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Hybrid Monitoring Systems for Global Processes. The Results of the Experiment at the First Point of the Hybrid System

V.K. Sarian[1], A.R. Mkrtchyan[2], V.V. Ermakov[3], A.P. Nazarenko[4], A. Lyubushin[5], R.V. Meshcheryakov[6]

[1]*Federal State Unitary Enterprise Radio Research and Development Institute (NIIR) 16 Kazakova Str., Moscow, 105064, Russia*
[2]*Institute of Applied Problems of Physics NAS of the Republic of Armenia, 25 Hrachya Nersissian Str., Yerevan, 0014, Republic of Armenia,*
[3]*Federal State Budgetary Institution of Science of the Order of Lenin and the Order of the October Revolution Institute of Geochemistry and Analytical Chemistry named after V.I. Vernadsky Russian Academy of Sciences (GEOKHI RAS), 19 Kosygina Str., Moscow, 119991, Russia*
[4]*Federal State Unitary Enterprise Radio Research and Development Institute (NIIR) 16 Kazakova Str., Moscow, 105064, Russia*
[5]*Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences 10-1 Bolshaya Gruzinskaya Str., Moscow, 123242, Russia*
[6]*V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences 65 Profsoyuznaya Str., Moscow, 117997, Russia*

E-mail: sarian@niir.ru,
ermakov@geokhi.ru,
apn@niir.ru,
lyubushin@yandex.ru,
mrv@ieee.org

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Abstract. This article is a continuation of the topic with which Sarian V.K. and A.R. Mkrtchyan [7] spoke at «International Conference on Electron, Positron, Neutron and X–Ray Scattering under External Influences & International School named after G. A. Askaryan 16–22 October 2017» «Invitation to the use of a powerful experimental ground created in the Russian Federation for monitoring the global processes based on new information technologies». The first point of the hybrid network was organized at the beginning of 2018 with the participation of scientists and specialists of the Federal State Unitary Enterprise NIIR, GEOKHI RAS, IPE RAS, IAPP NAS RA, ICS RAS and others at the field national center for complex environmental and biogeochemical studies of the GEOHI RAS, which is located on a geological base Moscow State University in the village N. Unal of North Ossetia (RF). The report will describe the measuring equipment used and discuss the significance of the results of measurements for short-term, medium-term and long-term forecasts of global processes, including emergency situations. The experiments will be continued from 2020 to 2021. It is planned to expand the experiment in potentially seismic areas in Kamchatka and Armenia. Similar experiments will be conducted at national training sites in the countries of the Asia-Pacific region in accordance with the decision of the 58th meeting of the Working Group on Telecommunications and Information in the framework of the Asia-Pacific Economic Cooperation (APEC), which was held at the end of 2018 in Taipei (Chinese Taiwan). Similar experiments will be carried out at national training sites in the countries of the Asia-Pacific region in accordance with the decision of the 58th meeting of the Working Group on Telecommunications and Information in the framework of the Asia-Pacific Economic Cooperation (APEC), which was held at the end of 2018 in Taipei (Chinese Taiwan). At this meeting, the authors made keynote speeches. In the future, on this basis, it is planned to establish an international interdisciplinary collaboration of scientists and specialists on the formulation of development goals and regulations on the use of the created global hybrid monitoring system for global processes of natural and technogenic origin.

Keywords: hybrid system, hybrid monitoring systems, global processes, distributed sensors

1. Introduction

The relevance of the presented work is very great, since improving the adaptive capabilities of a person in conditions of increasing technogenesis and increasing the risk of human and material losses from emergencies of natural and technogenic origin is a vital task (the task of survival) of modern civilization.

The article will consist of five sections:

1. Tasks to be solved with the help of hybrid monitoring systems.
2. Developed solutions.
3. Interdisciplinary research and international cooperation from 2016 to 2019. Research results.
4. The world's first experimental site of a hybrid monitoring system.
5. Further research plans (directions and scope).

