceilometer and present weather.



Simple system with pressure, temperature, wind sensors and dedicated displays.

11.2 CALCULATION OF METEOROLOGICAL PARAMETERS

11.2.1 Some meteorological parameters are given directly by a sensor (air temperature, for example), and others require calculations generally done by a central computer. So the algorithms have to be well-known and must follow the recommendations or standards in Annex 3, if any, or the WMO recommendations. This manual provides guidelines and references.

11.3 ARCHIVING OF DATA

11.3.1 Older measurement systems often had graphic recorders. Automated systems can record measured and calculated information, and information from a human observer, in numeric form, during a defined period.

11.3.2 An archive of information broadcast for local use is recommended. In France, this information is usually archived over a period of time of one month. If an incident or accident is reported during this period, the data are saved and kept for an investigation. The amount of information to archive is perfectly compatible with existing data processing methods.

11.4 DATA ACQUISITION TECHNIQUES

11.4.1 To provide a representative sample, meteorological sensors are sometimes spread out over the aerodrome. The information must then be transmitted to one of the system's central computer.

11.4.2 Analog signals from sensors should not be transported over a long distance, to avoid data loss and corruption. It is better to convert analog signals into digital signals at the sensor site, or to have an acquisition system in a meteorological enclosure close to the sensors.

11.4.3 Many sensors now provide digital output, particularly complex sensors such as scatter metres, ceilometer or present weather sensors, which have to process raw signals.

11.4.4 The central computer is therefore fed by one or more “digital” lines. These are, depending on the system builder and the infrastructures available at the airport: telephone lines and modems, telephone lines and RS485 current loops, fibre optics and radio transmissions. The methods used must also take into account protection against electromagnetic discharge. The techniques used should be robust and must often adapt to the transmission lines available at the aerodrome. Note that the cost of installing a cable can be a lot higher than the cost of the sensor itself.

11.5 PERFORMANCE CHECK AND MAINTENANCE

11.5.1 It is normal practice to check the operation of instruments, sensors, computers and data systems at regular intervals, and to carry out maintenance. The maintenance constraints and periodicity depend on the type of instruments used, local conditions and the manufacturer's recommendations.

11.5.2 The constraints specific to the different instruments are explained in greater detail in the chapters corresponding to the parameters.

11.5.3 There should be preventive and corrective maintenance plans for each sensor and for the entire system. All elements of an automatic system can malfunction or break down. Some sensors are currently capable of giving warnings of reduced performance before actually breaking down. For example: battery voltage, contamination of optical surfaces, radiating power of a laser diode and comparison of redundant measurements. Having a central computer makes it possible to perform cross checks between parameters to detect possible anomalies or drifts. If many sensors measuring the same type of parameter (meteorological optical range, for example) are installed, it is useful to statistically examine their variances.

11.5.4 Maintenance should be organized so that intervention time frames and the likelihood of successful repair can be predicted. Successful repair depends on the expertise of maintenance staff and on the availability and location of spare parts. Some sensors should be duplicated, as should the actual data acquisition and processing system, particularly at large aerodromes. Duplication leads to greater safety and reduces the burden on maintenance staff and, therefore, could be a valid economical alternative.

11.6 BROADCAST FREQUENCY

11.6.1 METAR messages must be broadcast every hour and sometimes every half-hour, according to regional procedures.

11.6.2 SPECI messages must be broadcast according to deterioration and improvement criteria defined in Annex 3. Automatic detection of SPECI conditions from measured information is possible. The USA's experience with ASOS systems shows that automatic detection results in many more SPECIs (about three times more) than when the SPECI conditions are determined by a human observer. A human observer uses his knowledge of the meteorological situation and his analytical abilities to avoid multiple SPECI codings due to a deterioration, followed by an improvement, then another deterioration. Despite the 10-minute time frame required to take an improvement into account, an automatic system stays close to the criteria and generates more messages. An airport with multiple RVR equipment is likely to see RVR limits overstepped several times, for deteriorations and improvements, by the different sensors. A human observer, on the other hand, sorts the information mentally and thus limits the number of SPECIs.

11.6.3 In Europe, a regional agreement makes it possible not to code SPECI messages if METAR are being coded every half-hour. This simplifies the behaviour of an automatic system which may not need to handle SPECI if coding half-hour METAR.

