Acquisition and application of running state information on automatic weather station

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Abstract *— In order to realize the remote monitoring of automatic weather station timely running status, based on the function structure of the second generation automatic weather station, this paper puts forward automatic weather station internal detection point classification, status definition, encode design and file structure rules. On the basis of this work, all status information can be compiled into a file to upload to data center according to the rules, which can be facilitate to carry out AWS fault diagnosis and analysis.*

Application results show that the status information design and acquisition is successful. and they are very useful for real-time monitoring equipment operation, help technician to carry out maintenance and improve the efficiency of maintenance. They can also be used to evaluate the automatic weather station performance, to provide reference for technical improvement and selection of next generation AWS.

Keywords—*Automatic weather station; Status information; Design and Application*

I. INTRODUCTION

Surface weather observation is an important part of integrated meteorological observation. The surface weather observing network of China meteorological Administration (CMA) is mainly consists of two parts: 2400 national manned automatic weather stations (AWSs) and 50000 unmanned AWSs.

How to successfully support such a large observation network has always been a major problem for the administrative departments. CMA has established a business center and operation system (named ASOM) to real-time monitor all surface weather station running status and data quality [1,2]. Main methods depend on data quality check and Manual site inspection information [3]. ASOM will issue a warning to notice personnel to handle once the data appear abnormal or inspection results found the problem. By this ways personnel can find some severe problems and timely processing [4].

Compare to the US Automatic Surface Observation System (AOMC), Weather Surveillance Radar system (WSR-88D) and other field of aviation and aerospace[5-7], automotive industry [8], train [9-10], electricity network [11] as well as oil pipeline systems [12,13], China's AWS lack both equipment components detection point design and specific running parameter information. Hence it is impossible to realize rapid discovery and diagnosis of Faults, resulting in a long time of Fault repair. It eventually affected whole surface weather observation network operation efficiency and availability.

In recent years, the relevant researches on automatic detection of the automatic weather station operational status have also been done in China [14-15]. Based on the new type architecture, AWS sensor circuit with BIT (built-in test) has been adopted, and its data collection and processing have been upgraded, which realized AWS components operational status and faults automatic detection. In order to better use these functions, obtain valid information, in this paper, we propose design criteria of internal detection point based on a new generation automatic station structure, including detection point classification, parameters definition, status code and file format design rules, etc. This work will facilitate these status information collection and application. Specially, it will promote the real-time monitoring technology of the surface observation network, and improve the maintenance efficiency.

II. DESIGN OF DETECTION POINTS

China's automatic surface weather stations have been upgraded to the second generations so far. The first generation AWS employ the collecting-distributing structure, it is composed of "collectors + sensors + peripherals", while its software consisted of "embedded software" and "operation software". The design of the second generation AWS is based on Controller Area Network (CAN) embedded system technology and external field bus technology. Its hardware employs the design structure of "main collector + external bus + sub-collectors + sensors + peripherals". The main collector and sub-collectors are connected with CAN bus. Its peripherals mainly include power supply, terminal equipment, communication interfaces and external memory. The software includes the embedded software and operation software. The CAN bus technology strengthens communication connection among components in a AWS and improves communication reliability. Moreover, its specific CAN open protocol standardizes the communication format between main collector and each sub-collector so that

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interchange of equipment from different manufacturers has an explicit standard. Therefore, the second generation AWS is replacing the first generation AWS to become the mainstay of automatic surface meteorological observation equipment in China.

The following equipment detection point design mainly based on the structure of the second generation AWS (2nd AWS).

A.Equipment structure and detection point

Accurate equipment classification and grading is the basis of designing equipment running status detection point. Based on the structural subdivision of instrument and equipment, the detection points for operational status of basic components can be designed to provide useful information for remote monitoring.

