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United States-Russian Federation Workshop on Responses to Radiation Accidents

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Falls Church, VA

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PREFACE

This year (1997) will mark the fortieth anniversary of the explosion in an underground storage tank near Kyshtym in the southern Urals region of Russia, the eighteenth year since the partial core meltdown at Three Mile Island in Pennsylvania in the USA, and the eleventh year since the catastrophe at Chernobyl. We are still addressing the health consequences of these accidents, in terms of not only the long-term stochastic risks from the released isotopes but also the psychological trauma and fears of the populations involved as well as those not significantly exposed to radiation. We have learned much from these accidents, and the nuclear power plants of today have incorporated structural and procedural changes and safety features designed to all but eliminate the risks of major radiation releases in the future. Yet the possibility of a future accident or incident involving the release of ionizing radiation has not gone away. Despite our progress in utilizing lessons learned from previous accidents, including their prevention, the response and dealing with the consequences of contamination, much further work still needs to be done.

In the fall of 1993 a conference between Prime Minister Chernomyrdin of the Russian Federation and Vice President Gore of the United States addressed the issue of collaborative research on the health effects of ionizing radiation. A subsequent binational agreement established the Joint Coordinating Committee for Radiation Effects Research (JCCRER) to coordinate research efforts. Included in the charter was the subject of the effects of radiation accidents on human health. It was felt that the first step to address this issue should be to conduct a workshop to evaluate the current status of knowledge in this area and to determine recommendations regarding further research needs.

This workshop, held under the auspices of Direction 3 of the JCCRER, was held at the DoubleTree Hotel at Tysons Corner in Falls Church, Virginia on November 12-14, 1996. There were a total of seventy-one registered attendees from five nations. A total of nineteen scientists, seven from the Russian Federation and twelve from the United States, made formal presentations, followed by questions and discussion from the audience. The three main topics of the conference were:

1. *Russian experience with the management of consequences from the Chernobyl and Urals accidents.*

2. *Scientific and technical support for decision makers concerning protection of the population from radiation accidents and incidents. Presentations and discussions covered the use of computer models to assist decision makers in anticipating consequences and determining population protective measures.*

3. *Emergency medical response to radiation accidents and incidents. Specific subjects included risk to the thyroid exposure, combined injury (mechanical, thermal and radiation trauma), and summaries of Russian and America experience in medical accident response.*

Formal presentations were delivered on specific subjects under each topic; these are described in the agenda. Each presentation was followed by a question and answer session from the floor, which often stimulated intense discussion, bringing out important points not directly covered in the presentations. Accordingly these sessions were transcribed and are included in the Proceedings along with the presentations and accompanying handouts and slides. In some cases there may be discrepancies between the material transcribed and the written material furnished; for completeness' sake we elected to include the handouts as they were submitted. The final session was devoted to panel discussions and concluding remarks recapitulating what was felt to be the main points of the workshop.

To summarize the panel discussions: the first panel concluded that dose reconstruction and its relation to health effects, especially in high risk groups, is a critical area for further study. The question of rehabilitation of the contaminated land for habitation and economic productivity is extremely important as well, and safety standards and guidelines for remediation need to be determined. For the second topic it was noted that both countries, the United States and the Russian Federation, have several well-thought-out theories and plans, while the Russian Federation possesses most of the experience in actual response. Both have critical needs and gaps in their response knowledge. It was felt that the best way to address these needs would be to do an exercise involving planners and responders from both nations. For the third topic there are two areas that need to be pursued. One is teaching and training the next generation of planners and responders. The other is to continue research in the field, particularly in the areas of radiation protection and molecular biology.

As one might expect from such an intense workshop with highly qualified and interested participants, areas of significant knowledge gaps as well as ways to address them were discussed. Clearly, while a Proceedings such as this document is an important contribution to the field of prevention and amelioration of the health effects from radiation accident and incidents, it cannot serve as the final word; more critically important work needs to be done. Several ideas were put forward in the summaries by the panel chairmen and the workshop co-coordinators, including the possibility of combined exercises (along the lines of those discussed under the first and second topics) as well as focussed laboratory research projects. These recommendations have been made to the JCCRER, and action is currently underway to determine and carry out the next steps. In summary, we feel the workshop has done its job in coalescing and assessing the current state of knowledge in this field as well as discerning the most appropriate next steps; what now remains is the willingness, in terms of personnel and financial resources, to carry them out.

Glen I. Reeves, M.D.

Col (Dr.) Glen I. Reeves
United States Co-coordinator

Dr. Rafael Arutyunyan
Russian Federation Co-coordinator

Pictured here from left to right are: Oleg Pavlovski, Anatoli Tysb, Rafael Arutyunyan, Gennadiy Romanov, Victor Vladimirov, Angelina Guskova, Robert Boudagov, and Col Glen Reeves.

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Welcoming remarks

Administrative announcements were made by Col Glen I. Reeves, the U.S. coordinator of the workshop.

American representative
Opening remarks on behalf of the United States were delivered by Dr. Anna Johnson-Winegar, Director of Environmental and Life Sciences of the Defense Directorate Research and Engineering, United States Department of Defense, Washington, DC.

Dr. Anna Johnson-Winegar: Thank you very much, Glen, for the very kind introductory remarks and good morning to everyone here. We are particularly pleased to have our Russian guests with us for this very important workshop. Although I am still relatively new at this position at the Pentagon, I can already tell you quite candidly that one of the areas with which I am most impressed is the one that we are dealing with here, the work done under the auspices of the Joint Coordinating Committee for Radiation Effects Research. I was very fortunate to be able to participate in the recent JCCRER meeting held in Moscow, October 26-28, just two weeks ago. I realized first hand how very important the efforts that we are jointly supporting are. I am particularly proud of the interagency support within the United States. While the Department of Energy is the lead agency and the Nuclear Regulatory Commission is also playing a strong supporting role, I feel that there is much that many other agencies can contribute as well. From the perspective of the Department of Defense, the research into the effects of radiation remains a critical area of interest for us. The outstanding work done by the Armed Forces Radiobiology Research Institute (AFRRI) in conjunction with the Defense Special Weapons Agency (DSWA) is certainly an outstanding example of the capabilities of some of Department of Defense's finest laboratories and scientists.

I had to do a little bit of research on the JCCRER in preparation for the meetings that I was able to attend. It goes back quite a way. There is a history of conferences held at the very highest levels, with the United States being represented by Vice President Gore and the Russian Federation by Prime Minister Chernomyrdin, dealing with a number of topics of mutual interest in the field of science and health. Specifically, a conference held in the fall of 1993 set the stage for future collaborative research dealing with the effects of radiation on human health. Following that, our Secretary of State, Warren Christopher, signed an agreement with the Minister of Foreign Affairs for the Russian Federation, Dr. A. Kozyrev, in January of 1994, to continue to cooperate in research on radiation effects to minimize the consequences of radiation contamination on both human health and the environment. The JCCRER was set up to direct this program. It is comprised of an Executive Committee, which essentially does the day to day operations of the committee. Several agencies from each government were designated to participate. The Department of Energy, with Tara O'Toole as the head of the delegation, is the lead agency for the United States, and EMERCOM is the lead agency for the Russian Federation. Under the auspices of the JCCRER, three directions of research have been established. Directions 1 and 2 deal with the effects of radiation on the population around the Techa River and the workers of the Mayak Production Association, respectively. Work has already begun in these two directions and is well under way as we speak. Work under Direction 3, originally entitled "Information Technologies in Research on Radiation and Decision Making Support," for radiation accidents and the health effects from radiation exposure from these accidents did not get started until much later. That is the topic of this workshop that we are attending now.

Now for a little bit of history specifically about this workshop. Dr. John Ainsworth, the Scientific Director of AFRRI and the Department of Defense representative on the Executive Committee, offered to sponsor this workshop at the JCCRER meeting in St. Petersburg, Russia, in July 1995. He deserves a great deal of credit, along with Col Reeves, for putting this workshop together. The aim of the workshop is to improve Russian Federation and United States response capabilities in the management of future radiation accidents and incidents by reviewing our past experiences and our current plans. Radiation effects and risks, both early and late, from the one time exposure to prompt radiation at Hiroshima and Nagasaki, have been extensively studied. Our understanding is continuing to grow from these research programs. What is less known is the risk and effects of high exposure levels received by relatively large populations. Radiation releases from accidents generate multinational interest. As the radiation plumes cannot be confined to borders, it is therefore imperative that we share our knowledge for not only our mutual benefit but for all other nations in the world as well. The Russian Federation has gained considerable experience in the ongoing consequences of a major radiation accident, such as the one in Chernobyl in 1986. Both nations here today have developed excellent modeling tools for tracking the plume of a radiation accident in a variety of terrain and weather conditions. Comparison of our respective strengths and weaknesses in these areas should prove very valuable in improving our models, our plans, and our procedures.

Briefly, this workshop will be divided into three areas. The first is entitled "Review of the Russian Federation Experience in Liquidation of the Consequences of the

Chernobyl Nuclear Power Plant (NPP) and South Urals Accidents, from an Emergency Response Point of View." The second is "Scientific and Technical Support for Decision Makers Concerning Protection of the Population at Radioactive Accidents and Incidents." The third is "Emergency Medical Response at Radioactive Accidents and Incidents, Specifically Health Concerns, Internal Exposure, and Combined Injury and Radiation Burns."

What are the expected results from this workshop? First of all, AFRRI, under the auspices of the JCCRER, will publish the proceedings, using the formal presentations as well as the summaries that will follow each panel. We will also attempt to identify what the next steps will be in understanding and improving our responses to radiation accidents and incidents. I think that planning the appropriate responses to accidents involving radiation is an extremely timely topic. The whole issue of weapons of mass destruction is one that remains among the highest priorities not only for the Department of Defense but for many other federal agencies as well. I am pleased to learn that we have representatives with us from a number of different agencies to participate in the discussions. As we go forward in planning our appropriate response, it is extremely important to remember how critical it is to communicate with each other. The lines of direct communication must remain open within an agency, with cooperating agencies, and of course between nations. The issues of radiation exposure, its health effects, and emergency planning measures are of vital interest. I look forward to reviewing the outcomes of this workshop and of course to participating further in JCCRER-sponsored activities. I thank you for the invitation to be with you today and am looking forward to meeting many of you and hearing several of the presentations. Thank you very much.

Russian representative
Opening remarks on behalf of the Russian Federation were given by Dr. Victor A. Vladimirov. Dr. Vladimirov is the Vice Minister of the Russian Federation for Civil Defense, Emergencies and Eliminiation of Consequences of Natural Disasters (EMERCOM).

Dr. Victor A. Vladimirov: Dear American colleagues, I am very glad to greet you on the behalf of the Russian Delegation. Russian-United States cooperation has developed very successfully in many directions in recent years, and the Gore-Chernomyrdin Commission really had a lot to say in this program. Many programs are being developed based on these specific bilateral arrangements, including our program on the study of the consequences of radiation effects. Unfortunately, at the present time the territory of Russia has served as an excellent proving ground for resolving these issues. Number one, we have a large number of people in vast territories who suffered as a result of the accidents in the South Urals and from the Chernobyl disaster as well as from nuclear weapons tests. Number two, we have accumulated a great deal of experience in how to fight these tragedies. Number three, we have a number of wonderful experts in this field, professionals, who have worked together in October of this year with the American specialists who visited Chelyabinsk and Moscow. We will also have a chance to prove this during the workshop this week.

We have successfully developed our program as was illustrated during the second meeting of the coordinating committee on the study of the consequences of radiation effects. Today we are working quite successfully in two directions: first, the medical aspects of the effect of radiation exposure on the population and, secondly, the medical consequences of radiation exposure on occupational personnel. These topics are very important and the results of this work are not only important for today but for the future as well since we are speaking about the health and lives of human beings. We have seen results that are very promising. As far as we understand, today we are at the point of deciding how to open up our collaborative work on the JCCRER's third direction, use of information technologies to support decision-making processes. We hope that the discussion of this problem in our workshop will be very useful. At our workshop, we are going to discuss about the liquidation of the consequences of radiation accidents and medical health, which are very important problems. Together with the European Commission we are developing several programs related to this topic. We have seen very promising results. We are conducting work on reconstruction of doses in the population that has suffered during the period of testing of nuclear weapons. We are inviting our American colleagues to join this effort.

In our activities we base our efforts on the principle that in the response to nuclear accidents the results of the research should be given to everybody; we should share it. Please do not misunderstand. Most of the problems we are talking about can be resolved by Russia, but, as they say, "One brain is good, but two brains are better." Now Russia is going through difficult times and cooperation in this research will help support our scientists and our scientific institutions to achieve results which will be useful for all mankind. I wish this seminar success. Thank you.

The film "PLANEX" and discussion of the preparations for a U.S.-Eastern European accident response exercise

The next presentation was a film entitled "PLANEX," showing preparations for a US-Eastern European accident response exercise. Discussion of the film was introduced by Mr. Max Alston, in the Emergency Preparedness Policy division of the Office of the Under Secretary of Defense for Policy.

Mr. Max Alston: Thank you very much. It is a privilege for me to be in the room with all of you and to enjoy thinking about something we hope never happens--nuclear disasters. I have had the pleasure to work with Minister Vladimirov, and with EMERCOM of Russia, in a partnership that is only now beginning to accomplish something after being initiated in 1992. This is a partnership between EMERCOM and several United States governmental agencies which are coordinated and brought together by the Federal Emergency Management Agency (FEMA). These agencies include the Department of Defense, Department of Energy, Department of State, Office of Foreign Disaster Assistance, and others. As you can see there are many parts of our federal government that work with EMERCOM now and will work even more closely with EMERCOM in the future. I am not a scientist; I am a planner, an organizer of people and programs. I am also a dreamer, thinking ahead and trying to enable civilians and military people to work together for a future that we all hope will be better than the past.

It is my job to imagine worst case disasters and to think how people that would be concerned, both civilian and military, from all nations that would be concerned, and from all organizations that would be concerned, would come together on a timely basis to save lives if disasters occur. My focus is also on the North Atlantic Treaty Organization (NATO). NATO is moving into the future with something called Partnerships for Peace. I am humbled by your technological and scientific expertise. I won't bother you with the anecdote of the professor in college who told me he would pass me in my first mathematics course if I never took another one. I accepted his condition--I never took another. It is your expertise in the medical field in particular, but also in all other aspects of radiological risk, that will have to be brought to bear in order to save lives in the future. As I say that to this audience, I am reminded of coming out of a small encounter with your counterparts in Ukraine, where I had just been tested for the amount of radiation in my body. I do not remember all the mathematics, but I can say that the numbers that they read to me about my body were something like 10 percent of all of theirs! I know you know far more than I will ever know about radiation; however, if another Chernobyl occurred in whatever nation and at whatever time, there will be a need for a political framework in which to work.

I first was educated to this need when I was in Latvia in 1992. My host explained to me that he has been in charge of 8000 Latvian Civil Defense personnel who went to Chernobyl. There is no longer any ability in the world to order thousands of people to respond to nuclear disasters. Any response is going to have to be done through cooperation, through mutual agreement, and above all else through effective planning. NATO is a military alliance, but, as peace began to be a real possibility, NATO began to change its personality. NATO has two different sides: one is called the Military Committee and the other is called the Senior Civil Emergency Planning Committee (SCEPC). The SCEPC has been dramatically changing in the last two or three years and has been doing things to help people cooperate and communicate in matters that are of great concern to you. They are that political framework which would handle an accident, not through command but through cooperation. They need your help. NATO committees need technological input and experience. NATO people need to know that all people are going to work together cooperatively if a disaster occurs, regardless of where it might occur. EMERCOM of Russia has taken a bold initiative and established the first partnership for a memorandum of understanding between any ministry of any nation and NATO. The memorandum of understanding (MOU) between EMERCOM and NATO is in fact a precedent for much of the work that we will be doing together in the future.

In a moment Commander Thompson is going to describe to you an activity that we in the United States have found to be a useful tool to help people cooperate in planning. It is not an end in itself; it is only one tool. What we need to do is to plan together in an orderly manner and to exercise our plans together for many, many years to come. The use of computers to build databases in which people will be able to know each other's capabilities, know whom will do what first when disaster occurs. These are techniques that seem perhaps common to you as technologists, as people who use computers regularly. They are not so familiar to the emergency planners of all of your neighboring nations. We are trying to help people learn to use computers for these processes. In the United States we do not have a huge budget for this. We have taken a series of contacts with the nations of Partnerships for Peace, including Russia, and we have gone one step at a time to do something which we think people will find useful and enjoy doing together. These we have called "PLANEX"--Planning Exercise. The planning is far more important than the exercise itself. We have helped Romania and Bulgaria work together in planning a response to a catastrophe at either of their nuclear power plants on the Danube River. We have worked with Lithuania, Belarus, and Latvia to work a similar planning process with regard to Igdalena. We have worked most recently with Ukraine, Poland, Czechoslovakia, and Hungary. In that case we did not work on a high tech radiological accident because the government of Ukraine did not want us to. They wanted to work on something more common, in this case an earthquake exercise. In the future these exercises will be using computers for planning and then for checking the plans. We feel this has a great potential for cooperation between the United States and Russia. The actual exercise, or the computer game, can be made available later today and tomorrow for those of you who would like to look at it on the laptop computer. It is a simple game. The importance of the game is that the people are working together. Perhaps it will be boring to those of you who are high technology experts, but perhaps it will be less boring if you realize that, if all the high technology to provide safety for people fails, and, if those people are in danger, then many people from nations must come together to respond. That's what the game is all about. We hope that you and your technological preparation, your technological leadership will someday make us useless, that there will never be another Chernobyl, but, if there is, we hope that everyone in the world will be as prepared to cooperate as possible. With that I will ask Commander Thompson to demonstrate and explain to you the process that we have used to develop the planning exercise and to build into the computer the means by which we plan together and train together.

(Lieutenant Commander Eric Thompson is the Chief of Operations Support of the Assessments Analysis Division of the Field Command of the Defense Special Weapons Agency in Albuquerque, New Mexico. LCDR Thompson's presentation followed immediately.)

LCDR Eric Thompson: The first thing that I would like to do is show you a short videotape of a conference we held in New Mexico, in Albuquerque, last summer. This conference involved the players in the PLANEX, which was held in Ukraine. We involved them in a training session to prepare for the exercise. I am going to go ahead and show the tape. It will be difficult for the translators to translate this tape because there are no pauses for translation, but I am sure they will do the best they can.

Videotape shown by LCDR Thompson: On June 22, 1996, delegations from four countries and the United States arrived in Albuquerque, New Mexico, to attend the 11-day Partnership for Peace (PFP) conference held at Kirkland Air Force Base. Thirteen delegates representing Poland, Ukraine, Slovakia, and Hungary were all in attendance. Representatives from the California, Ohio, Illinois, and Indiana National Guards also attended. Distinguished speakers at the conference included Colonel Elizabeth Herrell, Commander of the 377th Air Base Wing and Colonel Steven Haffner, Commander of Field Command, Defense Special Weapons Agency. The conference was designed to assist other countries in dealing with such events as a nuclear or chemical accident and natural disasters. The nations involved in the PFP program shared their knowledge in dealing with these types of events. The reason for their participation in this program is to help provide planning in preparation for the PFP nations. In the end each nation will be able to prepare and execute the plan on their own. The conference began with several days of briefings and demonstrations of each nation, providing an overview of their civil defense organization. Briefings were also given by representatives from the Office of the Secretary of Defense for Emergency Planning, the New Mexico State Emergency Management Agency, and other representatives from the Emergency Planning community.

The second part of the conference was dedicated to computer-based training. This training included an introduction to a geographical information system or GIS. GIS is digital maps used to automate road and waterways. This system's been allowing the user to clock the potential disaster areas, and help plan and execute emergency response. The GIS will be provided to each country for future use and to continue development. Another aim of the conference was to foster relations among the countries. By sharing information and communicating more openly, the participating countries will be able to help one another better in future emergency situations. PLANEX is an activity where senior officials and key staff with emergency management responsibilities are presented with simulated emergency situations. The scenario for PLANEX 96 is based on a sizable earthquake in the Transcarpathian region of Ukraine, leading national civil protection bodies to mobilize all capabilities and resources by the player nations and to request international assistance due to the disaster. Emphasis during PLANEX will be on damage and need assessment, notification, processing requests for international assistance and replies, and monitoring of the response for Ukraine in the international community. Objectives are to assess the effectiveness of planned damage estimation procedures, adequacy of notification and communications procedures (especially across national boundaries) communications with assisting international agencies, and maintaining public awareness of disaster situations with public affairs and emergency information. The broad goals for this exercise are to foster international communications and understanding, exchange information to save lives, prevent human suffering, and mitigate or prevent major property damage through civilian and military partnerships. The delegates hope that in the end the PFP program training and exercise will be beneficial to providing a foundation in the future in disaster relief. (Conclusion of videotape.)

Again my name is Rick Thompson. I am at Field Command, Defense Special Weapons Agency, in New Mexico. My office was asked to facilitate this exercise by Mr. Alston's office. I think this was mainly because we have a lot of experience in running exercises; however, this was a very new experience for us because normally our exercises are combat-type exercises. Our normal exercise expertise is in nuclear, chemical, and biological weapons, so working an exercise that involves protection of civilian populations and mitigation of damage from natural disasters is very new for us. We learned a lot. This conference was good for me and my people as well as all of the participants and observers.

I will give you a quick brief of some high points from the PLANEX exercise as well as a few points from the following exercise that was facilitated by Ukraine and our California National Guard. I just want to say also, as a side note, that it is good to see a lot of our navy colleagues here and some fellow sub mariners, including Admiral Vladimirov. That's unusual for me.

I will speak about the objectives of PLANEX, the execution of the exercise, what we feel our accomplishments were and then summarize. The objectives of the PLANEX were to conduct and exercise and carry out other related activities with the players, who were Ukraine, Poland, Czechoslovakia, and Hungary. All the United States did was to provide technical support and to provide meeting places in the U.S. and to try to help the Ukrainians coordinate. Next objective was to familiarize the participants with some of the technology that is available. That included the player countries and also the observers. We had, I think, 22 observer nations from the PFP community as well as quite a few other organizations, including the United Nations, NATO, and some nongovernmental organizations. I also want to note, by the way, that the technology that we tried to make available to the participants in the exercise was for the most part already in their countries. We provided some different software from what they were familiar with, but the hardware was already there in most of the countries, although there isn't very much of it because of the expense. The professional expertise is there though, in all of the countries, which was one thing we weren't sure about initially. We weren't sure if we were going to have technicians available that were really familiar with operating Pentium hardware and GIS software; however, we found that was not a problem; everyone knew all about it already.

Another objective of the exercise was to give the player countries an opportunity to experience Ukrainian and U.S. cultures. As you saw on this videotape, we brought the player countries to New Mexico for a planning conference. Unfortunately, we could not bring the observer countries also; that would have been a lot of fun, but we could not do that because of the expense. But they had a real good time in New Mexico. I love New Mexico; it's my home now. Everyone there loved all of our visitors, too, so if you ever get a chance to come out, give me a call and we'll show you a good time. I sincerely mean that.

I'll review the major events for PLANEX. The idea for PLANEX was seriously begun in October and November of 1995. Most of the initial planning was done by Mr. Alston and his colleagues. I was there at the meetings in Bratislava, Budapest, Warsaw, Kiev, and L'viv, but Mr. Alston and his colleagues really got the idea going and got all the leadership coordinated. Then after the initial planning visit and the initial germination of the ideas for the exercise, we had to get funding arranged through U.S. Government, which was really hard. The amount of money was not so great by U.S. Government standards, but the bureaucratic hurdles were tough. I think anyone working with the government will know what I am talking about. We finally got that squared away February or so. Then in April we had our first workshop, held in L'viv, Ukraine. By the way, that is a really nice city. If you ever have chance, go there; it's really a nice place to visit. What we did there was exchange geographic data for the exercise area and information on demographics, on hospitals, on fire brigades, seismic data, and on anything else to do with emergency planning in the civil protection arena.

That was an ongoing process. We did a lot of things in L'viv, but our contractors found holes in our data and we had to go back and get more; this took till July. During this time, the Ukrainians, Poles, Hungarians, and Slovakians got together and selected the site for the actual exercises, both PLANEX and its associated field exercise, called FIELDEX. FIELDEX was facilitated by the California National Guard with Ukraine. My office worked very closely with the California National Guard. I have to say that the California National Guard was really good. Natural disasters are an everyday thing for them. They have flooding, they have earthquakes, they have riots, they have forest fires. Any natural disaster you can think of happens in California almost every year! As a matter of fact, a good friend of mine, who is Chief of Operations for the National Guard, told me last week that almost 25 percent of their National Guard Force, which is a Reserve force, is on active duty at any one time to combat some natural disaster. That's out of a force of 26,000 people. The California National Guard is almost as big as or bigger than many countries' military services. So we thought it was a natural fit. Also, in the U.S. the National Guards in many states are partners with PFP countries. The California National Guard partner is Ukraine, so that worked out really well.

In July, we had the exercise preparation and training workshop, as shown on the videotape. We also had guests from the PFP nations here for 10 days. We spent several days in seminars, and we spent several days working with computer software and hardware that our contractors, Campbell Corporation and Teledyne Brown Engineering, put together. I want to give them a lot of credit because they worked really hard for this program, which was a very different program for them as well. We got some pretty good briefings from emergency planning people in New Mexico, the U.S. federal government, and from the player countries. For cultural events we took people out to some Indian reservations, called pueblos, in New Mexico. Everybody really liked that. We took people to the top of Sandia Peak, which is right next to Albuquerque. I took the Ukrainian Deputy Commander of Civil Defense to a big ranch out where I live, and he really liked that. We looked at a bunch of cattle. There were a lot of other animals all over the place, and he got a big kick out of that. One of the highlights was Los Alamos National Laboratory, where we had a tour of their emergency operations center. They are really concerned about any kind of chemical or nuclear problems that might arise at Los Alamos National Laboratory. The laboratory is in a mountainous area, and they do have some seismic activity there. They have a lot of laboratories there on the site, and they are very concerned about the possibility that they might have an earthquake or an accident in one of the labs, which would contaminate the surrounding area. So they have developed a very sophisticated operations center, fully staffed round the clock, complete with a really nice geographic information system. I think that probably rivals any emergency operations center that I have ever heard of or seen. It's as good as the one that the state of California operates for their whole state, but Los Alamos National Laboratory is a small site, covering only approximately 5000 hectares, which is small by western U.S. standards.

In September we actually conducted the PLANEX and FIELDEX in L'viv and the surrounding area. As Mr. Alston mentioned, what it consisted of was basically a computer software exercise that we developed with the four player countries. The purpose was to walk the countries through the planning stages of notification, response, etc. for an earthquake with flooding--a pretty massive natural disaster. The California National Guard wrote the scenario and gave it to the Ukrainians, who changed it around to suit their needs. But it was based on some real experience in California. When I first read it I thought, "This is ridiculous; no one has a disaster like this," but the guy who wrote it said, "We took it right out of real stuff that happened here in California." All we did, on the U.S. side, was to provide technical support. The players did all the work. Since we had an earthquake as part of the scenario and since there is a dam called Slenas Dam in Poland, we went ahead and cracked the dam, which made a pretty good flooding hazard. We found out that even though the dam is 50 kilometers from the Ukrainian border, if it were to break there would be flooding in Ukraine as well as Poland because the water flows through Poland and down into Ukraine. We had a unit from Slovakia whose speciality is containing oil spills. The Dragovich area, which, since it was part of the FIELDEX we integrated it into our PLANEX, is near. The Slovakian unit came up and stopped the imaginary oil spill on one of the rivers in Ukraine. We also had some buildings that fell down in Ukraine, so we had search and rescue teams from Poland and from Hungary. Since we had some California National Guard people over there, they demonstrated some techniques they use in California for search and rescue. All that was integrated in the PLANEX and actually demonstrated in the FIELDEX. Our Russian colleagues that observed our exercise told us that their geographical information system was pretty similar to what we used. The Ukrainians also had a system in place as do the Poles. So I think that most of the nations in the PFP committee already have some similar systems in place. The only limitation is availability of hardware. The template that we used to walk through the planning process has a lot of components; however, the technical aspects were really only a minor part of the whole PLANEX exercise. The major part was getting the planners together and actually getting them to talk to each other via the computer network we had set up at the exercise and to use this template together.

I have spoken a little bit about the field exercise already. The participants were the same as in the PLANEX. It was held the very next day. The weather was horrible. It was raining, it was cold, and they actually had some real flooding problems, which made this really good for an exercise of the natural disaster type of exercise! But it made it really hard for the people who were doing the work in the field, because they were actually really trying to fight a flood and they had a lot of people watching over your shoulders. Everyone was saying, "Well I wouldn't do it that way," and so on. It is hard working when you have lots of people watching you, but everybody learned a lot. There were a lot of people there observing the field exercise. I don't have the actual number of observers, but based on memory I would say there were at least 400 people who were observing, from all different types of organizations as well as the PFP countries, NATO, and elsewhere. They demonstrated oil spill mitigation. They talked about evacuations in buildings that collapsed. They showed some pretty good demonstrations on that. Disaster site management was coordinated by the California National Guard. Mutual aid coordination was mainly accomplished by the Ukrainian civil defense. "Communications" was demonstrated by all the people concerned. Communications was a big success. They did a really good job of coordinating the efforts among the player countries. Quite frankly as we went into this exercise, I wasn't sure if that was going to work to well, but the players did a great job in communicating with each other.

The following are my own personal observations about some of the good things that came out of PLANEX and FIELDEX. There was a lot of professionalism. Everyone was dedicated, which you would expect from civil defense personnel. You expect them to be dedicated and professional because if they are not, they are not going to be able to do their job. The Ukrainian civil defense did a really good job. They were enthusiastic even though they were operating under a big handicap because they don't have much money. They suffer from budget problems like the rest of the Ukrainian government, but they are not short of enthusiasm nor professionalism. They have a lot of that, which makes up for a lack of money in almost every way. They improvised when they couldn't afford to do something. If we could not help them do it they improvised and made it happen; that was really good. Everyone was impressed with that. They got a lot of personal attention too because their Minister of Matters for Chernobyl and for Emergency Actions (that's not his exact title but I think that is pretty close) was there in person watching, so there was a lot of pressure on the people who were running the exercise. They were very conscious of his presence.

We like to think that doing PLANEX 96 and FIELDEX is going to lead to more exercises of that type. What we really would like to see from an American viewpoint, and also from the viewpoint of the PFP partners who were there, are more exercises of this type in the future. We would like to see them get more complicated. This particular exercise was fairly well scripted, which we did so that the language barrier would not be a problem. What we would like to do in the future is to have more free play, in other words, bring out a new problem right in the middle of the exercise and see what happens. You run some risks when you do that. Military services all over the world do that as a matter of course in their own exercises, because when they make mistakes the embarrassment is only within the group, but when, during an international exercise, you throw an unexpected problem at somebody and maybe they don't handle it exactly in the way that is most efficient, there is a little bit of embarrassment in front of other nations. It is hard to get past that. But, if we increase the complexity of the exercise a little bit at a time, I think we will get past that, especially as the people get more comfortable working with each other.

Okay, in summary, it was a successful exercise, in the best spirit for PFP. We think PLANEX was a big success. PLANEX has a lot of room for improvement, by which I mean it has the possibility to be more valuable by becoming more complex, involving more players, getting more input from more observers. It is a really good tool, and it is especially good if you do it in conjunction with a field exercise. Probably the hardest part, besides getting over the hurdles of funding and some of the bureaucratic roadblocks that you run into within any government, is getting past the notion that, if you make a mistake, people are going to laugh at you and say that your country is not doing a good job in civil protection. That's not the object. The object is to learn from exercises. I think that, if we continue on with PLANEX type exercises, eventually we'll get to the point where we can throw terribly complex problems at a group of players and just see what happens. If they do wrong things--okay, no problem--but, if they do everything right, then that means the exercise wasn't hard enough, and you haven't learned very much. You need to make an exercise difficult enough, eventually to the point where you make a lot of mistakes; that way you learn more.

I will take any questions that you might have now, or you can come and talk to me later about PLANEX or FIELDEX and I will be happy to discuss it with you.

Mr. Jim Myska, AFRRI: Was the exercise template that you used interactive and networked so that someone could enter something in the event log at one place and it would show up at on the other computers so they could modify their plans?

LCDR Thompson: It was not fully interactive. In other words, we scripted the exercise so that people knew what to expect, but they could, if they wanted to, modify responses during the exercise, but no one did that. I take that back; the Ukrainians did modify a couple of things, which we were not looking for, and that made it a little interesting! But, in general they did not modify responses, though they could have. The template has the potential for that, but in this exercise there weren't many surprises.

Dr. Friedrich Steinhausler, Nuclear Advisory Council for the Austrian Federal Government: We have had some exercises with Scandinavian countries and with international organizations, conducting international exercises. One of our major stumbling blocks was data overload. Using the GIS and using sophisticated software to interpret the information is one thing, but the other aspect is that every other player, as you called them, is trying to do his best in providing data as possible. If you have Norwegian, Italian, German, and Swedish persons providing you with their own national data set you run into the problem of lack of harmonization and lack of standardization of input. The end result is system overload. So, I really congratulate you on your two component approach, planning and conducting in the field. I think it will be very valuable if, as you indicated, you include in the field component in the future this multinational data input approach for us to learn to harmonize and standardize the data input into the sophisticated software. I would like your comment on that.

LCDR Thompson: That is a very good point. I think that there are two ways to approach the problem of harmonizing the data. One is to try to get everyone to use compatible systems so that the software will talk to each other. Another approach, and I say this as a military person, is that the leadership has to be in harmony with all the different players and parties involved, in helping them combat a civil or natural disaster problem. That only comes from working together in exercises and social situations before a problem happens. It is a lot easier to work with someone when you know them professionally and maybe socially than it is to come in "cold turkey" and try to work out a problem that is really happening right now, because frustration levels are much higher and personalities may not work together so well. So, with either approach, computer software and hardware compatibility or, more importantly, leadership compatibility--if you can make these work together, most problems can be fixed.

Mr. Alston: I think that you have gone right to the heart of the problem in what we hope that PLANEX will do. We have no desire to sell or develop PLANEX from a U.S. point of view, but we have found out that the United Nations Department of Humanitarian Affairs, NATO Civil Emergency Preparedness Organization, Scandinavia, Austria, and almost everyone seems to be dealing with the same problem you are talking about. That problem is much smaller today than it will be in a few years from now. As the uses of computers, databases, and automatic communications expand, we will get what we call a "Catch-22" in that emergency response. In the future we'll have far more data available, and we must be prepared to use that data efficiently, yet, we cannot envision even in the United States when there has been any time with a single software system or management system for sharing information. The comment that was made to me by the European Community Humanitarian Organization is that the U.S. can help to build a network of networks. And as we go forward, we think that the PLANEX exercises, even somewhat more than the FIELDEX part, can enable all nations to learn to share information effectively. By sharing it effectively, I mean that we will know what to tell and what not to tell each other, particularly when time is very, very short in emergency conditions. In some ways it is more important for us in response to a disaster to all agree on the questions to be asked and the priority in which they must be addressed than it is to worry too far in advance about what the answers would be. This is one of the themes that we hope to keep going in PLANEX, whether those PLANEXs are led by other people with other systems, supported by the U.S., or perhaps when the U.S. is only an observer and all the nations in Europe will have a PLANEX which might be sponsored by Russia, by Austria, or by anyone else. But, I do believe that we must aim at the right questions in the right order rather than data overload.

LCDR Thompson: I want to add something very quickly about data overload. We did see that in PLANEX. We tried to adjust for that in the planning sessions for PLANEX, but it still came up.

Dr. Angelina Guskova from Russia: I would like to ask some questions and maybe to comment a little. I share the opinion of the speakers that the first stages of information should be limited, that it is good to not know too much; we should know appropriate information. Also, we should know only such information which leads to certain steps and activities. As for the next stages, the volume of information goes up, it becomes more detailed, and the decisions that were taken before are being corrected. My second comment: we should think through what information should be addressed to the specialists, including medical experts, and also what information should be told to the public in order to mitigate the consequences of the accidents. Also, what decisions should be made by large government agencies in order to mobilize the reserves, which may have been exhausted during the initial phase. I am also for the proposition that a sudden change in the situation may also lead to a sudden change of the decisions that have been made, because you cannot foresee what is going to happen and we should be prepared for sudden change and surprise. This is a very important and interesting consideration, so I agree with what you said about modifying the exercises. Thank you very much.

Mr. Alston: I couldn't agree more. I would like to be able to use the quotations of the things you have said in our own policy development. That was very articulate.

Dr. Bob Young, NWI: How did you handle demographics; what sort of demographic databases did you use; what sort of compatibility did you find and willingness to share that sort of information and how that worked in your exercise?

LCDR Thompson: The question of the demographic data was a little difficult at first because we didn't want to get so much information that we could not sort it out and enter it and make it useful. Also, some of the data, like the location of military airstrips and military units in Ukraine, was a little hard to get. The Ukrainian government did not want to give all that information to us, but--an interesting note--the information that they didn't want to give to us, we went in and got that information from the public library. We told them that afterwards and they thought it was pretty funny. It wasn't the people that we worked with directly that didn't want to give us the information, it was someone higher up in the security that didn't want to provide it. The Civil Protection Forces were very helpful.

(The next question from the floor concerned the technical and political aspects of the data; the name of the questioner and most of the question was not on the tape.)

LCDR Thompson: The technical aspects of the data varied with the player country who supplied it. In Hungary's case, they gave us all the data that we asked for, which was a two-page list of data, on CD ROM, and we just loaded it directly into the database. The Polish data situation was almost that good also. They had it on disk. That was very easy. The Slovakian and the Ukrainian data were on paper, so we had to hand enter it. That took a lot of time. Technically, it wasn't a big challenge; it just took a lot of labor. We had a bunch of people working on that for several months, so there were a lot of man-hours involved. This included integration with the GIS.

Mr. Alston: And the great thing about that is this is a declining curve, as far as this problem is concerned. When we did our first PLANEX in 1994, every bit of data for Romania and Bulgaria was entered by hand. This year, as Rick has told you, at least half of the total data came already available in automated format. This is happening all over Europe, and in fact all over the world there is an increasing use of the various technologies. This means that the data are going to be pretty readily available. Again, as mentioned in the earlier question, data overload is rapidly going to be a bigger problem than collecting data.

Dr. Steinhausler: May I ask you another issue that we have come across as a problem? We now have bilateral and multilateral agreements on the political arena, where you have the issue of notification and mutual assistance; however, there is a sort of "rubber period" or a gray area in those agreements in which the country experiencing disaster has to request the assistance from abroad and the country experiencing the disaster has to classify as a potential for trans-boundary effects. Only if these two requirements are fulfilled will you have an international response that, although it is technically feasible, would be politically viable. My question is, would NATO's framework, PFP, provide such a framework that these two obstacles could be overcome in the future so that the country undergoing this painful process would say, "I am linking into the Partnership for Peace Treaty, and therefore I can request technical assistance and most of all I am notifying you of my problems"? Would you comment on that?

Mr. Alston: Your question really has several aspects. First of all, there is not a PFP "Treaty," and, consequently, PFP is a system for cooperation not only between individual nations and NATO but for cooperations between members of PFP whether they are NATO members or not. It is a framework for cooperation. The mutual assistance agreements that you are talking about are something that we are very focused on with PLANEX. For example, the mutual assistance agreements between Ukraine, Poland, Czechoslovakia, Hungary were in fact underlying the exercise. The PLANEX was there to exercise the agreements that they had made. With respect to the multilateral environment, particularly the IAEA, which is of concern to you all, and the notification, which is required by law or by international treaty for nuclear disasters, we have done a couple of things that we hope one day will be useful. First of all, we have placed, or rather begun to develop, a language translation package in which notification can be given in the Russian language. The answers to the IAEA form questions can be answered in the Russian language, and the computer will translate it into the English language and vice versa. We did that only as an experiment, but we believe that in the future this will be an extremely important technology for not only Russian and English but for other languages and other forms of notification. The computer can begin to solve some of our language problems. There is nothing that the computer can ever do about someone who does not want to acknowledge to their public that a particular disaster is of a particular magnitude or nature. The debate's between who is in charge within a particular nation and who has the authority to notify not only the political structure within that nation, but its population and ultimately its neighbor nations are in fact political questions. These are political questions into which professionals, professional emergency planners, and professional emergency managers increasingly have a great deal of input. I think there is no doubt today that Russia would give notification of any form of radiological accident in a far different manner than they (sic) gave it at the time of Chernobyl. Everyone understands that Russia has made a commitment to openness, to disseminating information, that did not exist at that time, but that is only one step and there are still requirements that not only Russia but the United States and all other nations will be willing to share very quickly the trans boundary nature of a particular disaster. We think that things like PLANEX ultimately take some of the politics out of the decision and shift the decision to a professional level of notification, but this will have to be done one step at a time. It's not a panacea.

Unidentified Russian speaker: For more than an hour we have been discussing the policy of emergency preparedness. Please tell me, would PLANEX take into consideration general peculiarities of different emergencies? The point is that each emergency differs from another one significantly or not significantly. In particular I would like to receive some answers regarding the general methodological approach to emergency preparedness to radiation accidents. Mr. Alston has already briefly discussed it in his last comment. Would one of you be so kind then to answer my question?

Mr. Alston: The PLANEX is nothing but a planning tool, itself. By bringing nations together to choose to plan together and then to exercise together, we enable them to highlight the specifics of a particular form of disaster or multiple forms of disaster that are of most concern. The first two PLANEXs, conducted in Romania and then in

Lithuania, focused on nuclear power plant accidents. The third PLANEX, completed in Ukraine, did not focus on a radiological disaster. Because Ukraine felt that it had so much attention paid to Chernobyl for so long, they felt that it would be more useful to their planners to deal with some other subjects. And so they chose the complex disaster of an earthquake, which had pipelines that were broken, dams that were at risk of flooding, railroads that were disrupted and buildings that collapsed. The earthquake disaster happens to be the best vehicle for broad-range planning for everything except the very narrow specifics of radiological disaster, and it can encompass that as well. But, to make an earthquake scenario serve for a radiological disaster, you run into the contention that our nuclear power plant is designed to withstand the worst earthquake in the world; therefore you cannot have an accident that will crack open my nuclear power plant from an earthquake. That is a political choice. From a technological viewpoint, an earthquake can be used for planning on the assumption that it causes a radiological disaster. So we have attempted to build into what we are conceiving the PLANEX tool to be any form of disaster that the users would like to work on. We have some data from an earthquake; we have some data from flooding as a part of an earthquake, some data from chemicals as part of an earthquake, and some data from radiological, but PLANEX is cumulative. Everything that we put into building any one of these PLANEX exercises is available to those in the future who may want to build from that to something else. And we hope one day that there will be many such data exchanges available to all emergency planners.

Dr. Young: To follow up on the question, let me ask you, is there any integration between, as an input to PLANEX, of other tools, such as the Consequences Assessment Tool Set (CATS), or anything of that sort, because there are many different things you can address with that? And, since both of them are from DSWA, it seems like a natural, potential marriage, and I would like any comments that you would like to make on that, please.

LCDR Thompson: Dr. Young, CATS is a separate program, but we have not looked at any kind of integration between this exercise template and CATS. CATS is a kind of a compendium of a bunch of tools. MAJ Menchi of DSWA will give you a briefing tomorrow on CATS. As of right now there are no plans to integrate this template into CATS. This template is really a product of Mr. Alston's office, and it's a separate field from CATS, but, if you wanted to use CATS to help you access and respond to a disaster of any kind, you could use it along with the template to help work your way through the stages of planning, notification, assessment, and so on. You can do it; there's no problem with that.

Mr. Alston: If I may elaborate on that a little bit: We in 1996 added the United Nations Department of Humanitarian Affairs system, which they call the Military and Civil Defense Assets System of Planning for Response to a Disaster. We put what you would call a gateway into the template, information so that the planners in the template could call into another system. Now I am not a technologists, so Rick will have to correct my words. The idea of CATS or any other system that we like to think of is that the template can be used by planners to accumulate the network of networks. It can lead them into other tools. It's really up to each group of people who are choosing to build an exercise, a means of building their lasting planning together, to add anything in the way of tools that they would like to the PLANEX tool. When the United States is asked to assist a nation or groups of neighboring nations to build an exercise, and we have money available for that purpose, then we will enhance the software of the PLANEX with every successive exercise. It is far more sophisticated today than it was in 1994, and it's still not very sophisticated. It has a long way to go, and we think that the principle that we are dealing with is a correct one but that, one step at a time, we do have a long way to go.

LCDR Thompson: I just want to add a little bit to that. The template is mainly a kind of planning guide, sort of a way to step through a disaster and to help you not to forget something, whereas CATS is a consequence analysis tool. So you would take results which the CATS gives you and then go on and use your template to help you move along in the process of responding.

Col Reeves: I have a couple of questions. Start off with one. Were there already plans among the participating nations regarding mutual assistance, say on search and rescue team matters, or do you feel the fact that these nations were going into a PLANEX and FIELDEX tended to stimulate the development of these plans?

Mr. Alston: That's a fun one for me to answer because my whole introduction into this area began in 1993 in Lithuania, and Bob Ricks was in the room when it happened. I looked at a map that was being briefed to me as the emergency planning map for a disaster in Igdalena, and it had a circle, the 30 kilometers zone, that stopped at the Latvian border and at the Belarusian border. And I asked the head of civil defense for Lithuania, "Do you plan together with Belarusia and Latvia?", and his answer was, "No." And I, in my stupidity, said, "Why not?" Well, after we got over the history lesson, my next question was, "Would you like to meet your neighbors?" And we brought them to Pennsylvania, where the Pennsylvania National Guard was their host, and those nations began to plan together. As I mentioned earlier, in Hungary, Ukraine, Poland, and Slovakia, there were already mutual support agreements, but there was no planning for what to do under the mutual support agreements. And this is the important point: there are all levels of planning, all levels of agreement, but they will never all reach the same optimal level of a very detailed plan that everyone can pull from the shelf and use if a disaster occurs. They are all supported by agreements, but the head of Civil Defense for Poland said to me, shortly after he took his job, that he was very excited about PLANEX because he was going to take airplanes and helicopters and fly across the border into Ukraine. And if the agreements had already been made in advance of any disaster, which is our ultimate goal, then everywhere in the world it will be possible for search and rescue teams, lifesaving medical teams, radiological experts, and many others with abilities to help each other to be able to cross the borders quickly, knowing that the host nation that has the disaster will receive them because it understands who they are, what their skills are, and how they are needed. It begins with mutual support agreements. It is continued with planning and I emphasize planning, not any one plan, and then the exercise and the testing of those plans to build confidence. So it is something that answers your question in a very broad spectrum and not with a yes or no.

Col Reeves: My second question: in the three exercises, how would you describe the public response, not among the participants, but among the general public when they became aware that an earthquake, or reactor accident exercise, was going on? Did they appear to become excessively concerned that you were expecting the real thing to happen? How would you describe the response to these exercises?

