VISIBILITY CHAIN AT REGIONAL CIVIL AIRPORTS IN THE NETHERLAND

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ABSTRACT

Visibility (visibility for aeronautical purposes, VIS) and the related quantity Runway Visible Range (RVR) are meteorological parameters that are crucial for the operations at an airport. The introduction of the so-called AUTO METAR system at regional airports in the Netherlands automated the measurements and reporting of all meteorological parameters including visibility. During the evaluation of the AUTO METAR system several questions related to visibility arose, which eventually led to an analysis and the description of the visibility chain. This paper describes the entire chain of visibility ranging from definitions, measurements, sensors, calibration, sensor usage, derivations, backup rules, to data available to the aeronautical users. The main purpose of this document is to give insight in the visibility chain used at Rotterdam The Hague Airport. The situation at other regional civil airports in the Netherlands sometimes differs, mainly as a result of differences in instrumentation. The paper gives many recommendations that are either related to indistinctness, omissions or inconsistencies in the ICAO and WMO requirements and recommendations; KNMI practices deviating from these requirements and recommendations; or have another background. The recommendations are being discussed and evaluated by a KNMI expert team. For example the KNMI practices deviating from the ICAO and WMO requirements and recommendations are often historic of nature, i.e. KNMI kept in line with former specifications or the practices at airports. These items need to be reconsidered and verified with parties involved and then either solved or, if kept, documented and communicated.

1. INTRODUCTION

Observations are crucial for meteorology and climatology. Generally measurements are required not only on a local or national scale but on an international or even global scale. In order to ensure that the observations are consistent and of uniform quality guidelines and recommendations such as reported in WMO (2008 and 2010) are essential. These guidelines concern the observations in general and include the characteristics of the sensors or measurement techniques, the measurement setup and siting, the acquisition, processing and dissemination of the information. Often refinements on a national level or for specific applications are in place. For example in the Netherlands the observations are documented in KNMI (2005) and various other documents related to specific sensors or systems. For aeronautical applications ICAO (2010) gives recommendations on the measurements, including the position of sensors, the processing of data, and the information to be available to the aeronautical users.

The observation infrastructure at KNMI is not structurally compared to the requirements and recommendations or available documentation on a regular basis. When making changes to or renewal of the observation infrastructure the specifications of the old system and/or sensors are updated, but sometimes the current situation is taken for granted, particularly for systems that are outside the scope. In communication with users it is generally stated that the observations are compliant to WMO and ICAO requirements and recommendations although no regular verification is performed by KNMI. Often information is available within KNMI, but distributed over various departments or experts, and therefore not readily available and also not verifiable. After the introduction of the so-called AUTO METAR system at regional airports in the Netherlands the

aeronautical observations were performed fully automated. During the evaluation of the AUTO METAR system, performed internally as well as by external parties, several questions related to the observations were put forward. Often the questions required an explanation of the current situation following ICAO requirements and recommendations, but sometimes it turned out that the handling or background of the observations deviated from the requirements and recommendations and/or KNMI documentation.

Since many questions were related to visibility it was decided to review the entire visibility chain for a regional civil airport. Hence the entire chain of visibility ranging from definitions, measurements, sensors, calibration, sensor usage, derivations, backup rules, to data available to the aeronautical users was investigated and compared against international recommendations and KNMI documentation. The visibility chain of Rotterdam The Hague Airport has been documented in a KNMI internal report (Wauben, 2012). In this paper an overview of the results is presented.

2. DESCRIPTION OF RESULTS

The description below follows the sections of the KNMI internal report. For details the reader is referred to the internal report. Contrary to what the name of the publication series might suggest the internal report is publicly [available](). Here only a brief overview of the contents and the findings is presented.

It should be noted that some crucial deviations that were found during the review were fixed immediately and have therefore not been included in the internal report. Changes that were made included some bugs in the reporting software and the software configuration. Also the backup of aeronautical visibility at touchdown that is reported in the local MET reports by the sensor at the opposite end of the runway was disabled and the averaging of the 10-minute averaged aeronautical visibility was changed to take into account the so-called marked discontinuity.

2.1. Introduction

This section gives a brief background on the importance of visibility for aviation and the AUTO METAR system that KNMI employs at civil airports in the Netherlands.

2.2. Sources of meteorological information for users

The meteorological observations are provided to users via various channels: (i) a half hourly AUTO METAR; (ii) automated local MET reports consisting of a half hourly AUTO local routine report (AUTO ACTUAL) with AUTO local special reports (AUTO SPECIAL) in between if specific criteria are met; (iii) processed sensor information is made available; (iv) information that is provided by the aeronautical meteorological forecaster (AMF) to Air Traffic Control (ATC) orally during daily briefing or in case of specific situations.

2.3. Definitions of visibility

The different parameters related to visibility, i.e. Meteorological Optical Range (MOR), visibility for aeronautical purposes (VIS) and Runway Visible Range (RVR) are introduced. MOR is the basic physical parameter of "visibility" that is inversely proportional to the atmospheric extinction (m^{-1}). VIS and RVR at nighttime and during twilight is the greatest distance at which lights can be seen and identified against the background. For VIS a lamp with a luminous intensity of 1000 cd is used whereas RVR uses the actual light intensity of the runway lamps. A light source is visible when the illuminance exceeds the illumination threshold which is a function of the background luminance (BL).