2nd AWS is designed with the CAN bus technology and international standard CAN OPEN protocol, allowing collectors and sensors compatibility and interchangeability(Chen et al. 2011). The main structure of the second generation of AWS can be divided into four parts, i.e., data collection system, measure module, peripherals and software, in which, the data collection system includes main collector and sub-collectors. The measure module includes surface temperature (grass temperature, snow temperature) measure module, temperature and humidity measure module, barometric measure module, wind measure module, rain measure module, cloud and visibility and weather measure module, automatic soil moisture measure module and so on. The peripherals include power supply system, CAN bus, communication transmission devices, operation terminal equipment and accessory equipment. The software includes embedded software and operation software. Each main component consists of a number of Replace units (FRU), each of which can be defined as a detection point. The measure module is connected with the collector system by the plug-in design mode, and contains some state of self-checking function, which includes sensor, electronic link, micro diagnosis system, display system. The 2nd AWS structure is shown in Figure 1.

B.Detection information design

The design of detection information is to accurately define and express the results of the output of each detection point, giving it the meaning of running state.

1) Running status information design for main collector

The main collector detection points include mainboard temperature, mainboard power, AC (alternating current) power supply and cabinet door, etc., and the structural components such as CF card (Compact Flash card), CAN bus, GPS (Global Positioning System) module， A/D module (i.e., Analog/Digital converter), as specifically shown in Table 1.

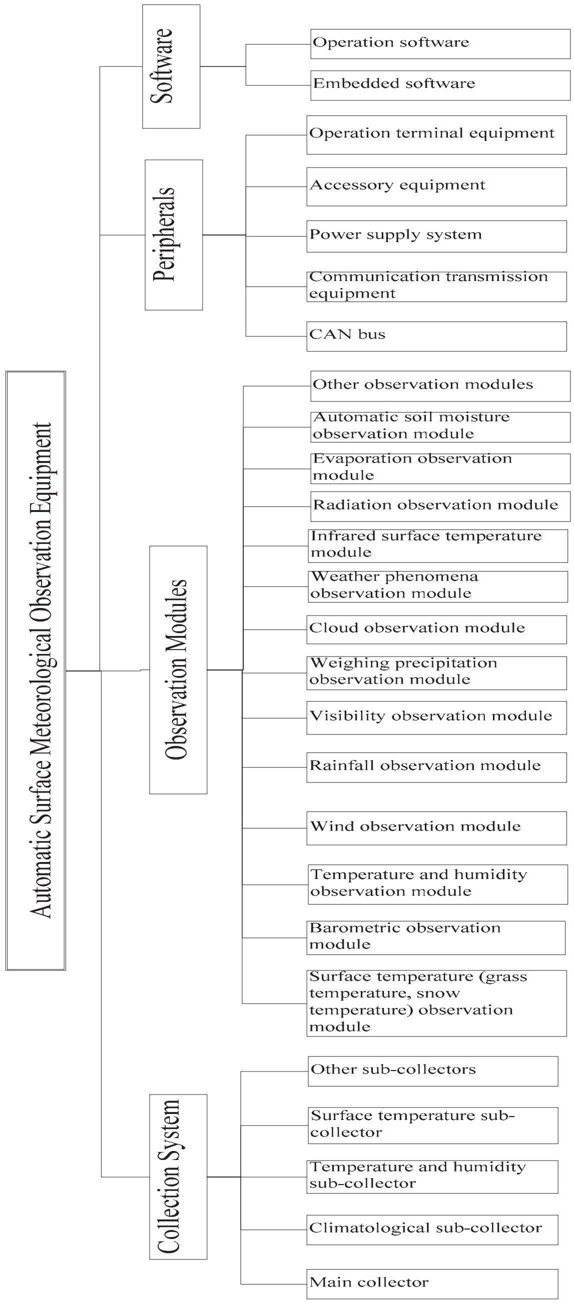

Fig. 1 Schematic of structural classification of 2nd automatic surface weather observation station

Table 1 Main collector Detection points and Running status information

NO.	Detection point	Running status
1~4	Status, AD module, Counter, Mainboard	Normal, Fault, No Detection, Null
5~6	Supply power voltage, Mainboard temperature	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
7	Power supply type	AC, DC

