THE NEW METEOROLOGICAL OBSERVATION NETWORK IN THE NETHERLANDS; STATUS AND OPERATIONAL EXPERIENCE

Wiel Wauben and Dennis Hart
Royal Netherlands Meteorological Institute (KNMI),
P.O. Box 201, 3730 AE De Bilt, The Netherlands
Tel. +31-30-2206 482, Fax +31-30-2210 407, e-mail: Wiel.Wauben@knmi.nl

ABSTRACT

At the TECO 2002 the new meteorological observation network of the Netherlands was introduced. The synoptic part of the network became operational as planned in November 2002. Since then all synoptical and climatological reports of KNMI are produced fully automated, including 15 stations that include visibility, cloud and weather information. The airport systems became operational in February 2003. The slight delay was caused by the adaptations required for the systems of the air traffic services provider. The most difficult part of the introduction of the new observation network was the embedding of the maintenance in the various departments within KNMI. In 2003 and 2004 the flexibility of the MetNet system was used extensively for making configuration changes. These changes include e.g. the introduction of the new fifth runway at Amsterdam Airport Schiphol in combination with the renumbering of nearly all runways, and the connection of 9 airbases of the Royal Netherlands Air Force to the network. The network acquires data from all stations centrally every 10 minutes and makes it available to users. This proved to be a major advantage compared to hourly reports. Internal as well as external users now use the 10-minute data extensively. KNMI developed several applications for presenting the data that is available in the network. Furthermore, functionality has been added to the MetNet system e.g. a fully automated METAR including algorithms for cloud and weather and the AUTO TREND. Apart from 3 major incidents the entire network proved to be very stable.

1. INTRODUCTION

At the end of the 90's, the Royal Netherlands Meteorological Institute (KNMI) realised that it had to replace its network of automated weather stations and the meteorological systems that were used at the Dutch civil airports. The system was getting too old so spare part were hardly available, the maintenance was cumbersome and expensive, and it could not be extended for future needs such as the automation of visual observation (Wauben, 2002) and the addition of the new runway at Amsterdam Schiphol Airport. Another reason was the separation of the air traffic services and the meteorological systems that resulted from new governmental regulations. Furthermore, the new network should use available new techniques like network TCP/IP connections and remote maintenance. The new system should be modular and flexible, and should replace the different systems that were used at automated stations, manned stations, airports and airbases. The boundaries of the redesign project were that the sensors and KNMI sensor interfaces should be kept, and on the other hand that the meteorological and hydrological reports should be continued, but in addition a 10-minute database should be made centrally available containing the data of the entire network. The architecture of the new meteorological observation network has been described in Kuik and Haig (2002) and Wauben et al. (2002). In 2000 KNMI and Almos Systems started the project to implement the new meteorological network. In total there are 23 fully automated observation stations, 5 civil airports, 2 navy airbases and a central site at De Bilt. Furthermore data is acquired from a lightning detection system and from another database providing 10-minute data from about 75 stations in the North Sea and the Dutch coastal waters. At the central site all data is collected, processed and stored. All meteorological reports are generated at De Bilt, except for the aeronautical reports that are generated locally at the airport systems, since airports should be able to operate stand-alone.

2. UPGRADE PROJECT

In January 2000 Almos was granted the contract after an EU tender procedure. The rest of 2000 was taken by making more detailed specifications and system designs. The functional specifications were described in a document of about 100 pages, but further details were given in 75 KNMI documents. The hardware and software requirements, interfaces, design and tests were documented within the project by another 100 documents. In order to check the specifications test data was provided for all algorithms and reports. It was agreed that when inconsistencies or omissions in the specifications turned up that the following priority should be applied: (i) the source code of algorithms provided by KNMI, (ii) the project documentation and minutes of meetings, (iii) the supplied KNMI documents, (iv) official WMO and ICAO documents, (v) and finally the Almos solution. In order to obtain more flexibility the KNMI algorithms were added to a DLL library that interfaces with the MetConsole Almos software. In order to get a feeling of the user interface several sessions were organised using demo versions of the systems. These sessions resulted in a design of the Human Machine Interface that was documented and later used as a starting point of the manuals. End 2000 the design phase was completed and Almos started building the prototypes that took most of 2001 and was completed with the Factory Acceptance Tests (FAT). Separate FATs were conducted for the automated observations stations and the central system in De Bilt in September 2001, and the airport systems in February 2002. After the FAT the central system in De Bilt and the automated observation station, and later the system at Schiphol airport, were installed by Almos and Site Acceptance Tests (SAT) were performed in November 2001 for the De Bilt system and July 2002 for the Schiphol system. The other automated observation stations and airports and airbases were installed after the FAT by KNMI staff. The new system was built up next to the old system. That way there was sufficient time to get experience with the new system. During this parallel period it also turned out that the automated observation stations were not stable enough and required a design change. Near the end of the project there was a planned opportunity for upgrading the new system. During this upgrade all relevant changes, which were made in the meantime to the old system, could be implemented in the new system, so that there was no deterioration of the quality of the data and reports. This upgrade mainly consisted of changes in the coding of the meteorological reports and to the relatively new algorithms for to the automation of visual observations that required some fine-tuning after operational experience with the old system. Finally, a Final Site Acceptance Test was conducted for the entire network under full load. At the end of the project a switch was made from the old to the new observation network systems. This mainly meant that the users switched to the new system for viewing and extracting the meteorological data, a similar switch was made for monitoring and maintaining the network and observers had to make the meteorological reports on their new systems. The only configuration required for the introduction of the new network was that the meteorological reports of the new system had to be processed by the message switch instead of the reports of the old systems. This change was made on the message where the appropriate connections were started and closed. The synoptical part of the system, including the automated observation stations, the central site in De Bilt and the 2 nave airbases became operational on November 20, 2002 one day before the day planned at the start of the project. The civil airports required at the last minute a new format for the dissemination of the local MET reports and were delayed. The civil airports became operational in February 5, 2003.