KNMI uses MOR for synoptical and climatological purposes and VIS and RVR for aeronautical purposes. Users often don't realize that different definitions for visibility are used and hence that values can be different.

2.4. Causes of visibility reductions

The visibility is always restricted to some extend by scattering and absorption of light by atmospheric particles suspended or falling through the atmosphere. Mist and fog are the primary

causes for significant visibility restrictions in The Netherlands. In addition heavy precipitation and particularly snow can cause reduced visibility. The visibility reduction caused by lithometeors is generally small in the Netherlands although sand and dust storms can lead to significant reductions in arid and desert areas during periods with substantial wind speeds.

2.5. Visibility requirements

The requirements for range, resolution and accuracy of the MOR, VIS and RVR measurements are summarized in the table below.

Table 1: Reporting range and resolution, and the uncertainty required for visibility related parameters in SYNOP, METAR and local MET reports, including AUTO reports.

MOR (SYNOP Vm, VV)		VIS (METAR/ACTUAL VVVV)		RVR (METAR/ACTUAL $V_RV_RV_RV_R$)	
Range (Step)	Accuracy	Range (Step)	Accuracy	Range (Step)	Accuracy
0-100 m (10)	-	0-800 m (50)	*	50-400 m (25)	±10 m
100-5000 m (100)	*	800-5000 m (100)	*	400-800 m (50)	±25 m
5-30 km (1)	±20 %	5-10 km (1)	±20 %	800-1500 m (100)	±10 %
30-70 km (5)	±20 %	≥10 km		1500-2000[#] m (100)	±10 %
>70 km				>2 km	

[*]MOR and VIS accuracy: ±50 m for MOR≤600m; ±10 % for 600<MOR≤1500m; and ±20 % for MOR>1500m.

[#]RVR is reported up to 2000 m at civil airports, but up to 3000 m at military airbases in The Netherlands (KNMI, 1994). Note that RVR values outside the range are reported as M0050 and P2000 or P3000.

KNMI uses a national code 5975Vm (KNMI, 1994) for reporting the horizontal visibility below 100 m in steps of 10 m in the SYNOP, but its accuracy is not specified.

WMO (2008) specifies the range of RVR as 10 to 1500 m, whereas ICAO (2010) recommends a RVR range from 50 to 2000 m.

The requirements for the background luminance are not clearly stated. The range is only given in examples and ICAO (2006) only mentions that an uncertainty of ±10 % is considered acceptable.

2.6. Sensors for the measurement of MOR

Transmissometers and forward scatter sensors can be used to measure the MOR. The measurement principle and characteristics of both types of sensor are reported. KNMI uses forward scatter sensors operationally because they are less expensive than transmissometers, require less maintenance, and can report higher visibility values accurately.

The MOR range of the FD12P is 10 m to 50 km and the accuracy is given as ±10 % for MOR below 10 km and ±20 % for higher values. The range of the background luminance sensor is 2 to 40,000 cd/m^2 and the accuracy is ±10 %.

2.7. Calibration of MOR measurements

KNMI uses a field reference setup consisting of a transmissometer and a forward scatter sensor. The transmissometer is calibrated with neutral density filters with a known transmittance. The calibration of the optical signal of the FD12P is performed by means of a so-called scatter plate. The field setup is used to make sure that the MOR of the FD12P is within the required uncertainty limits from the MOR of the transmissometer for MOR values up to 1500 m. In case a deviation of 10 % or more is detected the calibration of the FD12P is adjusted by an appropriate change of the prescribed value of the scatter plate that compensates for the observed differences in MOR. The background luminance sensor is verified against a field calibrator that can be mounted in front of the background luminance sensor. The deviation should be within ±2 %. The field calibrator is returned to the manufacturer every five years for a recalibration.

The field calibration is restricted to MOR values up to 1500 m and does not include precipitation. Since the scattering properties of the suspended droplets in fog differ from those of precipitation and other suspended particles, the relation between scattering and extinction may differ. Furthermore the linearity of the sensor over the MOR range is not verified.

The traceability of the calibration of the background luminance sensor needs to be verified.

2.8. Maintenance and effect of contamination

Optical visibility sensors are susceptible for contamination. In order to assure correct performance of the visibility measurements a maintenance interval of 2 months is used for the FD12P sensors at airports. This interval is based on experience, but the development of contamination can change rapidly under specific situations. The FD12P measures the window backscatter and in case the backscatter warning limit is exceeded additional maintenance is performed. Note that the window backscatter measured by the FD12P is not used for compensation of the lens contamination.

Contamination on the lenses will generally reduce the signal and lead to higher values of MOR. Objects in the sample volume enhance the scattered signal and hence reduce MOR. Objects that cause such reduced MOR values are spider rags, especially in combination with dew, and flying insects. The first generally gives a constant signal that cannot be distinguished from the continuous MOR signal. During humid and windy conditions it can sometimes be noted as faulty precipitation, but generally it shows up as too low MOR values during good visibility conditions. Flying insects in the sample volume can give significant reductions of the MOR at some locations especially around sunrise and sunset in summer and autumn. The insects show up internally in the optical signal of the FD12P as individual spikes when the insect traverses the sample volume. In contrast to precipitation the insect signal does not coincide with enhanced values of the wetness detector. Therefore it is possible to identify the spikes caused by insects and omit them during the calculation of MOR.

