

Cost effective monitoring of RWIS – Communication and maintenance

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ABSTRACT

In order to improve availability of road weather measurements and to minimize the cost of transmission expenses, The Danish Road Institute (DRI) has developed and implemented a system to superwise all **measuring stations** and communication lines in the Danish RWIS.

In Denmark measuring data from all measuring stations are collected in a common presentation system **VejVejr**. From the beginning the communication was depending of “state of the art” for communication on the delivery time. This meant that collection was done via 3 different networks. This was very difficult to maintain and the cost was very high. In 2005 it was decided, that collection of all information from measuring station should be done via IP/Internet connections.

Independently of type of measuring station DRI has developed the necessary interface between the measuring station and the IP network.

The interface is intelligent, and DRI has access to the full range of functionality in the measuring stations. Upload of new configurations can be done easy and with high reliability.

At the end of winter season 2007/2008 all measuring stations has been converted to communicate via IP connections.

Supervision programs for communication lines and measuring stations are available and can be used from any access point to the Internet.

At the same time the presence of IP network at a measuring station has made it possible to equip selected locations with **webcams** to watch both traffic performance and special weather situations. This information has been integrated in VejVejr and is available in parallel to the measured data.

1. INTRODUCTION

This paper describes how data collection has changed since the first Danish Road Weather Information System (RWIS) were installed approximately 25 years ago. This change is mainly a consequence of the development in the communication technology, but it is also a consequence of a standardization work done in 1994 and 1995 by The Danish Road Directorate (DRD) and the suppliers of measuring stations in Denmark at that time.

The standardization work resulted in defining the WMO (World Meteorological Organization) protocol as the basic standard for communication between measuring stations and central databases for measurements from measuring stations. The intention was that all stations in Denmark afterward should follow this standard.

Following the standardization, all Danish road authorities developed a common presentation system for road weather data in Denmark.

This new system and demands for very short delays in refreshing of the observations, established a need to have very fast data collection. This was, beside the economy, the major reason for developing IP-interfaces for the measuring stations in Denmark, and to convert all road weather stations to this technology.

The next part of the paper describes principles of the new communication system, and gives examples of the advantages this has given for the users of the road weather information, and for the people responsible for the maintenance.

The last part of the paper shows some of the improvements users of measuring data and maintenance can expect to have in the future.

2. STRUCTURE OF ROAD WEATHER DATA INFORMATION SYSTEMS IN DENMARK

In the mid-1980 the Danish Road Directorate started establishing RWIS for the motorways and other major roads in Denmark. The RWIS was established as stand alone systems each with own database, presentation system and a number of measuring stations. The presentation system also received and presented precipitation radar pictures, general forecasts based on data from the measuring stations and regional forecasts.