8	CF card	Normal, Not inserted, Fault, Inaccessible, No Detection, Null
9	Free memory of CF card	Sufficient, Insufficient, Exhausted
10	GPS module	Normal, Invalid time service*, Fault, No Detection, Null
11	GPS cable	Normal, Unconnected, No Detection, Null
12	Door open/close status	Closed, Opened or not closed completely
13~15	LAN status, RS232/RS485 terminal communication status, CAN bus status	Normal, Fault, No Detection

For voltage, temperature and other physical quantities in Table 1, "Normal" represents the value in the normal range. "Higher/Lower" indicates that the sampling value is higher/lower than normal one. "Over the upper/below limit" indicates that the sampling value exceeds the upper/lower limit of measuring range. "No Detection" means the current state of work cannot be judged. For component unit of the main collector, "Normal" indicates running normally. "Fault" means that the unit is not working. "Null" means that the unit is not configured.

2) Running state information design for sub-collectors

The sub collector is mainly divided into the sub collector of weather measure, the temperature and humidity measure sub collector and the ground temperature measure sub collector. Hardware components include embedded processor with high performance, A/D circuit with high precision, real-time clock circuit with high precision, read-only memory with high capacity, parameter memory, sensor interface, communication interface, CAN bus interface, monitoring circuit, indicators, etc. Similar to the main collector, sub-collectors of a 2nd AWS are also required to detect the physical parameters such as mainboard temperature and operating voltage, and structural units such as circuit board, AD module, counter module, communication

cable and interfaces, so as to judge whether sub-collector data sampling and transmission running status is normal . The detection points and running status information of weather measure sub-collector, temperature and humidity sub-collector and ground temperature sub-collector are listed respectively in Table 2~4.

Table 2 Weather sub-collector Detection points and Running status information

No.	Detection point	Operational status
1~2	Supply voltage, Mainboard temperature	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
3	Power supply type	AC, DC
4~7	Weather sub-collector, Circuit board, AD module, Counter module	Normal, Fault, No Detection, Null
8	Cable	Normal, Unconnected, Poor contact, No Detection, Null

Table 3 Temperature and humidity sub-collector Detection points and Running status information

No.	Detection point	Operational status
1~2	Supply voltage, Mainboard temperature	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
3	Power supply type	AC, DC
4~6	Temperature and humidity sub-collector，Circuit board，AD module	Normal, Fault, No Detection, Null

Table 4 Surface temperature sub-collector Detection points and Running status information

No.	Detection point	Operational status
1~2	Supply voltage,Mainboard temperature	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
3	Power supply type	AC, DC
4~7	Surface temperature sub-collector, Circuit board, AD module, Counter module	Normal, Fault, No Detection, Null

3) Running status information design for temperature and humidity measure module

The status detection information of temperature and humidity sensor include: signal voltage, signal resistance, working voltage, working current, etc. Operating state of a temperature and humidity sensor depends on whether these parameters are within the normal and reasonable working range, any out-of-range information indicates that an unit or some units get fault. When the signal cable is damaged or the platinum wire of temperature sensor is ruptured, the air temperature data will be shown as missing, so it is necessary to detect the status of the signal cable and platinum wire. When humicap fault or long-term in a hot and humid environment, humidity always display above 90% or 100% and constant, which lead to measure failure, hence it is need to detect humicap state(Zhou et al. 2012). Detection points and running status information design of the temperature and humidity measure module are listed in Table 5.

