

## Opportunities for Transforming Fundamental Physics Research into an Innovative Product

DOI:10.54503/18291171-2022.15.2-3-79

V.K. Sarian<sup>1\*</sup>, A.H. Mkrtchyan<sup>2</sup>, R.V. Meshcheryakov<sup>3</sup>

<sup>1</sup>*Federal State Unitary Enterprise "Order of the Red Banner of Labor Russian Research Institute  
of Radio named after M.I. Krivosheeva "(FSUE NIIR)  
16 Kazakova Str., 105064, Moscow, Russian Federation*

<sup>2</sup>*Institute of Applied Problems of Physics of the National Academy of Sciences of the Republic of Armenia  
25 Hrachya Nersisyan Str., 0014, Yerevan, Republic of Armenia*

<sup>3</sup>*V.A. Trapeznikov Institute of Control Sciences of the Russian Academy of Sciences  
65 Profsoyuznaya Str., 117997, Moscow, Russian Federation*

\*E-mail: [sarian@niir.ru](mailto:sarian@niir.ru)

**Abstract.** Currently, humanity, our entire civilization needs long-term forecasts of emergencies and systems of individualized control of the actions of people and robots (AI systems) in the event of an emergency in order to radically reduce human and material losses. This was shown by the events of this year – catastrophic in scale fires, floods, earthquakes, apparently associated with global space phenomena, and man-made disasters, including epidemics associated with the pace of economic activity – the concentration of the world's population in megacities, globalization of the economy, population mobility, etc. The article shows that only the introduction of a mass service of individualized subscriber rescue management (IUSA) of an infocommunication network with sensors developed as a result of fundamental physical studies, and its full-fledged industrial operation can be accelerated by creating the Association of Researchers of Applied Physics Problems (ARAPP).

**Keywords:** Association of Researchers of Applied Physics Problems (ARAPP), mass service of individualized subscriber rescue control

### 1. Introduction

Currently, humanity, our entire civilization needs long-term forecasts of emergencies and systems of individualized control of the actions of people and robots (AI systems) in the event of an emergency in order to radically reduce human and material losses. This was shown by the events of this year – catastrophic in scale fires, floods, earthquakes, apparently associated with global space phenomena, and man-made disasters, including epidemics associated with the pace of economic activity – the concentration of the world's population in megacities, globalization of the economy, population mobility, etc.

Namely, such long-term forecasts are provided by the methods and instruments that are being developed by physicists who have for many years been grouped around outstanding scientists, Academician of the National Academy of Sciences of the RA Mkrtchyan A.H. and Professor of the Physics Department of Moscow State University Bushuev V.A. and regularly speak at traditional conferences unification of scientists in the direction, unification around the IAPP NAS RA (Mkrtchyan A.H.) and the Physics Department of Moscow State University (Bushuev V.A.) for many years holding the International Conference on "Electron, Positron, Neutron and X-ray Scattering under External Influences" and International scientific seminars and International youth scientific schools-seminars" Modern methods of diffraction data analysis and actual problems of X-ray optics "(prof. V.A. Bushuev).

Applied issues of using the results of fundamental research to solve topical demanded issues of obtaining predictive signals (precursor signals) of future emergencies, to obtain short-term, medium-term and long-term forecasts with a radically large predictive potential (which can be

classified as economically important forecasts) in medicine, the environment, including the onset of an ES. Moreover, it is very important that the forecasts that can be made on the basis of our research are mainly long-term, which is very important for the new paradigm of personalized medicine, which is focused on early warning and timely relief of dangerous phenomena and for ES, taking into account the latest catastrophic natural and man-made ES. A long-term forecast of future ES will make it possible to better prepare for future ES and prevent such large-scale human and material losses as in the past years all over the world.

FSUE NIIR, ICS RAS and IAPP NAS RA participate in the processes of innovative development and we believe that our scientific community, organized by the efforts of such outstanding scientists as Academician of NAS RA Mkrtchyan A.H., should be directed in this direction and professor Bushuev V.A. and rallied by traditional conferences will become the main formation of the association, which we propose to call the Association of Researchers of Applied Physics Problems (ARAPP).

The front of these works is rapidly expanding and a lot of funds are required, the results of research at a faster pace than they are being introduced into life are acquiring important national economic significance.

