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Improvements in the Functioning of the Information System for Monitoring and Forecasting Emergency Situations in the Republic of Altai

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Abstract. This paper covers the *issues* of improving the efficiency of monitoring and forecasting operations based on the information system. The existing automated information system for monitoring and forecasting emergency situations in the Republic of Altai and Constanta County are considered. In the current study, *it is proposed to develop the system* by automating a number of operations related to *data collection*, *storage* and *processing*. Based on the initial and modified information system a comparative analysis of time taken to perform the main operations with the available hardware is conducted.

Keywords: Information system, Monitoring and forecasting of emergency situations, Automation, Data conversion.

1 INTRODUCTION

The systems of monitoring and forecasting emergency situations are intended to observe, control, *anticipate danger* and resist damage happen in the technological sphere and nature and their dynamics. Accident forecasting helps to prevent emergencies, determine their magnitude and undertake effective response measures. In the Russian Federation the system of monitoring and forecasting emergency situations is *authorized* by the Provision, approved by the *Order* of the *Ministry* of *Emergency Situations* of the *Russian* Federation dated on *04.03.2011 No 94* [1].

This paper considers the system of monitoring and forecasting emergency situations in the Republic of Altai. In the Republic of Altai the monitoring facilities are mainly determined by its physical and geographical characteristics. In particular, the probability of such emergencies as drought, natural fires, severe frost, snow, mudflow, etc. increases owing to the location of the Republic in the south of Western Siberia and the rugged topography which cause a sharply continental climate on its territory with high summer and low winter air temperatures and a large amount of precipitation. Also, the Republic of Altai is characterized by a large difference in absolute temperatures and mountain terrain with a high probability of developing hazardous geological and soil-geological processes of natural and natural-man-made origin. Permanent seismic activity on its territory is determined by the presence of a large number of seismic faults.

Dangerous natural phenomena in the territory of the Republic of Altai include hydrometeorological phenomena: hail showers, drought, flooding associated with *rainfall* and spring snow melt, strong winds, strong snow-storms, severe frost, dangerous geological and soil-geological processes: landslides, earthquakes, mudflows, natural fires. The most dangerous of these emergencies are fires, flooding and earthquakes. Constanta County is located in the Dobruja region, Romania on the border with Bulgaria and here the forecasting system for Black Sea can be easily applied.

The tasks of forecasting emergency situations, as well as their prevention and elimination are solved based on the data obtained as a result of monitoring various facilities in the Republic of Altai [2]. Various technical, software and information tools are used for this purpose. The technical support of monitoring includes equipment of stations, observation systems, computer and network equipment, communication lines, etc. *Data for the objects being monitored* are obtained from various automated information systems having different formats of data storage and output, which greatly *complicates their further use for* solving the tasks of forecasting, decision-making, reporting, etc. At the same time, the number of different information systems for forecasting each type of emergency situations is rather small, and many of them are implemented on the basis of the *All-Russian Center* of *Monitoring and Forecasting* of Emergency

Situations (the *Center* "*Antistihiya*")," and therefore have a unified format of input and output data, which to some extent simplifies subsequent processing procedures.

2 METHODS

The figure shows a model for solving the tasks of monitoring and forecasting emergency situations in the Republic of Altai, which is implemented on the basis of partial automation [2] in the form of separate applications and systems for data processing and analysis.

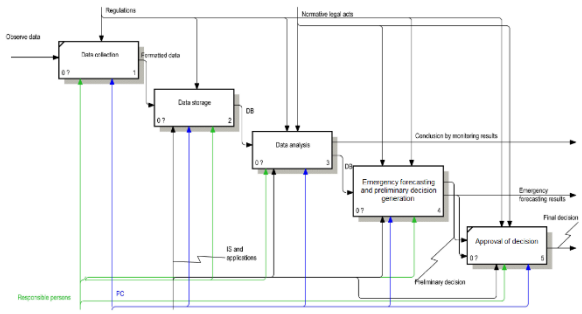

Figure 1. The model for solving the task of monitoring and forecasting emergencies in the Republic of Altai

Data are collected in the automated mode, but data storage, analysis and emergency forecasting with generation of preliminary solution are performed partially *manually* (Figures 2-4).