2.9. Sensor locations

RVR cannot be measured on the runway itself, but is measured on grass along the runway. The runway is made of concrete or asphalt. The resulting temperature differences can affect the distribution and density of fog along the runway. The visibility is furthermore affected by the aircraft themselves via turbulence and the exhaust gasses. The spatial variability of the visibility is the main source of error when the visibility is not homogenous. ICAO (2005) gives detailed information on the position of the RVR sensors at airports. KNMI complies with these recommendations. CAT III runways at Schiphol are minimally equipped with 3 visibility sensors at the touchdown, mid and end position and more in case of a displaced threshold or when the separation between the visibility sensors along the runway exceeds 1500 m. For the CAT I runway at Rotterdam The Hague Airport only one visibility sensor at touchdown is required, but since the runway can be used from both directions a visibility sensor is located at both ends of the runways.
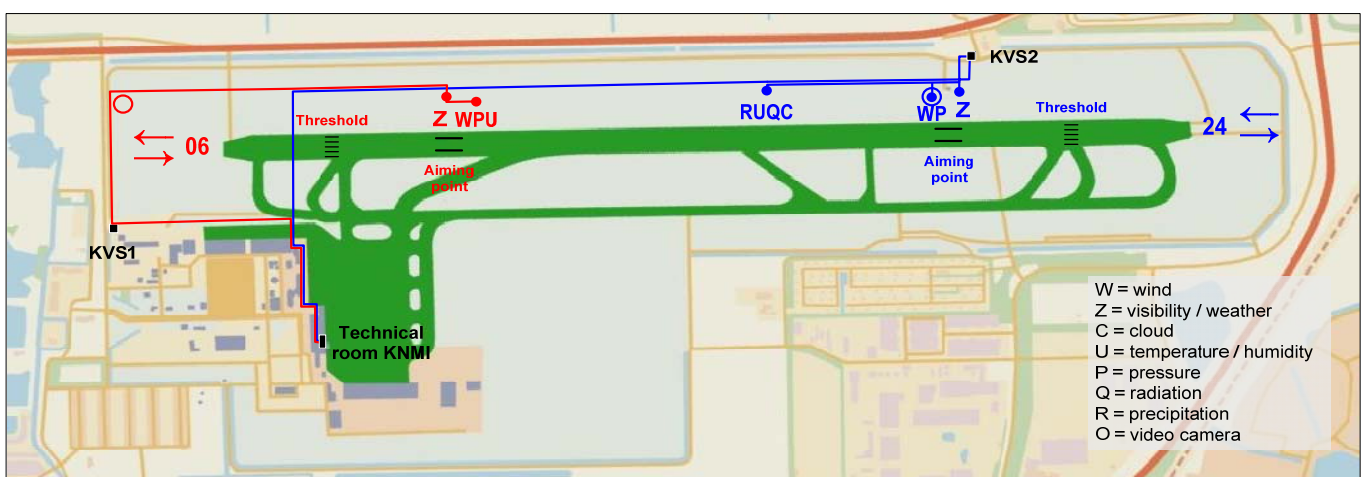

Figure 1: The position of the meteorological sensors and video cameras at Rotterdam The Hague Airport. The sensors and cameras associated to touchdown 06 and 24 and their respective relay station (KVS) and data communication line to the technical room of KNMI at the airport are shown in red and blue, respectively. The measurement field not only contains temperature and humidity sensors and a ceilometer for cloud observations, but also a rain gauge and a global radiation sensor for synoptic purposes.

Only one background luminance sensor is required at an airport by ICAO. The use of two or more background luminance sensors is preferable for redundancy. Both of the FD12P sensors at Rotterdam The Hague Airport are equipped with a background luminance sensor, since the KNMI policy is to place a background luminance sensor at each available touchdown position.

Video cameras are installed at Rotterdam The Hague Airport in the wind mast near 24 touchdown at a height of approximately 2 m and 9 m. The pair of cameras in the wind mast has been installed to facilitate the detection or identification of patches of fog and shallow fog. An additional camera is installed at 2.5 m height 500 m before the threshold of runway 06. Note that the cameras cannot be used to estimate the visibility accurately. They mainly serve as a verification tool for the aeronautical meteorological forecaster or as a means to check the meteorological situation. KNMI is not satisfied with the quality of the current video camera system. An update of the system is considered including a camera on the ATC tower so that good visibility conditions exceeding 3 km can be determined from the images using suitable visibility markers.