Recent events on emergency situations clearly show that processes on Earth are changing and the old methods of research and predictions are no longer suitable. Therefore, there is an acute question about the use of new earlier indicators of future negative events.

Currently, there is a favorable situation for the transformation of fundamental scientific research carried out by the participants of the mentioned conferences into popular mass services. An example of the successful practical implementation of such a transformation in our country is the implementation of the project of coordinate-time and navigation support (KTNS).

The report shows the possibility and necessity and timeliness of transforming (using) the results of fundamental scientific research carried out in different regions of our country by scientists from many institutes of the Russian Academy of Sciences, the National Academy of Sciences of the Republic of Armenia, and others and higher educational institutions into an innovative product that is in demand by mass users. However, this transformation, in other words, the process of monetization of fundamental research, is not a trivial task, serves as an example of the formation of a market for coordinate-time and navigation support (KTNS) services. The creators of the market for KTNS services in order to create a demanded innovative product in demand in the infocommunication market had to combine the results of fundamental research on the provision of KTNS, which includes the study and development of reference systems of reference, parameters of the Earth's rotation, time scales, the theory of motion of artificial Earth satellites, ephemeroid support, gravitational field of the Earth, relativistic non-gravitational effects, etc., to attract organizations that have developed and produced measuring and subscriber equipment, to create the necessary infrastructure for the formation and provision and administration of services, to interest potential consumers. FSUE NIIR from the very beginning participated in this process, and the General Director of those years, Butenko V.V. was a member of the working group on KTNS under the Presidium of the Russian Academy of Sciences, so that many employees of FSUE NIIR know all the nuances of this process firsthand. In addition, at the same time, the economic and legal aspects of the regulation of the services market were resolved. Scientists from ICS RAS and IAPP NAS RA joined this work. Although this transformation has dragged on for almost 10 years, it is now showing rapid growth and commercial impact. It is enough just to go to the website of the state operator of KTNS services "Era – GLONASS" to make sure of the demand for services based on KTNS. It seems that the task set by the Government of the Russian Federation for the KTNS to reach full self-sufficiency will be completed in the very near future, which will expand the scope of scientific work. The same happy fate awaits ARAPP's innovative products.

To make sure that creating an innovative product is not such a simple task, Fig. 1 shows a typical scheme for providing services and systems for administering these services. Note that the lack of such a working infrastructure will be a brake on the introduction of mass services.

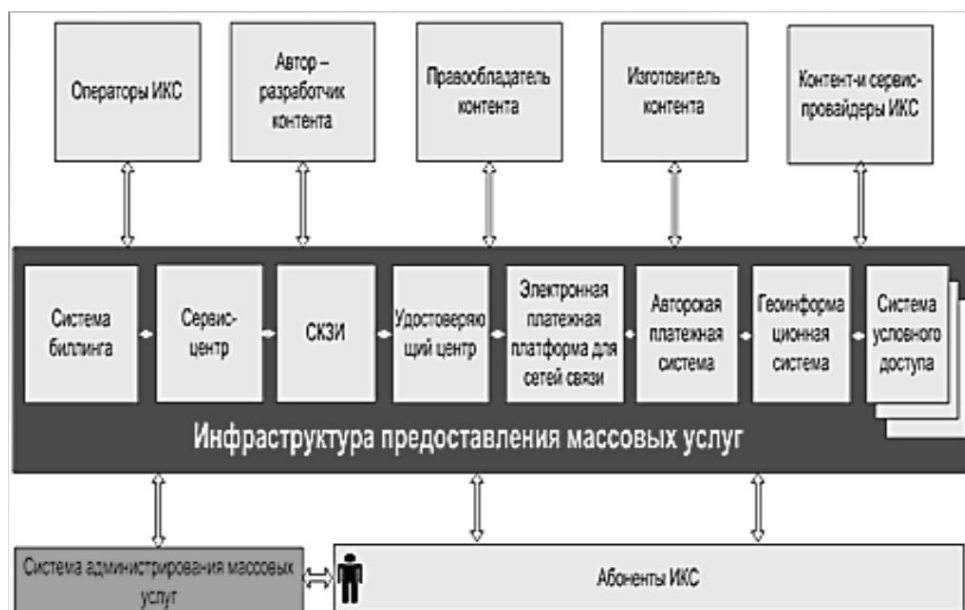


Fig. 1. Structure SAS.