2. Tasks to be Solved Using Hybrid Monitoring Systems

Statistics captures radical decrease in human and material losses from global emergencies of natural origin (hereinafter – emergencies) in today's world.

Each year, various global emergencies of natural origin cause unjustifiably large material and human losses in different parts of the Earth. These losses are equally high for both developed and developing countries. According to statistics, the risks of losses due to emergency situations, as a rule, increase annually in all countries of the world due to a noticeable increase in the frequency of emergency situations (earthquakes, tsunamis, floods, landslides, etc.). The situation seemed so bleak, that in 1997, a final and probably non-appealable sentence was passed by seismologists: "earthquakes cannot be predicted - that's the point.

But despite such a harsh verdict, these processes are so sensitive for all countries that in many countries, large amounts of money are still being spent on research to develop a reliable system of medium- and long-term forecasting, but their predictive potential is still so small that these predictions do not yet have economic values, and they are completely ignored in all countries. Indeed, all economic activity in the whole region (or megalopolis) will not be stopped for an indefinite time on the grounds that, according to scientific observations in this region, there may be an earthquake in the future.

Among the causes of increasing technogenesis should be attributed desynchronization reduction between the pace and scale of the introduction of new technologies, urbanization processes and other factors of increasing technogenesis and scientific research. The inevitable consequence of the victory of the fourth industrial revolution (digitalization), which all countries are striving for today, if not take urgent measures, will be a further increase in the environmental technogenesis. The diagram below illustrates the reasons for the increase in technogenesis associated with globalization processes.

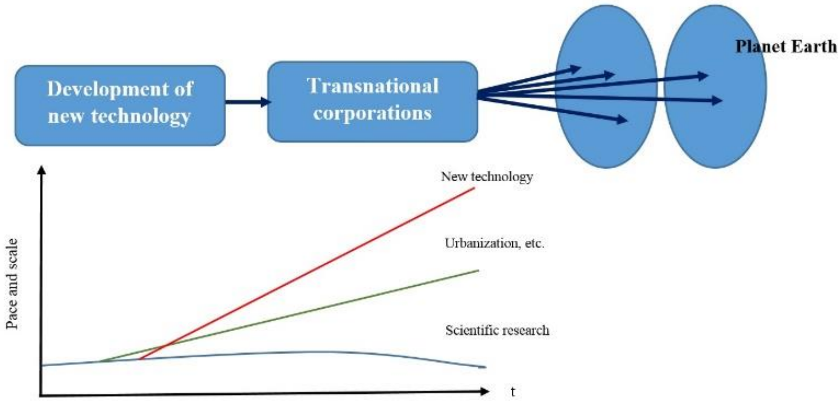

Fig.1. The decrease in desynchronization indicators

The decrease in desynchronization indicators is associated not only with the gap between the pace and scale of the introduction of new technologies, but also with the processes of urbanization and other factors of increasing technogenesis and scientific research. The anthropogenic burden on nature is increasing due to growing trends in the concentration of the population in megacities, the construction of smart cities, an increase in the pace of life and mobility of the population (including the development of mass tourism), rapid changes in technology, etc. Science is serious lags behind in studying the environmental impact of this burden, especially in developing countries.

3. Developed solutions

Choosing solutions, we decided not to abandon the use of existing national and, for a number of tasks, combined into global networks for monitoring earthquakes and other emergencies, although at present they have extremely low predictive potential and record only emerging emergencies. Today, the indicators are mainly used for scientific research of physical processes in the bowels of the Earth, development of models of the Earth’s dynamics and internal structure, study of Earth’s seismicity and earthquake source physics, seismic zoning, development of theory and computer science, technology for interpreting geophysical data, etc.