11.6.4 Local reports contain parameters very variable in time, such as wind, visibility and RVR, so messages need to be broadcast very frequently. A one-minute frequency is acceptable. Most parameters must represent a period of at least one minute. If they are calculated according to one-minute intervals, which is often the case, it is not necessary to broadcast the information more often. Certain parameters, such as wind, can be calculated using a greater frequency. A broadcast rate greater than one minute is then possible, particularly if the broadcast is done on a channel specifically for wind (dedicated display). If the broadcast is done on a single channel, with all the information, a one-minute period is a good compromise. A longer period must be avoided.

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Chapter 12

REMOTE SENSING

12.1 Introduction and use

12.1.1 Annex 3 does not deal much with remote sensing methods for meteorological observations, but some systems offer interesting possibilities for pilots and aeronautical users. However, there is an obstacle to getting the most out of the information they offer and that is the current method used to broadcast meteorological information: local reports and METAR/SPECI messages. The advantage of these reports is that they are simple, clearly defined and therefore recognized by the various people in the aeronautical industry. METAR/SPECI messages can also be broadcast by all transmission media, even the most simple or crude, which is useful when communication infrastructures are poor. The trouble is that information is lost when data from remote sensing systems is reduced to a few characters in an alphanumeric message. Nevertheless, this process is sometimes necessary to access information easily. A typical example of this problem is the detection of convective cells using a precipitation radar from which information can be extracted on the presence of CB/TCU clouds (see cloud chapter), but a radar image prepared to show these major reflectivity zones contains more detailed information on the extent of the zone, and its movement and severity. This would therefore be very useful for both the pilot and control officer, who could anticipate possible diversions. Such observation methods are sometimes used but are not currently standardized.

12.1.2 This chapter will describe the possibilities of certain remote sensing systems.

12.2 Measurement methods and potentials

12.2.1 Radar images

12.2.1.1 The use of radar images to detect and locate highly convective zones was discussed in the “Clouds” chapter.

12.2.1.2 A radar image or a radar image composite is not always perfect and can contains errors such as echoes from stationary objects, extremely widespread echoes or a bright band (liquid/solid transition). Techniques used to reduce these errors cannot be described here; researchers around the world are looking for solutions. A "raw" image must often be interpreted by a professional meteorologist and does not always meet aeronautical operational needs. Rather than using a "raw" image, it is more effective to prepare an image that can more easily be used as is. France is experimenting and using such a product with four reflectivity thresholds and a smoothing of convective zones, with the possibility of superimposing lightning information. This product makes it possible for control officers, through their knowledge of high reflectivity zones, to anticipate the possible deviation of aircraft, which often have their own onboard radar providing analogue information. This sort of image therefore contains much more extensive information than the presence or absence of CB clouds in a METAR, though local reports and METAR/SPECI messages are still important in identifying cloud type.

12.2.2 Lightning network

12.2.2.1 There are networks that detect the impact of lightning based on its electromagnetic signature. The time of detection of a lightning bolt's electromagnetic pulse is measured by a sensor network, which locates the lightning. The most widely-used technology detects cloud-ground lightning with a precision of location that depends on the density of the network and its topology, and that can, for example, reach 1 km, with sensors spaced at 200 km. More localized cloud-ground and intra-cloud lightning detection systems also exist.

12.2.2.2 This type of network is the best way of determining the electric activity associated with thunderstorms and is a valuable complementary tool for meteorologists, situation analyses and forecasts. It makes it possible to locate electrical activity in real time with excellent precision of location (at airport level). This information makes it possible to report to an automatic system the presence of a thunderstorm at the airport or in its vicinity. The technical difficulty lies in transmitting the information in real time from the central computer of a lightning network to an automatic observation system at the airport. Luckily, the evolution of communication media is offering more and more technical possibilities. Developments consisting in using information from a lightning network to report present weather TS (or VCTS) and possibly the presence of CB clouds in local and METAR reports are underway in many States.

12.2.3 Satellite images

12.2.3.1 Satellite images are very useful for meteorological analyses and forecasts. At the local level, they make it possible to better determine the meteorological situation. Infrared images allow the measurement of the temperature at the top of clouds and, combined with high radar reflectivities, the identification of thunderstorm cells. This is because CB (and TCU) clouds extend a long way vertically, so their cloud top is high and cold. Instruments that automatically identify thunderstorm cells have been developed in some countries and can be used, along with radar images, to identify cloud type.

12.2.3.2 Using satellite images with various wave lengths also makes it possible to detect low cloud zones and/or fog (it is difficult to distinguish between low clouds and fog). These images are an important tool in helping to write forecasts (TAFs), but for the moment are not used directly for local observations or METAR messages.