Mr. Alston: Rick told you that there were about 400 people observing the field exercise in Ukraine. Of those people, about 150 would have been professionals from Ukraine and from the NATO and the PFP nations who came to observe. The other 250 were members of the public and members of the media. This has been the most rewarding thing that I have done in my 35 years or so out of law school, because of the positive answer as to what to say to your question--totally positive. Whether it is in Ukraine or whether it is in Romania or Bulgaria, the public seems to want to know that government is working together and cooperating in being prepared to save lives, and I want to say to Minister Vladimirov in particular that no nation in the world in recent years has done more than Russia in this vein of developing exercises and field exercises for emergency management. I have had the privilege of participating in two with EMERCOM. My boss has gone to a third, and we have sent National Guardsmen to a fourth in the last three years. So, this is a very, very popular thing to do and our challenge is to not simply make it a show for popularity but to build an enduring planning reality with each exercise. This is what I hope that PLANEX will do, to contribute to processes that are enduring in addition to the very popular activity.

LCDR Thompson: I want to add something to what Mr. Alston said. During the PLANEX in Ukraine, we made a portion of time available to work with the media in Ukraine. The Ukrainians wanted us to do that. So we worked with Civil Protection of Ukraine to try to improve their transfer of information to the public via the media. And from what I understand, and Mr. Alston might want to correct me, this type of exercise play with the media has been increasing and I think it is probably becoming a more important part of these exercises.

Mr. Alston: I wouldn't say that is becoming a more important part, but it is an extremely important part to gradually exercise the media relationship and to plan for the media relationship. Perhaps the United States knows this better than anyone else in the world, because of our long-term overexposure, if you want to put it that way, to our media, but everyone in the world is faced increasingly with extreme media attention to any form of disaster. The media is looking, if you will, to find government making a mistake, and we must prepare for the media as a part of our planning and that has been an extremely important and very popular part of the PLANEX, preparing for media involvement and also exercising it, including real media, as Rick pointed out.

LCDR Thompson: I had a Ukrainian newspaper person come up to me after the exercise and he complained to me a little bit that we did not do enough with them and that he would have liked to have seen a lot more. I was surprised, I wasn't expecting that, so I would recommend that any exercises like that, that you would take media into consideration for a fairly large part of your exercise. It is very important, as we discovered.

Mr. Alston: Rick, I know, shares my deep appreciation for your enthusiasm and your questions. Thank you.

Dr. Vladimirov: The discussion that we just heard on this topic has shown that this problem is very acute and urgent and we all should cooperate in working on this problem. I would like to emphasize that the experience of extraordinary situations around the world at the recent time has shown us that assistance is needed. The assistance needed is not that of a couple of teams or brigades; the primary need for assistance is for specific experts, professionals, or professional experts that will help us resolve these issues. Number two is financial and technological assistance, because we come across certain items, certain circumstances where we will need experts, devices, medications, in order to resolve our problems. In this respect I would like to emphasize that the training exercises that we have discussed will allow us to orient ourselves towards establishing some regular procedures for what is needed when such catastrophes occur. Each nation has its own specific features, and these specific features, as our exercises have shown, should be taken into consideration. As an example I would like to tell you about two exercises that we conducted in Russia with the participation of international representatives--number one, in 1994 on the Astrakhan gas complex in which over 30 representatives participated from foreign countries. The exercises have shown that the majority of countries are interested in coordinating the issues related to the emergency response to accidents. In 1995, on the Kolsk Peninsula at the Kolsk nuclear power plant, we conducted a second and very important, I would say, international exercise on an accident at a nuclear power plant. Again, over more than 30 countries participated at this exercise, not only as observers but also as players in the exercise. Extremely important was the fact that during this exercise, we tried to develop an option, a version that included the participation of foreign experts in the liquidation of consequences of the accidents in the trans-bordering countries. The exercise was headed by an organization of the United Nations (UN). Also participating was the International Atomic Energy Agency. There was also a very large delegation from the United States. During this exercise with the participation of foreign experts, we considered the computer support for emergency response to this accident; the experience of this exercise has shown that the participation of international experts significantly assisted in the resolution of this problem in the development of the decision and the decision-making process and, most important, the participation of those countries in the direct liquidation of the consequences. In other words, the experts of a nation which is participating observe the course of liquidation. The experts themselves propose the services of their own countries to resolve the difficult situation. And it seems to me that this kind of experience, when certain serious situations will occur in a certain country, is very important. When we have, first of all, participating experts from those countries, this becomes a very important element that provides for successful work in the liquidation of extraordinary situations. Every year in Russia we conduct a series of exercises--first of all, at nuclear power plants. This year, 1996, we have conducted such an exercise at the Smolensk Nuclear Power Plant (NPP) with participation of representatives from foreign countries. Every year we conduct exercises at potential chemical and other dangerous sites. We conduct exercises on how to render assistance during earthquakes and floods, and the plan of cooperation and mutual efforts that we have developed and the work that has been conducted continues at the present time. That is on the coordination of our plans for every year on mutual participation in all these measures. We hope that all this will provide for more fruitful development and resolution of these issues.

I would like to use this opportunity to emphasize certain items that we have achieved already in Russia, because I think that this experience can be used also in the United States. Number one, we are developing national systems of control and observation of our seismic events. You know perfectly well that the long-term prognosis of seismology is not a big problem nor is the medium prediction either; however, short-term prognosis is a big problem today. So with the help of this system we want to resolve this problem as well. By concentrating our attention on all the accompanying elements that occur during earthquakes and by developing the computerized system with all the data about the accompanying elements being automatically forwarded to the information center and processed, we hope that within several hours before the earthquake we are going to have corresponding information about this event. A very important issue is the [public] reaction, and this afternoon I am going to dwell on that. The reaction, I would like to emphasize again, is a very important issue for us, especially for those who observed and who know the experience of the Sakhalin Island earthquake near Neftegorsk. These people are aware of the fact that for the first time perhaps it was in the international press when Russia, at Neftegorsk, was able to relatively successfully resolve the task of the emergency response after this earthquake. We were able to quickly concentrate our forces in Neftegorsk. We brought them from other parts of Russia. We did search operations and as a result 25 percent of the people who were under the collapsed structures were saved. Twenty-five percent is quite a large number. We think that this is a significant success. It also helped us for our search and rescue forces today to have advanced and sophisticated technological means in order to conduct search and rescue operations, to find people under these structures and corresponding means to extract people from the structures. This has helped us significantly toward resolving this problem.

(Next sentence not recorded.) That is a great success and we base our forecast on the floods which are caused by hurricanes in the Far East, an area which is subject to typhoons, hurricanes, and so on. So basically we pretty much rely on these forecasts. We also can pretty much forecast the temperatures, when the snow will begin to melt, and when the rivers will possibly overflow their banks and cause flooding. We are also concerned with various accidents at the pipelines. Of course our situation at our pipelines is very difficult. Approximately 20 percent of our pipelines have been in existence more than 30 years. About 30 percent have been in existence for 15 years or more, and if we are talking about various pipelines which lead to oil deposits, a lot of them need to be replaced, which often causes accidents, and quite often we have to respond to oil slicks, which as you know recently happened in Komi. You know that oil spills lead to contamination. This type of emergency response is

very difficult to conduct. Right now we are trying to resolve this problem. We're trying to prevent the oil from getting into the bodies of waters, and also we're trying to make sure that we will be able to get rid of this oil quickly and liquidate the consequences of oil spills. We are also concerned with forest fires. Every year in Russia, as much forest burns as we produce; in other words, the losses are extraordinarily large. This is now a priority. First of all, we are trying to rely on aircraft. You probably know that we have some specially equipped IL-76 aircraft, which carry up to 40 tons of water, and we also have some specially equipped aircraft, specifically helicopters, which carry from 1.5 to 6 tons of water. Right now we are developing a special aircraft B 200, which is going to get water to load when it is over the body of water which is near the fires. We also place a lot of importance to space tools so that we can coordinate and monitor these fire fighting operations, and we know from experience that this is doable, this is possible. Another issue which I would like to mention and to which we attach great significance is our operational center which we call the Crisis Situations Command Center and which exists at our Ministry, from which we coordinate emergency response in case of an emergency. Of course we also try to prevent disasters, but the main function of this center is to monitor and command operations during an emergency. We have all kinds of communication links, including communication links with foreign countries, and, as our recent experience has shown, we are able to get information about the developing, unraveling emergency quite quickly. We are computerized; in other words, our decision-making process is computerized. We are trying to make the decision as to what means to deploy for emergency response very quickly. We also have special quick response forces, and we transport our rescue squads, our rescue groups, as well as the necessary equipment to the location where the emergency has taken place. And lately we have been able to respond successfully to a number of emergencies. We think that this experience that we have accumulated should be shared with everybody when we participate in various exercises and other seminars and so on. We are trying to inform our foreign partners about our experience, and the delegation from FEMA which visited Russia this year actually demonstrated that it is possible to exchange information. We told them about our experience and we hope for good things from our further future cooperation with the United States, based on the MOU which was signed this year. This is the second time that we signed such a memorandum. The first time we signed it on behalf of the Soviet Union, and now we do it on behalf of Russia. We hope that it will lead to closer cooperation, to exchanges of information, and perhaps to positive results. Thank you.

Review of Russian experience in liquidation of the consequences of the Chernobyl NPP and South Urals Accidents from an emergency response point of view

Opening remarks of the session chairman

Dr. Victor A. Vladimirov, Panel Chairman: Dear colleagues, it is my opinion that we will tell you about our other presenters in the course of our work later on, but today at this meeting of our workshop we are considering the experience of the liquidation of the consequences of radiation catastrophes, of the example of the Kyshtym accident, the Mayak Production Association, and the Chernobyl catastrophe. I would like to be the first one to tell you about our experience.

Review of Russian experience in liquidiation of the consequences of the Chernobyl accident

The Chernobyl catastrophe, it is the only way to name it, that happened ten years ago in the night from 25 to 26 of April at the Unit 4 of the Chernobyl nuclear power plant turned out to be the most severe catastrophe of the present on the basis of its consequences. The national disaster, affected the fortunes of millions of people, residents of not only the vast territories of the former Soviet Union, but Europe itself.

Suffice it to say that in the Russian Federation alone the total area of territories contaminated with Cs-137 above 1 kBq/m^2 amounted up to almost 60 thousand m^2. About 3 million people inhabited these territories. In general 16 regions of Russia and three republics (Mordoviya, Tatarstan and Chuvashiya) contain contaminated areas. Fig. 1 demonstrates a map of cesium-137 contamination of the territory of the European part of Russia. Thirty million people live in the contamination zone.

Elimination of the consequences of the Chernobyl Accident required unprecedented, in peaceful time, mobilization of means and forces. Enormous resources were directed toward these purposes. Leading scientists and experts were recruited to overcome problems in Chernobyl.

It is necessary to mention that all the past years' scientific and practical support maintained the efforts to eliminate the consequences of the Chernobyl accident. Leading scientists in different fields, experts from different ministries, departments and organizations of the Russian Federation have done huge and useful work covering practically all sides of the Chernobyl phenomenon.

Therefore, in the first years after the accident (1986-1989 years) scientists concentrated their efforts mainly on solving the following problems: accident center "extinguishing"; radiation ranging and control on the

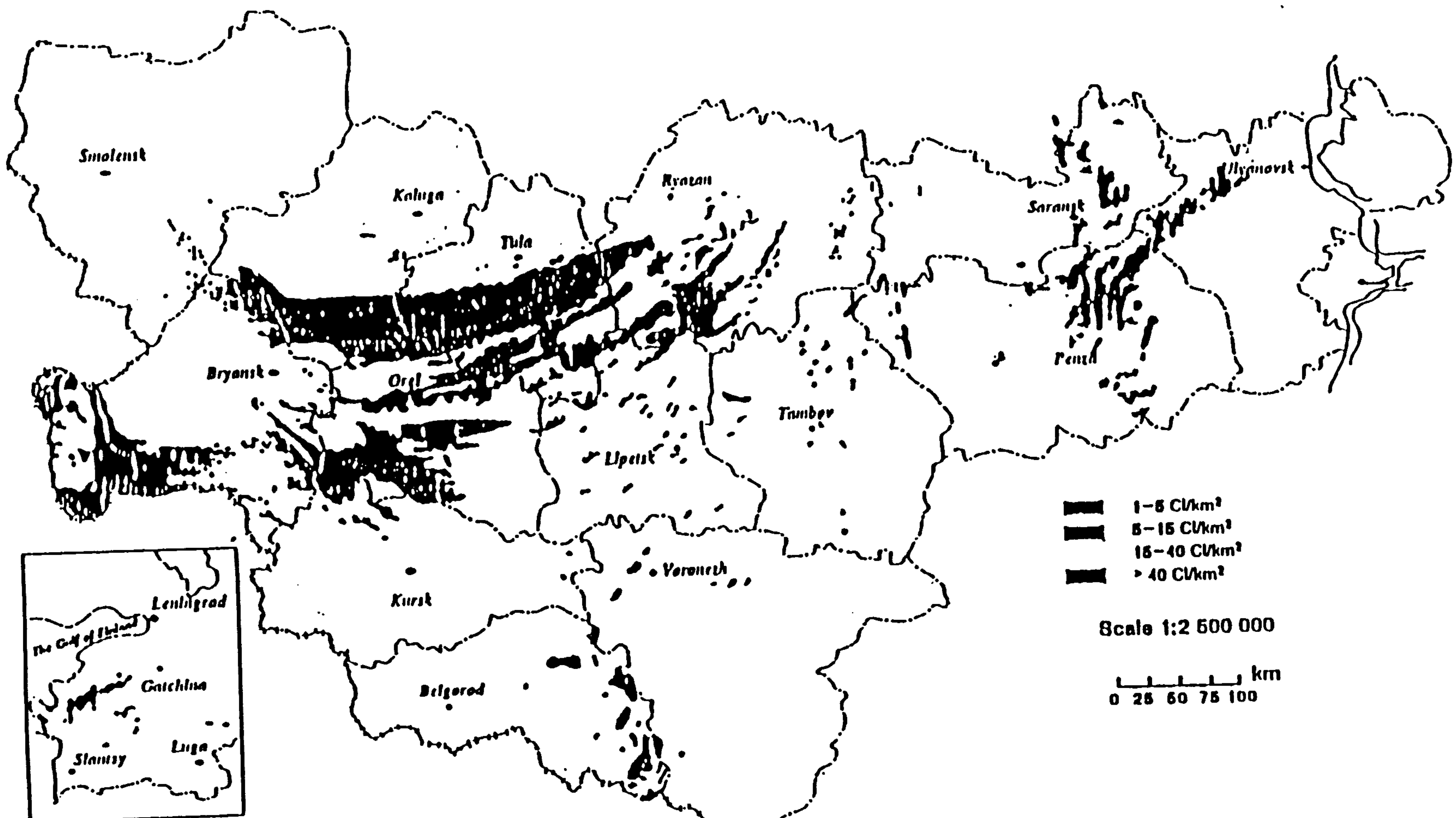

Fig. 1
Map of caesium-137 contamination density
with the margin ≥ 1 Ci/km² of the territory of the European part of Russian

contaminated territories; estimation of radioactive products release; resettlement of residents from contaminated areas; creation of the vital activity system for liquidators; decontamination of transport, production, administrative and residential lodgings, as well as contaminated territories; radioactive wastes burial; estimation of health condition of the population and medical protection measures; building of "cover" complex and others. The list of these problems is revealed on the picture. (Table 1)

The Main Problems for the Scientists to Solve in Eliminating Chernobyl Catastrophe Consequences in 1986-1989.

- "extinguishing" of the accident center;
- radiation ranging and control under contaminated territories;
- radioactive products release assessment;
- resettlement of residents from the contaminated areas;
- creating the vital activity system for liquidators;
- decontamination of transport, industrial and residential lodgings as well as contaminated territories;
- radioactive wastes burial;
- estimation of health condition of the population and medical protection measures;
- building of "cover" complex.

Table 1

In 1992, Russia accepted the State Program on Protection of the Population of the Russian Federation against the impact of the Consequences of the Chernobyl Catastrophe, implementation of which shifted the accents of scientific and practical works. The works are conducted in the following directions:

- health protection for people affected by the accident;
- social protection and social rehabilitation of the population, affected by the accident;
- ecological and radiological problems of the contaminated territories;
- agricultural industry and forest economy in the post accidental period on the contaminated areas;
- economic rehabilitation of the regions suffered from the accident, economical and organizational countermeasures, as well as technical features of the economy;
- management of the protective and restore measures to overcome accident consequences, including system analysis of countermeasures efficiency and informational problems;
- research investigations.

The list of these directions is presented in the picture. (Table 2)

The Main Directions of the Scientific and Practical Works to Protect Population Against the Impact of the Consequences of the Chernobyl Catastrophe

- health protection for those affected by the consequences of the accident;
- social protection and social rehabilitation of the population affected by the consequences of the accident;
- ecological and radiological problems of the contaminated territories;
- agricultural industry and forest economy in the post accidental period on the contaminated areas;
- economic rehabilitation of the regions suffered from the accident, countermeasures economy and organizational as well as technical features of the economy;
- management of the protective and restore measures to overcome accident consequences, including system analysis of countermeasures efficiency and informational problems;
- searching investigations.

Table 2

What are the main results of scientific and practical works on eliminating the consequences of the Chernobyl Accident for the period 1986-1996 and directions of efforts in the future?

1. Analysis of the results of radiation situation investigation, which have been carried out since the accident took place, enables us to conclude that the task to estimate and to define more precisely the scale and level of radioactive contamination of the territory of Russia has been tackled for the most part. A total of 6 million square kilometers have been investigated. Aerial gamma-radiation surveys and ground investigations have allowed us to prepare and publish contamination maps of the European part of Russia contaminated with Cs-137, Sr-90 and Pu-239 (1:500,000 scale) and Cs-137 (1:250,000 scale). The maps are shown on the pictures. It should be mentioned that for the specific features of the accident (release duration, physical and chemical conditions variation) and meteorological changes contamination of examined territories turned out to be non-uniform from the point of deposition density and radionuclides composition as well as physical and chemical characteristics. I determined that the total amount of

Cs-137, revealed on the territory of the European Part of the former Soviet Union, came to 0.28MBq. By now, information on radioactive contamination levels in more than 12,000 settlements is available.

At the moment, the whole contaminated territory of the Russian Federation should be subdivided into four following zones:

- 30-km zone around the Chernobyl NPP, where permanent living is restricted, and economic activity is limited;
- resettlement zone - density of soil contamination with Cs-137 more than 15 kBq km^{-2}. Therefore, the population living on the territories with density of soil contamination with Cs-137 more than 40 kBq km^{-2} as well as territories of this zone where average annual effective exposure dose can exceed 5.0 mSv is subject to obligatory resettlement. On the rest of this zone territory people may keep on living. For such people obligatory health control is provided, as well as protective measures to reduce population exposure levels;
- zone of residence with the right to leave - density of soil contamination with Cs-137 from 5 to 15 kBq km^{-2}. Residents of settlements of this zone may make a decision to leave this zone for another place of living. In so doing they will get corresponding compensations and privileges. Obligatory health control is also provided for the residents of this zone as well as protective measure to reduce exposure levels. Variation in resettlement of population from the above mentioned zones for the past years is shown in the picture;
- residence zone with privileged social-economic status - territories with density of contamination with Cs-137 from 1 to 5 kBq km^{-2}. Here, apart from the countermeasures complex including medical measures on radiation and radio-logical protection, the econmomical and ecological structure is beingelaborated to improve the living standard of the population. Restrictive zoning data are displayed in the picture. (Table 3)

It is necessary to notice that till now, the initial formation period of radioactive deposition, when the main contribution came from I-131 and other short-living radionuclides rather than cesium, has not been completely explored. Lack of reliable data on parameters of the radiation situation and its variation in first days and weeks after the accident hamper us today to estimate in a rather precise way during radiation burden on the population during the initial period of accidental situation. Lack of these data makes a number of tasks of methodological character concerning reconstruction of the radiation situation on the territory of the Russian Federation in the mentioned period difficult.

A large-scale analysis of the radioactive contamination of the Russian territories due to the Chernobyl Accident gave an estimate of radiation impact on the population of the territories classified as zones contaminated by the Chernobyl Accident. A calculation of a collective dose of external exposure of cesium-137 for the population showed that at present, the Chernobyl contamination does not contribute significantly to this value. Today, the Chernobyl component is not prominent at the level of global contamination by cesium-137.

Over the years after the Accident, annual exposure doses decreases many times for most of the contaminated territories. The external exposure dose lowered by a factor of 3 to 5, and cesium-137 intake with foodstuff lowered by a factor of 6 to 8 owing to the natural processes and special agro-meliorative arrangements. The slide shows the dynamics of the average annual doses for the population resident in the contaminated zone of 15 to 40 Ci/km^2.

Restrictive Zoning of Russian Territories Contaminated Due to the Chernobyl Accident, in Accordance with the Law of the RF

Residence zone with privileged social-economic status (Territories outside the 30-km zone, resettlement zone and zone of residence with the right to leave). Density of soil contamination with cesium from 1 to 5 kBq km^{-2}		Zone of residence with the right to leave (Territories outside the 30-km zone, resettlement zone). Density of soil contamination with Cs-137 is 5 to 15 kBq km^{-2}		Resettlement zone. (Territories outside the 30-km zone). Density of soil contamination with cesium-137 is note than 15 kBq km^{-2}		30-km zone (territories from which the population was evacuted or resettled).	
localities	inhabit., thous.	localities	inhabit., thous.	localities	inhabit., thous.	localities	inhabit., thous.
6594	2249	802	347	279	91	17	—

Table 3

However, since 1993, the content of cesium in human bodies in the most contaminated territories of the suffered regions grew noticeably. The explanation is that the population relaxed their vigilance and consumed wild mushrooms, berries, fish and milk from private farms.

According to our data, the annual exposure doses for the population of the 210 localities in the resettlement zone of the Briansk Region still exceeds 1 mSv, and in 4 localities these doses exceed 5 mSv.

At present time, reference books on exposure doses for the population are prepared for edition. They include committed accumulated exposure doses for the population up to 2056 and exposure doses for the population accumulated since 1986.

2. The analysis of the radiation and ecological situation in the radioactively contaminated regions drives us to the statement that in 1993-1994, the works in agro-industrial complex on elimination of the consequences of the Chernobyl Accident came into rehabilitation phase. In the first turn, this is a result of cleaning radioactively contaminated soils.

A half time of cleaning for the root layer of the soil is one of the main parameters, which characterizes the change in the soil contamination and thus in radiation situation. Effective half time of decreasing soil contamination by cesium-137 (with account of radioactive decay) is 10 to 25 years. These data can be used in predictive estimates.

Natural processes can be promoted by agro-technical arrangements (deep plowing, liming, enhanced potassium fertilizing, and other methods including in some cases engineering decontamination).

For example, in 1986-1994, the liming of acid soils in the 4 most contaminated regions of the Russian Federation (Briansk, Kaluga, Tula, and Orel Regions) was performed in the territory of 13348 km^2, and considerable improving of meadows and pastures was conducted in the territories of 1309 km^2.

In addition, measures on partial displacement of crops and types of cattle breeding were undertaken in the contaminated territories. The areas under some kinds of crops were reduced, the sheep breeding was curtailed, and forest exploitation was restricted.

The countermeasures undertaken in agro-industrial complex reduced the radionuclide content in production to permissible levels. Since 1991, all crop production was suitable for consumption.

In the Briansk Region, the production of milk contaminated over the quality standards was reduced from 76% in 1986 to 0.7% in 1994. The contaminated milk is mainly produced in private part-time farms.

The slides show the data characterizing the process of decreasing contamination of farm production in the most contaminated Briansk region.

The next period in the farming production will feature the gradual displacement of priorities from radiation protective measures to economic arrangements.

The main task in this field is to work out the measures for rehabilitation and development of agro-industrial production in all the territories referred to the accidental zone. Since this problem is to be solved with account of situation in particular region and farm, it is necessary to refine the current recommendations for the given climate, soil, and economic situation. This will demand serious scientific support of the industrial decisions at all stages of the rehabilitation period. It is necessary to continue the development of regional recommendations on choice of the most effective (in radiological and economic sense) technologies of crop production and cattle breeding structure.

Changes in conditions of cesium-137 in the soil and its accessibility to plants were registered since the accident, and this fact allows us to shift recommended agro-chemical methods from protective to protective and rehabilitative. It is necessary to develop accelerated methods for enhancing soil fertility and improving its mineral content (with account of microcomponents) disturbed by enhanced phosphorus and potassium fertilizing.

Stable production of crops, which meet standards on content of cesium-137 and strontium-90 in all radioactive contaminated territories, demands changing in radiation monitoring. Total radiation monitoring played positive role in the first years after the accident, but now it is rather negative than a positive factor, because it causes psychological stresses among the population and prevent stable developing economy in regions affected by the consequences of the accident. The development of a system for sampling preventive monitoring of crop production allows us to allocate significant resources into milk production, monitoring, and for revealing factors which cause milk production with radionuclide concentration exceeding the standard.

It should be mentioned that further measures undertaken for reducing radionuclide content in crop production involve large expenses and are not effective from the viewpoint of reducing dose burden for the population.

At the same time, temporarily excluded from utilization farming lands situated in the resettlement zone (more than

40 Ci/km^2) are still of phytopathalogic and radiation hazard (due to spontaneous haymaking). The developed methods of recultivation of these lands gave positive results.

3. On the territory of the Russian Federation the total area of forests with density of contamination by cesium-137 more than 1 Ci/km^2 exceeds 9500 km^2. In the most territories of Russia contaminated by the by the Chernobyl Accident, the cesium-137 concentration in barked timber does not exceed the permissible level in 1993-1995. Byproducts of timber such as turpentine, resin, tar, and alcohol actually do not contain radionuclides. At the same time, it should be mentioned, that the radiation situation in woods on the territory of more than 270 km^2 with density of soil contamination by cesium-137 of 15 to 40 Ci/km^2 features gamma radiation dose rates up to 200μR/day and radionuclide content exceeding current standards. In 30-km zone with 40 Ci/km^2, areas of forest equal 22 km^2, and dose rate is more than 200μR/day. Radionuclide content in barked timber reaches several dozens of thousand Bq/kg. Bark of leafy trees is mostly contaminated (up 150 000 Bq/kg). At these sites all kinds of forest exploitation are forbidden. The problem of these forests demands its solution and, first of all, in the part of fire protection.

In the post-accident period, the accessibility of cesium-137 for root assimilation gradually reduces, as well as for grass vegetation. Effective half-period of reducing concentration of cesium-137 in tree vegetation is of 6 to 15 years, depending on the kind of soil. So, even if we take the most conservative estimates, cesium concentration in main kinds of forestry production will reduce twice in the following 15 years.

Summering results of scientific and practical works on elimination of consequences of radioactive contamination of forest ecosystems shows, that for the rehabilitation phase of the Chernobyl Accident, a new concept of forestry must be developed, which will allow us to shift from restrictive to active measures in zone of residence with the right to leave, resettlement zone, and 30-km zone.

The conditions for the successful solution of this problem are the following: wide application of ecological and radiation-safety technologies, providing exposure dose reduction in all kinds of forestry, perfection of standards and development of forecasts for radionuclide content in forest production depending on density of soil contamination with radionuclides, types of forests, taxation indices of plantation, and season.

It is necessary to develop practical recommendations for purposeful using of the most clean forest production of various nature, preventing forest production with radionuclide content exceeding current standards and improving efficiency of forestry in territories referred to the accidental zone.

4. The concentration of radionuclides in water basins in radioactively contaminated territories are of the same level in the last three years. In average, the concentration of stontium-90 equals 0.2 10^{-12}Ci/l in 1995. This is two thousand times smaller than the permissible concentration. Cesium-137 concentration in rivers flowing over the contaminated territories of the European part of Russia (the Upa, Plava, and Oka) is less than the threshold of meters. In the Zhizdra river (Kozelsk town), it is not more than 0.5 10^{-12} Ci/l, which is considerably less than permissible standards for concentration and temporary permissible level TPL-91. So, contamination of water and bottom deposits in almost all rivers and reservoirs is not dangerous for water consumption. The exception is the Lake Kozhanovskoe (cesium-137 deposits are of 100 Ci for lake area of 6.5 km^2). Cesium-137 concentration in fish from this lake exceeds many times the permissible levels.

5. Radioactive contamination of the atmosphere before the Chernobyl Accident was caused by tests of nuclear weapons. In 1982-1985, the minimal concentration of long-lived beta-active products of explosion was established. The average concentration of cesium-137 over the country was 40.2 10^{-20} Ci/l. In May, 1986, concentration of the long-lived total beta-activity in the surface layers of the atmosphere increased by 4 orders of magnitude. But this was a short-term increase and concentration fell rapidly. By the end of 1986, it slightly exceeded natural background (less then twice). In 1992, an analysis of radioactive contamination of the surface layer of the atmosphere in the territory of the Briansk Region mostly contaminated by the Chernobyl Accident showed that concentration of cesium isotopes in air is considerably lower than requires restriction. Average annual inhalation dose does not exceed 0.05% of natural exposure dose and is equal to units of microsieverts.

6. The analysis of materials obtained by scientific groups on risk assessments for liquidators and the residents of the territories referred to the zone affected by the Chernobyl Accident shows that changes in health of liquidators and the population must be related not only with radiation factor, but with the whole complex of consequences of the Chernobyl Accident.

The mentioned above tendencies in deterioration of the total medical and demographic situation in monitored territories, and first of all for such integral factor as mortality of the population and the liquidators, prenatal, infant and mother mortality, and primary disability, are determined by a complex of reasons. The main role is played by social factors, which are typical not only for this region but for the whole Russia.

Analysis of distribution and tendencies for morbidity in the Briansk, Kaluga, Tula, and Orel Regions in pre- and post-accidental periods does not show pronounced increase of these factors during last years. In pre-accidental years, the morbidity in these four regions was higher than average morbidity in Russia.

On the whole, the performed investigations do not confirm or deny the impact of radiation factor of the Chernobyl Accident on the morbidity.

The ascertained factor is a progressive increase of thyroid cancer morbidity among people, who were children at the period of the accident. One hundred and twenty such cases are registered by the present time.

The slide slows the data on the thyroid cancer morbidity among children of the Briansk Region.

In 1992, the Russian State Medical and Dosimetry Register was established. It provides planned and systematic monitoring of suffered people's health and implementation of modern medical, preventive, and health measures. At present, more then 260,000 people are registered.

7. Analysis of social and psychological situation on the territories, referred to the accidental zone slowed that now the sense of radiation hazard relaxed.

We can state that by now social tension in the territories referred to the accidental zone does not exceed the average Russian level and is not related with ecological hazard, but rather with such social and economic problems as lowing living standard, inflation, disability to conform to new economic conditions, criminogenic situation, and low personal economic activity.
The analysis of the current situation shows the necessity to revise previous rehabilitation policy, which formed the "victims complex" in people living in contaminated territories. At the rehabilitation phase, the main goal is to shift from "compensation" mechanism to efficient regenerating territories by active involving people in processes of social-economic development of the territories.

Before the Chernobyl Accident, in the Soviet Union there was no law, regulating rights and responsibilities of citizens, administration and the government in case of radiation accidents, which cause contamination of territories. Immediately after the accident at the 4th unit of the Chernobyl NPP, temporary normative documents were operatively developed for protection of the population and liquidators. Prompt enactment of these normative documents moderated the impact of the accident on human health.

In 1991, the concept was developed on safe residence in regions contaminated by the Chernobyl Accident. This concept stated that citizens have rights on legislative privileges and compensations for improving their health and welfare. Average annual equivalent dose in 1991 and the following years was established as a criterion of possible injury. By these means the concept was related to actual radiation situation in the territories contaminated in result of the Chernobyl Accident by 1991.

On a basis of the concept a Law on social protection of citizens suffered from the Chernobyl Accident and was adopted, where along with the dose criterion (average annual equivalent dose in 1991 and the following years) zoning was established in accordance with densities of contamination by cesium-137, strontium-90, and plutonium. The relationship between human exposure dose and density of territory contamination is different for various biochemical regions and varies with exposure time and depends considerably on the taken counter measures.

In fact, privileges and compensations determined in accordance with density of contamination by cesium-137 of the residences zone, so there arose a discrepancy between the privileges and actual exposure doses.

For perfection of the normative basis on protection of the population from radiation impact, RNCRP developed a new "Concept on Radiation, Health, and Social Protection and Rehabilitation of the Population affected by Emergency Exposure." The concept is based on the dose criteria - annual exposure dose and the dose accumulated during a life period - and determines measures for protection of the population at current exposure (more than 1mSv) as well as at emergency exposure in the past. This concept provides a basis for the development of the comprehensive law on social protection of the citizens affected by emergency exposure and it will be a foundation for arrangements on the Unified State Program on Protection of the Population from Impact of the Consequences of the Chernobyl Catastrophe for the following period.

The analysis of the main scientific results and studies of the Chernobyl problems at Russian territories shows that the comprehensive approach is the right way for effective solution of actual problems on implementation of measures at the rehabilitation phase of the Chernobyl Accident.

It should be mentioned, that in this field Russian scientists work in close cooperation with researchers of Ukraine and Belarus Republics, and also with international organizations: WHO, UNESCO, and CEC.

The international cooperation allows the scientists to discuss widely the obtained results, to sustain or rebut scientific hypotheses on the basis of modern methods and technical support.

Russians researchers accumulated a tremendous experience in elimination of consequences of radiation contamination and moderation of the consequences of radiation impact on the population. This experience was formed at nuclear tests, elimination of the radiation consequences in Kyshtym (1957), and in elimination of the consequences of the Chernobyl Accident. Our goal for the nearest future is to preserve, summarize and publish the materials we have, and make all information on radiation impact available to the public.

Lessons and Conclusions Arrived at as a Result of Elimination of Consequences of the Accident the Chernobyl Nuclear Power Plant

More than 10 years have passed since the Chernobyl accident, the most grave catastrophe of the present time, which affected the fates of millions of people.

The lessons of the accident, its bitter experience, cannot be forgotten by the whole of mankind and particularly by the specialists working in the field of ensuring the safety operation of nuclear power plants and other nuclear facilities as well as by those who are responsible for the preparedness of respective administrative bodies, forces and means for elimination of consequences of possible accidents and catastrophes.

The Chernobyl catastrophe is not only the tragedy of the twentieth century, but also a heroic epopee of those who formed the first lines of fighters against a lot of hazards hitherto unknown to a sufficient degree and numerous "liquidators" (both civil and military specialists) who took an active part in the work on localization of the accident and elimination of its most severe effects, in decontamination work and construction of the "sarcophagus" to enclose the damaged power unit. It should be noted that much of the work was performed for the first time at such a large scale.

Below, I will briefly remind the readers some general information concerning the accident.

It occurred at the night of April 26, 1996 at the RBMK-1000 reactor (a high power channel-type reactor with an electric power of 1000 MW) of the fourth power unit of the Chernobyl nuclear power plant during some within-the-design-basis tests at one of safety systems of the unit, which were timed with the reactor shutdown for scheduled preventive repair.

As a result of some violations of the reactor regulation rules, combined with certain drawbacks of the design of relation bodies and nuclear-physics characteristics of the RBMK-1000 reactor, the experiment led to the explosion of the reactor. The core was damaged and the radioactive materials with an activity of about tens of millions of Ci were released into the environment.

The localization of the accident center took as many as ten days of intense efforts of scientists, specialists in various branches of industry, servicemen of the Ministry of Home Affairs and the Ministry of Defense.

The radioactive materials released into the atmosphere from the damaged core were carried by air flows tens or even thousands kilometers from the damaged NPP, which resulted in radioactive contamination of vast territories. The total amount of the fission products released was about 10 MCi, i.e., 3.5 percent of the total amount of radionuclides in the reactor as of the day of the accident.

In the former Soviet Union alone, the overall area of territories with a density of contamination by radioactive caesium above 1 Ci/km^2 amounted to more than 130 thousand km^2 (of which 56 thousand km^2, 7608 inhabited localities, are within Russia). The map of contamination of Russian territories by Cs-137 with a density of no less than 1 Ci/km^2 is presented in Fig. 1 *(located on page 13)*. As of the day of the accident, about 4.9 million people (2.6 million people in Russia) inhabited the suffering territories. On April 27, the population of the town of Pripyat (about 50 thousand people) situated 4 km from the NPP were evacuated in an organized manner and then, as the radiation situation was getting worse, the population of inhabited localities in the 10-km and 30-km zones around the NPP were resettled. In total, 116 thousand people were evacuated from zones of radioactive contamination.

The elimination of the Chernobyl catastrophe consequences demanded enormous human efforts, material expenses, great organizational work. In spite of all this, the work on elimination has not been completed yet.

The scale of the work at the first stage alone can be judged from the following.

While localizing the center of the accident via filling the reactor drift with heat-removing and filtering materials (which was recognized by the scientists and practical specialists as the most reasonable in the situation of those days), approximately 5 thousand tons of those materials (boron compounds, dolomite, sand, clay, lead) were dumped to the reactor from April 27 to May 10, 1996, which required over 1800 helicopter flights.

As a result, the reactor drift was covered with a layer of bulk materials that adsorbed aerosol particles intensively, which allowed to have reduced radioactivity releases by

May 6 and stopped the temperature growth in the reactor drift.

At the same stage, rather hazardous work on clearing an access to the damaged power unit, removing the nuclear fuel mass released as a result of the explosion, pieces of graphite masonry and structural elements was conducted.

The localization of the major center of radioactive contamination was actually finished only after the "sarcophagus" enclosing the damaged reactor ("Ukrytiye" project) had been completed, in which up to 96.5 percent of the nuclear fuel of the reactor was buried. In the construction work that lasted for 5.5 months, up to 10 thousand people were involved 24 hours a day. They cast over 300 thousand tons of concrete and mounted 7 thousand tons of metal structures. A view of the "Sarcophagus" enclosing the 4th power unit of the Chernobyl NPP is presented in Fig. 2. *(Fig. 2 unavailable for publication)*

An enormous volume of work on determination and monitoring of the radiation situation, decontamination, protection of surface and underground waters from radioactive contamination was accomplished.

Simultaneously, in the course of all kinds of the work, we acquired invaluable information on possible effects of accidents at NPPs, unique comprehensive experience that required some theoretical scientific efforts and often non-conventional solutions, violation of the accepted views of radioactive contamination nature and ways of radiation protection based on evaluation of the results of nuclear tests and respective recommendations.

We believe that this experience should become the common property of the whole mankind.

These issues will be discussed in what follows.

Peculiarities of Radiation Situation Formation

The experience of the Chernobyl accident evidences that, as distinct from a nuclear explosion, a release of radioactive materials in the case of an accident with destruction of the nuclear reactor is usually a relatively long process during which meteorological conditions may change, thereby giving rise to an extremely intricate nature of radioactive contamination of the atmosphere and territory. The nature of the contamination also depends significantly on some parameters of the reactor itself (type, power, time of operation, etc.).

This may lead to a situation similar to the Chernobyl one, i.e., radial, non-uniform contamination of the environment.

Moreover, in case of an NPP accident, the rising flows lifting radioactive materials are of a lesser intensity as compared to those appearing in cases of nuclear explosions, which, on the one hand, conditions a relatively low altitude of the materials lifted and, on the other hand, their dispersion throughout the entire altitude of the lift (this refers as well to the Chernobyl accident).

It is worth noting that the very initial release of radionuclides from the damaged reactor of the ChNPP produced two distinct radioactive plumes, namely, western and northern ones, because of the fact that the near-the-ground wind in the vicinity of the NPP was due east and that at an elevation of 500-600 m, due south-east. As a result, the most heavy, fast-condensed radionuclides spread due west while lighter ones (iodine and caesium radioisotopes) were transferred due north-west. This can be readily seen from Fig. 3 where the zones of countermeasures on population protection prior to and after the accident are given as of April 28, 1986.

Later, from April 28, 1996 to about May 10, 1986, the wind direction changed more than once. The intensity of radioactivity released from the reactor also varied as a result of the efforts on dumping heat-removing and filtering materials onto the reactor, which gave rise to a non-uniform radial contamination of the area around the ChNPP. This is clearly seen in Fig. 4 where the post-accident zones of population protection are displayed.

The foregoing allows us to conclude that prediction of possible scale and character of radioactive contamination in cases of accidents at NPPs demands taking into account a lot of parameters peculiar to every NPP and every accident. In this connection, our predictions as to possible accidents at NPPs are tentative.

I should like to point out that, taking into consideration a great number of long-lived radionuclides accumulated in the process of reactor operation prior to the accident (over two years), the natural decrease in the activity in contaminated territories is rather slow. For example, the gamma-radiation dose rate after two months reduced only by a factor of 4, after 6 months by a factor of 5, after a year by 8 times, after 2 and 3 years by 16 and 26 times respectively. This is much slower than the rates of activity decrease in cases of nuclear explosions.

For the time being, the contamination of territories is determined by Cs-137 and Sr-90 with a half-decay time of about 30 years. Hence, the theoretical expectation of natural cleaning of the territories is 8 to 10 half-decay times, i.e., 240 to 300 years.

As to the nature, the same process is more fast there. The effective period of half-reduction (half-cleaning) of the root-inhabited soil layer ranges within 10-25 years for

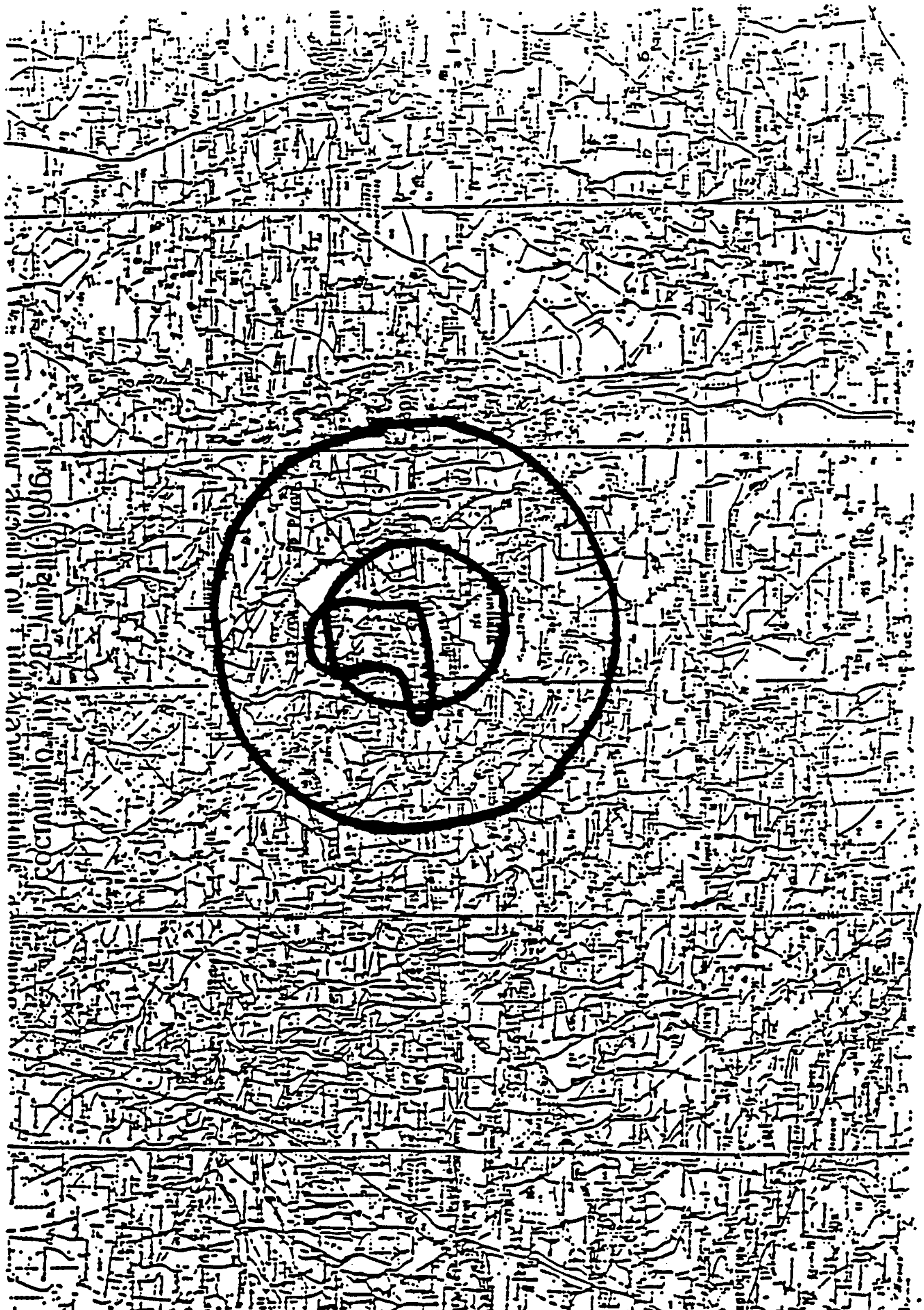

Fig. 3

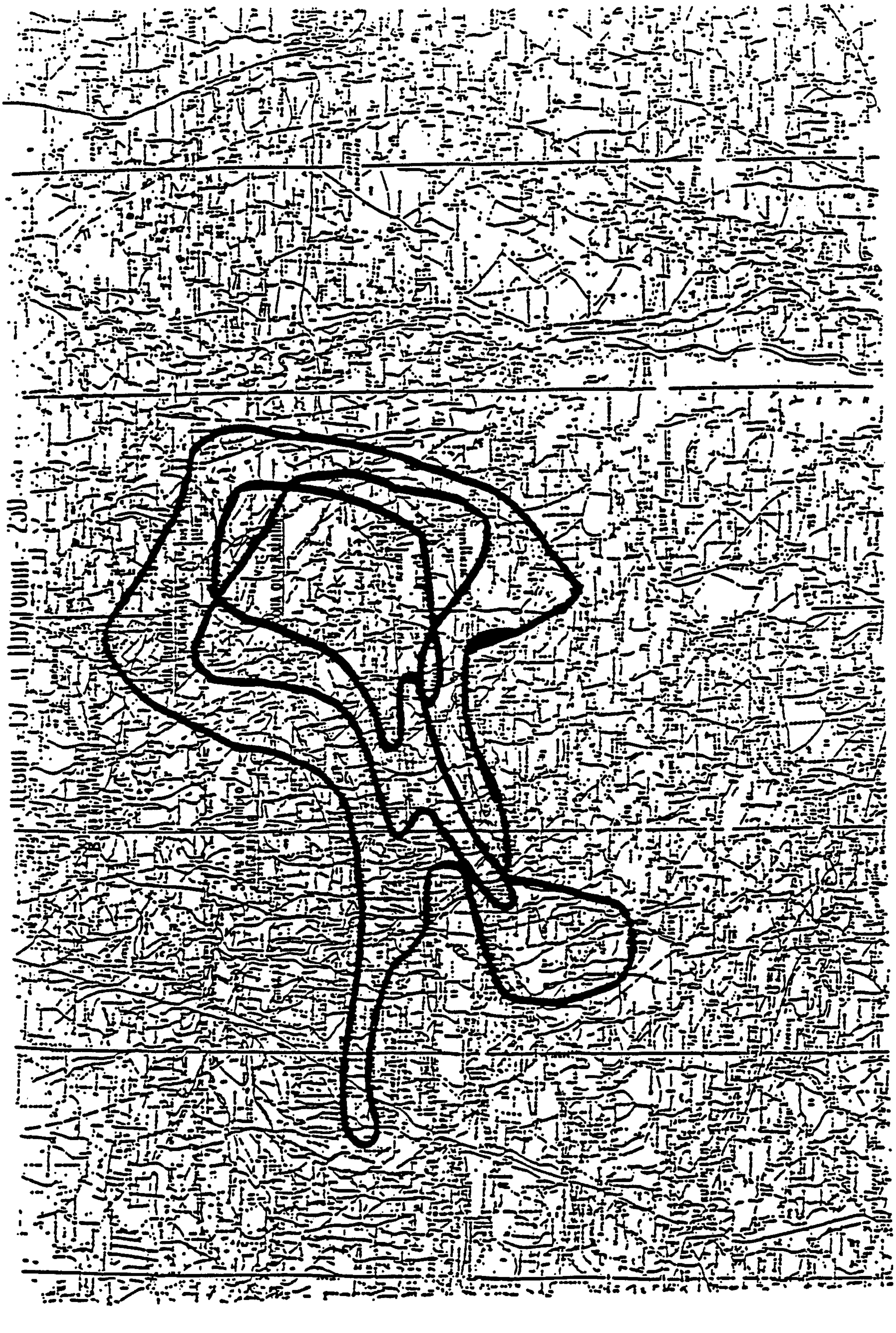

Fig. 4

Cs-137 (with taking radioactive decay into account) and is 1.2-3 times shorter for Sr-90.

