

## DAM'S RISK MANAGEMENT

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*Hidroelectrica ,the major power producer in Romania ,operates 8 dams with a height of over 100 m, 89 dams with a height of over 10 m and with a lake volume of 1 million cubic meters, amongst which 6 storage dams with a volume of over 100 million cubic meters, about 650 km of peripheral dykes at the storages with a permanent retention, as well as 205 SHPPs . Concerning the owners of hydro-technical constructions, the law specifies that: “they have to install warning-alarm devices in the event that a danger may occur, and to organize the activity of monitoring”.*

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### 1. Introduction

In Romania, the activity of risk management is based on a legal framework that stipulates the liabilities incumbent upon the dam owners, authorities, population, and businesses located within the area of the projects that are possible to be affected. Concerning the owners of hydro-technical constructions, the law establishes a series of liabilities as follows: “The owners having any such hydro-technical constructions, which either the damage of or the destruction of may endanger both human lives and goods or may prejudice the environment, are liable to endow any such works with monitoring and signaling devices required for monitoring the behavior of such works, to install warning-alarm devices in the event that a danger may occur, and to organize the activity of monitoring”. This column aims at highlighting the experience accumulated by Hidroelectrica, the major power producer of Romania, concerning its reservoir-related risk management.

### 2. Current situation

Hidroelectrica operates 8 dams with a height of over 100 m<sup>2</sup>, 89 dams with a height of over 10 m and with a lake volume of 1 million cubic meters, amongst

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<sup>2</sup> Vidraru Dam h= 166 m ; Gura Apelor Dam h= 168 m; Vidra Dam h=121 m; Izvorul Muntelui Dam h= 127 m; Poiana Marului Dam h= 125 m ; Cerna Dam h= 110 m; Dragan Dam h = 120 m.Iron Gates I Reservoir V = 2,100 million cubic meters; Iron Gates II Reservoir

which 6 storage dams with a volume of over 100 million cubic meters<sup>2</sup>, about 650 km of peripheral dykes at the storages with a permanent retention, as well as 205 small hydropower plants and micro hydropower plants. The constructions behavior monitoring system (CBMS) and the warning-alarm system (WAS) are currently running within Hidroelectrica, both of which being organized in compliance with the law.

## **2.1. Constructions behaviour monitoring system (CBMS)**

The CBMS monitors the constructions status. Therefore a number of about 10,000 monitoring and signaling devices (MSD) were installed. Such MSD were heterogeneously provided in conformity with the execution projects, and included mainly devices dating since the works were commissioned, 20 automatic stations for CBMS data acquisition and monitoring and 3 stations for the seismic activity monitoring are running. The UCCH-NET software, which provides an integrated background for monitoring the constructions behavior, is implemented throughout Hidroelectrica. The data acquisition and monitoring are mostly provided by manual input, excepting the works of which CBMS data acquisition automatic stations are under operation.

## **2.2. The warning-alarm system (WAS)**

During 1999÷2011 Hidroelectrica has implemented a number of 25 WAS and envisages implementing such other 4 new WAS. The systems are grouped throughout 13 development dispatchers, having 659 sirens under automatic remote control.

### **2.2.1. The Concept of Hidroelectrica's WAS**

The works for WAS were executed by the company ROKURA. The alarm systems implemented at the works under Hidroelectrica's operation were measured according to the flooding area found following to estimating the breaching of the dam or of the dykes. The sirens were installed in the cities or the locations within the flood wave area. The capacity of the siren and the height at which such a siren is mounted on the pillar were determined in such a way that the siren area should cover the populated area of the cities. The architecture of a warning-alarm system has the following components: the control center, the retranslation systems, and the electronic siren. *The control center* has the role of collecting, checking, and controlling the warning-alarm data. The development

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V = 600 million cubic meters; Fantanele Reservoir V = 225 million cubic meters; Strejesti Reservoir V = 225 million cubic meters; Beresti Reservoir V = 120 million cubic meters; Racaciuni Reservoir V = 104 million cubic meters.