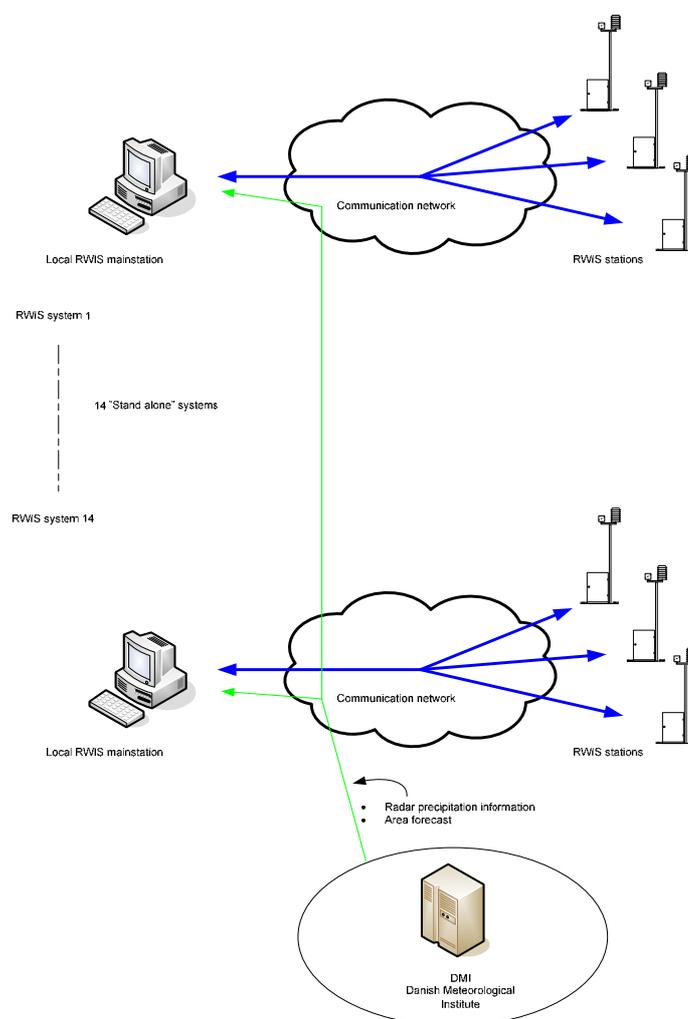


Fig. 1 First generation RWIS in Denmark

2.1 Formats and communications in the first systems

The systems (from 2 different suppliers) were different in both communication protocol and communication type, but the structure was more or less identical. The lay-out of the system is show in Figure 1. It is important to remark that all communication lines are supplied from the Danish Post and Telegraph (PTT). There are no internal communication lines along the motorways and major roads.

The systems were established in the 14 Danish counties, and it was complicated to exchange information between two systems of different type. And at the same time presentation of data was different between the systems, so verbal discussions between users were difficult. In general the systems were constructed according to the supplier's capabilities, more than to the road authorities' demands.

2.2 Standardisation of formats

With these experiences in mind, a standard protocol to for the communication with road weather stations was developed. The standard describes a lot of details about measuring stations (accuracy, resolution, minimum type of measurements) and especially about the protocol.

The protocol which was chosen is based on the WMO principles for data exchange. First of all because most of the measurements are meteorological, but also because the chosen protocol is open, for in principle, all types of measurements. And maybe as the most important it is very easy to handle and introduce new sensors and sensor types with, e.g. both measurements and observations, e.g. light precipitation.