We supplemented the existing solutions with new ones, implementing a new mass service based on modern ICT, primarily Internet of things (IoT) technology - individualized subscriber rescue management (ISRM) in the event of global emergencies (earthquakes, floods, etc.) that reduce human and material losses of not less than 90%. We emphasize that this service can be available to any user of an existing infocommunication network at any time and in any place and provides individual rescue control in the event of any type of emergency. These works are described in detail in [1-25].

A key point in the possibility of implementing such a service for any type of emergency was the proposal to create a hybrid network for monitoring natural emergencies, which differs from existing networks in that sensors based on the Internet of things are installed in the vicinity of the existing measuring station of the existing network. The joint processing of the signals of all sensors will make it possible to detect precursor signals, for example, earthquakes, before the start of earthquakes, and thereby ensure the evacuation of people to a safe area before the start of an emergency. In fig. 2 is a block diagram of a hybrid monitoring network.

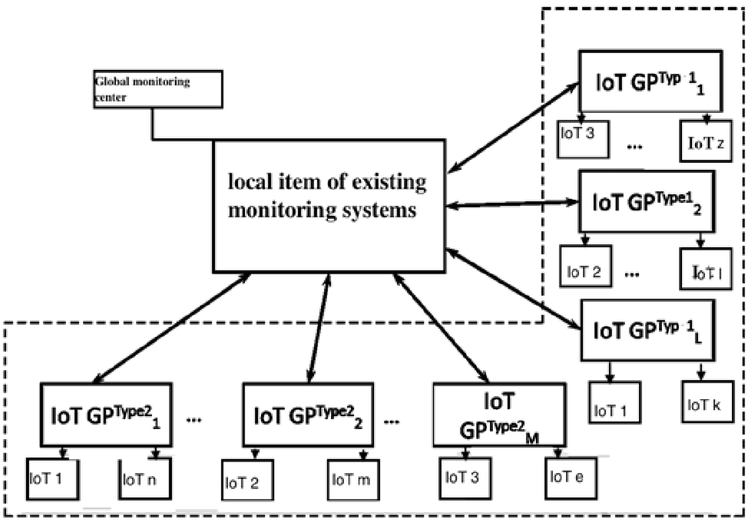

Fig.2. The block diagram of a hybrid monitoring network

4. Interdisciplinary research and international cooperation from 2016 to 2019. Research results.

Global emergencies of technogenic and natural origin, for example, earthquakes, do not recognize state borders and academic disciplines. Earthquake-related natural disasters needed to reduce interdisciplinary and international research and collaboration. Therefore, from the very first steps of our research, much attention is paid to probation proposals of technical decisions at reputable international venues such as ITU, ESCAP (Economic and the Social Commission for Asia and the Pacific), bringing together five regional commissions United Nations, APEC Forum. These organizations, in accordance with the resolution adopted by the General Assembly on June 3, 2015, the Sendai Framework for Disaster Risk Reduction 2015-2030, much attention is paid to the study of the possibilities of using ICT to prevent natural and man-made disasters origin, response to them and in the restoration of damage, calling for widespread international cooperation. The same tasks are included in the program of achieving 17 goals. UN Sustainable Development.

The following are the steps for forming an interdisciplinary team. Steps for forming an interdisciplinary team

2016 - NIIR, RF + IPPF NAS RA, RA

2017 + IFZ RAS, RF + GEOKHI RAS + NIIR-Svyaz LLC, etc.

2018 + IPU RAS + Kyrgyz Academy of Sciences + Serbian Academy of Sciences

2017 - 2019 Scientists from the USA, India, China, the Republic of Korea, Japan, Malaysia, Australia, and the Philippines also showed interest in this work.

We paid great attention to the wide testing of the proposed solutions at such authoritative expert sites as ITU, APEC, ESCAP, articles were published in leading scientific and technical journals, reports were made at international conferences in Atlanta, Brussels, Geneva, Taipei, Moscow, and others. fragments of the system were demonstrated at international exhibitions in Geneva, Hanover, Hong Kong, Moscow, etc. [25-34]

5. The world's first experimental site of a hybrid monitoring system

The APEC TEL 58 session in Taipei approved the decision to establish national pilot sites in APEC countries. In Russia, such a site was created in 2019 in the North Caucasus.

