WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON REQUIREMENTS AND IMPLEMENTATION AWS PLATFORMS (ET-AWS)
Sixth Session

GENEVA, SWITZERLAND, 20 – 23 APRIL 2010

CBS/OPAG-IOS (ET-AWS-6)/Doc. 7(1)

(30.4.2010)

ITEM: 7

Original: ENGLISH

Automation of Surface Observations

Development of guidelines and procedures for the transition from manual to Automatic Weather Stations

(Submitted by M. J. Molyneux)

Summary and purpose of document

This document presents guidelines and procedures for the transition from manual to automatic weather stations in view of ultimately publishing it in the WMO Guide to Meteorological Instruments and Methods of Observations.

ACTION PROPOSED

The team is invited to critically consider the guidelines and procedures presented in this document. In particular, the meeting is invited to assess whether all sections should be kept for the development of the final document and whether any additional section would be required.

DEVELOPMENT OF GUIDELINES AND PROCEDURES FOR THE TRANSITION FROM MANUAL TO AUTOMATIC WEATHER STATIONS

Mike Molyneux
Met Office FitzRoy Road Exeter EX1 3PB United Kingdom
Tel: +44 (0)1392 885803 Fax: 0870 9005050
E-mail: mike.molyneux@metoffice.gov.uk

Section Plan

1. Introduction

This is a largely non-technical paper concerning the factors that should be considered during transition from Manual Weather Stations to Automatic Weather Stations (AWS). For the most part it considers changing a network of many stations, but most factors will apply to individual sites. A paper of this size can only act as a starting point for successful system change. Projects of this nature can take a small team several years to run. The aim is to provide guidance on how to start.

In the simplest terms weather stations exist to produce data based on automatic measurements, staff input or a mixture of both. However, the detailed uses of those datasets are complex and the properties of the data are key concerns to paying customers and users. The properties can vary in terms of:

- Uncertainty of measurement
- Exposure
- Availability
- Timeliness
- Quality
- Maintenance

Detailed guidance on these topics can be found in WMO Guide to Meteorological Instruments and Methods of Observation WMO-No. 8 (Seventh edition), Part 1 Chapter 1.

The properties needed are linked to the use of the data, for example:

- Climatological temperature measurements - key properties: low uncertainty, unbroken, long time series;

- Safety critical at aerodromes – key properties: high quality, high availability, low delay,

- Numerical Weather Prediction (NWP) and very short-range forecasting – key properties: timeliness.

However, it should be noted there are often several users and this increases the need for high performance in several properties.

This material is concerned with the process of transition from stations that are manned to stations that are not. As part of the introduction, it should be pointed out that there is a range of solutions involving staff levels and automation. For example in the United Kingdom, manned sites typically change the level of manual interaction over the working week. At times the station is unattended and produces coded messages with no staff input. At other times the system prompts the staff for attention to check and overwrite sections as needed before producing coded messages. At times a full time professional meteorological observer is present, but at some times only a duty forecaster is available. It should be noted that a staff input interface adds considerably to the requirement of the system and therefore to the cost. However, the majority of transition processes apply to some extent regardless of the amount of input.

When making any changes to a station the customers and users will be most concerned that the data output and key properties are maintained. This should be considered at all times.

Meteorological data from a station also varies considerably in subjectivity, within the automatic or manual measurements. For example, at a simple manned station the air pressure can be measured with little uncertainty with a barometer. However, the observation of cloud amount by skilled staff is much more subjective. An automatic station can also measure pressure very well, but the assessment of cloud amount is considerably more challenging. Therefore the changes introduced by automation can be small for highly objective measurements, but significant for subjective observations of cloud amount, visibility and weather.

At an early stage the change process must link changes to the WMO agreed Karl or GCOS Principles. These have been developed by Climate data users but can be applied to all changes. These ensure the change process considers all aspects. These rules are important and re-stated here.

GCOS/GOOS/GTOS CLIMATE MONITORING PRINCIPLES

Effective monitoring systems for climate should adhere to the following principles

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.

2. A suitable period of overlap for new and old observing systems is required.

3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.

4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.

5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.

6. Operation of historically-uninterrupted stations and observing systems should be maintained.

7. High priority for additional observations should be focused on data-poor regions, poorly- observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.

8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.

9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.

10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

2. Factors to consider in the full system design and when to trigger change

There are many reasons to change weather monitoring systems. Chiefly these include:

- Ability of old systems
- Cost of running old systems

It is important to consider these factors very well before changing from a manned to an unmanned station or network of stations. All systems need updating eventually, however, choosing the point of change involves some complex factors. It is important to consider

- Cost of groundwork (for example non-instrument installation such as wiring and mounting plinths)
- Staff needed to run the new system and where they will be located – after the new system is working
- Staff needed to buy, test and run the new system – during the change time only
- Setting up the detailed processes that tune the system
- Relationships between Met Service, suppliers and customers

These factors can be built into a balanced analysis of the costs and benefits of the change. The expected changes in cost over the next 3-5 years should also be considered. However, this will need an estimate of the increased costs of running the old system. This estimate will have considerable uncertainty. Therefore, choosing the best time to change is not easy. However, it is helpful to consider that the time needed to replace an existing system will be several years from start to finish. Since the continuity of service of data supply is vital to Met systems, it is important to trigger change early so that the new system can be implemented without risking major failure in the old system.

