EnviroInfo 2005 (Brno)
Informatics for Environmental Protection - Networking Environmental Information
 ISBN: 80-210-3780-6

The Hydrological and Meteorological Monitoring, Forecasting and Warning System – Conception and Characteristic

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Abstract

Paper presents one of the basic elements of the System for Monitoring and Protection of the Country, which is telemetric measurement system at the Institute of Meteorology and Water Management in Poland. The entire project including radar system and lightning detection system was financed from World Bank resources.

Poland, and specially its southern part, is an area under the flood danger. Summer floods caused by long lasting rainfall appear here and less frequent snowmelt-rainfall floods. It is also area of summer flash floods. Concentration time, counted from the beginning of rainfall to the culmination phase of flood does not exceed 36 hours on the main rivers of southern Poland. Flood danger occurs also on the remaining area of country. The floods in Poland generate substantial economical losses, also cultural heritage is under danger when cities are flooded. Dull experience of the last years shown, that water is also danger for human life.

Taking into account geographical location and level of flood danger, functioning of system for hydrological and meteorological monitoring and warning of the country is essential. The Water Act, controlling the whole of water management issues, makes Institute of Meteorology and Water Management responsible for efficiency of this system. In frame of Institute, operate National Hydrological and Meteorological Services. The hydrological and meteorological monitoring, forecasting and warning system operating in Poland was developed practically since the beginning of regular hydrological and meteorological observations. Of course, one should remember, that it took place at the end of XIX century, as a result the beginnings of this system were only observations of flood phenomena. Actually, at the beginning of XXI century, system for monitoring and warning against dangerous phenomena occurring in hydrosphere, only to a little extent resemble the first systems being one of the largest and most modern system of this type in Europe.

The impulse for starting efforts connected with modernisation of hydrological, meteorological and warning system was shock for the Polish people resulted by flood in July 1997 on upper and central Odra and upper Vistula catchments. Thousands of flooded hectares of agriculture land, great many villages and towns flooded, danger and partial flooding of big cities (Wroclaw located by the Odra River was most significant example) and finally death of many persons is total effect of this flood. The obvious question appeared – how did operate hydrological and meteorological monitoring system, forecasting and warning system and communication system. It turned out that human factor did not let down in all points of system but in many places technology and communication failed. Detailed analysis and assessment of meteorological and hydrological monitoring and warning system behaviour during July 1997 flood resulted with a decision that technological support for those systems is highly required. Decision to take out a World Bank loan for financing necessary works and purchases was taken. Realisation of the hydrological and meteorological monitoring, forecasting and warning, system known under acronym SMOK (from Polish name of the project), took place in years 2000-2005. Tenths of firms and many co-operators from different

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parts of the World took part in project realisation. Practically all elements of monitoring and warning system were modernised – among them also network of meteorological and hydrological posts, which were extended by telemetric network, communication and data transmission system, data receiving and processing centres localised in hydrological and meteorological forecasting offices and also other measurement systems and information processing systems concerning state of hydrosphere.

Taking into account hydrological and meteorological protection and warning in case of dangerous phenomena occurring in the hydrosphere, the most important role play meteorological and hydrological forecasting offices. Actually, information from telemetric network, hydrological and meteorological posts, data from satellites, radars, lightning detection system and other measurements systems are coming to those offices in continuous way. In favour of those offices are performed calculations of forecasts using numerical meteorological models. Finally those offices analyze and process available data and disseminate results to the final users in form of information, warnings and forecasts. The key role in operation of hydrological forecasting offices plays hydrological and meteorological telemetric measurement system. Besides their basic task - delivery of observations results covering whole country for creation of announcements, warnings and hydrological forecasts, they play also important role of data provider for:

- radar imagery calibration procedures (determination of cloud water content and its result on the earth surface),
- auxiliary procedures used for calibration of mezoscale meteorological model (in local model work out process),
- procedures of meteorological forecasts verification by using them as an "input" for hydrological forecasting methods.

Created telemetric system of hydrological and meteorological monitoring operates in parallel with existing system of traditional measurements, operated by observers. From the assumption it is hierarchical system, where measurements results travels through the intermediate chains, so called Data Collecting Station, which have also access to transferred data. Such an access is important for validation and verification of data and to carry on local services. One of the aspects of hierarchical system is possibility for creation of different routes for transferred data. This property substantially increases system reliability, especially in crisis situations. Topology of telemetric system is presented on Fig.1.

