S&I
THE WORLD
OF INNOVATION

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INNOVATION TECHNOLOGIES FOR ADVANCED INFORMATION SYSTEMS

Introduction. *Ukraine has possessed space control (SC) technologies employing different means of control, which are based on the radar engineering solutions used for the development of Dnipro radar.*

Problem Statement. *The specific characteristics of advanced radar technologies make it difficult to maintain monopolistic positions in the technology sphere. In the global practice of creating large information systems, always there is the problem of availability and, even more so, the introduction of new technologies, so the developer has to work out his own innovation technology for all stages of the life cycle.*

Purpose. *The purpose of this research is to analyze and to generalize the design and technological features of advanced SC information systems development and production.*

Materials and Methods. *The system analysis of the aspects of design and technological support in the process of developing and manufacturing a new radar generation with the use of the conventional and cutting-edge R&D achievements has been used.*

Results. *It has been shown that because of the fact that while developing a space control radar innovation, the developer may not always use advanced scientific knowledge as basis for creating new technology and sometimes has to look for solutions outside the scholarly research field, based on the existing research and engineering experience and technological monopoly as a result of his/her own developments and inventions. Some specific aspects of the preparatory works and related problems, as well as the possible ways for their effective solution have been considered. Several proposals aiming at ensuring the equipment efficiency at all stages of new model life cycle have been presented.*

Conclusions. *Ukraine remains among a few countries having a full technological cycle of development and manufacture of highly advanced information systems. However, to ensure sustainable development of the industry, the necessary conditions are the availability of R&D experience and the development of their own innovation technologies.*

Keywords: innovations, technological documentation, technical process, and technological equipment.

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Technology is one of the most ambiguous concepts that refers not only to production, but also to any activity, and the modern era that is characterized by extraordinary practical activity is the era of technology. Before the era of technology, there was the rule of art: a person made something and he/she was the only one who could do it, it was like a gift – either given or not. With the help of technology, everything that is available to the chosen ones becomes available to everyone. Technologies are often classified in connection with a certain branch of production, or associated with specific materials and methods for obtaining and processing them, but technology is clearly becoming a factor that increasingly determines the very possibility of creating a new one, that is, it takes the form of technology capital [1]. The basis of any technical device is technology for its manufacture, and no new technical device may appear unless a new industrial technology for its creation has been designed. The world is assumed to have already passed through five technological systems, now the sixth technological system is coming. The fifth technological order and the level of production development based on it are currently incapable of ensuring new rates of labor productivity growth, hinder and delay mastering disruptive innovations of the new (sixth and seventh) technological orders [2]. As the experience of many scientific discoveries and inventions has shown, they were introduced, in the best case, in tens of years, and many of them have been still waiting for being commercialized.

For example, the term levitation traces its roots back to the 16th century, while the first vehicles operating on magnetic levitation appeared as late as the 20th century. The most famous technologies today are *Maglev* (Japan) and *Transrapid* (China). Even in these two countries, the roads have been extended for as few as tens of kilometers because of the fact that the existing transport infrastructure is unsuitable for magnetic levitation transport [3]. Another example is the photoelectric effect that was discovered in the 19th century and used in solar cells for obtaining electricity through the use of renewable energy sources (RES) as late as in the mid-20th century. However, the energy collapse that happened this winter in the countries that were proud of their achievements has showed the imperfection of RES technologies that still exist only at the expense of the so-called "green tariffs' paid by the state, and therefore, by the population.

Today, industrial capital has been being replaced by technology capital [4]. The role of capital is played by technologies with a high share of intellectual capital. instead of means of production. While reproducing itself quantitatively or qualitatively, the technology capital simultaneously performs the function of accumulation and the concept of "technology accumulation" has already been put into circulation. While developing in terms of functionality, that is, expanding the content of its traditional functions, the technology capital gets fundamentally new functions: innovative, intellectual, informational ones and so on.

Advanced scientific knowledge increasingly plays the role of a source for the creation of new technologies, therefore it is important that scholarly research from the very beginning is designed for the implementation of technology and the creation of science-intensive products. Today, the technologization of scholarly research and the enhancement of scientific capacity of technologies is an urgent and complex problem to be studied and addressed in Ukraine and throughout the world.

The equipment of radar systems is placed in large and complex structures with a height of 17–35 m and a face length of 100–150 m (*5H20 Pill Box* radar); *AN/FPS-85* radar is notable for its large dimensions (a height of 44 m, and a face length of over 100 m), as well. Given the specific features of the creation of space control radars, the technology consists of such components as the design component that deals with the methods for configuration design: the production component that is about manufacturability and compatibility of the configuration options, and the customization component that provides for the formation of a completely functional product at the place of its use. As for space control radars, the implementation of advanced solutions is possible with the use of both existing technologies and high-tech ones at the stage of design, development, and implementation of new high-tech products, which have not been available in the relevant industries.