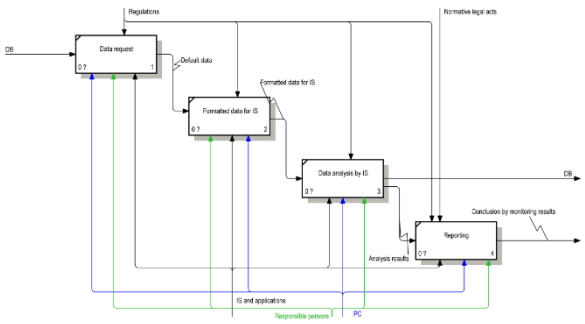

Figure 2. Decomposing a Model of Data Storage

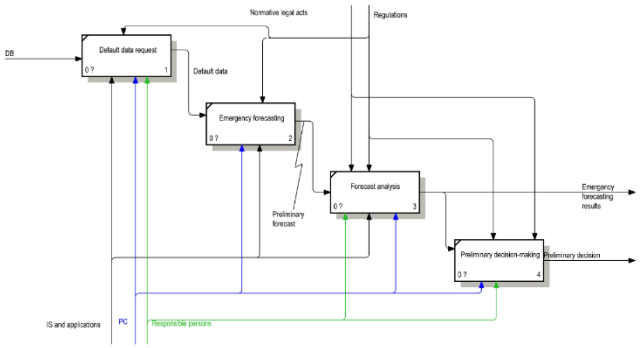

Figure 3. Decomposing a Model of Data Analysis

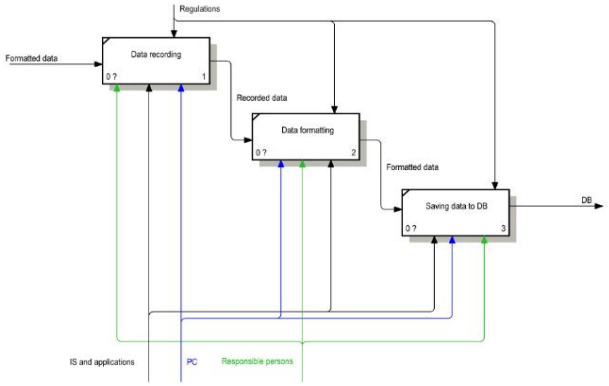

Figure 4. Decomposing a model of emergency forecasting and preliminary solution generation

The following operations shown in Figures 2-4 are performed partially or completely manually:

- Data recording. The readings of some sensors from monitoring objects are presented in the form of graphic or audio data, which are transferred to the computer memory for subsequent processing.
- Data conversion. To store information in the database, it is necessary to convert the existing information to a uniform format corresponding to the specified structure, which is also executed partially manually.
- Data conversion to a *specified format.* In order to solve the tasks of monitoring and forecasting on the basis of automated information systems it is necessary to convert input data to the specified format, which may be different for various applications. This operation is also executed partially manually.
- Summary reporting. Reports obtained by data processing in different automated information systems are presented in the form of separate documents in different formats. Summary report in the specified format and conclusion on the basis of the performed analysis are also synthesized manually.
- Development of the preliminary solution. This operation is performed manually *by the responsible employees* on the basis of the forecasts received, as well as the existing regulations.

So, *as it can be seen, much* of the manual operations involve processing a large amount of data (recording conversion, aggregation, etc.) obtained in real time mode as well. This influences speed, accuracy and, as a result, efficiency of the discussed and related operations, which can be critical in case of *rapidly evolving* situations requiring an emergency response. Therefore, it is advisable to improve the quality of the existing information system by automating the above-mentioned functions.

Modification of the information system for *monitoring and forecasting emergencies* is aimed at:

- Increasing the speed of monitoring and forecasting operations;

- Minimizing the probability of human errors that occur in the process of monitoring and forecasting emergencies;
- Increasing the efficiency of monitoring and forecasting emergencies.

To do this, the following operations need to be automated:

- Data conversion: conversion of data to the uniform format corresponding to the specified structure of data obtained from various monitoring objects for their further storage in a database;
- Data conversion to a *specified format:* conversion of data to a *format* specified by the requirements of automated information system for structure of input information and data stored in a database;
- Summary reporting: synthesis of summary report in the specified format on the basis of output information from various automated information systems presented in the form of separate documents in different formats;
- Development of consolidated forecast: synthesis of the report in the specified format based on the results of solving a task of emergency forecasting using output information obtained from the automated information system "Antistikhiya".

The current solution to the tasks of emergencies monitoring and forecasting is quite efficient despite some shortcomings identified, i.e., its structure does not need significant changes. Moreover, with such an approach functioning of the existing system may be required to be partially suspended, which is unacceptable. Therefore, it is advisable to improve the existing automated information system by integrating a subsystem which automates the above-mentioned operations.

3 RESULTS

Figure 5 shows the architecture of the corresponding fragment of automated information system.