dispatch center is the one responsible for decision making, and for dispatching to Committee for Emergency Situation (CES) the information required for triggering the signaling devices. The control center has the following functions: submits its own alarm system to tests and displays the deviations; stores the events and all the performed activities and generates reports upon request; provides unlimited configuration of the sirens that participate in an alarm (either one single siren, or a group of or all the sirens); selects the type of alarm to be used; displays the status of each siren that participates in the alarm. The access to the control center's resources is based on a hierarchical password system; the control center making available any reports on system's status. The control centers of the electronic sirens are placed in the operation dispatch centers within Hidroelectrica's subsidiaries. The sirens can be operated by radio waves (main option) or GSM (secondary option). The alarm dispatch centers are directly interconnected to the CES through a mobile radio station. *The retranslation system* is a transceiver used in terrestrial wireless networks to retransmit the signal transmitted by a station to another station, located at a far distance, which can not be directly communicated with. *The electronic sirens* can be controlled: either locally or remotely. The electronic siren provides the following functions: broadcasts scheduled alarms; broadcasts texts read using a microphone or pre-taped texts; broadcasts 7 different alarm signals; functions in the event of energy disruption (are equipped with dual power supply); submits the entire siren equipment to self-testing, including "mute" testing of the speakers; local and remote control (control center). The warning-alarm system is powered from the 220V network and, for proper operation, the system is equipped with batteries that can provide a seven day running time. The warning-alarm system developed by Hidroelectrica can be used for various types of contingencies (hydro-technical construction accidents, earthquakes, chemical or nuclear accidents, fire, war, etc.). It may issue the following signals: air alarm signal, disaster alarm signal, pre-alarm signal, alarm termination signal, live microphone announcements, pre-taped announcements or such other sound signals.

### **3. Risk integrated management system (RIMS)**

The development dispatch center fulfills the functions specific to the control center. Many times it does not have the specialized preparation as it is required for assessing the safety status of the hydropower development constructions. In order to reduce the human factor risk, who is responsible for making decisions in emergency situations, Hidroelectrica plans to carry out an RMIS, which should provide the technical support necessary to make as well as to implement decisions in emergency situations. Such a system is based on the interconnection of the CBMS component (based on risk parameters monitoring and

their analysis and assessment in real time, in order to provide the technical support for the decision makers in emergency situations) with the WAS that fulfills the role of warning and alarming the population in case of emergency.

### 3.1. System architecture

The architecture has been drawn up according to the location of the RIMS within the WAS and to the specific functions that the CBMS will have to provide. The Figure 1 presents schematically the components of the RIMS and the configuration of the IT connections in-between.

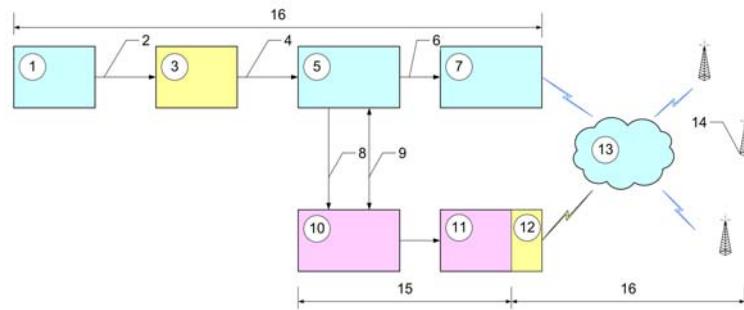


Fig. 1. Layout of alarm equipment and emergency situations management unit  
 1-Dam,2-Construction Behavior Monitoring measurements,3-Risk parameters monitoring system  
 ,4-Signals: normal behavior, reaching the critical thresholds set by the designer (attention, alert, danger),5-Dispatcher of the hydropower development,6-Warning command,7-Electrical systems warning center,8-data transmission ,9-Electronic connection,10-Command center – Committee for Emergency Situations (CES),11-CES alarm system ,12-Interconnection system,13-Sirens command ,14-Sirens,15-CES sites,16-Hidroelectrica's completed projects,17-Hidroelectrica's ongoing projects.