Based on this standardization the structure was as it is shown in Figure 2

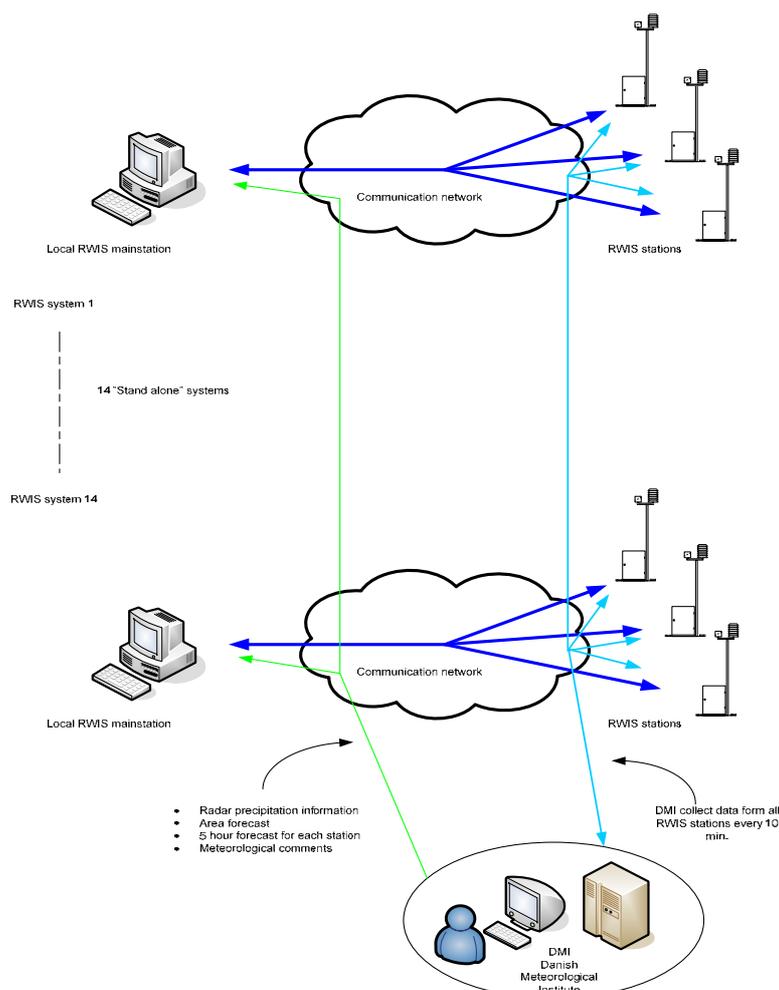


Fig. 2 Second generation RWIS in Denmark

From one point of view Figure 1 and Figure 2 are identical. But there are important differences, and special matters that have to be mentioned.

- All data are stored in the same format
- All data are collected twice each 10 minutes. From the central database and from local databases
- Each system has the same screen pictures, with different information
- A high level of integration between the central database and the local systems has been introduced.
- New (known) sensors can be added without operator assistance.

The principle for the data collection is that you first call one station, receives information, and then you call the next station and so on.

Communications between the databases and a very small number of the newest stations was done via IP/internet connections.

The system shown in Figure 2 represents a very robust system to collect observations, because there are several ways to get information from measuring stations to a specific terminal in a system. If the local system were defective a terminal could instead connect direct to the central database. The only problem in such a combination was that observations in worst case could be delayed for 20 minutes.

Another important matter was the transmission cost for collecting data. It was very expensive to collect data due to the price policy of the Danish PTT, and it was of course twice the cost to collect data two times.

2.3 Implementation of an IP network communication system

As it became more and more difficult and expensive to maintain the database structure, a new centralised system was developed from 2004.

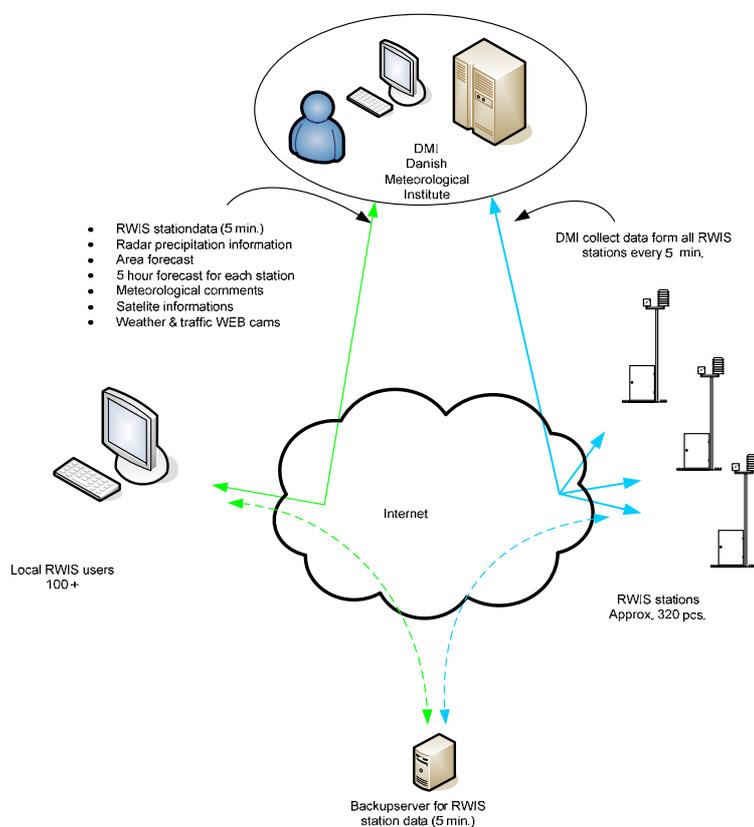


Fig. 3 Existing RWIS in Denmark

This new system was not in itself a reason to make collection of data via IP/internet connections. But with approximate 320 stations in the system, and “serial” data collection, the collection became difficult and time consuming to handle. The expenses for collecting observation for every 10 minutes were rather high, and the users were at the same time interested in observations every 5 minute.