It is suggested that all work of this nature is carried out in a well defined project. It is well known that these techniques have been shown to deliver outcomes in a predictable way. Techniques can be found in many business management handbooks. (For Example, PRINCE II is a complete project management system)

It cannot be overstressed that during the process of changing the stations the users' requirements must be central. Requirement capture is familiar in WMO under Rolling Requirement Review process. However the requirements of the full system will vary depending on national circumstances and the requirement capture needs to consider the full range of use and circumstances and complete system hardware.

A well developed system is needed to draw out the user needs and existing processes. For example it is possible to use "Business Analysis" methods. For an introduction see Business Analysis (Paul and Yates). These can be used to plan the new system. The techniques were initially developed to work with IT systems. However, AWS systems can increasingly be considered IT data systems and the techniques transfer well. Overall, the main aim is to use a systematic approach to ensure that users needs are satisfied in a complete and competent manner. The exact system used is not important; but using one that is widely used, has well prepared methods and expert advice has considerable advantage.

A new AWS system will be expected to have some flexibility in its design, and this can be hard to define. For example, it is most likely that after a few years additional instruments will be required, but these are unknown at design time. Another example is the number of stations needed. Systems will cope with some expansion, but defining the cost needed for all expansion is difficult. At an early stage consideration should be given to these factors.

New management processes will be needed when the new site is installed. For example, fault identification and resolution. Where possible these processes should be incorporated into systems that already exist within the Met Service. These processes may lead to staff skills changing. There is a considerable wealth of details concerning the choice and use of the instruments. However, the manner in which the system is run and managed is more open to discretion and change, therefore at design stage it may be harder to specify. However, the desired method of operation should be considered as part of the design process.

National Met Services have chosen to design and build their own AWS or alternatively, specify systems and buy from a manufacturer. The reasons for these decisions are complex and should carefully be considered on a case by case basis. A group of well known manufacturers have good links with WMO. This is established through HMEI - the Association of Hydro-Meteorological Equipment Industry, see web page at http://www.hydrometeoindustry.org/.

In addition there are a number of major risks that can be identified during the change process, logging these points and managing them for success depending on local circumstances is important. Key risks include:

- New system fails to deliver
- Testing plan does not cover wide range of use
- Key system components unreliable in all field conditions
- Staff skills not available
- Installation constraints not identified
- Users do not accept new system design

3. Audit of a typical site

A complete review of the station operations is needed to ensure the smooth continuation of operations. Below is a list of key aspects of station operations:

3.1 Measurements

What measurements are made?
What instruments are there?
Are non-meteorological measurements made?

3.2 Records

What records data and metadata are there on sites that are not duplicated elsewhere?

3.3 Activities and processes

What activities are underpinned by the staff? These may not be clear; staffs are resourceful, skilled and good at quality control. These items are not easy to automate. Interviews can be used to document these processes in detail. These are examples of site issues that will need to be considered in future. They are likely to change with automation.

- Measurement quality checking
- Maintenance
- Site vegetation control

- Service Restoration
- Algorithms (Equations, calculations, tables and methods used to transform measurements

Staff activities, on-site, off-site and how they will change as a result of the new system are vital to the success of the new system. Staff skills are a vital resource in any system, but there will be need to change as the system changes. However, staff may be reluctant or unable to changes, duties, develop new skills or change location. However, they form a vital pool of expertise that will be needed for testing, documenting and running the new system. Consideration of a staff change and training plan will be needed.

3.4 Infrastructure

The following aspects are likely to change if the level of manning is considerably reduced at a site.

- Security – What are the needs of the site in future and what needs to be kept away from the instruments?

- Ownership - Who owns the site? Changes may impact on any contracts or arrangements with the Landowners?

- Power supply – What power is required for the AWS and sensors. Checks on continuity and quality of supply may be needed

- New infrastructure should be considered so that it is suitable for future use.

For example, using a well designed instrument enclosure may be expensive initially. However, the infrastructure may last for more than one generation of AWS and prove less expensive in the long-term.

3.5 *Outputs*

What information is sent to other parties? This can be well known coded meteorological messages, but can also include many local messages and alarms and data streams. These may be needed in real time. The methods of sending this information can vary considerably. Examples include hand written forms, voice alarms, video links and data streams.

4. Off-site processes

Offsite processes can be grouped into 3 main areas:

- Interfaces to other hardware systems owned by the National Met Service (NMS)
- Interfaces to customer hardware systems
- Management

It should be noted that off-site changes can be considerable and often may result in increased costs to set up or run. These costs should be considered when planning changes.

4.1 Interfaces to other hardware systems owned by the NMS

In simple terms the existing data from a station is delivered to customers in an agreed format using a hardware mechanism. For example, at an existing station the data may be transmitted in SYNOP format from a PC via a modem. It is vital that some customers or users can access the data without interruption. NMS downstream systems may need to be:

- Modified to accept new data or formats; and
- Unmodified retaining data and formats but this needs considerable testing to ensure service is continued.

