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FRENCH RADIOSOUNDING AUTOMATION EXPERIMENTS

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ABSTRACT

To optimize the French upper air observing network and to allow extra observations , it could be necessary to automate the realization of radiosounding with an acceptable cost.

This paper presents the two experiments conducted by Météo-France: the first one with a complete automated system deployed in Bordeaux since 2003, the other one with an automatic launcher interfaced by Météo-France with the current operational systems, deployed in Nîmes since April 2008. Between the two periods, the offers in automatic systems have been evaluated and the needs of Météo-France have evolved. Updated information on offers and needs is also presented in this paper.

These two experiments and the benchmarking would be helpful to complete the requirements for the automation of the radiosounding and to enable the preparation of a realistic open tender for the automatic systems preferred by Météo-France. The program of automation of the radiosounding stations is in preparation for the next budget period 2009 to 2012. In the best case the intention for an open tender could be announced at the end of 2008.

FIRST EXPERIMENT OF A COMPLETE AUTOMATIC SYSTEM

The historical context

Although techniques of measurement by radiosonde have been significantly upgraded, to achieve a radiosounding still requires human manipulation, i.e.. for the preparation of equipment, the launch and metrological control.

In 1996, Météo-France has embarked on finding a system that could make automatic the main tasks related to the radiosounding activity. The chosen system, Autosonde, from the Finnish company Vaïsala, was currently the only available on the market. This system offers the possibility of preparing in advance up to 12 radiosoundings (24 possible) and programs automatically the release at expected hours.

After the adaptation of one Autosonde acquired by Météo-France to Vaïsala and a phase of tests operated in the experimental site of Trappes between 1996 and 2000, a feasibility study has been conducted on the question of introduction of this kind of systems into the upper air observing network of Météo-France. One of the conclusions was to pursue the experimentation on an operational site. Thus the Autosonde has been upgraded (2001-2002) and deployed in 2003 on the site of Bordeaux with the aim to experiment and to evaluate the system in operational conditions.

Five years after operating the complete system on the site of Bordeaux (2003 - 2007), it has been possible to have a feedback on its use, completed in part by experiments conducted by other meteorological services, particularly in Europe.

Functions expected and technical constraints

The functions expected by the system are satisfactory. However, the complete system is complex and technically remains limited in its ability to be integrated into the radiosounding network of Meteo France. The radiosondes and the ground system to receive and process radiosondes are embedded into the automatic system. This situation requires to purchase the radiosondes and the ground system from the same manufacturer.

Maintenance

A maintenance contract is required with the manufacturer, to cover the remote control, the help desk, the curative and preventive maintenance as well as the software development. Only the first level of maintenance is operated locally in Bordeaux, directly with the support of the foreign experts team. As Météo-France owns only one Autosonde, the department in charge of the upper air network, in Toulouse since 2004, does not get enough expertise to ensure the maintenance of it by its own, as it is the case for other observing systems. This limits the possibilities to monitor the system and to verify the actions carried out on it.

Functioning

It took about two years to stabilize the functioning of the complete system (2003-2004) at a proper level and to define the optimal organisation to achieve an operational use. In case of failure of the automatic system for a long period the use of a manual radiosounding can be activated. Since July 2005 the manual soundings accounted for only 3% of the launches.

Quality measurements

If we compare the stations of Bordeaux and Trappes, which have the same requirements (altitude, frequency, time, details), the availability of messages is better only for a few percents in Trappes, and remains acceptable for Bordeaux compared to the objectives fixed at 95%. In addition, the automated system offers better answer than the manual one to organise extra targeting observations on a daily basis with short notice. Since the beginning of 2008, the Autosonde of Bordeaux is used to produce extra observations for the European DTS Preview project (Data Targeting System).

Transfer of charges and employment

The time of work for the operations decreased taking into account the remaining tasks (preparation of probes and monitoring of the sounding during the day). In addition maintenance tasks have increased locally due to the complexity of the system.

However the employment benefit is important. The competencies have changed from observations to maintenance and forecasting activities. The schedule of the remained observations tasks have been totally transferred from night to day. Globally the radiosounding activity in Bordeaux needs now only 2 people, compared to the 5 people needed before automation.

Financial cost and return on investment

The total cost of using the Autosonde in Bordeaux has been evaluated, taking into account investment, deployment, upgrade, maintenance, consumables and depreciation. It has been compared with a manual station using a simpler ground system. The mean cost of an automated sounding made in Bordeaux is higher than a manual one. The extra cost is mainly due to higher costs of investments, maintenance and consumables for this kind of systems.

