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EFFICIENCY IMPROVING OF EMERGENCY MONITORING AND FORECASTING BASED ON THE INFORMATION SYSTEM

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The article is devoted to the automated information system modification to solve monitoring and forecasting problems of natural and man-made emergencies in order to increase the efficiency of its functioning, namely, to increase the execution speed of the main operations, to reduce the error probability. Monitoring and forecasting of emergencies are among the priorities in the field of population from emergencies protection, as the prevention and elimination of their consequences are carried out on the basis of these tasks. At the same time, the data collection speed, processing and analysis largely determine the efficiency of the obtained results. The existing system of monitoring and forecasting of natural and man-made emergencies, its functional model in IDEF0 notation, characteristic features, advantages and disadvantages are considered. The existing system can be improved by automating a number of tasks related to the processing, transmission and storage of large data amounts, including real time data, as well as the generation of consolidated reports on the results of monitoring and forecasting of various objects. The information architecture of the solution reviewed and the corresponding database model form the basis of the proposed solution. The IDEF0 model of emergency monitoring and forecasting has been introduced taking into account the proposed modification of the automated information system. The main operation execution time comparative analysis based on the initial and modified automated information system (AIS) using the existing hardware confirms the effectiveness of the proposed solution. Data exchange and generation automation of consolidated reports on multiple monitoring objects will simplify analysis of the obtained results and solutions development based on them aimed at prevention of natural and man-made emergencies, as well as elimination of their consequences.

Keywords: automated information system (AIS), emergency monitoring and forecasting, automation, data conversion.

ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ РЕШЕНИЯ ЗАДАЧ МОНИТОРИНГА И ПРОГНОЗИРОВАНИЯ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ НА ОСНОВЕ ИНФОРМАЦИОННОЙ СИСТЕМЫ

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Статья посвящена модификации автоматизированной информационной системы решения задач мониторинга и прогнозирования чрезвычайных ситуаций природного и техногенного характера с целью повышения эффективности ее функционирования, а именно: повышения скорости выполнения основных операций, снижения вероятности возникновения ошибок. Мониторинг и прогнозирование чрезвычайных ситуаций являются одними из приоритетных направлений в сфере обеспечения защиты населения от ЧС, так как предотвращение и ликвидация их последствий осуществляются на основе решения данных задач. При этом, скорость сбора, обработки и анализа данных во многом определяют эффективность полученных результатов. В статье рассматривается существующая система мониторинга и прогнозирования чрезвычайных ситуаций природного и техногенного характера, ее функциональная модель в нотации IDEF0, характерные особенности, достоинства и недостатки. Предлагается совершенствование системы путем автоматизации ряда задач, связанных с обработкой, передачей и хранением больших объемов данных, поступающих, в том числе, и в режиме реального времени, а также с формированием сводных отчетов по результатам мониторинга и прогнозирования для различных объектов. Рассмотрена информационная архитектура предлагаемого решения, соответ-

ствующая модель базы данных. Представлена модель решения задач мониторинга и прогнозирования чрезвычайных ситуаций с учетом предлагаемой модификации автоматизированной информационной системы. Проводится сравнительный анализ времени выполнения основных операций на основе исходной и модифицированной АИС при использовании существующего аппаратного обеспечения, подтверждающий эффективность предлагаемого решения. Предлагаемая автоматизация обмена данными и генерации сводных отчетов по множеству объектов мониторинга позволит упростить анализ полученных результатов и выработку на их основе решений, направленных на предотвращение чрезвычайных ситуаций природного и техногенного характера, а также ликвидацию их последствий.

Ключевые слова: автоматизированная информационная система, мониторинг и прогнозирование чрезвычайных ситуаций, автоматизация, конвертация данных.

Introduction. The main purpose of monitoring and forecasting systems for emergencies is to monitor, control and anticipate dangerous phenomena and processes that occur in the technological sphere and nature, as well as the dynamics of their development. Forecasting allows preventing emergencies, determining their scale and organizing effective measures to eliminate them. In the Russian Federation, the general procedure for the functioning of the emergency monitoring and forecasting systems is determined by the Order No. 94 of the Ministry of Civil Defence, Emergency Situations and Natural Disaster Response of 4 March 2011 approving the Regulations on the Functional Subsystem for Monitoring, Laboratory Control and Forecasting of Emergencies of the Unified State Emergency Management System [1].

Russian physical and geographical characteristics largely determine the wide variety of emergencies occurring on its territory. Therefore, constant monitoring of a significant number of objects is required. Based on the data obtained as a result of such monitoring, the tasks of forecasting emergency situations, as well as their prevention and elimination are solved [2]. For this, various technical, software and informational support is used. The technical support of the monitoring task is based on the equipment of stations, observation systems, computer and network equipment, communication lines, etc. Monitoring data for each observation objects comes from various automated information systems; each system has its own format for storing and outputting data, which greatly complicates their processing for further use: solving forecasting problems, making decisions, compiling reports, etc. At the same time, the number of different information systems for forecasting for each type of emergency is small, while many of them are implemented on the basis of the All-Russian Centre for Monitoring and Forecasting "Antistikhiya" of the EMERCOM of Russia, and therefore have a unified format of input and output data, which simplifies their subsequent processing.

The original system description. Fig. 1 shows the IDEF0-model [3] for solving monitoring and forecasting emergencies problems, which are implemented on the solution with partial automation basis [2] in the form of separate applications and systems for data processing and analysis.

