



**Convention on the Protection and Use of Transboundary
Watercourses and International Lakes**

**Seminar on flood prevention, protection and mitigation
(Berlin, 21-22 June 2004)**

**Conference room paper
MP.WAT/SEM.3/CRP. 3**

**A PROJECT OF MODERNIZATION
OF THE STATE HYDROMETEOROLOGICAL SERVICE IN POLAND**

Discussion paper transmitted by the Government of Poland¹

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Introduction

The 85 year-long history of Polish hydro-meteorological service has recorded a number of natural disasters brought about by a devastating and distractive course of the weather phenomena.

The 1997 summer flood which was caused by the abundance of precipitation in the source areas of the two largest Polish rivers- the Vistula and Oder, was regarded as the most dramatic both in the social and economic aspects.

The IMGW service carried out its duties effectively starting from the stage of forecasting the precipitation, next defining and passing on warning and forecasting the hydrological phenomena course, as well as constructing the possible scenarios of the situation, plans and solutions minimizing the flood effects.

The scope and dynamics of the flood course exposed the weaknesses of the formerly under-subsidized hydro-meteorological service, despite a well-developed network of the measurement and observation stations, as well as the communication devices at disposal, additionally international co-operation and exchange, involved staff continually carrying out tasks connected with monitoring the atmosphere and hydrosphere.

It became evident pretty soon that the warnings flowing from the Institute were not always perceived and publicized on time. A meaningful number of the stations were disconnected due to a damage of the measurement or communication equipment. Lack of modern measurement equipment, as well as transportation means makes the job of area teams impossible. It also results in an inefficient co-ordination between the sections of the service, as well as between the Institute and other branches of the State Flood Control System.

It can be stated here that although the dramatic effects of the flood could not be avoided, the degree of the losses could be reduced providing a more modern equipment and more efficient functioning of the IMGW service.

The general conclusion defined, resulting from the 1997 flood experiences, was connected with an urgent need of modernization of the operating system of monitoring and forecasting hydro-meteorological phenomena. It was the basis of the programme of the complex modernization of hydro-meteorological service, built by the experts from IMGW.

The programme comprising subsystems of observation and measurements, communication, data processing, forecasting, as well as information transfer was included into the Project for Flood Damage Removal, having received an approval from the state decision making organs, and was financed by the loan amount obtained from the World Bank.

Although the programme of the service modernization is directed mainly towards the problem of flood control, its assumptions also include monitoring, forecasting and warning against other disastrous phenomena such as winds, atmospheric discharge or storms.

Components of the Project of Modernization of the Hydro-Meteorological Service

The above mentioned Project for Flood Damage Removal was built on the assumption of a simultaneous realisation of undertakings comprised within the frame of three components:

- A- reconstruction of both urban and rural basic infrastructure
- B- flood control and flood hazard
- C- administration of the project and technical assistance

The B component comprises four tasks:

- B1- planning flood control in the catchment

- B2- monitoring, forecasting and warning
- B3- investments in the area of flood control structure
- B4- prevention and limiting of the hazard of flood

IMGW responsible for hydro-meteorological control of the country, carried out by the State Hydro-Meteorological Service, was appointed the implementing institution for component B2 in agreement with the Water Law bill passed in 2001.

Component B2 was divided into 9 subcomponents in order to define the undertakings and utilise the subsidies in a reasonable way:

- Construction and putting into service the telemetric measurement network
- Systems of control and hydrological forecasts
- Implementation of operational meteorological forecasting model
- Modernization of the tele-information system and constructing the Client Service System
- Equipping the measurement and service teams
- The system of detection and localization of atmospheric discharge
- Extension of the POLRAD meteorological radars system

Construction and putting into service the telemetric measurement network

The basic purpose of the operational flood management is a possibly early warning concerning an expected river water rise, defining its size, as well as its course.