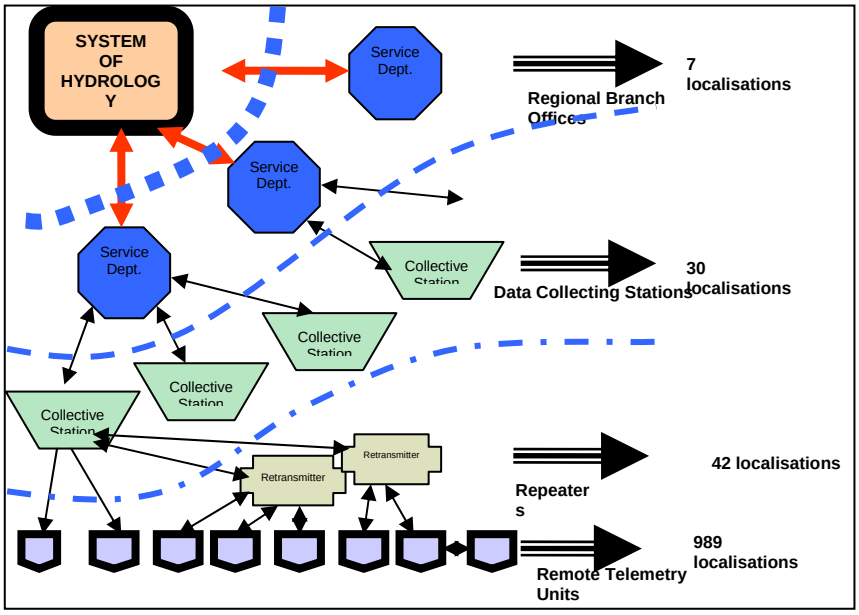

Fig. 1: Topology of telemetric system

The technical guidelines and bidding documents conditions for creation of telemetric system were prepared taking into account:

- accordance with World Meteorological Organisation standards being in force,
- conception to use highest quality measurement sensors, availability of spare parts and maintenance in next years,
- use of devices with known and verified quality in existing installations (prototypes were excluded) ,
- environment conditions at measuring posts in range of temperatures from -30˚C to +60˚C with possible heating at localisations where power supply 230 V is available,
- low maintenance cost and low level of complication for current service,
- easy future development, taking into account both number and type of the measuring sensors and also number of measuring posts in whole system,
- use of the most reliable communication means simultaneously considering exploitation cost.

According to the conception included in technical project, it was created telemetric system of meteorological and hydrological posts on the area of Poland, consisting of 989 measurement posts. It is necessary to add, that this system was dedicated for the systems exploited in hydrological forecasting offices, especially for system of hydrological modelling and forecasts, taking into account localisation and number of each post types and realised measurement programme. The following measurements are delivered to hydrological forecasting offices:

- water levels (570 points),
- additional water levels from so called "unmovable" posts, which are post localised and constructed in a way, that they can survive in case of catastrophic flood (30 points),
- water temperature (181 points),
- underground water levels from piezometric posts (41 points),
- liquid rainfall from pluviometers, heated and not heated (379 points),
- air temperature at meteorological cage (186 points),
- air humidity at meteorological cage (186 points),
- wind speed and direction (186 points),
- temperature at the ground level (186 points)

Fig.2 presents density of telemetric network. This density is highest on the area of south Poland, in place where flood danger is highest and floods have most violent character with most rapid development of this phenomenon.

- frequency of the measurements is a parameter which may be configured at the telemetric network. Following standard frequencies are used:
- rainfall measurements from the posts used for meteorological radar calibration – every 5 minutes,
- rainfall and water level for hydrological forecasting offices on the area of south Poland – every 10 minutes,
- remaining meteorological and hydrological measurement on remaining area – every 1 hour.

Frequency of data transfers to the hydrological forecasting offices is also configurable parameter. It is set to the standard level of:

- continuous collection of observation results from synoptic and other stations equipped with Vaisala MAWS measuring stations,
- highest frequency of data collecting – 20 minutes,
- average for mountainous areas and post transmitting by radio – ones per hour,
- average for mountainous areas and post transmitting by cellular connection (GPRS) – ones per 12 hours,

- average for remaining posts (GPRS contact) – ones per 12 hour.