Data collection takes place in an automated mode, but the tasks of storing, analysing data and forecasting emergency situations with the generation of a preliminary solution are partially implemented manually (fig. 2–4).

The following subtasks, presented in fig. 2–4, are partially or completely solved manually:

– data recording. The readings of some sensors from the monitoring objects are presented in the form of graphic or sound data; their transfer to the computer memory for subsequent processing is carried out manually;

– data conversion. For storage in the database, the available information must be brought to a single format corresponding to the given structure, which is also partially done manually;

– converting data into a given AIS form. To solve the problems of monitoring and forecasting based on automated information systems, it is necessary to bring the input data to a given format, which may be different for diverse applications. The corresponding operation is also carried out partially manually;

– consolidation report formation. Reports obtained on the basis of data processing in different AIS are presented in the form of various format separate documents. The report synthesis of a given form and a conclusion on the basis of the analysis performed is also done manually;

– preliminary solution development. This task is solved manually by responsible persons on the basis of the obtained forecasts, as well as existing regulations.

Consequently, a significant part of the tasks solved manually are associated with the processing of a large data amount (recording, converting, combining, etc.), including real time data. This affects the speed, accuracy and, as a consequence, the implementation effectiveness of the listed and related operations, which in the case of rapidly developing emergencies requiring an urgent solution can be critical. Therefore, it is advisable to improve the quality of the existing information system by automating the above functions.

The main goals of the information system for monitoring and forecasting emergency situation modification are:

– increasing the speed of monitoring and forecasting emergencies solving problems;

– reducing the errors associated with the human factor probability when solving the problem of monitoring and forecasting emergencies;

– improving the efficiency of monitoring and forecasting emergencies solving problems.

To achieve the goals, the following tasks are automated:

– data conversion: reduction to a unified format corresponding to a specific data structure [4; 5], coming from various monitoring objects, for their further storage in the database [6];

– data conversion into the form provided by the AIS: reduction to the necessary format, which is determined by

the AIS requirements for the structure of input information [7; 8] and data stored in the database;

– formation of a consolidated report: a report synthesis of a given form [9–11] based on output information from various AIS, presented as separate documents of different formats.

Existing system modification. Despite the identified deficiencies, the existing solution to the problems of monitoring and forecasting emergencies is quite effective, i.e. making significant changes to its structure is impractical. In addition, this approach may require partial suspension of the current system functioning, which is unacceptable.

Therefore, it is advisable to develop the existing AIS by integrating [12] a subsystem into it that automates the above tasks.

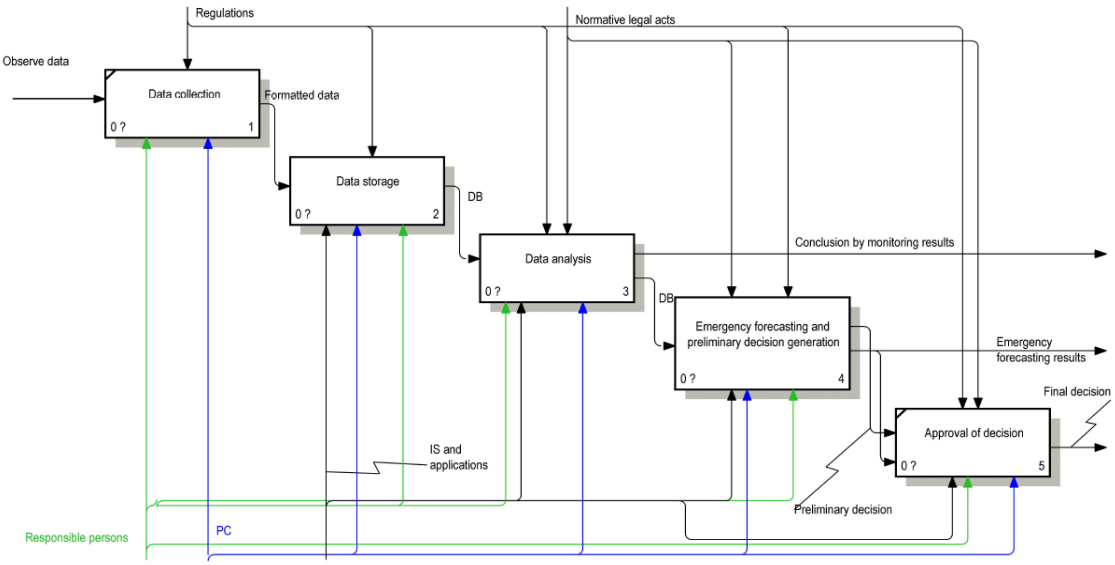

Fig. 1. Emergency monitoring and forecasting model

Рис. 1. Модель решения задачи мониторинга и прогнозирования чрезвычайных ситуаций