Additionally, the cleaning of the root-inhabited soil layer in some places can be accelerated via a number of agrotechnical steps (deep ploughing, conversion of radionuclides into insoluble compounds, and even engineered decontamination of the affected soils in some cases).

Similar to herbaceous vegetation, the availability of Cs-137 for uptaking by forests through roots is gradually declining during the post-accident period. The effective period of half-reduction in the Cs-137 concentration in lignosa ranges from 6 to 15 years depending on the soil type.

As to the radioactive contamination of aerial and water basins, in May 1986 the concentration of the total long-lived beta-activity component in the surface air in the vicinity of the Chernobyl NPP increased by nearly 4 orders of magnitude as compared to the background. However, that rise was short in time, and by the end of 1986 the concentrations of radioactive substances in the air were only in a slight excess over the natural background (4×10^{-20} Ci/l). In Russia, the contamination of water bodies and bottom sediments also present no hazards to water use (0.5×10^{-12} Ci/l), with the exception of Lake Kozhanovskoye in the Briansk Region, in which the amount of Cs-137 is approximately 100 Ci at a water surface area of the lake of 6.5 km^2.

It should be stressed that a peculiarity of releases from the damaged reactor was a very small mean size of radioactive particles ($<2\mu m$), which assisted in penetration of the particles into microcracks, paints, etc. and thereby hampered decontamination of the NPP site, inhabited localities, lands, machinery, and enhanced the danger of accumulation of biologically active radioisotopes in human organisms.

Radiation Situation Survey and Control

The specificity of radiation situation survey in the course of elimination of effects of the Chernobyl accident was conditioned to a great extent by the above peculiarities of formation of the radiation situation and its character. The data of the survey were required, first and foremost, for assessing the plausible levels of external and internal exposures to the ChNPP personnel, population of the town of Pripyat and those within the 30-km zone, establishing the world regimes for people involved in localization and elimination of accident consequences.

After some concentration of forces, the systematic surveying of the radiation situation started as early as in the afternoon of April 26, 1986.

The entire territory of the ChNPP and around it was divided into a number of areas (zones) assigned to respective ground survey units. In the zones, some obligatory measurement points were defined, 29 within the NPP site and 36 in adjacent areas within the 30-km one. The survey there was conducted using special vehicles of radiation and chemical survey at regular time intervals (6 hours). The zones of radiation situation survey in the accident region are displayed in Fig. 5.

Beyond the 30-km zone, about 20 stations for control of radiation situation, water, foodstuffs and the environment were deployed within a short time. Aerial gamma-radiation survey of the NPP area was performed as well, which allowed, beginning from April 28, 1986, prompt assessment of the radiation situation.

In the most hazardous zones, including the near zone of obstruction next to the walls of the reactor compartment and powerhouse hall, the survey was performed with the help of a special engineered clearing vehicle with an additional shield (the attenuation factor was up to 1000).

At the same time, it should be noted that, from the very beginning of the work on elimination of accident consequences, the lack of high-sensitivity devices for measuring all kinds of ionizing radiation manifested itself quite perceptibly. The army technical means for radiation sitiation survey were sufficient only within capabilities of standard equipment, primarily within the gamma radiation measurement region, but it immediately became obvious that the equipment for gamma-radiation control only was insufficient. Some information on radiation control means employed during the work on elimination of Chernobyl accident effects is given in Fig. 6.

A number of difficulties appeared when using mobile means of radiation situation surveillance (BRDM or RKhM type vehicles, helicopters).

For instance, the amount of radioactive substances accumulated within 24 hours on the overalls of the staff of survey vehicles on the basis of UAZ-469 cars produced a dose rate of 1 rem/h. This means that non-airtight survey vehicles cannot be employed under dusty conditions.

The backgrounds from radioactive contamination of outer surfaces of survey means were as follows: a few mrem/h from outer surfaces of helicopters, 3 to 5 rem/h from under frames of ground survey vehicles, hundreds of mrem/h from engines. Therefore, the use of open vehicles was impossible at low radiation levels. It was recommended to measure radiation levels in the field

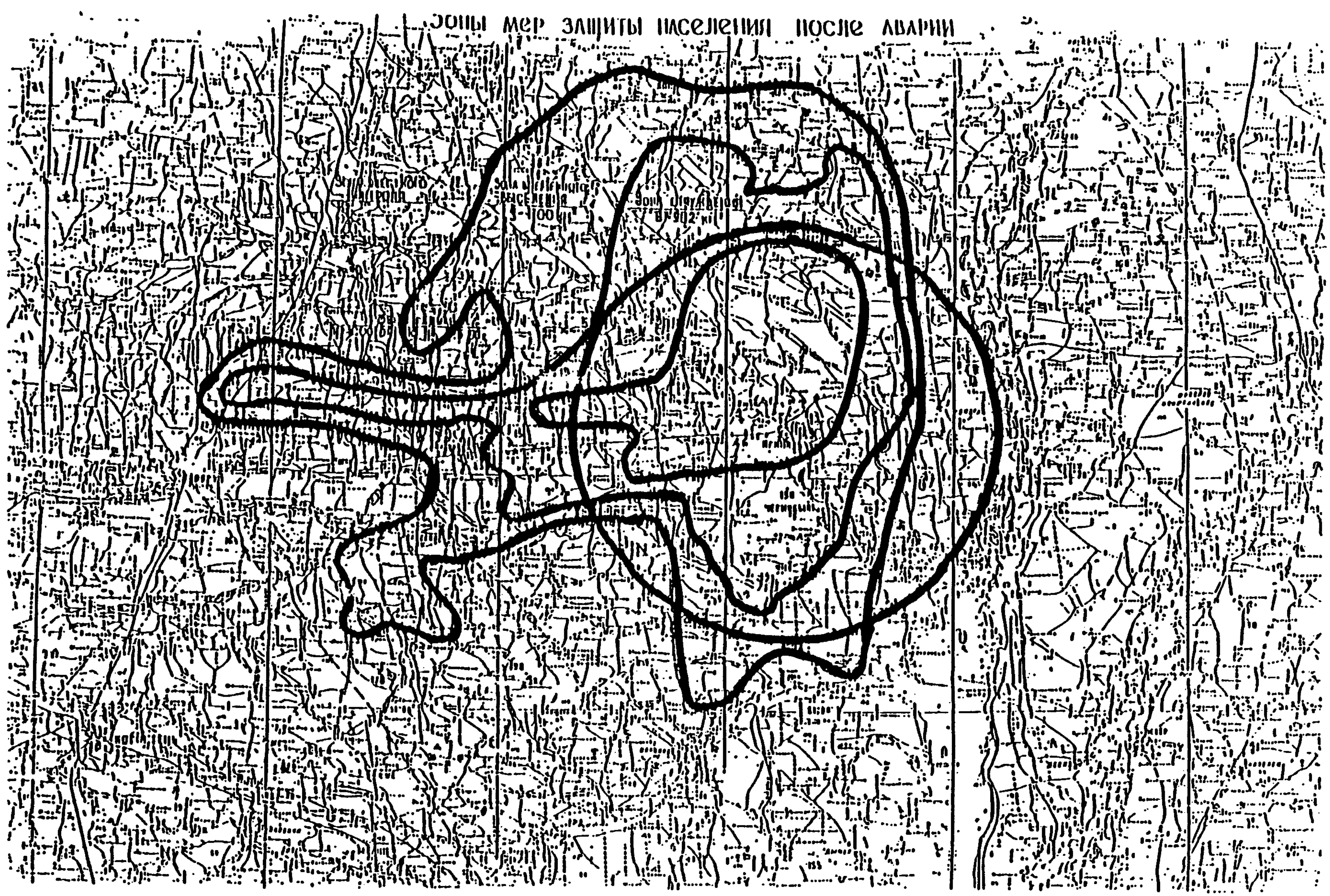

Fig. 5

Principal tactical characteristics and specifications of dosimetric devices					
Name of device	Purpose	Radiation absorbed dose measurement range	Range of measurable energies	Beta-Radiation measurement range	Measurement error
DP-5V	Dose rate meter	0.05 mR/h - 200R/h	0.084 MeV - 1.25 MeV	—	35%
DP-3B	Exposure dose rate meter	0.1 R/h - 500 R/h	—	—	15%
ID-1	Kit of personnel dosimeters	20 rad - 500 rad	0.08 MeV - 2.2 MeV	—	20%
DKP-50A	Personnel dosimeter	0 rad - 50 rad	0.1 MeV - 2 MeV	—	10%
DK-0.2	Personnel dosimeter	10mR/h - 200 mR/h	0.2 MeV - 2 MeV	—	10%
KRBG-1	Correlation radiometer	0.025 - 300 R/h	0.1 MeV - 2.5 MeV	5 x 10 - 5 x 10^6 fissions/(min x cm^2)	30%
ID-11	Kit of personnel dosimeters	10 rad - 1500 rad	—	—	15%
SRP-68-01	Detection of natural radioactive substances	0-3000 μR/h	Beginning from 0.05 MeV	—	10%
KRAN-IAN	Alpha/neutron radiometer	Thermal neutrons: 2.5-25 x 10^3 n/(min x cm^2)	0.1 MeV - 2.5 MeV	Alpha radiation: 2.5 - 25 x 10^3 fissions/ (min x cm^2)	20-30%
KID - 6	Kit of personnel dosimeters	0.005 - 2 rad 2 - 500 rad	300 keV - 1.25 MeV	—	10-20%

Fig. 6.

under such conditions by means of portable devices (DP-5V type) at a distance of 20-30 m from the survey vehicle under measurement (the same referred to helicopters that landed for each measurement).

Because of insufficient shielding of survey vehicles and helicopters for the work in the immediate vicinity of the damaged reactor, their protection was strengthened via mounting additional lead shields on them. As a result, the achieved attenuation factor for, e.g., a BRDM type survey vehicle was K=40, though, naturally, at the sacrifice of mobility and maneuverability.

It is also worth noting that, due to insufficient psychological stability of individual workers and fear of overexposure (especially at the initial stage), survey routes were sometimes shortened and/or the speed of the vehicles was increased, which gave rise to distortion of the actual situation in some areas. A number of steps (personal demonstration, explanation, etc.) had to be taken to prevent such tendencies.

Another solution to the problem was also suggested. Two survey vehicles would be used in tandem, one of which would go along the route and the second would keep within the areas with low radiation levels (as a rule, within the field of vision of the first vehicle) and maintain radio communication, playing, if necessary, the part of an emergency tow truck on duty.

The radiation situation survey by areas of responsibility (zones) within which radiation levels at reference points were measured also proved its efficiency. The accumulated experience suggests that the spatial choice of the reference points must be extremely accurate. This allows a more clear pattern of alterations in the radiation situation. In the Chernobyl zones, such points were marked off by special signs (pickets, fencing signs, inscriptions, etc.).

In the course of the work on elimination of accident effects, the necessity of determining the boundaries of zones with certain radiation levels had to be faced with more than once. We could mention the determination of the boundaries of the zones with doses of 75 and 25 rem/year (see Fig. 3.), zones of exclusion, temporary resettlement, strict control, as well as indication of zones with radiation levels 5 mrem/h or higher (Fig. 4.); in the latter case, ground survey vehicles moved along the boundary of a zone, performing the turns by 120 degrees (Fig. 7) *(Fig. 7 unavailable for publication)* which made possible to solve the problem.

The experience of the Chernobyl accident indicated the necessity of reliably protected, robotized mobile means for radiation situation survey (including unmanned aircraft), automated systems of radiation control, especially in those areas around NPPs and other projects that pose radiation danger, which would provide timely detection of radioactive substances released, warning of population, taking countermeasures on population protection, and prevention of exposure to population.

In general, an analysis of the results of radiation survey in the accident area allows the following conclusion. In cases of accidents at NPPs, the radiation survey should be organized in the following lines: **detection of the fact of an accident at an NPP** — on the basis of the data of the automated radiation control system; **prompt determination of the radiation situation scale and character** — by means of aerial survey using helicopters and planes equipped with an apparatus for aerial gamma-radiation survey and dosimetry control to measure the dose rate in the range from the natural background to several hundreds of rem; **determination of radioactive-contamination zone boundaries** — with the help of ground survey using dosimetric surveillance means and/or via sampling with subsequent processing to reference isotopes.

In the course of the work on elimination of consequences of the Chernobyl accident, we faced the problem of practical mass radiation surveillance for the first time and in full scale. We managed to solve it. In Fig. 8, this is proved by the data on the radiation situation in the accident area, characterized by Cs-137 and Pu-239 radionuclides. However, we must admit that our preparedness for solving the problem turned out to have been insufficient.

The causes are as follows:

- the lack of the requisite set of technical means, especially for prompt analysis;
- the lack of the requisite basis for radiochemical analyses;
- poor training level of the workers (DP-100, taking smears).

These problems were solved in the course of the work.

Nonetheless, the experience of eliminating the Chernobyl effects evidences that required are:

- technical means for control over alpha, beta and gamma contamination of various surfaces, soil, water, foodstuffs;
- apparatus for prompt analysis of such contamination, spectrometric equipment;
- good laboratory basis for radiochemical analyses.

The organization of dosimetry control also suffered from a lot of shortcomings. In the very beginning, the entire personnel exposure control was performed primarily by means of army dosimeters presented in Fig. 6 (DK-0.2, DKP-50, ID-1, ID-11). All of them did not enable to solve the problem of dosimetry control. Some devices (DK-0.2) gave off-scale readings, others (DKP-50) had a high self-discharge or (ID-1 and ID-11) could not provide dosimetry control up to 10 rem. An attempt to use some calculation procedures turned out to be rather insufficient. Only application of other types of dosimeters (D-2r, DPG-03, etc.) permitted to solve the problem.

The experience of the Chernobyl accident confirmed once more that, in order to solve the problem of control of exposure to personnel during both peace and war time periods, a kit of dosimeters is required, capable of providing exposure control within a broad range.

Nowadays, a large variety of radiation control devices have been developed.

Decontamination Work

To ensure further functioning of the NPP, prevention of overexposure to people and transfer of radioactive materials beyond the 30-km zone, the decontamination work at the Chernobyl NPP and in adjacent territories was organized. It started in April 1986 and included:

- decontamination of the territories, buildings and structures of the NPP, inhabited localities, transport and other machinery;
- gathering, removal and burial of radioactive waste;
- sanitary treatment of people, decontamination of overalls and personnel protection means;
- decontamination of roads and dust suppression.

The above tasks were entrusted to the Forces of Radiation, Chemical and Biological Protection of the Ministry of Defense, army units and non-military formations of the Civil Defense. The number of the personnel involved in the work ranged from 16 to 30 thousand people in different periods of time.

Taking into account the afore-mentioned peculiarities of radioactivity releases from the damaged reactor and those of formation of the radiation situation, from the very first days, along with solution of practical issues on elimination of consequences of the radioactive contamination, a wide search for the ways of improving the efficiency of decontamination work was performed, novel technical means, prescriptions, procedures and methods for decontamination were developed. Tens of scientific research institutions were involved in those efforts.

The volume of the main work on decontamination of the ChNPP and inhabited localities amounted to:

NPP

Decontamination of rooms — 31.4 million m^2, including 6.5 million m^2 in 1986.
Decontamination of territories — 9.7 million m^2 (2 million m^2 in 1986).
Burial of radioactive waste — 336 million m^2.

Inhabited Localities

Decontamination of inhabited localities — 868 (164 in 1986).
Decontamination of buildings (beginning from 1987) — 28.7 thousand.
Decontamination of territories — 12 million m^2.
Removal of contaminated ground — 4.6 million m^2.
Transportation of contaminated ground to special sites — 730 million m^3.

a) NPP decontamination

The first, most complicated decontamination stage accomplished under conditions of a "forced emergency regime" in the absence of experience in such a large-scale work started as early as on April 28, 1986.

The NPP site was divided into several zones, in each of which the decontamination was performed in the following order:

- removal of contaminated equipment and garbage from the territory;
- decontamination of roofs and outer surfaces of the buildings;
- removal of a ground layer 5 to 10 cm thick and transportation of the ground in specially prepared concrete or iron containers to a solid-waste repository;
- placement, if necessary, of concrete plates onto the ground or addition of "clean" ground;
- covering some roofs, plates and the territory not set in concrete by film-forming compounds.

As a result of the countermeasures taken, the overall gamma radiation background in the vicinity of the 1st power unit was reduced from several hundreds of rem/h to 20-30 mrem/h.

The compositions of some decontaminating solutions applied in Chernobyl are given in Figs. 9 and 10. In Fig. 11, those of SF type preparations employed for preparing decontaminating solutions are presented.

Treatment of the equipment and inner rooms of the plant was performed basically via manual cleaning with the help of rags and washing solutions. Later, to deliver the solutions to the surfaces under treatment, special devices (DKV-1) were used and hydrovacuum cleaners (versatile cleaning/decontamination facilities) were employed for gathering spent solutions. Painted surfaces of the rooms were treated by special solutions (0.3% SF-2u, SF3k).

As a rule, plastic floors and metal surfaces were treated in several stages: at first, by means of a water solution with 2-3% of alkali and 0.5% of potassium permanganate and an hour later the surfaces were rinsed with water and then treated by 2 to 3 percent solution of oxalic acid. Finally, the surfaces were rinsed with water. The overall discharge of water was 2-3 l/m^2. The decontamination factor was 3 to 5 in average.

Polymer coatings based on polyvinyl acetate dispersions, polyvinyl butyral, as well as the French composition 'Pelable' and others were applied rather extensively for the purposes of decontamination. In general, application of polymer coatings ensured a reduction in contamination levels by 10 times or even higher. The ultimate efficiency was achieved when treating dusty surfaces.
Outer surfaces of buildings and structures of the NPP were decontaminated primarily by means of washing solutions delivered by petrol dispensers or fire-engines. The efficiency of this process was not very high (the decontamination factor was 1.2 to 1.5) and, as a rule, to reduce the radioactive contamination density by a factor of 2-3, the procedure had to be repeated more than once.

Decontamination of roofs of the buildings and structures presented additional difficulties. Coated with bitumen sorbing willingly the radioactive substances, the roofs defied decontamination via conventional procedures (by means of washing solutions). Mechanical removal of bitumen coatings provided the highest efficiency, but it implied a low productivity, especially under conditions of a high external gamma-radiation background.

Some information on efficiencies of the procedures applied to decontamination of the NPP site and buildings is given in Figs. 12-14.

Compositions of some sorbert-based DSs applied in Chernobyl

Components		DS, %, conventional numbers			
Purpose	**Name**	**1**	**2**	**3**	**4**
Sorbent	Sulfite/alcohol distillery	45	46	—	—
	grains	—	(46)	46	—
	Bentonite clay				15-20
	Zeolite (clinoptylotite)				
Oxidizer	Potassium permanganate	—	—	0.2	—
Acid	Oxalic	2.5	1.0	—	—
	Adipic	—	1.0	—	—
	Isabelic	—	—	—	0.5-1.5
Alkali	Caustic soda	—	—	4.0	—
Complexing agent	Trilon B	—	1.0	—	0.3-0.4
SF-2u		—	—	—	0.5-0.6
SF-3		2.5	1.0	—	—
Solvent	Water	50	50	49.8	Rest

Fig. 9

Compositions of some oxidizer or acid-reagent based DSs applied in Chernobyl

Components		DS, %, conventional numbers			
Purpose	**Name**	**1**	**2**	**3**	**4**
Oxidizer	Potassium permanganate	0.2	—	—	0.2
	Sodium fluoride	—	0.5	—	—
Acid	Oxalic	—	4.0	—	—
	Adipic	—	0.5	—	—
	Isabelic	—	—	0.5	—
Alkali	Caustic soda	4.0	—	—	4.0
SF-2u		—	—	0.5	—
SF-3k		—	—	1.0	—
Solvent	Water	95.8	95.0	98.0	95.8

Fig. 10

Formulations of SF type compounds employed in Dss					
Components		Mass Content, % for			
Purpose	Name	SF-2	SF-2u	SF-3	SF-3k
SAS	Alkylbenzenesulfonates	25	18	18-20	9
Complexing agents	Sodium tripolyphosphate	—	50	—	25
	Sodium hexametaphosphate	—	—	25	—
	Trisodiumphosphate	30	—	—	—
And Acid	Oxalic Acid	—	—	—	50
Active additions: for concentration reduction	Sodium Sulfate	16	18	16	9
To improve the quality of units under treatment	Organic bleach	—	—	2	1
Admixtures	Sulfidized substances and water	Rest	7	Rest	Rest

Fig. 11

Efficiencies of treating some materials with oil-paint coatings by decontaminating films				
Material	Radioactivity, kBq/m^2		Decontamination factor	Transfer coefficient
	Before Decontamination	After Decontamination		
Splint slab	1.5	0.45	3	0.66
Plaster, wood,	1.0	0.33	3	0.66
Concrete, masonry	1.5	0.33	4	0.75
Ceramic Board	200	20	10	0.90

Fig. 12

Efficiency of decontaminating films based on polyvinyl butyral (contamination estimated by ß-fissions)

Surface	Initial contamination level, mBq/m2	After decontamination	
		1st cycle	2nd cycle
Stainless steel	3.2	25/128*	1.6/200
Titanium	2.3	380/	23/100
Aluminum	2.2	41/54	10/220
Glass	2.2	55/40	13/169
Plasticate 57-40	1.7	26/65	-/→∞
Epoxy enamel	1.8	23/78	-/→∞

Fig. 13

Note: *)In the numerator — the level of residual contamination (kBq/m^2), in the denominator — the decontamination factor.

Indices of efficiency of processes applied to deconatmination of ChNPP site and main building

Decontaminated object	Process	Decontamination factor
Roofing of the 3rd power unit and some rooms of other units	Raking of radioactive materials into the damaged unit by means of robots, mechanical appliances or manually	2 to 50 times, depending on maximum exposure dose
Inner rooms of ChNPP	Treatment with DSs delivered by DKV-1 specialized automobiles and hydrovacuum cleaners	3 - 5
ChNPP territory	Isolation by plates 20 cm thick	10 - 20
Territory without surfacing	Isolation by a sand layer 10 cm thick	4 - 5

Fig. 14

The work on gathering high-level radiation sources in the vicinity of the damaged power unit was performed using at first clearing machinery and then radio-controlled means. All the sources were either raked into the room of the damaged reactor or gathered into containers and transported to repository for solid waste.

b) Decontamination of inhabited localities

The decontamination work was performed by battalions for special treatment, forming part of chemical-protection regiments. One reinforced battalion was allotted to an inhabited locality. 250 to 300 people and to 50-60 machinery units (35 to 40 ARSs-14, one or two BRDM-2rh, one or two bulldozers) were involved. As a rule, 2-3 homesteads were decontaminated within a day with the help of each ARS-14.

At the same time, the processes employed for decontamination of the inhabited localities often turned out to be of low efficiency, primarily because of porosity of the surfaces of building materials (especially in rural areas) and constant transfer of radioactive particles by winds and transport means. The percentage of repeat decontamination was nearly 30-40%. Some structures were decontaminated three times. Gathering and disposing of spent washing solutions presented a lot of difficulties. Pumps of ARSs and sprinklers did not provide the necessary pressure when treating many-storied buildings.

c) Decontamination of roads

Decontamination of roads was achieved through a set of steps. In the first place, we treated the dust-forming sections of roads and adjacent areas through which the cleaning machinery involved in the decontamination work had to move (such treatment was performed via moistening from fire-engines or ARSs equipped with AN-3 nozzles). Then, carriageways were treated. Decontamination of roads with solid surfacing was effected using ARSs-14 and fire-engines (the consumption of decontamination solution was 3 to 5 l/m^2). In some areas, the treatment was performed with additional rubbing with brushes and subsequent washing-away of the spent solution with water. A single-pass treatment of roads, using the afore-described procedure, allowed nearly 2-time reduction in the contamination level. To achieve the established contamination norm, the decontamination usually had to be repeated in 2-3 days. In some cases, a road or its certain sections was covered with asphalt anew.

After treating a carriageway, shoulders and ditches were decontaminated through removing the contaminated ground via gradering at a depth of 2-5 cm. Gradering was also used to decontaminate carriageways of dirt roads. The factor of decontamination reached 5 to 8. The removed ground was transported to burial sites.

Some data on efficiencies of the procedures used for decontamination of the inhabited localities, lands and roads are presented in Fig. 15.

d) Dust suppression

When eliminating effects of the Chernobyl accident, we had to face the problem of localizing radioactive materials and fixing them to prevent their transfer.

Localization was effected by means of various film-forming compounds (polyvinyl alcohol, sulfite-alcohol distillery grains, latex, oil slurry, etc.), the selection of which continued in the course of the work.

To solve the problem of localization of radioactive contamination, specially equipped planes and helicopters of the Air Forces and the Ministry of Civil Aviation were involved as well as special-treatment formations of forces of radiation, chemical and biological protection of the Ministry of Defense. For example, one ARS with 2.5 tons of the decontaminating solution, moving at 12 km/h, is capable of treating 1 km of the shoulder of a road 2-3 m wide (the solution consumption is about 2.5 l/m^2).

The experience of the work on localization of radioactive contamination allows the following conclusions:

- to suppress dust formation in areas not subject to mechanical attack, the formulation on the basis of GIPAN suits the requirements most completely;
- to cover concrete plates and individual areas set in concrete, it is expedient to use the formulation based on carbamide resin and polyvinyl dispersion (PVA);
- prevention of dust formation on dirt roads and shoulders of roads with solid surfacing can be effected successfully with the help of oil slurry.

Indices of efficiency of processes used for decontamination of inhabited localities, lands, roads

Decontamination object	Decontamination process	Decontamination factor
Outer surfaces of brick buildings	Removal of radioactive surface layer (1 mm) by a grinding machine	6 - 7
	Treatment by SF-2u	1.2 - 1.5
Inner surfaces of dwelling houses	Treatment by SF-2u or SF-3k special solutions using DKV-1 automobile or hand operated appliances	1.5 - 2.5
Areas in inhabited localities	Removal of an upper ground layer (10-15 cm)	3 - 4
	Isolation by sand and gravel (layer thickness is 10 cm). Reploughing	3 - 4
	Isolation by ferroconcrete plates 20 cm thick	10 - 20
Solid surfacing of roads in inhabited localities	Double treatment by water solutions of SF-2u	2 - 3
	Removal of contaminated snow (ice) to a depth of 15-20 cm	2 - 5
Solid surfacing of roads beyond inhabited localities	Triple treatment by water solutions of SF-2u, using ARS-14 or sprinklers	2 - 3

Fig. 15

The experience acquired while eliminating the Chernobyl consequences suggests that application of dust-suppressing means reduces significantly the probability of transfer of radioactive materials.

e) Decontamination of machinery and overalls

Decontamination of the machinery used was performed in the accident area at summer or winter sites of special treatment (SSTs) constructed and equipped in a short time. Those were 2 or 3 sites of special treatment and a decontamination center. Each site had: a control and distributive station, a site for rough cleaning of the machinery from dirt and mud (snow, ice, etc.), a decontamination line with equipped working places, a site for decontamination completeness control.

The work was performed in shifts (8 hours each). At each SST, up to 200-400 machinery units were treated in 24 hours during hard work days.

The experience shows that, to reduce the contamination level by 60-70 percent, the decontamination procedure should be repeated once or twice. The consumption of the decontaminating solution based on SF-2u powder was 500 liters per machinery unit in average.

The decontamination of running gear of vehicles was a challenging problem due to a low pressure in ARS-14 fire pumps, impossibility of performing treatment without a special platform the lower portion of a vehicle, lack of means and procedures for decontamination of engines. All these issues had to be solved in the course of the work, using even unit-by-unit treatment (i.e., after disassembling) of the machinery.

Some problems had to be faced with when decontaminating overalls and underwear. Rigorous norms of peace time forced finding a solution to these issues using field automobile extraction stations (EPASs) and field mechanized laundries (MPPs-1).

The experience of decontamination work in the 30-km zone around the Chernobyl NPP bears witness to the necessity of further active efforts aimed at improving the processes, procedures and technical means for decontamination.

At the same time, as become clear by the discussion of decontamination issues during the "Polyarnye Zori" command and headquarters exercise (May 1995), in which representatives of UN DHA, IAEA, USA, France, Germany and some other countries of Europe and the CIS took part, many aspects related to decontamination of inhabited localities still do not have an unambiguous perception.

At a high laboriousness and hence a high cost of such work, its efficiency was often rather low. In rural areas and particularly under conditions of an irregular relief (mountainous state, large extent of forests, etc.), decontamination beyond inhabited localities is an extremely challenging problem, and the radiation background after decontamination would gradually level off due to transfer of radioactive particles.

That is why the majority of those who took part in the discussion agreed on the expediency of "aimed" decontamination in such cases, which is to be effected only after the radiation situation stabilizes.

Major efforts should be aimed at sanitary and everyday-life measures in localities still inhabited as well as at prevention of radioactivity transfer, dust suppression, special treatment of machinery transported beyond the contaminated zone.

Needless to say, my report includes only a small part of the conclusions made on the basis of the experience of the work on elimination of effects of the Chernobyl accident.

In particular, of significance is the issue on protective means for NPP personnel and those who work in the most dangerous areas.

The protective structures available at the NPP site turned out to incapable of ensuring the radiation safety of people who for some reasons worked and, in effect, lived there for a period of time. The filtration systems in those structures had to be updated through addition of a number of absorbing filters with additional special cloths. Filters based on Petryanov cloth were fabricated that enabled cleaning with an efficiency of 99% at an air flow of 250 $m^3/(h \times m^2)$.

The necessity of improving gas masks manifested itself quite markedly. Anti-gas boxes that accumulated radionuclides turned into sources of additional exposure. The box charge was incapable of cleaning the air from gaseous radioactive iodine, inert gases and other radionuclides in the form of a fraction of finely divided aerosols, most widespread in the first months after the accident.

A variety of pretensions to protective overalls were voiced.

The obligatory conclusions inferred from the experience of the work on elimination of consequences of the Chernobyl accident were made and the appropriate countermeasures taken. A number of technical means have been created that meet the requirements for such work (robotized complexes, radiation control apparatus, aerial and ground survey means, etc.).

Nevertheless, as stressed at the meeting of leaders of the "Great Seven" and Russia (April 20, 1996) where the issues of nuclear safety were discussed, the most important lesson taught by the Chernobyl catastrophe is that the mankind must create highly reliable engineering facilities, novel safe nuclear power facilities, joining for this purpose the efforts of specialists from various countries. Extremely rigorous measures should be taken to exclude an accident similar to the Chernobyl one.

It should be emphasized that the work on elimination of effects of the Chernobyl accident has not been completed yet. It will take many years, though now in 80% of the Russian territory contaminated by Cs-137 with a density above 1 Ci/km^2 the situation can be considered normalized. The yearly effective dose of exposure to population in these territories is under 1 mSv. "Clean" agricultural products are grown (produced) there.

In spite of all this, even in these territories, there are still some problems in what concerns:

- population health protection;
- social protection and social rehabilitation of population;
- rehabilitation of contaminated territories;
- economic rehabilitation of suffered regions.

A serious problem to have been faced with is rehabilitation of the so-called "liquidators", i.e., participants in the work on elimination of effects of the Chernobyl accident (their number is about 300 thousand people in Russia alone). The main problem consists in the state of their health. In Russia alone, there are over 30 thousand liquidators registered as disabled people.

For the purposes of further elimination of consequences of the Chernobyl accident, a special state program was adopted and is being realized, which, we hope, will reduce today's tension in the above issues. Thank you for your attention.

Russian experience in liquidation of the consequences of south urals accidents

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Dr. Gennadiy N. Romanov:

1. Causes of the accident and characteristics of the subsequent radiation situation

The radiation accident at Mayak PA, which is located near Kyshtym town in the northern part of Chelyabinsk region, occurred on September 29, 1957.

The cause of the accident was a breach of cooling of one of the tank-storing liquid high-level radioactive wastes from radiochemical operations (70-80 tons). It led to subsequent evaporation of the solution due to radiation self-heating and led up to formation of dry residuum, and from this residuum an explosion occurred, mainly because explosion cloud at a height up to 1 km. Explosion products deposited up on the soil surface along the way of the transported cloud where they formed the East Urals Radioactive Trace in the part of the territory of Chelyabinsk, Sverdlovsk and Tyumen' regions of Russia (Fig. 1). The rest of the activity was concentrated in the enterprise site territory near the explosion place on an area of about 15 km^2 [1-3].

Characteristics of the accidental discharge in the environment are given in Table 1 [1-3]. The primary contribution to the radionuclide mixture activity formed on the radioactive trace was due to Ce^{144} (66 % of the total activity or 1.3 mln Ci). However, the presence in wastes of long-lived ^{90}Sr (2.7 % of the total activity or 54 thousand Ci) caused the long-term existence of the contamination of radioactive territory and contributed to the population exposure risk. The maximum level of the initial territory reached 150 thousand Ci/km^2 total ß-activity or 4 thousand Ci/km^2 by ^{90}Sr. The minimum contamination levels determined with detecting limits at that time were about 4 Ci/km^2 total ß-activity and 0.1 Ci/km^2 by ^{90}Sr. γ-exposure dose rate (at 1 m height from the soil), 150 R/h and 0.6 R/h corresponded to the minimum and maximum levels of the territory contamination [1-3]. The distinctive peculiarity of the created radiation situation was the presence in the contamination composition of short-lived γ-radiating nuclides, the rapid decay of which comprised most of the external γ-exposure dose during the first 4 years after the accident (Fig. 2). Practically almost all the dose from external exposure was formed over the first year. This means also that at the end of the first 2-3 years the main pathway of population exposure was ^{90}Sr intake with diet [2, 4].

**) One considers only post-accident correcting actions, undertaken in the so called initial and intermediate stages of the post-accident periods, when the radiation situation hasn't yet been stabilized and there is the necessity of accepting urgent and effective measures for reducing the accident consequences. Because of this the considered problems of the long-term management with the contaminated territory of the East Urals Radioactive Trace were increased.*

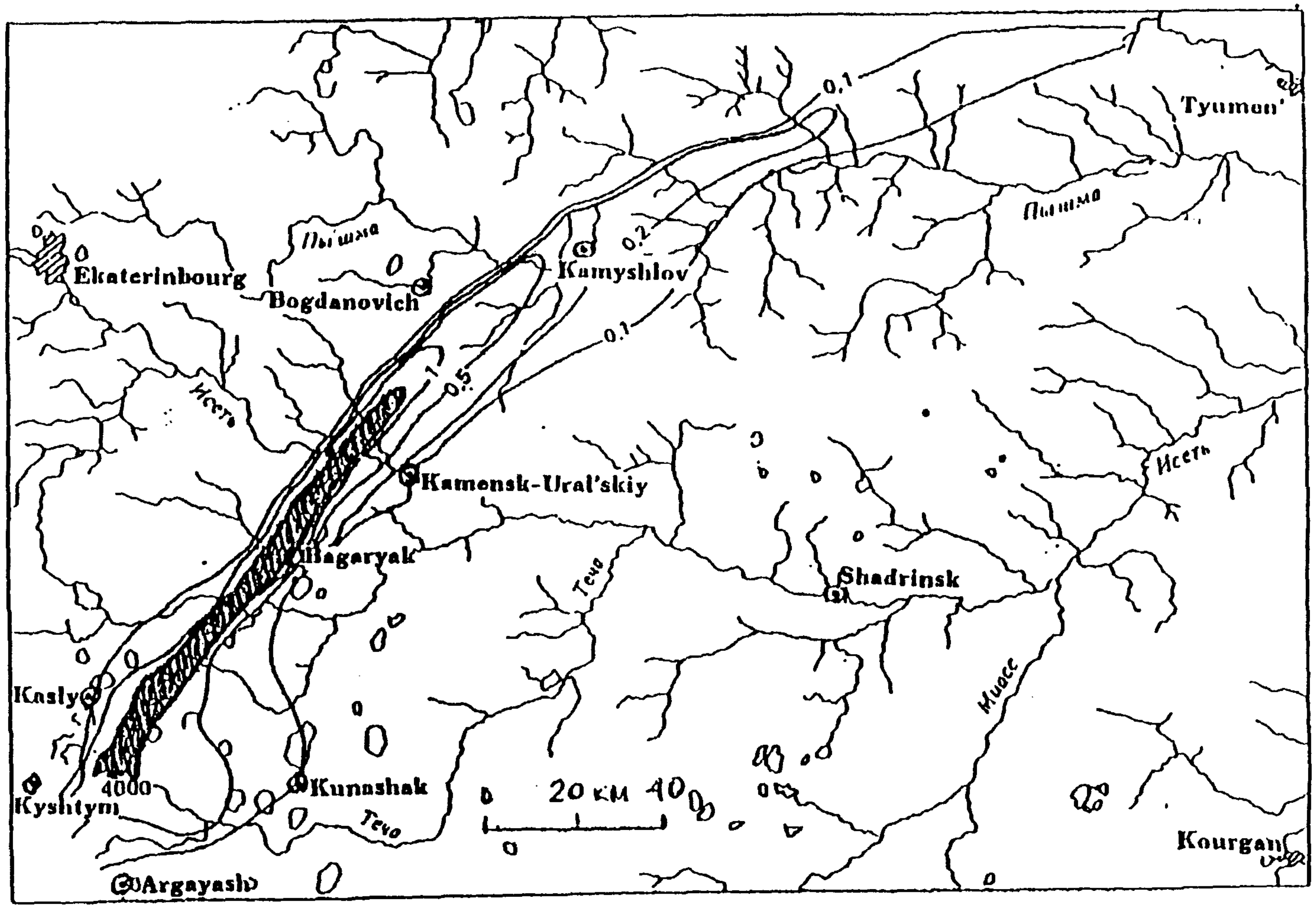

Fig. 1. The East Urals Radioactive Trace. The territory with contamination level over 2 Ci Sr^{90} /km^2 is shaded.

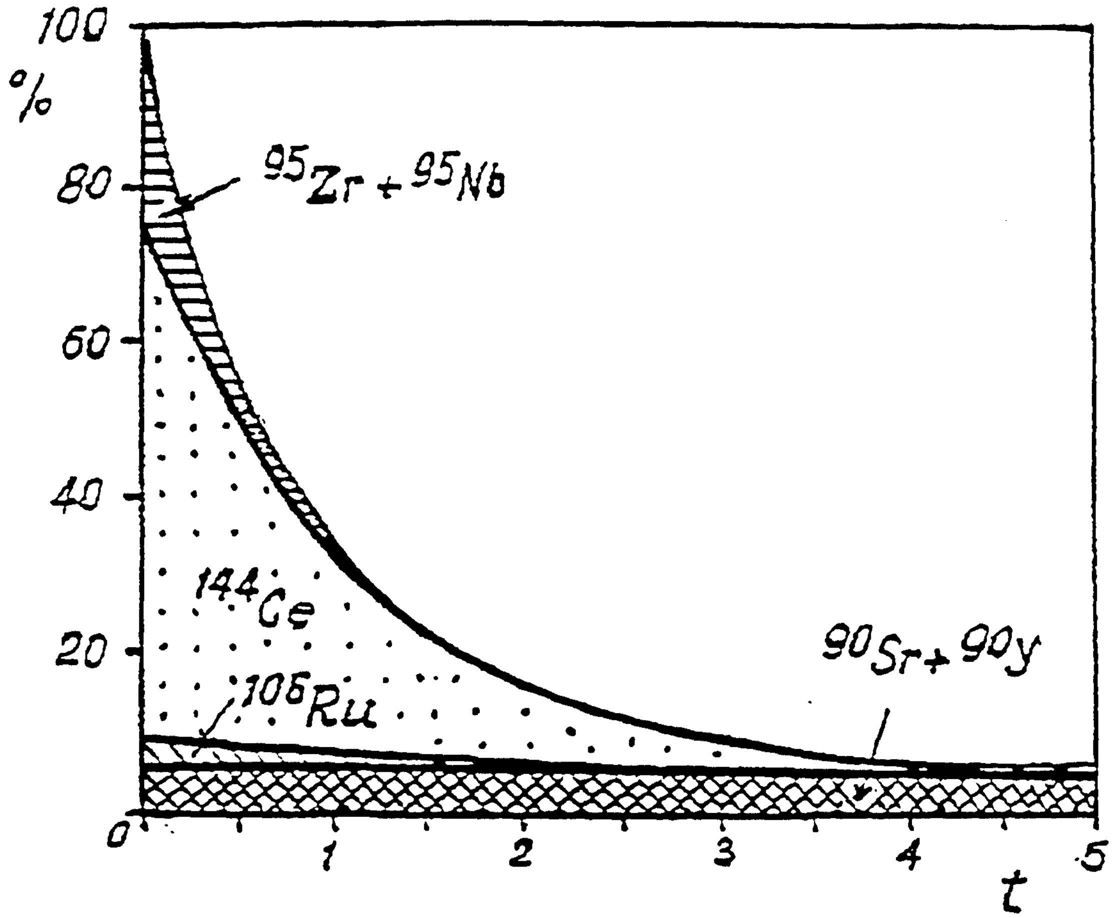

Fig.2. Change of contamination radionuclide composition in the first five years

Initial radiation characteristics of the East Urals Radioactive Trace territory									
Radionuclide composition					Level of territory contamination		y-dose rate, R/h		
Radionuclides	T 1/2	Radiation type	Contribution to mixture activity		min, Ci/km²	max, kCim²	Calculating on 1 Ci⁹⁰Sr/km²	min	max
			kCi	%					
^{89}Sr	50.5d	ß, y	?	signs	?				
^{90}Sr	29.1y	ß	54	2.7	4.0				
^{90}Y	2.67d	ß	54	2.7	4.0				
^{90}Zr	64.0d	ß, y	249	12.5	18.5				
^{90}Nb	35.1d	ß, y	249	12.5	18.5				
^{106}Ru (+^{106}Rh)	1.01y	ß, y	74	3.7	5.5				
^{106}Cs(+^{137}mBa)	30.0y	ß, y	0.72	0.036	0.053				
^{144}Ce(+^{144}Pr)	284d	ß, y	1320	66	97.08				
^{144}Pm	2.62y	ß, y	?	signs	?				
^{155}Eu	4.96y	ß, y	?	signs	?				
∑Pu	-	a	?	signs	?				
Total			~2000	100	~3.75	~150	$1.5 \cdot 10^{-4}$	$1.5 \cdot 10^{-5}$	0.6

Table 1

The formed East Urals Radioactive Trace has a spatial distribution of the radioactive contamination sufficiently typical for a solid aerosol substance dispersing from a point source. It is characterized by the evidently expressed exponentially decreasing maximum concentration of the contamination along the "axis" of the cloud moving and by the sharp reduction of the territory contamination levels in both cross directions. Within the boundaries of ^{90}Sr minimum contamination density of 0.1 Ci/km² the trace area makes up approximately 20 thousand km² (300 km x 30-50 km, Table 2). Within the boundaries of contamination density of 2 Ci ^{90}Sr/km² accepted as the permissible ones for the permanent population living - about 1 thousand km² (105 km x 8-9 km). On the whole about 270 thousand people were living in the trace area within the range of 0.1 Ci/km² by ^{90}Sr. There were about 11 thousand people living in 23 settlements of a rural type in the trace territory with a minimum contamination levels of 2-4 Ci/km² by ^{90}Sr. On reaching this level radiation protection measures of the population were required. [1-4].

2. The problems caused by the accident consequences

The explosion of the tank with radwastes and the subsequent intensive radioactive contamination of the enterprise site territory and the region around its location raised a number of complex problems requiring-implementation of both urgent and long-term countermeasures.

In the territorial plan the problems were referred to in three main territory parts:

- the enterprise site;
- the territory of the closed Ozyorsk City where the personnel of the enterprise and of other organizations that ensured its activity were living;
- the territory outside the enterprise site and the City zone (the East Urals Radioactive Trace) [2-4].

Problems which had to be solved at the enterprise included maintenance of the normal production activity, personnel radiation protection and prevention of anthropogenic migration of the intensive radioactive contamination out of the enterprise site.

During the explosion the ventilation system of the whole radwaste storage complex was damaged and, means of control and cable nets were put out of service. The

Differentiation of the East Urals Radioactive Trace territory by contamination levels and population quality			
Initial contamination level, Ci^{90}Sr/km^2	Area, km^2	Settlement numbers	Population numbers, thousands of people
>0.1	15 000-23 000	217	270
>1*	1 400	71	17
>2	1 000	23	11
>10	400	13	3
>100	120	3	0.6
>1000	17	-	-

Table 2

principal task of the post-accident work was restoration of the capacity for work and increasing the reliability of the high-level waste storage complex [2].

The intensive radioactive contamination of a part of the industrial site territory created a heightened risk for the exposure of enterprise personnel including those who didn't directly participate in post-accident works. Besides the unceasing production activity, first of all, movement of the personnel and motor transport along the enterprise site territory led to spreading the radioactive matter both to its uncontaminated plots and to production buildings and to the territory of Ozyorsk City. These circumstances required implementation of regulation of the production activity and decontamination of the contaminated territory, transport communications, and a part of buildings and constructions [2].

The territory of Ozyorsk City wasn't subjected to the radioactive contamination by the passing of the discharge cloud from the accident. However, already the next day after the accident on separate parts of the city territory, in particular; on bus stops and in places of people concentration the radioactive contamination levels of solid covered surfaces increased 60-1100 times and y-exposure dose rate in 20-40 times as compared to the period before the accident. This was due to spreading the radioactive contamination from the enterprise site territory by motor transport including one carrying personnel and by the personnel itself. The tasks of prevention of further activity spreading and of decontamination of the city territory contaminated plots and separate buildings arose [4].

