Guaranteed management of the prevention, detection, and proof of offenses in socio-technical construction using a geoinformation system

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Abstract. In the conditions of narrow departmental management, the administrative practice integrity in socio-technical construction is being destroyed by a lack of completeness and authenticity of administrative offense proceedings within a reasonable time. The timely application of the geoinformation system in order to prompt prevention, reliable revealing and proper proving of offenses ensures a preventively guaranteed efficiency and security of socio-technical construction. This paper proposes a synthesis of the administrative practice management model in construction, based on the natural-scientific approach to the adoption of managerial decisions. The condition for the existence of guaranteed management, which relates the characteristics of processes and performance indicators, is concretized by the Kolmogorov-Chapman equations system. Network models of interacting processes of the revealing and proving of offenses, the origin and identification of violations, their neutralization through the managerial impact on the limited resources of administrative practice in construction and of geoinformation system are built. Based on the simulation results, the requirements for the geoinformation system that ensure guaranteed management and maximum security to the socio-technical construction within a reasonable time are determined.

Keywords: guaranteed management, administrative practice, socio-technical construction, geoinformation system, natural-scientific approach.

1 Introduction

The huge latency, estimated up to 3/4 of the really committed, administratively punishable misconducts, indicates an unsatisfactory ensure of engineering and ecological security in socio-technical construction in terms of incomplete revealing and inauthentic proving of administrative offenses [1]. The problems are associated with unauthorized development of protected and dangerous zones, illegitimate subsoil use, non-compliance with environmental standards, deviations from the design and regulatory documents, environmental and landscaping damage. The destruction of the integrity of administrative practice is caused by the random nature of the reasons used to initiate cases in accordance with article 28.1 of the Code of Administrative Offences of the Russian Federation (Code) [2]. The sporadic and post-factum response of law enforcement officials to the flow of administrative offenses gives a vicious punitive-fiscal meaning in the proceedings on them. The administrative law enforcement agencies are focused on collecting fines for committed acts and are indifferent to the damage caused [3]. Overcoming the incompleteness and unreliability of administrative practice is especially relevant in relation to administrative offenses, the traces of which are hidden behind the features of the terrain or covered by offenders. A mechanism for early fixing, proper investigation and minimization of consequences is required for 1/7 of the Special Part compositions of the Code. Administrative prevention, revealing and proving in socio-technical construction within a reasonable time regularly require the geographical coordinates with the signs of preparation or commission of offenses for administrative law enforcement agencies in the territory.
under their jurisdiction, for conduct of targeted inspections immediately and for prevent or suppress of harmful consequences[4].

To implement the geocoordinate support of preventive and operational-search activities, it is necessary to systematically analyze cartographic information on tracking changes in the position, shape, and structure of anthropogenic or natural objects with an eye to the ascertainment of event and of elements on the administrative offense[5][6]. Addresses for targeted inspections can be obtained using the geoinformation system during the monitoring of territories under the jurisdiction of the administrative law enforcement agency[7]. Dozens of geoportal solutions at the federal, regional and local levels operate in government or municipal departments, commercial structures of Russia[8]. But due to the failure to timely prevent and suppress of administrative offenses, the catastrophic consequences of destructions, fires, floods, pollutions, misuses of land and forests annually arise[9]. Therefore, in socio-technical construction, at the junction of administrative practice and geoinformatics, an adequate model for managing administrative proceeding using a geoinformation system is gaining scientific and practical interest[10][11].

According to the theory of functional systems, a decision-maker implements the management process based on the model, which is manifested in the chain of basic elements of its formation: “excitement” - “recognition” - “reaction to the situation” [12][13]. The relevance of this paper to the automation of management is determined by the lack of an adequate mathematical model for managerial decision making, based on ensuring a balanced unity of the functioning of social and geoinformation systems, the basic laws of the world order within the framework of a single approach to the universal formalized criterion[14][15][16].

In contrast to analysis, synthesis forms processes with predetermined properties[17][18]. The synthesis of production management will allow guaranteed to ensure the revealing and proving of administrative offenses in socio-technical construction within a reasonable time[19][20].

Thus, in this paper, the following tasks are solved:
- synthesis of a mathematical model for managerial decision making;
- substantiation of the criterion for guaranteed management of administrative proceeding using a geoinformation system;
- construction of structural-functional technology for automated management of administrative practice in socio-technical construction.