Flush forecasting for the flood management purposes is based upon the knowledge on the current hydrological situation in the protected catchments and precipitation forecast. Today, the latter is developed inter alia on the basis of results generated by mesoscale meteorological models, continuously developed and producing increasingly more precise quantitative precipitation forecasts. This improves the quality of hydrological forecasts, whereby the mathematical hydrological models are applied. Proper hydrological modelling cannot be ensured without constant inflow of data from meteorological models and those generated by the network for measurements of precipitation and water levels at the selected points of the river system.

The built-up and maintenance of telemetric flood management networks is extremely expensive. Nonetheless, the per annum cost of the system development equals just a few basis points of the losses caused by a catastrophic flood on the protected area.

Work on the SMOK concept began in the end of 1997. The countrywide hydrological and meteorological monitoring network will be just one of the elements of the planned system. The network consists of approximately 1100 individual installations, including 516

hydrometrical stations, 246 precipitation stations, 217 meteorological stations and 60 already existing automated synoptic stations, some of them being also the collecting Centres of the system. The other stations include Regional Data-Collecting Centres, located in the IMGW branches in Poznan , Warsaw, Bialystok, Gdynia, Wroclaw, Katowice, Slupsk and Kraków, radio repeaters and re-transmitting stations. The exact number of the latter two will be determined only following completion of the System Technical Design. The stations for measurement of the unsaturated ground layer water level (30) will constitute a conceptually new element of the network.

The distribution of the measurement stations in Poland is not regular. The highest density network will cover South of Poland. It is there where the flood waves on the Oder and Vistula are formed and the mountain regions are most threatened with the disastrous phenomenon.

Data flow continuity must be assured at the level of the system design. It particularly concerns the hydrometrical stations, most vulnerable to destruction or damage during floods. All hydrometrical stations will be constructed and equipped so as to meet the data flow continuity requirement in all conditions. A certain group of stations, referred to as "indestructible" will be particularly protected in terms of their location, construction, power supply and telecommunications. An additional protection and maintenance measures will be taken to organize a special service in the time of flood. Majority of hydrometric stations in Southern Poland, nearly all stations on the Oder and Vistula and the estuary sections of their largest tributaries will be available to the data collectors through at least two independent communication channels.

The advancement of the realization of the telemetric network is at the stage of progressing field works and completing the issues connected with legal proceedings .

The Hydrological Monitoring, Forecasting and Warning System

The knowledge of the current hydrological and meteorological situation is insufficient for effective flood management. Quantitative forecasts of water level changes (flows) are also indispensable, since only such forecasts enable taking timely decision as to the scope of the planned operations. However, the primary task of hydrological forecasting is the on-line optimising of the operation of the flood control system in order to meet the predetermined criterion, minimizing the losses. It should be noticed that any properly working hydrological management system is expected to mitigate flood consequences.

An unobstructed and continuous access to credible observation results, independently of the time and scale of the catastrophe, i.e. the telemetric system described above, remains a crucial issue. On the other hand, the volume of information received from such a system (for instance around 500 posts will operate in the Upper Oder and Upper Vistula catchments) with the average of 1 hour observation interval evidence the unsurpassable requirement of automated processing of the observation results. It is delivered by the uniform IT system for hydrological management, aimed at:

- Unification of the access to all observation results utilized for the hydrological management and forecasting;
- Streamlining and formalising of access to the information utilized for forecasting and management;

- Providing full access to the digital interpretation of meteorological situation and to numerical meteorological forecasts;
- Implementing an effective system for the verification of the information used for forecasting;
- Development of the platform compatible with mathematical models indispensable for forecasting; and
- Streamlining and simplification of the service management procedures applicable to the users and analyses.

Easy access to credible data on hydrological situation will enable the use of mathematical models for forecasting. This concerns both the existing Polish models and those successfully operated in other countries. Effort consuming though, this part of the B2 component will impact the final effect that is the forecast. However, it should be noted that quantitative meteorological analyses, to be improved within the Monitoring, Forecasting and Warning System, substantially influence the forecast quality and advance, particularly in the mountain regions.