The specially important problem which already being solved for the period of past 39 years after the accident is maintaining the radiation protection of the population which found themselves in the East Urals Radioactive Trace territory. This problem was complicated by absence of experience in consequence softening of large-scale radiation accidents, by lack of knowledge about radionuclide behavior in the environment, in man's food chains and in his organism, by absence of radiation-sanitary standards, by lack of methods and means of radiation protection of the population [2, 4].

3. Organization of improving post-accident actions

The accident of 1957 was unexpected by all levels of management - state and departmental ones. At that time, there were no international and national recommendations for management of large-scale accident consequences and standards of permissible population exposure from an accident and any accident plans as well. Making decisions of the strategy and subject-matter of post-accidental works required the unification of efforts, knowledge, and erudition of large number of specialists, scientists and authority representatives. One should remember that all the activities were conducted in conditions of the strictest secrecy.

Depending on the subject-matter of tasks of the post-accident actions the scheme of the state and departmental management of their implementation was changed (Fig. 3).

The Ministry of Middle Engineering Industry of the USSR, its 4th Central Board and management of Mayak PA directed the post-accidental actions at Mayak Production Association. In addition to the departmental management from the part of the Ministry of Middle Engineering Industry and Mayak PA, organs of the local authority located in Ozyorsk City, the Medical and Sanitary Department No. 71 were subjected to the 3rd Central Board of the Ministry of Public Health of the USSR. They managed the problems of radiation protection of Ozyorsk City population (Fig. 3).

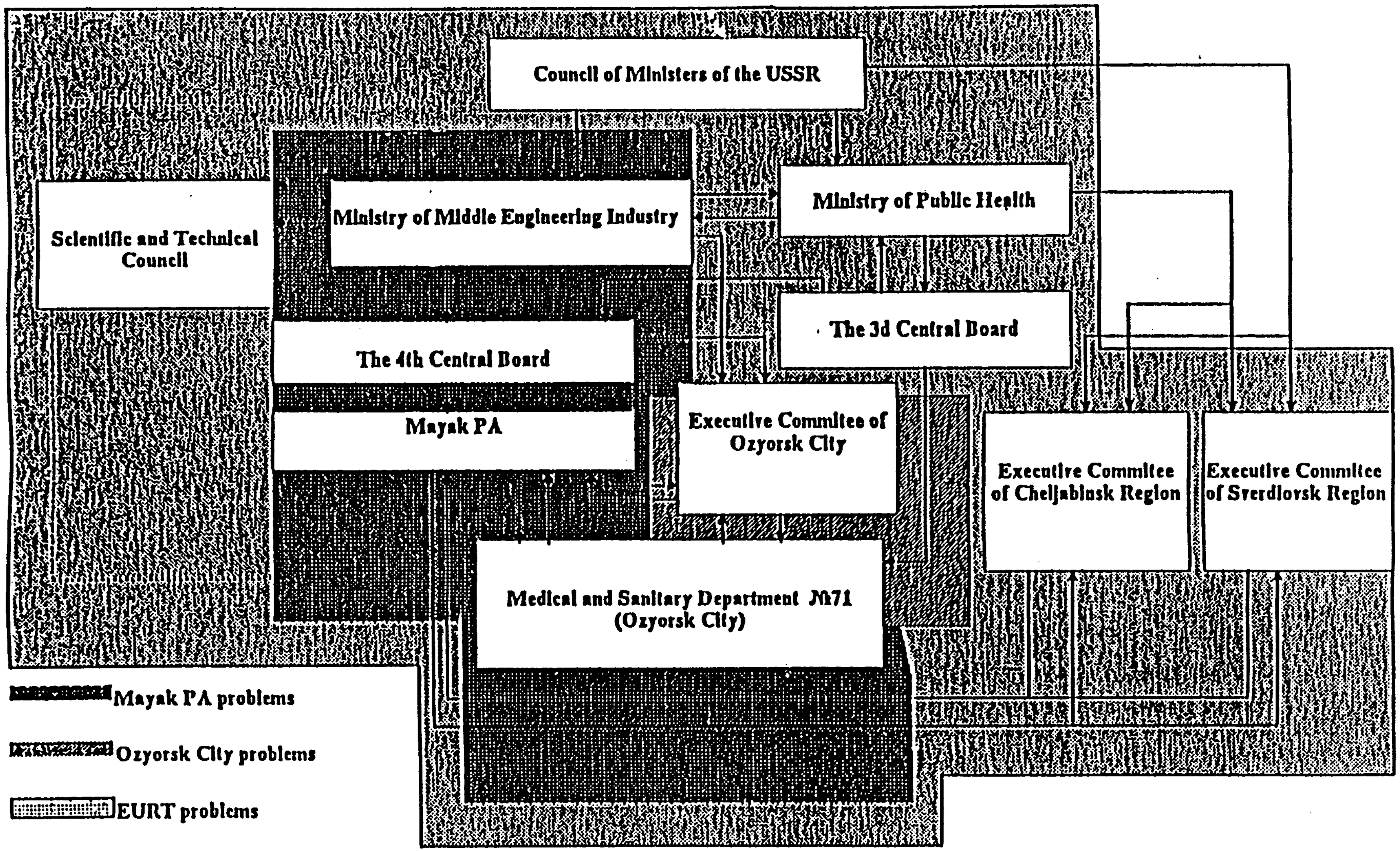

Fig. 3
Scheme of post-accident interaction and management

The management scheme of the post-accidental actions in the East Urals Radioactive Trace territory was specially complex and responsible. The general management was conducted by the Council of Ministers of the USSR. Implementation of the large majority of measures was carried out by Mayak PA and the Executive Committees of Chelyabinsk and Sverdlovsk regions. Development of radiation and sanitary standards and the control of the population health state were performed by the Ministry of Public Health of the USSR and its 3rd Central Board along with the local sanitary medical institutions.

4. Countermeasures applied to Mayak PA

The brief description of tasks and countermeasure matters conducted at Mayak PA and at its industrial site during the initial post-accident period [2, 4] are given in Table 3. It especially should be noted that the accident in 1957 didn't lead to the temporary stopping or ceasing of the enterprise production activity and though the accident significantly complicated the activity, liquidation of the accident consequences was begun practically the next day and later was conducted by specially developed programs that were refined in time.

Decontamination works were performed by specially created mechanized detachments consisting of the enterprise and military-construction units personnel.

The first decision on radiation protection of the population living in the four settlements at a distance of 12-23 km from the explosion place (Berdenish, Satlykova, Galikaeva, Kirpichiki villages with average contamination density of 650 Ci $^{90}Sr/km^2$, 1100 persons) was taken for the prevention of significant external γ-exposure doses, that by the assessments could make up 100 rem in the first month. The population of the villages was evacuated (practically removed) on the 7th to 10th days after the accident [4].

The general subject-matter of radiation protection measures of the population in the initial period are given in Table 4.

In decontamination of the industrial site territory, of roads, buildings and constructions, the guiding dose standards were those applied for the personnel accepted at the enterprise at that time. The values for the permissible levels of personnel exposure and of the surface industrial equipment contamination were 15 rem/y.

Special increased accidental dose standards for the personnel were not introduced.

Decontamination of the contaminated territory plots was performed up to the levels of γ-exposure dose rate and up to the surface contamination which were typical for the adjacent plots uncontaminated by the accident.

Enlisting the enterprise personnel to liquidation of the accident consequences didn't lead to exposure over the established annual limits [5].

5. Countermeasures carried out in Ozyorsk City [4]

The countermeasures undertaken in Ozyorsk City for reduction of the level of the radioactive territory contamination of the residential zone, public buildings and places enriched in people (Table 4) were begun practically the next day after the accident and therefore can be considered as the urgent ones. The bulk of their measures was completed before the winter beginning in 1957-1958. The works were performed under the leadership of local organs of the authority, under Mayak PA and local medical and sanitary organs.

The main part of the decontamination work was completed by the forces of special subdivisions created at Mayak PA. The countermeasures were effective. The radioactive surface contamination levels out and inside of buildings were reduced by 100 to 1000 times. That side by side with the radioactive short-lived radionuclide decay, effect caused enough progress to have a sufficiently successful radiation situation in the city for the coming winter of 1957-1958. In 1958, the main task of the dosimetric services was control of the radioactive contamination levels of food-stuffs brought to the city from without.

6. Radiation protection measures of the population in the East Urals Radioactive Trace territory in the initial and intermediate after-accident periods

The tentative assessment of radioactive contamination scales of the territory adjacent to the enterprise was made practically the next day and led to the conclusions:

- of necessity of urgent and detailed study of the radiation situation which had arisen;
- of possibility of serious radiological consequences for the population;
- the advisability of taking urgent radiation protection measures for the population [4].

It should be noted that at that time there were no scientifically justified radiation protection criteria of population in radiation accidents. Therefore, the paramount tasks were the development of radiation protection criteria for the population that required the competent study of characteristics, dynamics and peculiarities of the exposure dose, ways of forming as well as, on the basis of such criteria, determining the intervention levels. Nevertheless the tentative prognosis and the subsequent large-scale study of the radiation situation allowed us to come to the conclusion that in spite

Countermeasures applied to Mayak PA industrial site		
Principal Problems	**Task**	**Countermeasure Matter**
Maintenance of normal production activity	1. Restoration and increasing reliability of the liquid high level waste storage complex	Restoration of ventilation system, modernization of controlling instrument system, cable net and cooling system. Decontamination of complex. Liquidation of destroyed tank (all completed at the beginning of 1958).
	2. Construction and putting into operation the new liquid high level waste storage complex	Temporary closing of the old complex (waste removing, decontamination of tanks, filling of tanks with clean water). Putting on line the new complex equipped by reliable systems of cooling, ventilation and control (1961).
	3. Regulating the production activity	Partial changes of distribution of working places and technology. Stopping construction in territory plots with intensive radioactive contamination. Removing the military construction unit dislocation place out of the industrial site. Temporary closing the separate buildings and installations (all completed during the first 2-5 days).
Radiation protection of personnel. Prevention of radioactive contamination spreading beyond the borders of the industrial site.	1. Putting on line an effective dosimetric control system	Increasing the dosimetric service personnel number. Urgent supply of service with dosimetric and radiometric instruments including made at Mayak PA. Development of the extensive control net (during the first week).
	2. Decontamination of contaminated plots of territory and transport communication	Filling up the most contaminated plots surface with clean ground up to reduction of y-dose rate by no less than 10 times. Removing and burial of the top (5-10 cm) layer of ground roads and sides of asphalt and concrete roads. Filling up of railroad permanents and slopes with clean gravel. The volume of removed and buried contaminated ground was $320.10^3 m^3$, the volume of imported clean ground and gravel was $423.10^3 m^3$. Principal works were completed at the beginning of 1958.
	3. Decontamination of motor and rail transport, separate buildings and installations	Wash cleaning (water and deactivating remedies: 40% alkali, K_2MnO_4, kerosene $+H_2SO_4$, oxalic acid), mechanical clean-up with brushes (during the autumn of 1957).
	4. Regulating of road and motor transport exploitation.	Modification of motor transport traffic scheme, partial limitation of motor transport industrial site gates (during the first week). Putting on line motor transport washing installation and dosimetric check point (January 1958).
	5. Maintenance of personal radiation safety	Methods improvement and volume increasing the personal dosimetric and radiometric control. Obligation and controlling sanitary personal washing after the working day (during the first week).

Table 3

Countermeasures in Ozyorsk City	
Tasks	**Countermeasure Matter**
Maintenance of effective dosimetric and radiometric control	1. Creating and technical equipment of dosimetric control service (during the 2 days). 2. Execution of permanent radiometric control of food-stuff (in store-houses, grocery and provision shops, dining-rooms, bread-baking plant, dairy plant), dosimetric and radiometric controls of the city territory, roads, motor transport, public buildings, school and kindergarten buildings, separate dwellings (during the autumn 1957).
Territory decontamination	1. Systematic wash cleaning the roads with the help of mobile and stationary water-supplies (since October, 1). 2. Partial replacement of road hard cover (before winter beginning). 3. Didding lawns over again, tidying up and removing sweepings (fallen foliage), the first snow fall out (before winter beginning).
Decontamination of public buildings and dwellings	1. Decontamination of floor of dining-rooms and shops. 2. Careful and multiple sanitary tidying up of kindergarten rooms. 3. Written recommendations for the expediency of methods of dwelling decontamination for tenants. (all - during the autumn 1957).
Vital activity regulating	1. Limitation of motor transport (bus) traffic routes from industrial site (during the first week). 2. Removal of contaminated food-stuffs, clothes, foot wear (after radiometric control) (during the autumn 1957). 3. Putting of separate "clean" and "dirty" baths and laundries on line (during the first week).

Table 4

of the absence of criteria, the urgent radiation protection measures of the population had to include [4]:

- evacuation;
- territory decontamination;
- control of the radioactive contamination levels of food-stuffs and their withdrawing from use when exceeding the permissible contamination levels.

For the population that remained in the trace territory the risk of significant external exposure doses was not high; however risk of the internal exposure, mainly of gastro-intestinal tract and bone tissue from the product fission mixture intake and from ^{90}Sr with diet, was present [4, 6].

The unceasing and continually intensifying study of the radiation situation characteristics and of the forming of the population exposure doses had already shown, during autumn 1957- winter 1958, that further measures of radiation protection of the population planned then would have to include:

1. Prognosis of development dynamics of the radiation situation and forming the population exposure doses.
2. Development of criteria for the possibility of population living in the contaminated territory.
3. Establishment of the permissible radioactive contamination levels of environmental objects and food-stuffs.
4. Choice of the effective measures of radiation protection of the population.
5. Substantiating methods and volume of medical and radiological population control [4].

In January of 1958 the Ministry of Public Health of the USSR established the ^{90}Sr annual permissible intake with diet for the population during the first year after the accident to be equal to 1.4 accident equal to 1.4 μCi/y (Table 5) [4, 5, 6]. On the basis of the value of the ^{90}Sr annual intake limit as well as data of the contribution of separate diet components in the resulting annual intake,the permissible activity content levels in food-stuffs and farm produce were established [Table 6]. The establishment of criteria values for the permissible annual intake and the specific product activity showed that in the first year after the accident the ^{90}Sr actual intake with diet could reach 3 nCi/d calculating on an initial contamination density of 1 Ci ^{90}Sr/ km^2 (the population was obliged to consume the private farm produce contaminated at the moment of forming of the trace for approximately 9 months excluding the milk). On this ratio of the daily intake to the territory contamination level the theoretically permissible consumption time of the contaminated produce was respectively 1 year, 1 month and 3 days at ^{90}Sr initial contamination density of 1; 10 and 100 Ci/km^2 [4, 5, 6].

This meant that the population of 19 settlements (at $\geq$ 2 Ci ^{90}Sr/km^2), excluding already removed people, could be subjected to internal exposure over the permissible limits during the first year. Planned radiation protection measures, the necessity of which was determined on the basis of the above-state criteria, included the two principal types of undertakings were [4,6,7]:

- Setting the radiation control of food-stuffs and farm produce and with-drawing from use the produce contaminated over the established limits;
- planned removing of the inhabitants from settlements with a contamination density of 2-4 Ci ^{90}Sr/km^2 (Fig. 5).

For the organization of the control of radioactive contamination of food-stuffs and farm produce a net of 8 radiological laboratories that followed the permissible produce contamination levels established in 3 months after the accident was created (Table 6). The necessity of the development of control methods, of the technical laboratory equipping and training their personnel allowed the work to begin in only 4 months after the accident and to develop it in full-scale in only 10-12 months. During that time the produce significantly or entirely contaminated by the accident was used. Nevertheless, during 1957-1959 the radiation control was conducted in 50 settlements on the total land comprising an area of about 1000 km^2 up to minimum contamination density of 0.5-1 Ci ^{90}Sr/km^2.

Intervention levels for population in the East Urals Radioactive Trace territory [7]

Object of intervention	Initial basic or derived dose limit	Established intervention level	Time of putting into operation
		Initial Period	
External exposure preventing		100 rem for the first month	In 3 days
		Intermediate period	
Decrease of ^{90}Sr intake with diet	^{90}Sr permissible content in skeleton 20 nCi (IAEA, 1958)	^{90}Sr annual permissible intake (established by the Ministry of Public Health of the USSR): 1.4μCi for the first year; 0.18μCi/y	01.01.1958 01.01.1961

Table 5

Permissible radionuclide content levels in food-stuffs and farm produce, nCi/kg

Produce	1958, January		1959, January	
	^{90}Sr	$\Sigma\beta$	^{90}Sr	$\Sigma\beta$
Grain	2.5	24	2.0	6.7
Potatoes	2.5	24	2.0	6.7
Vegetables	2.5	24	2.0	6.7
Milk	0.75	4.0	1.0	3.1
Meat	2.5	2.5	2.5	7.5

Table 6

During that time 8500 t of produce including 240 t potatoes, 1300 t grain, 61 t vegetables, 104 t meat and 67 t milk was rejected and withdrawn from use. Although for 2 years of the work approximately 100 thousand analyses were carried out, the control volume was insufficient, since only part of the overall supplies or production volume of the produce, mainly from completed economies, was subjected to analysis. The summary volume of the whole rejected produce was close to the annual supply of food-stuffs and forage of only 2-3 settlements. One more shortcoming of the radiation protection measure was the social and economic impossibility of replacement of the rejected produce of private farms by the new one [4, 6, 7].

The real possibility of significant exceeding the established limit of ^{90}Sr annual intake with diet during the first year after the accident (1.4μCi/y) for the population living on the territory with contamination density over 5 Ci $^{90}Sr/km^2$, as well as the impossibility of provisioning the population with uncontaminated food-stuffs against the background of tardiness and insufficient completeness of the radiation produce control, compelled the Councils of the Ministers of the USSR and RF, the Ministry of the Middle Engineering Industry of the USSR, the Ministry of Public Health of the USSR executive committees of Chelyabinsk and Sverdlovsk regions to make a decision for the planned removal of settlement inhabitants located on the territory with contamination density $\geq$2Ci $^{90}Sr/km^2$ in the head and middle parts and $\geq$4 Ci $^{90}Sr/km^2$ in the remote East Urals Radioactive Trace (Fig. 5) [4]. Dynamics of the removal are given in Table 7.

The performed removal was accompanied by accommodating the people in other settlements on the uncontaminated territory and by the compensation of economic damage connected with the loss of houses and grounds and other property.

After removing the inhabitants the abandoned settlements were liquidated by the burial of all buildings. On the contaminated areas within the limits of contamination density of 2-4 Ci $^{90}Sr/km^2$ all economic activity was stopped. Within the same limits the restriction regime of population access was established which existed in full measure up to 1962 [4].

The control of the health state of the removed and unremoved inhabitants on the East Urals Radioactive Trace territory and giving them medical aid were organized during the first year after the accident by the forces of Medical and Sanitary Department No. 71 of Ozyorsk City. During the subsequent period (1959-1960) this task was conducted by the specially created Branch No. 4 of the Biophysics Institute of the Ministry of Public Health of the USSR.

It should be noted that the control was first made in only 4-9 months after the accident and first of all applied to the inhabitants removed in 7-10 and in 250 days after the accident (2055 persons). In 15 months a part of the removed and unremoved inhabitants (245 persons) was examined, in 2 years-236 persons. Fortunately, evident symptoms of radiation effects in the examined population were not detected . However, displacement in the morphological composition of the peripheral blood, manifested in increasing the leukocyte number and in a tendency to increasing of the thrombocyte number was noted in the most exposed adults during the first months after the accident.

In subsequent time, these changes disappeared [4].

7. The efficiency of the countermeasures

It should be admitted that the efficiency of the countermeasures undertaken at the initial and at the intermediate periods both at Mayak PA and in Ozyorsk City and in the East Urals Radioactive Trace territory were different; that is explained either by their insufficient substantiating or their subject-matter incompleteness, deviations from accepted tactics and impossibility of realization.

First of all, it seemed that measures of restoration of the technological processes of radioactive waste management at Mayak PA, as well as measures of decontamination of

Planned population removing

Removing date, days after the accident	Settlement numbers	Distance from accident site, km	Territory contamination level, $Ci^{90}Sr/km^2$	Total population quantity, pers.
250	6	24-57	8-65	2280
330	7	69-80	4-18	4200
670	6	20; 88-98	2-6	3100

Table 7

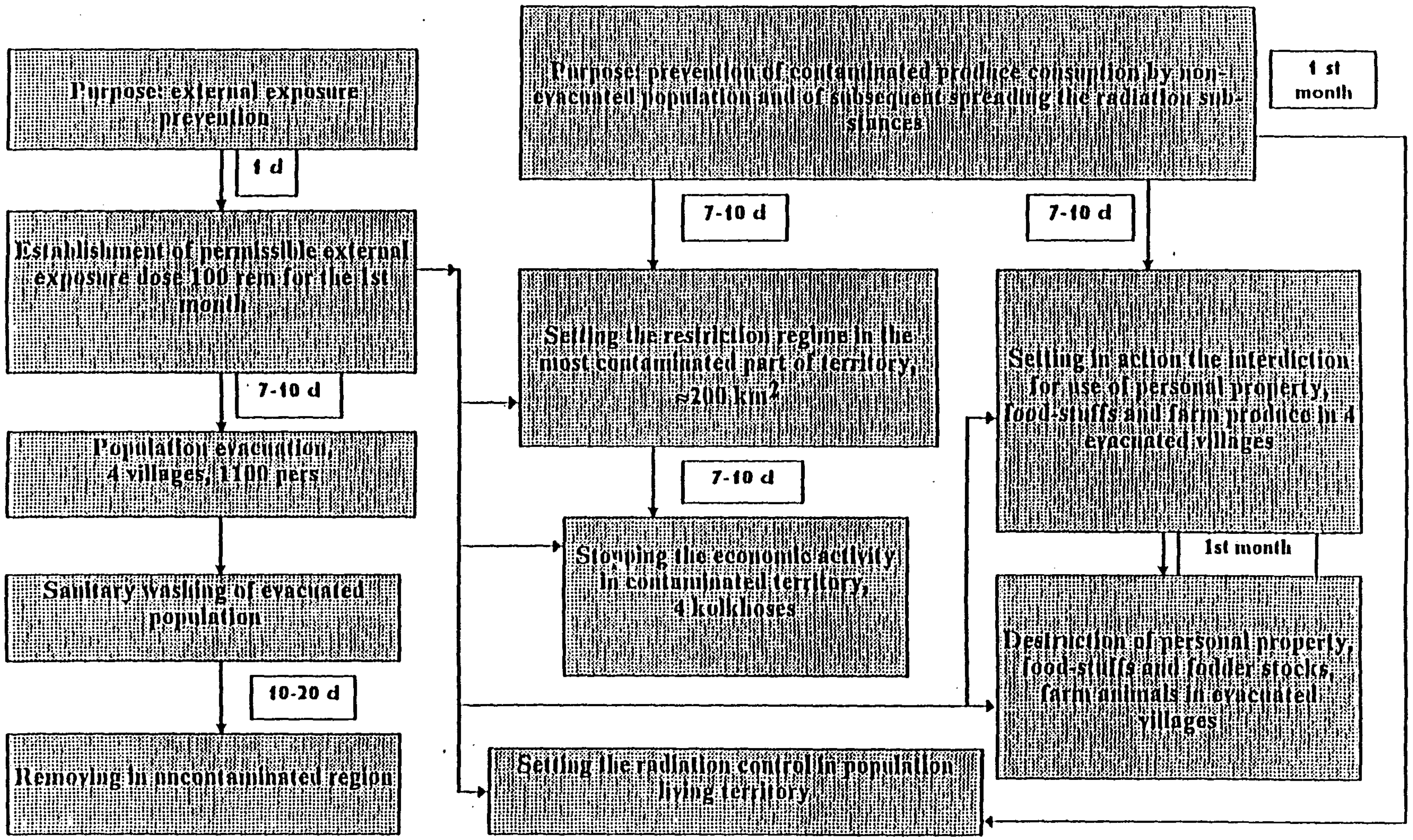

Fig. 4
Population radiation protection measures in the initial period (1st month)

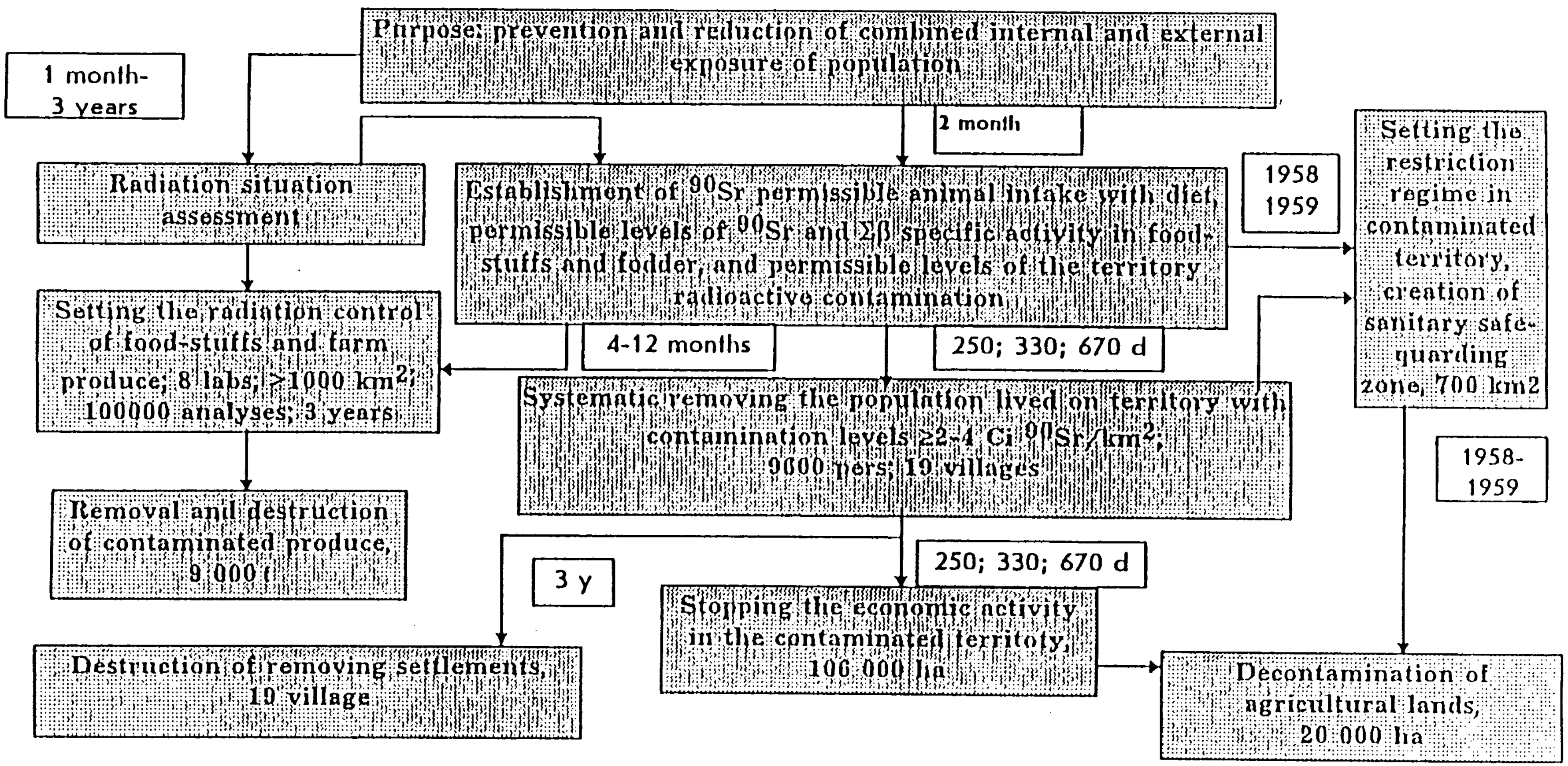

Fig. 5
Population radiation protection measures in the intermediate period (the first 2-3 years)

the territory, transport and transport communications, production, public and dwelling buildings at Mayak PA and in Ozyorsk city, as well as measures of the organization of dosimetric control in the same enterprise, were adequate, since against the general background of essential complications of the production and civil activity these measures had led to their normalization already by the beginning of 1958.

The range of the efficiency of countermeasures providing the radiation protection of the population in the East Urals Radioactive Trace territory is wider. The efficiency of the undertaken measures, from the point of view of the current knowledge and the experience of liquidation of consequences of Kyshtym, Windscale, Chernobyl and other significant radiation accidents, depends on the following factors [13]:

1. Direction of the countermeasures to compensate for influence of the major factors determining the formation of potential external and internal exposure doses during the forecasted period of time.
2. Level of the dose prevented by implementation of the countermeasures.
3. Timeliness of bringing the countermeasures into use.
4. Dependence of completeness of countermeasure realization on social and economic, technical and organizational possibilities.
5. Priority of public benefit over detriment from the realization of countermeasures.

On the basis of the efficiency of the applied countermeasures one can assess the following ways.

7.1. Removal

Removal is one of the most effective measures of radiation protection of the population in radiation accidents with long-lived radionuclide discharges in the environment [13]. In the situation considered the removal at early dates stopped external exposure of the population as well as internal exposure from short-lived radionuclide intakes with diet [4, 6, 7]. Though at the initial period the purpose of removal was the prevention of external exposure dose, however the current retrospective assessments of the population exposure doses (based on ICRP dose criteria [8,9]) in the East Urals Radioactive Trace territory showed that the measure was very effective for the prevention of internal gastro-intestinal tract exposure by the short-lived nuclides (mainly Ce^{144}, the early contribution of which was underestimated), if it was conducted in time (Table 8). Delayed planned removal is

Dose commitment of the combined exposure for the removed population (critical age group is presented by children, up to 1-2 year at the time of accident date)

Dose	No removal	Removing date, d			
		10	250	330	670
Calculating on 1 $Ci^{90}Sr/km^2$, rem:					
- effective	3.0	0.12	1.8	2.0	2.8
- GIT (gastro intestinal tract)	27	0.92	17	19	2.6
- red marrow	4.5	0.12	2.5	2.8	3.4
Average for removed population group, rem:					
- effective	-	60	47	19	12
- GIT (gastro intestinal tract)	-	450	440	180	120
- red marrow	-	61	64	25	15
Prevented in the result of the removing, %:					
- effective	-	96	41	33	7.0
- GIT (gastro intestinal tract)	-	96	37	28	0.4
- red marrow	-	97	44	38	24
Contribution in effective dose, %:					
- of 144Ce	76	78	76	76	76
- of external exposure	31	7.2	4.0	4.0	4.0

Table 8

characterized by essentially less commitment dose prevented, since its main part was formed in the first months after the accident mainly by the short-lived nuclides and not by ^{90}Sr as it had earlier been supposed. From the present positions and radiation protection standards the removal of the inhabitants living in initial contamination density of 2-6 Ci $^{90}Sr/km^2$ almost in 2 years after the accident was ineffective by the prevented dose criteria and by the detriment-benefit criteria.

Today delayed removal as well as the insufficient efficiency of some other countermeasures could not be justified. However, radio-ecological and radiobiological data necessary for the prognosis of changing the radiation situation and of the exposure population doses were absent then. For example, dose factors of man's external exposure from the inhabited environment contaminated with the definite radionuclides, and internal exposure dose factors by radionuclide intake though inhalation and ingestion were unknown. Information regarding systematic level reduction of ^{90}Sr annual intake with diet with a half-reduction period of 12 years and then - 8 years in the trace territory, wasn't forthcoming in the first 10-15 years after the accident.

As a whole, during the initial and intermediate periods of the accident the principal factors determining the ways of exposure and choice of the corresponding countermeasures weren't well known. However, the significant importance of ^{90}Sr in the population exposure over the late period was correctly estimated and establishment of ^{90}Sr maximum territory contamination density equal to 2-4 Ci/km^2 permitting the prolonged and safe population inhabiting was faultless, even from the current point of view, if one does account for the dose received by the population during the first months after the accident.

7.2. Radiation control and withdrawing of contaminated produce

This measure (removal of produce) could have effective and even completed with efficiency, if it had been introduced at the earliest post-accident dates and had subsequently been able to provide the population with uncontaminated food-staffs. Both of these complicating factors essentially reduced the importance of withdrawal of the contaminated food-stuffs and therefore, the efficiency of this countermeasure in dose reduction can be considered at levels of approximately several percents. The rejection of contaminated food-stuffs in the accident effect zone at Chernobyl Nuclear Plant was unsuccessful on the same scale.

7.3. Establishment of the restriction regime

The restriction regime of access of the population into the contaminated territory and cessation of all economic activity on it could also have been sufficiently effective if it had been introduced directly after information of the East Urals Radioactive Trace and if it hadn't been able to break by the population. In practice, after-accident measures considered for the restriction regime were introduced step by step after removing the population from the contaminated territory parts. Therefore, before the removal there were no restrictions on the vital activities and the use of any produce from the contaminated territory.

Living conditions in the rural area led to use of the adjacent territory with a radius of 5-10 km for cattle pasture, laying in hay and firewood, getting the produce of forest, hunting and fishing. Such a practice without any restriction existed to full extent before the removal of the population, and partially - after establishment of the restriction regime. It led to the additional activity of entering into small personal plots, which increased contamination levels of vegetables and potatoes. (By the assessments of 1964 ^{90}Sr average content levels in the produce of personal plots in the settlements within the contamination level about 1 Ci $^{90}Sr/km^2$ were 2 times higher then that on the adjacent arable lands being under the authority of state farms. Approximately 5-10 % of the personal plots were characterized by high contamination levels which required intervention in their economy management practice).

Even after establishment of the restriction regime, the militia was not adequately guarding the population of nearby villages because it did not provide information about the nature and the extent the radiation hazard because of secrecy. The people were still continuing to make attempts at traditional use of the alienated territory for their needs.

One can suppose that the practice of establishment of the restriction regime after the population removal in 250-670 days wouldn't lead to sufficient efficiency. The efficiency of that measure essentially increased over the late after - accident period, though the doses already prevented had not been large.

7.4. The territory decontamination

In 1958-1959 years, the territories of the removed villages and arable lands adjacent to them were subjected to decontamination.

On the territories of abandoned villages, the destruction and burial of dwellings and commercial buildings for the purpose of prevention of the plundering of contaminated real property and its further economic use were conducted with the help of special mechanized detachments.

The purpose of decontamination of the arable land, mainly in the head and intermediate areas of the East Urals Radioactive Trace within the limits of contamination level of 2 Ci $^{90}Sr/km^2$, was prevention of the further wind resuspension of radioactive matters and its transport out of the trace boundary that was described in autumn of 1957 and in spring of 1958. The decontamination was conducted by ploughing the arable lands with usual agricultural ploughs [4, 7]. It is difficult to estimate the efficiency of the measure since it didn't compensate for the effect of the main factors. One can only affirm that it was not helpful for the population subjected to removal, and not sufficiently justified from the point of view of radiation protection of the unremoved inhabitants, since wind resuspension from the most contaminated territories in the head of the trace and increase of the radioactive contamination levels in adjacent territories were more appreciable only in spring of 1958. But that resulting additional contamination didn't lead to the necessity of intervention in normal vital activity on the territory of its less windy area (Kunashak district of Chelyabinsk region) [1, 4].

8. Conclusion; lessons for the future

The above presented analysis of the subject-matter and the efficiency of the counter measures undertaken for reduction and compensation of negative consequences of the accident in 1958 at Mayak PA over the initial and intermediate after-accident periods, as well as comparison of the analysis with current conceptions of the management strategy of radiation accident consequences, [10, 11] as a whole are evidence of the sufficient successful realization of the main tasks of liquidation of the consequences of the accident.

First of all, it was revealed in restoration of the normal production activity of the enterprise, of the normal vital activity of Ozyorsk City, in prevention of the manifestation of determined radiation effects of the population in the contaminated territory, though similar ones could be in the inhabitants of the settlements of the head East Urals Radioactive Trace.*) The practice of liquidation of the accident consequences may be considered more effective if one takes into the account the absence at that time of radioecological and radiobiological scientific knowledge correstponding to current international and national recommendation of managementwith radiation accients, of accidents standards and sufficient practical experience of liquidation of the consequences of radiation accidents.

*)There are also no evident arguments for increasing the frequency of late carcinogenic effects in all the population living in and subjected to prompt and prolonged radiation exposure as the result of the accident.

The main factors that determined the possibilities of implementation and efficiency of a significant part of the complex of accident countermeasures were:

- the efficient organization of interaction of the central and local authorities, departments and institutions subordinated to them;
- the urgent development of investigations to study the radiation situation and the characteristics of the prognosis of its change, of the determination of potential ways of exposure and exposure dose levels of the population;
- competent substantiation (as well as in number of cases right intuition caused by the high competence of specialists) of most of the undertaken measures;
- enlisting the highly qualified specialists and scientists of the Ministry of Middle Engineering Industry and the Ministry of Public Health of the USSR and other departments;
- self-discipline and high executive discipline of work participants of all levels of interactions;
- high authority of action and opinions of work leaders and specialists anvil scientists (that was significantly worse in liquidation of Chernobyl accident consequences).

Nevertheless, consideration of practice of liquidation of the consequences, the accident of 1957 brought definite lessons that can be useful in an organization of the same measures in the case of possible accidents with radioactive matter discharges in the environment, taking into account current conceptions and requirements of radiation protection.

1. The accident of 1957 was unexpected for Mayak PA (though at present it is difficult to forecast causes, place and time even of the projected technological accidents) and the enterprise was found unprepared for such a serious radiation accident. Insufficient efficiency of a number of urgently developed and undertaken counter measures, in particular in the East Urals Radioactive Trace, was caused by absence of the following substantiation of these measures' documents and organization actions:

- of the accident plan and accident basic and derived dose standards;
- of reliable and timely information on characteristics and dynamics of the radiation situation and of factors of the radiation hazard, of prognosis of forming the exposure doses of population;
- of recommendations of the typical effective countermeasures with indication of their efficiency and the application dates;
- of organization, methods, material and technical preparedness of radiation safety

services of the enterprise and the Ministry as a whole;
- of accident dosimetric, medical and radiological restoration technical parties at the enterprise, at the Ministry and in the regions.

This proves that at present every enterprise using radioactive matters and the region around its location have to develop accident plans for the case of typical projected accidents. Tasks and subject-matter of these plans have to correspond to the requirements of national and international recommendations of management of radiation accidents [10-12].

2. Insufficient efficiency of the separately applied measures of radiation protection of the population, except for the above-pointed cause, is also explained by tardiness of their application. Today it is generally known that the main part of the population's potential exposure dose in radiation accidents is formed in the initial period for some days or weeks. Therefore, the most effective countermeasure directed to compensation for the influence of the main exposure factors have to be brought into use as soon as possible. The delay of their bringing into use led to reduction of the efficiency of such measures as late population removal, withdrawing contaminated food-stuffs from use, and introduction of the restriction regime.

3. On the other hand, introduction of the theoretically competently substantiated and potentially effective measure of radiometric control of food-stuffs, their withdrawing from use when exceeding the permissible contamination levels and when their possible replacement by clean ones hadn't led to adequate decreasing of the population exposure doses due to the huge volume of works on organization of the control and the withdrawing of the contaminated produce, as well as the economic impossibility of provision of the population with uncontaminated produce. This is confirmed by the experience of liquidation of the Chernobyl accident consequences as well. Consequently, this measure is advisable only for small contaminated regions but, for serious radiation accidents, the consequences of which can cover hundred-thousands of square kilometers, the measure hardly can be realized to their fullest extent and it is advisable to replace it by evacuation or removal if the high contamination levels of food-stuffs will persist for several weeks or months.

4. One can also note that the restriction regime of population access to the contaminated territory and of its economic use can lead to the population exposure dose decreasing if this restriction is introduced directly after the accident evacuation or removal, that is, in the period of forming the main part of the potential exposure dose. Delayed introduction of the measure provides only reduction of the essentially lesser exposure doses of the unremoved inhabitants in the intermediate and late periods.

5. As the experience of liquidation of consequences of both the considered accident and Chernobyl has shown implementation of measures of the contaminated territory decontamination in the initial and intermediate periods of the accident is not always substantiated and therefore can be ineffective, especially against the background of large expenditures of time and resources for implementation of the measure. It should take into account that decontamination in the early accident stages is advisable in those cases when it is intended to the reduction of the exposure dose to the personnel conducting post-accident actions or employees at the production subjected to the accident contamination effect, as well as the population obliged to live in the radioactive contamination conditions [13]. In the light of these propositions the decontamination of part of the industrial site territory subjected to contamination by the accident was necessary and advisable. However, the decontamination of the territory in the location places of the removed villages essentially didn't reduce exposure doses for either the removed or unremoved inhabitants. One can suppose that such a measure, if its efficiency in reduction of the external exposure dose is confirmed economically, should be used in the places of population living in the late accident stage.

6. One example progress in liquidation of the accident consequences of 1957 is the sufficiently competent prediction of ^{90}Sr population exposure in the prolonged late accident stage. If conditions of forming the population exposure doses in the course of the initial and intermediate periods weren't completely taken into account, including the importance of short-lived radionuclides, however, ^{90}Sr potential radiological hazard was competently estimated even the context of present-day knowledge. This led to the fact that the choice of radiation protection measures subject to introduction 1-2 years after the accident when ^{90}Sr contribution to the potential dose was insignificant, nevertheless was directed towards prevention of its radiological hazard that could be revealed only during the late accident period.

It should be recommended in developing accident plans to pay attention to the main factors determining the population exposure in each stage of the accident and to take into account the necessity of development of such countermeasures, introduction of which could reduce population exposure doses then and in the late stage.

Literature

1. Study of radiological, radiation hygienic and social and economic consequences of intensive radioactive contamination of large areas. Vol. m. Radiation situation and dynamics of radionuclides environmental behavior.

Ternovsky I.A., Teverovsky E.N., Mayak PA, 1984 (unpublished). (In Russian)

2. Kyshtym accident in large-scale plan - "Priroda", 1990, 10-15. (In Russian)

3. Romanov G.N., Drozhko E.G., Nikipelov B.V. Kyshtym accident: causes, scale and radiation characteristics. (In Russian) - Proceedings of CEC/EUR Symposium "Comparative Assessment of the Environmental Impact of Radionuclides Released during Three Major Accidents: Kyshtym, Windscale and Chernobyl", Luxembourg, 1990. CEC, EUR 13574, 1991.

4. Study of radioecological, radiation hygienic and social and economic consequences of intensive radioactive contamination of large areas. Vol. V. Ensuring of population radiation protection. Ternovsky LA., Teverovsky E.N. - Mayak PA, 1984 (unpublished). (In Russian)

5. Vasilenko E.K Personal communication, 1996. (In Russian)

6. Results of study and the liquidation experience of consequences of territory accidental contamination with uranium fission products. Ed. A.L Burnazyan. - ~, Energoatomizdat Publishing, 1990. (In Russian)

7. Romanov G.N., Buldakov L.A., Shvedov V.L. et al. Basing of criteria and population radiation protection measures efficiency in the Kyshtym accident. (In Russian) - Proceedings of an International Seminar "Intervention Levels and Countermeasures for Nuclear Accidents", Cadarache, 1991. CEC 14469, 1992.

8. Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 1. ICRP Publication 56. Pergamon Press, 1990.

9. Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5. Complication of Ingestion and Inhalation Dose Coefficients. ICRP Publication 72. Pergamon Press, 1996.

10. Principles for Intervention for Protection of the Public in a Radiological Emergency. ICRP Publication 63. Pergamon Press, 1993.

11. Conception of radiation, medical, social protection and rehabilitation of Russian Federation population undergone an accidental irradiation. Russian Scientific Committee on Radiation Protection, 1994. (In Russian)

12. Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities. Safet Serices No. 55. IAEA, Vienna, 1981.

13. Romanov G.N. Elimination of Consequences of Radiation Accidents. Guide Book. Moscow, Nuclear Society, 1993.

Role of federal radiological monitoring and assessment center

The next speaker is Mr. Milton Chilton\, United States Department of Energy (DOE). He is currently Radiological Emergency Response Program Manager and is responsible for managing the Federal Radiological Monitoring and Assessment Center (FRMAC), the aerial measuring system, the Accident Response Group (ARG), and the radiological assistance programs for DOE/Nevada.

(As the attached copies of Mr. Chilton's slides are fairly self-explanatory, they are inserted after the brief summary. The following is a short abstract taken from his presentation that merely summarizes the slides, with a few additional details.)

Mr. Milton Chilton: At the time of the accident at Three Mile Island in 1982, there was no coordinated plan for the federal agencies that responded to the accident. The federal agencies that responded took the emergency protective actions and conducted their monitoring and sampling activities to assess the hazards that existed, but many agencies were acting on their own. The cooperation was not very good. Accordingly, a Federal Radiological Emergency Response Plan (FRERP) was established in 1985 and updated in 1996. It coordinates 17 different federal agencies. It established a Federal Radiological Monitoring and Assessment Center (FRMAC), which is led by the Department of Energy during the emergency phase after an accident. Responsibilities are stated in Fig. 5. Should the accident impact international territory, then the Department of State helps to coordinate with those other countries that have been impacted. Note that the state has the final authority to make decisions on what protective actions will be taken to protect the public within that area. The state's responsibilities are described in Fig. 7. DOE is responsible for providing the data and assessments of the data to lead federal agencies, state, local, and other tribal agencies. In our case, dealing with tribal agencies is like dealing with a foreign country in many respects. The FRMAC would also provide other technical assistance and respond to the emergency situation if the state requires assistance in population monitoring. Eventually, the responsibility for the FRMAC does transfer to the EPA once we move into the long-time monitoring phase actions. The turnover process is schematicized in Fig. 23. In case a decision to evacuate and/or relocate people is made, the state implements this. FRMAC is there to assist them in assessing the situation. The state also establishes recovery levels for residences and agricultural and pastoral areas with the FRMAC's assistance and advice as requested.