2.10. SIAM sensor interface and MUF cascade

All sensors are operated by KNMI in combination with a so-called SIAM sensor interface. A SIAM communicates with the sensor and converts the sensor output into meteorological quantities including status information in a fixed serial format. The sensors and SIAM sensor interfaces are installed in the field and are connected via fixed copper lines to a nearby relay station of ATC (KVS) which also supplies the no-break power supply. A relay station typically serves half of the runway. The SIAM information of all sensors arriving at a KVS are multiplexed and put on one serial line to the airport server system. The information from the sensor at the other end of the runway is multiplexed and forwarded via another serial line to the server. Note that the information of the Runway Information System (RIS) of ATC, which indicates which runway is in use, is also fed as a SIAM string into the MUF cascade. In the technical room all incoming information is duplicated by splitters, multiplexed onto a single line and given to the server pair for further processing.
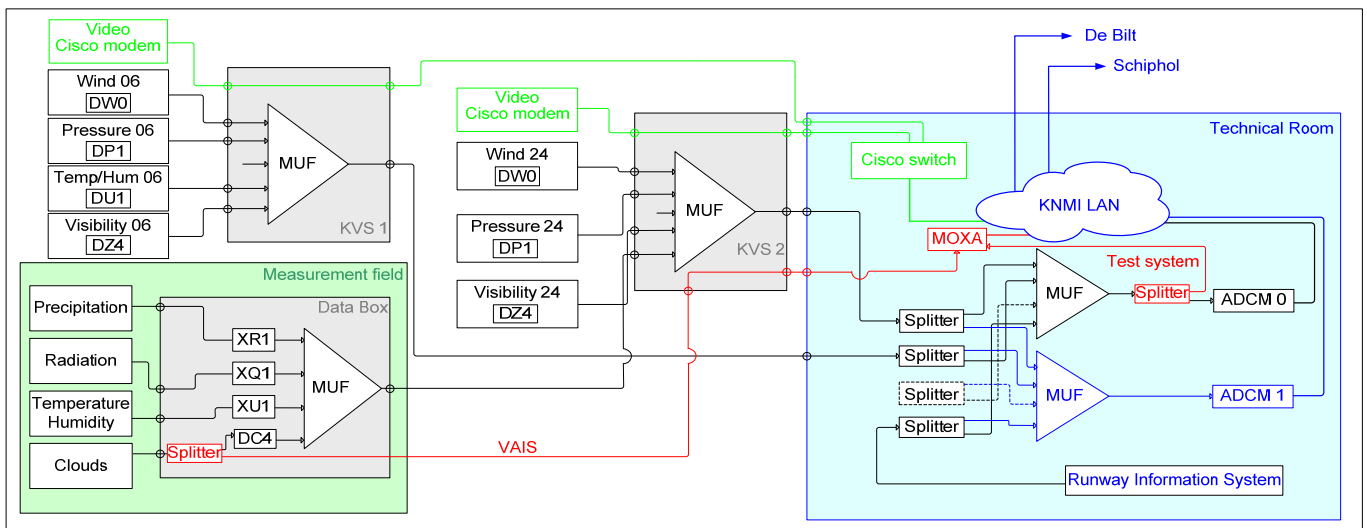

Figure 2: Overview of the sensors and SIAMs and splitters in the MUF cascade at Rotterdam The Hague Airport. Black line and boxes denote connections and components with a single point of failure. Blue lines and boxes show the secondary server system with associated sensor data. The video cameras components are denoted in green and the sensor data that is forwarded to the test server system in De Bilt is shown in red. The backscatter information of the ceilometer that is forwarded to De Bilt for monitoring of volcanic ash is also given in red.

2.11. Server and client network systems

In normal operation one of the server systems is hot and ingests and processes all sensor data. The backup server gets a copy of all data from the hot server and continually checks whether the other server is alive. If not it takes over. Client systems can be located anywhere on the network

and connect to the hot server. Client systems are used to monitor the system and sensor status, view the measurements and derived products, validate and complement the meteorological reports and change the system configuration. The functionality depends on the user group and is password protected. A separate server pair that gets a copy of all data is used to handle the data requests for local users at the aerodrome. All network components at an airport are duplicated and all servers connect to both. The servers are located at the airport so that continued operation is independent of the WAN connection to the central facilities of KNMI in De Bilt.

2.12. System monitoring and data validation

The visibility sensor and the SIAM sensor interface perform a first real-time validation step of the measurements. The FD12P checks for the correct functioning of its modules as well as the intensity of the optical transmitter and the sensitivity of the optical receiver. Furthermore the contamination of the lenses is monitored and blocking of the optical path is determined. Since the visibility can vary rapidly in time, the sensor interface can only check whether the reported MOR is within the sensor range and that the information received from the sensor is complete and compliant with the manufacturer's data format. The result of the checks of the sensor and the sensor interface are available as status information in the measurement network.

An operator monitors the correct functioning of all crucial KNMI systems continuously. In case of malfunctions service staff can be alerted. The operator is supported by various tools that facilitate the monitoring of the correct operation of crucial server systems and the availability of sensors and sensor information. KNMI service staff monitors the sensor status of the entire network on a daily basis using the SIAM status information. Based on this information corrective or preventive maintenance is planned. If e.g. contamination of the lenses is reported then an additional maintenance visit is made to clean the lenses. A real-time check of the sensor status and output is made during and after maintenance has been performed. If a sensor fails, or if the sensor produces an error status, then action is taken according to the Service Level Agreement which is part of the ISO 9001-2008 certified quality management system of KNMI. The importance and hence the priority of the maintenance of the visibility sensor depends on the (expected) visibility. If required corrective maintenance will be applied on a 24*7 basis.

