# Expert medical assessment of the project by "COURSE-AS1"LLC "Microsecond X-Ray Radiology"

One of the most impressive achievements of modern clinical medicine is the development and implementation of remote minimally invasive interventions performed under X-ray guidance. Intracardiac and intravascular methods of treating acute myocardial infarction, acute ischemic stroke, organ hemorrhages, tumors, and a number of other serious diseases or their complications are widely known and have proven their effectiveness.

The success and safety of these procedures, in addition to the professionalism of the physician and the use of special instruments, depend largely on the technical characteristics and reliability of the X-ray equipment used. X-ray machines designed for these purposes have a rather complex design and must provide high-resolution images with minimal radiation exposure to patients and medical personnel. The latter requirement is particularly important given that many of these procedures are time-consuming and involve significant radiation exposure for the patient and staff involved in the operation.

At the same time, the scope of application of such methods in medicine is constantly expanding, and the advisability of their use in emergency situations, in cases of severe trauma to victims, and even in military field conditions is already clear. This creates a need for portable mobile devices that can be used both for diagnostic purposes and to accompany open surgical operations on blood vessels, bone fragment repositioning, foreign body removal, etc.

The key elements of any device for this purpose are a reliable X-ray tube with the smallest possible focal spot, up to 0.3 mm or less, a pulse generator with the minimum sufficient power, a dynamic image detector of various sizes with high resolution, and a convenient software package that allows the necessary transformations, calculations, and visualization to be performed.

Unfortunately, modern domestic angiographic systems are either unavailable or exist only as single prototypes.

We analyzed the materials provided with the characteristics of promising X-ray systems within the framework of the "Microsecond X-Ray Radiology" technology (hereinafter referred to as the "Project"), in which the authors propose three major, from a medical point of view, fundamental changes in the technique of obtaining diagnostic-grade dynamic X-ray images:

1) Fundamentally new high-resolution dynamic X-ray detectors with a volume of 9-12 megapixels (instead of the currently existing ones with a resolution of 1-2 megapixels) have been proposed, which allows reducing the size of the X-ray tube's focal spot by 3-4 times while maintaining the same instantaneous power, and to form a higher-resolution X-ray image (by the same 3-4 times) compared to standard X-ray systems;

2) reduction of the average power of the X-ray generator by more than an order of magnitude and a proportional reduction in the heating of the X-ray tube, which removes the limitations on the duration of examinations and the problems of reliability and durability of expensive X-ray tubes;

3) reduction of the dose load on the patient and medical personnel by more than an order of magnitude is extremely relevant for long or repeated examinations, as well as X-ray imaging in surgical operating rooms or intensive care units, where it is very difficult to isolate other patients and personnel in these rooms with protective screens.

The co-executors of the Project's team of authors have developed and are mass-producing medical pulsed nanosecond X-ray diagnostic ward devices with a voltage of 110 kV with a fully solid-state switching system, a maximum permissible short-term power of 1500 W, a pulse repetition rate of up to 4 kHz, and a weight of 45 kg, which is 1.5-2 times lighter than the best foreign analogues. In creating these devices, the problem of dividing the high-voltage nanosecond generator into blocks has been solved, which makes it possible to reduce the weight of the radiation block. It has been experimentally proven that when using nanosecond diagnostic devices and standard photographic radiation receivers, the absorbed dose is reduced by 9-30 times compared to devices using a direct current X-ray tube.

All existing principles underlying this Project are well known and technologically proven, but are applied separately in different segments of the industry.

For example, high-voltage, high-frequency generators of adjustable direct voltage and X-ray emitters: tubes with a rotating anode, grid control, and direct-heated cathode are taken from standard radiology.

The system for focusing the electron beam on the anode surface to obtain a microfocus is used in microfocus radiology.

Multi-pulse mode of X-ray radiation operation to obtain each image frame with a significant reduction in X-ray dose – used in technical flaw detection when performing nanosecond radiography.

At the same time, the authors of the Project offer not only a combination technology, taking the best achievements in the industry to date, but also add new technologies to the system. In particular, dynamic ultra-high-resolution X-ray detectors built on CMOS technology sensitive elements, which represent a new step in the already known technology of using a microfocus emitter and a detector built on a CMOS camera, demonstrating the possibility of reducing the X-ray dose by an order of magnitude or more while simultaneously increasing the resolution of the images obtained.

In terms of image processing, the authors of the Project propose conveyor-based multi-core systems for real-time digital processing and visualization of image streams with real-time calculation of image characteristics, a system for measuring all radiation parameters, and real-time control of radiation parameters based on the results of calculations obtained from previous images. This part of the Project is a further development of the technology of real-time pipeline 2D processing and visualization of high-resolution X-ray image streams.

The novelty of the project developed by NPP "KURS-AS1" lies in combining in a single technical system consisting of four interconnected components—an X-ray tube, a high-voltage generator, an X-ray detector, and real-time processing and visualization computer programs—technologies previously used in different, incompatible X-ray devices, with changes in the design, technological, and management functions in all components of the X-ray system, which constitutes the "Microsecond Radiology" technology.

The authors of the Project have managed to combine them into a single whole, which requires only R&D in the design of a small line of components, as a system engineer, to create digital X-ray systems for diagnostic X-ray equipment, for industrial non-destructive X-ray inspection systems, and for X-ray screening and security systems.

Considering all of the above, we believe it is necessary to support the "Microsecond Radiology" project, the implementation of which will enable the creation of a new generation of X-ray diagnostic devices and will be a major breakthrough in both domestic and global diagnostic and interventional radiology.

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