Table 5 Detection points and Running status information of temperature and humidity observation module

No.	Detection point	Operational status
1~4	Signal resistance of temperature sensor, Signal voltage of humidity sensor, Working voltage of temperature (humidity) sensor, Working current of temperature (humidity) sensor	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
5	Cable of temperature (humidity) sensor	Normal, Unconnected, Short circuit, No Detection, Null
6	Signal wire of temperature (humidity) sensor	Normal, Damaged, Unconnected, No Detection, Null
7	Temperature sensor	Normal, Platinum wire ruptured, Platinum wire short-circuited, Too large resistance value, No Detection, Null
8	Circuit board of humidity sensor	Normal, Damaged, No Detection, Null
9	Humidity-sensitive capacitor	Normal, Damaged, Saturation failure*, No Detection, Null
10	Radiation shield	Normal, Abnormal, No Detection, Null

4) Running status information design for barometric measure module

Currently, air pressure sensors widely used in AWS is mainly PTB220 intelligent digital air pressure sensors produced by the Finland Vaisala company. It has 5 detection points, ie working voltage, working current, sensor cable, signal cable, Sensor. The voltage range of power supply for pressure sensor is 10~30V, the average supply current is less than 30 mA. By detecting the voltage and current value, we can know the working status of the sensor. The status of voltage and current is expressed with "Normal", "Undetected", "Higher", "Lower", "Over the upper limit", "Below the lower limit", "No Detection", respectively. The status of sensor cable and signal cable is expressed with" Normal", "Damaged", "Unconnected", "Poor contact", "No Detection", "Null". The state of Sensor is defined as "Normal", "Damaged", "No Detection", "Null".

5) Running status information design for wind measure module

According to the function design, wind measure module has 8 detection points. the wind direction sensor output signal voltage ranges from 0 to 2.5V, while its output signal current ranges from 4 to 20mA. The average supply current of wind speed sensor is less than 5mA, voltage is DC (5±0.5)V. So the sensor running status can be reflected by detecting current, voltage and frequency. All running status detection points of wind measure module and its status definition are listed in Table 6.

Table 6 wind measure module Detection points and Running status information

No.	Detection point	Operational status
1~ 4	Signal voltage (signal current) of wind direction sensor, Working voltage of wind direction/speed sensor, Working current of wind direction/speed sensor, Signal frequency of wind speed sensor	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
5	Cable of wind direction/speed sensor	Normal, Damaged, Unconnected, Short-circuited, No Detection, Null
6	Signal wire of wind direction/speed sensor	Normal, Damaged, Unconnected, No Detection, Null
7	Wind direction/speed sensor	Normal, Damaged, Frozen or stuck*, No Detection, Null
8	Bearing of wind direction/speed sensor	Normal, Contaminated or worn*, No Detection, Null

6) Running status information design for rainfall observation module

At present, the rain sensors used in AWS usually employ double or single tipping-bucket rain gauge. When the precipitation reaches 0.1mm, the counter tipping bucket is flipped, the reed pipe is scanned by magnet steel, so that magnetized reed pipe contact closes once instantaneously to send a pulse, which is equivalent to 0.1mm rainfall. After the rainfall pulse signal is filtered and reshaped, it will be counted by the counter, the CPU will read the value from the counter every one minute to obtain the rainfall value. When the signal wire or reed pipe is damaged, the rainfall data will be always displayed as 0, it is need to detect the working status of signal wire and sensor. When the hopper, tipping bucket or strainer of sensor is clogged, resulting in a lower rainfall value, it is need to detect the working status of hopper or strainer. When the magnet steel becomes loose or falls off, there will be a flipping sound of tipping bucket but no signal output, so it is need to detect the magnet steel separately. All detection points of rainfall observation module and its working status definition are listed in Table 7.