12.2.4 Wind profilers

12.2.4.1 These measure the vertical profile of upper wind. They can be useful for sites subject to upper wind shear.

12.2.4.2 There are two types of wind profiler: ultrasound (SODAR) or electromagnetic waves (UHF radar). An antenna system emits pulses in several vertical directions. Part of the signal emitted is back-scattered by small inhomogeneities in the atmosphere (such as variations in the refractive index), to the antenna system, now serving as a receiver. The time the signal takes to return determines the distance. The frequency of the signal shifts according to the radial movement of the atmospheric zone that back-scattered the signal (Doppler effect). The combination of radial speeds in the different pulse directions (at least three) makes it possible to calculate the horizontal speed in different altitude bands.

12.2.4.3 These instruments can calculate high-frequency profiles, every 10 minutes for example, ensuring a follow-up in real time. Profiles can contain errors caused by parasitic signals, so filtering algorithms are required. These algorithms mostly use the preceding profiles to monitor the temporal coherence of successive profiles. The output of such systems is typically a temporal succession of wind profiles represented as vectors. It is possible to set wind shear thresholds to extract a synthetic indication that can be used locally by the control officer and possibly included in a METAR/SPECI as an additional observation.

12.2.5 Lidar

12.2.5.1 A lidar emits a laser light pulse and analyses the return signal back-scattered by the atmosphere in one or more directions, from which it can deduce the wind, the extinction coefficient and other parameters. A slant measurement from a distance would make it possible to measure the wind above the runway or in the approach zone. Unfortunately, the optical signal must not be reduced by clouds or fog, in which case the instrument is blinded and its usefulness diminished. Slant visibility could possibly be measured, but with limitations and performances difficult to assess. This type of instrument is expensive and is used only for research. A laser ceilometer is a specific lidar designed to detect clouds, so being blinded behind a cloud is not a problem.

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Chapter 13

QUALITY ASSURANCE

13.1 Annex 3 (Chapter 2.2) recommends a quality management system guaranteeing that the products and services are appropriate to the needs of aeronautical users.

13.2 Quality management should follow ISO 9000 version 2000, details of which cannot be given here. Suffice it to say that beyond ensuring that products and services match needs, these standards introduce the idea of continuous quality improvement.

13.3 A system of quality management does not exist to respond to user needs at any price. These needs must be translated into realistic goals, known to and accepted by the user. Products and services must be adapted to the goals, and there must be a way of measuring whether the goals have been achieved. Finally, faults must be corrected, bearing in mind the limits of the quality management system.

13.4 Here is the general scheme:

— know client's requirements;

— identify the processes set up to respond to these requirements;

— define the goals of the various processes;

— have clients accept these goals (or renegotiate);

— set up methods to achieve the goals;

— measure achievement of goals and set up appropriate indicators;

— follow up performance and identify and treat anomalies;

— assess client satisfaction;

— take corrective and preventive action; and

— link the different operations with a view to continuous quality improvement (Plan - Do - Check - Act).

13.5 In the case of an automatic aerodrome observation system, the scheme is roughly as follows:

— know the requirements of aeronautical users. Annex 3 provides the basis for meteorological observation;

— identify and document the processes of production, management and support in relation to aeronautical meteorological observation;

— define the goals: capacities of an automatic system, associated performances, reliability sought, acceptable and unacceptable timeframes for repair service;

— have users accept goals (or renegotiate) and send if required an official notification of difference (AIC, Doc. 8126). A lack of money or personnel (in the case of human observation) might mean that systems and/or observation methods are installed that do not satisfy all the ICAO standards and recommendations. This can for example lead to a disagreement over service levels between the meteorological authority and the national aeronautical administration. Quality must depend on a clear definition of the possibilities and limits of the systems and of the associated services;

— make sure the goals are achieved, i.e. define human maintenance, spare parts, preventive maintenance, etc. The rules and solutions are many and cannot be given here; the essential is that they be defined and assessed. This is particularly important for automatic systems, which can easily be "forgotten" precisely because they are automatic. This applies especially to simple systems at small aerodromes, where the financial means for observation might be reduced;

— the calibration and maintenance frequency are also defined;

— measure achievement of goals and set up appropriate indicators;

— ·follow up performance and identify and treat anomalies, measure user satisfaction and actions for quality improvement;

— assess user satisfaction regarding the service of automatic systems, in terms both of local observation and METAR/SPECI and of the follow up permitted by the system, to ensure the necessary forecasting. Reports are not only for users, but are also an important element in supporting the production of TAF and the TREND; and

— take corrective and preventive action. This means improving the system over its lifetime in order to increase capacity and decrease the limitations. This is particularly important for automatic observation systems, which cannot yet fulfill all the requirements in Annex 3.