The FRERP assigns responsibilities for monitoring, sampling, and analysis to the FRMAC. The organization chart is described in Fig. 11 and the responsibilities for monitoring in Figs. 12 and 13. Some of the equipment used is shown (Figs. 14 and 15). The Manager of Assessment oversees and reviews the data products before they go to the FRMAC director for release to the state. Assessment tasks are described in Fig. 18. The FRMAC has GIS (geographic information system) capabilities as part of their data collected and their products (Figs. 19, 20, and 21). The EPA has several protective action guides (PAGs) established for the state for action. Generally, there are four specific PAGs that EPA looks at. The PAGs for relocation of a population are based on four-day, one-year, two-year, and 50-year projections. The four-day PAG is a range from 1-5 rem. The actual number chosen would be based on the actual conditions that existed; if the evacuation was difficult or considered to be hazardous, one might choose a 5 rem limit and use 1 rem when it is a small population and beautiful weather. Plots can also be made to address other specific concerns, such as what kind of contamination has been deposited on the food crops, what is being taken up from the livestock, and, finally, the bottom line is what kind of exposures are going to occur to the population and what kind of actions are we going to take on that basis? Again, we would implement health and human services guidelines for ingestion. In our calculations, we also allow for weathering, wind, rain, dew; runoff can occur and the levels will start dropping. We can look at those activities and make some assumptions to help us assess the long-term exposures. We can also consider the effect of sheltering and factor that into our assessments. The intention is to use reasonable conservative assumptions in our calculations and document those so we don't get very large numbers for exposure levels and end up evacuating lots of extra people unnecessarily. We try to see what is valid, what is reasonable, and to document this so people can reassess what we did, why we did it, and the validity of it. This was learned from an exercise we participated in some months back. It is a quick overview of the process and the final products, certainly some of the most important products, that needs to come out very quickly. A very great concern is how large is the total impacted area. We need to take into account the public perception standpoint and the national standpoint, if we are trying to protect the people. Also, another concern becomes the economical impacts for trying to help protect state crops and the marketability of those crops and livestock. To do this we need to demonstrate control very quickly of the impacted area. In effect, this is something that was developed after a couple of days within the exercise. We are showing a definition of an embargo area for food crops and livestock and such. Again, this is something we are assisting the state in doing. They are the ones who have to make the final decision on what levels are implemented, but we have to move beyond what are the immediate concerns with evacuation and sheltering and relocation to what will be the total impacted area where we must take some kind of protective measure to minimize the exposure and the impact on the population. Here the idea, obviously, would be to develop a conservative boundary and shrink that in as the data become available to support this. Initially, for instance, the lower part of the ground deposition plume would be something that you could not monitor and certainly couldn't detect from the aircraft; probably even our gamma in situ systems could not make those measurements. We would have to go out and take samples on the ground and vegetation to identify those levels. In effect, what we initially would have to do is look at the predictive modeling based on working the concentrations in the air, then start normalizing that based on the actual base measurements to validate or invalidate the modeling. We need to take into consideration uncertainties like the actual wind predictions and their accuracy to establish some boundaries for controlling food crops and livestock so those things, if contaminated, would not get out into the public domain; thus, we can protect the public from that exposure. Also, an important part of that is, if we can do that and demonstrate it properly, we have a chance of protecting the marketability of the rest of the crops and livestock of that area. We have at least one of these battles, in my personal opinion. I am not sure if you can ever win because of the perceptions and the concerns about contamination--an example would be boycotting all potatoes from Idaho because a part of that area has been contaminated--but we in effect need to keep that from occurring and that is one of the things that has to happen here. This last slide (Fig. 23) shows the transition that occurs between DOE and EPA. Initially, while you are in the emergency response phase and characterizing the extent of the contamination and the exposure levels, DOE is in charge. At some point we move beyond that, when the facility or material that caused the problem is under control again and you have characterized the contamination and the extent of contamination. You now basically understand what EPGs are required and have implemented those. The situation now has a restoration and long-term monitoring requirement, so you can transition over to EPA; DOE in effect starts transitioning out. So, you can see the DOE level of involvement declining over time and the EPA level rising over time. That is all I have unless there are questions. Thank you very much.

Mr. Chilton's slides begin on page 53.

OVERVIEW OF FRMAC OPERATIONS

DOE/NV FRMAC

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FRERP AND THE FRMAC

DOE/NV FRMAC

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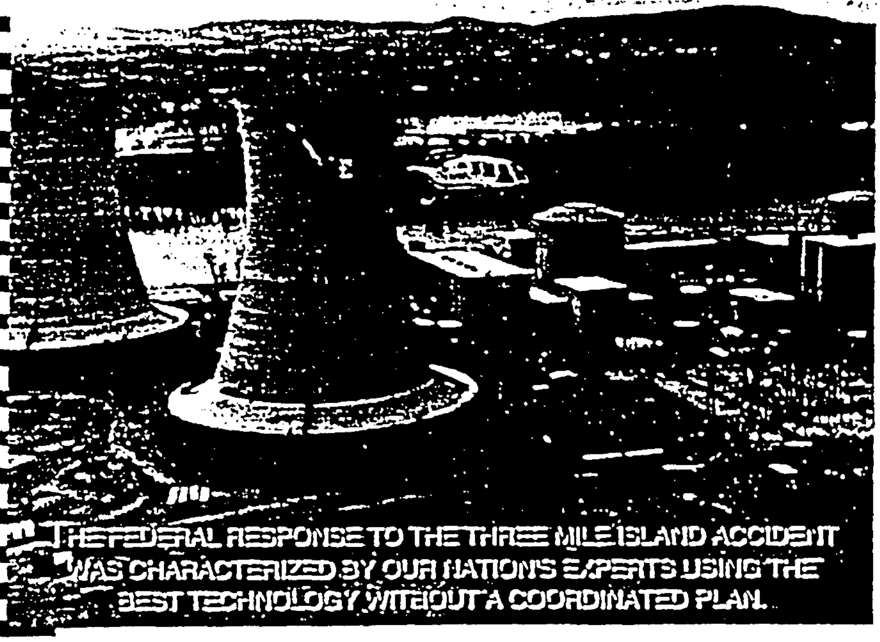

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DOE/NV FRMAC

FEDERAL RADIOLOGICAL EMERGENCY RESPONSE PLAN (FRERP)

- FEDERAL REGISTER - NOVEMBER 8, 1985 UPDATED May 8, 1996
  - ESTABLISHES A FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT CENTER (FRMAC)
  - ASSIGNS THE COORDINATION OF THE FRMAC DURING THE EMERGENCY PHASE TO THE DEPARTMENT OF ENERGY

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DOE/NV FRMAC

LEAD FEDERAL AGENCY RESPONSIBILITIES

- RESPONSIBLE FOR LEADING AND COORDINATING ALL ASPECTS OF THE FEDERAL RESPONSE *
- ON-SCENE COORDINATION
- ON-SITE MANAGEMENT
- RADIOLOGICAL MONITORING AND SAMPLING
- PROTECTIVE ACTION RECOMMENDATIONS
- NON-TECHNICAL RESOURCE SUPPORT
- PUBLIC INFORMATION COORDINATION
- CONGRESSIONAL AND WHITE HOUSE COORDINATION
- INTERNATIONAL COORDINATION THRU DOS

* 9/15/95 FRERP, pg II-1

DOE/NV FRMAC

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FRERP - DOE RESPONSIBILITIES

- ESTABLISH A FRMAC
- MAINTAIN A COMMON SET OF OFF-SITE RADIOLOGICAL MONITORING DATA
- PROVIDE DATA AND ASSESSMENTS TO THE LFA, STATE, LOCAL, AND/OR TRIBAL AGENCIES
- PROVIDE TECHNICAL ASSISTANCE, UPON REQUEST, TO STATE AND FEDERAL AGENCIES
- TRANSFER MANAGEMENT OF THE FRMAC TO EPA UPON MUTUAL AGREEMENT

DOE/NV FRMAC

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State Responsibilities

- Releases information to the public
- Establishes radiation levels requiring public protective actions
- Initiates actions for public protection
- Establishes recovery guidelines

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DOE/NV FRMAC

FRMAC Mission

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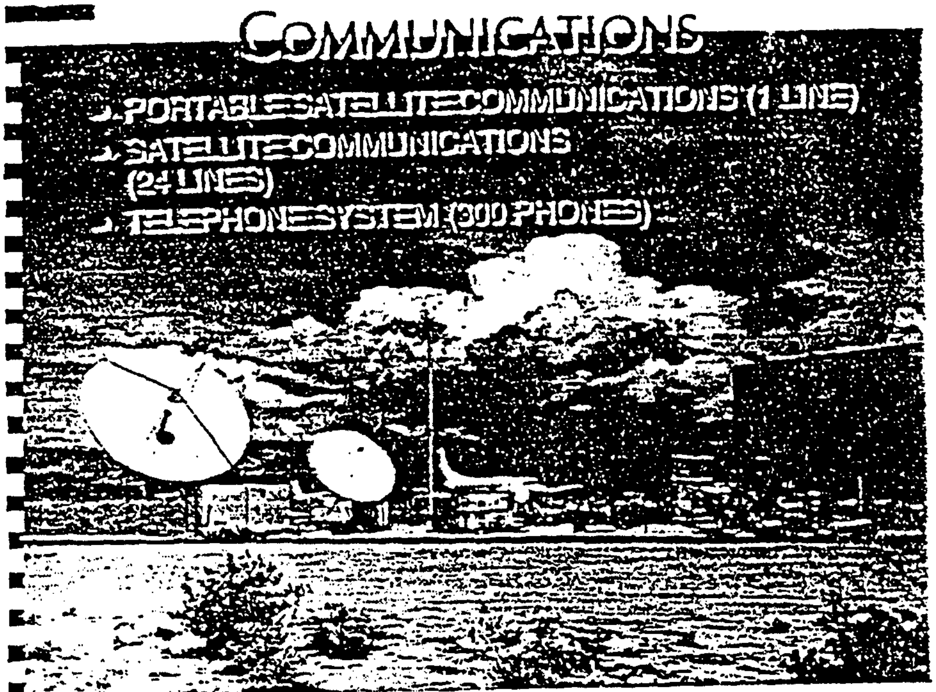
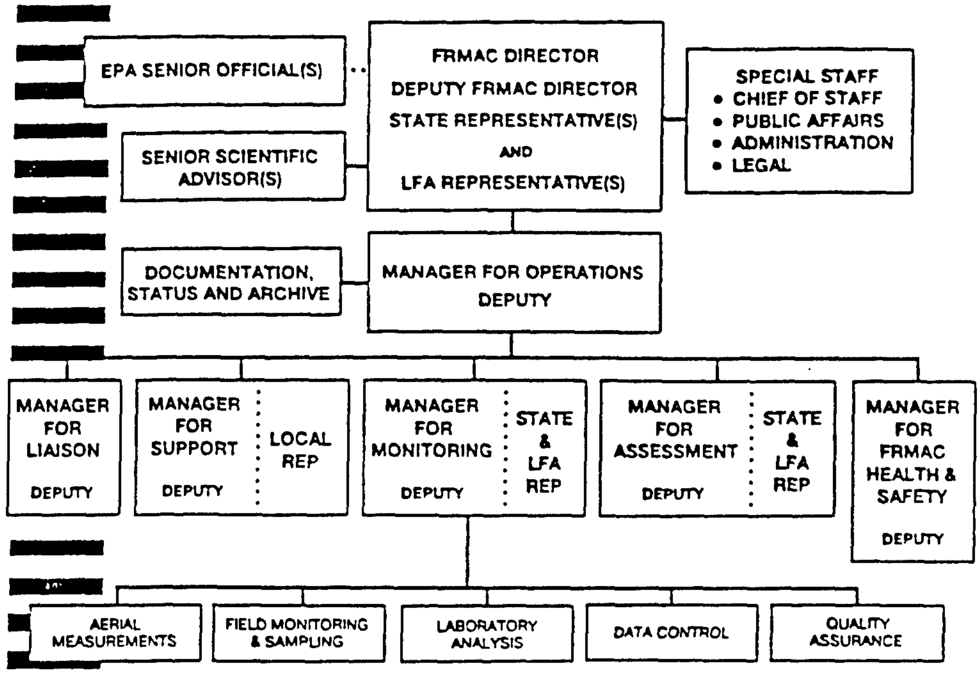


DOE/NV FRMAC

MONITORING, SAMPLING, AND ANALYSIS

DOE/NV FRMAC

FRMAC Organization Chart



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DOE/NV FRMAC

Manager For Monitoring

- Coordinates and directs field monitoring efforts
- Works with State(s) and LFA to develop a monitoring and sampling plan
- Identifies personnel, equipment, and resources needed
- Provides reviewed raw data to assessment, States, LFA, and the FRMAC community

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DOE/NV FRMAC

MONITORING RESPONSIBILITIES

- COORDINATE AND DIRECT ALL FRMAC PERSONNEL AND EQUIPMENT (FEDERAL, STATE, AND LOCAL) INVOLVED IN:
  - AERIAL RADIOLOGICAL SURVEYING - FIXED-WING AND HELICOPTER
  - FIELD MONITORING AND SAMPLING
  - RADIOANALYSIS - MOBILE AND FIXED LABORATORIES
  - RADIATION DETECTION INSTRUMENTS - CALIBRATION AND MAINTENANCE
  - ENVIRONMENTAL DOSIMETERY
  - QUALITY ASSURANCE

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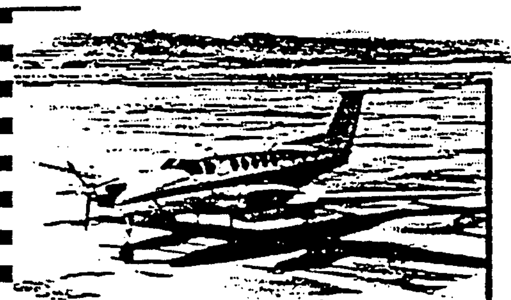
AERIAL MEASURING SYSTEM (AMS)



BEECHCRAFT B-200 AIRCRAFT

- PLUME TRACKING
- PLUME SAMPLING
- INITIAL APPRAISAL OF THE EXTENT OF DEPOSITION

MBB BO-105 HELICOPTER

- DETAILED RADIOLOGICAL MAPPING

DOE/NV FRMAC

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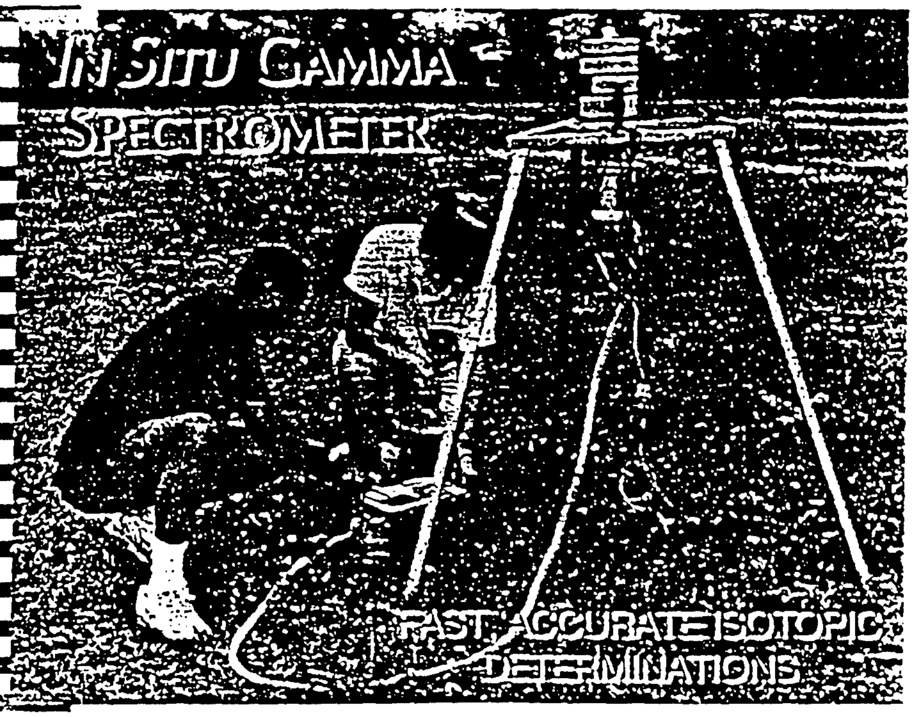

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DOE/NV FRMAC

ASSESSMENT

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DOE/NV FRMAC

MANAGER FOR ASSESSMENT

- OVERSEES PROCESSING, EVALUATION, ASSESSMENT AND REPORTING OF ALL DATA
- ENSURES COMPREHENSIVE AND TRACEABLE DATABASE
- REVIEWS ALL OUTPUT PRODUCTS BEFORE BEING SENT TO THE FRMAC DIRECTOR

FRMAC010495 78 3a

DOE/NV FRMAC

ASSESSMENT TASKS

- ASSURE TECHNICAL INTEGRITY OF DATA
- PROVIDE OVERVIEW OF RADIOLOGICAL SITUATION
- PROVIDE RADIATION CONTOURS
- PROVIDE PROJECTED DOSE LEVELS
- PREPARE RESULTS AS BASIS FOR PROTECTIVE ACTION RECOMMENDATIONS AND RECOVERY
- PREPARE RESULTS IN UNDERSTANDABLE FORMAT AS NEEDED BY THE STATE(S) AND LFA
- MAINTAIN A COMPREHENSIVE AND TRACEABLE SET OF ENVIRONMENTAL RADIOLOGICAL DATA

FRMAC010495 110 3a

DOE/NV FRMAC

FRMAC ASSESSMENT

- DATA CENTER FUNCTIONS
  - PHYSICAL RECORDS
  - DATABASES
  - DATA AND OUTPUT PRODUCTS

DOE/NV FRMAC

FRMAC010495.113.3a

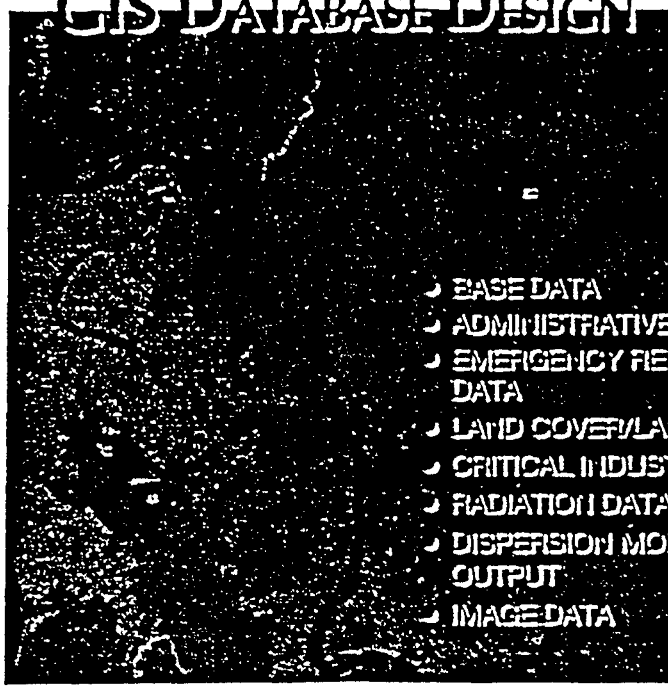
FRMAC EXPECTED PRODUCTS

- PLUME PROJECTIONS
- AERIAL SURVEY RESULTS
- REVIEWED RAW DATA
- SUMMARIZED AND ASSESSED DATA
- CONTAMINATION CONTOURS
- DOSE PROJECTIONS
- COMPREHENSIVE AND TRACEABLE DATABASE
- PROVIDE DATA TO SUPPORT LFA PAG DECISION MAKING PROCESS

DOE/NV FRMAC

FRMAC010495.120.3a

GIS Database Design



FRMAC010495 121.3a

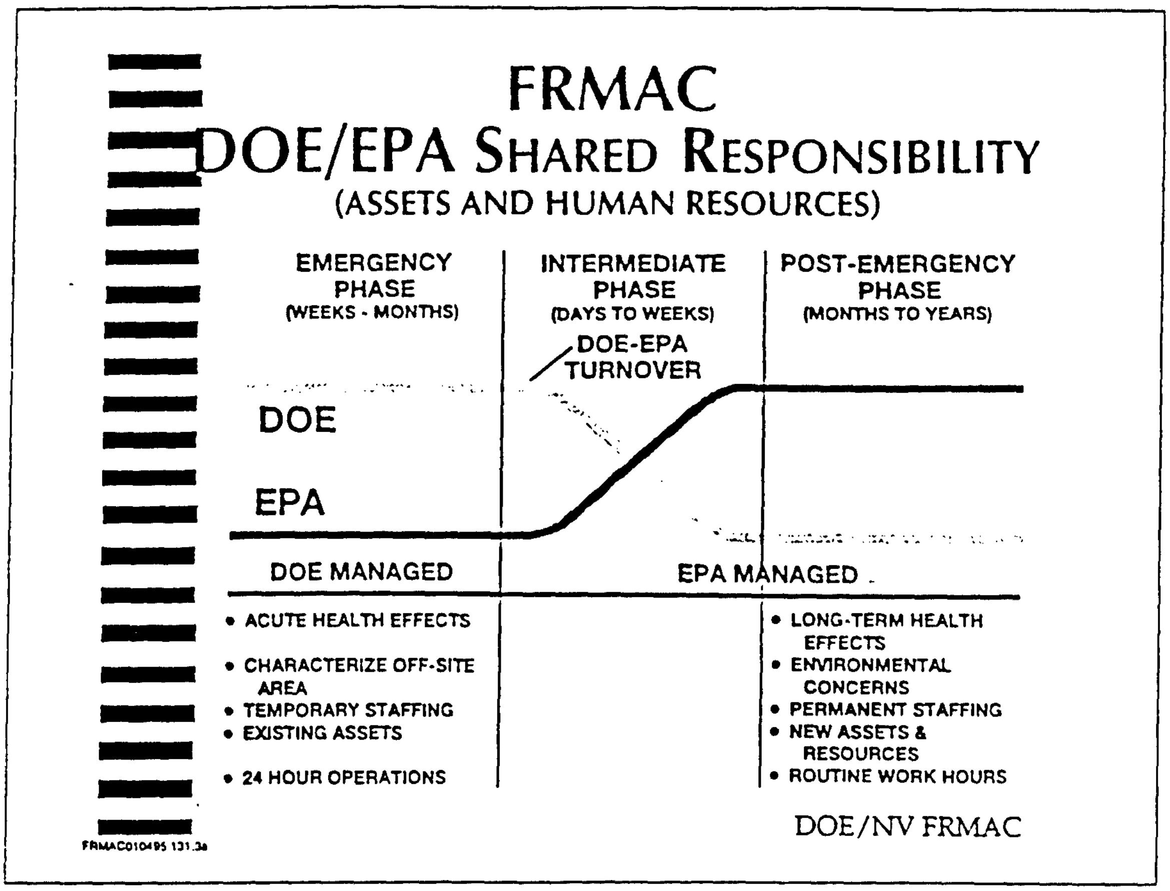
DOE/NV FRMAC

Dose Projections

- 4 DAY, 1, 2, & 50 YEAR PROJECTIONS
- 0.1, 0.5, 1, 2, 5, & 10 REM DOSE LEVELS
- SPECIFIC PROJECTIONS (MILK, WATER, ETC.)
- DOSE PROJECTION MODIFICATIONS, AS APPLICABLE (WEATHERING, DILUTION, SHIELDING, ETC.)
- REASONABLE CONSERVATIVE CONSIDERATIONS
- ASSUMPTIONS DOCUMENTED

FRMAC010495.123.3a

DOE/NV FRMAC


FRMAC
DOE/EPA SHARED RESPONSIBILITY
(ASSETS AND HUMAN RESOURCES)
EMERGENCY PHASE (WEEKS - MONTHS)
INTERMEDIATE PHASE (DAYS TO WEEKS)
POST-EMERGENCY PHASE (MONTHS TO YEARS)
DOE-EPA TURNOVER
DOE
EPA
DOE MANAGED
EPA MANAGED
• ACUTE HEALTH EFFECTS
• CHARACTERIZE OFF-SITE AREA
• TEMPORARY STAFFING
• EXISTING ASSETS
• 24 HOUR OPERATIONS
• LONG-TERM HEALTH EFFECTS
• ENVIRONMENTAL CONCERNS
• PERMANENT STAFFING
• NEW ASSETS & RESOURCES
• ROUTINE WORK HOURS
DOE/NV FRMAC
FRMAC010495 131.3a

Col Reeves: The next speaker is Mr. George Bickerton on the Emergency Programs Staff of the Food Safety and Inspection Service, U.S. Department of Agriculture. He is also a member of the Federal Radiological Preparedness coordinating committee and the Federal Radiological Monitoring and Assessment Center management panel.

Role of advisory team for environment, food and health

Mr. George Bickerton: Thank you, Glen. Good afternoon. I've been asked to speak with you today about two subjects, one, how we in the United States plan to protect the food supply in the event of a radiological emergency; and the second topic, the advisory team for environment, food, and health. The two topics are really directly related because the advisory team provides one of the means for providing information for protecting the food supply.

Abstract

The procedure for implementing the technical response to a peacetime radiological emergency is outlined in the Federal Radiological Emergency Response Plan (FRERP). The objective of this plan is to establish an organized and integrated Federal capability for providing a timely and coordinated response to peacetime radiological emergencies. The FRERP covers any peacetime radiological emergency that has actual, potential, or perceived radiological consequences within the United States, its Territories, possessions, or territorial waters and that could require a response by the Federal Government.

In the United States, the Ingestion Exposure Pathway Emergency Planning Zone, is defined as the area within an approximate 50-mile or 80.5 kilometer radius around a commercial nuclear power station. It is characterized by the deposition of radionuclides, notably iodine and cesium, on crops, other vegetation, bodies of water and ground surfaces, and the subsequent ingestion of contaminated food, milk, and water.

Advice on environment, food and health matters will be provided to the Lead Federal Agency and the States through the Advisory Team for Environment, Food and Health (Advisory Team) consisting of representatives of the Environmental Protection Agency, the Department of Health and Human Services, and the Department of Agriculture, supported by other Federal agencies, as warranted by circumstances of the emergency. The Advisory Team would use assessed data from the Federal Radiological Monitoring and Assessment Center to develop informed protective action recommendations to protect public health and safety, and the food supply should a radiological emergency occur.

Introduction

Good afternoon. I have been asked to speak with you today about two subjects: Protecting the food supply in the event of a radiological emergency and the Advisory Team for Environment, Food and Health. The two topics are directly related because the Advisory Team provides a means for protecting the food supply. To begin, permit me to first briefly discuss the Federal Radiological Emergency Response Plan.

Federal Radiological Emergency Response Plan

The procedure for implementing the technical response to a peacetime radiological emergency is outlined in the Federal Radiological Emergency Response Plan (FRERP). The objective of this plan is to establish an organized and integrated Federal capability for providing a timely, and coordinated response to peacetime radiological emergencies. The Federal Radiological Emergency Response Plan covers any peacetime radiological emergency that has actual, potential, or perceived radiological consequences within the United States, its Territories, possessions, or territorial waters and that could require a response by the Federal Government. The level of the Federal response to a specific emergency will be based on the type and/or amount of the radioactive material involved, the location of the emergency, the impact on or the potential for impact on the public and environment, and the size of the affected area. Emergencies occurring at the fixed nuclear facilities or during the transportation of radioactive materials fall within the scope of the Plan regardless of whether the facility or radioactive materials are publicly or privately owned, federally regulated, regulated by an Agreement State, or not regulated at all. Also covered are other incidents such as satellites containing radioactive materials and the providing of technical assistance in response events involving radiological sabotage and terrorism.

Ingestion Exposure Pathway Emergency Planning Zone

In the United States, the Ingestion Exposure Pathway Emergency Planning Zone, is defined as the area within an approximate 50-mile or 80.5 kilometer radius around a commercial nuclear power station. It is characterized by the deposition of radionuclides, notably iodine and cesium, on crops, other vegetation, bodies of water and ground surfaces, and the subsequent ingestion of contaminated food, milk, and water. The safety of the food supply within the 50-mile ingestion exposure pathway emergency planning zone will be of great concern to members of the agricultural community.

State and local governments use guidance developed by the U.S. Department of Health and Human Services, Food and Drug Administration to determine whether levels of projected radiation dose warrant protective actions, and if so, what protective actions are appropriate. With respect to human food and animal feed that are involved in interstate commerce, the Department of Health and Human Services and the Department of Agriculture are assigned Federal regulatory authorities and responsibilities.

The decision to recommend protective actions will be based on the emergency condition at the nuclear power station, available information on the amount of radiation that has been released to the environment, and consideration of the potential health, economic, and social impacts of the proposed actions.

These protective action recommendations would be transmitted by radio or television stations that carry emergency broadcast information or through local agriculture extension offices that are familiar with the demographics of the agricultural community: For example, the Agricultural Extension Offices would know the number and location of dairies, meat processing plants, and orchards; what crops are in season; what types of game and wildlife are in the area and what hunting seasons are currently in progress; the location of family roadside fruit and vegetable stands; and the location of commercial fisheries and apiaries.

There are two recognized protective actions. They are preventive and emergency actions. Some states also refer to a third protective action called Precautionary:

- Precautionary Protective Actions are any actions implemented without the verification of radionuclide measurements by field monitoring or laboratory analysis. These actions may be ordered by State officials based solely on deteriorating plant conditions or the possibility of an imminent release of radioactive materials from the reactor. When measurements from food samples are available, State and local government officials can determine which preventive and emergency protective actions are appropriate.

- Preventive Protective Actions prevent or reduce contamination of milk and food. Farmers are advised to shelter the animals, if possible, especially milk-producing animals, and to place animals on stored feed and water. These actions may be taken when there are known measured releases of radioactive materials that exceed the Food and Drug Administration preventive protection action guides of 1.5 rem to the thryoid and 0.5 rem whole body and other organs, and when events are I process or have occurred which involve actual or likely failures of plant functions needed for the protection of the public.

The following are example of specific protective action recommendations and related information that may be transmitted to the agricultural community by appropriate State or local government officials.

- Milk:
  -- The most critical early ingestion pathway is the milk pathway (pasture-cow-milk-processor-distributor-consumerA) because of its possible effects on children. Radionuclides will appear in milk several hours after dairy cows consume contaminated forage and will reach a maximum between 24 hours and several days after a contaminating event. Farmers would be advised by the public emergency broadcast system to remove all lactating animals from pasture, shelter if possible, and provide them with protected feed and water. In order to deteremine if products are contaminated, State and local government officials will take milk, feed, and water samples for laboratory analysis.

  -- If dairy products are found to be contaminated, it may be recommended that milk be withheld from the market to allow for the radioactive decay of short-lived radionuclides. This may be achieved by freezing and storing fresh milk, concentrated milk or milk products. Storage of milk for prolonged periods of time at reduced temperature is also possible provided ultrahigh temperature pasteurization techniques are used during processing. Using fluid milk for the production of butter, cheese, non-fat dry milk, or evaporated milk may also be possible.

- Fruits and Vegetables:
  -- The public would be advised to wash, brush, scrub, peel, or shell locally grown fruits and vegetables, including roots and tubers, to remove surface contamination of short-lived radionuclides, such as iodine-131. Preserving by canning, freezing, or dehydration and storing to allow time for decay of Iodine-131 is another option.

- Soil:
  -- Radionuclides in the ingestion pathway may remain as a long-term problem since the radionuclides in the soil could be taken up by vegetation growing at the time, or by future crops including vegetables, fruit trees, grains and forage; this could endanger future harvests. Variations in deposition and uptake may require detailed field testing and long term protective actions. If State or local

government officials find that the soil is contaminated, proper soil management procedures can be implemented to reduce contamination to safe levels.

-- Idling, or the non-use of the land for a specific period of time, may be necessary in some cases. Although this may be relatively easy to implement, it would have a long lasting effect. In cases of highly contaminated soil, removal and disposal of the soil may be more appropriate. This would probably not be practical in large areas.

-- Alternating field crops may be beneficial in some situations. For example, it may be feasible to plant non-food crops such as cotton and flax in place of fruit and vegetable crops. This, however, is technically, socially and economically complicated and takes a long time to establish.

-- If the plant root system is near the surface, deep-plowing the soil may keep radioactive substances below the plant root zone, prevent plants from taking up contaminated nutrients, and allow the level of radioactivity to decrease with the passage of time. Also, liming soils and treating with high potassium content fertilizer, will limit the uptake of strontium and cesium, respectively, by the crops.

- Water:

-- Establish priorities for sampling water supplies in the area and determine if the water supplies are safe for human and animal consumption.

-- Collect raw water samples near the sources of contamination to determine if gross contamination of raw water is evident. The ground water source should be monitored over an extended period of time to ensure that it has not been affected.

-- Open wells, rain barrels and tanks should be covered to prevent contamination of water. Covered wells and other covered water sources normally will not be affected by radioactive depositions.

-- Filler pipes should be disconnected from storage containers that are supplied by runoff from roofs or other surface drain fields. This will prevent contaminants from entering the storage containers.

-- Close water intake valves from any contaminated water sources to prevent distribution of or irrigation with contaminated water.

-- The necessity of taking protective actions to prevent public consumption of contaminated water supplies is unlikely since the accident sequences, which would result in major releases to water pathways are very remote possibilities. In addition, there will be significant reduction in the radionuclide concentration by dilution in the water course and chemical treatment prior to public consumption. There are possible exceptions. If large amounts of cesium or tritium are detected in the water supply, the water solubility of cesium and tritium would render treatment measures ineffective. If contamination is at unacceptable levels, an alternate water source must be considered.

- Meat and Meat Products:

--The intake of cesium-134 and cesium-137 by an adult via the meat pathway may exceed the intake through the milk pathway. Therefore, levels of cesium in milk approaching the preventive protective action level should cause surveillance and protective actions for meat as appropriate, such as removing livestock from pasture, sheltering if possible, or corralling, and placing on protected feed and water.

-- Monitor poultry if they are raised outdoors, especially if they are used for egg production. If poultry are raised indoors and fed stored rations, contamination is unlikely.

--Fish and other marine life raised in ponds should not be harvested until an appropriate State or local government official has been notified and arrangements have been made to sample and analyze the water, fish, and marine life.

-- Grains should be permitted to grow to maturity and then harvested. Milling and polishing will probably remove any remaining contamination. If the incident occurs during harvesting season, contaminated and uncontaminated grains should be stored separately.

-- Honey and bee hives will need to be sampled and analyzed by appropriate State or local government officials if radioactive contamination is detected in the area. The bee keepers would be instructed by the government officials on how to handle the hives and honey if they are contaminated.

- Game and Wildlife: The general public would also be advised that the possible contaminated ingestion products will not be limited to just the agricultural community. At many locations there is an abundance of game and wildlife. State and local officials need to be knowledgeable of various species, and ensure that sportsman understand health hazards associated with ingesting contaminated meat.

- Emergency Protective Actions isolate food to prevent its introduction into commerce and to determine whether condemnation or other disposition is appropriate. Samples exceeding the Food and Drug Administration emergency protective action guides of 15 rem to the thyroid and 5 rem whole body and other organs will be cause for implementing emergency protective actions. For example, officials could restrict or embargo agricultural and dairy products from the marketplace by prohibiting transportation from the affected areas.

I have briefly discussed many of the protective actions that the agricultural community in the United States should be aware of and may be advised to follow in an emergency. However, knowing which protective actions should be recommended is only part of the action that will enable the States to successfully protect the public's health and safety. We believe that having an effective response plan in place is essential. For several years, our staff has worked closely with the States in the development and exercise of radiological emergency response plans. We have developed several thoughts and ideas from these experiences. I will share some of what we consider the more significant issues.

Planning for an Ingestion Exercise: It has been our experience that planning efforts have been enhanced when most of the following steps were followed:

- A planning meeting was held 6 months to a year in advance of the exercise. The meeting, which involved State and public utility planners, Federal and other State officials, served as an opportunity to identify the exercise objectives.

- Federal agencies were requested to provide exercise players as well as evaluators.

- Protective Action Recommendations that were developed were specific rather than general.

- Ingestion exercises were designed to include at least some play in ingestion counties outside the 10-mile or 16 kilometer plume emergency planning zone that might not otherwise be involved in exercise play.

- Exercise plans included provisions to release general public information to the agricultural community as well as relevant agriculture specific information.

- Exercise plans included provisions for ingestion, reentry, relocation and return activity during the post-emergency phase.

- To the extent feasible, provisions were made to involve key personnel as players in the post-emergency phase of the exercise.

Alert and Notification: Even if all State and local officials are extremely knowledgeable and confident in the development of agricultural protective action recommendations, they will not be effective if the protective action recommendations are not transmitted to the agricultural community. I will briefly discuss several methods which are considered for distributing information in the United States.

- The Emergency Broadcast System is activated by the State and local officials during the early stages of an incident. This involves not only the initial notification to the general public, but also may include specific information relevant to the needs of farmers, processors, distributors, and other participants in the food production process located in the 10-mile plume emergency pathway zone.

- States are also required to publish and distribute an Agriculture Brochure to the agricultural community within the 10-mile radius of the commercial nuclear power station. This brochure provides emergency information to the agricultural community. For example, the brochure includes recommended protective actions to protect family, farm animals, and agricultural products. It must be available for distribution throughout the entire 50-mile ingestion emergency planning zone in the event of an emergency.

- Cooperative Extension System: Has an electronic mail network that can transmit information from the Department of Agriculture's Cooperative State Research, Education, and Extension Service headquarters in Washington, D.C. to State Extension offices throughout the United States. The State Extension offices notify the County Extension Agents, and they notify the agricultural community through local television, radio, newspapers, or by telephone.

Sampling Strategy: Developing a sampling plan or prioritizing sampling collection is a key part of the planning process. Once radiation is released, States and local officials must be able to develop a "footprint" or map of the contamination. Having site specific information, such as maps and other documents that show land use data, (e.g., dairies, pastures, fruit and vegetable growers, processing plants, water treatment plants and reservoirs, dams, and canals) helps identify where to sample. After determining the location of samples to be taken, trained and experienced teams are deployed to collect, transport, and analyze samples.

Farmer Reentry: Many states have developed a policy of permitting farmers to reenter evacuated areas for limited time periods for the purpose of tending livestock or performing other essential functions. A question that must be resolved is who will decontaminate farm animals and buildings and when?

Contaminated Waste Disposal: States and local officials must know which officials have regulatory authority and responsibility for clean-up and reclamation. This could be as simple as dumping milk contaminated with short-lived radionuclides such as iodine or as complicated as destroying large groups of meat animals contaminated with radionuclides such as cesium and strontium. Consider the prospect of relocating and disposing 100 head of beef cattle or approximately 225 cubic meters of contaminated flesh. This would not be an easy chore.

- Public Perception: I once heard public perception defined as "pictures in your mind". People often have a mind set about radiation. When we make such references as "radioactive contamination", "slightly contaminated" and "plume exposure pathway", we may be contributing to a public perception that is already misinformed. If we can assume that people will take action most of the time based on how they feel, not what they think, it is easy to understand why fear can often cause more damage than the potential danger from radioactivity. Here is the a question we are beginning to ask our State officials. In your emergency plans, have you made provision for involving a credible, credentialed individual to explain to the general public why certain protective actions are being taken and what radioactivity is and what it can and cannot do? It has often been stated that following an emergency, things don't return to normal. A new norm is established. A credible expert can help facilitate this adjustment. Remember, even with minimal or no environmental damage, a community may be faced with severe problems. The problems could be of a social, economic or political nature. But that is an entirely different set of challenges and not for this discussion.

Role of the Advisory Team for Environment, Food, and Health

Before discussing the Advisory Team I would like to define two terms: Lead Federal Agency and Federal Radiological Monitoring and Assessment Center.

The agency which is responsible for leading and coordinating all aspects of the Federal response is referred to as the Lead Federal Agency and is determined by the type of emergency. In situations where a Federal agency owns, authorizes, regulates, or is otherwise deemed responsible for the facility or radiological activity causing the emergency and has authority to conduct and manage Federal actions onsite, that agency normally will be the Lead Federal Agency.

Federal offsite monitoring and assessment activities will be conducted with those of the State. If the situation dictates, a Federal Monitoring and Assessment Center may be established to be used as an on-scene coordination center for Federal radiological assessment activities.

Advice on environment, food, and health matters will be provided to the Lead Federal Agency through the Advisory Team for Environment, Food and Health (Advisory Team) consisting of representatives of the Environmental Protection Agency, the Department of Health and Human Services, and the Department of Agriculture supported by other Federal agencies, as warranted by circumstances of the emergency. The Advisory Team provides direct support to the Lead Federal Agency. The Advisory Team will normally collocate with the Federal Radiological Monitoring and Assessment Center. The Team will include, as necessary, health physicists, food scientists, environmental engineers, public health officials, emergency program specialists, and professionals from other disciplines. The Team would be headed by a senior official. Federal emergency personnel familiar with the risk area would be added to the Team along with State officials with skills similar to the Federal team representatives.

For emergencies with potential for causing widespread radiological contamination where no onscene Federal Radiological Monitoring and Assessment Center is established, the functions of the Advisory Team may be accomplished in the Lead Federal Agency response facility in Washington, D.C.

The primary role of the Advisory Team is to provide a mechanism for timely recommendations to the Lead Federal Agency and the State concerning matters related to the following:

- Environmental assessments (field monitoring) required for developing recommendations.

- Protective Action Guides and their application to the emergency.

- Protective Action Recommendations using data and assessment from the Federal Monitoring and Assessment Center.

- Protective Actions to prevent or minimize contamination of milk, food, and water and to prevent or minimize exposure through ingestion.

- Recommendations regarding the disposition of contaminated livestock and poultry.

- Recommendations for minimizing losses of agricultural resources from radiation effects.

- Availability of uncontaminated food, animal feed and water.

- Relocation, reentry, recovery and return issues.

- Health and safety advice for the public and for emergency workers.

- Estimate effects of radioactive releases on human health and the environment.

- Guidance on the use of radioprotective substances (e.g., thyroid blocking agents), including dosage and projected doses that warrant the use of such drugs.

- Other issues, as requested by the Lead Federal Agency.

In the past fifteen months, we have been able to test the Advisory Team in three Federal/State exercises. On each occasion, the value of having such a team was validated.

Summary

I have discussed the Ingestion Exposure Pathway Emergency Planning Zone and some of the protective actions that might be recommended to protect the food supply in the event of a radiological emergency. I have also described the Advisory Team for Environment, Food and Health, the Team that would use assessed data from the Federal Radiological Monitoring and Assessment Center to develop informed protective action recommendations to protect public health and safety, and the food supply should a radiological emergency occur. Thank you.

Russian national system of accident response at radioactive accidents

Dr. Victor A. Vladimirov: Dear colleagues, in the life of contemporary mankind, the troubles related to overcoming various crisis phenomena occurring in the course of earth civilization development occupy a constantly increasing place. Some part of the scientific community even holds the viewpoint that mankind has faced the era of catastrophes and an elevated rate of catastrophes has become an habitual aspect of life. Indeed, our everyday experience suggests that at the present stage of development the situations of emergency caused by accidents, catastrophes and natural disasters occur more frequently, and they are more dangerous and large-scale.

It will suffice to say that in the year of 1995 alone, 1,549 relatively large-scale emergency situations both natural and technogenic natures took place in Russia, in which over 57 thousand people suffered and 4,679 people perished. And these figures do not take into account the most frequent, local, situations of emergency, namely, traffic and industrial accidents, and domestic trauma. By the way, these numbers are far in excess over those of 1994 (1,200, 10,000, and 1,3000 respectively).

In general, the situation in the territory of the Russian Federation is rather complicated in view of potential natural and technogenic hazards.

It should be noted that the same problem is acute in other countries as well.

According to some experts estimates in the USA, the total direct expenses related to accidents, catastrophes and associated injuries and diseases amount to 4 to 6 percent of the GNP. Fifteen to twenty-five percent of the total rate of early mortality is due to such injuries and diseases. The contribution of natural disasters to the rate of early mortality is 3-5% and that to the overall material damage is about 1% of GNP. In developing countries, emergency situations of natural origin cause 10 to 25 percent of the overall number of all early deaths and the damage caused is up to 15% of GNP.

In this connection, the solution of problems linked with prevention and elimination of emergency situations of technogenic or natural origin, which is aimed at reducing their impact upon life and health of population, ensuring a stable economic functioning is currently a component of the national security of many states, including Russia.

1. Unified State System for Prevention and Elimination of Situations of Emergency in Russia

The lessons of the Chernobyl catastrophe of 1986 have led us, here in Russia, to understanding the necessity to solve at the governmental level, the problems of preventing emergency situations and eliminating their effects and to create a unified state structure for managing emergency situations. The tragedy of the Spitak earthquake (Armenia, 1988) forced us to make a decision to create a state system for prevention and elimination of emergency situations. In this connection, to radically improve the efficiency of efforts on protection of population and national economy projects in cases of emergencies of both peace and war time, to give this work a nation-wide status and to raise it to the level of state policy, the Russian Rescue Corps with the status of an RF state committee was established in 1990. Now, after a number of transformations, it has turned into the Russian Federation Ministry for Civil Defense, Situations of Emergency, and Elimination of Consequences of Natural Disasters (EMERCOM of Russia). In April 1992, the same reasons brought the Russian Federation Government to establish the Russian System of Disaster Management (RSDM).

The main objective of the System was to consolidate the efforts of federal executive bodies, representative and executive authorities of RF subjects, cities, towns, regions, as well as organizations, institutions and enterprises, and their resources in the field of prevention and elimination of emergency situations. The creation of the System was based on a number of principles, prerequisites, and realities of the actual situation.

Firstly, the necessity to observe a complex approach when forming the system, i.e., registration of all types of industrial, natural or ecological emergencies, all stages of their development, all variety of consequences, as well as all countermeasures and the requisite composition of the staff to be involved.

Secondly, the recognition of the non-zero risk principle, i.e., the fact of impossibility to exclude a risk of emergency situations in all cases of potential hazards.

Thirdly, the basic principle of preventive safety, which implies the maximum possible reduction of the probability of emergencies, preference to preventive measures. In addition, a clear and validated system of priorities. Under conditions of limited resources, the optimal result can be gained only on condition of taking such a system into consideration. And, finally, the current realities, such as the continuing state system reconstruction, economic reforms, strengthening of independence of RF subjects, were accounted for when forming the RSDM and choosing the ways, forms and procedures of its activities. The tasks embraced by the RSDM are presented in Fig. 1.

Principal Tasks of RSDM

1. Development and realization of legal and economic norms related to ensuring territory and population protection from emergency situations.
2. Realization of special programs and scientific and engineering programs aimed at prevention of emergency situations and improvement of stable functioning of enterprises, institutions and organizations irrespective of their organizational and legal forms, as well as production and social projects the afore-mentioned enterprises etc. are in charge during emergency situations.
3. Ensuring readiness of administrative bodies, forces and means intended for prevention and elimination of emergency situations for practical actions.
4. Acquisition, processing, exchange, output of information associated with population and territory protection against emergency situations.
5. Preparation of population for actions in cases of emergencies.
6. Prediction and assessment of social-economic consequences of such situations.
7. Accumulation of reserve financial and material resources for elimination of consequences of emergency situations.
8. State expert examination, surveillance and inspection in the field of territory and population protection measures from emergencies.
9. Elimination of situations of emergency.
10. Implementation of measures aimed at social protection of population suffering from emergency situations, realization of humanitarian actions.
11. Realization of rights and obligations of population in the area of protection from emergencies, including the people directly involved in work on elimination of consequences.
12. International cooperation in the field of territory and population protection from emergency situations.

Fig. 1

At present, the RSDM unites RF administrative bodies of all levels, various economic structures and organizations, including public ones, whose activities were related to the safety and protection of population and national property against accidents, catastrophes and disasters, as well as forces and means allocated to the afore-named purposes.

The RSDM is based on the territorial and production principle and includes territorial and functional subsystems. In total, the System consists of 5 levels (federal, regional, territorial, local and on-site). Its structure is displayed in Fig. 2. *(Fig. 2 not available for publication)*

The RSDM's territorial subsystems are formed in RF subjects within their respective territories in accordance with administrative and territorial subdivision of these territories.