Table 7 Rainfall measure module Detection points and Running status information

No.	Detection point	Operational status
1~5	Sensor signal voltage, Sensor signal current, Sensor waterlogging signal voltage Number of pulses, Pulse number of upward tipping bucket	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
6~7	Sensor cable, Sensor signal wire	Normal, Damaged, Unconnected, No Detection, Null
8	Sensor reed pipe	Normal, Damaged, Short-circuited, Unclosed, No Detection, Null
9	Sensor strainer	Normal, Clogged*, No Detection, Null
10	Sensor magnet steel	Normal, Loose*, No Detection, Null

7) Running status information design for surface temperature observation module

Surface temperature includes land surface temperature, grass surface temperature, snow surface temperature, shallow geotemperature and deep geotemperature, all of they are measured with the standard 4-wire platinum resistance thermometer. The new automatic weather station consists of totally 10 surface temperature sensors, among which, one for land surface temperature, one for grass surface temperature, and other 8 sensors for soil temperature at depths of 5cm, 10cm, 15cm, 20cm, 40cm, 80cm, 160cm and 320cm respectively. These sensors are marked in sequence by 1~10. Table 8 shows all status detection points of surface temperature observation module and its running status definition.

Table 8 Surface temperature measure module Detection points and Running status information

No.	Detection point	Operational status
1~30	Signal resistance, Working voltage, Working current of Sensor 1~10	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
31~40	Cable of Sensor 1~10	Normal, Damaged, Unconnected, Poor contact, Short-circuited, No Detection, Null
41~50	Signal wire of Sensor 1~10	Normal, Damaged, Unconnected, No Detection, Null
50~60	Sensor 1~10	Normal, Platinum wire ruptured, Platinum wire short-circuited, Too large resistance, No Detection, Null

8) Operational status information design for power supply system

The power supply system is usually composed of switched-mode power supply (SMPS), charger, accumulator, and lightning protection module. The common parameters for operational status detection of power supply are: SMPS output voltage, SMPS output current, accumulator voltage, and accumulator discharge current, load voltage, and load current. All operational status detection points of power supply system and its information design are listed in the Table 9.

Table 9 Power supply system Detection points and Running status information

NO.	Detection point	Operational status
1~5	Voltage of SMPS, Current of SMPS, Accumulator voltage, Accumulator current Load voltage, Load current	Normal, Undetected, Higher, Lower, Over the upper limit, Below the lower limit, No Detection
6~9	Circuit board of power supply system, Power supply controller, Charger, SMPS	Normal, Damaged, No Detection, Null
10~11	Fuse of power supply system, Accumulator cable	Normal, Rupture, No Detection, Null
12	AC power supply	Normal, Abnormal
13	Accumulator	Normal, Damaged, Overdischarged, Low battery level, No Detection, Null

C.*Design of coding rules for detection information*

Based on the above detection points and status information design, the 2nd AWS structural components, detection points and running status values need further be encoded separately before they can be applied. The specific coding rules are designed as follows.

1) Coding of structural components

The coding for 2nd AWS structural components status is expressed with capital letters “ZXX”, in which, the first letter Z represents that this segment content is status information. XX represents the name of each component unit (Acronym in English). For example, ZMC represents that this segment content is about Main Collector's status information. According to above rule, the coding for structural components of AWS are as follows: main collector – ZMC, climate sub-collector – ZCC, temperature and humidity sub-collector – ZTC, surface temperature sub-collector – ZDC, barometric measure module – ZPP, surface (grass, snow) temperature measure module – ZDT, temperature and humidity measure module – ZTH, wind measure module – ZWI, rainfall measure module – ZR, power supply system – ZPS.

2) Coding of detection points

Detection points are represented by a combination of English capital letters and numbers. English capital letters indicate the name of each detection point (acronym). Normally, the similar detection points of different structural components are expressed with the same English letter. For example, both the supply voltage of main collector and that of weather observation sub-collector are expressed with PV (Power Voltage). Remarkably，besides identifying the detection point itself (e.g., RS232/RS485 terminal communication of main collector), numbers are also used to discriminate similar detection point of same type sensors. For example, for surface temperature sensors, the working voltage of the first sensor is represented by PV1, the working voltage of the second one is represented by PV2. The coding for detection point is not more than 3 English letters. If it has only 2 letters, the missing one should be replaced with a space. According to the above rules, detection points of each substructure are encoded. For example, supply voltage is PV, power supply type is PT, power frequency is PF, main-board temperature is MT, the cable is EC, signal wire is SW, radiation shield is RS, reed pipe is RP, and so on.