Fig. 1 shows a typical block diagram of the infrastructure and system of administration of infocommunication services (SAS).

Fig. 1 shows that the SAS has a complex structure, which in its elements performs many functions:

- system of cryptographic protection of information (SCPI) is a program or device that encrypts documents and generates an electronic signature (ES);
- billing system is software designed specifically for operators (providers). It allows you to read (take into account) and rate the provided access services;
- authoring payment system protects the copyright of the content owner;
- geoinformation (KTNS, for example, GLONASS or GPS)) and other technologies, including services that will be provided by ARAPP;
- service center – determines the procedure for accessing the service and controls the reliability of the service, that is, the correct operation of all components of the service;
- system of conditional access ensures the order of interaction between different information providers in the case of converged services, which are not indicated in the figure for simplicity.

It is obvious that all components of the SAS infrastructure are equally important for all types of mass services.

It is important that the mass services that provide the population of the country due to the criticality of their importance for the functioning of many important processes in the country, they are under strict government regulation and will not remain without funding at any twists and turns. This was the case with KTNS services for almost eight long years, when the services were ready, and the market had not yet been formed. On the contrary, with our services, mass markets for personal medicine services and services for individualized management of human rescue in the event of an emergency event are already ready, but ARAPP services are not yet available, as research lags behind in matters of their digital transformation. So, we have more favorable starting conditions.

Since we are talking about long-term forecasting, the main criterion for the functioning of systems in view of their critical importance is safety and reliability. And it is impossible to fulfill these criteria without effective administration by the state, without the formation and legitimization of a single operator and service provider.

The authors, using the example of KTNS services, show the possibility of transforming, that is, monetizing, fundamental scientific research carried out at the institutes of the Russian Academy of Sciences and higher educational institutions into a rapidly developing and profitable mass market of infocommunication services that is in demand. The solution of this problem allows researchers of applied problems of physics to come closer to solving the problem of the self-sufficiency of scientific research, which is of great national economic importance. It is shown that it is advisable for these researchers to use the experience of developers of KTNS services, including the experience of the authors of this report. At the same time, it should be noted that the creators of ARAPP have initial advantages over the developers of KTNS services, since our market of mass services has already been formed and is waiting for the availability of ARAPP services, including such massive ones as personal medicine and IUSA services. The creation of an interdisciplinary association of researchers of applied physics problems (ARAPP), along with the inevitable acceleration of the pace of digital transformation of research, will significantly speed up the formation of a civilized market for these services, in contrast to the spontaneously formed market of KTNS services.

It is shown that, despite the great scientific achievements, which are also evidenced by the reports presented at the conferences of the IAPP NAS RA and the Physics Department of Moscow State University, carried out in fundamental physical research, nevertheless lag behind the requirements of their digital transformation, the most important of which is currently the requirement, so that the results of their research should become the subject of mass services for the inhabitants of the country. This prevents the widespread use of the obtained research data in medicine, in the prevention of emergencies (ES) and other industries, the presence of which can significantly increase the predictive potential of possible negative consequences. At present, medicine, emergency warning systems, etc. are already entering industrial operation, that is, at the stage of providing mass information services. Such a lag in APP research from the requirements of digital transformation does not allow moving from the stage of academic research to the creation of an innovative product, which could significantly increase their economic and national economic significance of the research. The article argues that the organization of the All-Russian Interdisciplinary Association of Researchers of Applied Physics Problems (ARAPP) will allow to go this way in the required tight time frame.

However, the high rates of digital transformation of the Russian economy and new tasks form increased requirements on the part of traditional and future users and customers of mass personalized services and services for personalized management of rescuing people in the event of an emergency. It should be noted that such increased requirements can be provided only within the framework of the ARAPP, which will allow researchers to move from the stage of academic research to the stage of creating an innovative product, which will significantly increase their economic and national economic significance. To go this way in the required tight time frame, it is necessary to coordinate the directions of work carried out by different scientific teams, as well as the choice of control systems, software used, communication infrastructure, including administration systems, measuring equipment, standardization of measurements, etc. standards for the provision of mass information services.

The authors want to show, using the example of two industries they are related to, the effectiveness of the use of future ARAPP services in medicine and in emergency prevention systems to reduce the risk from the negative consequences of ES.