2 Materials and Methods

2.1 Synthesis of a model for managerial decision making

In order to exclude arbitrariness in reasoning and conflicting conclusions, the axiomatic-deductive method is used. To ensure the adequacy of the model for managerial decision making, its synthesis is based on the law of object integrity conservation, as a stable repetitive relationship between the properties of the object and the properties of its actions for a fixed mission.

In accordance with the natural-scientific approach, integrating the properties of the world around us, consciousness and cognition, the process of managerial decision making is considered in the light of its three properties at each of the three levels of world cognition (see Figure 1).

The formation of an adequate model for managerial decision making is to establish formal analytical relations between the three technological components that are characterized by temporary resources, irreversible for the decision-maker (see Figure 2):
1. Situation (Object) is a set of current state characteristics of the administrative proceedings, factors, and conditions of decision-maker activity, which is identified with the period of the target process $\Delta T$ and the periodicity of offense occurrence (average time to emergence problem) $\Delta t$;

2. Procedural Decision (Mission) is the provision by the decision-maker of the condition for administrative proceedings implementation within a reasonable time in the current Situation to achieve the management goal, which is identified with an adequate periodicity of response to offenses (average time to neutralize problem) $\Delta N$;

3. Information-Analytical Work (Action) is the continuous extraction, accumulation, generalization, analysis of geodata about the current Situation, which is generalized into periodicity of offenses detection (average time to identify the problem) $\Delta I$.

Using the methods of decomposition, abstraction, and aggregation, the process of managerial decisions making is formalized into the mathematical aggregate of the model, where:

$$ P = f(\Delta T, \Delta t, \Delta N, \Delta I) \quad (1) $$

- $P$ is the probability of finding administrative proceedings during the management in each of its basic states: Initial, Target, Identification or Neutralization;
- $\Delta T$ is the generalized characteristic (average period) of the regular implementation of the target process, functionally consolidating acts (works) on the transition through its states to achieve the target task;
- $\Delta t$ is the generalized characteristic (average time) of problem occurrence, functionally unifying the works for moving through its states to problem maturation;
- $\Delta I$ is the average time of problem identification, functionally linking information-analytical works on the passage of process states to identify the problem;
- $\Delta N$ is the average time of problem neutralization, functionally linking the acts of decision-makers on advance through process states to eliminate the problem.

2.2 Criterion for guaranteed management of administrative proceeding

In a real environment of socio-technical construction, the decision-maker is focused on the implementation of targeted activities for the prevention, detection, and proof of offenses within a reasonable time due to the procedural methods defined by law and departmental methods. The implementation of proven administrative practice schemes based on normative time and other resources provided is complicated by a stream of objective and subjective circumstances that make it difficult to quickly establish the geographical coordinates of the administrative offense place where there are signs of the event and corpus delicti [21]. Stochastically emerging problems can and should be proactively identified using a geoinformation system and guaranteed to be eliminated with the involvement of additional resources in the conditions of restrictions on their availability. If the goals of reliable fixing and proving the administrative offense are not achieved within a reasonable time, the decision-maker is forced to delay, procedurally extend or terminate the case investigation, which is tantamount to the target failure and to the breakdown of production management.
Considering the three-component nature of the basic model of managerial decision making to protect from the interference of problems (offenses) in the target activity, the management of administrative proceeding includes four interacting processes. The target process during the execution of administrative practice in the normal mode is objectively accompanied by a Poisson stream of problems leading to failures of a reasonable time. When a reasonable period of implementation is delayed, the target process breaks back to the initial state by the extension or termination of administrative proceedings. In order to prevent the non-fulfillment of the target task and the failure of management, the identification and neutralization processes due to the works of the decision-maker in the automated management subsystem based on the geoinformation system to diagnose the problems occurrence and to take the remedial measures for elimination them with the comparable time and the resources deficiency. In cases of insoluble problems, part of the identification and neutralization processes can also be disrupted to the initial state (see Figure 3).

The administrative proceeding management model in the form of a continuous Markov chain is characterized by the probabilities of being in one of four basic states associated with the intensities of target process $\zeta=1/\Delta T$, of problem occurrence $\lambda=1/\Delta t$, of its identification $\nu=1/\Delta I$ and neutralization $\omega=1/\Delta N$, as well as the failure rates of target process $\xi=f(\Delta T)$, of identification $\mu=f(\Delta I)$ and neutralization $\tau=f(\Delta N)$ (see Figure 4):

Figure 3. Management scheme of administrative proceeding management.