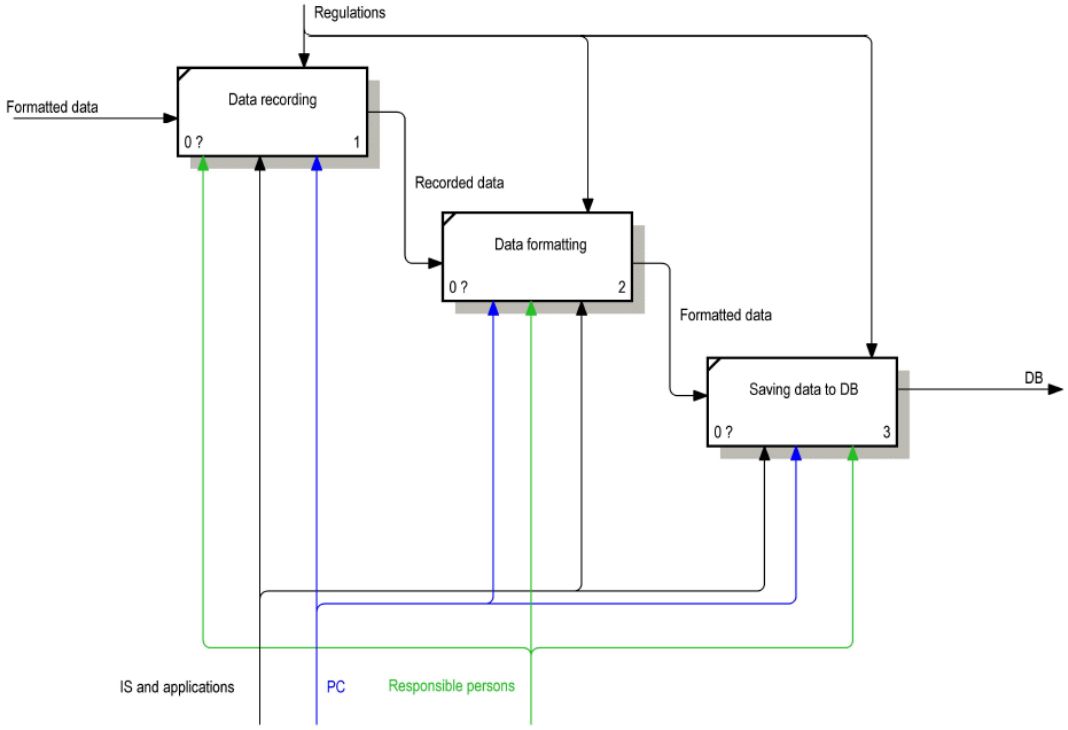

Fig. 2. Data storage solution model decomposition

Рис. 2. Декомпозиция модели решения задачи хранения данных

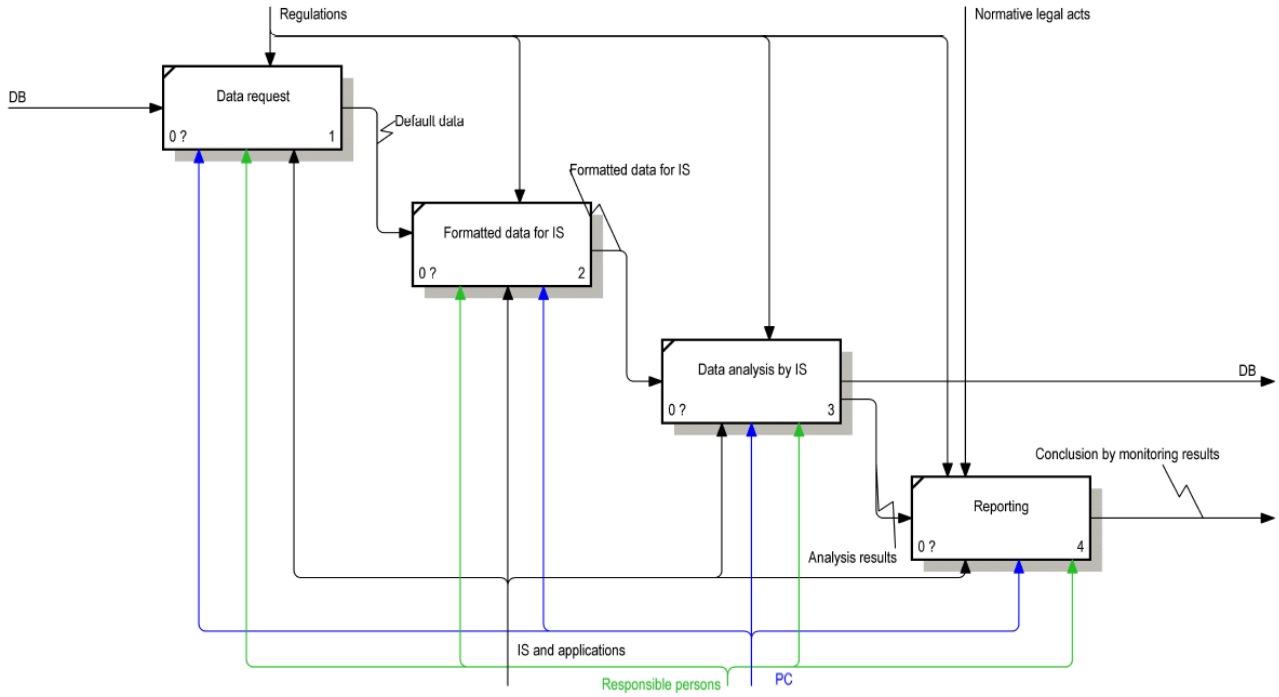

Fig. 3. Data analysis solution model decomposition

Рис. 3. Декомпозиция модели решения задачи анализа данных