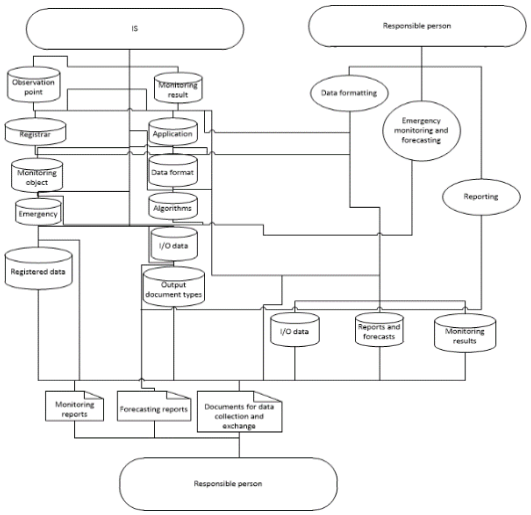

Figure 5. Architecture of automated emergency monitoring and forecasting system in the Altai Republic

The basis of the automated system is a database that stores the information necessary to solve the tasks of emergency situations monitoring and forecasting, as well as modules that implement the main functions: data conversion, reporting. The database model is shown in Figure 6.

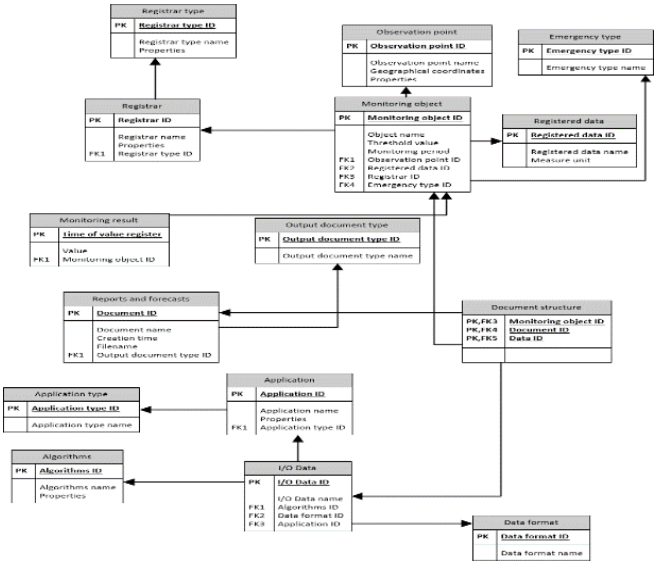

Figure 6. Database model of automated emergency situations monitoring and forecasting system in the Altai Republic

The form and frequency of the main documents are defined [3].

Figure 7 shows the functional model of emergency situations monitoring and forecasting in the Altai Republic, which is implemented on the basis of automated information system with partial automation in the form of separate applications and systems for data processing and analysis.

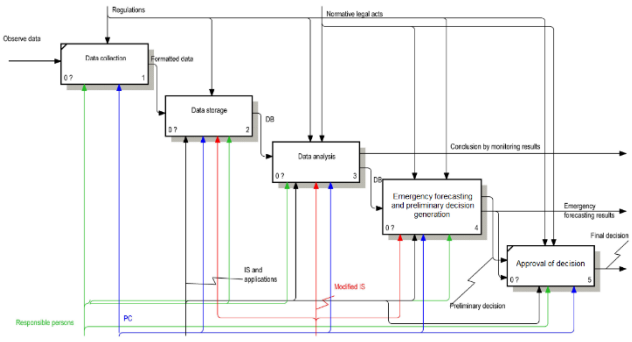

Figure 7. Model for solving the task of monitoring and forecasting emergency situations in the Republic of Altai using an automated system

Data collection and solution approval have not changed, but such operations as storage, data analysis and forecasting of emergency situations with generation of the preliminary solution have been subjected to higher degree of automaton (Figures 8-10).