However, if we include the economy made on employments, the return on investment can be globally evaluated. This kind of information is well adapted for the purpose of automation, and could be a relevant criteria of global comparison between different systems.

Feedback from other countries

Other meteorological services use Autosondes in their networks, with a stronger level of automation, particularly on remote sites. They are generally satisfied with the performances, not all of them have taken a maintenance contract, and the quality and availability level could be quite variable.

UPDATE OF NEEDS IN AUTOMATION AT MÉTÉO-FRANCE

Evolution of the radiosounding network

Since 1996, the needs of automation in Météo-France changed and are more precise. Between 2005 and 2007 a study has been conducted on the evolution of the upper air network for the needs of Météo-France and the radiosounding network has been redesigned.

The current radiosounding network is composed of 22 sites including 2 ASAP ships. The new designed network would be composed of 18 sites with 4 ships. The main objective of this new network is to optimise the observations by reducing or increasing the number and the altitudes of the soundings depending on the applications and the meteorological situations. To implement this network the use of automation could be one of the answer in particular for the sites were it is planed to increase the number of soundings.

Main issues for the choice of an automatic system

Depending on the level of automation expected, the system chosen may not be the same, and the number of sites to be automated may be limited for reasons of cost and resources. Each kind of system offers its own advantages and benefits, depending on the aim of the automation : reduction of time work duration, optimisation of employments, safety, extra observations, etc. If the reduction of vacations is attempted only the nights, the number of automated launches will not be the same as for a complete automation for a week.

The choice of a system will depend also on the main orientation followed by the meteorological services in terms of observation. For example, the use of hydrogen instead of helium in certain sites could be attempted to reduce the cost. This kind of choice could imply to look for safer systems and to build new infrastructures to implement the system far from habitations.

An other orientation is the capacity to implement automation in term of human resources, competencies and organisation. This capacity could drive the choice to survey and maintain the systems by the Met Service itself or by a subcontractor.

Both, needs and technical issues will define the main functions required for the system and the technical constraints to take into account. Other criteria have also to be introduced to compare the systems and the services : the performances, the facility of implementation and maintenance, the financial costs of investment and functioning as well as the human resources needed to operate a network of automatic systems. The final question would be the return on investment.

Functions expected from an automatic system

A first version of specifications has been drafted in Météo-France with the assumption of a minimum of 2 launches, to cover at least one launch at night and a possible release in the event of failure of the first one. The option of 6 or more successive releases could be however asked in the final version of the tender, to cover the weekends too. The main functions to be fulfilled would be :

1. To prepare in advance balloons and on-board equipment
2. To plan the launch of a radiosounding
3. To automate the inflation of the balloon
4. To automate the start of the radiosonde
5. To automate the release of the equipment
6. To release a radiosonde in case of failure of the first
7. To have a simple management interface

Technical constraints to take into account

On a technical point of view the preference for Météo-France should be to have a system independent from the radiosondes and the associated ground equipment in order to be able to control the measurements and to manage separately the tenders for sondes and automatic systems. The technical constraints identified so far are :

1. Ease of adaptation of the automatic system with the radiosondes used in the network
2. Ease of interfacing with the ground system used to receive and process radiosondes
3. Possible use of balloons that could fly up to 30000 m
4. Use of helium with a robust connection to bottles
5. Safety for the operators when preparing the equipment and using the system
6. Power supply security in the French standards
7. Heating and air conditioning for acceptable working conditions
8. Facility of deployment and transportation
9. Possibility of remote monitoring

EVALUATION OF THE UPDATED OFFER ON AUTOMATIC SYSTEMS

The program of automation in Météo-France still has to be decided in term of sites, schedule, organisation and budget. It will mainly depend on the future radiosounding network, on the general needs and budget, but also on the current and potential technical offer.

After the feedback made for the Autosonde, Météo-France has conducted a benchmark to update the suppliers of automatic systems, to verify if there are no other systems on the market which could respond to its needs. In 2006-2007, the systems identified were :

-- The full systems developed in Finland by VAÏSALA
-- A recent full system developed in Japan by MESEI
-- A launcher developed in USA by YES
-- A launcher in development in France by MODEM

Some other manufacturers informed their intention to develop automatic systems too. The main differences between the systems are the number of successive launches that can be operated automatically (1 to 24), their level of independence with the radiosondes and the ground systems, their ability to use different sizes of balloons, and the possibility to use helium and hydrogen.

Autosonde and Autolaunch from the Finnish company VAÏSALA

The Autosonde has been already evaluated by Météo-France and is still on experimentation in Bordeaux. As the Autosonde was the first and single system to be developed and implemented for a long time, its conception should cover all kind of uses by the meteorological services. The general conception of the present systems is the same as the previous system used in France, but at a different price and return on investment.