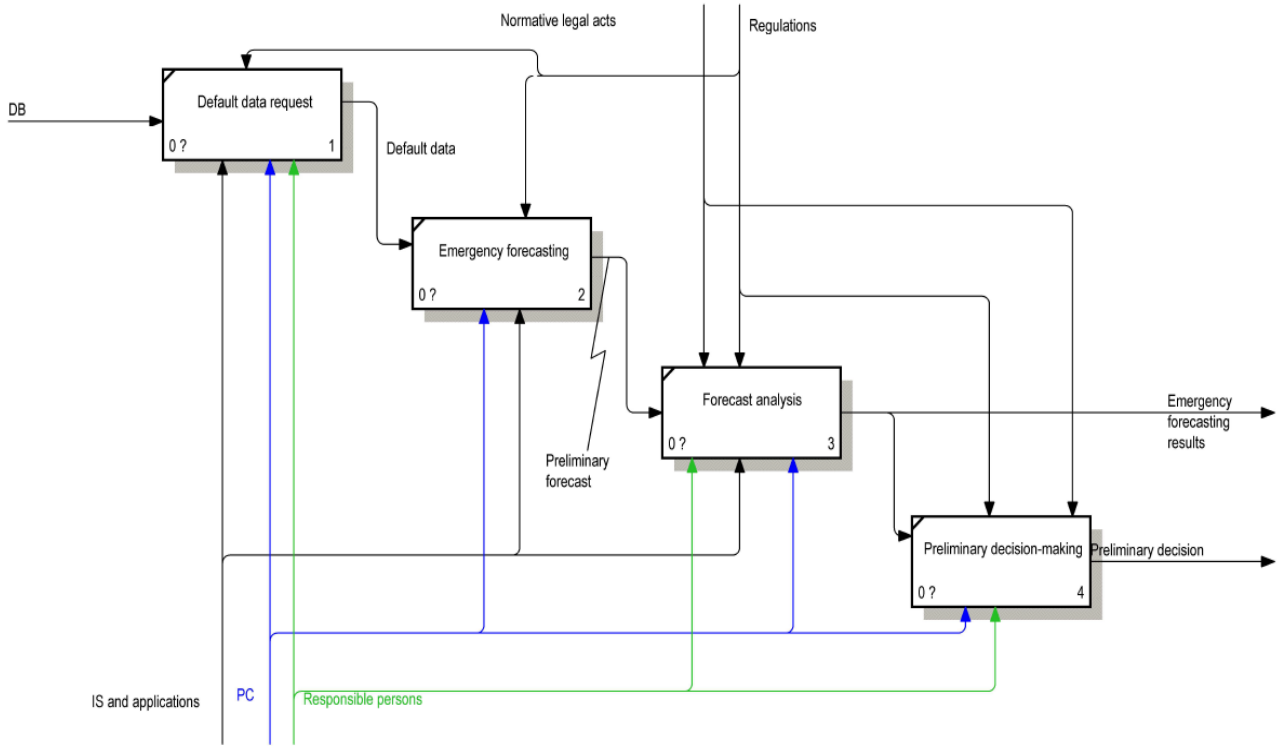

Fig. 4. Problem solution model for emergency forecasting and generation of preliminary solution decomposition

Рис. 4. Декомпозиция модели решения задачи прогнозирования ЧС и генерации предварительного решения