The territory of the Unal depression is located in the mountainous region of North Ossetia (Fig.3, 4.), where lead-zinc deposits are located and almost all the mining industry of the republic is concentrated. It is a technogenic zone of increased environmental hazard. The main sources of environmental pollution by lead, cadmium, copper, zinc are: Arkhon-Kholstinsky dumps, Mizursky mining and processing plant (GOK) and the Unal tailing dump (pulp). The content of heavy metals (HM) in soils, waters, and biota is markedly increased here relative to their natural background, especially lead.

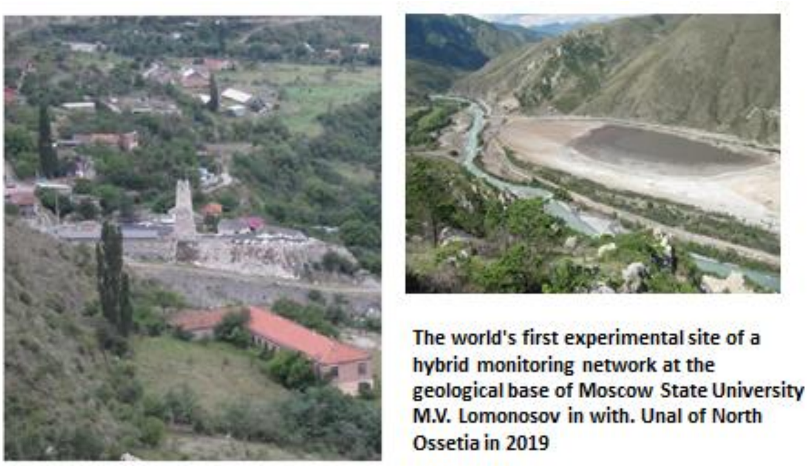

Fig.3. The world's first experimental site of a hybrid monitoring system

The base is located in a highly seismic mountainous area at an altitude of $900m$ above sea level on the slopes of the Rocky Range. In the basin of the mountain rivers of North Ossetia, avalanches, glaciers, landslides, mudflows, earthquakes and floods are frequent. To date, the base has been used for the work of local geologists who control natural disasters. The territory of the Unal depression is located in the mountainous region of North Ossetia, where lead-zinc deposits are located and almost all the mining industry of the republic is concentrated. It is a technogenic zone of increased environmental hazard. The main sources of environmental pollution by lead, cadmium, copper, zinc are: Arkhon-Kholstinsky dumps, Mizursky mining and processing plant (GOK) and the Unal tailing dump (pulp). The content of heavy metals (HM) in soils, waters, and biota is markedly increased here relative to their natural background, especially lead.

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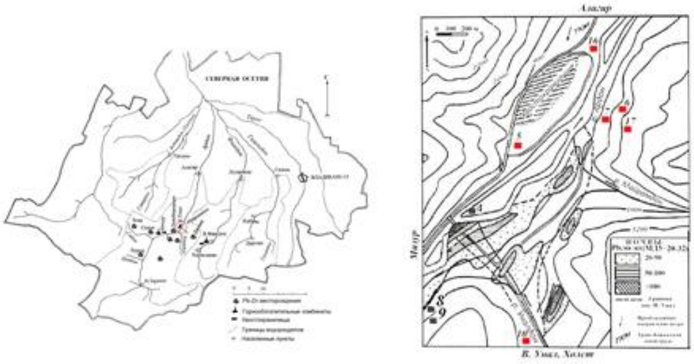


Fig.4. Area of work. Experimental sites.

Equipment of the experimental site:

a) Sensors,

b) Wireless equipment,

c) Ionospheric station,

d) Addition of signals from sensors, including signals from sensors of the nearest seismic station and joint processing to identify the synchronization effect.

a) Sensors.