- $\Theta$ is the probability of initial state when the administrative practice of the decision-maker is in the initial state of administrative proceedings, which does not require the identification or neutralization of problems;
- $\Psi$ is the probability of target completing when the decision-maker fulfilled the target task of administrative proceedings with the guarantee of neutralizing the associated problems (offenses) within a reasonable time;
- $\Lambda$ is the probability of identification when the decision-maker identifies problems leading to a breakdown of a reasonable time for their subsequent neutralization;
- $\Omega$ is the probability of neutralization when the decision-maker, based on the results of identification, neutralizes problems that cause disruptions in ensuring a reasonable time.

The relation (1) of the probability $P=(\Theta, \Psi, \Lambda, \Omega)$ of finding administrative proceedings in each of its basic states, respectively, with the intensities $\zeta, \xi, \lambda, \nu, \mu, \omega, \tau$ of continuous Markov transitions between states of the graph is specified by Kolmogorov-Chapman differential equations system:

$$
\begin{align*}
\frac{d\Theta(t)}{dt} &= -\Theta(t)[\zeta + \lambda] + \Psi(t)\xi + \Omega(t)\mu \\
\frac{d\Psi(t)}{dt} &= \Theta(t)\zeta - \Psi(t)[\zeta + \tau] + \Omega(t)\nu \\
\frac{d\Lambda(t)}{dt} &= \Theta(t)\lambda - \Lambda(t)\nu \\
\frac{d\Omega(t)}{dt} &= \Psi(t)\xi + \Lambda(t)\nu - \Omega(t)[\mu + \omega] \\
\Theta(t) + \Psi(t) + \Lambda(t) + \Omega(t) &= 1
\end{align*}
$$

When, over time, the Poisson streams of interacting processes tend to the limiting stationary mode, the Kolmogorov-Chapman differential equations (2) are transformed into a system of linear homogeneous
algebraic equations, the solution of which using the Cramer method is system-forming factors of management:

\[
\Theta = \frac{\xi \nu \omega + \nu \mu (\xi + \tau)}{\xi \mu (\lambda + v) + \mu (\lambda + v)(\xi + \tau) + \nu (\xi + \lambda)(\omega + \tau) + \nu (\xi + \xi)}
\]

\[
\Psi = \frac{\nu \xi (\lambda + v) + \xi \nu \mu}{\xi \mu (\lambda + v) + \mu (\lambda + v)(\xi + \tau) + \nu (\xi + \lambda)(\omega + \tau) + \nu (\xi + \xi)}
\]

\[
\Lambda = \frac{\xi \lambda \omega + \lambda \nu (\xi + \xi)}{\xi \mu (\lambda + v) + \mu (\lambda + v)(\xi + \tau) + \nu (\xi + \lambda)(\omega + \tau) + \nu (\xi + \xi)}
\]

\[
\Omega = \frac{\nu (\xi + \lambda) + \xi \lambda \nu}{\xi \mu (\lambda + v) + \mu (\lambda + v)(\xi + \tau) + \nu (\xi + \lambda)(\omega + \tau) + \nu (\xi + \xi)}
\]

(3)

3 Results

In the current situation, characterized by the intensities of target process \(\zeta\) and of problem occurrence \(\lambda\), at the normatively established levels of the maximum allowable disruption frequencies \(\xi, \mu, \tau\) and of the minimum sufficient efficiency \(\Psi\), guaranteed criterion (3) of production management allows the decision-maker to control the sufficiency and to optimize the intensities of identification \(v\) due to the Information-Analytical Work within geoinformation system and of neutralization \(\omega\) due to the Managerial Decision by rationalizing the durations of transitions by their events.

The dependence of management efficiency \(\Psi\) on the failure rate of the target process \(\xi\) is close to a decreasing exponent (see Figure 5). At the same time, a step-by-step twofold increase in the intensities of identification \(v\) and neutralization \(\omega\) causes an exponentially decaying increase of efficiency \(\Psi\) within identical slice \(\xi\). Therefore, the failure rate of the target process \(\xi\) sets the status of compliance (suitability) of administrative practice by the signs of a reasonable time. It is within the framework of the suitability indicator \(\xi\) that the necessary management efficiency \(\Psi\) is adjusted by varying the intensities of identification \(v\) and neutralization \(\omega\).

The management efficiency \(\Psi\) decreases more significantly from the increase in the share of neutralization failure \(\tau\) than from a similar identification failure \(\mu\) (see Figure 6). Technical errors of the geographic information system can be partially corrected by other means of information and analytical work. A limited set of procedural means of neutralizing offenses does not leave by the decision-maker the opportunity to compensate for irreparable losses within a reasonable time.