The Autolaunch is the system adapted by Vaïsala for the radiosounding operated on the ships ASAP. Météo-France uses an other system on the French ASAP and did not evaluate further the Autolaunch as it allows to prepare only one launch.

ARS from the Japanese company MESEI

Among the automated systems already identified, the recent system ARS (Automated Radiosonde System) developed by the Japanese Mesei company seemed close to the Autosonde in its main conception : it is a complete system with a capacity of 16 automatic launches. As Météo-France looked for a simplest system, like launchers, no further evaluation has been conducted with it at this stage.

ARL from of the North American US company YES

The American company YES developed some years ago a prototype of automatic launcher, ARL (Automatic Radiosonde Launcher) offered for sale through the French company ATMOS. Actually the system has been designed initially for research campaigns and the main issue for Météo-France was to evaluate its capacity to be used in an operational context.

To evaluate this system, two phases were conducted. The first phase consisted on the examination of the technical documentation of the system, translated in French. Then a visit of experts from Météo-France has been organised by the both companies at the factory in December 2006. Exchanges of information allowed to evaluate the capacity of the system to meet the general requirements and the possibility of technical adaptation for an operational use. The factory evaluation carried out by the experts concluded that the system could meet the requirements.

Robotsonde from the French company MODEM

The French company MODEM was currently developing an automatic launcher, Robotsonde. The design of the system was finished and the main elements constituting the system were in phase of building . To carry out a technical evaluation Météo-France asked at the beginning of 2007 to the company to provide a prototype of the entire launcher with the possibility of review of the technical documentation and tests of the components in the factory. This first phase of evaluation was successful in November 2007.

SECOND EXPERIMENT WITH A MIXED AUTOMATIC SYSTEM

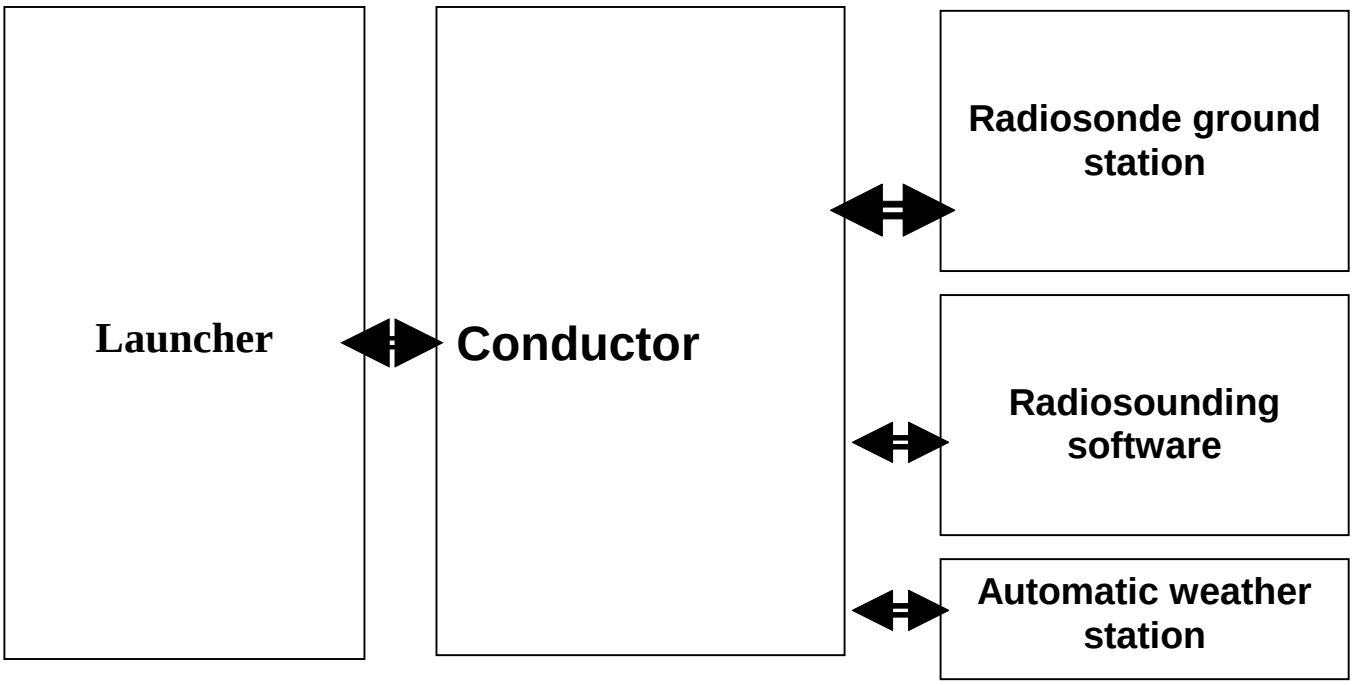
After this phase of evaluation Météo-France decided to go further and to conduct a second experiment in an other operational radiosounding station as it has been done for the first one, but with an other kind of automatic system, consisting in a launcher interfaced with the current observing systems and consumables used in Météo-France. The decision was then made at the end of 2007 to experiment the launcher developed by Modem.