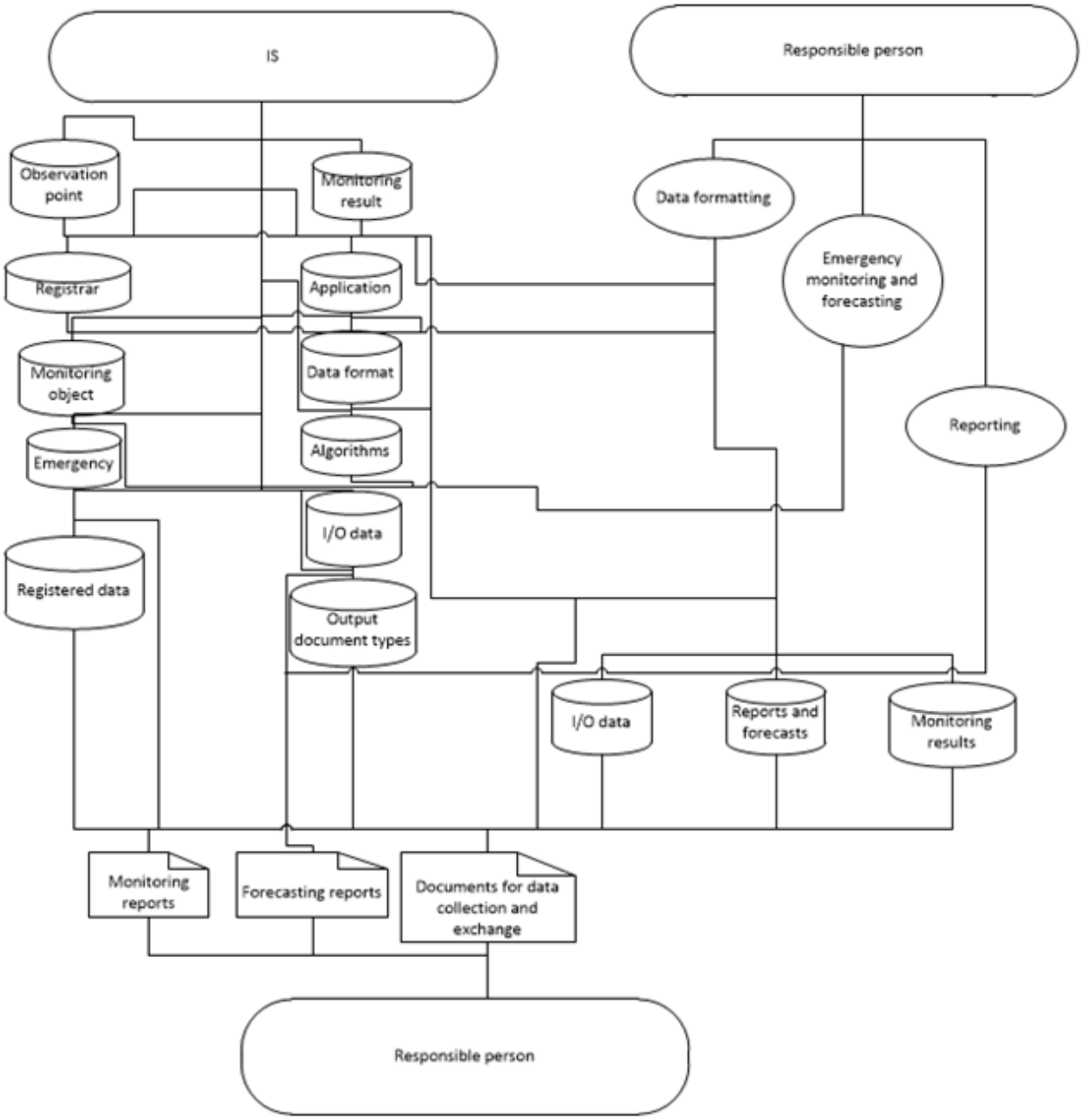

Fig. 5. AIS modified information structure for emergency monitoring and forecasting

Рис. 5. Информационная структура модифицированной АИС мониторинга и прогнозирования чрезвычайных ситуаций

Fig. 5 shows the information structure [13] of the AIS corresponding fragment.

The basis of the automated system is the database that stores information necessary to solve problems of monitoring and forecasting emergencies, as well as modules that implement the main functions: data conversion, report generation. The database model [14] is shown in fig. 6.

The form and frequency of the basic documents formation are determined [15].

Fig. 7 shows the functional model for solving problems of monitoring and forecasting emergencies using the modified system.

The data collection solution tasks and decision approval have not changed, however, the automation degree of storage tasks, data analysis and emergency forecasting with preliminary solution generation has significantly increased (fig. 8–10).

The following subtasks, presented in fig. 8–10, are still partially or completely solved manually:

– data recording;

– preliminary solution development.

The following tasks are automated, with insignificant human involvement:

– data conversion;

– data conversion into a required AIS form;

– consolidated report formation.