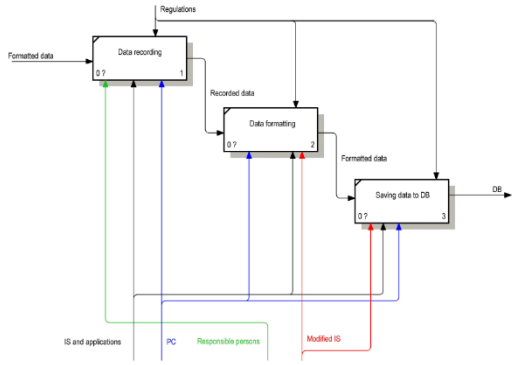

Figure 8. Decomposing a Model of Storage Using an Automated System

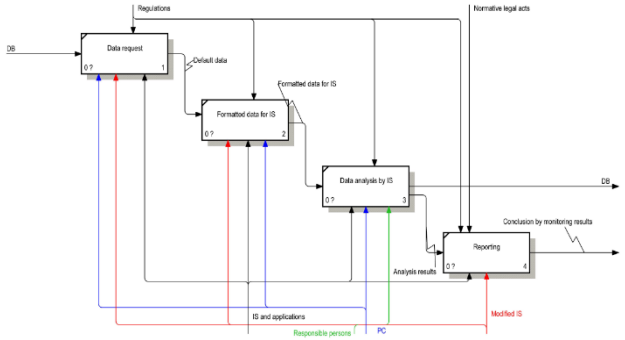

Figure 9. Decomposition a Model of Data Analysis Using an Automated System

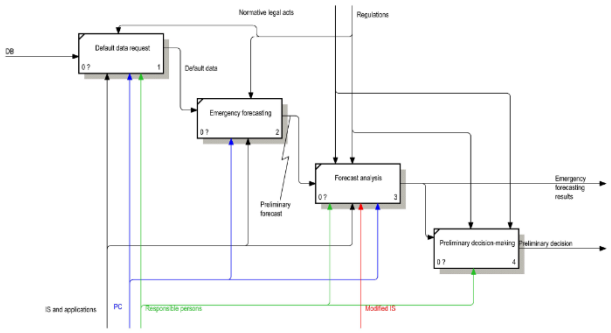

Figure 10. Decomposing a model of emergency forecasting and preliminary solution generation using an automated system

The following operations, shown in Figures 8-10, are still performed partially or completely manually:

- Data recording. The readings of some sensors from monitoring objects are presented in the form of graphic or audio data, which are transferred to the computer memory for subsequent processing.
- Development of preliminary solution. This operation is performed manually *by the responsible employees* on the basis of the forecasts received, as well as the existing regulations.

The rest operations become automated with little human involvement in the modified system:

- Data conversion: conversion of data to the uniform format corresponding to the specified structure of data for their further storage in a database.
- Data conversion to a *specified format:* conversion of data to a *format* specified by the requirements of automated information system to solve the tasks of monitoring and forecasting.
- Summary reporting: synthesis of summary report and conclusion in the specified format on the basis of analysis by various automated information systems.

4 DISCUSSION

A number of operations related to processing a large amount of data (recording, conversion, aggregation, etc.), obtained in real time mode as well, can be automated on the basis of a modified information system. This will have a positive impact on speed, accuracy of data and related operations. All input data can be updated to Constanta County when all data will be freely available, at this stage of research data was not enough for calculus but was enough for comparison and establishing similarities.

Table 1 shows the time spent on execution of main operations based on the initial and modified automated system using the existing hardware.

Table 1. Comparative analysis of *time spent executing various operations* in emergency monitoring and forecasting

№	Operation name	Average run time using initial system, s	Average run time using modified system, s
1	Data conversion by one parameter with a record in a database	12,4	< 0,001
2	Data conversion for automated information systems by one parameter	6,8	< 0,001
3	Development of summary report on emergency monitoring	312,8	< 0,001
4	Development of consolidated forecast of emergencies	248,2	< 0,001
5	Completion of one document for emergency data collection and exchange	141,6	< 0,001

Thus we see that modified automated system significantly

increases the speed of basic operations performance related to data storage, processing and analysis. With a large number of operations, especially in the context of fast-growing emergencies, the application of automation can significantly increase the efficiency of solving related tasks.

5 CONCLUSION

The following conclusions can be drawn from this study:

- Monitoring and forecasting emergency situations *is one of priority* tasks in the sphere of safety. It is connected with collecting and processing *vast amounts* of *information*. Accordingly, in order to improve the efficiency of these processes, it is advisable to use automated information systems, which will significantly increase the speed of data processing, analysis and decision-making.
- The analysis of emergency monitoring and forecasting practices in the Altai Republic *has shown* that a considerable part of operations performed manually is connected with processing large amounts of data (record, conversion, aggregation, etc.) obtained in real time mode as well. This influences speed, accuracy and, as a result, efficiency of the discussed and related operations, which can be critical in case of *rapidly evolving* situations requiring an emergency response. Therefore, it was concluded that the above functions should be automated.
- Based on the modified system of monitoring and forecasting emergency situations a considerable part of operations can be automated. This positively affects speed and accuracy of corresponding functions. A comparative analysis of time spent to perform basic manual and modified operations using available hardware showed a significant increase in speed of data storage, processing and analysis. This indicates that such *automation* results in *higher efficiency* for both regions in discussion.

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