These two experiments and the previous evaluations should be helpful to identify and precise the relevant information needed to prepare a realistic open tender and to propose the automation of a part of the stations of the network. In the framework of this experiment, the main following activities would be studied too : preparation, infrastructure, installation, backup, training, documentation, security, connections, survey, maintenance, operations, controls, etc.

Preparation of the experiment

The automatic system as designed by Météo-France would consist in five sub systems :

- a launcher to manage the sondes , schedule the launches and inflate the balloons
- an automatic weather station for the surface observations
- a radiosonde ground station to receive and decode the raw data of the sondes
- a radiosounding software to analyze the data, encode and send the messages
- a conductor interfaced with the previous elements to organize and synchronize the tasks



For this particular experiment a prototype of automatic system has been built with the launcher of Modem able to launch from 1 to 6 sondes, and the sub systems and consumables currently used in the network : the weather station Cobalt, the radiosonde station IR2K2 and the sondes M2K2 DC, the home made radiosounding software STAR II.

To built this system Météo-France adapted its software to produce automatically the messages and developed an interface to conduct automatically all the processes between the launcher and the sub systems. This interface has been designed as generic as possible to be easily adapted to other kind of launcher or radiosounde station.

The tests of the prototype of this system began at the end of 2007 in Toulouse and has been carried out by the upper air observing department for 4 months. In the mean time, the infrastructure was prepared on the site of Nîmes in the south of France to support the system on the ground, to fill in the gas and to connect it to the office for the electricity power and the exchange of data on the network. In Spring 2008 the system was deployed in the station of Nîmes successfully.

Phases of experimentation

Different phases of several months have been defined for this experiment to test progressively the automation of the manual tasks, to identify the issues to solve for the implementation of a such automatic system, and to maintain at least the same level of quality measurements as the manual.

The first phase concerned the functioning of the system and the appropriation of its different components by the operators, to be able to report and to correct in case of failure. The soundings at 12 h 00 were doubled by using the manual system as the reference and the automatic one as the experimental. The tests began on April 2008 and ended at the beginning of June 2008 with a skill score of about 80% of functioning for the last 15 days. Behind this global score other elements have been controlled eg. the number of changing of sondes before launch which could be a concern if it is too frequent.

The second phase consisted in the use of the automatic system as reference, both at 00 and 12 h UTC, but the sending of the TEMP message still remained manual. In case of failure the sounding could be released manually. The objective of this phase is to assess the preparation of the sounding and to test the cases of anomalies eg. the releases of sondes or failures of the system. The phase began on the 9th of June and is still under way. It is planned to end on September 2008.

The third phase will consist in the automation of all the tasks from the launch until the sending of the messages, but with the presence of the operator in case of failure, to be able to interact or relaunch manually if necessary. The objective is to correct the last issues. The duration should be 2 months.

The last phase would be similar to the previous one, but without the possibility of actions by the operators. The objective is to evaluate the performance of the automatic soundings by comparison with the operational indicators and attempted objectives. This phase is planned for a duration of 2 months more.

After the experiment

The final results of this experiment would be available at the end of 2008, just one year after receiving the launcher in Toulouse. More than 400 soundings would have been realized by the system. That should be enough to identify all the major cases that could happen during a sounding.

A lot of interesting issues have been already identified and solved, eg. the change of the sondes, the adjustment and the changing of the frequency, the calibration of the sondes, the availability of the surface observations, the level of gas, the releases of sounding in case of failure, the analyses of the raw data and the rejection of the wrong ones, the control of selected data, the sending of the messages and so on.

The general method to design the system is to analyse with the operators and the experts in radiosounding what is exactly done when the sounding is manual and to design an equivalent solution for the automatic system. The approach then is to look for the simplest way to solve technically these issues in order to get an efficient system, sufficient for the operations, easy to maintain and costless to build. These solutions would be then required for the operational network.

On the basis of this experiment and the previous one realistic requirements and specifications should be possible to write for an open tender. In parallel the internal discussions have begun with the direction and authorities to conduct a programme of automation for the next period 2009 to 2012. In the best case the intention for an open tender could be announced at the end of 2008.