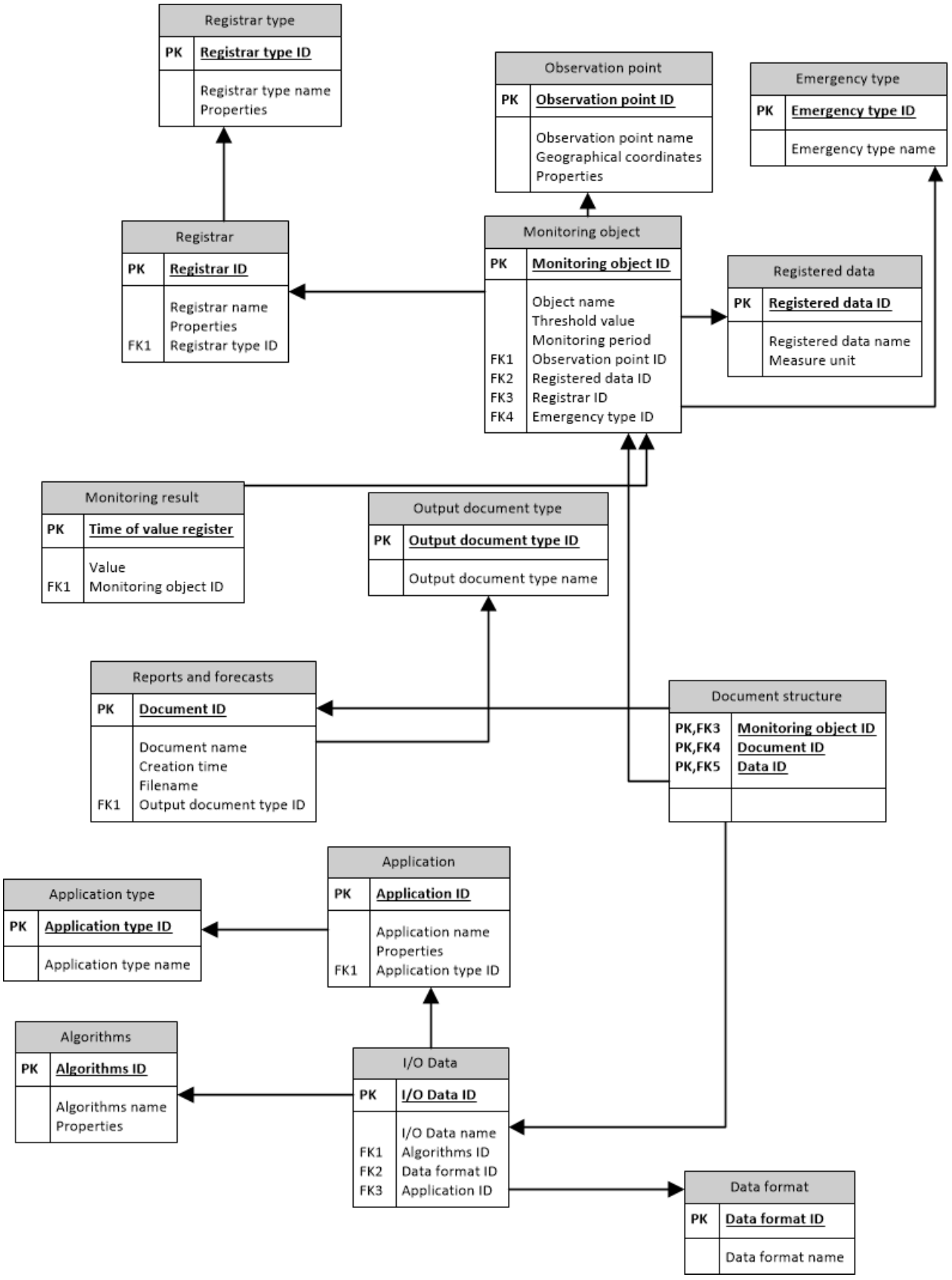

Fig. 6. Database model for the automated emergency monitoring and forecasting system

Рис. 6. Модель базы данных автоматизированной системы мониторинга
и прогнозирования чрезвычайных ситуаций

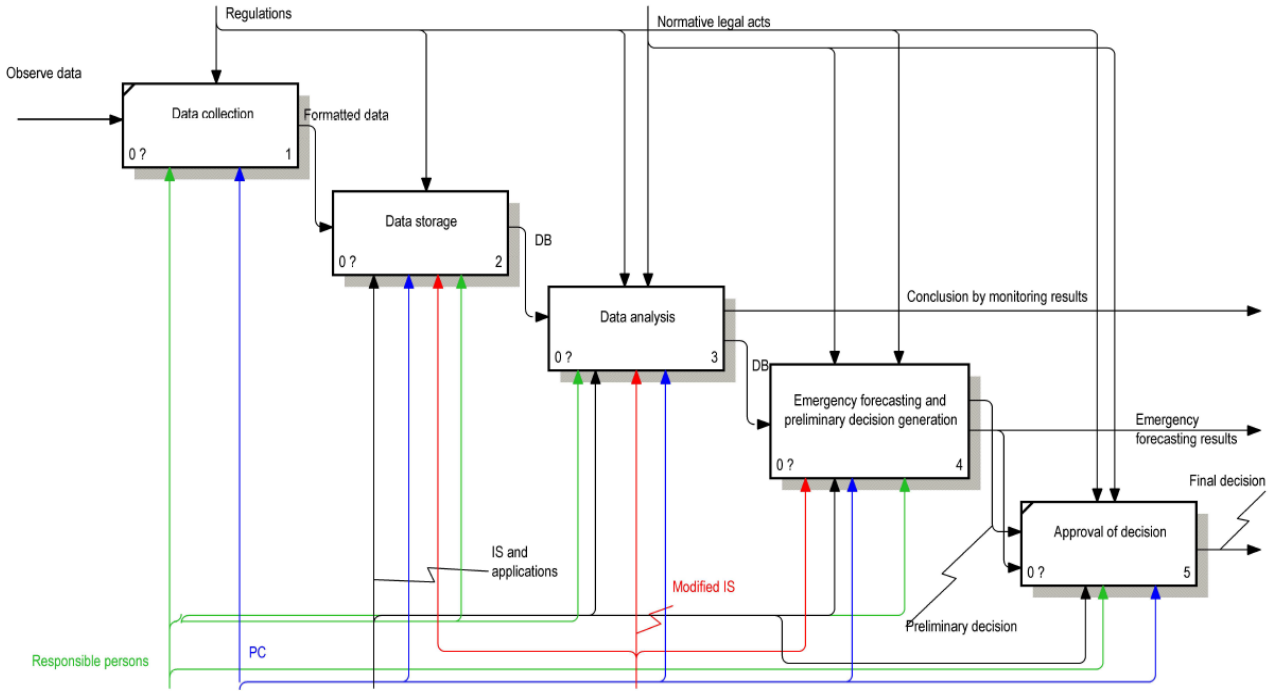

Fig. 7. Model for emergency monitoring and forecasting using the modified system

Рис. 7. Модель решения задачи мониторинга и прогнозирования чрезвычайных ситуаций с использованием модифицированной системы