Real-time monitoring of biogeochemical parameters using a system of existing sensors and sensors, for example, such as Stevens Hydra Probe Field Portable soil monitoring system, VAISALA GMT220 carbon dioxide sensor, RADEX MR107 radon indicator, UKR-1MTs mercury analyzer, 3000 IP mercury sensor, portable gas analyzer of mercury vapor in the air and other gases, ORP sensor (Redox) - redox potential pH S406 DG, digital optical oxygen sensor S423 / C / OPT, etc.

b) Wireless equipment.

Due to the small number of installed sensors (six in total) on the territory of the experimental site (Fig.5.), a local wireless network was used to transfer data from these sensors to the addition device for joint processing, despite the fact that its parameters at the sensor installation points were extremely unstable (temporary scheme) and require another solution that is available in the Russian Federation.

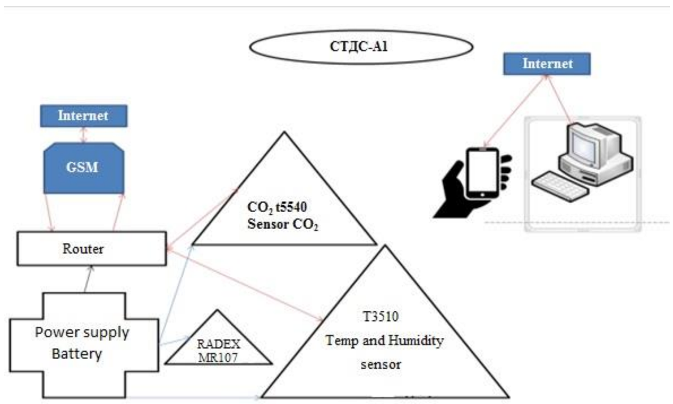


Fig.5. The temporary connecting diagrams of the geographically distributed sensors

The two figures (Fig.6, 7) below show the results of real measurements.

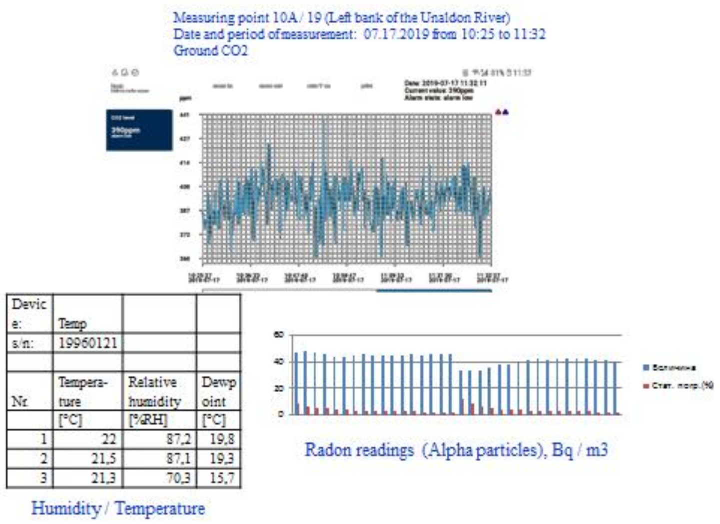
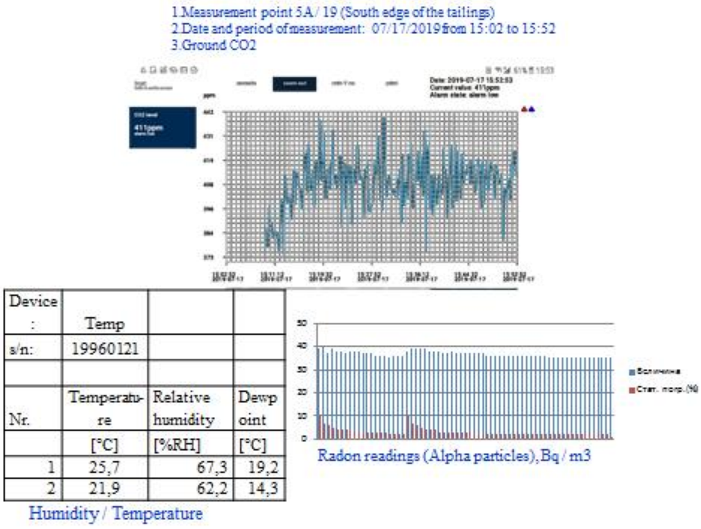