4.2 Interfaces to customer hardware systems

If dataflow is modified - customers will be impacted by the changes. These impacts can be mitigated by early communication and help with change planning. New systems often have additional benefits to customers and these benefits should be stressed.

4.3 System and site management

A new system will change existing structures. Early planning is required to ensure that the impacts are minimal. It may be that other processes need to expand to accommodate the changes. For example, Calibration Lab activities and maintenance staff may need to be increased. Often greater staff skill levels will be needed in these systems.

List of Functions or teams needed to run an Automated AWS system:

- Calibration
- Stores
- Engineering Repair and service
- IT support
- Communications support
- Site Management
- Sensor and Measurement development planning and procurement
- Meteorological Coding and formatting development and planning
- Post measurement quality checking – data and coded output
- Databases for measurements and metadata

Some of these functions can be contracted to staff outside the NMS, but this has to be done on a case by case basis considering each carefully.

During the installation of a new AWS or network of AWS further skilled staff are needed

- System designers/experts
- Project manager and administration
- System test experts
- Installation planners
- Installation engineers

These skills may only be needed for a short period. However, it should be considered that during transition, it is likely that the old system will be running as before and overheads will not drop rapidly. At the same time the new system will need staff to run it and as it is new it will not run efficiently as it is bedded in.

5. Future Proofing

This paper has so far described a system largely designed to continue the service of the existing site or network. However, it is not intended that this limits the changes made when a station is automated.

For example, additional items to be considered can include:

- Ability to duplicate sensors of existing type
- Ability to add new type of sensors
- Higher frequency sampling
- Adding or modifying algorithms
- System management and control tools

For the project to run on time it is vital to identify all the areas of impact so that clear decisions can be made. It is hard to include very open ended additional functions while keeping the project scope under control.

6. Planning and documenting instrument change

It is important from the Karl Principles in section 1 that measurement changes are documented. However, the risk of change varies considerably. Examples include:

- Temperature and pressure measurement. These elements are likely to be highly objective at established stations, but their use is scrutinised very carefully by climatologists. Therefore, they need to be treated with great care.
- Cloud height and amount, visibility and weather. There is a high risk of change between manned and automatic observation, therefore the selection of instruments, data processing and use has again to be treated with care, but with a different focus to the measurements above.

Examples of non-ideal performance should also be considered here. It is also in the nature of instrumented measurements that failures are inevitable. However, processes needed when failures occur are not well defined. These need to be well understood as part of automation since they vary between systems.

7. Agreeing the completion of the change

A formal testing system should be agreed and carried out as part of the system change. This should be a sign-off process to show the new system or site is acceptable. For a system with an Observers interface the testing and sign off process can take a considerable time. This is due to the complexity of the AWS system itself and the episodic nature of weather conditions.

A full network of AWS is a complex working system. It is highly likely that issues will arise after the first installations occur. A good process to identify faults, issues and tuning requirements will be needed. This raises the need to have an ongoing change completion process. For example a routine test plan to show that new changes are working and have not impacted on other operations is important. It is highly likely that this will be used regularly in the first phases, and it may need to be done urgently if the impacts are considerable. As the system matures, changes will probably be less frequent but will be needed. In addition it must be considered that these change are being applied to a live system and frequent interruptions will not be acceptable.

8. Staff change process

Staff management will be an important aspect for the success of automation of stations. It is well known that staff are sensitive to change. Meteorological Observers are known to take great pride in their work. This means that they are a highly valuable resource in the transition process. They can act as testers and can be re-trained to make highly successful team members working with the new system. However, that process needs skilled input from staff managers. A detailed staff change plan should be considered at an early stage.

The transition following installation needs to be carefully considered and again staff change is highly important. Changing any system in an operational environment carries risks to service continuity. It is assumed that staff were heavily involved before the change and will most likely be involved to some extent after transition. This means that staff are required to maintain service continuity during the change and provide skilled back-up in case of installation or functionality problems.

9. Process and Documents

The process to specify design and test an AWS is complex. As an example here is a selection of important documents used in implementing the United Kingdom Meteorological Monitoring System (MMS). While this dealt with upgrading automatic stations – manual stations are still included and it gives a good insight into what can the involved. This project did not change existing sensors or ground works, their inclusion would add considerably to the project. This project was run using an outside company to design and build the system based on existing products. Since a lot of the functionality was provided derived from existing software this should be considered a minimum of documents needed.

Document	Purpose	Size Indication - Pages
System Specification	Details for the full system design (using references to WMO standards for coding)	200
Design documents	Manufacturers response showing the system design	250 (Outline only not all details)
Test plan and results (not field test results)	Comprehensive list of software component tests	375
Installation process	Working arrangements for installing the new equipments	30
System intercomparison	Results of side by side field tests	100

10. References

Business Analysis – Paul and Yates – British Computer Society IBSN 978-1-902505-70-1

Final Report of ET-AWS, Fifth Session, Annex 7 (Geneva, Switzerland, 5-9 May 2008)

http://www.wmo.ch/pages/prog/www/OSY/Reports/