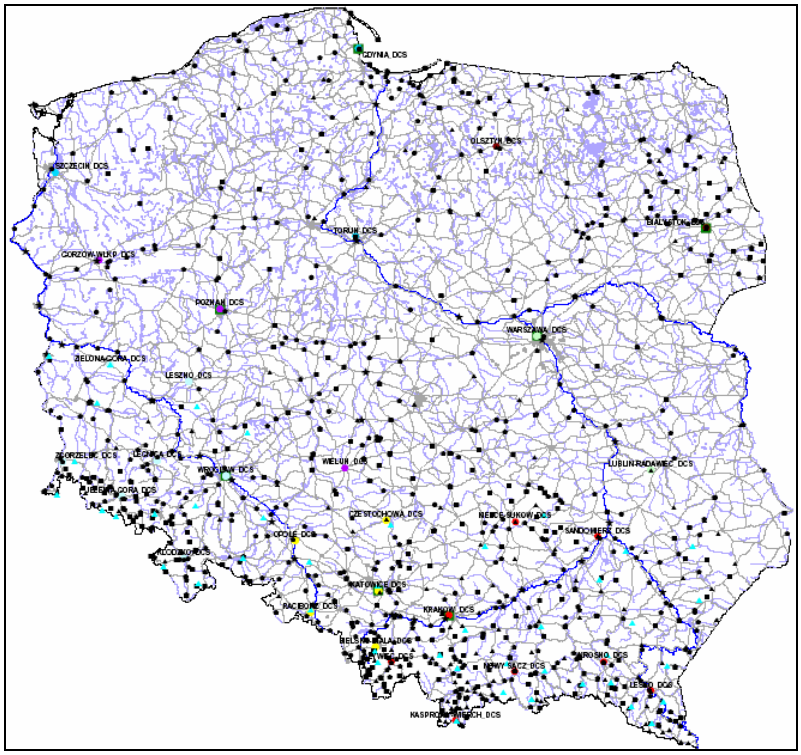

Fig. 2: Density of telemetric network posts

Change of frequency of measurements and number of transmissions may be done from the hydrological forecasting office level for the entire range of measurements and all posts or for selected elements of measuring system and selected posts. Change of frequency depends on flood threat and needs of individual hydrological forecasts.

One of the important elements of telemetric systems, often determining its efficiency is communication subsystem. Such a subsystem use radio communication, GPRS and at the slight level Polish Telecommunication Operator. The basic premises for creation of communication subsystem of telemetric system based on radio communication resulted from experiences gained during floods in last years. Several times, communication using GSM technology for data transfer from measurement posts, met severe problems in critical situations. As a result neither network management, nor data collection was possible. Positive experiences with radio communication during the 1997 flood in region of Krakow and Krosno (channels in 300 MHz band) resulted with the decision to apply similar solution for maximal possible area of Poland using 10 multiplex channels in available for this purpose 416-426 MHz band. Optimization of build cost and also maintenance cost of such designed system, lead to selection of 450 posts contacted by radio communication. Remaining 532 posts is controlled with use of GPRS technology. Only 7 posts use PSTN network. It is result of technical problems not allowing for application of other communication means in those cases.

Telemetric system, according to applied quality level, owns several protections, specially in telecommunication part. Backup communication are applied on the all levels:

- for selected 30 posts („unmovable") doubled water level sensors an doubled communication means where apllied, additional solution - INMARSAT-C satellite transmission was used,

- Collecting Stations which are not connected to IMWM wide are network (WAN) use V-SAT solution,
- for remaining Collecting Stations, wich are in the range of IMWM WAN, ISDN connection was applied as a back-up,
- additionally during construction of the system, possibilty for spare connection to retrasmitting station with use of GPRS technology was added.

Emergency communication is automatically started by the managing system of Data Collecting Stations and Regional Branch Offices.

In the technical specification, besides technical requirements concernig measuring sensors, measuring posts and communication devices were included also requirements concerning software on all levels of system, scope and conditions of testing and prestart conditions.

It's necessary to remark, that telemetric system of that size, realised as an one task is evenement in the World scale. As a result of announced application for tender and after fulfilling the procedure according to World Bank requirements, selected contractor (Canadian consortium leaded by Hydro Quebec) presented the list of devices in accordance with Technical Specification which were a basis for offered solution:

- Datalogger SUTRON Xlite
- Radiomodem SATEL
- GSM/GPRS modem WAWECOM
- INMARSAT-C Thrane receiver
- Measurement sensors:
- Vaisala
- Sutron
- MetOne
- Aplisens
- KFAP

Main contractor cooperated with two subcontractors from Poland: XYLAB firm from Krakow and AKSEL from Rybnik (repeater station construction) and also with DrQ from Krakow in frame of software.

All works connected with modernisation of country monitoring and protection network were already finished. Both during design phase and during construction of telemetric network, the biggest problems were not technical ones but mainly matters concerning obtaining necessary administrative approvals and decisions and also observed more commonly problem of devastation and robbery. During completition of tender for network construction, appared new technical possibilities to apply solutions of GSM technology, i.e. use of GPRS technology. At this moment the only solution was changing of GSM modem specification, which requirements were adopted to GPRS technology. All further steps adapting system to emerging technological possibilities were done during its realisation. Application of GPRS technology, make possible certain simplification of the system sticking to the fundamental condition for the system acceptance, which is delivery of observation results from all telemetric posts to the database of System of Hydrology within 20 minutes after beginning of data collection process. Actually, guarantee tests and implementation of the system in operational service are performed leeding to the finish of all works.

Giving to the operational exploitation the system for monitoring and warning of the country against dangerous phenomena occurring in hydrosphere created new possibilities in following fields:

- continuous automatic monitoring, data transfer, processing and collection of data with defined timestep adquate to actual and forecsted situation,
- preparation of required warnings and forecasts,
- delivery of information to the Polish people and to the national administration, concerning actual and forecasted situation.