2.13. Continuous remote verification

A near real-time verification of the validity of the meteorological information is performed by the aeronautical meteorological forecaster. The validation is performed by using the information from other nearby visibility sensors, by consulting the video camera images at the airport and by considering the general meteorological conditions using other information sources. The aeronautical meteorological forecaster has also access to near real-time data from other airports, off-shore platforms and automated weather stations that are part of the observation network, as well as satellite and weather model information. Contact between the aeronautical meteorological forecaster and local staff of the airport or air traffic control can be established in order to give information or feedback on the current and upcoming meteorological conditions. Note that the aeronautical meteorological forecaster can force sensors to fault so that the sensor data is disabled or, if applicable, the backup is used and can overrule the information reported in the aeronautical reports orally. The aeronautical meteorological forecaster also adds the TREND, a landing forecast with a validity of 2 hours, to the meteorological reports.

2.14. Derivation of VIS and RVR

The derivation of VIS and RVR is described in this section. VIS and RVR are calculated for the touchdown and end positions of runway 06 and 24 separately. VIS is calculated using the MOR and BL sensor at the position of interest, whereas RVR uses the MOR sensor at the position of interest in combination with the background luminance sensor at touchdown. The reason for the latter is related to the fact that in the past the background luminance sensor was oriented parallel to the runway so that the background luminance as experienced by the pilot during landing was measured. However, since currently all BL sensors are oriented North the BL usage for RVR calculations should be reconsidered.
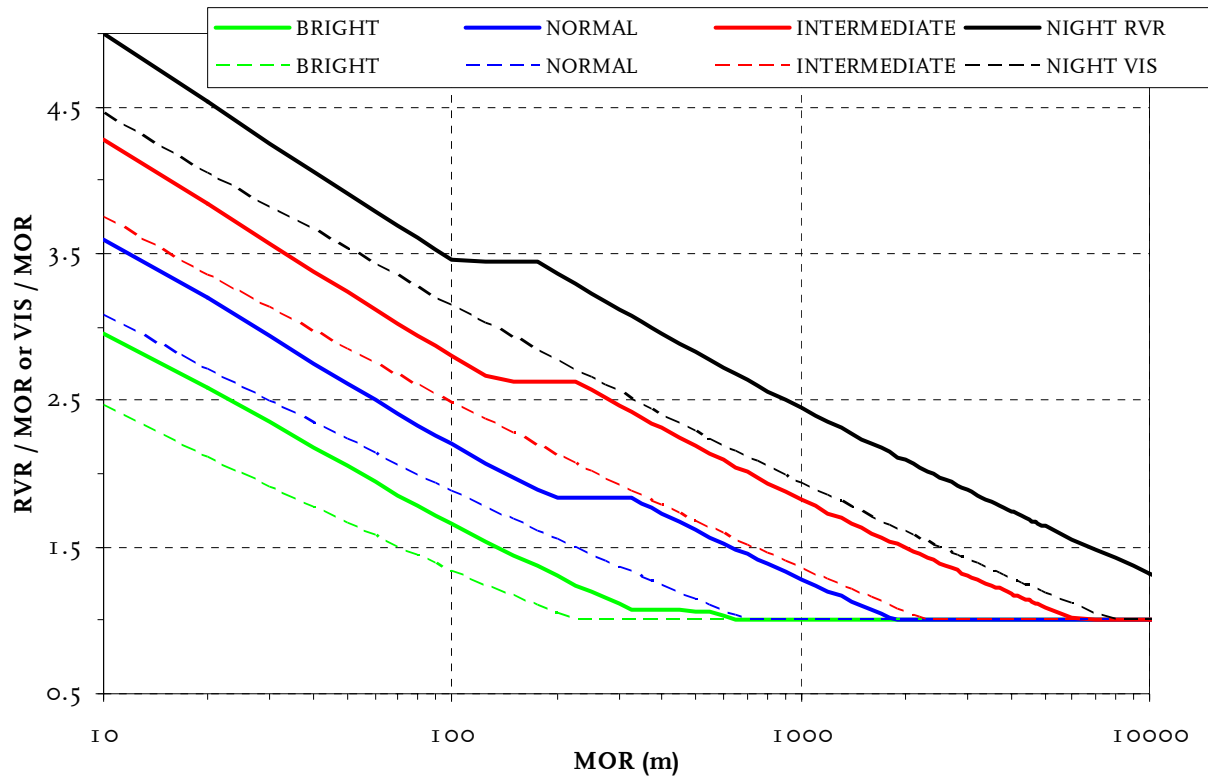
Figure 3: The ratio of RVR to MOR and VIS to MOR as a function of the MOR for four atmospheric brightness conditions.

The ratio between RVR and MOR can be as large as 4 during low visibility at night. The ratio is less for VIS and both ratios decrease with increasing MOR and increasing background luminance.

The RVR and VIS calculation does not entire follow the ICAO recommendations. Differences are the resolution of the coefficients in the relationship for the illumination threshold which are reported in 2 to 4 significant digits in the documentation; the lower limit of 8.10^{-7} lux for the illumination threshold is not used; 350 and 600 m are used as the boundaries for the transition from centre to edge lights instead of 200 and 500 m; and a general runway light intensity table is used in the RVR calculation and not the actual runway light characteristics.