When the situation changes, characterized by the intensity of the target process \(\zeta\) and the problem flow \(\lambda\), the intensities \(v, \omega\), of activity of the geographic information system and of the decision-maker must be strengthened by the available reserves to identify and neutralize offenses within a reasonable time taking into account the failure frequencies \(\mu, \tau\).

Figure 5. Dependence of efficiency \(\Psi\) on the failure rate \(\xi\) during double extension \(v, \omega\).
4 Discussion
The intensity of the stream depends on the structure and duration of transitions by states (events) within the process. Therefore, it is advisable to obtain the intensity of target process $\xi = 1/\Delta T$, the intensity of problem occurrence $\lambda = 1/\Delta t$, the intensities of its identification $\nu = 1/\Delta I$ and neutralization $\omega = 1/\Delta N$ by the structural-functional method. When using it, by clearly linking the works on transitions and the time spent on them in the network model of each process, network analysis makes it possible to evaluate periods $\Delta T$, $\Delta t$, $\Delta I$, $\Delta N$ through the critical path of each process[22]. According to the observations of administrative statistics regarding the timeliness of the issuance and enforcement of judgments in cases of administrative offenses, $\xi \approx 0.25\xi$ and $\tau \approx 0.05\omega$. The probability of technical errors in the functioning of the geographic information system does not exceed $\mu \approx 0.10\nu$.

Based on the average statistical durations of transition between process events, the following indicators are calculated in each network model:

- the earliest possible time of event $j$
  \[ T_p(j) = \max_{i \sqsubseteq j} \{ T_p(i) + t_{ij} \} \]  
  \[ \text{where } i \sqsubseteq j \text{ occurs when event } i \text{ precedes the next event } j; \]
  \[ t_{ij} \] is the duration of process transfer from event $i$ to $j$;
- the latest allowed time of event $i$
  \[ T_n(i) = \min_{i \sqsubseteq j} \{ T_n(j) - t_{ij} \} \]  
- the time reserve of event $i$
  \[ R_i = T_n(i) - T_p(i) \]  
- the full reserve of time for transfer from event $i$ to $j$
  \[ r(i, j) = T_n(j) - T_p(i) - t_{ij} \]
- the duration of the critical path of the process, considered as the maximum total duration to transfer the process from the initial to the final event of the network model or as the durations sum of work for which the full reserves of time are zero.

5 Conclusion
A numerical assessment of system-forming factors (3) on network models of the processes of administrative practice in socio-technical construction confirmed that, based on the average statistical duration of the process procedures, the proposed management model is capable of monitoring critical changes in the situation according to the conditions of efficiency and security. It also helps to

Figure 6. Dependence of efficiency $\Psi$ on the failure rates $\mu = f(\nu)$, $\tau = f(\omega)$. 
reconfigure the structure and functionality of prevention, detection, and proof of administrative offenses within a reasonable time under the current situation.

The leadership of the enforcement agencies and socio-technical construction was proposed a geoinformation mechanism that, within the regulatory acceptable range of suitability for administrative proceeding, allows maintaining sufficient efficiency in the prevention, detection, and proof of offenses by timely attracting the necessary resources.