With this information in mind The Danish Road Institute developed a common Internet interface to be used with all types of measuring stations used in Denmark (Rosa from Vaisala, GFS2000/3000 from Boschung and 888 from Malling. The unit is at the same time both a router and a fully functional firewall.

The development was done during spring 2005, the field trial during the summer 2005 and installation started September 2005. Today all Danish measuring stations (app. 320) have been converted to communicate via the Internet.

3. ADVANTAGE IN IP NETWORK

For The Danish Road Institute (DRI), who installs and maintains most of the measuring stations in Denmark, the presence of the Internet connections has opened a new range of possibilities regarding installation, maintenance and new features from the measuring position.

3.1 Connection types

In the installation phase it is interesting to have several possibilities to make a communication connection. The suppliers for Internet equipment offer huge amounts of transmission possibilities. But since the transmission equipment must follow technical demands according to Danish standards, we have chosen equipment for 3 different installation types. The 3 types are shown in Figure 4.



Fig. 4 Measuring station interfaces

3.1.1 Cabled connections

Where possible we prefer to use wired broadband from the measuring station to the Internet, with the lowest possible data transfer speed (for the time being 512/512 kbps).

The interface unit –TG5 - has facilities to store records of data going to and coming from the measuring station. There is also a possibility to analyze and trace “attacks” from hackers on the Internet. And in this way construct new firewall rules to prevent intrusion.

We have also arranged that all the units from wired connections are placed in a so called closed group. This gives the possibility to restrain non authorized persons to access any of the installations. The function is not in use today, but if the need should occur, it can be put in service within a few hours.

Most of the Danish measuring stations (app. 95 %) are connected via cabled connections.

3.1.2 Wireless connections

In some areas where the telecommunication infrastructure is poor or absent, we have selected an interface – SIG5 - with an extra wireless communication port. The typical position is along a new motorway, where a telecommunication infrastructure not has been established during the construction period.

The communication media is basically GPRS, but dependent on the type of agreement with the telecommunication supplier it can also be UMTS, or even better transmission speeds.

The facilities in these two first types of interface are for supervision purposes at the same level. But one interesting facility is that the two external ports in the interface can be used at the same time. This gives a possibility to collect observations via two completely independent communication networks. For critical measuring spots this can definitely improve transmission safety.

3.1.3 Wireless low power connections

In some areas, typically along motorways, there is no communication infrastructure, and there is any power supply. In these areas we establish measuring stations powered with solar cells and telecommunication via GPRS connections. In this situation the communication interface – AMPLEX is special designed for low power operation. This means that part of the facilities in the network has been disregarded to keep the power consumption at the lowest possible level. A measuring station powered with solar cells and wireless communication is shown in Figure 5.



Fig. 5. Measuring station with solar cells and wireless transmission

3.2 Improvements in RWIS

For the RWIS in Denmark as a whole, the conversion has given desired improvements of both functionality and safety for stable and reliable collection of observations from the stations.

About the functionality the most interesting point is that we collect 1 dataset per station every 5 minutes from all 320 stations. In combination with the distribution of the collected data to the terminals, an average delay for an observation is less than 2 minutes. This is an improvement that gives a better and more precise foundation for decisions about preventive salting in a critical situation.

A positive consequence of having broadband connections to all measuring stations is the addition webcams for supervision of snow situations at a large number of positions. Today about 15% of the stations are equipped with webcams.