Approximately 30–40% of the time inputs required to create a new generation of radars are spent on the development of manufacturing technologies. The share of new technical solutions and technologies in the structure of newly created radars is about 40%, while the share of proven ones makes up about 60%. The peculiarity of the formation of innovations in the space control radar industry is that while developing a space control radar innovation, the developer may not always use advanced scientific knowledge as basis for creating new technology and sometimes has to look for solutions outside the scholarly research field, based on the existing research and engineering experience and technological monopoly as a result of his/her own developments and inventions. The availability of experience and R&D base is crucial for reducing the duration of space radar development process. The world experience has shown that, on average, the lack of proper R&D base leads to a 1.9-times increase (as compared with the initial estimate) in the time inputs for the creation of high-tech products, a 40% increase in the costs, and a 20% rise in the purchase prices of the final samples [5]. The connection between science and innovation may be described as follows. Science is the conversion of money into knowledge and ideas, whereas innovation is the conversion of knowledge and ideas into money [6]. In the general case, the creation of R&D base is a continuous process combined with the formation of an information base that stores documents and guarantees the copyright of their developers.

The methodology for continuous creation of R&D base is of crucial importance in connection with the problem of singularity (particularity). According to many researchers, the current exponential growth of technologies leads to the "point of no return," after which the development of technology and engineering becomes so rapid and sophisticated that it is impossible to understand and to comprehend its result [7,8]. However, on the one hand, exponential growth never lasts long for many reasons, often simply because of scarcity of resources, and, on the other hand, until recently, the global acceleration has been rather hyperbolic than exponential in nature [9]. Technological singularity is a hypothetical moment, but today information technologies are rapidly changing and information becomes twice as much every nine years [10]. Paradoxically, the information explosion hinders the development of science, but the above mentioned examples have testified to the opposite, and the experience of designing several generations of space control radars has clearly shown that there was always a risk of the impossibility of improving existing technologies and creating new ones within the framework of existing R&D base.

Nowhere, there is a regulated general procedure for creating R&D base in different fields. Therefore, enterprises and organizations do it each in their own way. The publications that deal with the aspects (technical, not organizational) of the methodology for creating R&D bas are too private or general theoretical in nature, as they do not take into consideration many limitations that are entirely determined by the structure of technological systems in the economy and the general laws of the development of engineering systems. In Ukraine, there are government structures, public and commercial organizations, a startup fund that hold various startup competitions at the expense of budget funds. However, unfortunately, the viability and innovativeness of the projects implemented raises doubts whether they have any relation to innovations in the field of technologies and science-intensive systems. At the same time, the existing world agencies are engaged in the creation of anticipatory technologies

(DARPA, USA), advanced technologies (DGA, France), applied technologies for solving important practical tasks (MAFAT, Israel), the reproduction and implementation of advanced technologies (SASTIND, China; DRDO, India). As for the space control radar, not every country that is a developer of such systems (for example, *EL/M-2080* radar, Israel) may afford the development of advanced technologies, therefore they have to be satisfied with their reproduction. So, it is necessary to create a single database of existing and new technologies in every branch of industry, both domestic and global, to create an anticipatory R&D base for the future [11]. Given the interdependence of science and technology and the importance of technologies at the current stage, it is advisable to include the innovation technologies in the priority areas of competitions held by the National Academy of Sciences of Ukraine. However, currently, given the owner of R&D base, keeping and replenishing the R&D base requires material costs. In our opinion, the creation of an innovation R&D base may be funded from state budget, based on already existing R&D (fully or partially) for those projects that, according to the results of the analysis, have been classified by the National Academy of Sciences as promising for the introduction of new technology generations. When it comes to innovation, it most often involves the application of new knowledge, methods and means of solving very specific issues. In the case of complex information systems, innovation technologies should spread to a greater or lesser extent to all stages of their life cycle (LC).

As for the innovation technologies developed during the creation of space control radars, they are characterized by narrow specialization, low accessibility, temporal determinism, uncertainty, high riskiness of financial resources, which is ultimately reflected in high costs of creating a sample. However, at the same time, the experience has shown that the know-how technologies developed for the relevant generations of space control radars have become replicated and tended to spread rapidly [12]. The experience of developing many generations of space control radars has shown that there has been established a trend towards increasing the number of corporations' own innovation technologies for the manufacture of elements, materials and other products of the lower, usually, the first or the second, radar hierarchical level.

For example, despite the fact that there were numerous manufacturers of various types of capacitors among the suppliers for space control radars, none of them produced high-voltage capacitors with a rated voltage of 40–70 kV of the required type on industrial scale. Therefore, they were manufactured directly at the radar factory from primary materials. The technology for manufacturing such capacitors was a complex and lengthy process as the initial element of the capacitor was made of pre-rolled and cut tin foil and mineral mica plates of the same size. Several packages were assembled into a block that was placed in a bath of molten ceresin. The assembled block was boiled under constant pressure for several days until it reached a thickness of 2–2.5 mm. Further, the blocks were assembled in a forming line and subjected to "dry test," by gradually increasing the voltage to a certain level. If some blocks failed, they were replaced, and the process started from very beginning again. If everything was successful, the forming line was filled with a special mineral oil having high dielectric parameters, vacuumed and tested by increasing the voltage up to 75 kV and keeping it at this level for 24 hours.