2.15. Averaging of VIS and RVR

For aeronautical purposes 1- and 10-minute averaged VIS and RVR are required. The 1-minute averaged values are generally used for the AUTO local MET reports and 10-minute averaged values are used in the AUTO METAR. The calculation of the 1-minute averaged VIS and RVR is straightforward. The calculation of the 10-minute averaged VIS and RVR is more complex since it needs to take a so-called marked discontinuity into account. A marked discontinuity is an abrupt and sustained change in VIS or RVR, lasting at least 2 minutes, which reaches or passes through criteria for the issuance of an AUTO SPECIAL report. In case of a marked discontinuity only the VIS or RVR values after the marked discontinuity are used in calculating the mean. When a marked discontinuity occurs the 10-minute averaged VIS or RVR are in fact 2-minute averaged values. Next, the 2-minute interval is gradually increased at each subsequent update interval until the maximum interval of 10-minute is reached or a new marked discontinuity occurs.

KNMI uses the 10-minute averaged VIS in the local MET reports instead of the 1-minute averaged VIS as recommended by ICAO.

RVR is not included directly in the local MET reports. If one or more of the 10-minute averaged VIS or RVR values at the airport is below 1500 m a flag is set in the local MET report. When the flag is set ATC starts requesting all 10-minute averaged VIS and 1-minute averaged RVR values.

The AUTO SPECIAL thresholds for VIS are 800, 1500, 3000, 5000 and 8000 m (note that the last criterion is not specified by ICAO, but by local agreement) and the thresholds for RVR are 150, 350, 600 and 800 m.

The RVR tendency is determined from the current value of the 10-minute averaged RVR and the value 10 minutes ago whereas ICAO specifies using the two 5-minute averaged RVR values obtained by splitting the last 10-minute interval in two.

Note that KNMI calculates the minimum and maximum RVR from the extremes of the RVR sample values in the past 10 minutes, whereas ICAO specifies using the extremes of the 1-minute running averaged RVR values.

The special cases for minimum VIS (report prevailing VIS and minimum VIS if possible with indication of the direction with respect to the aerodrome reference point when the latter is below 1500 m or less than 50 % of the prevailing VIS) and fluctuating VIS (criterion not specified, but is only relevant for manual observations) in the AUTO METAR are not used by KNMI.

2.16. Selection and backup of VIS and RVR

Runway 06/24 of Rotterdam The Hague Airport is equipped with a FD12P forward scatter visibility sensor with background luminance sensor at the touchdown zones of runway 06 and runway 24. Since runways 06 and 24 are used for CAT I operations only a single visibility sensor at touchdown position, the so-called "A" position, is required. The same sensor is used for reporting the VIS and RVR in the AUTO local routine and AUTO local special reports, regardless whether the runway is used for arrival or departure. In fact the local MET reports at regional airports only produce a report for arrival. Only at Amsterdam Airport Schiphol, where different runways are in use for arrival and departure, separate local reports for arrival and departure are generated. The Runway Information System of ATC provides real-time information on which runway is in use. This is used to automatically select the RVR and VIS of the runway in use that are reported in the AUTO METAR and the AUTO local MET reports, respectively. When the runway changes an AUTO local special report is issued.

The visibility reported in the AUTO METAR uses the VIS reported by sensor of 24 touchdown with the VIS of the sensor at 06 touchdown as backup. A backup of the RVR is not allowed since the RVR should be representative for the touchdown zone. Similarly the VIS reported in the AUTO local reports has no backup. When the RVR is not available the runway cannot be used for instrument precision approach and landing operations, except under so-called Visual Flight Rules (VFR) conditions. The issue in case of a malfunction of a visibility sensor at Rotterdam The Hague Airport is whether VFR conditions are applicable or not, i.e. concerning visibility whether it can be correctly assessed that VIS exceeds 5 km or not. In such a situation the aeronautical meteorological forecaster decides whether VFR visibility conditions apply by using all information available. In case of doubt the meteorological situation is verified with local staff of the airport or ATC. This is facilitated by asking closed questions, e.g. whether visibility marker "X" can be seen or not, since KNMI is still responsible for the reported visibility. When VFR conditions apply, then the visibility reported by the visibility sensor at the opposite end of the runway is used instead and is reported orally to the users. Naturally the failure is handled by KNMI service staff according to the agreed response time as stated in the service level agreement. Note that during such a malfunction of the visibility sensor at touchdown the runway can still be approached from the other side for instrument precision approach and landing operations. Since the capacity of a runway is not an issue at regional airports and the meteorological conditions, particularly wind, during low visibility generally put no further restrictions on the runway use, except possible noise abatement regulations, such a change in the approach of the runway can generally be facilitated.

KNMI reports the 10-minute averaged VIS of a selected sensor in the AUTO METAR instead of the prevailing VIS as recommended by ICAO.

Currently no discrimination between VFR (VIS above 5km) and Special VFR (VIS between 3 and 5 km) conditions is made in the backup procedure for visibility.

