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Logistic Issues in Data Network Implementation

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1. Introduction

We will show how to construct 1000 hydrological and meteorological stations on the basis of the experience we gained while working on the Monitoring Forecasting and Warning System (SMOK) implemented in Poland for the Polish Institute of Meteorology and Water Management (IMGW). The undertaking was implemented as Task B.2.1.3 *Hydrological and Meteorological Telemetric Measurement Network* in the context of the *Emergency Flood Recovery Project* and coordinated by the World Bank. Under a tender procedure, the implementation of the System was awarded to the Canadian company Hydro Quebec International (HQI), which signed a relevant contract with the IMGW.

The purpose of the SMOK is to ensure a better control and understanding of hydrological and meteorological phenomena, which leads to improvements in a system warning of dangerous weather phenomena, such as torrential rain causing floods and also to improve environmental studies and water management.

Our considerations will be performed under the assumption that a Project (in the case of the SMOK, such a Project was a result of implementing Task B.2.1.2 *Design of Hydrological and Meteorological Telemetry Measurement Network*) has been received, including detailed information concerning such topics as:

- the number of stations required for the smooth and reliable operation of the system as well as defining the types of particular stations and their spatial distribution with precise GPS coordinates;
- construction-related assumptions for particular stations, the types of sensor mounted on them and methods of power supply for the station;
- the spatial distribution of the Data Collection Centres, their equipment and methods o data transfer between stations and Centres;

We also assume that guidelines have been received regarding high-level software designated for data collection and display (in the case of the SMOK, these were developed under Task B.2.2.3 *Monitoring, Forecasting and Warning System*).

2. Description of preparations

Given the fact that the Project, in particular as regards the location, is mainly based on hydrological and meteorological conditions it will be necessary to conduct a field examination aimed at making any required corrections related to location, construction, means of transport of large-size elements or access by heavy-duty equipment (e.g. piezometric well surface installations). It is recommended that such an examination be documented with photographic evidence.

To ensure good coordination of the works embracing all their aspects, a team should be organized of people competent in various areas, so as to enable problem solving in each matter, at any stage of the project. A Coordinating Team must be in place, which would be in charge of organizing, coordinating and controlling field operations. It is also necessary to ensure appropriate communication, understanding of the general conditions as well as of the entire project by each team member.

Equally vital is selecting such equipment as: cars, notebook computers with wireless internet access, telephones, palmtops, automatic maps and GPS receivers, which would enable work in any field conditions.

Next element is to divide work into layers, so that it is possible to decide, which work should be performed on our own and which by subcontractors. The selection of subcontractors and arrangements with them should be made much earlier than the planned start of the works where they are involved, so that all the activities are synchronized, even if deadlines for the completion of particular work stages are changed.

The effectiveness of project management depends on using tools which support decision making. Schedules must be developed for each work type to define how to plan operations over time. Our experience tells us that a critical aspect preceding work implementation launch is solving any formal issues, for example in case of electric works that might involve making notices and obtaining relevant permits. Such activities should be included in the schedule as an element of a given work layer, so that work can begin on time, without delays caused by negligence in handling formalities. An example tool used while the SMOK was being developed was SMOK MANAGER - software allowing for defining work stages and controlling work progress. Picture 1 shows a window of that program, where the current status of each station could be checked as well as the most recent measurements transmitted by the station.