Also, there was no factory that serially produced resistors with a dissipation power of more than 300 kW, which would be suitable for operation under conditions of high power and generation frequencies and strict limitations on the reactive component. In the case of the use of air cooling, a high dissipation power required resistor configurations having extraordinary dimensions. Therefore, our own technology for the production of non-inductive resistors, which employed water cooling of the resistor for keeping the required thermal conditions was developed. The developed water-cooled resistor was shaped as a tube and made of particularly strong plexiglass. A meander-like shaped resistive tape that ensured reducing the reactive component of the load to permissible values was wound counter-crosswise on a prefabricated frame made of glued ceramic elements and fixed inside the tube.

The given examples were rather widespread and led to the need to master and apply virtual design technologies of various hierarchical levels, which became a characteristic feature of all generations of radars.

The technology of an active element for transmitter of 5N20 radar was atypical for the element base developer, as the test required the very transmitter to act as a test bench. However, creating a transmitter required the active element, since unless it was impossible to create a transmitting device. There was a dilemma: what was the first – a functionally completed device or one of its elements. In order to get out of this dilemma, the technology of virtual development of the transmission module was employed. It implied that, in the absence of a physical element base, designers and process engineers should work in parallel. This technology allowed the designer and the process engineer, having only overall mounting dimensions, to develop design, engineering, and process solutions, which had a positive effect on the time inputs. Moreover, as early as at this stage, the designers and process engineers could have seen problems with manufacturability of the designed element, and because of the labor-intensive mechanical works related to the production of nodes and assemblies of *Servant* active element for the transmission module of 5N20 radar, the manufacturer, instead of an element developer, had to develop the processes for manufacturing most of the mechanical parts of the transmitter. In addition to reducing the time inputs, this approach made it possible to make good savings on the purchased components for the radar.

The complexity of the preparations for manufacturing processes (PMP) of the 31Zh6 sea-based radar was that in the absence of the design documentation of the ship, the design works were done virtually, in the conditions of a great uncertainty of the dimensions of the planned space for placing the radar on the ship. The most difficult element in the design and manufacture of stand equipment (SE) was over 400 m long high-power waveguide. When the ship was ready, in the course of mounting the radar systems, it was found that the dimensions of the planned space for the placement of waveguide tract on the ship did not match the design solution, as the tract was about 1 m shorter than it was necessary for docking. So, it was necessary, visually observing, to develop docking options with the use of "cardboard modelling" technique directly on the ship (thanks God, there was much cardboard and glue). With the use of a bank of almost all technologies for the manufacture of waveguide equipment (including the flexible elements), real products for the completion of the docking could have been chosen.

Starting with the first generation, the technology for the development and production of space control radars is based on *Design Documentation of the Chief Designer* (DDCD) standard [13] that provides for skipping out all stages of design and developing working drawings that further are forwarded to manufacturer. PMP is governed by many standards that cannot be fully applied to the development of space control radars, insofar as in order to take into consideration the specific features of the radars it is necessary to search for and to implement innovation technologies at all stages of the product lifecycle, especially at the stage of creation, when the feasibility of future technology, including the economic aspect of the project, is studied.

Process design is a long and time-consuming part of preparations for manufacture. In the case of single- and small-batch production, the labor intensity of this stage accounts for 40–50% of the total labor intensity. PMP includes ensuring the manufacturability of product structures, developing processes, design and manufacture of process equipment, managing the PMP process. Ensuring the manufacturability of structures and components of the advanced generation radars implies a complex solution of design and process tasks, which aims at increasing labor productivity, achieving the optimal labor inputs and material costs, and reducing time inputs.

Advanced design technology uses automatic design systems (CAD) that today are rather widespread and available to a wide range of consumers. The specificity of space control radar design is that the designer and process engineer use exclusively their own systems of design documentation (DD) and process documentation (PD). The local nature and lack of integration of these systems resulted in errors, therefore, given the consequences of inconsistency between DD and PD, it was decided to create parallel design technologies. Starting with the 3rd – 4th generations of the space control radars, the parallel design of DD and PD has been employed. It implies that PD, documentation for measuring devices, and methods for the automated verification of developed products with the use of control devices are prepared simultaneously with DD. Such a unified CAD is not only a tool for the automated development of DD and PD, but also the core of the automated process management system (APMS). The previously introduced and the new local automated means of production, together with the automated workplaces for all members of the unified CAD system have become peripheral devices of the system, to which process information, programs for manufacturing and quality control of products, and data on process progress are sent via communication lines. The creation of such a unified CAD has made it possible to develop a new, so-called “paperless technology” for the development and organization of production as part of the integrated process of creating radar components and parts, when a significant part of the processes of manufacturing equipment is realized with the use of automated means of production and quality control. About 100% of printed circuit boards and cells, about 80% of microwave substrates and products based on them, about 50% of machining works, and more than 70% of commissioning and testing works are produced with the use of this technology.

The main production processes consist of procurement, processing, assembly, and tuning/adjustment stages. At the stage of production of radar components to be assembled, the relative labor intensity is as follows: mechanical processing (machining) (10–15%), assembly (15–20%), electrical installation (wiring) (40–60%), adjustment (debugging) (20–25%). The first generations of space control radars quite successfully used the production facilities of the 3rd–4th technological order, but the transition to a new generation of radars has clearly highlighted the problem of moral aging of production facilities before their physical wear.