#### 3.1.1. The main functions of the RIMS components

The CBMS component provides the following functions: risk-related physical quantities acquisition and their transformation into engineering measurement units; engineering measurement units display and storage as relational data bases in the dam's control center; engineering measurements units processing and assessment within the dispatcher, CES, and Hidroelectrica, with the view of facilitating the decision making in case of emergency. The WAS component provides the following functions: electronic sirens maneuvering through a redundant radio communication network; alarm signals and voice messages transmission; registration and storing of system's events. The interconnection system between the dispatcher's control centers and CES provides the following functions: risk parameters display within the CES territorial

operational center; voice and data communications network between the hydropower dispatcher and CES; Hidroelectrica's sirens maneuvering in case of emergency at dams. The warning system component for decision-making staff in emergency situations – “AlertManager”: emergency alarm messages transmission to the mobile terminals; mobile terminal information display; inter-communication with the development site dispatcher via mobile terminals.

#### **4. Risk integrated management system (RIMS)'s constructions behavior monitoring system (CBMS) component**

Unlike the WAS, which was conceived and implemented so that it could fully respond to the emergency requirements, Hidroelectrica's CBMS has been drawn up heterogeneously and built in time, once the dams were commissioned. When this system was conceived, it was not foreseen to provide the real time support in case of emergency decision making. In order that such a system could respond to the requirements of the risk integrated management concept, some adjustments in the data acquisition and processing need to be done.

##### **4.1. Assessment of risk parameters**

A first step in building the CBMS component within the RIMS is to assess the risk parameters of each dam. The major risk factors leading to a dam's failure are the extreme natural phenomena: floods produced by rainfalls or by an upstream dam's failure, natural earthquakes or earthquakes induced by the over storage of a dam, and massive slides of reservoir slopes. The failure scenarios are classified into three major groups: extern erosion of a dam's body (to dams built from local materials) or of a dam's foundation (to concrete dams) produced by overflowing; erosion inside a dam's body or into a dam's foundation land produced by concentrated underseepage; instability of a dam's body, of a foundation ground or of a reservoir's works, produced by increased hydrostatic pressure, under-pressure, or water pressure of pores. An adequate systematization of a dam's failure mechanisms could be made only according to the specifications of each dam, starting with their specific behavior functions. Therefore the risk parameters and their relevant range shall be assessed according to each dam.

##### **4.2. Risk integrated management system (RIMS)'s constructions behavior monitoring system (CBMS) platform scheme**

There will be a staged implementation of Hidroelectrica's RIMS. The first implementation stage will include the dams classified as constructions of exceptional and special importance. This year the feasibility study of a pilot project within Bistrita Subsidiary has been initiated. The CBMS component

includes the following operational platforms: a risk parameters database; a CBMS parameters database; an IT platform scheme for CBMS data processing and risk parameters assessment and computation; a communication interface with the development site warning system; a communication interface with NIEP – National Institute of Earth Physics; a communication interface with RWNA – Romanian Waters National Administrations; a communications network between the monitoring system's operational platforms; a warning system for decision-making staff in emergency situations - “AlertManager”. The upgrading of the monitoring and signaling devices (AMC) by installing remote sensing devices and CBMS data acquisition automatic stations is necessary also for the risk parameters data acquisition. The Figure no. 2 presents schematically the components of the risk parameters monitoring system and the configuration of the IT connections in-between.

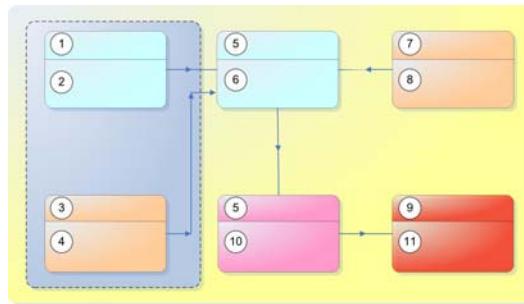


Fig. 2. Layout of Dam's Risk Parameters Monitoring System

1-Hydropower development (HPD),2-Equipment acquiring the data related to the Constructions behavior monitoring at HPD's own dam ,3-Local seismic station,4-System monitoring the local seismic activity ,5-Dispatcher of hydropower development,6-Risk parameters interpretation and discharge system utilizing UCCH-NET application ,7-National Institute for Earth Physics (NIEF),8-Seismic activity monitoring system,9-Alert – Manager,10-Systems alerting decision-making staff, in case of emergency,11-Alarm installation.