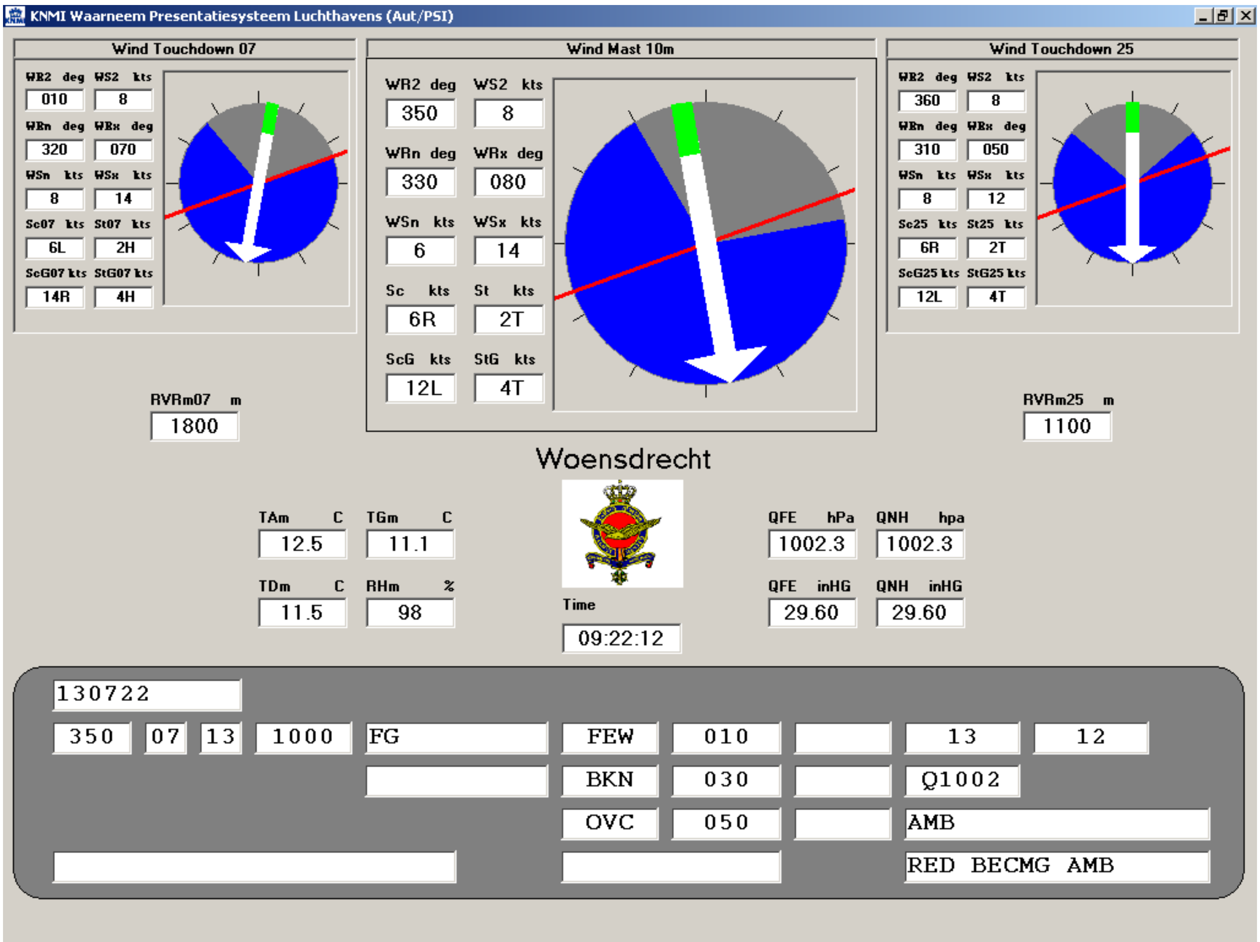

Figure 1: Screen shot of the KNMI WPL application that is used to present real time sensor information and current reports available in the MetNet server systems to local users.