One of the specific features of the radars is the uniqueness of the functionally completed product and small series of component systems. As a result, it was necessary to develop special devices/implements for making only one part/operation. The design and manufacture of such devices accounted for 60–80% of the entire preparation cycle. The machine tools were practically single-use systems, and the costs of manufacturing and purchasing the tools reached 15–20% of the total cost of the equipment, while a significant share (80–90%) of the total fleet of tools consisted of machine tools for mounting, basing, and fastening processed workpieces. In the structure of the PMP costs, the design and manufacture of equipment accounted for 80% of the total labor intensity and 75–90% of the time inputs.

The solution to the emerging problems was the application of a new technology for the construction of process equipment, which implied the transition “from mono- to multifunctionality”, when it was possible to build reconfigurable devices, which was one of the conditions for the organization of flexible production. The main task was the development and implementation of universal devices and universal dies. More than 10,000 devices were assembled from unified parts annually. The toolmakers produced a large set of various elements and created a voluminous bank of DD for the elements of universal devices and universal dies, which enabled quickly manufacturing almost any production equipment.

The production of the 4th generation radar equipment required a radical modernization of almost all production capacities of the plant, including mechanical processing/machining ones. The production of 70M6 radar based on microelectronic solid-state technologies required particularly accurate machining (1st–2nd accuracy class) of parts. For the first time in the practice of the development and production, it was necessary to use preventive technologies, for which PMP started when nothing of DD but the concept of radar-building was available. Such requirements have changed the very concept of a machining shop, transforming a monofunctional production into a multifunctional one. The developed mechanical processing technologies provided for the equipment integration into the general system of PMP, the possibility of developing and storing control programs, as well as the group control from the central processor. The technology involved the automated processing, control of all process operations, starting with procurement, including the tools, the minimization of the human role in the manufacturing process, the development of control programs and process maps, as well as the introduction of new manufacturing processes and delivery of finished products to the warehouse. Since the purchased equipment guaranteed the accuracy, as per its passport, with the use of tools produced by leading manufacturers, the plant's toolmakers developed a number of their own tools that were able to ensure the necessary accuracy of manufacturing parts and had an acceptable durability. Given the costs of service applications for machine tools, the plant's employees developed documentation for the construction of an automated warehouse and a software for managing the operation of a complex for the manufacture of warehouse structures, installed, assembled, and adjusted the equipment. It should be noted that the production of precision mechanical products with machine tools of the 5th technological system made up as little as about 10% of the production space of the facilities of 3rd–4th technological system; the production of microelectronic elements was located in a new building with an area of 22,000 m^2, while that of the elements of previous generations occupied an area of more than 65,000 m^2.

The adjustment technologies for many generations of radars provided for equipping each workplace (RM) with appropriate special process and stand equipment (PSE), which significantly lengthened the PMP process. The analysis of PMP for many generations of radars has shown that the reason for a large number of PSE is its monofunctionality that led to an increase in not only the number of stands, but also in the labor intensity and time inputs. On average, the stand equipment necessary for the radar adjustment exceeded 450–500 items, and this required the search for a new type of PSE. The way out of this problem was to ensure the multifunctionality and multiple use of PSE for different structural levels at all stages of the radar lifecycle. The new technology for adjusting new generations of radars is based on the principle of full configurational compatibility and unambiguous reproduction (up to the reference copy) of the functioning process of tested object in the corresponding design-hierarchical structure. The stand should reproduce real operating conditions, process automation and have a software-controlled architecture rather than simulate certain actions on the tested object. The new concept of building stand equipment has made it possible to significantly reduce the number of required stands and to increase the scope of their application. For example, about 20 computer-based stands were needed to adjust the transmission module and sections of the special computer (SC) of a phased antenna array (PAA), while the workstation (WS) of adjuster/debugger of the receiving and processing digital hardware was equipped with only one type of stand. However, its software-controlled architecture allowed the adjustment of two generations (5N20 and 70M6) both in the course of the manufacture and during the operation. Fig. 1 shows a general view of automated workstation (AWS) of the digital receiving and processing system, cell, and module (top down).

The selected radar division schemes required the development of new technologies for "packaging" products of the hierarchical level of division, the implementation of which required the development of almost all known packaging methods: cabinet, container, and modular ones, the choice of packaging method depended significantly on the method of the PAA formation. For example, the 5N20 radar transmitter module had dimensions of 1000×1000×6000, while the 70M6 radar module had a size of 120×1000. In the course of the transition to the next generation of radars, the modular technology in the manufacture of transceivers became absolutely dominating one. It positively affected the economic indicators of the manufacturer's activity, but at the same time, it greatly increased the requirements for the perfection of engineering solutions and manufacturing technologies, in order to unconditionally ensure the interchangeability and repeatability of products. During the installation (disassembly) of modules (elements of the radar PAA) in the panel, where their number was 288–8000 pieces, the automatic replacement technology (without stopping the radar) was used, therefore, a technological operation of interchangeability control was additionally introduced to the module manufacturing process. For this purpose, there was developed a stand on which the process of real operation and the process of simulating the installation (disassembly) of the module were implemented with the use of the developed template of the module's seat in the radar screen, agreed with the radar developer. As one can see from Fig. 2, the manufacturer's stand for module testing in many aspects reproduces the features of real application (Fig. 3).