Authors of implementation assumptions for this component appreciated the importance of cooperation with the institutions responsible for response operations, in particular those responsible for the operation of water engineering structures. The impact of such a structure (for instance large retention reservoirs) on the hydrological situation, including the forecast quality must not be neglected. It is also of importance for water dams' safety, since their destruction inevitably threatens the areas situated below the given reservoir. Therefore, the inter-dependency between water structures control and forecasts requires an efficient information exchange system.

The task implied directly by the above presented description consists in ensuring the least formalized and unrestricted access to hydrological information necessary for response operations.

Implementing of meteorological forecasting model into operating practice

Weather forecasting is a complex cognitive process, involving both objective methods and subjective interpretation of numerical modelling results. The increasing users' demand, who require more exact forecast timing and more precise territory indication, as well as the growing dependency of the economy and population upon the weather and natural environmental conditions necessitate continuous improvement of the meteorological forecasting system. These requirements could be met exclusively through the launch and routine operation by IMGW of the numerical mesoscale forecasting model with the use of the institution's own computer hardware. The aim is to put in place the hydrodynamic, non-hydrostatic forecasting model with the calculation grid in the order of 2.5 x 2.5 km and from 35 to 50 atmosphere layers, adjusted to the orographic conditions of Poland. The computer hardware should enable 4 recalculation cycles of one or a few models every 24 hours, including hydrological models and the models of pollutants distribution in the atmosphere.

The system of numerical mesoscale forecasting, compared to other existing models, features high time and spatial resolution. Currently forecasts are calculated based on the 7.5 x 7.5 km grid (150 x 150 km in the hitherto models) and the time raster of over 10 minutes (between 6

and 12 hours in the hitherto models). Hence, the models enable objective forecasting of atmospheric phenomena, well identified in terms of time and territory. The capacity of quantitative forecasting of the phenomena like precipitation, wind velocity or vertical air streams is an important feature of such models. The development of the research concerning models and the increase in the processing capacity of computers lead to the development of the new class of models that is the non-hydrostatic models with higher time and spatial resolution and greater forecasting precision..

Cooperation will be continued with the meteorological organisations involved in the development of the ALADIN mesoscale meteorological model and with the Interdisciplinary Mathematical Modelling Centre of the Warsaw University and the United Kingdom Meteorological Office (in respect of the UKMO model). Moreover, cooperation will enhance with other centres performing similar experiments to ensure the model development in line with the latest scientific achievements. Within its research programme IMGW will make efforts to use optimally the results of the meteorological model in hydrological and other related models.

Training on the modelling methodology, numerical methods and forecast models will be delivered in the leading world research centres of WMO and other research institutions. Due to long-lasting duration of the Project, the training is not expected to be a one-time exercise, but rather a process of adjustments to the modified organization, methodology and technology requirements.

The results of the meteorological model will be accessible for other models, e.g. hydrological, through the national data transmission system. Following completion of processing, the selected group of the model results will; be transferred through the LAN (an element of the data transmission system) and made available to the external users, particularly those logged into the Internet through the Client Service System. The new telecommunications infrastructure should be put in place to enable parallel processing of a few numerical models and the process's switch over to other centres, outside of the IMGW.

Improvement of the Telecommunication and I T System and Development of Client Service System

IMGW Telecommunication and IT System and the Client Service System (SOK) are crucial for distribution of the data and products generated by the Institute. The multilevel client structure is envisaged, starting from the mass recipients of the basic forecasts, distributed through the Internet, through the recipients of specialized forecast of economic importance (construction sector, transport, agricultural sector, forestry and municipal sector) and the forecasts of particular importance for the national safety (flooding, gales, fire, etc.). Recipients of specialized forecasts and warnings should also have access to the general and basic forecasting. Thus, the system structure will enable information receipt and processing with the standard software applications.