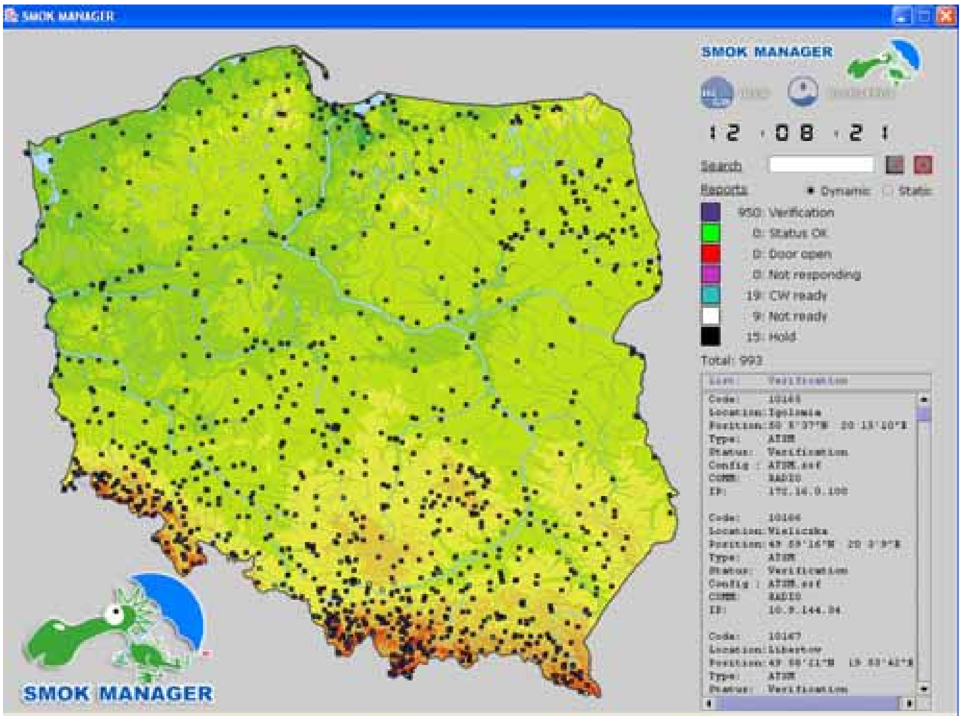

Fig. 1: A window of the SMOK MANAGER program. Status on 2005-06-27

Thanks to defining a precise spatial distribution of the locations where works are being done, it is possible to, smoothly and on an ongoing basis, specify the order of the operations, striving to develop an optimal temporal and spatial structure through such a work division which lets all the staff present in the filed define the order of their movement between staked out locations. This narrows down the area of operation by particular staff member so that unjustified crossings are avoided while the time of necessary crossings is minimized.

3. The course of the implementation stage

At the planning stage, the works should be precisely divided into layers. The Project under discussion involves the following Layers: Preparation, Site Transfer Protocol, Assembly, Civil Works, Electric Works, Communication, Installation and Instrumentation, and System Acceptance Test.

The Preparation Layer should include: creating a Coordinating Team, office organization, defining material and equipment demand plus purchase (cars, notebook computers, telephones, palmtops, automatic maps, GPS units), training for staff familiarizing them with the project, warehouse organization, finding, negotiating and signing contracts with subcontractors to do outsourced works, finding and hiring people competent in the coordination and reception of such works.

The Site Transfer Protocol Layer is a stage where there are most opportunities of introducing changes to the project. Verifying the actual conditions against the Project may necessitate changes in the construction or location of a station. Only direct field examination and contacts with local experts will enable detailed solutions, depending on specific local conditions. While implementing the SMOK project, we encountered the following issues which should be taken into consideration in network design:

- verifying which constructions require construction permits and which only notices of construction, in particular in the case of installing tall masts,
- the necessity of making construction-related modifications, such as: lowering the height of masts due to a high-voltage line running in the vicinity, mounting a Remote Telemetry Unit (RTU), as a snow deposition layer or the water level during floods went above the originally projected assembly points, which might result in damage to electronic equipment, amended methods of founding foundations for masts due to the depth at which a base course was present or the ground type,
- the necessity of assembling stay ropes due to the location in strong wind areas (mountains, seaside areas), in particular in case of mounting solar panels or RTU boxes at considerable heights what decrease mast stability and measurement accuracy,

The range of works under the Assembling Layer should include the design, production and tests of the RTU, i.e. both the box providing protection of electronic appliances as well as its contents like a datalogger, a GPRS or radio modem, a transformer, a battery, and interfaces for sensor connection. The equipment's working temperature range should depend on the climate zone. All the electronic elements should be unmanned, so as to avoid extra maintenance costs when in use. RTU boxes, electronic equipment and measuring sensors are the critical elements of the station and influence measurement accuracy, data transmission and the station's power supply. If a national telemetric network is under construction RTU boxes should not be mass produced before comprehensive Factory Acceptance Tests (FAT) have been performed. Casings for RTU equipment must be fit for work in harsh climatic conditions for many years and heavy manoeuvring.

Another layer is construction Civil Works. They include, among others:

- basic field work like the installation of masts, fencings, foundations for rain-gauges (in case of meteorological or precipitation stations), piping for a later installation of wiring for sensors or the station's power supply,
- the installation of hydrometric stations and all the elements (including underwater installations) for proper functioning of water level measuring sensors
- boring piezometric wells in order to measure the level of groundwater in case of groundwater level measuring stations.