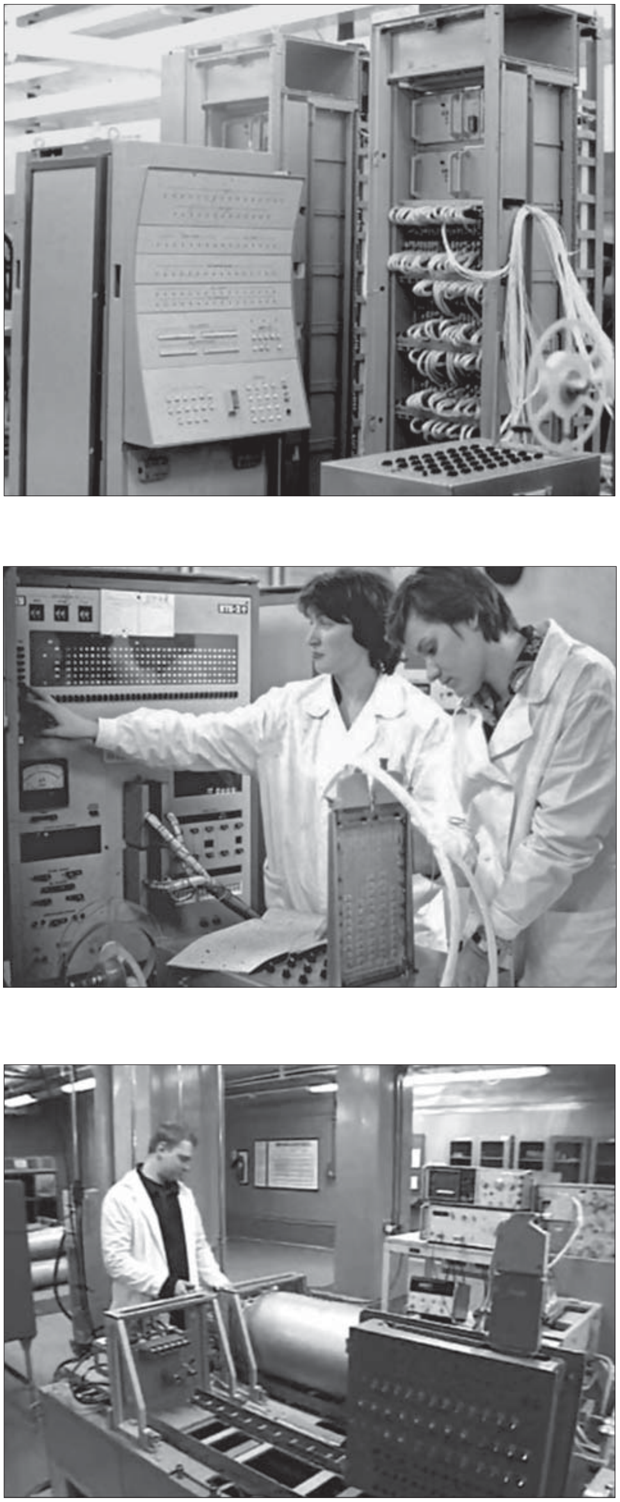

Fig. 1. AWS for scanning the receiving and processing digital equipment

Fig. 2. Module testing stand of transmission modules manufacturer

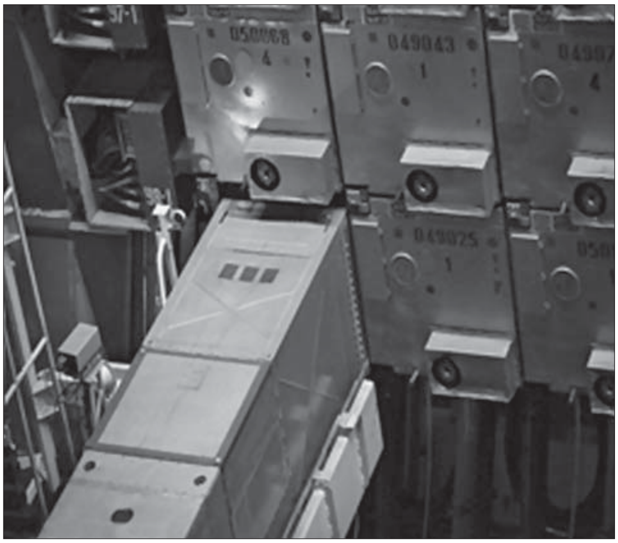

Fig. 3. Installation of a PAA module

The workstations for adjusting and repairing modules in the PAA on the ite were equipped with the same stand. This allowed significantly reducing the time of preparatory works, increasing the serial production of stands and reducing the time of putting the radar into operation.

For each new generation of radars, it was necessary to develop base-bearing structures (BBS) "cabinet-block-cell-module," which made it possible to significantly increase the level of repeatability of products in production and, in addition, to improve manufacturability of equipment. New generations of BBS were created on more advanced bases that which took into account the features of the next generation of elemental base, levels of its integration, options of circuit packaging and conditions of its operation. The base-bearing structures for the equipment of the *Dniester* radar (2TSh) were designed for the placement of up to 40 functional cells in them, whereas in the radars of the 3rd and 4th generations (5H20 and 70M6) there was used BBS 7TSh that allowed placing in each cabinet more than 50 cells of 160 microcircuits with a high degree of integration and with different types of cooling. The high labor intensity of BBS of 70M6 radar modules led the development of technology for the production of cast and stamped parts (Figs. 4, 5).