The IMGW data transmission system is supposed to provide reliable, secure and continuous data exchange between organization units of the IMGW hydrological and meteorological service, constituting an important part of the WMO World Weather Watch. The WMO Global Telecommunication System provides all member countries with an access to data

necessary for hydrological and meteorological forecasting. High flow capacity telecommunication channels enable exchange of all data available in the area of hydrology and meteorology (on-ground observation data, satellite and radar data and data generated by numerical, hydrological and meteorological models). Many users from the hydrological and meteorological services have the opportunity of using common and uniform operational database. The IMGW electronic data exchange network is connected to the Internet through one, secure gateway-enabling access to all available services. The Data Transmission System provides also multimedia e-mail service.

The Client Services System (SOK) is a universal hardware, system and software platform designed for conveyance of all types of information to and from the client. The system can be used by any administrative or organization unit, having any type of access to telecommunication infrastructure and operating standard communication software. SOK is split into the general access subsystem and the subsystem available to authorised users, granted the data access through a user verification system. The system supports all commonly applied and approved standards.

Equipment for the measurement and maintenance teams

The updated observation and measurement system which was built following the completion of the other subcomponents requires an increased organization and technical effort to ensure its continuous and flawless operation. Also, at the system implementation stage active involvement of the measurement and maintenance teams is necessary. Apparently the service teams need to continuously supervise and maintain the system using the right equipment and resources. The number of hydrometric and geodesy measurements will increase substantially, with a view of feeding the forecasting models with correct data. In order to ensure credibility of the information and periodic maintenance and result validation of the facilities installed, the appropriate equipment was necessary for the measurement apparatus verification lab.

Delivery of all logistics-related tasks of the measurement and maintenance functions should precede any work conducted under other subcomponents.

Thus, the measurement teams were provided not only with the modern hydrological and meteorological apparatus, but also with land and water transport means (vehicles and vessels) and the devices and ancillary equipment enabling delivery of their tasks.

In particular the measurement teams were equipped with modern measurement apparatus, using the principle of ultrasonic running water velocity measurement. Due to the nature of Polish rivers having changeable, untrained beds it is planned to apply the moving boat method using the sonic depth finder and the stadia, or apply the Doppler acoustic flow measurement.

A hydro-meteorological station expected to operate continuously and under any conditions is the basic element of the hydro-meteorological service. Therefore, the stations have been equipped not only with the automated measurement systems, but also with the emergency power supply systems, ensuring autonomous operation even for a few days. To this end, diesel generators and the equipment allowing for autonomous on-the-ground operations of

maintenance teams and tool kits and equipment for repair and installation of measurement instruments were purchased.

All measuring devices are obligatorily checked and certified. The Measure Act (Official Journal No. 55, paragraph 248), of 1993 introduced the obligation of certification of the measurement instruments, specified by the President of the Supreme Office of Measures. In pursuance of the Act, the President of the Office" may vest the certification of the certain measurement devices with laboratories and institutes" once the President is satisfied that these labs " comply with the requirements concerning technical equipment and staff qualifications". Such labs should be accredited and supervised by the Supreme Office of Measures.

Lightning monitoring system

The lightning detection and location system covers the entire area of Poland, and detects both the cloud to cloud and cloud to ground lightning with the accuracy of lightning location equal to, or greater than 1 km. The system should enable superimposition of the detected lightning location onto the map of Poland, with colour coding of the lightning occurrence time and its type. It generates data in the form of a file including the lightning time, date, altitude and longitude, the charge and amplitude, i.e. the signal strength and type of charge for each lightning.

One of the most difficult tasks of the contemporary meteorology is precipitation forecasting, in particular from convective clouds. In order to forecast the precipitation from such clouds it is necessary to understand the stage of their development. The information may be provided by the system for lightning detection and location. According to the current decade research, the electric phenomena occur at an early stage of the convective cloud build-up. The phenomena intensity increases in line of the cloud enlargement, reaching the level of internal or cloud-to-cloud lightning and the ground-bound lightning. The internal lightning accounts for 70% to 99% of the total lightning within the given thunderstorm process. The remainder is the cloud-to-ground lightning. In principle, such a lightning is initiated at the mature stage of the convective cloud development, reaching the maximum 10 to 15 minutes before the beginning of the disintegration stage. It is accompanied by dangerous atmospheric phenomena, such as showers, hail, strong descending air streams, etc. This was the case between 22 and 23 of July 1997 in Kotlina Klodzka. A few people died and material losses were substantial. The capacity of monitoring the electric phenomena inside the cloud enables forecasting of the related phenomena, such as intense atmospheric precipitation zones. The lightning detection and location systems enable diagnosis of the thunderstorm situation with a greater advance than provided by the other remote sensing systems (e.g. the radar), thereby the greater advance of the forecast relating to hazardous atmospheric phenomena, including intense precipitation. This is of substantial importance for the flood hazard forecasting.