Fig.6. The results of real measurements. Date and period of measurement: 07.17.2019 from 10:25 to 11:32



Device :	Temp		
s/n:	19960121		
Nr.	Temperature	Relative humidity	Dewpoint
	[°C]	[%RH]	[°C]
1	25,7	67,3	19,2
2	21,9	62,2	14,3

Fig.7. The results of real measurements. Date and period of measurement: 07.17.2019 from 15:02 to 15:52

c) Ionospheric station - Complex of sounding of the ionosphere "Rainbow", fully domestic equipment.

The Rainbow vertical and oblique sounding ionosphere complex is designed for vertical, oblique and radiotomographic sounding and real-time determination of the ionosphere parameters (Fig.8.), as well as the formation and continuous monitoring of the regional ionosphere model and its correction according to sounding data.

The Rainbow ionosphere sounding complex is currently unique and one of the best in the world, among similar equipment.

The uniqueness of the equipment lies in the high resolution, which allows you to record the precursors of earthquakes at their initial occurrence in the ionosphere.

The resolution of the equipment reaches 50 meters in the ionosphere and allows you to continuously monitor the dynamics of changes in the total electronic content in different layers of the ionosphere.

It should be noted that the Rainbow equipment also has the ability to record earthquake precursors at a great distance (including over the ocean) due to oblique sounding of the ionosphere over 3,000 kilometers. For this, equipment is located at intervals of up to 3,000 km (including on the islands).

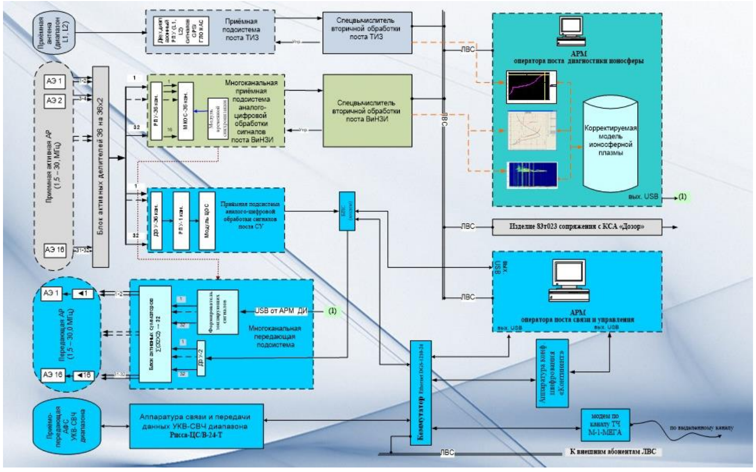


Fig.8. The block diagram of the Rainbow vertical and oblique sounding ionosphere complex

d)Addition of signals from sensors, including signals from sensors of the nearest seismic station and joint processing to identify the synchronization effect.

This item will be implemented in the future.

In spite of this, the objectives of the first stage of work at the experimental site of the hybrid monitoring system are to put together all the equipment and try to connect to the communication networks and find out the compatibility of the interfaces of individual devices to develop a user interface concept for such experimental sites. Ultimately, this is a step towards designing and testing a software product for effective product interaction, which would be delivered from the experimental section of the hybrid system to users: a) operators of situational centers and b) subscribers of mass IUSA services. In principle, the goals of the first stage, as all participants admittedly, have been achieved.