However, it should be taken into account that about 40 pieces of equipment, including more than 20 high-precision molds to make castings of aluminum alloys, were necessary for manufacturing parts of only the body (pipe) of the T01FM module.

The high power capacity of the radar required the search and development of heat supply technologies for both the entire radar and its individual elements. The cooling technology for previous generations involved the use of alloy stainless steel pipes of various diameters, which significantly complicated and increased the manufacturing process and especially installation in cooling structures. In addition, the cooling technology also created one of the electric engineering problems of powerful transmission devices, which was the isolation of the active device anode with water cooling. The machining and assembly operations were significantly simplified in the process of developing a new cooling technology with the use of polyethylene hoses instead of stainless steel ones. At the same time, it was necessary to develop a technology to ensure the strength of the hose by reinforcing it with mylar layers. This technology made it possible to ensure a high degree of free placement of cooling agent discharge

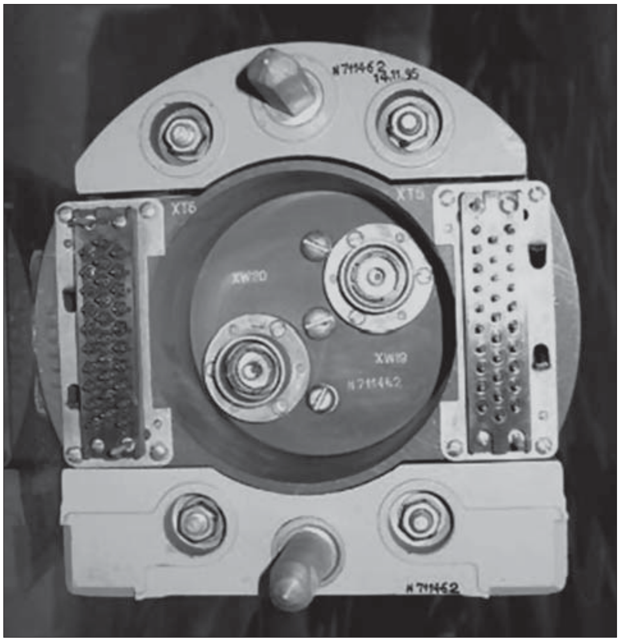

Fig. 4. Cast body parts

Fig. 5. Cast housing of sub-blocks

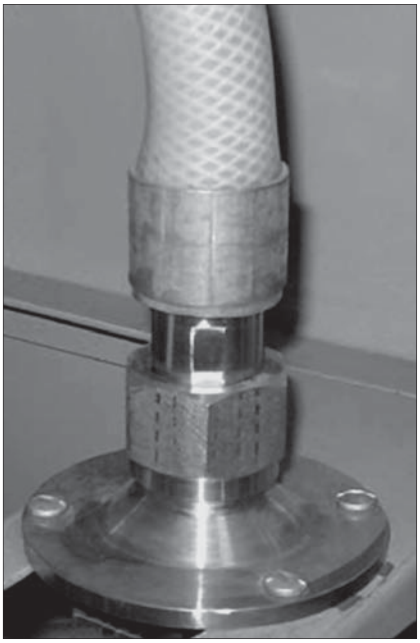

Fig. 6. Mylar reinforced polyethylene hose

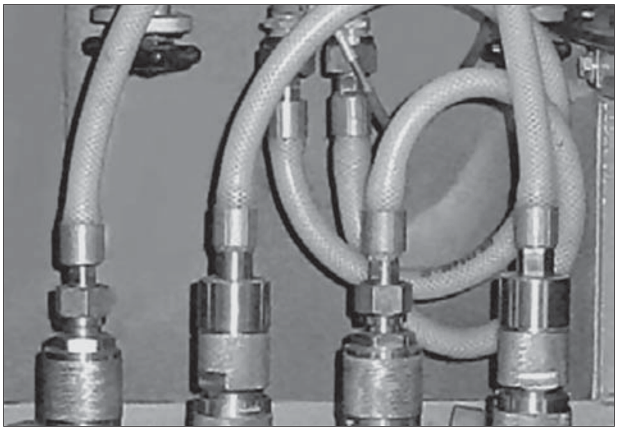

Fig. 7. Connection of a module cascade

hoses in the closed steel module of the transmitter, with the bending radii of the hose practically not limited. However, when the metal reinforcement was compressed, the polyethylene started “failing” and the connection weakened. This shortcoming was eliminated by introducing an additional process operation: the hoses were irradiated in a powerful field of ionizing radiation. After this, it was possible to obtain a fairly rigid body of the hose with reduced shrinkage of polyethylene, when the steel reinforcement was fixed to it. These hoses were used for laying the cooling systems at 8.0 and 16.0 atm. for all cooling elements. This decision allowed not only to reduce costs, but also to solve one of the serious problems of radar seismic resistance. Figures 6 and 7 show samples of products of a new type of cooling. Because of the lack of suitable production