Development of the Weather Radar System POLRAD

The construction of the IMGW radar system was begun in the 80's of the 20th century, although the studies and preparatory work had been launched much earlier. On the basis of the data, received from the then operated MRL-2 radar, advanced scientific research was carried out relating to the use of the radar data for the meteorological and hydrological purposes. In 1992 the installation of the later MRL-5 radar in Legionowo enabled intensification of work and development of, e.g. the algorithms and programmes for the quantitative precipitation estimates.

In 1995, thanks to the loan extended by the World Bank Another radar was commissioned, i.e. the modern Doppler radar produced by GEMATRONIK. This unit was located on the Ramza hill near Katowice. Another GEMATRONIK radar, was installed near Pastewnik in the vicinity of Wrocław. The stage of constructing and installing radars has already been completed. Apart from the above mentioned, remaining radars have been introduced into the system in Poznań, Szczecin, Gdańsk and in the vicinity of Tarnów and Rzeszów. Thus the whole area of the country has been covered. Substantive cooperation has been entered into with the meteorological organizations of the Germany, Czech and Slovak Republics in terms of the use of data and research results.

A single weather radar supports the hydrological and meteorological management of the area of between 100 and 200 kilometre radius. Thus for the protection of the entire country a system of radar is necessary, comprising 8 units in the case of Poland. Additional advantage of the radar network is the capacity of simultaneous monitoring of the same phenomena by two or three radars, which many times increases the probability of dangerous phenomena detection and preparation of the appropriate warning. In view of the operating cost optimisation all radars should be automated and should not require on-site operators, since their operation, control and maintenance will be remote. Supreme performance and reliable telecommunication links are used for data transmission to the central control, processing and maintenance system. The radar data are used both for the online hydrological and meteorological management and for complex hydrodynamic, hydrological and meteorological models. The radar system is, in functional terms, coupled with the systems of the automated hydrological and meteorological measurements, the automated lightning detection network, the system for hydrological and meteorological forecasting and the forecasting and decision making system.

The system organized in this manner enables precise identification of the precipitation area. Given the intense and spread precipitation, particularly in the mountain regions this is of a decisive importance for the quality of meteorological forecasting and hydrological protection.

The radar network data are used in all fields of management provided by IMGW. Predominantly these are: the flood management and the system of early warning against the dangerous phenomena. This concerns mainly the protection of the civil aviation, energy sector and water management facilities, road transportation, agriculture and provision of information for mass media and tourism.

Final conclusions

1. The project of modernization of the hydro-meteorological service, constructed in IMGW is a complete and expertly built set of defined undertakings aiming at improvement and updating of the hydro-meteorological control built into the complex system of flood protection of the whole territory of Poland

2. The Project will ensure:

- Earlier and more accurate flood hazard warning, tailored to the specific nature of local conditions. This is of particular importance for the cities, administrative districts, arable land, industrial facilities and national heritage, threatened with inundation;

- Earlier and more accurate warning on dangerous phenomena such as sea storms, gales, thunderstorms and showers. Warnings issued several minutes in advance may prevent substantial material losses and reduce threat to human life;
- Well-defined warnings and hydrological and meteorological forecasts for specific users such as aviation, maritime economy, water engineering and management, agriculture and industry;
- Reduction of risk of building erroneous forecasts and warnings, thereby increasing users' trust in meteorological and hydrological services;
- Longer notice of medium-range forecasts, hence better protection of the society and economy.