28 05 2021 in St. Petersburg at the Institute of Obstetrics, Gynecology and Reproductology named after D.O. Ott held the "First International Scientific and Practical Conference" Data

Analysis in Medicine ", which considered the issues of digital transformation of medicine and the degree of its readiness to provide new services. The authors took part in this conference and made a presentation.

As the speeches of the conference participants in St. Petersburg showed, modern domestic medicine has accumulated sufficient experience in the formation of large databases of typical diseases, for the creation of artificial intelligence systems in order to move to the provision of mass services, including personal medicine. Using the examples of such dangerous and widespread diseases as cardiovascular and oncological diseases, it is shown that thanks to the methodological measures taken at the state level, the introduction of new digital medical technologies and personalized technologies, a decrease in mortality and an increase in the quality of life of patients is recorded. Thanks to digital transformation, medical science is now undergoing a significant restructuring and focuses on the tasks of early diagnosis, as well as modeling the processes occurring in the body. It is this approach that determines the development of personalized medicine, which makes it possible to ensure the identification of early predisposition to diseases and the selection of suitable personalized solutions. But at the same time, from these reports that physicians are starting to provide services based on digital medicine and our future must hurry so that innovative ARAPP products are used as soon as possible in the provision of mass medical services. In addition, the SAS of medical services has not yet been formed, how we could help the doctors.

Consider the second example, to which the authors are also directly related. The use of the innovative product ARAPP can also significantly increase the effectiveness of existing and developed systems for reducing the risk of human and material in the event of an emergency by accessing a mass citizen of the country to the information individualized rescue service for a resident of the country (subscriber) (IUSA). infocommunication environment (ICE).

The IUSA concept, in the creation of which the authors take an active part, were reported at previous conferences and described in detail in the scientific and technical literature.

## **1. Possible composition of ARAPP members**

Organizations of conference participants, developers of infocommunication and measuring equipment and software, organizations–consumers of products, providers of infocommunication services, developers of infocommunication equipment, operators of communication networks (including operators of mobile and satellite communication systems), etc., for whose participation in the Association will be an opportunity to integrate their products into the emerging mass market for the provision of infocommunication services, as well as consumers and customers, primarily to mass consumers of infocommunication services, subdivisions of state structures (for example, in the Russian Federation – Ministry of Emergency Situations, Rospotrebnadzor, Ministry of Natural Resources and Ecology, Ministry of Health , Ministry of Agriculture, Regional Administration, etc.).

It is important that the innovative products created within the framework of the ARAPP will be created in the country and bring profit to the country that assumes the burden of financing personnel training and organizing scientific research. The report will contain the proposals of the authors on the practical implementation of the proposed association.

The authors believe that the topic of creating ARAPP touched upon in the report is of great national economic importance for the countries participating in the conference:

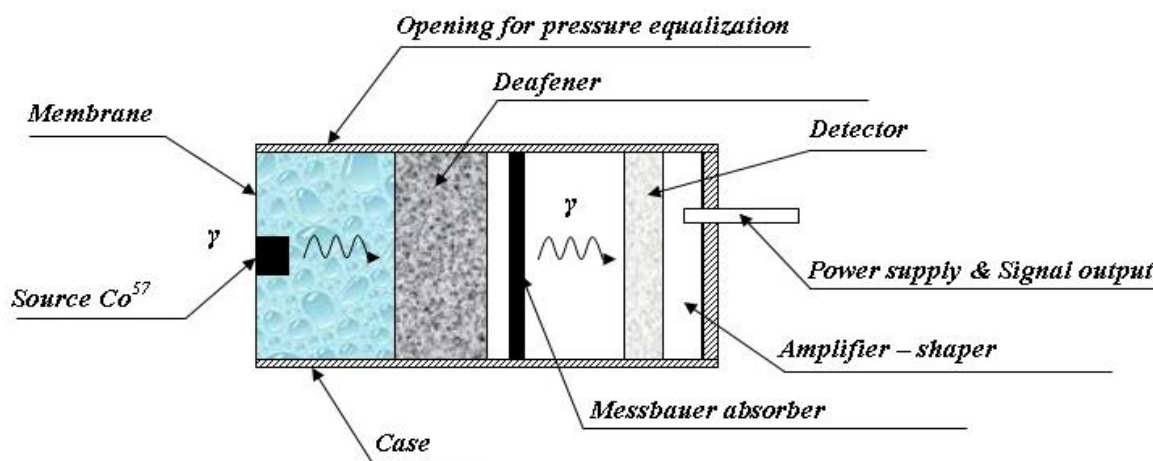
- for researchers of applied physics problems,
- for consumers,
- for ICT and industry – provision of orders,
- for education,
- for governing bodies.