The quality of the video camera system and the lack of suitable visibility markers limit the backup procedure of the aeronautical meteorological forecaster.

2.17. Available VIS and RVR variables

About 75 different variables related to visibility are available at the meteorological server systems. These include the MOR and BL data received from the sensor interface, the derived VIS and RVR variables for various averaging intervals and their extremes. Furthermore variables for backed up

elements are available (VIS only). The variables are generally available for four locations (24 and 06 touchdown and end position) and have a 12-second update period. However, the variables are also available for the runway in use, which contains the runway dependent VIS and RVR that are copied from the appropriate location. Some visibility variables have a 1-minute update, for example variables that are used for synoptical purposes and in the determination of the weather and vertical visibility. Lastly, there are visibility related variables that are directly related to the information in the AUTO METAR and AUTO local MET reports. These variables contain the proposed and confirmed values that are used for generating the reports and checking the criteria for issuing an AUTO local special report.

Most of the variables are stored in the database and are therefore available to the aeronautical users. The variables that are used by ATC have been specified in order to make sure that the correct variables are used and to notify ATC in case of upcoming changes. It is also common practice to make these variables easily available on the client systems for meteorologists and maintenance staff of KNMI.

2.18. Meteorological reports

In this section the AUTO METAR and AUTO local MET report are described. The code is given as well as the related screens on the client systems that are used to generate the report and the variables that are used.

KNMI does not use NDV in reporting VIS in the AUTO METAR although ICAO states that when visibility sensors are used and they are sited in such a manner that no directional variations can be given, the abbreviation NDV shall be appended to the visibility reported. Directional variation in visibility is also not reported.

The VIS reported in the AUTO METAR is also used for reporting present weather. The phenomena fog (FG), mist (BR, brume) and haze (HZ) can be reported, where the relative humidity is used to distinguish between mist and haze. Freezing (FZ) is the only visibility descriptor that is used in combination with fog in the AUTO METAR and AUTO local MET reports. The fog descriptors MI (shallow), BC (patches), PR (partial), VC (vicinity) are not used.

The AUTO local MET report generally complies with the ICAO recommendations. By national agreements the format of the report is different. The report consists of a comma separated string containing the information in fixed positions so that decoding is easier. Furthermore the RVR is not included, but an RVR indicator is included which notifies ATC when any of the RVR or VIS at the airport is below 1500 m or all are above 2000 m. In these situations ATC starts and stops dissemination of the RVR information.

KNMI uses an additional AUTO SPECIAL criterion that is related to the so-called VFR status. When the status changes an AUTO SPECIAL is issued. Also note that the loss or return of data delivery of one or more variables in the AUTO local report is reason for issuing an AUTO SPECIAL.

Table 2: Criteria for determination of the VFR status.

Visibility	Cloud base (BKN or OVC)	Cloud base (FEW or more)	VFR status
≥ 5 km	≥1500 ft	all	normal
≥ 5 km	<1500 ft	≥ 600 ft	special
≥ 5 km	<1500 ft	< 600 ft	below limits
≥3km and <5km	≥1500 ft	≥ 600 ft	special
≥3km and <5km	≥1500 ft	< 600 ft	below limits
≥3km and <5km	<1500 ft	≥ 600 ft	special
≥3km and <5km	<1500 ft	< 600 ft	below limits
<3km	all	all	below limits

2.19. Technical infrastructure

This section gives an overview of the technical infrastructure at Rotterdam The Hague Airport indicating the various hardware components and the data communication lines. The redundancy of the components and connections is indicated. The interactions with systems of ATC are included.