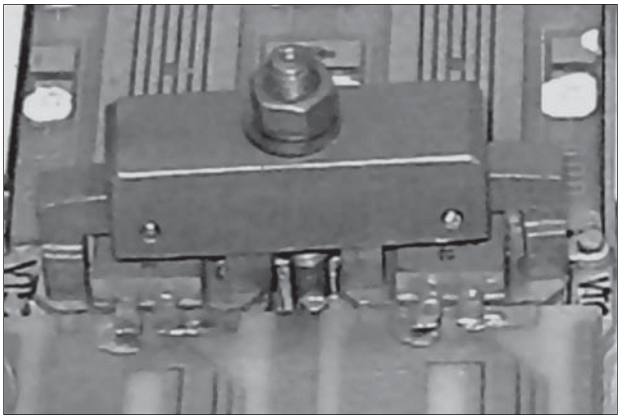

Fig. 8. Cooling of a cell

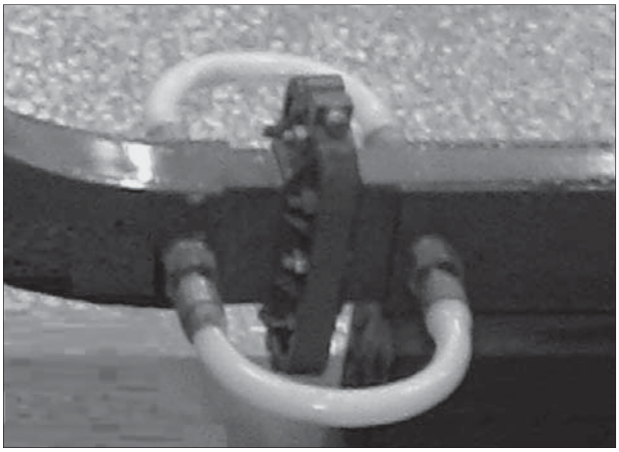

Fig. 9. Cooling of a waveguide

facilities in all branches of industry, our own production of hoses for pressure up to 150 atm. was created, with polyethylene hoses replacing stainless pipes in the design of radar devices. This is one of the examples of the introduction of innovation technology in various industries and the creation of a dual-use technology. Another innovation was the complex technology for ensuring the thermal conditions of the amplitron with the use of liquid (for the anode) and air (for the cathode) cooling, when for the air cooling it was necessary to develop our own fan operating at 20,000 rpm, as no analogs were produced by global manufacturers.

Despite a low power consumption of each microcircuit, the consumption of the cabinet reached up to 5 kW, and heat removal was possible only with liquid cooling of the cell structure. The cooling liquid technology was used for cooling various devices, even waveguides and radiohermetic shutters of waveguide technology. Figures 8 and 9 show examples of various liquid-cooled products.

In general, fasteners are used in all branches of industry. This issue has long been considered resolved, as the existing range of fasteners may satisfy any consumer requirements. With regard to the space control radar, the technology for manufacturing fasteners required the use of the same material as for the parts to be fastened. This became one of the reasons for their absence at most fastening manufacturers and led to the creation of our own production of fastening products.

Starting with the first generation, fasteners without protective corrosion-resistant coatings have not been used in the space control radar. The most common coatings of fasteners in the radar were zinc and cadmium coatings. Meeting various requirements for radars was impossible unless the existing technologies for electroplating and paint coating of parts and assemblies during their manufacture were upgraded or new ones were created. The task of applying corrosion-resistant coatings was technologically complex and required the creation of production of all types of works related to covering parts and assemblies with many types of galvanic, chemical and paint coatings. Electroplating technologies involved galvanizing, cadmium plating, nickel plating, chrome plating, copper plating, brass plating, silver plating, anodizing and deep anodizing of parts made of aluminum and its alloys. Chemical coating technologies included phosphating and oxidation (blueing) of steel, chemical nickel plating, electrically conductive oxidation of aluminum, as well as application of all types of paints and varnishes (weatherproof, chemically resistant, resistant to marine conditions).

Wiring technologies are one of the most important processes in the manufacture of all generations of space control radars. They involved the use of lead soldering technology that has been proven by many years of the operation of all radar generations. However, choosing the right wiring technology is very important, which has been confirmed during the wiring of diodes of 2A *Kostianytsia* series. This diode was a circuit element of widely used receiving devices. Over 1,500 pin diodes were used in one device. 5U88 and 90N6 radars contained 73 and 179 such devices, respectively. The results of the acceptance tests were positive, but after some time of operation the pin diodes started failing. The cause was found in the inconsistency of the soldering technology, namely the choice of improper solder type. Instead of lead solders, it was necessary to use indium solders with higher coefficients of wettability and thermal conductivity, which did not change their properties during thermal cycling. The wiring technology was especially important and difficult in the manufacture of special computer (SC) for 5N20 radar. Given the fact that over 50 m radio cable with low electrical losses and high dynamic stability of the electrical length was required for the installation of one hardware cabinet of the SC (that included more than 400 cabinets), for ensuring the performance characteristics of the SC it was necessary to use exclusively precious metals. For reducing the cost of production, initially, a radio cable with a silver-coated central conductor was used in the process. However, the tests of the first SC sample did not show the required performance, so it was decided to use a radio cable with a gold-alloy coating of the central conductor, which ensured the required performance. The use of such a quantity of gold was an innovation in wiring (although palladium and other precious metals were already used), but later became typical for wiring the modules of 70M6 solid-state radar. Also, it is worthy to note the plasma pressure technology that made it possible to obtain circuits for the 90N6 radar units with reduced consumption of silver solders and brass.

