

**POLITECHNIKA ŚLĄSKA**  
**WYDZIAŁ GÓRNICTWA I GEOLOGII**

**PRACA DOKTORSKA**

**Mgr inż. Piotr Wojtas**

**Wpływ integracji systemów  
dyspozytorskich i konfiguracji  
sieci telekomunikacyjnych na ich  
niezawodność i funkcjonalność**

**Promotor:**

**Prof. dr hab. inż. Stanisław Cierpisz**

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**ABSTRACT**  
of the doctoral dissertation entitled:

**“Influence of integration of dispatching systems and configuration of telecommunication networks on their reliability and functionality”**



A mine is a complex enterprise whose production is supervised by a dispatcher who communicates continuously with workers operating a coal mining process, a coal transport and preparation. Nowadays a dispatcher makes use of information delivered to a data communications system of a mine control room by means of autonomous monitoring systems as well as mine ventilation services and other department services of a mine. Decisions taken by a dispatcher are of great importance for production processes and staff safety. Therefore a capability to generate automatically by an integrated informatics mine control system the warning and alarm messages, synthetic information and reports on arising situations to be used currently by dispatcher and technical services of mine grow still in importance.

The fundamental problems which occur currently at use of mine control (dispatching) systems in mines result from their design character, i.e. they have been developed so far as separate, autonomous telecommunications systems. The autonomy of the systems exists frequently at all stages of signal/information transmission, it means from their sources (sensors, contacts, verbal information), and next by transmission lines up to information receivers. The information processing made by individual computer systems, display of messages, alarming and reporting have frequently autonomous character. A consequence of this situation is a serious inconvenience for dispatcher's work and for other production officers, especially under conditions of grave failures of machines and devices, as well as occurrence of disasters which lead to organizing complex mine rescue operations.

As a result of the analysis of the recent research works in functionality and reliability of integrated dispatching systems, there have been formulated the general aims of the dissertation consisting in determination of methods of integration of telecommunication systems being used currently in mines, and determination of reliability rate of autonomous telecommunication systems integrated on various levels.

The detailed aims related to integration of gasometric and alarm-broadcasting systems have concerned a development of an idea of an integration method of the gasometric system of type SMP with the alarm-broadcasting systems of type STAR and SAT, and next extended by an idea of an integration method of gasometric and alarm-broadcasting systems made by any manufacturers (with application of a specialized communications computer MAW).

The analysis of the above mentioned issues and the results of the conducted research works allowed the following theses of the dissertation to be formulated:

1. The state of art, the experiences and the available technical solutions including their parameters of reliability allow the integration of the devices and the autonomous dispatching systems playing a decisive role in work safety in underground mines.
2. The integration of dispatching systems in a mine should be made mainly by programming way with use of relational databases; the automatically loaded data to the databases will be completed with information received from operators and dispatchers of the system.

The integration of the SMP gasometric system with the STAR and SAT communications alarm-broadcasting systems was made under real mining conditions. The integration of any gasometric and alarm-broadcasting systems by means of the communications computer MAW is currently in development. The examples of practical use of integration potential of the systems in the Budryk and Pniówek coal mines have been presented in the dissertation.

The reliability tests of selected elements of the dispatching systems which operate in mines were made. The tests included:

- assessment of reliability parameters of telecommunications elements of cable lines;
- examinations of influence of a cable network structure on the reliability of the system;
- assessment of reliability parameters of the SAT communications alarm-broadcasting system;



- examinations of parametric reliability of methane-meters;
- assessment of a human reliability (of a dispatcher).

Within a telecommunications cable network there have been distinguished: shaft cables, bus level cable networks and district networks. For each segment of a network the reliability parameters have been calculated (a failure rate per length unit of a cable, an average time of repair) on the basis of results of questionnaires. A reliability model of an exchange line has been developed. The reliability of the end-device determines the reliability of the exchange line. The impact of a telecommunications network structure on the reliability of the system has been examined with using threshold circuits. There has been determined that the application of the parallel cable lines improves on reliability of the system.

The reliability parameters of the SAT system have been evaluated on the basis of the analysis of the event files saved in the memory of the maintenance station of the SAT system.

The parametric reliability of methane meters has been investigated by means of analysis of calibrating characteristics of methane meters. The successive calibrations of a methane meter have shown its accidental sensitivity variation, i.e. a certain fall trend in a function of an operating period of a methane meter.

A dispatcher remains an extremely crucial link within the respective dispatching systems. He may make some mistakes, therefore it is indispensable to analyse his work relating to reliability, i.e. it is necessary to determine a probability of a mistake which may be made by him. The correctness of human decisions is of great importance for safety (e.g. nuclear power engineering, aeronautics, but also the mines). The respective elementary processes related to dispatcher's operation include: detection, diagnosis, decision, execution, control and feedback. The dispatcher's reliability has been evaluated in the dissertation by means of the SPAR-H method. There have been distinguished two fundamental activities made by a dispatcher, i.e. diagnosis and execution. Using the assumed method there has been calculated the probability of a wrong dispatcher's response and its value is 0,034. That means if the set alarm threshold of a respective methane meter is exceeded, it is possible that the dispatcher in 3.4% cases may not send the alarm signals to appropriate group of signalling devices.

On the basis of the conducted laboratory and industrial tests made within the dissertation, and analysis of the results obtained by means of questionnaires, the following general conclusions may be drawn:

- Integration of autonomous dispatching systems of a mine is indispensable for efficient management of safety and production processes;
- Additional functionality of the integrated systems will take various forms of supervision processes of safety and production which require the dispatcher's actions, e.g.:
  - automatic transmission of warning and alarming messages to selected areas after determining a dangerous, hazardous situation by a monitoring system (gasometric, production, geophysical);
  - statistic analysis of courses of the most important parameters and the safety as well as interpretation of associated hazards.
- Integration of autonomous systems in order to obtain new functions is to be made by hardware and software way. The connection of the systems requires:
  - acceptance of common electrical and logical standards of transmission links (e.g. RS485 + RTU Modbus or Ethernet);
  - archiving signals and information in a shared relational database, which may occur in centralized or dispersed form;
  - defining data exchange protocols among autonomous systems;
  - defining data exchange protocols with visualization systems.
- One of the significant parameters which characterize the integrated systems is a delay time caused mainly by communications software. The investigations have shown that its value is from several up to dozen or so seconds for the SMP-SAT and SMP-STAR systems.
- The reliability of the integrated SMP-STAR (SMP-SAT) system is determined by the reliability of the data transmission across all components of the system, i.e. from the data sources in a form of methane sensors, next telecommunications cables, station devices, up to acoustic signalling devices in the areas included in the system.
- On the basis of calculations and reliability analyses there has been determined, that the integration of the autonomous systems improves on the reliability of response of the whole system to the occurring alarm states and at the same time the integration reduces possible wrong dispatcher's responses.