A picture can in many situations give you much more informative description about snow-fall than even the best precipitation detector or snow depth sensor. Webcams at measuring stations are the most important extension in the Danish RWIS in the latest four years.

Another improvement is establishing a back-up database for observations from measuring stations. With a centralized system design, there is always a risk that a single point of failure can stop the complete system. It happens very rarely, but when it happens, this will constitute an extremely critical situation.

For this reason a back-up system has been established geographical apart from the normal system. The back-up system is a complete stand alone system for observations. This back-up system collects its own data-sets independent of the normal system.

This back-up system could of course also have been established in any other system with standard modem connections, but since there is no transmission fee at the Internet, the only expense for the extra safety is the

database system. Later in this paper the economical consequences for the transmissions cost in a traditional system are described.

3.3 Supervision systems

The new system also provides improvements for the technicians, who maintain the whole system. In the 2 first generations of systems, and according transmissions line, there was in most situations only one way to discover the cause of missing data. Start the car and drive to the location. Once there, the technician could identify problems and solve them.

3.3.1 Supervision system for communication lines

In the new communication system a new program for remote device monitoring, called GateManager, has been introduced. GateManager is closely related to the equipment we are using as interface between the measuring station and the Internet.

Basically GateManager helps service engineers to supervise all communication connections and corresponding interfaces. When failure occurs, GateManager can as an example send e-mails to the relevant engineer, with description of the situation. In this way it is easy to discriminate between failures from transmission, and failures from measuring stations. And based on this information it is easy to act in the most efficient way.

The most important function, however, is that an operator within few minutes can make identical changes in all interfaces in the complete network. This could be addition of a new firewall rule or updating of firmware in the interfaces.

The two functions mentioned helps in an effective way our service engineers in minimizing the periods where measuring stations are out of service.

3.3.2 Supervision system for webcams

The GateManager system helps in supervision of communication lines and interface equipment. For supervision and maintenance of webcams and video servers there has been implemented a new system.

At this moment it is a test system to be used in connection with one of the supplier's products. We will use the experiences from this system to make a requirement specification for a general supervision system for video servers and webcams.

4 Return of investment

It is always difficult to make comparisons on return of investments, but the basis for the decision about making the investment was the system lay-out described in Figure 2 and collection of data at intervals at 10 minute from Danish Meteorological Institute (DMI) and from one local system.

The calculations are shown for one station.

Investment:

Development costs	€	135
Interface equipment	€	735
Installation	€	160
Conversion fee to the PTT	€	200
Total	€	1.230

Running cost per year - before the conversion:

PTT transmission fee - local system	€	1.100
PTT transmission fee - DMI	€	750
Total	€	1.850

Running cost per year - after the conversion:

PTT transmission fee - local system	€	800
PTT transmission fee - DMI	€	15
Total	€	815

The annual saving is therefore €1035.

This means roughly that the return of investment time is 18 month.

The value of the investment has later been increased, since data collections now takes place at twice the original collection rate.

5. CONCLUSIONS AND FUTURE IMPROVEMENTS OF SYSTEM

The conversion to Internet communication lines is done with the only purpose of improving data communication from measuring stations. The improvements until now are

- Lower transmissions costs
- Higher update rate
- Better supervision facilities
- Easy inclusion of webcams at measuring positions

Improvements of the system shall give the users of RWIS reel benefits. These benefits include faster detection of failures, shorter down periods and better basis for prognosis.

GateManager and the interface can of course not make a judgment whether a measured value is correct or wrong. But all 3 types of measuring stations in Denmark all have additional information on internal technical status. This information is a part of the dataset sent to the database. But since the database only has meteorological data, the information is lost.

By building in an agent -a small program – in the interface, it is possible to “listen” to the data and find out when a failure is reported in the dataset. This failure will then be reported to GateManager, which can handle this message by sending an e-mail or a SMS.

With this additional tool failures will be detected at a very early stage, maybe before RWIS users find out there is a failure.