The project was conducted almost exactly as scheduled. The delay was only small considering the requested 20 changes that were made during the project. Most changes had little impact on the project, but the new format of the local MET reports (aeronautical), the inclusion of Valkenburg airbase of the Royal Navy and the new civil airport Lelystad at a later stage of the project could only be handled after rescheduling the tasks. Also the problems with the automated observation stations which lead to a redesign of the system and therefore required an exchange of all systems by a combined effort of Almos and KNMI staff did not lead to a delay. Even the largest delay encountered in the project, i.e. the Site Acceptance Test of Schiphol airport that occurred with a delay of 8 months, had almost no impact on the overall progress of the project. The reason for this is the KNMI could continue with the installation of the automated observation stations and also started with the installation of the other airports. When the SAT of Schiphol was finally accepted, a software upgrade could be applied to all other airports remotely from De Bilt. KNMI also developed the WPL application in order to facilitate the presentation of real time data to local users. A screen dump of the WPL application is shown in Figure 1. When the new observation network became operational KNMI already had a lot of experience with the new system. The required functionality was available and the network had already proved to be very stable.

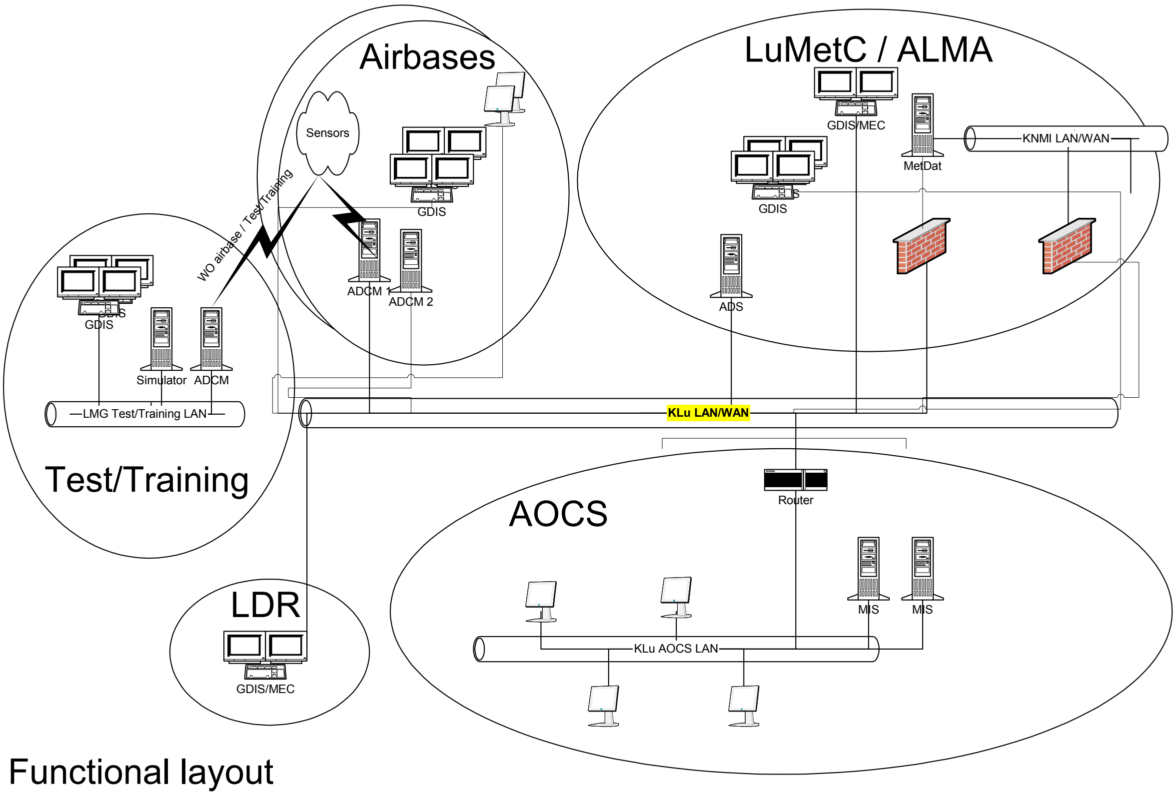

Figure 2: Functional layout of MetNet systems of the Royal Netherlands Air Force indicating the airbase systems, the Test and training system, the maintenance systems at LDR and LuMetC, the central database and the uplink to KNMI at Woensdrecht and the central data server system at AOCS.