References
[1] Derjuga A N, Motrovich I 2013 The reasons of the latency administrative delictology Adm. law Process pp 57–62
[2] Mironov A Y 2017 Problems to implementing a reasonable time of criminal production in the stages of initiating a criminal affair and its preliminary investigation The 70th International Scientific Conference of State University of Aerospace Instrumentation vol. 3 (St. Petersburg: State University of Aerospace Instrumentation, Boer, V.M. (ed.)) pp 126–131
[3] Mironov A Y 2016 Automated management system of production on affairs about administrative offense at the regional level The 69th International Scientific Conference of State University of Aerospace Instrumentation vol. 1 (St. Petersburg: State University of Aerospace Instrumentation, Boer, V.M. (ed.)) pp. 314–318
[4] Mironov A, Mironova A and Sipovich D 2019 Information security of revealing and proving administrative offenses when using geoinformation system Reg. informatics Inf. Secur. pp 402–406
[5] Bondur V G and Gordo K A 2018 Satellite Monitoring of Burnt-out Areas and Emissions of Harmful Contaminants Due to Forest and Other Wildfires in Russia Izv. Atmos. Ocean. Phys. 54 pp 955–965 DOI: 10.1134/S0001433818090104.
[6] Burlov V G, Gomazov F A, Uvarova A O 2018 Technology for Managing the Processes of Ensuring Labor Safety at Municipal Waste Processing Enterprises International Conference"Management of Municipal Waste as an Important Factor of Sustainable Urban Development" (WASTE) pp 72–74 DOI: 10.1109/WASTE.2018.8554168.
[7] Savinykh V P, Oznamets V V, Selmanova N N and Tsvetkov V Y 2018 System-categorical analysis used while monitoring of the land according to the remote sensing data Geod. Aerophotosurveying 62 pp 106–113 DOI: 10.30533/0536-101X-2018-62-1-106-113.
[8] Kuznetsov A M, Trusov S V, Baraboshkin O I, Bobrovskij S A, Romanov A A and Romanov A A 2018 An alysis of the Results Obtained over Three Years of Operation of AIS Vessel Monitoring Equipment Based on the Resurs-P No. 2 Spacecraft. Rocket. device Eng. Inf. Syst. 5 pp 80–87 DOI: 10.30894/issn2409-0239.2018.5.4.80.87.
[9] Istomin E P, Abramov V M, Burlov V G, Sokolov A G and Fokicheva A A 2018 Risk Management Metod in Parametric Geosystems 18th International Multidisciplinary Scientific Conference on EARTH & GEOSCIENCES (SGEM, Alberna) pp 377–384
[10] Koshitskii A V, Lupyan E A, Balashov I V, Konstantinova A M 2017 Technology for designing tools for the process and analysis of data from very large scale distributed satellite archives. Atmos. Ocean. Opt. 30 pp 84–88 DOI: 10.1134/S1024856017010080
[11] Burlov V G, Mironov A Y, Mironova A Y 2019 Application of geoinformation system in prevention, identification and evidence about administrative offenses Proc. Russ. State Hydrometeorol. Univ. pp 126–146 DOI: 10.33933/2074-2762-2019-57-126-146
[12] Sudakov K V 2015 Theory of Functional Systems: A Keystone of Integrative Biology Cognitive Systems Monographs pp 153–173 DOI: 10.1007/978-3-319-19446-2_9
[13] Burlov V, Grachev M 2017 Development of a Mathematical Model of Traffic Safety Management with Account for Opportunities of Web Technologies Transp. Res. Procedia 20 pp 100–106 DOI: 10.1016/j.trpro.2017.01.023
[14] Mironov A Y 2017 Model of optimal management by administrative production. The 70th International Scientific Conference of State University of Aerospace Instrumentation vol. 2
(St. Petersburg: State University of Aerospace Instrumentation, Boer, V.M. (ed.)) pp. 139–144.

[15] Burlov V, Andreev A, Gomazov F 2018 Mathematical model of human decision - a methodological basis for the realization of the human factor in safety management Procedia Comput. Sci. 145 pp 112–117DOI: 10.1016/j.procs.2018.11.018.

[16] Burlov V, Mironov A and Kostareva K 2019 Synthesis of automated management by production on affairs about administrative offenses Inf. Technol. Syst. Manag. Econ. Transp. law. pp 110–114

[17] Andreev A V, Burlov V G, Grachev M I 2019 Information Technologies and Synthesis of the Management Process Model in the Enterprise International Science and Technology Conference “EastConf.” pp 1–5 DOI: 10.1109/EastConf.2019.8725428

[18] Burlov V G, Mironov A Y, Baranov Y V 2019 Synthesis of model of management of affairs about administrative offenses Information-measuring Manag. Syst. pp 22–34

[19] Burlov V G, Mironov A Y 2019 Synthesis of automated management The All-Russian Scientific and Practical Conference on Innovative technologies and security issues of the real economy (St. Petersburg: St. Petersburg State University of Economics) pp. 27–37

[20] Burlov V G, Mironov A Y, Mironova A Y 2019 Guaranteed management of production on affairs about administrative offences when using geoinformation system Glob. Reg. Res. 1 pp 200–210

[21] Burlov V G, Grachev M I, Shlygina N S 2017 Adoption of management decisions in the context of the uncertainty of the emergence of threats XX IEEE International Conference on Soft Computing and Measurements (SCM) pp 107–108 DOI: 10.1109/SCM.2017.7970510

[22] Burlov V G, Grobitski A M, Grobitskaya A M 2016 The management of construction production taking into account the indicator of successful fulfillment of a production task Mag. Civ. Eng. 63 pp 77–91 DOI: 10.5862/MCE.63.5