Each territorial subsystem is intended for preventing and eliminating emergency situations in territories within their respective jurisdictions. Each subsystem includes a guiding body (commission for emergency situations), a body for routine management, its own territorial forces and means, and forces and means of functional subsystems in the respective territories, including financial, food, medical, and material and technical resources, communication, warning and information support systems, shelters, and specialized training institutions.

Specific structures of the territorial subsystems and their elements chosen by respective executive authorities of RF subjects. As a rule, each territorial subsystem has its own hierarchy that incorporates city, district and on-site emergency commissions, as well as their respective bodies for routine management, forces and means.

The RSDM's functional subsystems are established by federal executive bodies for organizing the work on population and territory protection from emergency situations within the sphere of activities of the bodies and branches of economy they are responsible for.

Organization, composition of forces and means, procedures of operation of the RSDM's functional subsystems are defined by regulations approved by the heads of respective federal executive bodies as agreed with the RF EMERCOM. In total, there are over 30 functional subsystems. As an example, some of them can be mentioned: a subsystem for observation and control of natural hydrometeorological and heliophysical phenomena and the environment (on the basis of flee RF State Committee for Hydrometeorology); a subsystem for forest fire-fighting (on the basis of the RF Forest Service); a subsystem of situation monitoring at potentially hazardous sites; a subsystem for seismic monitoring and earthquake prediction, etc.

As to the RSDM's levels, the federal one includes federal executive bodies, forces and means of federal subordination, i.e., commanded directly by the EMERCOM of Russia, as well as administrative bodies, forces and means subordinated directly to federal ministries.

In particular, the RSDM's federal level includes:

- the central machinery of the EMERCOM of Russia;
- the All-Russian Research Institute for Problems of Civil Defense and Emergencies;
- the Academy of Civil Defense;
- the Central Aeromobile Rescue Team;
- the Civil Defense Forces of central subordination;
- reserve funds;
- the federal element of the centralized warning system;
- the top element of the information and control system.

The structure of the RF EMERCOM is displayed in Fig. 3 *(Fig. 3 unavailable for publication)* and the tasks to be addressed to by the Ministry are named in Fig. 4.

The RSDM's regional level is formed through dividing the territory of Russia into 9 regions, namely: Central region (Moscow);

- North Western region (Saint Petersburg);
- North Caucasian region (Rostov-on-Don);
- Volga region (Samara);
- Ural region (Yekaterinburg);
- Western-Siberian region (Novosibirsk);
- Trans-Baikal region (Chita);
- East-Siberian region (Krasnoyarsk);
- Far-Eastern region (Khabarovsk).

Each region embraces the territories of some RF subjects. In Fig. 5, the subdivision of Russia into the regions is presented.

The administrative body responsible for functioning of forces and resources of the RSDM'a subsystems in the region territory is the respective regional center for civil defense, situations of emergency and elimination of consequences of natural disasters. The principal task of the regional center is coordination of activities of territorial executive bodies, organization of their cooperation in work on prevention and elimination of emergencies.

The territorial level includes executive bodies, forces and means of the RSDM's territorial subsystems with elements of functional subsystems located in these territories.

Main Tasks of EMERCOM of Russia

1. Elaboration of proposals on state policy in the field of civil defense, prevention and elimination of emergency situations, including overcoming of consequences of radiation accidents and catastrophes, execution of special-purpose underwater work.
2. Management of the RF Civil Defense, RF Civil Defense Troops, RF EMERCOM Rescue Service.
3. Ensuring of functioning and further development of the RSDM.
4. Organization and realization of the state surveillance of the readiness for actions in cases of emergencies and the execution of preventive measures.
5. Management of work on elimination of major accidents, catastrophes and other emergency situations (by orders of the RF Government).
6. Performance of special-purpose underwater work, creation and ensuring of readiness of forces and means that are to be involved in elimination of emergency situations.
7. Coordination of activities of federal executive bodies, those of RF subjects, local self-administration authorities, enterprises, institutions and organizations in maters concerning overcoming the effects of radiation accidents and catastrophes control of the progress of such measures.
8. Organization of development and realization of federal special-purpose programs and scientific engineering programs aimed at prevention and elimination of emergency situations.
9. Coordination of work on creation and use of the system of emergency funds, including government reserves, to execute top priority work on elimination of emergencies.
10. Organization of population training, preparation of officials of executive bodies, civil defense units, and RSDM subdivisions for actions in cases of emergencies.
11. Organization of international cooperation on issues under jurisdiction of the RF EMERCOM.

Fig. 4

The local level embraces the territory of a district, city or town (town or city district) while the on-site level includes the territory of an enterprise, institution or organization.

Emergency commissions of respective executive authorities are the principal management bodies responsible for counteraction to emergencies in respective territories.

As collective bodies, such commissions consist of representatives of local departments, which makes it possible to realize measures on prevention of emergencies in a timely fashion, promptly mobilize territorial resources and efficiently eliminate emergency situations. The commissions are headed by deputy leads of executive bodies. Committees, directorates, departments on civil defense and emergency situations, are working bodies of the commissions. It should be noted that these organs, being basic routine management bodies, function at all levels, including down to rural districts.

At the federal level, the Interdepartmental Commission for Prevention and Elimination of Emergencies has been established. It includes representatives of ministries and departments in the rank of deputy ministers, who are responsible for solution of issues related to territory and population protection from emergency situations. The tasks the Commission are charged with are presented in Fig. 6. It is worth noting that decisions of the Commission are obligatory for all ministries and departments and executive bodies of RF subjects.

The forces and means of the RSDM form its most significant part. They are subdivided into monitoring and control forces and resources, and those for elimination of emergencies.

Since we are discussing here the issues of radiation accidents, let me give you an example of the subdivision of the Ministry of Atomic Energy of the Russian Federation, MINATOM. Here you can see on this diagram (not included) our ministry EMERCOM; MINATOM, which includes the ENERGOATOM

РАЙОНИРОВАНИЕ РОССИЙСКОЙ ФЕДЕРАЦИИ ПО РЕГИОНАМ

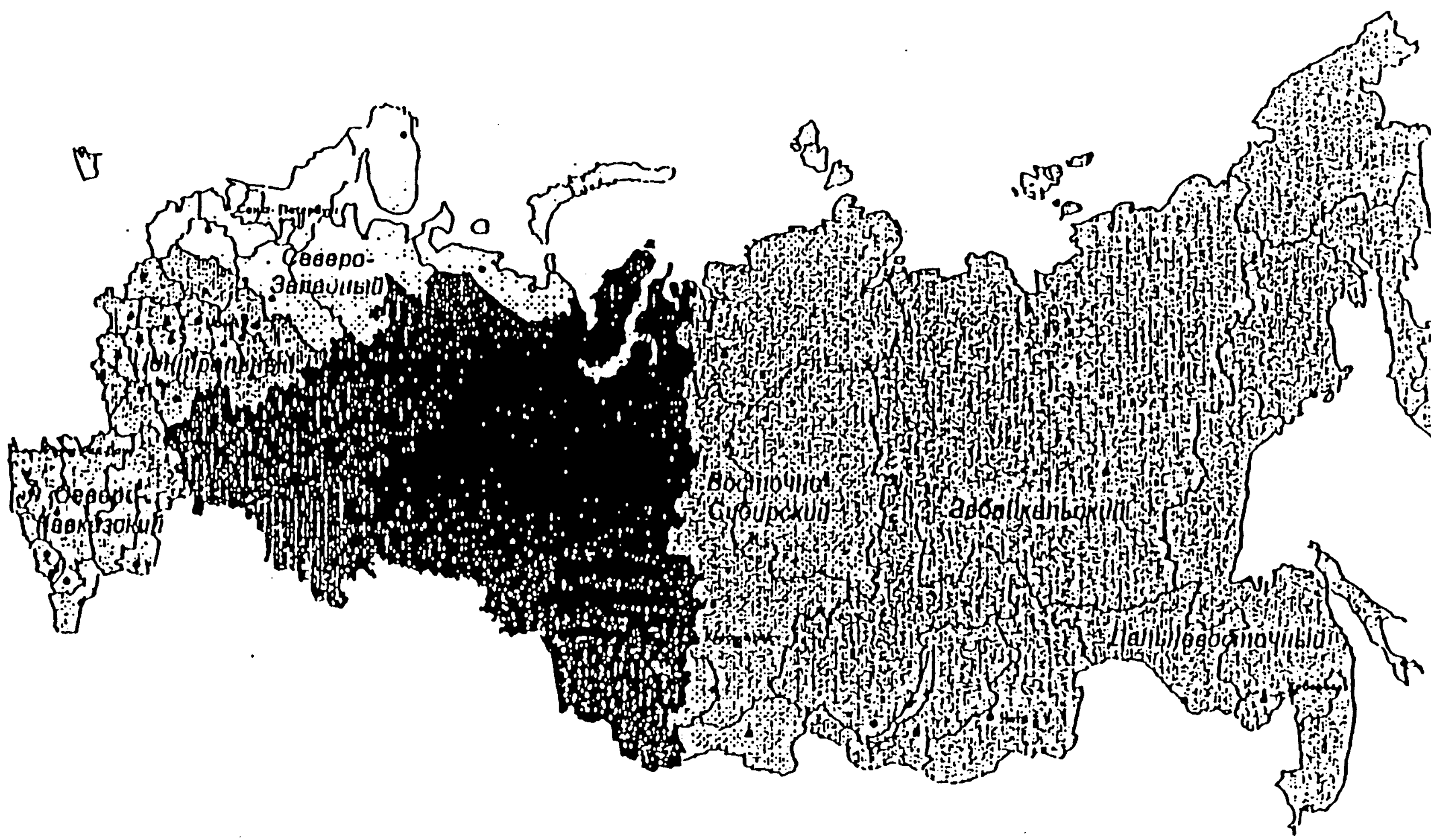


Схема 5

Fig. 5

Main Tasks of the Interdepartmental Commission for Prevention and Elimination of Emergencies

1. Formation and realization of a unified state policy in the field of prevention and elimination of emergencies from accidents, catastrophes, natural and other disasters.

2. Coordination of activities of federal executive bodies in what concerns projects of legislative acts and other normative legal acts related to questions under jurisdiction of the bodies, as well as consideration and submission of drafts of such documents to the RF Government.

3. Preparation of proposals on formation of a system of economic, organizational and technical steps and other measures aimed at ensuring the safety and protection of population and territories from emergencies caused by accidents, catastrophes, natural and other calamities.

4. Conducting a unified technical policy in the area of creation and development of forces and means for prevention and elimination of emergencies.

5. Determination of main lines of improvement and further development of the RSDM.

6. Organization of elaboration of federal special-purpose programs and scientific and engineering ones aimed at prevention of emergencies, territory and population protection from emergencies, coordination of work on implementation of such programs.

7. Coordination of activities of federal executive bodies, those of RF subjects and local self-administration bodies in the course of elimination of emergencies, solution of issues related to socioeconomic and legal protection, medical rehabilitation of citizens suffered from accidents, catastrophes, natural and other calamities, as well as participants of work on elimination of emergencies.

8. Determination of main lines of international cooperation in the field of prevention and elimination of emergencies.

Fig. 6

plants; then ROSATOM. ENERGOATOM has the Opus Group that includes representatives of various agencies and ministries. These people gather together and if necessary they visit certain sites in order to render assistance to the people there for the liquidation of consequences of the accidents. This group resolves problems related to the liquidation of consequences of the accidents on the area of the station. Everything which is beyond the area of the power plant must be resolved by our ministry and the local authorities who deal with the protection of the population during radiation accidents.

The monitoring and control forces and means include those bodies, services and institutions that provide state supervision, inspection and monitoring of the environment, natural processes and phenomena, potentially hazardous sites, foodstuffs, forage, substances, materials, population health, etc. These forces and means also incorporate those of state supervision bodies, hydrometeorological service, veterinary service, and others. They allow prediction of a certain portion of emergencies and warning of administrative bodies and population against the danger.

The forces and means for elimination of emergencies consist of:

- RF Civil Defense Troops;
- Search and Rescue Service of the RF EMERCOM;
- formations and military units of the RF Armed Forces, which are intended for elimination of consequences of accidents, catastrophes, natural and ecological disasters;
- fire-fighting formations, emergency and rescue teams, emergency and reconstruction units of ministries, departments and various organizations;
- institutions and formations of emergency medical aid service, etc.

The forces and means for elimination of emergencies are employed in echelons.

The 1st echelon is formed of:

- departmental units of gas rescue and mountain rescue teams;
- fire-fighting unites;
- specialized formations for rendering urgent medical aid.

The time of their arrival at the emergency area does not exceed 30 minutes. The main tasks are as follows: localization of emergencies, organization of radiation and clinical monitoring, rescue operations, rendering of first aid.

If the first echelon is not able to cope with an emergency, the second one comes into action, which includes:

- rescue units of the Civil Defense Forces;
- units of the Search and Rescue Service of the RF EMERCOM;
- specialized formations for rendering urgent medical aid (burns, traumas, etc.);
- departmental rescue teams. The time of their arrival at the disaster area is within 3 hours. The main tasks are rescue and other urgent work, radiation and clinical survey, populations life support, rendering of special medical aid.

If the second echelon also is not able to cope with the situation, the third one is to be involved, which includes:
- Civil Defense Forces Title powerful machinery;
- formations and units of the RF Armed Forces;
- specialized units of construction and mounting organizations, etc.

The time of their arrival at the disaster area ranges from 3 hours to several days. Their main tasks are as follows: radiation and chemical monitoring, rescue and other urgent work, restoration of a minimum life support system in the disaster area (heat and electric power supply, reconstruction of transport lines, food supply, etc.).

As a rule, elimination of situations of emergency is effected by forces and means of that element of the RSDM or that territorial or functional system, in whose territory the emergency occurs.

If the scale of an emergency is so large that the territorial or departmental commission on emergencies is unable to cope with its localization and elimination, the commission requests assistance of a higher-level emergency commission.

The RSDM, its subsystems and elements are financed from special funds allocated respectively from the federal budget of the Russian Federation, those of RF entities and local budgets. The EMERCOM of Russia and local commissions on emergencies are in command of the above funds.

For example, in the federal budget of the Russian Federation for the year 1996, 1 trillion 300 billion roubles were allocated for elimination of emergencies.

We should like to note that, depending on a specific situation, the scale of a predicted or actual emergency situation, three regimes of RSDM operation are envisaged which are to be introduced by decisions of their respective executive bodies within territories under their respective jurisdictions.

The list of the RSDM operation regimes is given in Fig. 7.

2. Matters of RSDM Activities

Every organization system is created and exists to inset some public needs. These latter are defined through target functions the system is charged with by the society. An analysis of actual needs of the state and Russian citizens in the area of counteracting situations of emergency shows that these needs are reduced to three target functions, for realization of which the RSDM has been created.
These are:

- prevention of emergencies;
- reduction of damage and loss from emergencies;
- elimination of consequences of emergencies.

RSDM Operation Regimes

Regime of routine activities: functioning of the system in normal production and industrial, radiation, chemical, biological (bacteriological), seismic and hydrometeorological situations in the absence of epidemics, epizootics, epiphytotics, long-term work on elimination of effects of accidents, catastrophes, natural and other disasters.

Regime of enhanced readiness: functioning of the system in case of deterioration of a production or industrial, radiation, chemical, biological (bacteriological), seismic and hydrometeorological situation or in case of prediction of a relatively high probability of emergencies.

Emergency regime: functioning of the system in case of actual emergency situations and elimination of their consequences.

Fig. 7

Provided these target functions were executed efficiently, the state and public need in the system would be satisfied. According to some calculations, normal functioning of RSDM subsystems can reduce the drainage from emergencies by 25 to 30 percent and, in case of efficient interaction of the subsystems, by 30-40%.

The principal target function of the RSDM is preventive in its character, namely, that aimed at prevention of emergencies. It includes several major directions of activities as seen in Fig. 8.

The second preventive function of the RSDM, namely, reduction of damage and loss front emergencies, is bared on the presumption that all emergencies cannot be prevented and that, if such an emergency occurs, special prompt preventive measures should be taken, aimed at minimization of possible drainage. Both preventive This list of measures does not exhaust the totality of all kinds of the RSDM's activities on realization of the function under consideration and can be continued. functions are interrelated, though still different as they have different targets and are effected via essentially different sets of measures. The other thing is that their execution can be combined and a number of preventive measures are performed to suit both functions simultaneously.

Among the main steps aimed at reduction of the damage and loss are those presented in Fig. 9.

The third target function is elimination of the consequences of emergencies. The RSDM is charged with the task of performing rescue and other urgent work in the course of emergency elimination, restoration of basic conditions for population survival. What is meant is localization or suppression of the emergency source, search, extraction and rescue of people, rendering of medical aid to the suffered and their evacuation to a safe place, removal of obstructions, declassification, decontamination and disinfection, urgent repair and reconstruction work to ensure the basic conditions for population survival. However, we often have to solve some problems of the next elimination stage, i.e., that of reconstruction.

Principal Lines of RSDM's Activities on Prevention of Emergencies

1. Control over sites that are hazardous in radiation, chemical and fire aspects, as well as supervision of safe execution of work in industry, power engineering, and transport.

2. Prediction of the possibility of emergencies or hazardous natural phenomena that can be prevented; taking anticipatory steps to mitigate emergencies.

3. Designing and construction of industrial and public projects with taking into account potential danger related to origination of technogenic or natural emergencies in a specific territory.

Fig. 8

Principal Measures to Reduce Loss and Damage from Emergencies

1. Rational siting of productive forces, economic or social infrastructure projects from the viewpoint of their safety with respect to technogenic and natural disasters.

2. Planning and realization of preventive measures to protect population, personnel, the environment, including construction of shelters, creation of warning systems, improvement of physical stability of most dangerous facilities, creation of engineered structures against mud streams, land slides, etc.

3. Early evacuation or relocation of population from potentially dangerous or unfavorable areas.

4. Training of population and administrative bodies for actions in situations of emergency, accumulation of material and financial reserves for elimination of emergencies.

Fig. 9

To realize the above target functions and perform efficiently some specific work, the EMERCOM of Russia and the RSDM generally proceed from the tasks declared by the government.

Let us briefly dwell on the major lines of the RSDM's activities and the part played by the RSDM in the systems of the national security.

First, the important line of the activities is formation and realization of the state policy in the field of the afore-described target functions.

The RSDM carries out such work through consolidation of those management bodies, forces and means involved in elimination of emergencies, which hitherto dealt separately with such problems. The RSDM's consolidating role appeared to be constructive, promising and novel in the field of activities under consideration. For the first time, the state has gained a universal system featuring common responsibility, sufficient scope of powers, joint resources, and ability to maneuver.

Under such conditions, an opportunity is opened for implementation of joint measures to protect population and national property.

A significant component of the state policy being realized by the RSDM is the activities on creation of a legal basis. An extended complex of laws and normative documents is being created on a systematic basis. From the whole legislation on state security, the field of the RSDM's competence has been separated out. The set of documents regulating the RSDM's activities is being created under federal control. Such an approach guarantees elaboration of all the required documents without inconsistencies and duplications.

The RSDM's leading role in realization of the national policy in our field manifests itself in elaboration and implementation of special-purpose programs on most significant issues. A special federal program, "Creation and Development of the RSDM," has been developed and is nowadays being realized, which includes a number of subprograms, including those on population training, equipment of rescue formations, creation of an information and control system within the RSDM, etc. As the methods of the program and objective planning turned out to be rattler efficient, we are now extending their application. At present, long-term regional target programs, as well as those on counteracting the most serious kinds of hazards, are being developed and realized.

Second, the managing role of the RSDM should be emphasized.

The RSDM's leading body, the EMERCOM of Russia, is authorized to coordinate the activities of governmental bodies on protection of population and national property. To solve this problem, the Interdepartmental Commission for Prevention and Elimination of Emergencies under the RF EMERCOM has been established (as was already mentioned above).

The next, also very important role of the RSDM, is that of inspection. It is fulfilled through state surveillance to ensure safe execution of work in various branches of the economy, social sphere and everyday life as well as through inspection of various RSDM elements and related structures. The RSDM also includes governmental inspection bodies. In addition, some officials and units of our Ministry are entitled to perform in the whole territory of the Russian Federation the state surveillance of execution of measures aimed at prevention of emergencies and of preparedness for actions in cases of emergencies. The state surveillance and the associated system of sanctions play a significant part in realization of preventive target functions of the RSDM. Additionally, the inspection function is performed through regular checkings, both planned and unexpected, of the RSDM's subsystems and elements.

It should be also stressed that the RSDM performs not only the managing and inspection functions, but also the practical ones. It carries out practical work on preventive measures, and preforms rescue and older urgent operations in the course of elimination of emergencies. This kind of its activities is effected by the RSDM's executive bodies and forces.

Since the completion of the RSDM, the system has responded to practically all large-scale emergencies and eliminated their consequences. It happens most often at the level of RF agencies. Nevertheless, the federal level is also constantly engaged in one or a few large-scale situations. It sends its operational teams to the sites and organizes various kinds of assistance or attracts directly the federal forces.

The EMERCOM of Russia organized expeditions to the Republic of Tuva for elimination of a cattle epizootic there, to the Republic of Armenia to take part in suppression of major centers of the fire at an ammunition depot, and later to Vladivostok to eliminate the consequences of a similar accident at artillery depots of the Pacific Fleet. Among the most severe emergencies of the last year, we should mention the radiation accident at the Tomsk chemical plant (Siberia), the fires at the KAMAZ engine plant and at an oil tanker on the Volga River, accidents in oil pipelines in Mordovia, the Irkutsk Region and the Republic of Komi, floods in Buryatia and the Primorski Krai, earthquakes in the Kurils and Sakhalin. The RSDM's forces and means were extensively involved in the above emergencies. During its existence, the Central Aeromobile Rescue Team of the RF EMERCOM took part in several dozens of rescue operations, such as delivery of food and evacuation of refugees from Abkhazia, convoys with humanitarian cargoes in Sarajevo. The search and rescue service of the EMERCOM participated in work under extreme conditions a few hundreds of times. Several thousands of staff rescuers and volunteers were involved. A great volume of work has been done by the Civil Defense Forces. They took part in the elimination of effects of dozens of industrial and transport accidents, floods and forest fires. In total, they eliminated about 7,000 dangerously explosive objects and transported about 2,000 tons of humanitarian cargoes.

The practical activities of the EMERCOM in the sphere of humanitarian aid deserves particular attention. The very first experience of such a kind was gained in South Ossetia. The working group of the Ministry first assisted in accommodation of more than 100 thousand refugees and provision with life support means. Then, pursuant to the Russian-Georgian agreement on the principles of settling the Georgian-Ossetian conflict, our staff took part in the restoration of water, gas and electric power supply to Tskhinvali, a number of vitally important objects, provision of the population with food and medical supplies.

The experience gained was used some time later during the Moldova-Pridnestrovie conflict. There, medical aid to the injured and diseased was rendered by use of a deployed hospital. Humanitarian aid cargoes were delivered to refugees and population.

The EMERCOM of Russia directly participated in the settlement of the Ossetian-Ingushetian conflict. At that period, one billion worth of humanitarian aid cargoes were sent to North Ossetia and Ingushetia.

From the very beginning of the conflict in Abkhazia, the Ministry was involved in its settlement and rendering of assistance to the suffered population. The vacationers were evacuated from the Black Sea coast. Our forces delivered foodstuffs, medical supplies and dressing to the region. A few expeditions reached the blockaded Abkhazian town of Tkvarcheli first by helicopters and then by land. Those teams delivered food to the town and evacuated the most suffered people.

A set of measures were developed and realized by the EMERCOM of Russia in collection with the civil war and natural calamities in Tadjikistan. Some measures on rendering assistance to Russian-speaking population who decided to leave the country were effected. Humanitarian aid cargoes were delivered to the suffered regions.

The Ministry took part in the rendering of assistance in the territory of former Yugoslavia. There, our convoys delivered humanitarian cargoes under the aegis, of the UN.

The next important function of our system is the training one.

Within the framework of the RSDM, a system of training of Russian citizens for actions in emergencies has been formed for training both the RSDM's specialists and the whole population. At present, the system provides:

- training of officials from governmental and local administrative bodies, those from organizations, institutions and enterprises involved in solving the issues related to emergencies;
- training, retraining and improvement of professional skill of all specialists in emergency situations;
- training of administrative bodies and the RSDM's formations as a whole;
- training of the population.

One more rather significant role of the RSDM, namely, the supporting one, should be noted. The effectiveness of the RSDM depends to a great extent on how good its material base, material and technical supplies, financial support are.

Simultaneously with the formation of the RSDM, that of the system of the above kinds of support was provided. Unfortunately, this work has not been completed yet as the realities of the continuing economic reforms have not allowed us to establish conclusively all the necessary mechanisms.

In conclusion, the role of the RSDM in the field of international cooperation should be stressed. The openness of our state allows purposeful integration of the RSDM into the systems, now being established in Europe and the world, for prevention and elimination of emergencies.

The cooperation is effected through agreements and other international acts, creation of a common legislative basis on the issues of mutual or collective interest, efforts within the framework of leading specialized international organizations.

As can be seen from the foregoing, countermeasures to emergencies are a difficult, but quite an essential activity. We hope that the experience in creation and functioning of the unified state system for prevention and elimination of emergencies in Russia will be of use for specialists of other countries.

Dr. Vladimirov: Are there any questions for any of our speakers of this afternoon?

Dr. Joe Himes, Nuclear Regulatory Commission: I am very much interested in the information flow for decision making. As you recall, the United States was surprised by what happened at Three Mile Island. I am sure the Soviet Union was surprised at Chelyabinsk, and I think that, should we ever have another emergency, we will be surprised at that time also. We need to prepare our decision-making apparatus to handle surprises. That is something we didn't plan for. In your opinion are you now set up [for surprises] in Russia with the decision-making process which you showed us?

Dr. Vladimirov: Well, I cannot say with all certainty that everything has been done to achieve this objective. I don't think to say this would be justified because we cannot do everything, but what we have achieved at this point, what we have now, is the fact that we have drawn certain lessons from the Chernobyl accident and other accidents which have occurred in Russia. We believe that the preparedness of our resources, of our apparatus, those measures that we conduct in order to prevent emergencies, contribute and to a great degree enable us to solve such problems and implement the functions with which we are charged. I also mentioned today the accident, the greatest accident which took place in Russia. I am talking about the earthquake in Sakhalin, when the town of Neftegorsk was practically destroyed and [we faced the problems of] getting timely information and notification of various agencies, transportation of forces to the site of this natural disaster and also appropriate utilization of the equipment, which is state-of-the-art equipment. All that ensured that we would and did achieve good results. This example demonstrates that Russia has drawn certain lessons based on Chernobyl and shows that we won't find ourselves in such a situation again.

Mr. Alston: Would you discuss a little bit the roles and relationships between MINATOM and EMERCOM, specifically with respect to notification of the public and of the world in the event that there is a radiological emergency?

Dr. Vladimirov: To be brief, I would like to say that we have no problems as far as our relations with MINATOM are concerned. MINATOM is part of our system and it is part of the interagency committee dealing with the problems of prevention and emergency response. MINATOM has created some subsystems for our system, and it works in close cooperation with us. We assist one another. First of all, MINATOM has created emergency centers in order to liquidate the consequences of various emergency situations. We also help them with the equipment, with the technological means for appropriate measures, and we also do cooperative work in order to develop the appropriate means for resolving such issues. So, in other words, from that point of view, everything, one may say, is basically okay. We have solved all our problems. As far as the notification of the public and so on, I believe we do not have any problems in this respect. First of all, our NPPs at this time have certain means of notification, including the means with which we notify our foreign partners. For example, the Kola NPP and other NPPs have certain systems which transmit information about an accident to Finland and the Scandinavian countries and there is no prior restraint regarding this information. We also have a document which delineates our relations with MINATOM with regard to giving information to foreign bodies, such as the IAEA. We will also have to give information to certain other international bodies, and would do that if something happens. Also, during those exercises that we conduct in Russia and also at NPPs, we involve in those operations various international bodies. For example, recently DGV and other organizations took part in the exercises with our NPPs. We exchange information with MINATOM, so that's how we get additional resources. That is how we get assistance and support when we conduct such exercises, and we might need such support if a real accident occurs.

Dr. Vladimirov: I'll ask the final question. Dr. Romanov, how do you determine, when plowing under the topsoil to reduce contamination, that the advantages of plowing the isotopes under outweigh the risk of resuspension?

Unidentified Russian speaker: Well, here's how I would answer this question. This depends on the objectives. If we want to reduce the rate of exposure for the population, that is the external exposure, then of course we should immediately plow, but if there is no population we should not do that. If we want to reduce the flow of [contaminated] produce into the population, then of course that should be done at the later phase after the accident, but we then have to do deep plowing, because any other type of plowing will not be effective. If we are talking about pastures, then we basically would destroy them. Regular plowing, I am talking about 20 centimeters deep, probably reduces the contamination by 500 percent but no more. So that's what I can say regarding the effectiveness of such measures and when they are used. Also, in principle, what has been said by Romanov means that we make decisions on a case-by-case basis. In other words, what are the objectives? It depends on the objectives. So, for example, the Chernobyl experience, basically prompted us to realize that it's very important to reduce dust by various means. That is very important, especially when we are talking about various roads and thoroughfares and highways. So this dust suppression is extremely important. We also had to do this dust suppression when we tried to prevent the radioactivity from getting into the bodies of water, so we would cover everything with the appropriate film-generating substances, which would prevent radioactivity from being washed off into the bodies of water. This is the type of experience which we have accumulated based on Chernobyl, and it shows that these are some of the measures that have to be planned and implemented in case of accidents.

Dr. Vladimirov: I thank you all very much for your patience, and we will see you tomorrow morning at 8:30.

Scientific and technical support for decision makers concerning protection of the population at radioactive accidents and incidents

Col Reeves: The chairman for this morning's session is Dr. Rafael Arutyunyan. Dr. Arutyunyan is the First Assistant Director of the Nuclear Safety Institute of the Russian Academy of Sciences.

Opening remarks of the session chairman
Dr. Rafael Arutyunyan: Thank you, Glen. Ladies and gentlemen, dear colleagues, we are going to start discussing the second topic of our workshop, the scientific and significant technical support for decision makers concerning protection of the population during radiation accidents. The scientific and technical support in the emergency response system is one of the elements, but we also need to take into consideration the high scientific capabilities of decision making and predicting outcomes during traditional incidents. This is suppose to be a very important element of the system because it determines the correctness of our actions and determines the efficacy of our practical measures. The errors that were made in the forecast in the situation assessment can lead to extreme expenditures of labor forces and lead to the fact that we will underestimate the danger, or we can overestimate the danger. We know that, based on our experience, it will also lead to big damages to the population when we overestimate the danger; thus, the scientific and technical support is the initial point where we begin to assess the situation and forecast the situation and also develop scientific recommendations and thus give the general directions to the practical measures of the entire system. When we speak about scientific and technical support, we mean methodological approaches. We mean various models that allow us to forecast situations. We mean our expert evaluations, our expertise, our knowledge, and, finally, we mean our capabilities to develop precise recommendations on the basis of which the decision-making personnel would calculate their practical actions and resolve the problem of population protection during radiation accidents. Before lunch we are going to have four presentations. The first one is devoted to the review of the models and analysis of the consequences that, as far as I understand, were developed by the DoD of the United States. Colonel Mark Byers, let's begin your report.

Overview of the U.S. Department of Defense hazards assessment and consequences analysis (HASCAL) model

COL Mark Byers is an active duty Army officer now in his twenty-fourth year of service. He is currently the Deputy Director of the Office of Nuclear Weapons Management, Department of Energy.

COL Mark Byers: I am very pleased to be here today because I get a chance to talk about something that I find very interesting, challenging, and something I believe is very, very important. Julius Caesar reminded us 2,000 years ago that somebody must pay attention to the small things. The situation in the world today is that we have more than 500 nuclear reactors at our commercial power plants, so that at any place where U.S. forces are deployed reactors are our concern. In addition to these power reactors there are another 100 or more research reactors and about 200 fuel cycle facilities. In areas that are not densely populated with reactors, there are many chemical facilities and then there are all biological agents and potential biological facilities; and so for the modern battlefield commander having a prediction is a necessary and routine part of his planning. What I want to do now is review some of the events that drove the development of the Hazards Assessment and Consequence Analysis (HASCAL) model and then some of the things we found that enabled it. In 1992 General Zokhor Dudayev of Chechneya said, "If you attack me I may bomb Russian reactors." That was passed to me for analysis as to whether this was a credible threat, and the answer was yes. General Dudayev had airplanes and bombs where he could reach a significant number of reactors in Eastern Europe and the western half of Russia. Did he do it? No. Could he have done it? Yes. Would it have been bad? We'd have to see. In 1993 tensions rose on the Korean Peninsula with the North Korean Nuclear Weapons Program. In South Korea there were 10 reactors operating at four sites--33 percent of the power on their grid. So the question was, if hostilities break out and we start shooting, what are the risks to those reactors and what are the risks to the people in the vicinity of those reactors? In 1995 tensions rose between India and Pakistan and again the call came, what about the nuclear facilities? Finally, in 1996, the mainland Chinese fired missiles in the vicinity of Taiwan. There are reactors in Taiwan that could have been targets there. One thing that I didn't show on the slide was the earthquake in Kobe, Japan. I was in Honolulu when our Pacific forces were responding to that. The big issue for them was, "Where do we get enough five-gallon water cans to help these people?" So the forces are there, they are working, they are responding. One of the key events that drove the development of the HASCAL model was that, as we got calls from the field about these scenarios, one call was, "If this happens, what would be the temperature of the fuel cladding?" I had to sit back because if the person in the field is going to use the temperature of fuel cladding as a decision point, I really wish he could figure it out himself! So we knew we had a training problem and an information problem. It's good they are concerned, but they are not smart enough yet. At the same time we have what we call a revolution in military affairs. Modern combat is not expected to be large, Napoleonic forces closing on each other, large land armies. We have small, swiftly moving, very agile forces.

Those forces are supported by real-time communication links that reach globally, and the commanders have very detailed digital information of the battlefield. This is new. It gives us a new capability that we didn't have 10 years ago, something we can make great use of. And then, finally, in the last five years, we have had an explosion in the computing power of personal computers. The supercomputer of 1986 can be purchased for two or three thousand dollars and put on your desktop today. That is something that we use for leverage in this program.

Having said that, our objective with the Hazard Prediction Program that was at the (then) Defense Nuclear Agency to develop an application that would support planning by those forward commanders, because any military officer is delighted when he spends his life planning and rarely executes those plans; however, we must be good in our planning. We have a training need to educate them on what is a real concern and what they really should not be concerned about. Finally, if an event happens, they need training on initiating the response and managing the response activities to that. Now, in planning, training and responding, we must focus on having credible answers. I will give two examples of things I found that were not very credible. One group I worked with imagined that a 500 lb. bomb striking a spent fuel pool would aerosolize the entire inventory of the spent fuel pool--a 500 lb. bomb vaporizing 500 tons of material! That to me is just not credible. If it is, if they can do that, I want to buy those bombs! Another one: I was in a war game this summer and the scenario planners had a uranium mining and milling facility. They thought we would be very concerned if they bombed the mining and milling facility. I did not find that a big risk! They were surprised at my response to that. So we have to work and make sure our answers are credible and that we are responsible. If we have a facility out there that if damaged could cause large numbers of casualties, we must be prepared to protect the facility; and, if our protection fails, we must be prepared to assist in bringing medical treatment or evacuating those folks that are injured near there. So credibility and responsibility are guiding words. The military commander realizes that while the reactors are the big plum, you must look at the entire fuel cycle, because all facilities have some degree of hazard with them. Of course, we have the concern that you can pervert the fuel cycle and develop nuclear weapons. For me, starting HASCAL was very easy because, like other folks, I stood on the shoulders of giants. I went around and talked to many people. I talked with the facility of Massachusetts Institute of Technology. I traveled to the NRC headquarters and talked with Janet Quissel, who manages their RASCAL Program, and Tom McKenna, who oversees modeling and support of their Emergency Operations Center. I took their one week course to study how they work their Emergency Operations Center and finally walked away from there with their RASCAL Model--Radiological Assessment and Consequence Analysis. This is a very nice little PC-based model that covered only U.S. reactors, so we had a start. I then went to Livermore National Laboratory, the Atmospheric Release Advisory Capability (ARAC), and talked with Tom McKenna. I spent a couple days with Tom, watched his staff go through their daily operations and procedures, talked about his philosophy, and checked to see what his capabilities were. I went to the Air Forces Global Weather Central in Omaha and looked at their atmospheric modeling. Their atmospheric models are impressive. They are in use by the forces worldwide today. You can dial in from your PC and download weather, which is something that we make use of, but what they had that was very, very valuable was a climatological database that covered the entire world that goes back 20 to 45 years which gives me a history of the weather observations every one hour or three hours. I went to Defense Mapping Agency because the flow field has to go over something. They have a product that's finished, the Defense Terrain Elevation Database. From that I got a mapping of the surface of the earth with elevation posts every 100 meters, so that's what we use to define the ground in our calculations. They are working to update the database to where we can get elevation data every 30 meters. That's not yet complete. At 30 meters I'll have very, very fine resolution of the surface. We had a team visit IAEA. From the IAEA we picked up their power reactor information system, the research reactor information system, and their nuclear fuel cycle information system. These are databases of facilities to tell us what they look like. We also used Nuclear Engineering International's annual volume about reactors in operation, planned, or under construction as another source of information.

Finally, we had a contractor do a direct mailing to all the utilities in the world asking for information on their plants. It was amazing how much we actually got back from the plant operators. I visited the European Command, the Pacific Command, and folks in the Pentagon because I wanted to understand what kind of communication links they had and how their command center operated--who was talking to whom, how did they make their decisions--and, finally, wherever I went I talked with the technicians. We looked at fallout models, atmospheric models, and then their transport models.

I am sure it's no surprise that we have to consider complex terrain and land/water effects. This is very tricky for the meteorologists but important for a person who considers nuclear facilities because most are located at a land/water interface where we can get water for cooling. To get a reasonable and credible answer, we must use real world weather and real world forecasts. Higher resolution flow fields probably give better answers. (Perhaps not, but probably they do give better answers.) The dominant uncertainty in the problem is the uncertainty in the source term (i.e., what really happened). I have to know the operating state of the facility, the exact way the facility was damaged, or as best I can, and then know what kind of response the crew has taken that's working with the facility. As long as there's man in the loop, it's not simple to solve what you've got, since it's very scenario-dependent.

Finally, we've found that there was much ambiguity in terms of human or equipment response. What does this dose of radiation or chemical agent or bioagent actually do to that person or the piece of equipment it falls on? So again, our objective was to develop a product that could be run locally for training and planning, that was very fast running so that we could get an answer in a few minutes, and that was easy to operate because, while most of the hazard prediction operators in the field have a master's degree or some military training, they are not subject matter experts. So the model just serves to get them to the point where they can discuss things meaningfully with a subject matter expert. To support the technicians in the process, we have built a three-tier computational scheme. The first level is the PC-based tools; I can run them on my desk, I can run as many cases as I want, and it's easy. I train the staff people to use that routinely. The second step up, which would be at a major command headquarters in the Pentagon or at an emergency operations center, would be workstation-based models. These would have higher resolution flow fields, more detailed source models, and hopefully smarter, better trained and qualified subject matter experts. And then, finally, you reach back to supercomputer level modeling done by the world's experts at Livermore or Oak Ridge or other places, because, if the event is really big and it's going to have large consequences, then very high ranking decision makers will be involved. They deserve and will have access to the world's best experts out there. We found too that the time period for which you are doing your calculation drives what kind of data you can use. If you are planning more than 10 days in the future, that climatological database that we got from the Air Force is just fine. It's as good as anything else you could use. I believe it is better than the practice that we discovered four years ago, where people would go out and just pick the weather on some day from last year! A day from last year is not nearly as good as the average across 20 or 30 years. I get a better trend there. If you are within 72 hours on your planning horizon, use a good three-dimensional atmospheric model that runs in a prognostic fashion, that forecasts where the winds are going to go. Of course, if you get to the event time and are moving forward, the PC can run either with the last weather that it has downloaded or you can pass to the sources up higher. So you can launch the PC-based model, pass the other information to the second and third tier, and get higher resolution answers as you go.

Let me talk to you about some of the technology blocks. Any hazard prediction and assessment capability, of course, must first define the sources, move the hazardous material through a flow field so you have to have the effects of weather and the transport over the terrain, and then, finally, lay down the effects in a way that I, as an operator, can use. [I need to be able to advise whether to] stay out of this area, go through it very quickly, or whatever the guidance is going to be to the forces--evacuate or shelter. The HASCAL model, which Brian Worley will show you later, does nuclear facilities or nuclear weapons, chemical, and biological facilities. Here, we worry about military strikes against those facilities that may be taken to interdict a program or in response to chemical and biological attack. So many things have been put into the source term package. To review the nuclear facilities source term generation, we have the nuclear facilities database. What is the plant? Where is it located? It was hard to get precise coordinates for the location of each of these reactors. This was much more difficult than I had expected. From the facility database, which gives us location, characteristics, and then recent operating history, we can go through various models, origins, one model, or you can go through a venture/burner model to come down to generated source terms released to the atmosphere and then push it into transport model. This diagram is the upper level management symbol model. In the actual suite of tools used by nuclear engineers, you start with cross section libraries and finally come down to HASCAL when you get to the bottom here. You can read this later in the proceedings. Anyway, even though HASCAL runs on a PC, the source terms we use are generated through a large suite of very good codes on a number of different computer platforms, so it's not a little trick that comes out of a PC.

Selecting a transport tool was challenging until we located SCIPUFF, second order closure integrated puff model. SCIPUFF is, I believe, the most efficient Gaussian puff model in the world today because it has routines where it can split a puff that gets stretched or it can agglomerate puffs. It's very quickly running and it runs at a very high resolution. The other thing I like about it is that it considers the uncertainty in the flow field, so if my flow field is very coarse I get larger regions with the uncertainty noted, if I go beyond my calculated flow field and am extrapolating the plume will diverge. It is nonphysical, but it tells me as decision maker that I don't have confidence in what I have done out there but instead I have extrapolated, and it will warn me.

Three types of plots come out of the SCIPUFF application. The first is the traditional ensemble mean dose, and if you ran a simple Gaussian model you would expect to get that kind of a plot. That's one way to look at the situation. The plot that I like to use most often is a probability plot that shows me a map of the areas where I will probably exceed some dose criterion or whatever other criterion I care to use, so now I know that folks in these areas will probably have a certain chance of exceeding that limit. And, finally, SCIPUFF can generate a realization, which we include to remind the commanders that this is only a calculation, this is not what you are going to find on the ground. If you ran a Monte Carlo calculation with lots of particles, this is what you would get. If you ran out and measured on the ground you'd have hot spots and cold spots, but you wouldn't find that. I include this so that the commander can know that if he goes here and measures nothing, that it doesn't mean the plot is wrong--he just found a cold spot--or, if he comes over here and it's 100 times higher than the prediction, the plot is not necessarily wrong either--he's just in a hot spot. So this teaches the commander that he has to measure at many sites to get a real picture of what the situation really is on the ground.

I saw on the climatological database that you could get mean winds or the molar winds. What winds do you use for planning? For an example, we took Kori (?) Unit I Reactor in South Korea and, for the date and time which we were considering, the molar winds, the most frequently occurring winds that were blowing directly offshore. If you took the mean of those winds, we got sort of a lollipop that tended to be offshore but didn't move very strongly out. We dialed the Air Force and said, "Send us your weather," but when the data came through on the PC from Global Weather Central, we found the plume went exactly the other way! So a database is just a database. If you want to make a bet on it, this is one bet we would have lost! You have to use real winds in real situations. We often get asked, "Which is more dangerous, nuclear, biological, or chemical things?" and the answer is, "It depends," but, for reference, this is a 900 megawatt reactor where we melted the core and imagined that the containment had been breached. I got that plumage on the left. In the center we released 100 kilograms of anthrax into the same flow field and, finally, on the right, we released 90,000 gallons of Sarin, a railroad tank car full of it. I don't think I would get 90,000 gallons of Sarin. I pray nobody uses 100 kilograms of anthrax, because the Sarin release has almost no lethal area, though a fairly large affected area. The nuclear power plant is in the middle, but with the bio agent there is a very extreme area of contamination and high lethality. Using a different set of weather, and again using Kori as a convenient calculational site. This plume shows again what happens assuming the core melted and the containment was breached: a small lethal area and a very large area where the dominant consideration is food chain contamination. Does that affect the military commander? You bet, because, while we have a small number of casualties to work with, we would have a large population, had this blown up over the peninsula, that we would have to feed or assist in relocating. So it will impact on military operations even if it's nonlethal.

We said before that complex terrain is essential in this modeling as are scenario factors. This plot is of a biological agent, anthrax. The difference between top plots and bottom plots is day and night, because anthrax decays at different rates in sunlight but at night has very little decay at all in the atmosphere. So I must have the time of the event, the right flow field, and the terrain in which it's flowing over to get any kind of answer they are going to believe. It is important to understand that when the event happens you must continue to follow the event for many hours, maybe days, after that event. Three hours after the event, it looks like the plume is moving to the northwest. If I stopped there I would say, "Yes, boss, it's okay." But at six hours, the wind shifted so that the plume moved toward the city, and, finally, at 12 hours, I am going to start seeing people get sick in the vicinity of the city. Had I stopped at three hours, I would be irresponsible in supporting the commander or that population. Now if each of these incidents did occur we would have to follow it. So now the computing burden gets bigger and bigger and bigger for that commander.

This is an example from a war game we played where we postulated that there was a reactor in Morocco (this doesn't exist), a 500 megawatt reactor built near the town of Mohomedia. U.S. forces were offshore. We were going to do a forced entry into Morocco. The government of the country decided to deny us entry by destroying their own reactor and spreading radioactivity. If you do a calculation and used the standard NATO agreement criteria for protection of forces, there's no hazardous area, but that criteria is for thermonuclear warfare. I said, "This can't be." So we went back and said, "Just plot the plume and let's look at some doses." We had a very large area. Let's go back and look at the probability of exceeding 10 rem for the landing forces. This tells the commander that if he will not accept 10 rem exposure, he must land upwind of the plume. If his criterion is one rem exposure, there is no place to land between Mohomedia and Raba. He has been denied. So the challenge now is to get better exposure criterion for the commanders because I would hate to have them plan the operation based on this as their criteria. It's just not good enough.