We also believe that the creation of such an association and its launch into operation deserves the category of megasign and we suggest that the working group prepare the need to submit a corresponding application to the Russian Science Foundation.

As an illustration of what has been said, that is, the evidence of the need for the participation of physicists in the organization of ARAPP, we will give an example of the possible use of the results of fundamental research of the Institute of Applied Physics of the National Academy of Sciences of the Republic of Armenia, which deployed an experimental site on Lake Sevan for use in the AISA for the region of Lake Baikal. The lake itself is used as a sensor.

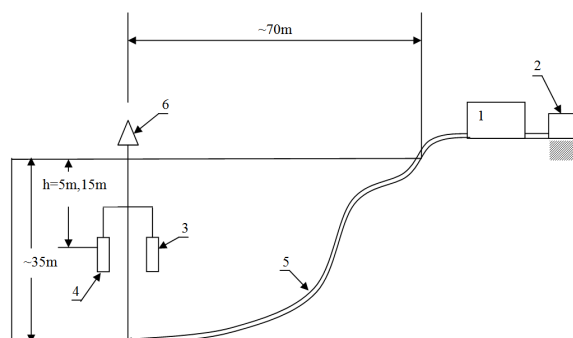
Various types of seismic receivers and hydrophones are used to record ultraweak low-frequency acoustic waves in reservoirs and caves. However, they have a number of disadvantages, such as the dependence of the hydrophone sensitivity on temperature, the limited frequency range of sensitive recording, the absence of retuning of the characteristic frequency, a short service life, low sensitivity, etc.

IAPP NAS RA has developed unique systems for recording acoustic waves based on the phenomenon of modulation of Mössbauer radiation under the action of external acoustic fields.



**Fig. 2.** Schematic representation of a detector of modulated Mössbauer radiation.

Experimental studies to solve the main problems and confirm our proposal to use some reservoirs and caves as supersensitive antennas of acoustic vibrations were carried out according to the following scheme (Fig. 3).



**Fig. 3.** Scheme of the experimental setup: 1 – the center of comparison of the received data; 2 – seismic sensor; 3 – Mössbauer acoustic detector; 4 – hydrophone; 5 – power cable; 6 – buoy.

Seismic sensors SM-3 (2) for recording the horizontal and vertical components of the vibration process were placed on the shore of Lake Sevan on a special pedestal with an area of  $52 \times 52 \text{ cm}^2$ .

The sensors are connected by a secure cable to a multi-channel recording device and to a computer. Hydrophones (4) were placed in the lake in a suspended state and held by a buoy (6) under water in a vertical position. This installation of hydrophones ensures uniform contact with the environment and free from parasites created by surface waves.

The Mössbauer acoustic detector (3) is placed in the lake together with hydrophones and is connected to the GAS and to a personal computer using a special underwater cable, which ensures the storage, processing and interpretation of the recorded temporal and modulated Mössbauer spectra of hydroacoustic signals. At the same time, acoustic vibrations were recorded by seismic sensors located on the shore of the lake and under water at depths of 5 m and 15 m using hydrophones and a Mössbauer modulation sensor.

As shown by the experiments in which A.H. Mkrtchyan took part. and Sarian V.K., such a sensor, which uses Lake Sevan as a sensor, is several times more sensitive than the most modern seismic sensor, which significantly increases the predictive potential of the hybrid monitoring network. Hence the idea was born to use this sensor on Lake Baikal, which in this case will be a sensor.

For the convenience of work and experiments at the experimental site of the hybrid earthquake monitoring network, it is necessary to purchase your own seismic station, for example, the Express-4 portable seismic station, which is designed to receive seismic vibrations, convert them into digital form and register (record) with reference to the same time. End-to-end automatic calibration and control of the station is provided. The seismic station software runs in the Windows operating environment. The equipment of the station provides for its operation both in the laboratory and in the field.

Obviously, it is advisable to carry out all the legal and economic issues necessary for the organization through All-Russian Interdisciplinary Association of Researchers of Applied Physics Problems.