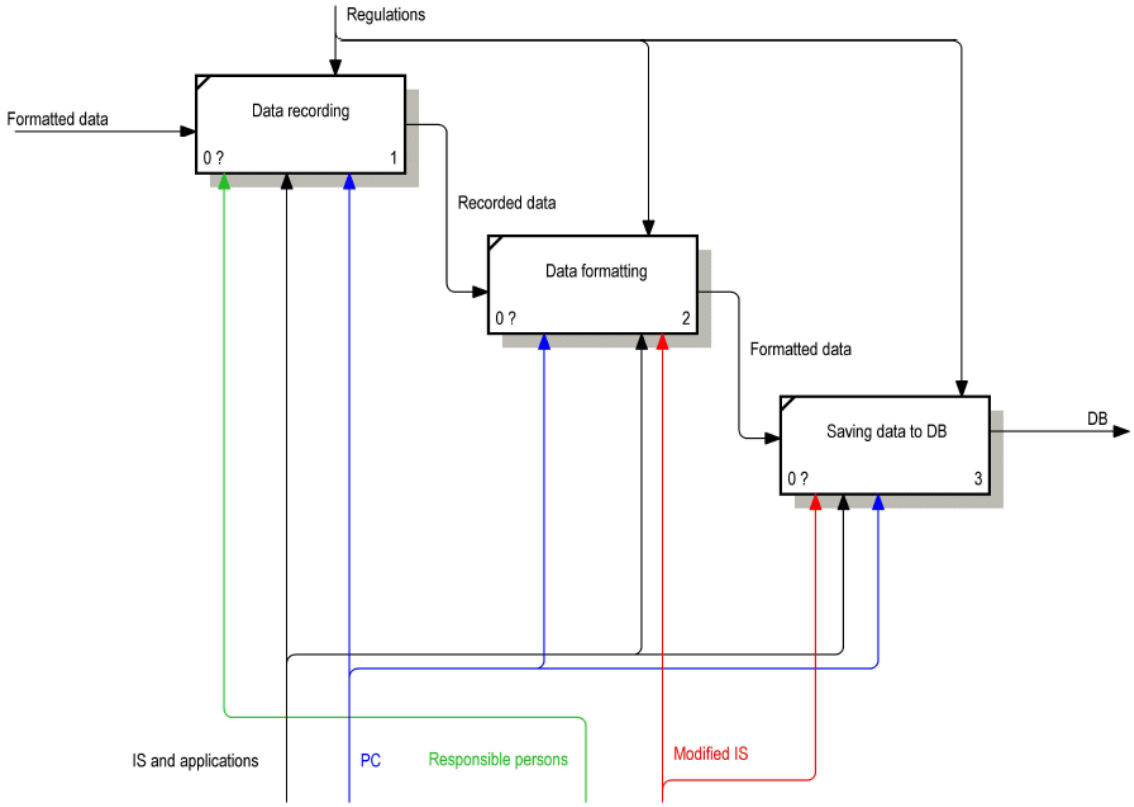

Fig. 8. The storage solution model using the modified system decomposition

Рис. 8. Декомпозиция модели решения задачи хранения данных с использованием модифицированной системы

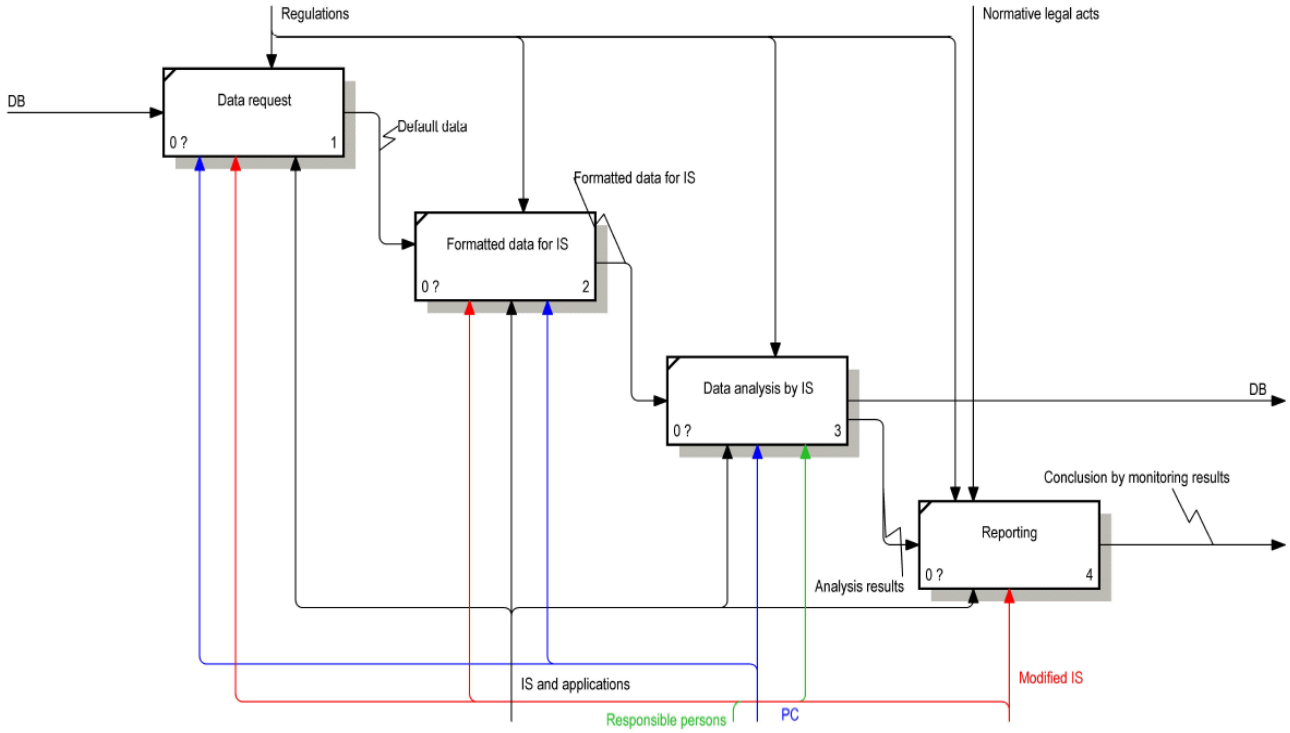

Fig. 9. Data analysis solution model using the modified system decomposition

Рис. 9. Декомпозиция модели решения задачи анализа данных
с использованием модифицированной системы