Finally, the HASCAL Model was developed with what we call "user in the loop." The operator in the field is a collaborator and a participant in a development team, so all U.S. combatant commanders in chief and all the various regional commanders participate in the development of this tool. DSWA, of course, leads in the development, but it uses HASCAL routinely to support commanders in the field. NORAD uses it in at least four of its different sectors. The Joint Chief of Staff is a participant in the HASCAL development. The U.K. and

Canada are helping us, the U.K. both in terms of chemical transport and modeling and then, because they have gas-cooled reactors, their expertise is much greater than ours so we rely on them to help us with source terms. Likewise in Canada, with the CANDU reactors, we get a lot of help from them on how do you really generate a good credible fast running source term. The French have joined in on the effort of two different ways. From Electricitè de France we got the MINERV code, which I think you know of and we brought MINERV down from a workstation to a PC so the operator can use it at his desk. The other area that they are interested in is a chemical attack upon their forces, so they are helping us also with chemical weapons agent modeling. It has been shared several times in the PFP program. And, again, we would like to share our technology and get help from the operators of these facilities because no one can characterize his facility better than the operator. FEMA, of course, is involved. We are very proud that HASCAL was used by our U.S. forces in Bosnia. Again, the dominant concern here is chemical weapons and chemical facilities. And the last item to mention is that it was used in Atlanta during the Olympic games.

I'll wrap up by saying that the HASCAL tool is a tool and a spectrum of tools, where we look for fast response because the commanders need to know what they are going to do very quickly. The other point is that the forward commander, not somebody two or three thousand miles back, knows what risks he is willing to accept. He's right there and he has to do it. Integrated tools to plan and support the local decision making. You must have real-time weather if you have any hope to get a good answer. It will be multi-scaled. The dominant uncertainty is in the source; what happened and how is it developing. Thank you.

Dr. Arutyunyan: Thank you. If there are any questions, please ask them now.

Col Reeves: Speaking of actual situations, I noted in this morning's paper that they were concerned about the effects of the bombing of the Iraqi bunkers during Operation Desert Storm, where chemical agents may have been. Have you done any HASCAL plots on those?

COL Byers: Yes, in fact I got yelled at a lot about some of this. DSWA, a year or more ago, began and is probably continuing even today to do modeling of the attacks on different bunkers in Iraq. We did two calculations to validate it. The first, to see if we were doing bio agents right was the accidental release of anthrax from Sverdlovsk. Those data have been made available. There are big uncertainties on the source term, but we used the climatological database to get the winds in there and went back and we matched the published plots with one exception. We came up a little short in predicting the actual area in which cattle died, and we were also a little short in determining the area in which people died. So our plumes didn't go quite that far. At the same time, we did a calculation where we released anthrax in a notional case over the headquarters of Defense Special Weapons Agency in Alexandria, and the wind blew up over the eastern seaboard. We showed that people would die as far up as Philadelphia, and you would kill cattle all the way to New York City. Now, many people came up and criticized us because their calculations used offensive kill criteria for chemical and bio warfare and their last contour is at the lethal dose for LD_5; 5 percent of the people were going to die. We used the medical exposure criteria for anthrax, which postulates that if you inhale 8,000 spores you are probably going to die, and for other plots we used LD_2 and again used the medical criteria rather than offensive war fighting criteria. So our plots were much, much bigger. Using that same methodology, when we went back to the Middle East and looked at those Iraqi facilities, it's very amazing how much larger the affected area is if you look at it with medical criteria rather than warfare criteria. Similar to the reactor I showed you in Morocco.

Col Reeves: What's the difference between medical and military criteria?

COL Byers: The difference between medical criteria and the military operational criteria is that the exposure guidance used by the military chemical, biological, or even nuclear warfare planners is something that will give you a certain kill when the average person in the population is a 19-year-old healthy male soldier. Now for our forces today the 19-year-old healthy male soldier is not typical, and surely, as you go across the population, the way a two-year-old child or an 80-year-old grandmother responds is going to be much different. So the criteria for these people cannot be the same point value as those for that 19-year-old male; they have to be something that expands to include the entire population, and we are bringing that into the modeling system because we are talking about all the people, not just the young, healthy male soldier. I think we found that the LD_5 probably had a factor of 5 overkill placed into it to be sure it was right, thus requiring a much higher dose for the LD_5 area. When used for offensive targeting purposes, this was probably appropriate; when applied for medical, defensive purposes for a whole population, it certainly is not.

Dr. Arutyunyan: Thank you. Any more questions? If not, now we will listen to the second presentation, which is Modeling for the Chernobyl Accident. This presentation will be made by Dr. Brian Worley. He is currently serving as a group leader for the Reactor Physics Team and is also the Project Manager for Oak Ridge National Laboratory work supporting the Defense Special

Weapons Agency Program,which includes the development of HASCAL. Dr. Worley...

Simulation of the Chernobyl accident using the HASCAL model

Dr. Brian Worley: Thank you. Several years ago the Defense Nuclear Agency, now the Defense Special Weapons Agency, and in particular Mark Byers came to Oak Ridge and asked us to carry on and help develop a forward deployable tool the HASCAL Code that he just described. We at Oak Ridge had been involved in the development of the Nuclear Regulatory Commission tool that is used to do similar analysis for the commercial Presssure Water Reactors (PWRs) and Boiling Water Reactors (BWRs) that we have in the United States, and Mark asked us to use that as a starting point and to do the following. First of all, rather than model accidents that occur for the first 24 hours, since they were using a three-dimensional adaptive grid model, SCIPUFF, they would like to model accident sources further out in time and therefore would require some new modeling for us to look at certain aspects of the accident, in particular the decay during transport, and how we might handle ground shine and cloud shine in a different way than the NRC might. Another thing he asked us to do was, rather than take the source inventory for a typical BWR and PWR, he asked us to develop inventories for all the commercial reactors in the world, which was quite a challenge for us. Then he added research reactors and all the fuel cycle facilities, so it's been quite a challenge for us. In the development process, as we went through this, it became clear to us that we were faced with quite a validation problem. That is, validating our source terms not only for the reactors that we are familiar with in the United States but those from around the world. And in doing so we worked with, as Mark mentioned, the different agencies in Canada, U.K., and through the IAEA and our contacts that we normally have. It also became clear to us that another validation exercise that we should carry out is to look at existing accidents that have happened over the last 50 years. Of course, the one that we have been asked most about and the one that I thought would be of interest to this particular group would be the Chernobyl accident. So what we attempted to do was take the HASCAL Code, for which we had developed reactor-specific inventories for all the commercial reactors in the world and without really trying to change anything in the Code, just apply the Code as it now stands to the Chernobyl accident to see what we would get. As Mark mentioned, the HASCAL Code is part of the DOD hazard, prediction and assessment capabilities, is based on the NRC model RASCAL, and calculates doses, and I might mention here that not only does it calculate an external dose but it calculates doses to the thyroid, acute dose to bone marrow. There's a list of about 10 different doses that can be calculated with HASCAL, doses that are recognized by decision makers. And these doses, as Mark has mentioned, are based upon the latest NCRP and ICRP dose factor data that account for doses to the general population. If you look at a HASCAL contour output, the default contours follow what people might be used to, and that is the 500 millirem annual exposure to a nuclear plant worker limit and so forth. HASCAL employs the SCIPUFF module, which was developed originally for the Electric Power Research Institute, which is a research institute that is funded by the nuclear reactor vendors here in the United States. It has had years of validation, not only for reactor plumes but also, more recently, against measured data out at White Sands. HASCAL uses the NUREGs based on NRC approximations for severe accidents for PWR and BWR accidents, and we have had to develop some more criteria for the other accident types. The methodology applied is also one that the NRC has adopted and is explained in NUREG-1228. The references that we are going to cite today are here (slide). This is our first preliminary look at the Chernobyl accident using the HASCAL Code. It is based upon the Soviet report and the INSAG reports that came out the same year as the accident. Some information that we got from *Nucleonics Week* and the more recently published OECD report, the 10 year report that came out in November, and also some of the initial weather data that were used in these simulations was taken from the ARAC group. So if we look at default source terms for Chernobyl that are in HASCAL that we developed, one of the first things we wanted to do was to compare that with the published data and the total core inventory at the time of the accident, which in HASCAL was about 16,300 megacuries, which compared well with the OECD report. The total core inventory is date corrected to May 6, and the reason we date corrected it to May 6 is a lot of the published data have been published in that form. It also compared well with the INSAG report which dropped it down to 1,620 megacuries by that time. Now, for the source term released, we relied on the fraction release of the different types of the nuclides, the volatiles, noble gases, etc., from all the different expertise that had been developed on this subject over the last 10 years and applied that source term fraction release for those categories to the HASCAL inventories. Our source term release date corrected to May 6 was 114 megacuries, about half that from noble gases; this compared well with reported estimates of about 100 megacuries and 50 megacuries of noble gases from *Nucleonics Week.* The release fractions of the OECD report are larger than the fractions of the Soviet report. I think this is largely based on the fact that there have been continued studies between the two. If the release fractions from the OECD report are used, the source term release for the first day of the accident is approximately 3,000 megacuries with 1,000 megacuries coming from noble gases. Date corrected to May 6 are 162 megacuries and 54 megacuries; I just mention these numbers here for those who may be intimately familiar with the Chernobyl accident and they can form their own opinions. During the Chernobyl accident, on the very first day, there was the explosion that released most of the core inventory, and then in the last, I guess, four days the fires were burning, and, after May 6, pretty much the fires had died out and we received very little release. In our HASCAL simulation we could have simulated all 10 days but because of the histogramic features we decided to release it in three separate phases. The first phase was that released in the first explosion, the second phase between the two big releases, and the third phase during the fires. Each release phase corresponds also to a different weather pattern as it was reported in the ARAC report and this simplified weather data. I might mention that the HASCAL operator is faced with three options. He will be asked if he wants to use historical data from the last 30 years or if he wants to read in the real-time data that's being observed around that site or if he wants gridded data from a weather model. In terms of responding to an accident, the philosophy would be to take the real-time data that are being observed and make it use the (tape unclear) model to get the wind data to drive the SCIPUFF model during the first few hours. One can go ahead and run a three-day gridded model for predictions after that, but in this case we will be simulating the fixed wind data as taken out of the ARAC report. Each phase of this, as Mark mentioned, was intended to be a full-bore, fast running tool not only for planning but response. Each phase of this took about 20 minutes on a 133 megahertz PC. To repeat again, the weather that we input for this simulation was local weather data when available. If these were not available, the prevailing wind conditions were used and resulted in the correct plume in both time and location. We took the data from the published ARAC report. The next phase of this simulation that we hope to carry out in the next few weeks will use some gridded weather model data to see how that changes the look of our plumes. These are plots of the initial phases of the accident (referring to slide): up in the left-hand corner was April 26; April 28 is the center left, April 30 in the bottom left; May 2, May 4, and then finally May 6. As was reported yesterday by our Russian colleagues, the initial wind pattern was to the north-northwest, and, towards the end of the accident, to the south. So what kind of a picture might you expect from HASCAL? For this first phase we get one similar to one where we might have the explosion at a high altitude. Using just simple wind data from the ARAC report, this is the kind of plume that you see, with the scale on the right showing the dose rates. This is the total effect of the equivalent dose rate that one would get from inhalation and ground shine and external exposure. As I mentioned before, there are several types of doses one can look at; in particular everyone always asks what's the dose to the thyroid, particularly because it affects young children so adversely. This plot shows what you can get from an operational sense, a quick look at what the plume distribution of the doses to the thyroid would look like. I am just going to go quickly through the second and third phases to show you what types of data come out of HASCAL. I might mention at this time that when you run HASCAL it saves the doses at every hour and has an animation feature so if you want to animate the simulation forward or backward in time you can. Also it has a zoom capability; you can zoom in and zoom out. The underlying math data bring up selectively as you wish, roads, railroads, names of cities, etc. Also in the newest version of HASCAL there is now an important option where you can print out to any selected scale you want--1:250,000, 1:500,000, 1:24,000 scale maps--so that you print it out on a clear overhead and overlay it on a map. It's been very useful in an operational sense. This shows the thyroid [doses] from the second phase and here's the third phase that went south and then back to the west. This shows the total equivalent. This is a thyroid [dose plot calculating for the wind] that went south and west in the third phase. If we look at the published data and how this simple wind pattern, not even using gridded wind data, will compare with published data, we see that by and large we fall somewhere in the range of the reported data. We are probably a little bit on the low end since we only carried these plots out for four days, but at least we have the confidence that we are getting the typical results that one might expect from such a simulation.

In conclusion, we think that the total core inventories that are in HASCAL agree well with the published data. The source terms released by category, and these are the categories that have been agreed upon by the NRC as that group of different nuclides, agree well. The plume distributions also agree well with those by gridded models. Dose calculations agree fairly well and in our HASCAL code are modeled fairly well by this first preliminary study. In the next study we will be looking at more detailed calculation where we follow all 10 time steps of the release, go further out in time with gridded data, initially at 160 kilometers and then in the last phase at a finer mesh. Thank you.

Dr. Worley's slides begin on page 89.

Modeling the Chernobyl Accident with the HASCAL Code

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Oak Ridge National Laboratory
November 13, 1996

Work sponsored by the Defense Special Weapons Agency

Introduction and Scope

Description of the HASCAL Code

References cited

Chernobyl core inventory and source term releases

Total duration of release divided into three different phases

Calculation for each phase compared to dose data

Conclusions

References Cited

Soviet Report: August 1986, USSR State Committee on the Utilization of Atomic Energy, "The Accident at the Chernobyl Nuclear Power Plant and Its Consequences"

INSAG Report: August-Sept., 1986, IAEA Safety Series No. 75, "Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident'

Nucleonics Week: September 4, 1986, Vol. 27, No. 36, p. 8, Mc Graw-Hill Publication

OECD Report: November 1995, Organization for Economic Co-operation and Development, "Chernobyl, Ten Years On, Radiological and Health Impact"

ARAC: Atmosphere Release Advisory Center of the Lawrence Livermore National Laboratory. Report UCRL-96934.

Description of the HASCAL code

HASCAL (Hazard Assessment System and Consequence Analysis) Code is part of

HPAC (Hazard Prediction and Assessment Capability) and is based on

RASCAL (Radiological Assessment System for Consequence Analysis).

HASCAL calculates doses, can be used for emergency response planning

HASCAL can analyze accidents at nuclear and non-nuclear facilities.

HASCAL employs SCIPUFF (Second-Order Closure Integrated PUFF) for turbulent transport of effluent outside the facilities.

In-containment source terms are from NUREG-1465, or input by user.

Methodology of NUREG-1228 is used to determine fission product transport and attenuation inside the plant.

Sponsored by Defense Special Weapons Agency (DSWA, DOD).

HASCAL Calculations of Chernobyl Inventories

- Total core inventory at the time of the accident (April, 26, 1986, 1:23): **16,300 MCi (6 x 10^{20} Bq)**
- This total inventory agrees well with OECD Report.
- Total core inventory, decay corrected to May 6, 1986: **1,620 MCi (6 x 10^{19} Bq)** in agreement with INSAG Report.
- Source term released, decay corrected to May 6, 1986, using Soviet Report release fractions: **114 MCi** (**54 MCi** from Noble gases)
- This value compares well with reported estimates of **100 MCi** released, with **50 MCi** from Noble gases, and 50% error (Nucleonics Week).

Chernobyl Releases

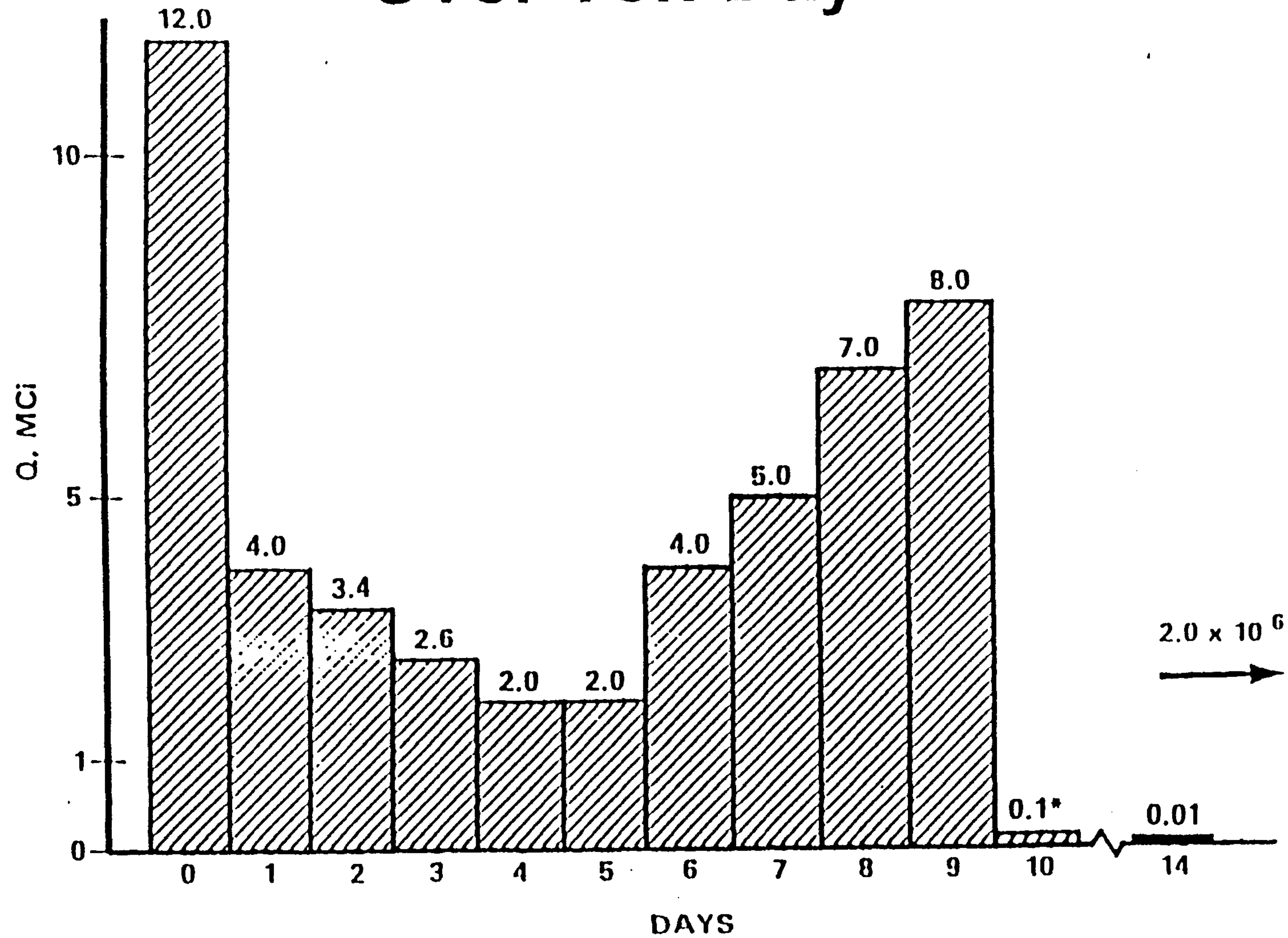
The release fractions of the OECD Report are larger than the fractions of the Soviet Report.

If the release fractions of the OECD Report are used:

Source term released for April 26, 1986, 1:23 am (time of the accident) is **3,081 MCi**, with **1,070 MCi** from Noble gases.

Source term released, decay corrected to May 6, 1996, is **162 MCi**, with **54 MCi** from Noble gases.

The Chernobyl Release Took Place Over Ten Days



Three Phases Were Considered with HASCAL

First release phase:	April 26, 1986, 1:23 am
	April 29, 1986, 5:00 pm
Second release phase:	April 29, 1986, 2:00 pm
	May 2, 1986, 0:00 am
Third release phase:	May 2, 1986, 0:00 am
	May 6, 1986, 11:00 pm

Each release phase corresponds to a different weather pattern.

Simplified weather data taken from ARAC.

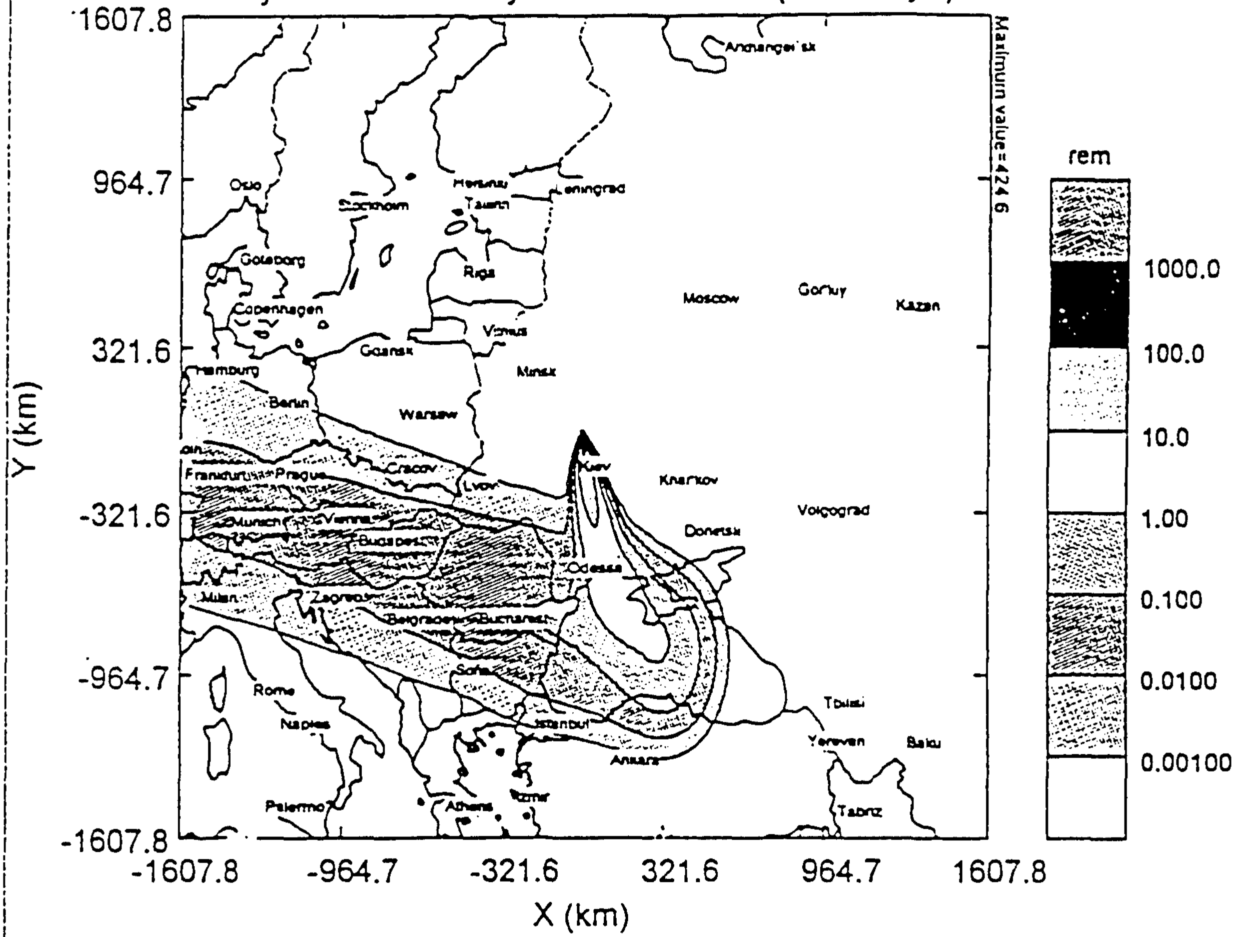
Each phase run in 20 min on a PC 133 MHz.

Dose Comparisons

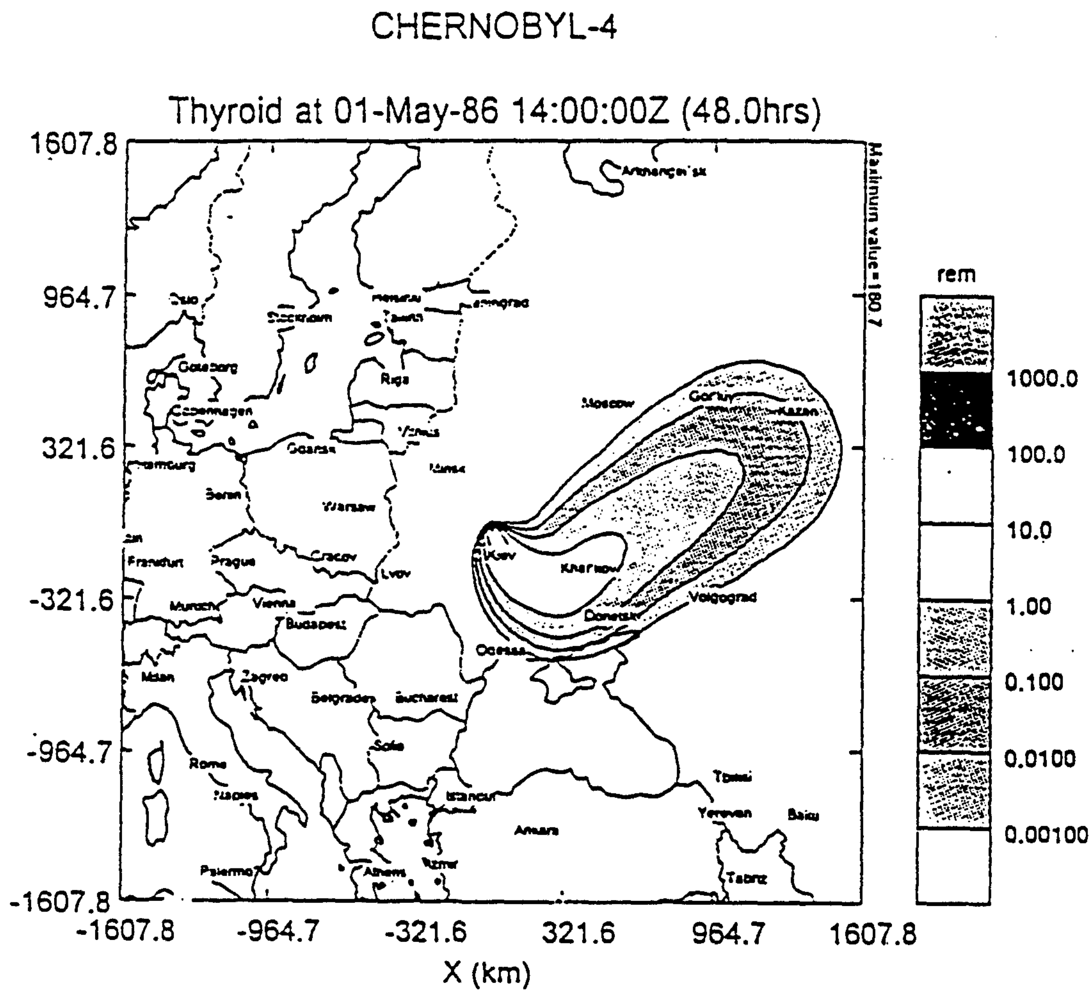
Location	Dose Reported	HASCAL Calculation
Chernobyl	800-10,000 rad	1,000 rem
Belarus	30-1000 rem,thyroid	500 rem
Russia	1-20 rem,external	1-10 rem
Ukraine	1-10 rem, total	1-10 rem
Sweden	0.26 rem	0.1-1 rem
Finland	0.11 rem	0.1-1 rem

CHERNOBYL-4

Thyroid at 06-May-86 22:32:45Z (4.94days)



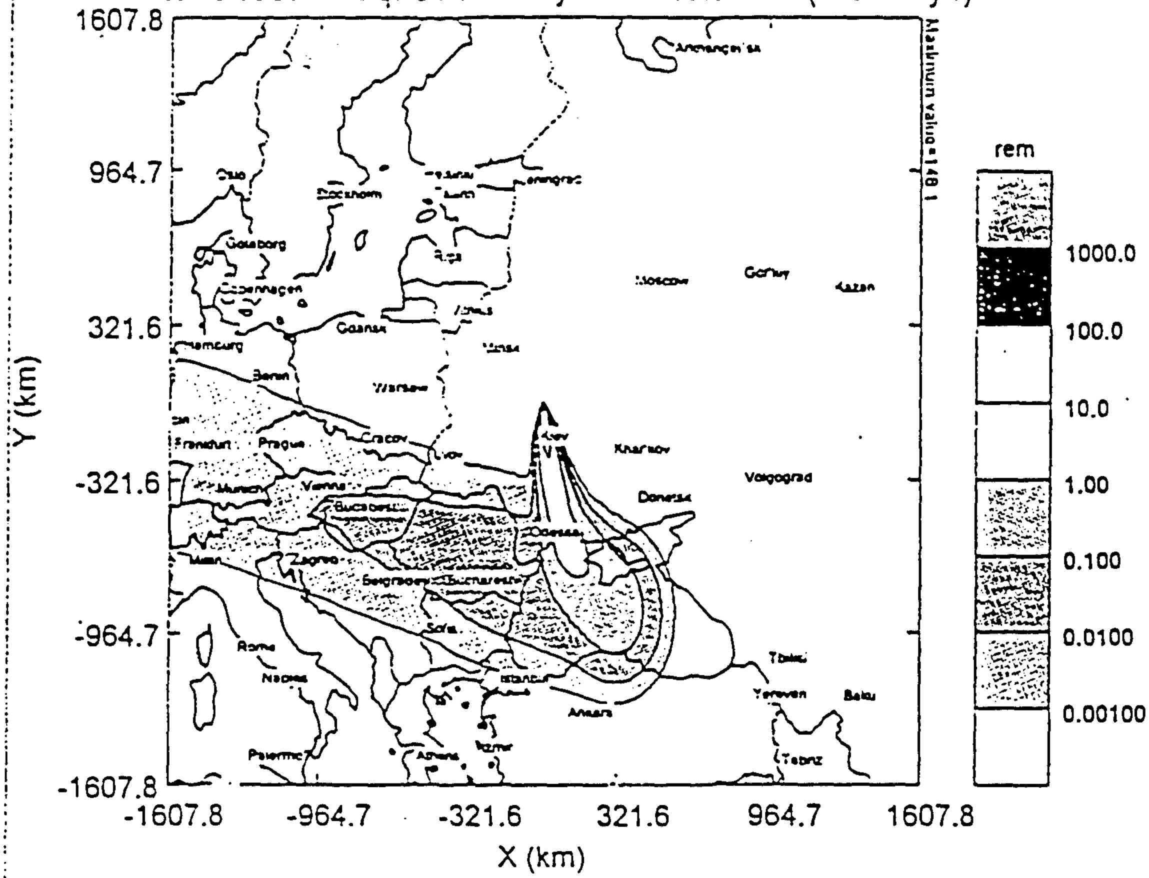
Project: cher2m	Analyst: Not specified	Classification: Not specified
Type: HASCAL	Version: 0.420	Created: Tue Oct 29 13:00:30 1996
Start time: 02-May-86 00:00:00Z	Stop time: 06-May-86 23:00:00Z	Current time: 06-May-86 16:04:29Z
Duration (hrs): 119.00	Max timestep (sec): 900.00	Output interval (hrs): 8.00
X Domain (°E): 6.93278 - 53.2672	Y Domain (°N): 36.9245 - 65.8422	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational	Bowen: 0.60	Albedo: 0.160
LSV=Model		
Materials: DEP (Gas)	Density (kg/m³): 1.20	Deposition (cm/s): 0.30
NDEP (Gas)	1.20	Deposition (cm/s): 0.00
Incidents: cher2m	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)



Project: cher30 Type: HASCAL	Analyst: Not specified Version: 0.420	Classification: Not specified Created: Tue Oct 29 10:13:14 1996
Start time: 29-Apr-86 14:00:00Z Duration (hrs): 48.00	Stop time: 01-May-86 14:00:00Z Max timestep (sec): 900.00	Current time: 01-May-86 14:00:00Z Output interval (hrs): 2.00
X Domain (°E): 6.93278 - 53.2672	Y Domain (°N): 36.9245 - 65.8422	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational LSV=Model	Bowen: 0.60	Albedo: 0.160
Materials: DEP (Gas) NDEP (Gas)	Density (kg/m³): 1.20 1.20	Deposition (cm/s): 0.30 Deposition (cm/s): 0.00
Incidents: cher30	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)

CHERNOBYL-4

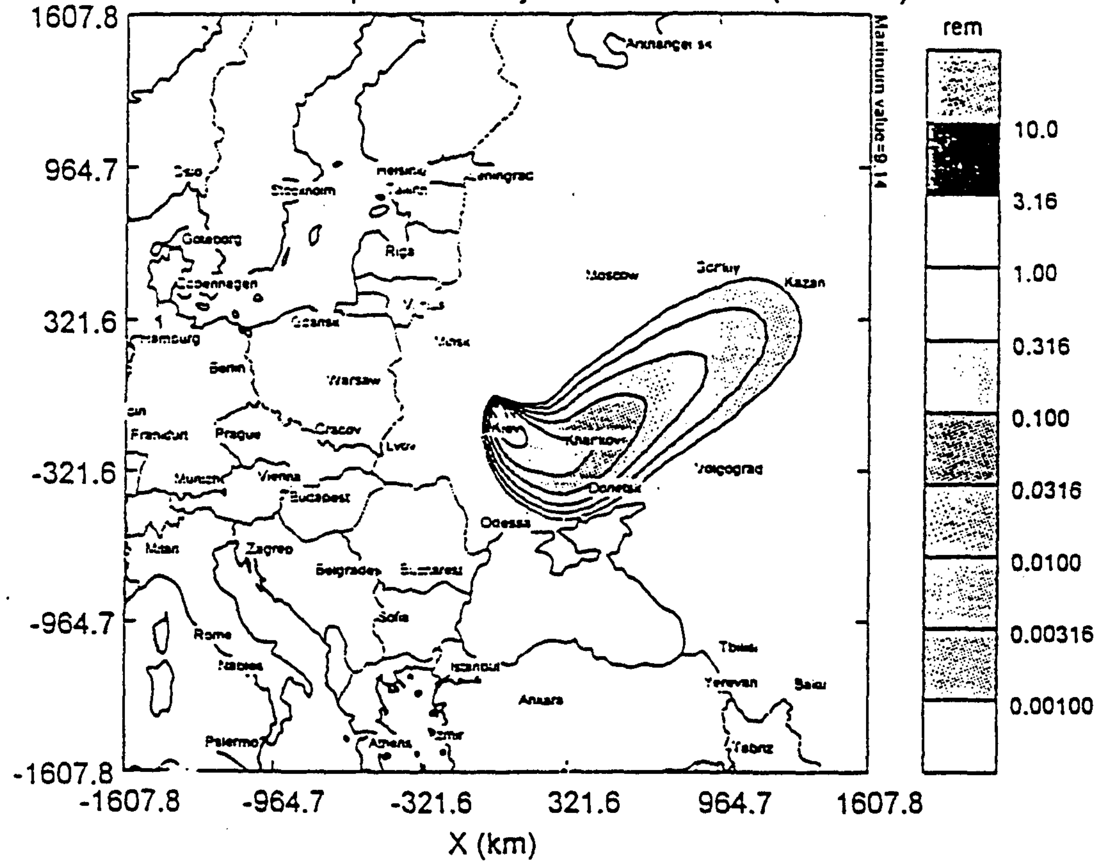
Total effective eq. at 06-May-86 22:32:45Z (4.94days)



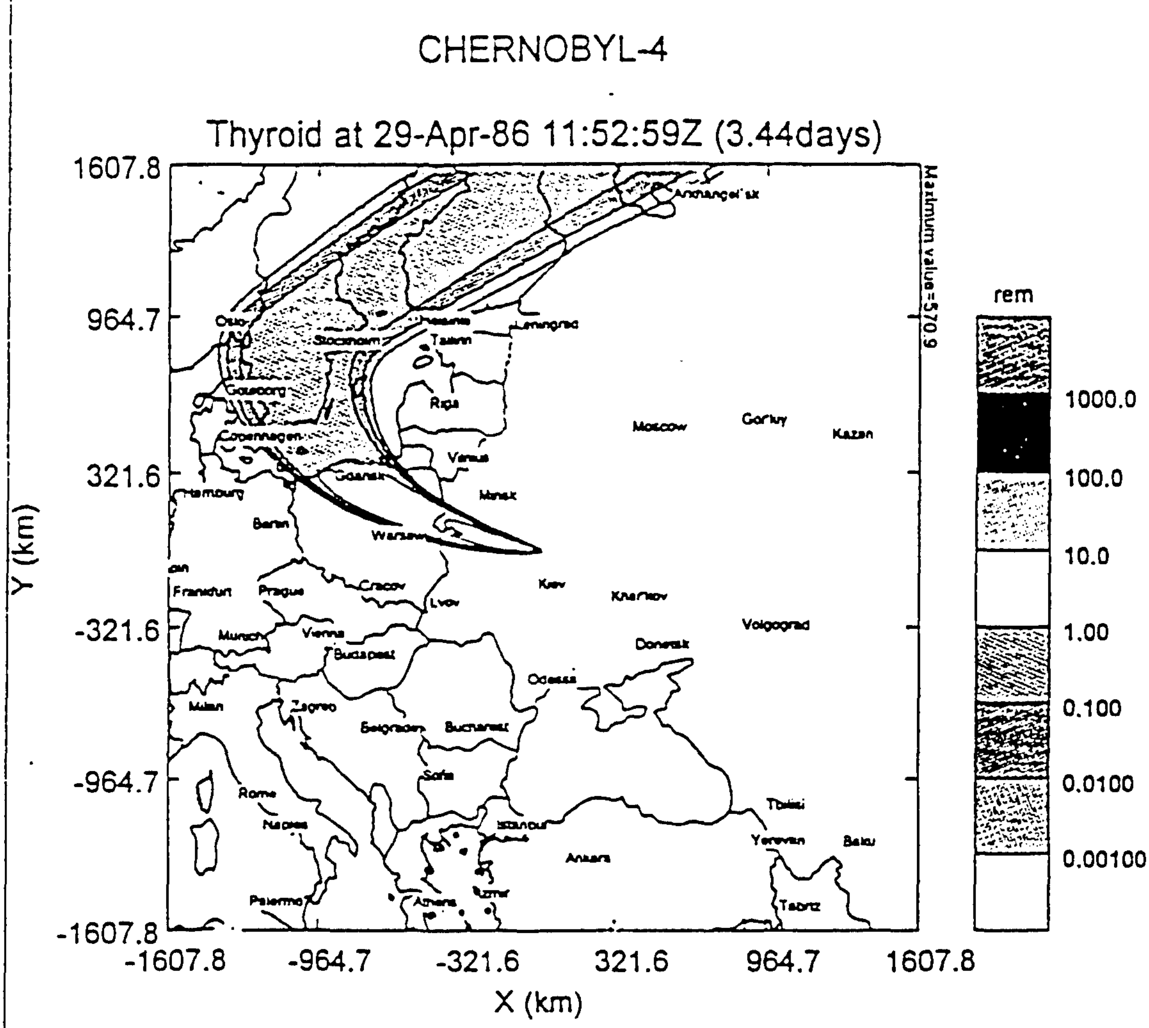
Project: cner2m Type: HASCAL	Analyst: Not specified Version: 0.420	Classification: Not specified Created: Tue Oct 29 13:00:30 1996
Start time: 02-May-86 00:00:00Z Duration (hrs): 119.00	Stop time: 06-May-86 23:00:00Z Max timestep (sec): 900.00	Current time: 06-May-86 16:04:29Z Output interval (hrs): 8.00
X Domain (°E): 6.93278 - 53.2672	Y Domain (°N): 35.9245 - 65.8422	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational LSV=Model	Bowen: 0.60	Albedo: 0.160
Materials: DEP (Gas) NDEP (Gas)	Density (kg/m³): 1.20 1.20	Deposition (cm/s): 0.30 Deposition (cm/s): 0.00
Incidents: cner2m	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)

CHERNOBYL-4

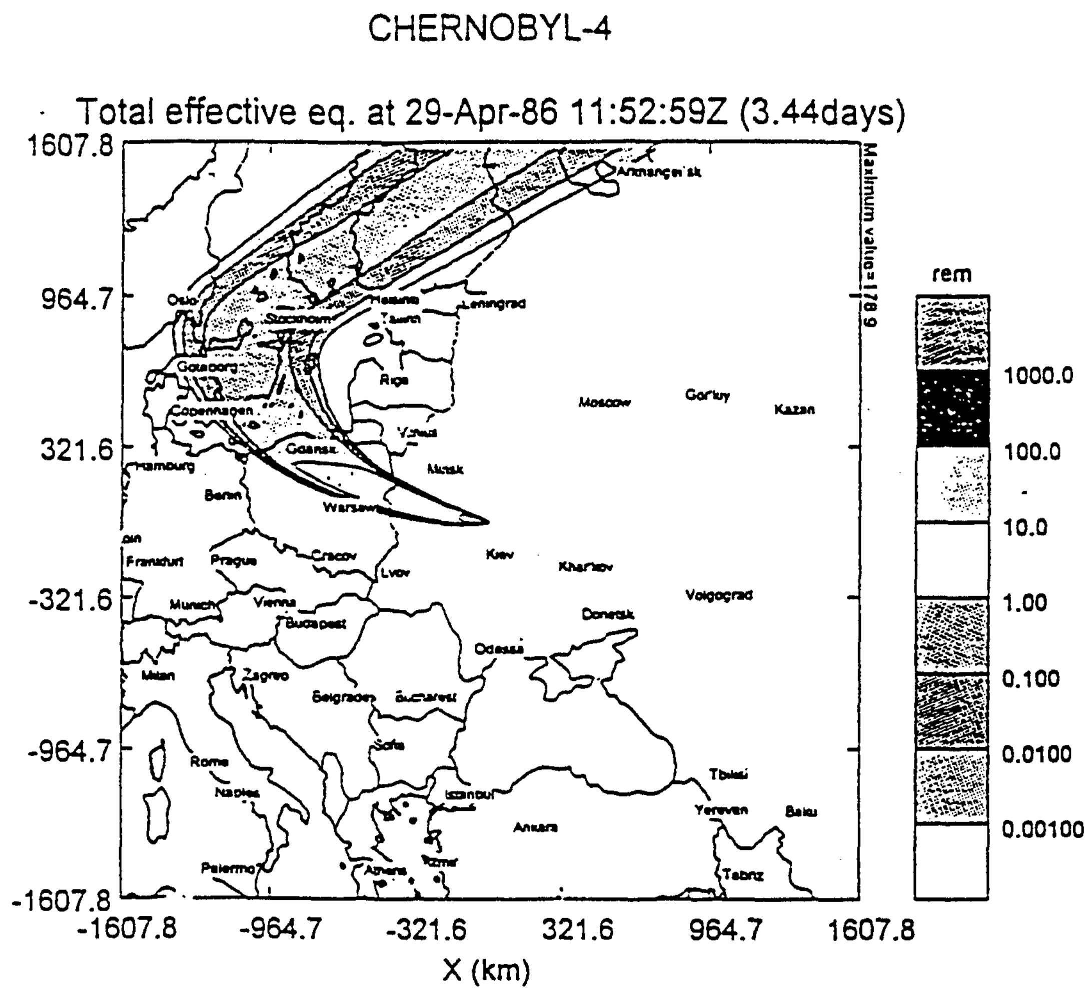
Total effective eq. at 01-May-86 14:00:00Z (48.0hrs)



Project: cher30 Type: HASCAL	Analyst: Not specified Version: 0.420	Classification: Not specified Created: Tue Oct 29 10:13:14 1996
Start time: 29-Apr-86 14:00:00Z Duration (hrs): 48.00	Stop time: 01-May-86 14:00:00Z Max timestep (sec): 900.00	Current time: 01-May-86 14:00:00Z Output interval (hrs): 2.00
X Domain (°E): 6.93278 - 53.2672	Y Domain (°N): 36.9245 - 65.8422	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational LSV=Model	Bowen: 0.60	Albedo: 0.160
Materials: DEP (Gas) NDEP (Gas)	Density (kg/m³): 1.20 1.20	Deposition (cm/s): 0.30 Deposition (cm/s): 0.00
Incidents: cher30	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)



Project: cher Type: HASCAL	Analyst: Not specified Version: 0.420	Classification: Not specified Created: Tue Oct 01 15:03:13 1996
Start time: 26-Apr-86 01:22:59Z Duration (hrs): 93.6167	Stop time: 29-Apr-86 23:00:00Z Max timestep (sec): 900.00	Current time: 29-Apr-86 11:22:59Z Output interval (hrs): 8.00
X Domain (°E): 6.93287 - 53.2671	Y Domain (°N): 36.9245 - 65.8421	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational LSV=None	Bowen: 0.60	Albedo: 0.160
Materials: DEP (Gas) NDEP (Gas)	Density (kg/m³): 1.20 1.20	Deposition (cm/s): 0.30 Deposition (cm/s): 0.00
Incidents: cher1	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)



Project: cher Type: HASCAL	Analyst: Not specified Version: 0.420	Classification: Not specified Created: Tue Oct 01 15:03:13 1996
Start time: 26-Apr-86 01:22:59Z Duration (hrs): 93.6167	Stop time: 29-Apr-86 23:00:00Z Max timestep (sec): 900.00	Current time: 29-Apr-86 11:22:59Z Output interval (hrs): 8.00
X Domain (°E): 6.93287 - 53.2671	Y Domain (°N): 36.9245 - 65.8421	Resolution (°): default
Meteorology: Data=Surface Obs	File: scipuff.sfo	
BL=Operational LSV=None	Bowen: 0.60	Albedo: 0.160
Materials: DEP (Gas) NDEP (Gas)	Density (kg/m³): 1.20 1.20	Deposition (cm/s): 0.30 Deposition (cm/s): 0.00
Incidents: cher1	Time (hrs): 0.00	Location(°E,°N,m): (default,default,0.00)

Weather Input

- When available, local weather data was input.
- If weather data were not available, prevailing wind conditions were used resulting in the correct plume (both, in time and location).
- Weather data from ARAC (Atmospheric Release Advisory Center).
- Simplified weather data used.
- Future calculations will employ detailed gridded weather data from OMEGA.

Conclusions

- Chernobyl total core inventories calculated by HASCAL agrees well with other data (OECD, INSAG Reports)
- Source term releases used by HASCAL also agree well with data (Soviet Report)
- The plume distributions calculated by HASCAL agree well with data (ARAC).
- Dose calculations also agree with other calculations and data.
- In summary, the HASCAL Code has modeled the Chernobyl accident well, despite simplification used.

Dr. Arutyunyan: Now questions, if any. Then, actually I have a question for Dr. Brian Worley. What do you think about the accuracy of the forecast of exposure rates, specifically in Chernobyl? In other words, what accuracy are we talking about--several times or an order of magnitude or what? In other words, what is the accuracy for forecasting the situations?

Dr Worley: If we look at the published estimates of the uncertainties in the inventory itself, the initial estimates had accuracy error bars of about 50 percent just on the inventory alone. If we factor in the additional uncertainty in the weather patterns, I would say we are talking an order of magnitude at least.

Dr. Ainsworth: I was not clear whether those were doses, total doses, or dose rates. Could you clarify that for us please?

Dr. Worley: Those were integrated doses through that time period.

Dr. Steinhausler: I have a question with regard to the inventory release numbers. When we did the international Chernobyl project, as you may recall, one of the conclusions was that only three percent of the core inventory plus 100 percent of the noble gases was released. If I wrote down those numbers correctly, the modeling revealed an inventory of 16,300 megacuries and the release on April 26 was about 3,081, so we have 16,000 versus 3,000. Could you help me understand that and the three percent published on the international Chernobyl project?