3) Definition of status values for detection points

An AWS has many detection point, they are usually divided into four categories. Each category is given corresponding state values which are expressed with numbers 0~9 and capital letter N. The numbers and N represent various state meanings. For example, Category I represents running status of main collector, sub-collectors and sensors three components. Of which, "Normal" status is uniformly encoded as "0", "fault" status is uniformly encoded as "2", "No Detection" is encoded "9", and "Null" is "N". These 4 kind codes are fixed and universal and they are suitable for all detection points of Category I. The remaining running statuses are expressed with numbers 3 ~ 8. The various numbers represent different status meanings. Even with same number, for different components detection point, its meaning different. For example, for a temperature sensor, numbers "3" means platinum wire fracture, "4" represents platinum wire short circuit, "5" indicates resistance is too large. But for capacitive humidity sensors, "3" means saturated failure. For wind sensor, "3" indicates equipment frozen or card damage. The category II represents the running states of supply voltage and mainboard temperature of main collector or sub-collectors, as well as that of signal voltage, signal current, signal resistance and signal frequency of the sensor. Specifically, Using "0" means the values in the normal range, "2" no detected signal, "3" high sampling value, "4" low sampling value, "5" sampling value beyond upper limit of measurement range, "6" represents sampling value lower than measuring range, "9" means no detection. The category III represents running statuses of sensor signal wires, connecting cables for main collector, sub-collector or sensor. Number "0" means normal, "2" means that the cable is damaged, "3" means non-connected, "4" means in poor contact, "5" means short circuit, "9" means No Detection. The category IV is more peculiar, which mainly include power supply types of main collector and sub-collectors, free memory capacity of CF card, and main collector switch status. Its working status coding method differs from those of the previous three categories. For example, for power supply type, "0" means AC power supply, "1" means DC power supply. For CF card, "0" means sufficient free memory, "1" means un-sufficient free memory, and "2" means exhausted free memory.

Further, in order to better identify the operation status of each unit, so personnel as to carry out the maintenance work in a timely manner, 5 kinds of alarm coding are defined according to Definition of status values. Their codes are expressed by Capital English letters as follows: "NM" indicates normal. "FT" represents fault, which means the device or work units are damaged or no any signal and need to be repaired. "MA" is the acronym for "Maintainable Alarm", which indicates some detection points running status value is beyond the normal range and device can continue to work, but is need to be maintained. "BA" for "Broken-down Alarm", which represents the value of the work status of device has exceeded the threshold value, it most likely to be a fault and needs to be diagnosed and maintained. "ND" for "No Detection", which means there are no detection points. "NL" is abbreviation for "Null", which means no configuration (More of the similar content is no longer detailed here).

III. DESIGN OF OPERATIONAL STATUS FILE

In order to timely collect various state information from an AWS to upload to business center so as to be analyzed by operation system and personnel, it needs to form a file. File formats and content must conform to a certain specification.

A. File name rule

According to Surface Meteorological Observation Data File And Record Book Formats, (CMA ,2005, China Meteorological Press), the AWS status file name is defined as:

Z_SURF_I_IIiii_yyyyMMddhhmmss_R_EQU_FTM.TXT.

where, "Z" means it is a file of information exchange in China, "SURF" represents surface observation, "I" is an observation area code, and "IIiii" is site ID of observation station, "yyyymmddhhmmss" represents the time that file generated, its order is "year, month, day, hour, minute and seconds" (UTC, international time). "R" means that the file is about status information. "EQU" is an identifier of equipment type (e.g., AWS is national automatic surface weather station. REG is unmanned automatic weather station. ASM is automatic soil moisture observation station). "FTM" means data of regular observation, and "TXT" indicates that the file is a text file.