As you know, there is a common problem for both the modern element base and space control radars – to ensure their high reliability and its verification. All generations of space control radars were designed for operation in closed space, under normal climatic conditions, which is a significant factor in ensuring their high reliability. Practically, specified performance can be verified only based on the results of long-term tests of large samples of equipment or during long-term operation in real conditions. Given the uniqueness of the equipment, the first method cannot be employed, and therefore we have to use the second option. Leading manufacturers of electronic products have been widely using accelerated test technologies to determine the reliability of electronic elements, which, in relation to space control radars, are conducted for macroclimatic areas, in the most severe conditions instead of the normal ones. The entire architecture, including products produced at our factory (resistors, capacitors, polyethylene hoses, etc.) was tested. The test method allowed using a large number of various means to conduct all the necessary types of tests, but, given the dimensions and weight, the seismic resistance tests for 5N20 radar transmitter modules (6 m × 1 m × 1 m, weight 1850 kg) remained problematic. On the test stand, it was necessary to create vibration loads in the three planes (linear and rotational), while the exposure time ranged from microseconds to milliseconds, and in some cases even seconds. It was impossible to equip the testing laboratory with its own test stand, given the requirements of machining equipment for the production of high-precision products. Such a stand was found at the Institute of Building Structures. The developed technology involved testing equipment made with the use of modular (for the transmitter) and cabinet (for the modulator) technologies. The tests showed a high seismic resistance of samples as their full working capacity was kept during and after the tests. It should be noted that the radio equipment was tested for seismic effects for the first time in the practice of domestic radar-building, and perhaps in the world practice.

The technological process of space control radar production was not considered complete until the radar was handed over and delivered to the site where it would operate. This was preceded by a long, post-operational process of handing over the constituent parts of the entire configurational and hierarchical structure. The assembly and adjustment works accounted for 10–12% of the total production. The objective component of the technology for forming the functional completeness of the radar at the installation site required the development of a technology for step-by-step commissioning of the equipment and technological means of the radar and their delivery to customer's site. The technology provided for the installation and adjustment of systems, the creation of a repair and verification base and its metrological attestation, the equipping and commissioning of the WS and service station for the main process operations similar to the manufacture, adjustment and control in manufacturer's conditions.

A broad understanding of information systems assumes that its integral components include data, hardware and software, as well as personal and organizational resources. The authors have considered only the technologies implemented in the hardware component of the information system, without mentioning the other components of the system. Studying new principles of system-building, safety assessment, feasibility study of component technologies and other directions is an important research task, for solving which it is necessary to continue research, the results of which may be used to increase the efficiency of the development (modernization) of new (existing) systems.

The authors have considered only certain features of the technological aspects related to the creation of radar systems and hope to continue the discussion of this subject in order to fully and systematically describe all the features of such systems with the involvement of a wide range of professionals. Ukraine remains one of the countries capable of developing and producing information systems in the mass scale, but to ensure the sustainable development of the industry, it is necessary to effectively use the existing technologies and to develop new innovation ones, as well as to have proper R&D base and well-developed production and technological base.

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ІННОВАЦІЙНІ ТЕХНОЛОГІЇ ПЕРСПЕКТИВНИХ ІНФОРМАЦІЙНИХ СИСТЕМ

Вступ. Україна володіє технологіями контролю космічного простору (ККП), використовуючи різноманітні засоби контролю, основою яких є радіолокаційні технології, впроваджені при розробці радіолокаційної станції (РЛС) «Дніпро».

Проблематика. Специфічні характеристики сучасних технологій створення РЛС обумовлюють складність збереження позицій монополізму в технологічній сфері. У світовій практиці створення великих інформаційних систем завжди існує проблема наявності, а тим більше впровадження нових технологій, тому розробнику доводитися опрацьовувати власні інноваційні технології, причому для всіх стадій життєвого циклу.

Мета. Аналіз й узагальнення конструкторсько-технологічних особливостей розробки та виготовлення перспективних інформаційних систем ККП.

Матеріали й методи. Застосовано метод системного аналізу особливостей конструкторського й технологічного забезпечення процесу розробки та виготовлення нового покоління систем з використанням наявного та інноваційного науково-технічного доробку.

Результати. Показано, що оскільки при формуванні інновацій в РЛС ККП сучасні наукові знання не завжди можуть бути основою створення нових технологій, розробнику часом доводиться шукати рішення поза науковим полем, спираючись на наявний науково-технічний доробок і технологічний монополізм, одержаний в результаті власних розробок і винаходів. Викладено окремі специфічні особливості технологічної підготовки й проблем, а також можливі шляхи їхнього ефективного вирішення. Наведено низку пропозицій, спрямованих на забезпечення ефективності технологічного оснащення на всіх стадіях життєвого циклу нового зразка.

Висновки. Україна залишається однією з небагатьох держав, яка має повний технологічний цикл розробки й виготовлення високоінформативних перспективних систем, але для забезпечення сталого розвитку галузі необхідними умовами є наявність науково-технічного доробку та розробка власних інноваційних технологій.

Ключові слова: інновації, технологічна документація, технічний процес, технологічне оснащення.