3. METNET OVERVIEW

The layout and architecture of the new meteorological observation network has already been described in Kuik and Haig (2002) and Wauben et al. (2002). The system layout today is more or less the same, although some automated observation stations have been rearranged. However, in 2004 the locations of the Royal Netherlands Air Force (RNLAF) were connected to MetNet. Within this project KNMI was contracted by RNLAF to upgrade the network, whereas Almos was contracted by KNMI to assist in the upgrade. Almos purchased all hardware and made some changes to the software in order to handle the specific local aeronautical report of the RNLAF. Furthermore, the central systems in De Bilt were upgraded in order to be able to handle the additional data efficiently. Within this project the RNLAF locations have been upgraded and connected to the MetNet system one by one and separate acceptance tests were executed per location. While Almos assisted in the installation of the central RNLAF sites of Woensdrecht and Nieuw Milligen, all other sites have been installed by a joint effort of RNLAF and KNMI staff. At present all locations have been installed except 1 and the project is running on schedule. Figure 2 gives a scheme of the functional layout of the RNLAF network. All 9 airbases will be equipped with single or dual server systems processing the sensor data and providing data and digesting manual input from observer systems. Real time data is also presented at several locations, e.g. in the tower and at the fire brigade, using the KNMI WPL application. All airbases are connected to the RNLAF central site Woensdrecht where a central database is located to store all airbase data for a period of 100 days. The CIBIL system of KNMI can connect to each airbase via Woensdrecht in order to acquire all sensor data for generation synoptical reports. Woensdrecht also contains the Test and Training system of the RNLAF that is used for education and testing new software and configuration releases. The Test and Training systems of RNLAF and KNMI in De Bilt can be connected for performing integrations tests of the entire network. At the meteorology group of LuMetC in Woensdrecht the software configuration and maintenance is performed while the technical and sensor maintenance is performed from by LDR. In both cases RNLAF and KNMI cooperate closely together. Finally the RNLAF operates a dual system for providing data to users at the centralised Military Air Traffic Services Unit (AOCS) in Nieuw Milligen. These systems acquire sensor and derived data and reports from each airbase and make it available to the RNLAF air traffic staff at centralised approach. Again the KNMI WPL application is used for presenting the data of each airbase to the users. The user can select which airbase is presented.

All systems of MetNet run identical software, i.e. MetConsole, and by configuration the system is told whether it should operate as the central CIBIL system or a specific airport. A separate configuration is available for each server system in the network, although e.g. the 4 server systems that make up the Schiphol MetNet system (a dual server system for the data acquisition and processing of the data and a dual server system for providing the data to the users) use the same configuration. The usage of identical software ensures that the products of all systems are the same and requires less effort in keeping the software up to data. The MetNet systems also use the same hardware, although the server and client systems are different and by now also the recently installed systems of the Royal Netherlands Air Force use different hardware, but these systems can also be used within the KNMI network. Identical hardware has of course the benefit that less spares are required. The MetNet system can optionally be configured as a single or dual system and can furthermore be separated in a data acquisition/processing unit and a unit providing data. The above mentioned Schiphol system uses a full set of 4 servers consisting of a dual system for acquisition/processing and a dual system for providing data, whereas e.g. the Deelen Military Aviation Terrain system consists of a single data acquisition/processing/providing system. It should be noted that the automated observation stations use a tailor made hardware that is designed for outdoors usage and require no configuration. It simply stores all incoming sensor data as provided by the sensor interface in a fixed format and makes this data, upon request, available to the central system. At the central site the data is processed according to the rules contained in the configuration.

Figure 3 gives an overview of the data flow and the data processing in the MetNet system. Sensor data is acquired by an AWS or an airport or airbase systems or enters MetNet via the RMI system, a central system that contains North Sea and coastal area data. Data is also obtained from a lightning detection system and a precipitation radar and METEOSAT, although the latter 2 are not operationally used in the production of meteorological reports. Synoptical data is processed at the central site, whereas aeronautical data is generated at location and provided to the users. For that purpose the servers can be configured to perform calculations. The airports and airbases run algorithms that derive the cloud layer heights and amounts from ceilometer data and check for vertical visibility in cases of low visibility when the ceilometer data shows no details. The aviation systems also determine the weather based on the measurements of several sensors such as a present weather sensor that reports precipitation type and uses the lightning discharges detected by the SAFIR system. The SAFIR data is provided to the airport and airbase systems via CIBIL. In case the connection to the central site is lost, the airport systems can still generate the automated reports although it will remark in the reports that lighting data is not available. Similarly the central site also uses algorithms to provide e.g. cloud and weather data but the processing of synoptical data differs from that of aeronautical data as a result of different requirements.

4. SOME METNET NUMBERS

The MetNet system of Amsterdam Airport Schiphol acquires the data of about 60 sensor interfaces. This sensor interface reports the sample, 1-minute average, 10-minute average and extreme values of meteorological parameters and their status. All sensor information, including the running averages are updated every 12 seconds. The sensor data at Schiphol is stored in 66 sub-stations. These stations include the 23 physical locations that are used for the 23 visibility sensors situated along the runways of Schiphol as well as other physical locations for providing selected sensor information of other airports throughout the Netherlands as well as data from other stations that are used in the generation of the so-called Regional QNH and the Transition Level report. Furthermore so-called pseudo stations are used that do not correspond to a physical location, but are used to generate the data for e.g. the 12 available runways and the up to 4 runways in use for take-off and landing. Note that Schiphol has in fact only ‘6’ runways, but since some runways can be operated from both sides and since regulations regarding backup of sensors and cross and tail winds differ between landing and take-off operation a further distinction had to be made. In total the Schiphol system contains about 2100 variables, 1300 of which are updated every 12 sec. A example of a screen of the Schiphol MetNet system is shown in Figure 4.