B. File content design

The contents of a state file include 3 lines, 16 sections. The first segment of the status information file is the basic parameters of the station, the second segment includes the identifiers of collector, sensor, etc., segments 3-15 are status information of various detection points, the 16th segment is reserved for the running status information of other extended observation modules of automatic surface meteorological observation equipment. Each segment is ended with carriage return and line feed characters "<CR><LF>", the 16th segment is ended with "=<CR><LF>", which indicates that the data of a observation station is ended. "NNNN<CR><LF>" is added at the end of file, indicating the end of all station records.

IV. APPLICATION

Through effective information of AWS status file extracted, analyzed and processed, all automatic stations operating status can be displayed in the ASOM system (ASOM is a CMA operation platform, which is used for real-time monitoring CMA atmospheric observing network, managing and tracing the observing network maintenance and support activity, analyzing and evaluating observing network performance). Figure 2 shows all China's manned AWS status real-time monitoring result that is provided by ASOM system. The figure can be seen all automatic station overall operation state in each provinces on every hour, including the number of normal stations, the number of faulty stations, the number of alarm

stations. We can also see the equipment fault or alarm start time and its duration from a time series map. In addition, the ASOM system can also query the detailed information of each station (figure 3), the information includes the basic information of the station, equipment failure type, failure location and its causes, to facilitate personnel to carry out effective maintenance activities.

Fig.2 all surface weather stations running status monitoring from ASOM (All provincial AWSs hourly status real-time mornitoring display, Round cakes and data represent each province's normal AWSs, abnormal AWSs and fault AWSs ration Statistics

Station detailed information					
Basic information					
Station Id:	54535			progress:	maintain completed
Repair personnel:	Dong jia	report time:	2016-12-14 08:21	upate time:	2016-12-14 08:21
Province:	HeBei	station name	CAO FEI DIAN		
Equipment	AWS	Model:	DZZ4	Manufacturer	Jiangsu radio Scientific
Fault Location:	supply power system				
status Code:	Z P S-PV-2, supply power system, power voltage, no signal				
Cuase:	Switch off, battery stop working				
Start time:	2016-12-14 00:49	End time:	2016-12-14 5:15		
Maintenance unit:	Meteorological Equipment Support Center				
Summary:	null				
Repair activity					
	start time	end time	type	level	repairer
1	2016-12-14 5:00	2016-12-14 5:15	maintian	station	Dong jia
	return to normal				

Fig.3 A sample for running state detailed information form of a surface weather station

In addition, using the database management of the status information, we can analyze the AWS working ability and the fault distribution, and the results can help to support AWS technical upgrade and improvement. Figure 4 indicates all Chinese automatic stations annual statistical results of fault distribution and its proportion in 2015. It can be seen that sensor fault accounted for the largest proportion of 31%, followed by the collector of 20%, the communication system of 14%. Hence, these are the key points in the technical improvement and maintenance job of automatic station. Using state information of AWS, ASOM system can automatically analyze various AWS types failure times and mean time between failures (MTTF), to compare the pros and cons of various types of AWS, provide the basis for future selection. For example, it can be seen that ZZ1-1 automatic station is the worst, its mean failure times is 0.21, MTTF is 2.52 hours, On the contrary, DZZ1-1 is the best in figure 5.

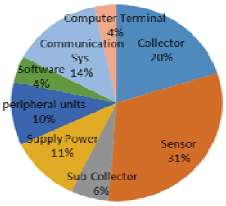

Fig. 4 All china surface automatic weather statons failure distribution and its proportion based on annual status information statistic in 2015.

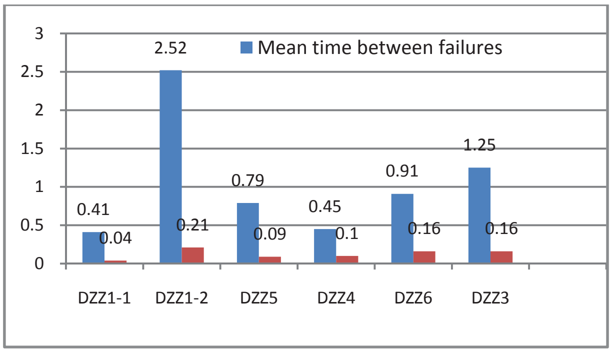

Fig.5 China's 6 models AWSs mean time between and mean failure times based on status information statistic in November 2016.