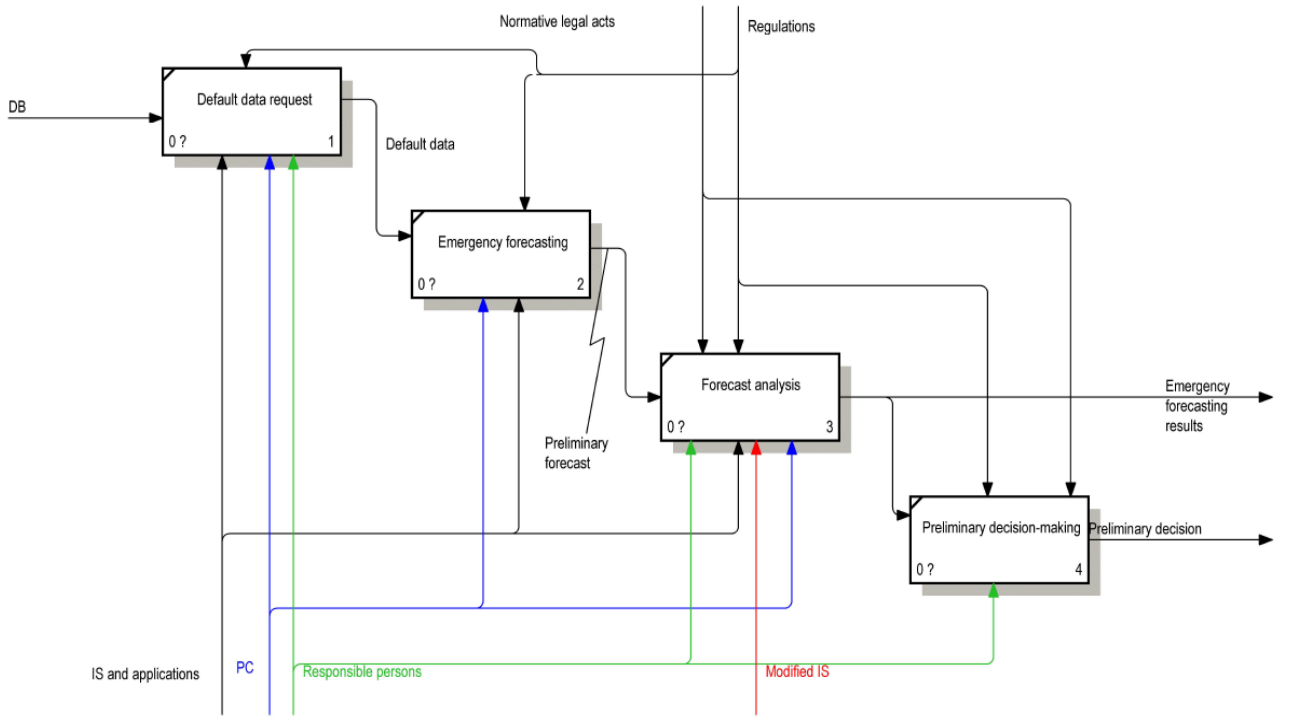

Fig. 10. The solution model of the emergency prediction and generation problem
of a preliminary solution using modified system decomposition

Рис. 10. Декомпозиция модели решения задачи прогнозирования ЧС и генерации
предварительного решения с использованием модифицированной системы

Comparative analysis of the various operations execution time when solving monitoring and forecasting emergencies problems

No.	The operation name	Average execution time using the original system, s	Average execution time using the modified system, s
1	Data conversion by one parameter with writing to the database	12.4	Less than 0.001
2	Data conversion for AIS by one parameter	6.8	Less than 0.001
3	Consolidated report formation on emergency monitoring	312.8	Less than 0.001
4	Consolidated emergency forecasting report formation	248.2	Less than 0.001
5	One document completion for collection and exchange of information on emergencies	141.6	Less than 0.001

Comparative analysis of the original and modified systems. The significant part of the tasks associated with processing a large data amount (recording, converting, combining, etc.), including real time data, can be automated based on the modified information system. This has a positive effect on the speed, accuracy of data implementation and related operations. Table shows data on the execution time of basic operations based on the original and modified automated system using existing hardware.

The use of the modified automated system can significantly increase the speed of performing basic operations related to storing, processing and analysing data. With numerous operations, especially in case of rapidly developing emergencies, the use of automation can significantly increase the solving tasks efficiency.

Conclusion. According to the study, the main conclusions are:

– the task of monitoring and forecasting emergencies is one of the priorities in the security field, while its solution is associated with the collection and processing of large amounts of information. Consequently, in order to increase the implementation 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 based on them;

– the emergencies monitoring and forecasting implementation analysis showed that the significant part of the tasks solved manually are associated with the processing of a large amount of data (recording, conversion, merging, etc.), including real time data. This affects the speed, accuracy and, as a result, the efficiency of the data implementation and related operations, which can be critical in the case of rapidly developing emergencies requiring an urgent solution. Therefore, it was concluded that it is advisable to automate the above functions performance;

– on the basis of the modified system for monitoring and forecasting emergency situations, a significant part of the tasks can be automated, which has a positive effect on the corresponding functions implementation speed and accuracy. The comparative analysis of the manual basic operations execution time and execution time of a modified system using the existing hardware showed the significant increase in the speed of solving problems associated with storing, processing and analysing data. This indicates the high efficiency of the proposed solution.

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