#### 4.2.1. Data acquisition platform

This platform provides the following functions: electric measurement units acquisition supplied by sensors and their conversion into numerical data; numerical data conversion into engineering measurement units; engineering measurement units storing and display according to the local units computation system; engineering measurement units export to the local database system; local database visualization and risk parameters display; database connection with the development dispatching IT center. The platform measures the physical quantities, which are relevant to the risk monitoring. The sensors are specific for each physical quantity as they are mounted within the dam's structure and the areas

that are related to the construction's safety. The Figure 3 presents the functional connections concerning the information transfer between the components.

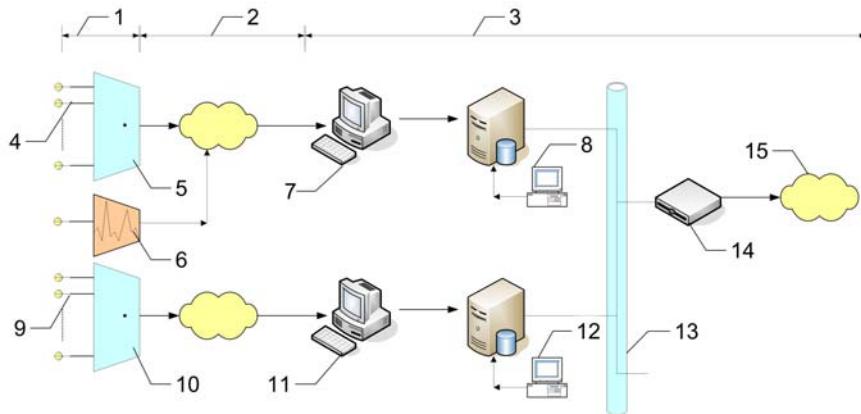


Fig. 3. Hydropower constructions behavior monitoring and risk data acquisition equipment architecture

1-Dam,2-Optical fiber local communication network ,3-Dam maintenance building (dam attendant's house),4-Network of constructions behavior monitoring sensors ,5-Constructions behavior monitoring data logger 6-Seismic station ,7-Automated station acquiring the constructions behavior monitoring data,8-Read-out of constructions behavior data base ,9-Risk sensors network,10-Risk data logger,11-Automated station acquiring the risk data,12-Read-out of risk data base ,13-Ethernet local network,14-Remote communication equipment ,15-Network transmitting data to the dispatcher.

#### 4.2.2. IT platform for data processing and risk parameters assessment

This platform is placed at the development dispatcher and provides the following functions: the access of the dam's behavior parameters from the database managed via the UCCH-ALL IT software and of the physical quantities (levels, flows) stored into the dam's section and managed via the technical management IT software; taking over the risk data from the IT system of the NIEF; taking over the risk data from the IT system of the RWNA; processing of accessed data and display of measured quantities; risk parameters computation and display of the quantities resulted following to their processing via the behavioral functions specific to each dam; warning the decision making staff in emergency situations via the "AlertManager" system; supply of the vigilance, warning-alarm, and danger upper limits with the view of triggering the warning system; data storage and short reports display. The main components and the functional connections concerning the data processing and risk parameters assessment system is presented in the Fig. 4.