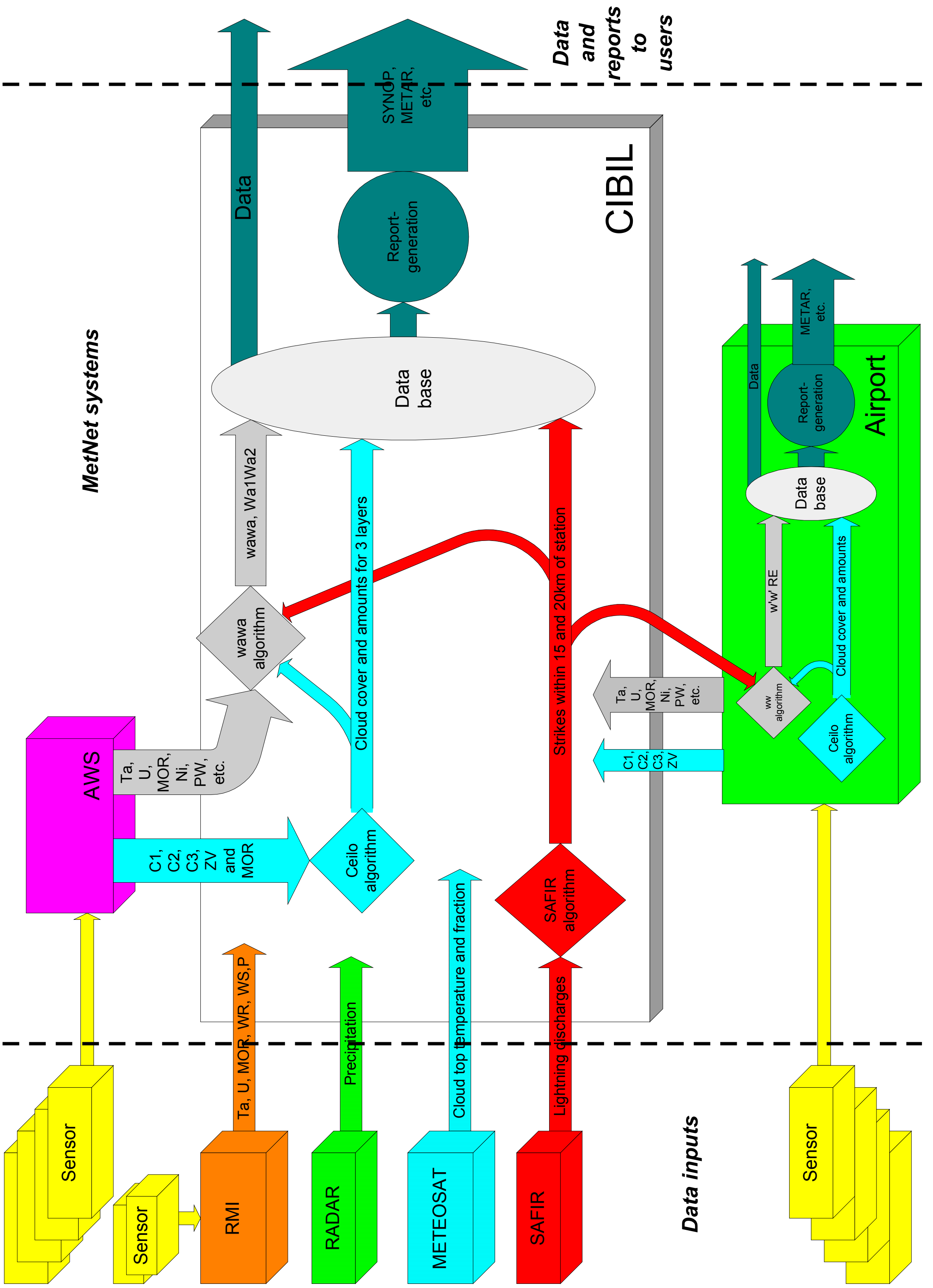

Figure 3: Schematic view of the data flow and processing in the MetNet system.

In the beginning of 2003, after the new airport systems were already operational, the fifth (new) runway of Schiphol became operational and was added to the system. This meant that a total of 16-substations had to be added. The new runway required 4 visibility sensors since the length did not allow the regular usage of 3 sensors along the runway. Furthermore, the touchdown position of the runway was equipped with 2 visibility sensors because it was agreed that the observer, situated at a distance of about 8km, would not always be able to detect incoming fog banks. In order to accurately detect such events using visibility sensors, sensors were posted at both sides of the touchdown position. Since the systems of the air traffic services require only 3 positions per runway, the data had to be reduced. The minimum visibility of the 2 sensors near the middle of the runway of the mid position is reported as the visibility at the mid position. The same holds for the visibility at touchdown, but here the visibility is only reported when valid data is obtained from both sensors at either side of the runway. Hence in addition to the 4 physical stations, 2 pseudo stations were required and this times 2 for operation as take-off and landing. Since the runway may only be used from one side, only one set of take-of and landing pseudo stations needed to be included. The introduction of the new runway coincided with a new runway designation scheme. Runways 19R, 19L, 01L and 01R were renamed as 18C, 18L, 36C and 36R, respectively, and the new runway was named 18R/36L. This renumbering changed the names of nearly 30 sub-stations and affected the other airports and the central system in De Bilt as well, since they used data of (some) of these stations.