6. Further research plans (directions and scope)

Briefly describe plans for further work:

- Introduce a new wireless network at the test site that fully meets all research objectives.

Duplex based domestic networks universal service for inhabitants in sparsely populated points of residence on the territory of the Russian Federation and the new low cost sustainable telecommunication network for the countryside. These are entirely domestic development. Created by the “Russian Communications Corporation", part of the state Rostec Corporation. This development is protected by patents.

In fig. 9 a block diagram of a traditional and new wireless communication system is shown. From a comparison of the block diagrams, it can be seen that the new system can provide wireless access to objects even in sparsely populated areas, which makes it economically feasible to use the information interaction of the remote center of the hybrid network and the IoT-based sensors located in the pilot area.

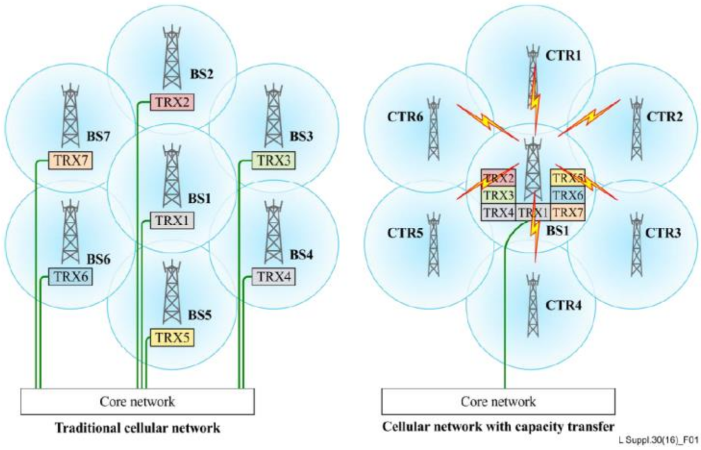


Fig.9. Cellular network with capacity transfer principle

- Implement the function of adding signals from sensors, including signals from sensors of the nearest seismic station, and ensure their joint processing to identify the synchronization effect.

- Continue the work of the experimental site, transferring measurements to the round-the-clock mode with remote multi-user control, including with foreign experimental sites, which, according to the APEC decision, should be deployed at the end of this year or at the beginning of the next in the Republic of Korea and Taipei.

- To expand the network of pilot sites in the country in Kamchatka, as well as in Kyrgyzstan and Armenia. The beginning of such practical work in Armenia was dreamed by our dear friend and co-author of this article, academician of the National Academy of Sciences of Armenia Alpik Rafaelovich Mkrtychyan, and we are obliged to bring these plans to life.

Actively research the search for sensors based on IoT-living (including humans) and oblique objects located in the vicinity of the experimental site to identify sensitive sensors of emergency precursors that are specific to this region.

- Embed services in new promising:

-- communication systems, such as 5G and 2030 networks for providing individualized subscriber rescue management (ISRM) anywhere and anytime, so that the proposed solution to radically reduce the risk of emergency losses could be implemented on the whole planet;

-- KVNO systems;

-- e-medicine systems, etc.

- To increase the effectiveness of biogeochemical monitoring of ecosystems through the widespread introduction of dynamic studies of processes occurring in ecosystems, including by testing physiological sensors: vascular pulsation, muscle tremors, tension etc. in a large number of animals and humans. These non-specific parameters may give a surge in case of emergency.

- To expand our collaboration and set ourselves the goal - to achieve, no later than 2021, an international mega-grant for this work.

Acknowledgements

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Conflict of Interest

There is no conflict of interest.

Author Contributions

Each stage of this initiative study was accompanied by active joint discussion, including during the business trips of Academician of NAS RA A.R Mkrtychyan to Moscow and the business trips of co-authors to Yerevan. We believe that it will be fair to indicate the equal contribution of each co-author.

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