Factors which may have an impact on the course of the works performed under the Civil Works Layer include weather and field conditions, in particular in a moderate climate, where construction works can be done only from April to November. Possibilities to consider are temperatures below zero, precipitation and other weather phenomena resulting in stoppage or slower progress of works. In case of the SMOK project, also some other impediments occurred, like:

- the necessity of modifying the foundation method due to the ground type or natural conditions, allowing us to abandon the traditional foundation method,
- no possibility of applying standard constructions: fencings due to significant slope inclination (using elements specially adapted to the slope inclination angle - rhombic elements),
- problems with transport of large-size elements (long folding masts had to provide for disassembly option; foundations designed for installation in areas inaccessible for heavy-duty equipment, due to their weight, had to be replaced with twisted, charge-type elements)

In the course of schedule implementation, it should be assumed that the Electric Works Layer, aimed at providing power supply for the station, will take the longest, due to the extensive formal procedures, the requirement to obtain permits and approvals for electric projects given at several levels of local administration. Station power supply may be carried out from an electric power grid, solar panels, or batteries periodically replaced by maintenance teams.

In case where periodically replaced batteries are used, a replacement cost calculation should be performed (transport costs and maintenance team labour costs). At the stage of network construction, this is technologically simplest solution but cause additional logistic works. Using solar panels eliminates the problem of periodical station service as regards power supply for the station, yet it must be borne in mind that the cost of the solar panel is relatively high, as is its vulnerability to theft. The final, the most costly and the most complicated solution, is connecting the station to a AC 230V power grid. It is the best option as regards long-term maintenance of a station network.
Some problems we encountered while performing electric works under the SMOK project included:

- inconsistent interpretation of regulations in various regions,
- the necessity of performing cross-cuts, rebores, and overhead lines in order to ensure connection to the existing power grid, necessitating the requirement to obtain additional administrative permits (e.g. from road authorities or those in charge of a river and water reservoir network),
- a very long wait for the required approvals and permits, extensive formal and legal procedures requiring obtaining permits from or agreements with Power Supplying Plants, Project Documentation Clearing Teams, and Local Authorities as well as the necessity to obtain approvals from plot owners as regards running cables through their land.

Another layer is that of Communication. The type of communication at stations is conditional upon their location. Possible types of data transmission include GPRS transmission, using infrastructure of GSM operators, radio transmission, using radio infrastructure of an institution utilizing a station system network or leased (masts, aerials, repeater stations), and satellite transmission.

Package GPRS data transmission does not require ownership or lease of any transmission infrastructure, just signing relevant contracts with GSM operators. At the stage of network development, that solution is technologically simplest and cheapest, yet at the usage stage it requires regular payment of data transmission charges. While planning the Communication Layer, one should take into consideration the rage of networks of particular operators. The problem of low signal reception is an issue, in particular at stations located in mountains and far from populated areas.

To establish radio communication, it is necessary to construct a transmission network, as data transmission in that case is restricted by distances. There must exist intermediary points between the station and a Data Collection Centre. Radio transmission requires a permit for band usage and using appliances working at a given band. It incurs no charge for data transmission, however.

Satellite transmission is the most expensive but is also most reliable way of data transmission. That is why it is recommended to have it in place at stations of key importance.

Another stage is that of Works is Installation and Instrumentation, or a stage when RTU boxes and measuring sensors are assembled. Standard measurements performed at the stations are: of wind direction, velocity and gust, precipitation intensity, humidity, air temperature and air temperature at the ground as well as of water level. Most parts of the stations under the SMOK system are hydrological units. The sensors used for water level measurement vary in construction and measurement methods depending on the condition they work in. Some hydrological sensor types used in the SMOK project were:

- a bubbler – defining the level by measuring the pressure of the water column,
- a shaft encoder – performing a direct measurement of the water level,
- a radar – mounted mainly at bridges, in places where a shaft encoder cannot be used.
- a submersible pressure sensor - performing measurements of the pressure of the water column.

The System Acceptance Test (SAT) Layer includes works preceding handing the station over to the investor. These step includes the acceptation that the station is installed according to the project's technical specification and tests the correct operation of applications and data transmission. The tests should be divided into stages. In case of the SMOK, regionalization was a criterion in that regard. At stage one, stations were received from a given area, after which coordination followed of the activities aimed at the creation and the operational approval of an integrated system .

4. Summary

Our considerations regarding the implementation of a system of telemetric network of hydrological and meteorological stations have been carried out assuming that the contractor has the Project, and so without regard to the necessity of collecting or developing required documentation. The vast volumes of the documents that would have to be obtained in order to complete the Project would significantly lengthen the implementation time. Starting with system implementation, it must be made clear whether the priority is the completion date or the financial expenditure incurred (accounting for the stages of both implementation and usage – the maintenance of the transmission network). If a prompt work completion is the key guideline, particular attention must be paid to the works done under the Electric Works Layer. The formal and legal procedures related to such works tend to be laden with red tape and the validity of the documents obtained is short, which necessitates the repetition of the procedures related to winning them.