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APPENDIX F

LIST OF TASKS FOR FUTURE WORK OF THE AERODROME METEOROLOGICAL OBSERVING SYSTEMS STUDY GROUP (AMOSSG)

The AMOSSG is envisaged to assist the Secretariat in pursuing the specific tasks as follows:

TASK No.	TASK	REFERENCE	ESTIMATED DATE FOR COMPLETION	RESPONSIBILITY (LEAD IN BOLD)	NOTE ON PROGRESS
1.	Consider the need for harmonizing the criteria for issuance of SPECI and those for including change groups in TAF	MET Div Rec 2/3	Amendment 74	AMOSSG, Secretary	~~To be discussed at AMOSSG/4~~ Draft amendment at AMOSSG/5
2.	Study the expansion of the use of fully automated observations during operational hours	MET Div Rec 2/3	Amendment 74	AMOSSG, Working group, Secretary	~~To be discussed at AMOSSG/4~~ Draft amendment at AMOSSG/5
3.	Update the desirable forecast accuracy ~~requirements~~ and amend Attachment E to Annex 3 if necessary	ANC 136-18	Amendment 74	AMOSSG, Saad Secretary	~~To be discussed at AMOSSG/4~~ Awaiting response from WMO
4.	Study the operational feasibility and desirability of requiring a greater accuracy in the first 3 hours of a TAF, possibly by limiting the use of PROB	ANC 137-16	Amendment 74	AMOSSG, Henry Secretary	To be discussed at AMOSSG/~~4~~5
5.	Monitor the use of modern observing techniques (e.g. remote sensing)	AMOSSG/1 – SoD, 4.4.1 a); 4.4.3	Ongoing	~~Michel~~AMOSSG	~~a~~ proposals, as necessary, expected for AMOSSG/~~4~~5
6.	Revise the weather phenomena to be reported under "present weather" and "recent weather"	AMOSSG/1 – SoD, 5.3.1 c)	end 200~~3~~4	~~Earle, Benoit, Kevin, Pete, Will~~ AMOSSG	~~initial proposal presented at the AMOSSG/2;~~ to be re-addressed at AMOSSG/~~4~~5
~~7.~~	~~Monitor results from research on the automatic detection of cloud types~~	~~AMOSSG/1 – SoD, 5.3.1 c)~~	~~Ongoing~~	~~AMOSSG~~	

TASK No.	TASK	REFERENCE	ESTIMATED DATE FOR COMPLETION	RESPONSIBILITY (LEAD IN BOLD)	NOTE ON PROGRESS
8.	Finalize the assessment of the capability of AWS to meet the expected future requirements	AMOSSG/1 – SoD, 6.2.2 b)	Ongoing	AMOSSG	assessments carried out at ~~the AMOSSG/1, AMOSSG/2 and AMOSSG/3~~all meetings
9.	Revise the definition of "VC"	AMOSSG/1 – SoD, 5.3.1 d)	Amendment 74	AMOSSG, Secretary	~~Further consideration at AMOSSG/4 following MET Div Rec 2/3~~ Draft amendment at AMOSSG/5
10.	Prepare guidance material	AMOSSG/1 – SoD, 5.3.1 e) MET Div Rec 2/2	~~Initial draft by AMOSSG/4 Meeting~~ 2004	AMOSSG, ~~consultant~~Secretary	~~draft outline presented at the AMOSSG/2; to be discussed at AMOSSG/4~~ Comments by end October 2003
11.	Monitor States' progress in forecasting RVR	COM/MET/8 2, MET/AOP PT Eur Region	Ongoing	AMOSSG	Depends upon input from States and MET/AOP PT
12.	Update the attainable accuracy of observation and measurement in Annex 3, Attachment B	ANC 153-9	Amendment 74	~~WMO~~Saad, AMOSSG, Secretary	A proposal from WMO for AMOSSG/5
13.	Enable the use of the BUFR code form for the exchange of METAR/SPECI and TAF	MET Div 2/5	Initial phase Amendment 74, completion Amendment 76	~~WMO~~Saad, AMOSSG, Secretary	WMO plan, enabling clause for AMOSSG/5
14.	Consider the need for provisions concerning the display of cloud base height in ATS units	EANPG/44	Amendment 74	AMOSSG, Secretary	Draft amendment for AMOSSG/5
15.	Consider the need for provisions or guidance material to cater for the reporting of gusts in the calculation of crosswind and tailwind	EANPG/44	Amendment 74	AMOSSG. Dennis Secretary	Draft amendment for AMOSSG/5 if necessary

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