V. Summary and Conclusions

Based on the structure of the CMA second generation automatic weather station, this paper designs the function detection point, the state classification of each module, and the corresponding coding. The design specification is also applies to reserved device components, sensors, and interfaces.

According to the design and coding of the state information of the device, the standard status file has been worked out. It has been applied to the second generation surface automatic weather station. The hourly status files are uploaded to operation center to help personnel to monitor and support surface observing network.

the status information of AWS not only can be applied to real-time monitor all AWS , timely detect problems, help personnel to carry out support activity and improve the efficiency of maintenance, but also can evaluate the AWS performance regularly, to provide reference for technical improvement and selection of new generation AWS. This work has become a regular business of China Meteorological Administration, and constantly improved.

Because the influence of various abnormal state of equipment on the observation data quality is not very clear, need to be further verified in the future work。 Therefore, it is necessary to continuously adjust and perfect the equipment state detection points and its judging standards to get more accurate information.

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References

[1] CHONG P,SONG L,WU K,et al.The Designing and Application of the Atmospheric Observing System Operations and Monitoring in China[J].Meteorological Monthly, 2011,37(2):213-218.

[2] LI F, QIN S,ZHOU W,et al.Upgrading Design of Integrated Atmospheric Observing Monitoring operation and System Platform[J].Meteorological Science and Technology, 2014,42(4), 539-544.

[3] ZHOU Q,LIANG.Failure Analysis and Troubleshooting Methods of Automatic Weather Stations[J]. Meteorological Science and Technology, 2012,40(4):567-570.

[4] LI Y.Construction of Operation Monitoring System of Mesoscale Automatic Weather Stations in China[J]. Meteorological Science and Technology, 2013,41(2):231-235.

[5] YANG X Q,HUANG Z G, ZHANG J,et al.Implementation of Aircraft Condition Monitoring System on Air-ground Data Link[J]. Telecommunication Engineering, 2003 (1):68-72.

[6] LU A H, WU J Q. Application Of Multi-Sensor Information Fusion Technique In Aircraft Engine Condition Monitoring System[J]. Sensor World , 2004(7):22-25.

[7] DOU.Analysis on ACMS Reports Failure for Engine Monitoring[J].Aviation Maintenance & Engineering,2013(2):52-53.

[8] YUAN D, WU D X.Design and Implementation of Condition Monitoring System for Vehicle Based on GSM/GPS/GIS[J]. Microcomputer Information, 2006,22(25):246-248.

[9] WU Y,LIU W, LI K.Application of WSN In Railway Running Status Monitoring System[J].Computer Measurement & Control, 2012,20(3): 627-629.

[10] LIAN Z, LI H, LI X Q. Remote data acquisition and Failure diagnosis system for DF (7G) Locomotives[J]. Railway Quality Control, 2013,41(6):25-27.

[11] XING J Y, LIU N,HAO J T.Present situation and development of condition monitoring techniques for electrical equipment[J]. Power System Protection and Control, 2005,33(1):80-84.

[12] YUAN.The Application of the MTL8000 in Monitoring and Controlling Pump Running State[J]. Automation Panorama, 2008 (6):70-73.

[13] DU H, MENG X.Development of Monitoring System on Operation Conditions of Pipe-type Detection Flowmeters[J].Technology Supervision in Petroleum Industry, 2008(2):51-54.

[14] XIE WJ, LIU B X, JIANG Y W,et al.Discussion on weighing precipitation sensor[J]. Gansu Science and Technology, 2013,29(1): 60-62.

[15] LI Y,ZHOU Q,LI F,et al. Automatic detection technology of ground meteorological observation equipment[J].meteorological science and technology, 2015(6):1030-1039.

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