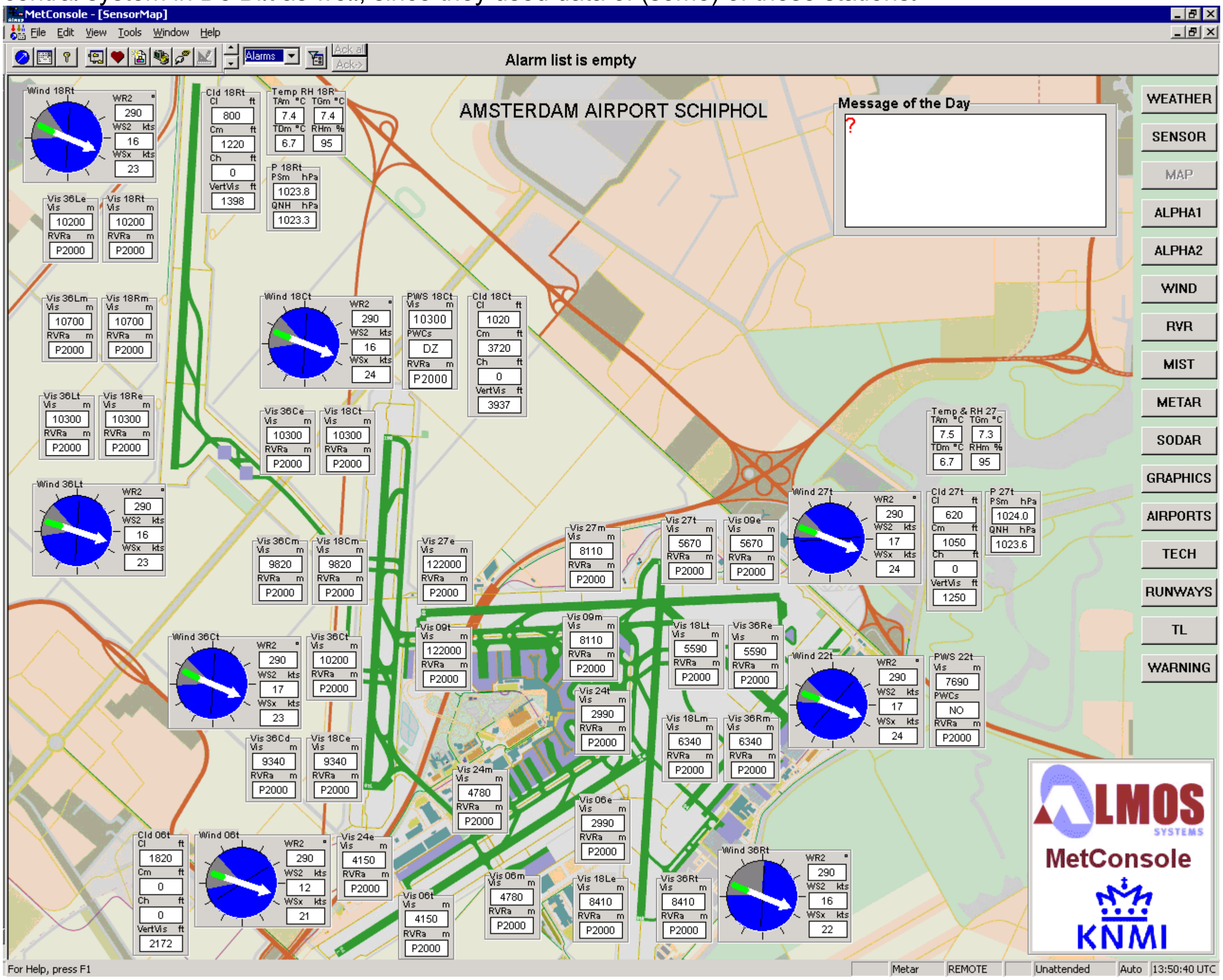

Figure 4: The sensor map overview screen of the MetNet system for Schiphol airport.

The central system in De Bilt currently acquires data from 21 fully automated observation stations. These stations range from basic stations measuring P/T/U/W/R/Q to the 200m research tower in Cabauw containing, apart from a basic station, wind and temperature/humidity measurements at several levels. In total Cabauw consists of 20 sub-stations and 35 sensors. The central system also acquires data from 5 airports, 2 navy airbases and currently 8 air force airbases. Furthermore, 10-minute data is obtained from 27 locations in the North Sea and 46 locations near the coast. In total the central system contains 350 sub-stations and has 9600 variables, of which about 2500 variables are updated every minute, and 4900 variables that update every 10 minutes. All this information is stored for a period of 7 days, during which the data is provided to user systems including the climatological department.