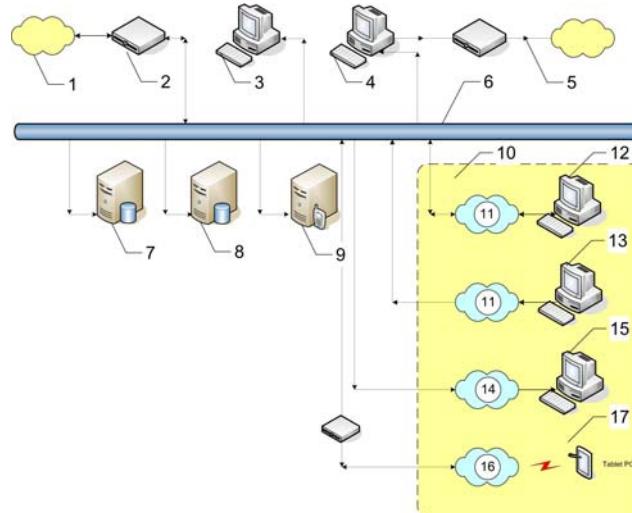


Fig.4. IT platform scheme for data processing and risk parameters assessment

1-Communications network – dams,2-Communication interface,3-Computation and risk parameters assessment,4-Sirens control system,5-Interconnection system with Command center – Committee for Emergency Situations (CES),6-Ethernet local network,7-Construction behavior data base,8-Risk parameters data base,9-Mobile communications server,10-Extern IT systems,11-Hidroelectrica VPN,12-Hidroelectrica – IT center ,13-Romanian Waters National Administration (RWNA),14-Hidroelectrica's radio network,15-Command center – Committee for Emergency Situations (CES),16-GSM network,17Warning system for decision-making staff in emergency situations.

#### 4.2.3. Headquarters control center

The headquarters control center is located in Hidroelectrica's headquarters and aims at centralizing the data stored and processed within the dispatching centers with the view of providing the decision making support for the operational center team that has a temporary activity or that is formed for emergency situations at Hidroelectrica's headquarters.

#### 4.2.4. Communications network

The information exchange between the functional platforms is performed via a communications network. We can mention the following components of the communications network: the local communications network is located at the dam and provides the connection between the data acquisition unit and the processing system from the dam attendant's house. The connections are relatively short and are positioned in the front of the dam or on its side. The optic fiber support and radio communication are the technologies possibly to be used. The

communications network between the dam and the dispatcher is located in the hydropower development site and provides the connection between the dam attendant's house and the hydropower dispatcher. The connections are medium and long and are performed either directly or via some informational retranslation intermediary locations. The optic fiber support, radio-relay, short band radio or satellite, are the technologies possibly to be used. The communications network between the dispatcher and the extern IT systems spreads on an extended area according to the positioning of the extern connection locations. It provides the IT connections between the risk parameters monitoring system from the dispatcher and: CES, NIEP, RWNA, Hidroelectrica's Bucharest Headquarters and the third parties. The local subsidiary communications network is presented in the Fig. 5.

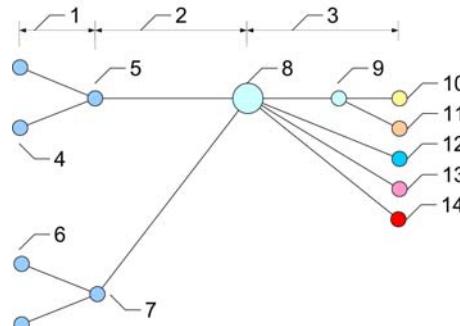


Fig. 5. Local communications network, local risk monitoring system

1-Local communications network, 2-Development communication network, 3-Extern network, 4-Data acquisition units – dam no. 1, 5-Dam maintenance building (dam attendant's house), 6-Data acquisition units – dam no. 2, 7-Dam maintenance building (dam attendant's house), 8-Development site dispatcher, 9-Hidroelectrica, 10-Third parties, 11-National Institute for Earth Physics (NIEP), 12-Romanian Waters National Administration (RWNA), 13-Command center – Committee for Emergency Situations (CES), 14-Warning system for decision-making staff in emergency situations.

## 5. Conclusions

The reservoir-related risk management is based on the implementation of some policies, procedures, and applications, which aim at minimizing the risks and finally their removing. Hidroelectrica, the major power producer in Romania, plans to carry out a RIMS, which should provide the technical support necessary to make as well as to implement decisions. Having this in mind, a study that defines the architecture and the main components of the future system was drawn up. There will be a staged implementation of Hidroelectrica's RIMS; the first implementation stage will include the dams classified as constructions of exceptional and special importance. The system's concept will be validated by a pilot project, which will be carried out within one of Hidroelectrica's

subsidiaries. The implementation of the risk integrated management system will lead to diminishing the human factor risk but it does not aim at being a substitute for the involved decision makers.

## R E F E R E N C E S

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