2.20. Data flow

This section describes the data flow and the relationship between the variables related to visibility and the calculations in the configuration of the server systems at Rotterdam The Hague Airport. The calculations are indicated by the square boxes. The arrows indicate the input and output variables. Note that the order of the calculations is relevant. The variable names and calculations are explained in the KNMI internal report.
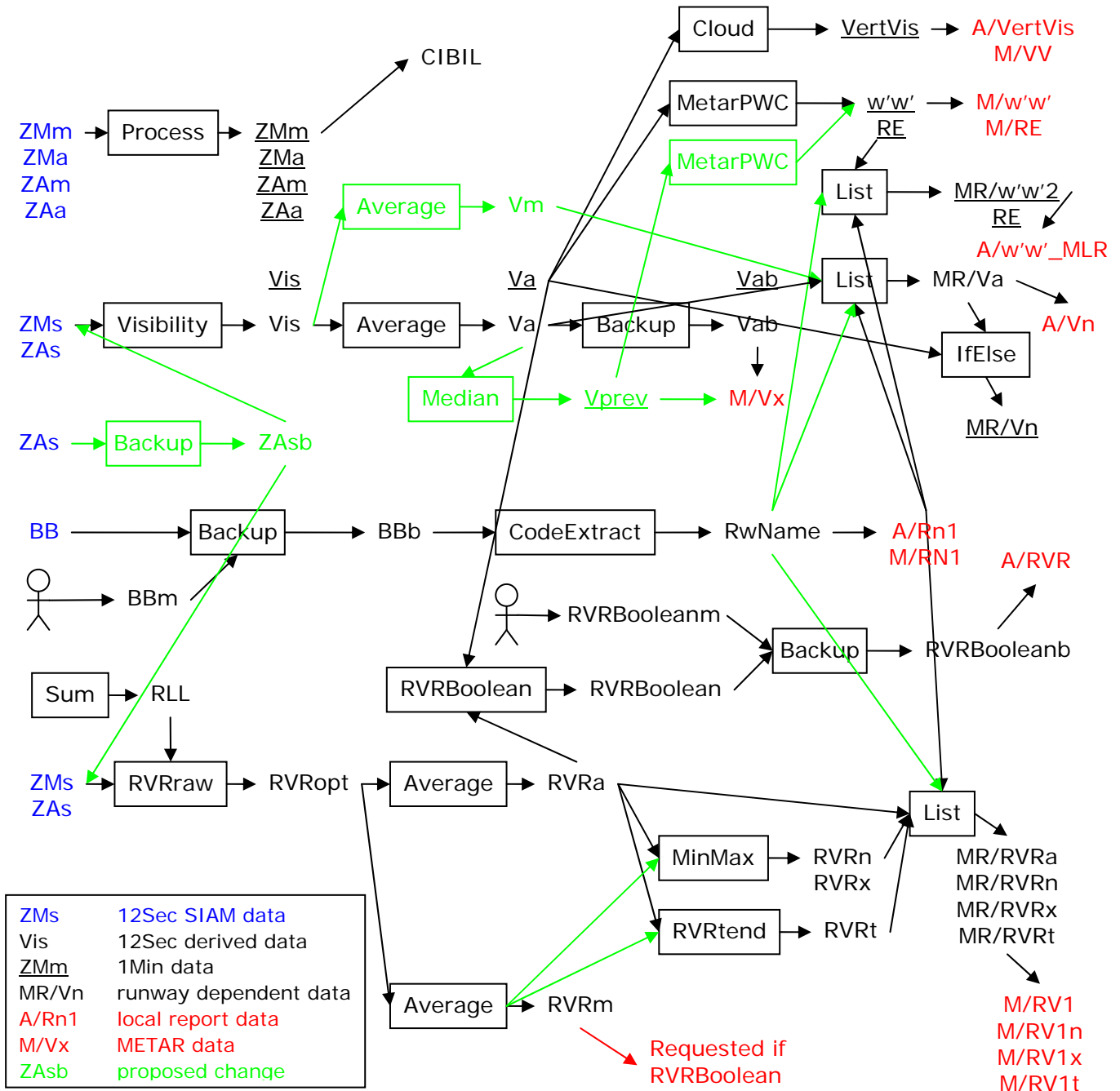

Figure 4: Overview of the data flow and the relationship between the variables related to visibility and the calculations in the configuration of the server systems at Rotterdam The Hague Airport.

The above figure shows that configuration of the system is rather complex and needs to be treated with care. For example when the users ask for a backup it requires to be specified in more detail. KNMI now follow the rule that a backup of a primary variable is performed at the end product whereas a secondary variable is backed up directly. This means that we do not backup the MOR reported by the sensor, but the derived VIS and RVR products. Hence in case of a backup situation we do not temporarily mix the MOR of two sensors. However, the background luminance,

which unlike MOR is a variable of secondary importance in the VIS and RVR calculation, is (proposed to be) backed up before VIS and RVR are calculated.

2.21. Conclusions and recommendations

The internal report gives many recommendations. The recommendations are grouped into: (i) items that are either related to indistinctness, omissions or inconsistencies in the ICAO and WMO requirements and recommendations; (ii) KNMI practices deviating from these requirements and recommendations; or (iii) are of another category. The recommendations have been discussed and evaluated by a KNMI expert team. The inconsistencies between the ICAO and WMO may have been introduced by the fact that the ICAO and WMO are updated at different moments so that they do not match temporarily. However, this does not always need to be the case as changes with respect to the previous version are not indicated in the documents and might easily be overlooked. The KNMI practices deviating from the ICAO and WMO requirements and recommendations are often historic of nature, i.e. KNMI kept in line with former specifications or the practices at airports. These items need to be reconsidered and verified with parties involved and then either solved or, if kept, documented and communicated.

3. CONCLUSIONS AND OUTLOOK

The review of the visibility chain was appreciated by internal and external users that, up to now, did not have an overview of the various aspects involved in visibility measurements. The document describes the situation in July, 2011. In June 2012 the recommendations were updated and decisions or actions were added. The maintenance of the document is still under discussion. The relevant information should be included in the Dutch handbook on observations (KNMI, 2005) that will be extended to include aviation. However, in order to avoid duplications or outdated documentation individual parts of the documentation should be maintained by the staff involved and coupled to the change management of the underlying systems, regulations and agreements. In addition there is a demand for reviews of the chains for other parameters.

As a result of the review some errors in the chain could be pointed out. Some of these were directly solved, but others require consensus between parties involved and/or further investigations. The recommendations are managed in a spreadsheet. Persons have been assigned to the action items, but items have not yet been prioritised and sometimes their impact is unclear. Meanwhile new items have been added to the list while others are temporarily put on hold e.g. as a result of proposed changes to ICAO requirements and recommendations.

4. REFERENCES

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