5. METNET EXPERIENCE

The flexibility of the MetNet systems was already illustrated above when the addition of the airbases of the Royal Netherlands Air Force to the MetNet system and the addition of the fifth runway and renumbering of the runways at Schiphol was discussed. Apart from these large changes, many smaller changes on a sensor or station level were performed. The total number of functional configuration changes of the central system now largely exceeds 100. Apart from the configuration changes other changes were made that often required additional functionality to be implemented by Almos. These changes are upgrades of the Windows 2000 operating system and MSSQL server, which were required for security purposes, as was the implementation of anti-virus software to all MetNet server and client systems. The MetNet systems were also equipped with a maintenance tool that is used to monitor the correct functioning of the system and given automatic alerts when certain threshold are exceeded, e.g. CPU and disk usage. Furthermore software was installed in order to be able to perform remote maintenance on the system, besides the remote maintenance available within the Almos MetConsole software. Changes also had to be made to the software so that the central system could process the lightning data in the new HDF5 format after an upgrade of the lightning system. Apart from these changes new functionality was added to the MetNet system on request of KNMI. One of these changes is the AUTO METAR that now also includes algorithms for cloud and weather and is used operationally by KNMI during closing hours of some airports. Another extension was AUTO TREND, which reads the so-called pseudo TREND that are produced by KNMI using centrally available 10-minute MetNet data in combination with precipitation radar and model output. The airport system acquires the pseudo TREND for a specific location and performs a validation and correction step on the airport system so that there are no conflicts in the observation reported in the METAR and the forecasted TREND. Furthermore, KNMI is currently changing the costly ISDN dialup connections to the automated observation stations into GPRS connections. Future changes to the MetNet system include the introduction of the new WMO BUFR format for exchanging synoptical and climatological information; a sensor upgrade of the RNLAF stations that facilitates the generation of fully automated synoptical and aeronautical reports including the visual parameters; a new data input for platforms in the North Sea that will provide detailed sensor data and allow fully automated synoptical and aeronautical reports including visual parameters.

During the extensive Almos projects for the implementation of the new KNMI observation network and the equipment of the locations of the RNLAF the cooperation between Almos and KNMI was very good. Both projects finished nearly on time and the result was satisfactory for both KNMI and Almos. KNMI obtained a system that met the requirements and was very stable, whereas Almos was able to make a product that was in demand in the meteorological community. The smaller projects related to the changes mentioned above were generally not so successful, because the limited amount of man power assigned to them made it hard to get a good and efficient feedback. Almos and KNMI made appropriate changes to the service level agreement and expect that this situation will improve in the near future. The availability of the MetNet system is very good. The synoptical part had an overall availability of 99.64% in 2003 for the automated observation systems, whereas the overall availability of the airport systems was 99.72%. The maintenance staff of the MetNet system had a difficult start when the system became operational. This was partly caused by the fact that although the old and the new system ran parallel for about a year the maintenance staff was not able to make time free to get acquainted with the new system. It was also difficult to get the various aspects of a KNMI wide system settled in the appropriate maintenance groups within the organization. This proved also difficult because the new system changed the distribution of workload within the organization. There was a decrease of workload related to the automated observation systems because those systems did not require any configuration. However, more time had to be spent on the airport systems that were formerly the responsibility of the civil aviation community. This was particularly felt in functional maintenance where one central database was exchanged by another central system with more flexibility and hence more changes were requested requiring additional time. Furthermore the functional maintenance of the hitherto unknown airports systems was added to their responsibilities. During the first year of operation a significant support from the project team was still required. As experience grew and a staff member was added to functional maintenance for the airport systems, the maintenance staff was able to cope with the new network. During the first 2 years of operation there have been some major incidents. During one incident an old configuration of Schiphol was introduced by mistake followed by subsequent coincidences and uncoordinated actions. Since the old configuration contained the old Schiphol names the users did not get the requested information for most of the sub-stations. After remote activation of the correct configuration the problem was solved. Two other incidents involved virus attacks at regional airports. As a result of these attacks several security measures were implemented and the entire network is separated from the outside world by Fire Walls. The last incident involved a leap year bug that showed up on some server systems when the time difference became too large. During this incident Almos provided support and advised KNMI to switch the time synchronization of in the configuration. The following day the bug was traced and new software was made available. However, by that time some damage had already been done.

Another point that needs attention is related to the fact that the introduction of the new observation network at KNMI coincided with the full automation of the entire synoptical network. With the introduction of MetNet the manned stations ceased to exist, except for the airports, but even there the observers only made the aeronautical reports. This automation put much stress on the project and many user complaints that were obtained during the project were not related to the incorrect functioning of the MetNet system, but were the result of the automation of the visual observations and the expected differences. The automation of the visual observations also required that more extensive use should be made of the available 10-minute data. In another project a tool was developed for presenting the available 10-minute data in time series and geographically. The user can easily select the parameter and can show loops or go to a specific time. Furthermore the users can set alarms for any combination of parameters. An example of a screen of the KNMI AVW-Tools application is shown in Figure 5. Please note that KNMI decided that the MetNet system should only acquire, process and make data available to users. The MetNet systems provide information to the maintenance staff and allow monitoring and change of the configuration. The airport systems have a more detailed user interface that is required by the observers for viewing the data en generating the reports. The subsequent visualization of the available data was part of another system, i.e. the meteorological workstation, and the AVW-Tools application has been made as a first step in order to learn by experience how the 10-minute data can be best made available to forecasters.

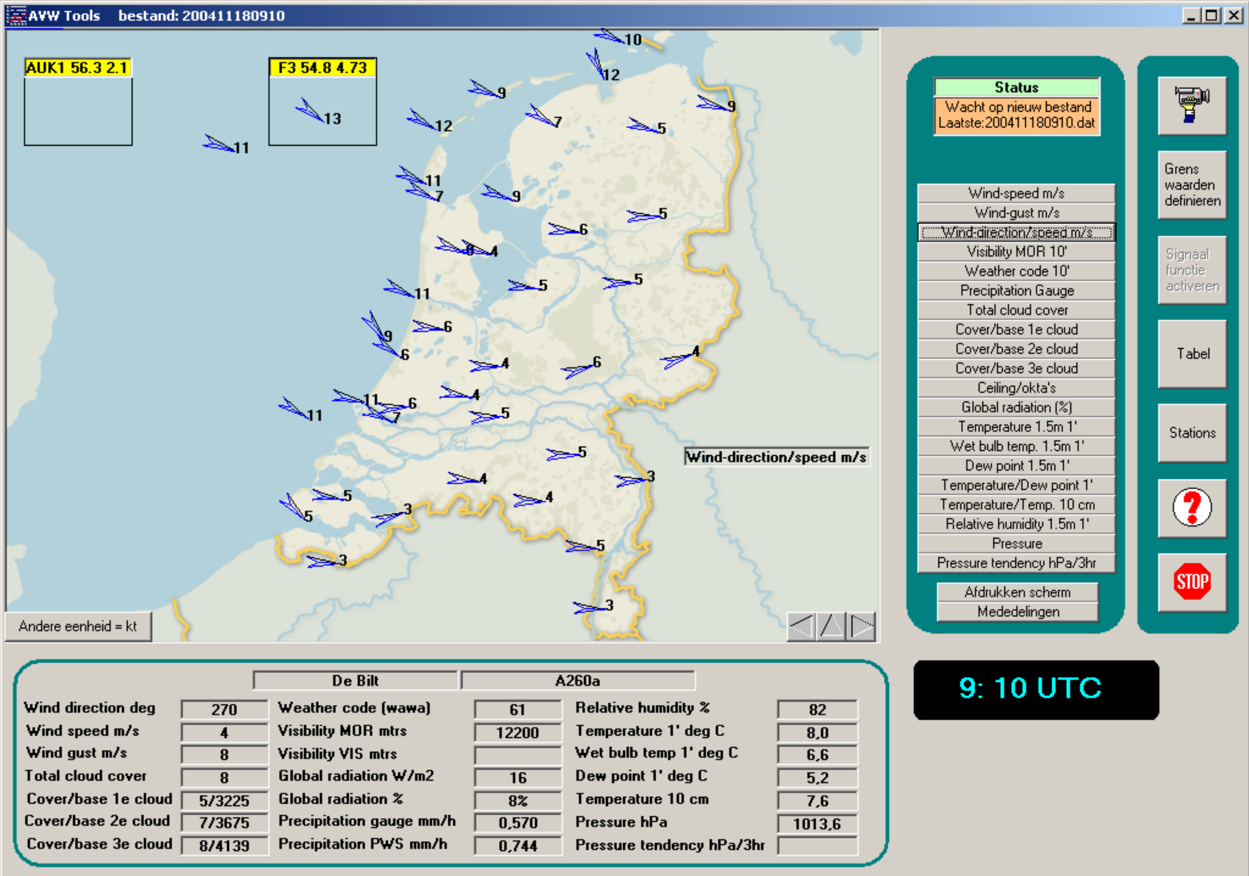

Figure 5: Screen shot of the KNMI AVW-Tools application that is used to present 10-minute data, which is acquired and generated by the central MetNet server systems, to users.

6. CONCLUDING REMARKS

At the TECO 2002 the new meteorological observation network of the Netherlands was introduced. The synoptic part of the network became operational as planned in November 2002. The airport systems followed in February 2003. The most difficult part of the introduction of the new observation network was the embedding of the maintenance within the various departments within KNMI. The entire network proved to be very stable. The availability for synoptic and airport systems in 2003 is 99.66% and 99.72%, respectively. The flexibility of the system was used extensively for making configuration changes. These changes include e.g. the introduction of the new fifth runway at Amsterdam Airport Schiphol. In 2004 9 Royal Netherlands Air Force airbases were equipped and connected to the network. The network acquires data from all stations every 10 minutes and makes it available to users. This proved to be a major advantage compared to hourly reports. There have been made some changes to the MetConsole software in order to correct or change functionality. Furthermore, the automated METAR was extended with algorithms for cloud and weather and an automated TREND was added. A test is performed for GPRS connections to automated weather stations in order to reduce communication costs. Upcoming changes include the introduction of the WMO BUFR format for exchanging synoptical and climatological information.

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