Unidentified speaker: The 3,081 MCi, that's the total amount of the initial inventory that was still inside the reactor, and it was going to be released in the next 10 days. In other words, this was the fraction of the total inventory of the reactor that was still inside the reactor but was going to be released in the next 10 days. The 162 MCi is that number when decay corrected for 10 days. In other words, the first number (3,081 MCi) is for the date of April 26, the second number (162 MCi) is for the date of May 6. Is that clear now? Not yet?

Dr. Steinhausler: I'm afraid not. The EA report states only three percent of the total inventory was released as a consequence of the Chernobyl accident plus 100 percent of the noble gases. Now the total inventory according to the modeling is 16,300; three percent of 16,300 does not tally to 3,081. That's why I have difficulties.

Unidentified speaker: This table has been generated from HASCAL and has been using the latest release fractions from the OECD report; that is the one released last year. As you can see the total source term at the time of the accident, April 26, was 1,620 MCi. Now 100 percent of the noble gases is 1,070 MCi, that's the one that you have in your value, and this is the rest of the things that add to 3,081. As you can see, the three percent that you are mentioning is the three percent across the board, but for each isotope you have different releases. Like for instance for a class two, cesium, and class four, which is iodine, you have values up from 40 percent and 60 percent according to the OECD report, so the three percent is for solids. It's an average value. As you can see, for the other classes you have three and a half percent You can see that over there, but it's more than three percent in average, as you can see, because you have 100 percent of noble gases plus 40 percent of the cesium plus 60 percent of the iodine, that's also 60 percent of thorium (?), which is class number five. These are the latest values we got.

Dr. Worley: I have the OECD report here. It says that 100 percent of the core inventory of noble gases was released, xenon and krypton, and between 10 and 20 percent of the more volatile elements of iodine, tellurium, and cesium was released The early estimates for fuel material released to the environment was three percent plus or minus 1.5 percent. This estimate was later revised to 3.5 plus or minus 0.5 percent, only talking about the fuel material differentiating it from the total material.

Dr. Arutyunyan: Thank you very much. Any other questions? I would just like to add that when we say a three percent discharge it's a relative number. That was mentioned in the first report, and this is kind of an assessment of the total activity. The discharge was very complex for different isotopes, with different percentage rates. The three percent is our dated number. Now people speak about other numbers. We do have a topic for discussion here. Thank you. Another question?

Dr. Eugene Saenger, University of Cincinnati: I thought some of you might be interested in a little anecdote that took place back in May 1986. Dr. James Kariakis, our physicist, and I, our radiologist, were requested to report to the headquarters of the Seventh Army Medical Command in Heidelberg, and the question that was posed for us was whether it was necessary to evacuate all the women and children and other dependents within the Seventh Army Medical Corps area of responsibility, which covered all of the continent and I believe the British Isles and some part of Turkey. When we arrived there, we were fortunately abetted by a group of about six Army personnel who were skilled in health physics and physics and we were able to get over the next several days some estimates of the amount of radioiodine which was deposited. These data came in such numbers as the number of microcuries per square millimeter and the number of disintegrations per hectare and various other ways of communicating activity to us over this period of time. The reason I mention this is that I am struck by the now. We digested all this information. It took us about five or six days to get a handle on how we analyzed the data, and, without having any numbers with me, I will say that we made the report to General Ledford, who was the commanding officer, that we felt that there was no hazard to these people and there was no need to evacuate. I said to General Ledford at the time, "Would you like me to make a report, would you like me to go on radio or television and explain what we found?" He said, "The best thing for you fellows to do is to get in an airplane and go home!" Which we did. It was very interesting to me to know that in retrospect we came up with what is a correct answer. Our data and so on were analyzed in several publications subsequent to our visit there, and we were able, by doing sort of a seat-of-the-pants analysis, to come up with what in retrospect was a correct interpretation of the data in spite of the fact that we had no knowledge of the various techniques which we saw here today.

Dr. Arutyunyan: Thank you. Any other questions?

Dr. Oleg A. Pavlovski: My name is Pavlovski. I have a question. Does your code take into consideration local settlements, residues, rains, and contamination of soil? Do you take into account any precipitation?

Dr. Worley: The model has an option to take into account rain out and washout. It also separately accounts for deposition and ground shine and subsequent decay, and we hope the future version will address resuspension.

Dr. Arutyunyan: Any other questions?

Dr. Young: Let me ask you about insertion height and how you handled that for plume because I remember back when we were trying to make these estimates using ARAC real time in 1986; they were wrong, continually wrong, and had to be continually readjusted. Eventually we got them right by jacking it up and jacking it up until we got it right. It is fine from a historical perspective, but my question is specifically this: how does HASCAL handle this for an event, for instance, in which we don't have the best benefit of historical data and we are trying to do the kinds of projections that you have done, given lack of or imperfect knowledge about insertion heights and that sort of thing, because it's so dependent on that.

Dr. Worley: The current version of HASCAL just came out about a week and a half ago. I might mention that it is distributed by DSWA on a compact disk along with the map and detailed data. The current version of HASCAL has an option for the user to manually input the height of the release and that's how we handled the Chernobyl accident because, like we said, we had the advantage of hindsight. The current version of HASCAL has a capability for non-nuclear sources to handle buoyancy terms and distribution of particle sizes. This has been used in the chem and bio areas, I think. The next version of HASCAL that will come out in September '97 will include the characterization of the initial release in terms of temperature, heat, and particle size and will contribute to the buoyancy term and hopefully get some estimate, real time estimate, of the release height.

Dr. Saenger: I wanted to ask one other question, if I might, of a speaker. Would HASCAL and these other systems have predicted the same consequences of radioiodine spread over the European theater that we found from the Chernobyl accident?

Dr. Worley: We haven't compared yet the deposition of just the iodine, but we plan to do that in our next few studies.

Dr. Saenger: The methods that we used were described in the *Journal of Nuclear Medicine*, I think sometime later in 1986 for those of you who might be interested.

Dr. Arutyunyan: Thank you. Are there any questions?

COL Byers: Two more slides. Back to the last question on the buoyancy treatment in SCIPUFF. SCIPUFF is far, far from your typical Gaussian puff model that you see, just moving things horizontally. What this graphic shows is a challenge problem that we gave the SCIPUFF development team. We have six cells of counter-rotating gas just moving around, and, in the center of the middle two cells, we laid in a sphere of particulate matter distributed uniformly, spherically, and then just turned on the clock and let it run. We also constructed it so that we had an analytic solution to test the tool. In the center is the analytic solution after whatever length of time we ran. On the right is SCIPUFF's calculation. Now I have never seen any other Gaussian puff model that can even come close to that, so SCIPUFF is pretty sharp. It's for this reason that, instead of just injecting the material up to some elevation in the atmosphere, we like to get SCIPUFF involved very early on because it has the buoyant rise treatment. Remember we would use SCIPUFF in some of our nuclear weapons calculations and that's a very strong buoyant rise. Likewise, when doing chemical agents, you have to treat buoyancy because heavy gases will settle in lower areas. This is a picture that I found impressive for those who really like to look at models. This is a cross section to show that it's not just fluke; it's not a picture you just think is sort of close, it actually trends and follows nicely through the whole calculation, so we really like SCIPUFF.

Dr. Arutyunyan: Thank you very much. We have a break for half an hour, then we are going to discuss for 50 minutes this particular topic.

Scientific and technical support for decision making to protect inhabitants near radioactive accidents: Methods, models, information technologies

Dr. Arutyunyan: Dear colleagues, I would like, together with Dr. Pavlovski, to continue our joint presentation. I would like to tell about our experience in the issues of scientific and technical support in the emergency response to radiation accidents. When we speak about scientific and technical support I would like to tell you that it's really important here to have an idea of the entire scope of issues that are related to the assessment of the situation, especially the prediction of the situation and development of recommendations. We are working on the topics related to the analysis of the safety of atomic energy sites. We mean here technical safety. From this we get an idea of what kind or types of accidents can occur, what conditions emerge from the point of the discharge of the inventory, what the aerosol composition and height of the cloud could be, etc. Anyway, we need something that can become the starting point in order to forecast the consequences of radioactive accidents. Also, we are working on the issue of systems analysis of the consequences of radiation accidents, mainly the accident at Chernobyl, which serves us as a basis for understanding what actually can happen. We combine this with the fact that we can model, calculate, and compute, and on the basis of these two trends we are working on the scientific and technical support for decision making to protect inhabitants. So I would like to tell you about the information database concerning the Chernobyl accident.

Actually, beginning in 1986 we have been collecting data concerning all the aspects of the Chernobyl accident. These are not only the extent of contamination and the doses from radiation exposure (both calculated doses and actual doses); these are also the data concerning the contamination of foodstuffs, on contamination of agricultural products, data on chemical contamination at the Chernobyl area, demography, medical statistics, social aspects, the issues related to psychological aspects. Today all this kind of information has been collected in a central bank of generalized data within the framework of the work that we are conducting for the Ministry of Extreme Situations. So this central data bank actually contains, at the present time, all the accessible information on 10,000 populated areas. These are the data for individual areas-- agricultural areas, forestry, atmosphere, soil, water--atmospheric data for regions, districts, and contamination zones. There are also the personal data related to the liquidators of the accident. The characteristics that I am discussing here are economic, contamination, chemical, and social characteristics and the progress of the problem itself. Of course, you understand that this data bank is a result of the work of many research and scientific organizations, ministries, and agencies which gathered together in order to resolve the issues related to the assessment and forecast of the situation. This data bank is organized as a geoinformational system in which you can take a look at each of the inhabited areas, and you can get information on 200 to 600 parameters, depending on the degree of completeness of the data bank. This information extends from 1986 to the present time. Of course, this information is not complete. For 1986 we have information that until now was controversial and has not been determined correctly, including the issues related to the doses at the initial stage of the accident, contamination of the territory by iodine, etc. Anyway, this is actually the entire set of information on the consequences of the Chernobyl accident. The data bank on the demography and medical statistics contains information for 9 or 12 years, depending on the regions, and includes information on mortality at birth, mortality rates and causes of death. The oncology data is on 26 [primary site] locations for all the age groups, etc.

This is the map that shows you the distribution of lung cancers and mortality due to lung cancer on the territory of the country for all the Russian regions. I would now like to show several examples of how in real life we can take a look at these data, and I would like to demonstrate to you that we are dealing with not only some figures or individual numbers, say average doses or average contamination, but we are dealing with very complex distribution patterns with doses that pretty often could be either very far from those numbers that we can derive by calculation or they are not even close enough so that based on the calculation data we would be able to make certain decisions. A simple example is contamination of the area that you have seen already which is not even on a global scale. If we take a look under distribution of the dose in the thyroid then we can say that this is not monotonous function that has a decline in pattern depending on the distance: this is the cesium contamination density in the scale of 200 kilometers per one square; this is the Gomel area; this is Germany. If we go further to a scale of about one kilometer (pointing to slide) as you can see, this is half a kilometer and this is 1.5 kilometers, we can see the type of distribution where the contamination density actually changes by one order of magnitude. Even if we take a look at the level of a single inhabited settlement, and we do get this kind of information within the framework of the EMERCOM program, the Kurchatov Institute has developed a special program. We have a data bank, though not for all the inhabited area, where we can see the contamination is distributed within the framework of one area. For example, using a scale of 10 meters--these are individual houses and residential buildings--you can see that the contamination density is changing even within the limits of one settlement with the same degree of difference. If we take a look at the nature of distribution in various zones of the contamination density then we can see that there is not only a numerical difference but also a qualitative difference; that is, the distribution is different in various zones. If we take as an example the correlation of the doses of internal and external radiation and exposure with density, we can see that the distribution is different in various regions. In other words, to take a dose of external exposure and internal exposure and sum them up to receive a generalized dose, this actually could be natural when we speak on the level of the individual human being, but if you do the same operation for the doses across the territories then you are going to receive results that would not have anything to do with real situations. These distributions are complex for professional groups, for age groups, and that is why, depending on what a population is doing in a particular area, the correlation between the internal and external doses can be different. I am giving you this example only because I want to tell you that when we deal with real situations, we come across certain questions that are not in correspondence between the data upon which we have based our measurements and those that were calculated using various methodological approaches. Generally speaking, the question is raised on which bases should we make our decisions. Of course, it would be best if we do direct measurements, not only during the initial stage of the accident but even during the intermediate and later stages as well.

The results are represented within the framework of the geoinformational system. This is a simple example of the Gaussian model which can be used on a personal computer and which makes it possible to have not only the forecast results of the calculations but simultaneously to have the monitoring data. This system of radiation monitoring is in the Mayak territory. In the red circles, these are the sensors or gauges. This code includes the database on the characteristics of the sites--in other words, the enterprises, lands, facilities. You can take a look inside each of these boxes and get the characteristics and particular features of this particular site, including the list of possible [word unclear] accidents and the sources of discharge, etc. This is again an example of the representation of data of the monitoring system around the city of St. Petersburg that is included in the monitoring system of the Radium Institute. This is an example of how this system works in Kazakstan. Of course, the Gaussian model is a very simple one and in the past, of course, it was useful, but at the present time more complex three-dimensional models are used that are being implemented on PC computers, and we do not have to use the Gaussian model just because it's very simple. We can do more complicated calculations rather rapidly and, in particular, the model that we are developing is a three-dimensional combined, long-range, and Monte Carlo model, which makes it possible to calculate the shift of the activity in the atmosphere. You can use the entire bulk of meteorological data that you receive either from the specialized meteorological organizations or by calculation. This model makes it possible to input the meteorological data in the simplest way--in other words, on your screen. If you have a limited volume of information, you can input very simple characteristics, say speed and direction of wind, also precipitations, from the screen or as files if available and if you can receive them from certain systems. This (pointing to slide) is an example of calculations. Here the rain fell and you see the spot of contamination. You can take into account the aerography. This is again an example of such an aerography calculation, and the final results are given by the system in the format of dose radiation from internal and external inhalation, using the list of the inhabited areas. You get this information of course. You can input the countermeasures that you have either performed or you plan to perform, and you will receive the recalculated forecast, taking into account the countermeasures--iodination prevention measures, shelters--and in this case you can input the time of beginning of your countermeasure. For example, for iodination prevention measures, it's a very important factor, and the system takes into consideration the effectiveness of the iodine prevention measures, depending on the time of their initiations, and would give you replies. Of course, we do verifications of these models on all the experiments that exist today. This is the comparison of the atmospheric model with a known set of models for experiments--in particular, in Germany, KFK experiments--about 700 cases of measurements during this experiment, also the experiments that were conducted in Idaho. We compare these models with other existing models, but I would like to emphasize the fact that the accuracy of the best atmospheric models, if we are speaking not on a local scale but regional and global scales, then of course this model is not sufficient in order to receive realistic assessments in order to make certain decisions. We can have an error of one degree since we have a lot of unconditional circumstances and uncertainty in isotopic composition, our result composition, in the uncertainty of meteorological parameters, uncertainty of the model itself, when we take into consideration aerographic factors, etc. I'm going to show you this last. We are developing similar models for chemical contamination. This is a simple sectorial model. The model on vertical migration in the soil includes the database on the types of soil and on meteorological data for many years in the past. It includes the model of vertical migration and makes it possible to forecast 10 or 15 years in advance in order to resolve the problems related to the access of cesium to root systems for various types of agricultural situations. This is the model for groundwater. These are the models of radiation risk. This was the forecast for the Bryansk area based on the dynamics of the actual doses with the utilization of well-known international methodical approaches, demography, and medical statistics (that is, additive multiplication model by ages). This is the forecast of the years of the intestinal cancer, and of course, we can calculate how many additional cases because of radiation we can expect. We can compare it with the background values. This is for the Bryansk area. We can see that irrespective of radiation factor we can observe the growth of all the types of cancer for rural populations. As for any additional cancers that we can forecast, we really cannot see this because of the background of oscillation. I'm speaking about cancer, not thyroid cancer; this is a specific topic and Professor Tsyb is going to discuss it later on. This is the model for assessment of the chemical risks based on the methodological approaches of the EPA of the United States. You can input the contamination of water, soil, foodstuffs; depending on what you have, you can input the ration of food and get an answer of various chemical contaminants for 4,000 substances that are included in the database of EPA and forecast cancer diseases and/or other diseases.

Of course, in order to forecast the consequences of the accidents we must be able to forecast the behavior during the initial stage; this is the model that makes it possible to assess the height of the cloud during fires. This is the comparison with various experimental data on fires that occurred in the past. This is the fire in Hamburg. This is the calculation and these are the data on that particular fire. Similar models apply if you have a blast or an explosion, so you can calculate the data on the height of the cloud, bottom and top boundaries for low capacities and high capacities on the one kiloton level. This is a comparison with experiments of nuclear explosions. We have to be able, using experimental data, to restore or restructure the parameters that were very weak in the calculations. In particular, this is the model that makes it possible, using measured data of the dose rate in the contamination area, to calculate the initial parameters of a radioactive cloud; I mean to restore these parameters. The height, activity and in this case, the answers that we get are not a particular number or figure, but it is a probability factor. For example, if we want to know 60 percent of probability, then the spread on the height or activity would have this kind of number, say figure two for this particular case, depending on the real measurement. The more measurements you have, the more precisely you can restore the situation. These are methodological approaches that make it possible to develop maps of the territory, because blocking the map of contamination is a very complicated task, and simple interpolation methods very often yield great errors. By using geo-statistical methods we can build the isoline and, besides that, we will also build some uncertainty in the position of this isoline. This is extremely important when we make a decision. We should understand not only the average value but also our error.

Based on our data and models, we are performing the forecast of the situation for all of the Chernobyl territory, which is an assignment that was given to us by the Ministry of Extreme Situations. We use various approaches that can be offered as a decision for these territories, and we use in these situations all of the volume of data, all the models that I discussed. Then we can forecast what we can expect in 10 years, in 15 years, as far as exposure doses, contamination of foodstuffs are concerned, etc. If we come back to our topic, we can say that in real life we have to use models even if those models are not that good. This is the situation during the initial accident phase when we don't have any data; we have to say something at least. Number two, we use the models when we want to calculate possible situations in advance and when we develop our emergency plans. We want to use these data as a basis for data development, but here it's very important to know that we should not really base our planning on very simple models, say a Gaussian model, say we develop 10 mile, 50 mile zones. In real life we don't have 10 mile or 50 mile zones; the picture is much more complicated--you have seen it already. It's important to take into account the whole set of real parameters, including rain, the uncertainty in the aerosol composition, and so on, but I would like to say that modern technology, modern mathematical methods, and the capabilities of modern computers allow us to use computer models in practice, in reality, which was very difficult 10 years ago. In that sense certain progress has been achieved. We saw the models which our colleagues showed, and also the models that we are developing, but it's very important to understand the relationship between these models and reality.

There is one more situation where models are absolutely necessary. This is the situation where we have some experimental data, but they are insufficient. This is a common situation. It is possible to interpolate or basically connect to points and forecast something, using this simple method, but when you interpolate using a model, when you correct the calculation data using real data, your interpolation becomes more realistic, so this combination of real data and modeling data allows you to assess and forecast the situation with greater accuracy. I shall conclude at this point and give the podium to Dr. Pavlovski.

Dr. Arutyunyan: I would like to introduce the speaker. Dr. Pavlovski is working at our institute, and he is Director of the Laboratory of Radiological Impact of Radiation Accidents at the Russian Academy of Sciences. He is also one of the UNSCEAR experts, and for a long time he was a member of ICRP. Right now his interests revolve around protecting the population during nuclear accidents, as well as material and technical support for the decision-making process.

Dr. Pavlovski: Thank you very much, Mr. Chairman, ladies and gentlemen. I'm showing this slide again because we probably have already forgotten where we started. My presentation is an attempt to demonstrate how multiple models and huge databases allow us to sort of build a bridge between our decision makers and scientists because it very often happens that something is easy to understand for a scientist but administrators do not understand it that easily. We didn't want all these massive databases which we have regarding Chernobyl to become a cemetery for information, for data. We want this to be a real database, which can function and which can enable the decision makers to make decisions during large-scale nuclear or radiation accidents. The problem which arises when such assessments are made is connected to the fact that real data have a very complicated distribution spread but the decision must be made on a specific norm or level of an existing standard. Also, there are certain problems which arise when you try to assess the contamination. Also there is almost certain contradiction between the assessment of the consequences by the population and mass media, and the real effectiveness of the countermeasures that had been taken, versus the scientists. Here is one of the examples of real spread of exposure, doses of external and internal exposures, which were obtained as a result of the liquidation of the consequences of the Chernobyl accident, and you can see that this spread is very complex. And to find a point where you can say these data are good and these bad, in other words, to compare this figure with the real fixed value of the standard of the norm, this is a problem for a decision maker, and the interaction and cooperation between the people who make decisions showed that the easiest method of building this bridge between the scientists and administrators is to conduct full-scale games or exercises. Our institute, the Nuclear Safety Institute, took part in the planning and implementation of five such games or exercises. I would like to say a few words about these exercises. I would like to also note what exactly was the characteristic property of each of these exercises, how they differed from others, because the scenarios were different, and also these exercises covered different periods of time. It's very important that during the St. Petersburg game real administrators took part in it, the administrators from the Kaluga Oblast. At the beginning, when the exercise was being planned, it was not easy for us to cooperate, to work together with these administrators, because they relied on their staff, the people with whom they work on a day-to-day basis, but afterwards, having supplied computer support for this game, which was quite powerful, and also having created a database which was rich enough, we were able to communicate and interact with these people. The experience with our cooperation with our French colleagues from the IBSM really helped us in that. When the scenario was being developed, the decision was made to assume that a large-scale contamination of the Kaluga Oblast had taken place during the spring, in other words, the time which has the most severe effect on milk consumption and also allows vegetables to be contaminated and then be ingested by the population. This is an example of the contamination that was used in that exercise. It's very important to keep in mind that this map was not known to anybody except the scenario writers and developers. The whole exercise that had taken place was as follows. Various measurements were used in order to reconstitute this picture. During the first day of the exercise, the information was minimal and was mostly related to the measurements of the exposure rate, of the dose rate, and also to certain results of measurements of the nuclide composition; however, on the basis of these data, the administration had to make a decision regarding the possible evacuation of a number of population centers. This decision was made in consultation with the experts, and this work allowed us to see a lot of problems with regard to our computer support, a lot of things that had to be done but hadn't been done. Another very important factor is that, according to the desires of the administrators from the Kaluga Oblast, this exercise also simulated the situation seven years after the accident. This was related to the fact that we wanted to use this exercise for specific corrective measures, to the real program of emergency response and the liquidation of consequences of an accident in the Kaluga Oblast.

The next exercise was sponsored by the EMERCOM of Russia, as well as the Committee on Humanitarian Support from the United Nations. This exercise was somewhat different. This exercise attempted to use real-time regime or methods for the first day after the accident, and, therefore, the exercise tried to access the reliability of the communication links, as well as the effectiveness of various computer models mentioned by Dr. Arutyunyan, starting from the simplest models which were used at stage one. We're talking about common Gaussian models, which more or less oriented us as to which decisions had to be made, and then, as the new meteorological information came in from the GIDROMAT system of Russia, we started to utilize more complex systems, which enabled us to assess the critical point in that area of hard heavy rain and enabled the administration to see what measures and steps should be taken in that area. The next stage, stage three of the exercise, we used a REVERS package which allowed us to use the points which are marked on this template. We were able to reassess the discharge and thereby significantly improve the forecast of the radiation situation, and, as an example of the data supplied to the administrators, this is the forecast of the thyroid exposure doses for small children in order to access the consequences of such an accident.

The next exercise that was conducted was probably the most serious test for the software developed at our institute. This is the exercise conducted in Murmansk Oblast in 1995. It's important to remember that this exercise was done simultaneous with the EMERCOM headquarters command exercise, and they were conducted in a parallel manner--that is, they basically corrected one another as they went along. This exercise attempted to assess the possibility of various countries' experts working together because the idea of this exercise basically dealt with transborder transport and the contamination of the territory of Finland. Quite a few experts from different countries were involved in this exercise. These people, while working together, were developing on the basis of their common accumulated experience and on the basis of their own computer calculations. These were done not only at the site of the exercise but also by means of the use of the satellite communications system in different countries. This cooperative effort allowed us to assess how possible such cooperative ventures are and also proved to be very useful because the accumulated experience of various experts had been combined. Most importantly, it demonstrated that the methods of calculations showing the differences between computer codes and so on were obstacles that could be overcome. The databases are being opened gradually, on a real-time basis, in real time. In other words, in the beginning, it's just a set of measurements of the exposure dose rate. Gradually, these databases are enriched with radiometric and spectrometric data as well as data resulting with the measurements done in human bodies, and the summation of this information allows us to assess the consequences of this accident with a significant degree of accuracy and give relatively reliable recommendations to the administrators charged with the liquidation of the consequences of the accident.

Here again some problems arose related to precipitation in the area of Kovdar. A group of international experts spent some time discussing whether it was necessary to evacuate this population center. Finally, the decision was made that this was not necessary and the administration of the Oblast concurred, although in the beginning the preliminary decision was made to evacuate almost the whole population of the population centers. You can see what information systems were used to assist the administrators and the local governments. They were provided with full data as to the situation and as well as the forecast of dosages for this stage and for the future. I will not talk too much about the Desnogorsk exercise because it was posed to be very similar to the 1994 exercise, which was dedicated to the Kalinin NPP accident. It was supposed to demonstrate to what extent it was possible to implement protective measures in Belarus, and it was supposed to show how these recommendations were going to be communicated at the level of a relatively small region. Quite recently, in October, an exercise of this type was conducted in France. It was supposed to model an accident at Osiris in Saclay. I would like to talk at length about this exercise because a special computer code had been developed for it which in real time enabled us to do measurements on the map of the gamma radiation dose rate, as well as the contamination of the air and soil. The computer code was loaded into PCs and the experts used these PCs at the site of contamination. They were supposed to find the coordinates of their location and get the results of the measurements of the dose rate and soil contamination and so on, at a given moment in time. In other words, this code demonstrated that it was highly effective and that it was possible to assess the radiation situation directly at the site in real time. This computer code also was supposed to have not only these scale measurements but also local measurements at certain points in the area. In other words, it was possible to do measurements near a given this piece of equipment or near a particular building. Apart from that the experience which has been accumulated through such exercises allowed us to develop computer codes called PARIS. The idea behind this code, which is basically a simulator, is that a version or scenario of the discharge could be programmed or input and then you will get, based on the countermeasures that you had conducted in various population centers, full databases regarding the results of the measurements of various environmental objects, food products, as well as the results of the measurements of the radiation in human bodies. This package allows one to assess the effectiveness of various measures; however, its main advantage is that, when it was planned, real spread or dispersions of the contamination in food products, and so on, were used. The result basically has the shape of local measurements. On that basis the decision maker can more accurately assess the situation, and, of course, what we're doing now is not a complete process. We are trying to include more and more data that are accessible to us, and I believe that this work in cooperation, especially if this cooperation is international, could be very useful. Thank you.

<u>Dr. Arutyunyan</u>: Thank you. Now are there any questions regarding this presentation, either for Dr. Pavlovski or me?

<u>Professor Anatoli Tsyb</u>: Can we come back to that slide where we have the inhalation doses to the thyroid? What about radiation affecting the thyroid entering the body through other routes, the ingestion of milk in particular?

<u>Dr. Arutyunyan</u>: Let me answer that question. These are not calculated data. These are just an illustration of the non-monotonous nature of the doses, the doses that were assessed by your institute also. No calculations were made. What if we have to do it in a real situation? For a decision maker, can he get these data? Dr. Pavlovski will answer regarding doses in your model, including inhalation and ingestion, because other models have more significance. Of course in the PARIS code we conduct modeling in order to fill up the database in our exercises. We take into consideration all the factors, including

inhalation, milk, food chains, and vegetables. It is important to note that we take into consideration the various contamination of products produced in a private sector and in the state-owned sector, and all those correlations between the density of contamination and the forecasted contamination of the foodstuffs we take from the real Chernobyl experience.

Dr. Pavlovski: I would like to add something. It seems to me that, at the present time, if we are speaking about Chernobyl, that even when we use all the models available to us, the best models that we have, it is unlikely that we will be able to restore the exposure radiation doses with the precision that we need in today's life. The Chernobyl accident was too complicated. Today we would not be able to determine all the sources and meteorological conditions using only our models. In other words, this is not realistic. Models can help you when you can restore something from your measurement, interpolate or extrapolate your data, which is supposed to be a more realistic task.

Unidentified questioner: What should I do in the real situation when I take our Russian legislation on the social protection of our citizens, which says that the citizens have some benefits if their annual dose is one [parameter not understood] annually? What should I do? Should I take the middle, the top level of your assessment. I am an administrator.

Unidentified speaker: This is exactly the issue that we tried to answer, but maybe we did not succeed. The task of the scientist is to have information with all its peculiarities. You can't say that the average dose is this, and then make a decision, because tomorrow that administrator will be given other data yielding a higher dose from somebody else, based on contamination of foodstuffs, etc., then a different decision will be made. This is not science only. Even if you calculate all the versions the administrator still must take into consideration the social and political aspects. Is the administrator ready to explain to the inhabitants and citizens that, yes, sometimes the dose is higher, but we cannot do anything about it. He will have to make a decision on an extreme framework. This is something that represents a mistake. People sometimes think that only the answers given by the scientists are used for decision making. No! The scientists will give you just the basis, and you will have to make a decision based on the totality of your factors. There are more competent experts in this room, and I know they also make certain decisions. You have to work with citizens; you have to work with administration, with legislatures. If, for example, the dose is one or two, then maybe we should rest, but this is beyond our field. I don't know all of the details, so my answer would be similar to answers of other people. Victor Alekseyevich [Vladimirov] has been doing this for many years already. He is an expert.

Unidentified questioner: Are your predictions all based on modeling and/or algorithms, or are there lookup tables or data imbedded in it? If so, how are these things used together? You obviously have a lot of experience and data on which to base them, but is it all strictly algorithmically derived or is part of it from databases or lookup tables? Could please you tell me a bit more about that?

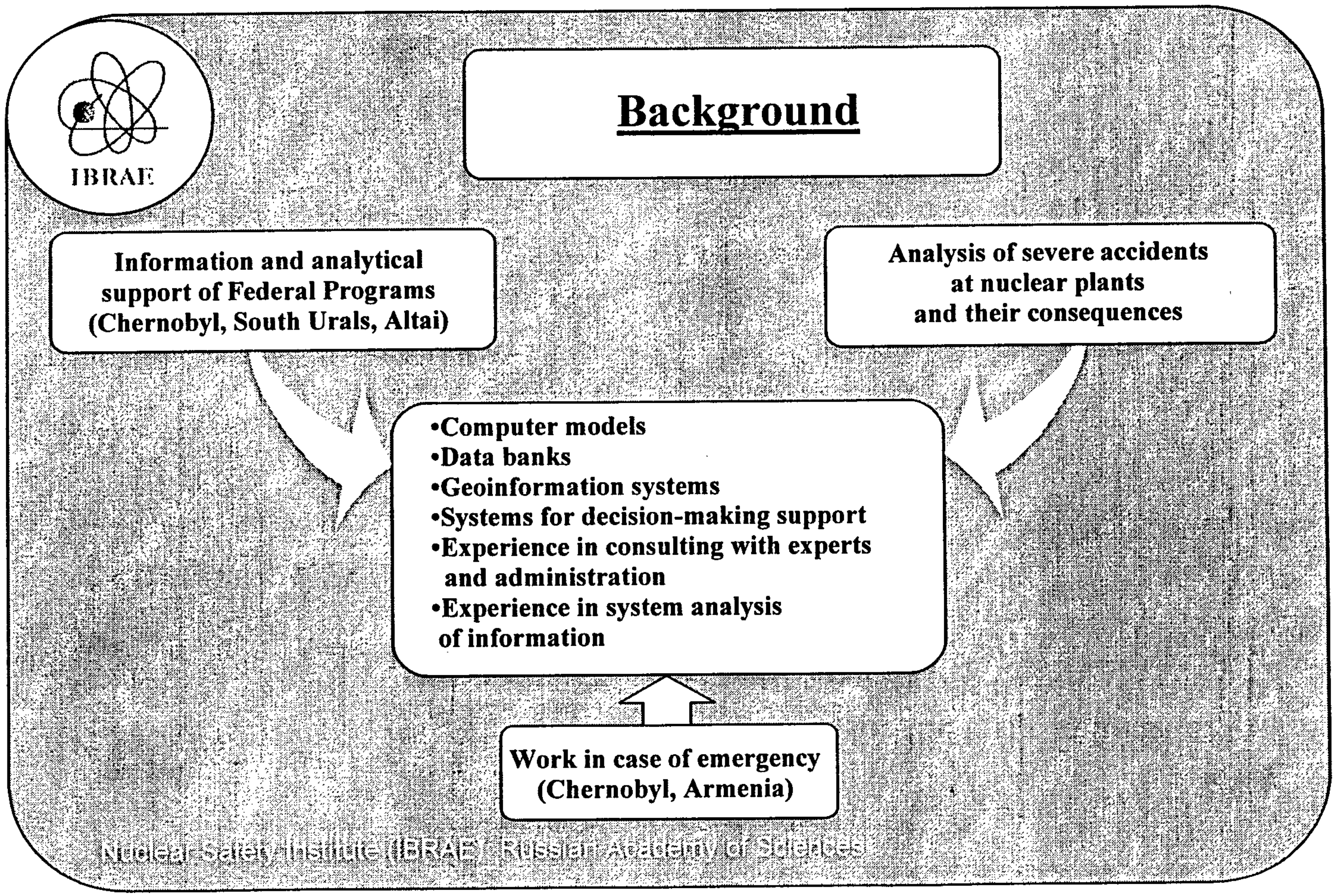
Unidentified speaker: I assume you are speaking about computer exercises, and the codes that we are using (e.g., the PARIS code). We have a computer, so after lunch break we can take a look at how it works. If we are speaking about atmospheric models, then we do have algorithms, meteorological approaches. When we mathematically resolve these diverse problemsand we restore the parameters of the cloud based on our measurement parameters, these are mathematical procedures, and we can receive some precise answers. There are situations when we base our answers on databases of reference material. We don't have algorithms; we have forecasts, we have actual data, and we use databases in which there are many situations of how things can happen. We can tell the experts how to make the decisions. Of course, errors can occur and naturally it is a more pleasant situation when we can "algorithmacize" our actions, if we can.

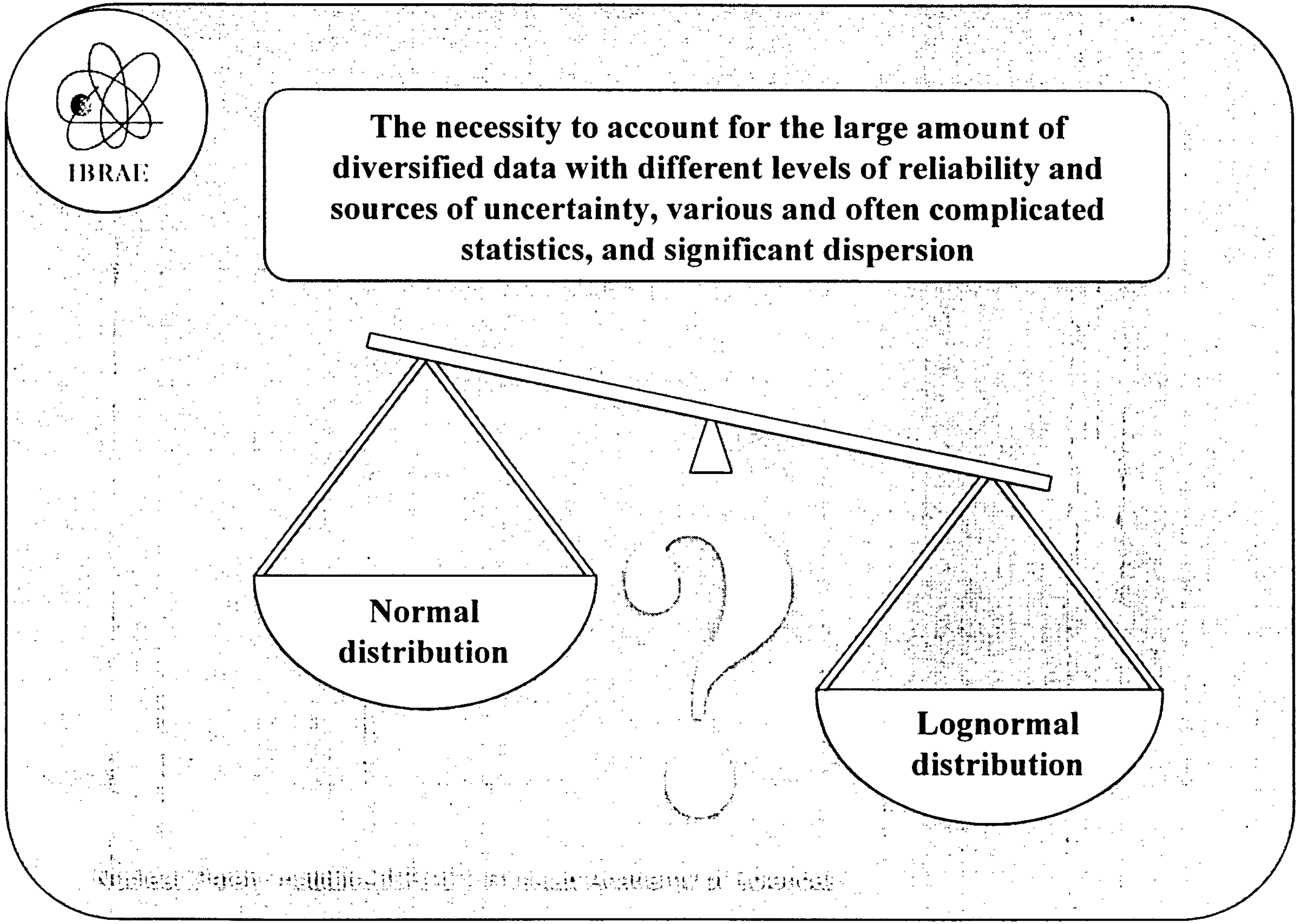
Dr. Pavlovski's slides begin on page 114.

Nuclear Safety Institute
Russian Academy of Sciences

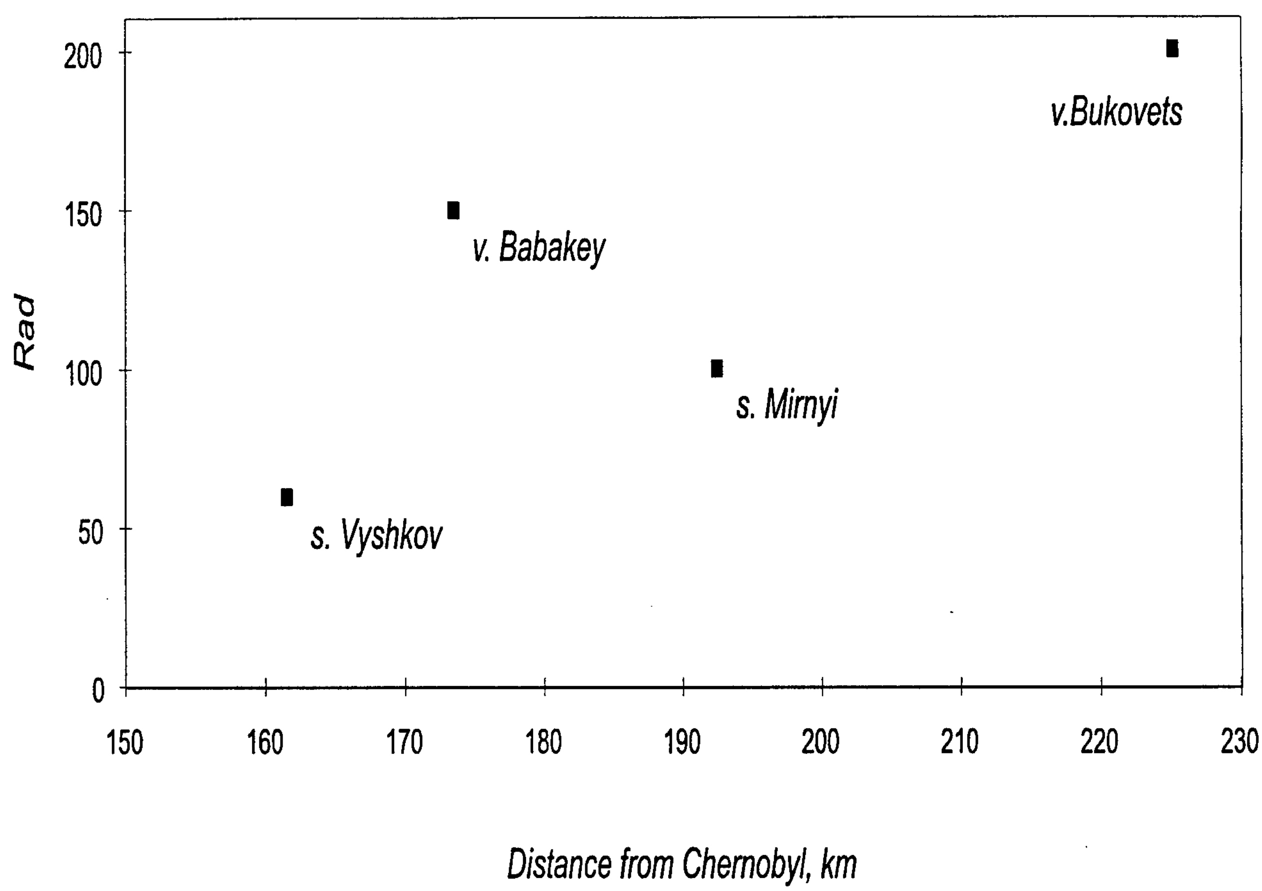
Rafael Arutyunyan

- Probabilistic - deterministic analysis of radiation accidents of safety objectives for atomic energy
- Systemic analysis of consequences of radiation accidents
- Scientific - technical support for making decisions for protection of the population from radiation accidents

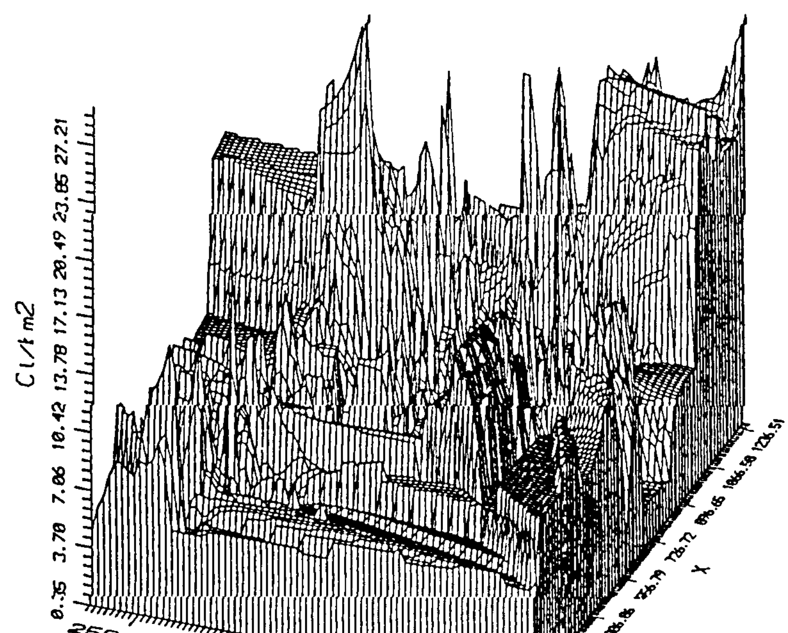

IBRAE
Background
Information and analytical support of Federal Programs (Chernobyl, South Urals, Altai)
Analysis of severe accidents at nuclear plants and their consequences
•Computer models
•Data banks
•Geoinformation systems
•Systems for decision-making support
•Experience in consulting with experts and administration
•Experience in system analysis of information
Work in case of emergency (Chernobyl, Armenia)
Nuclear Safety Institute (IBRAE) Russian Academy of Sciences

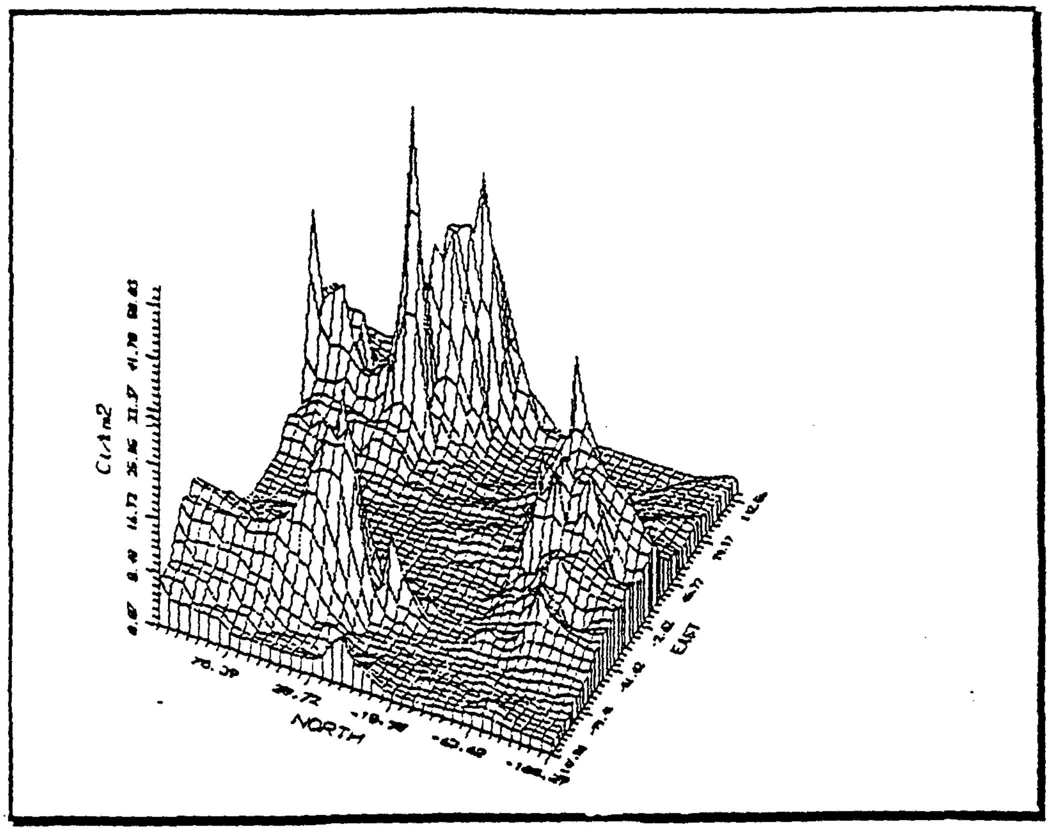

IBRAE
The necessity to account for the large amount of diversified data with different levels of reliability and sources of uncertainty, various and often complicated statistics, and significant dispersion
Normal distribution
Lognormal distribution

Mean Doses to the Thyroid Got by Children under 7 in Bryansk Oblast

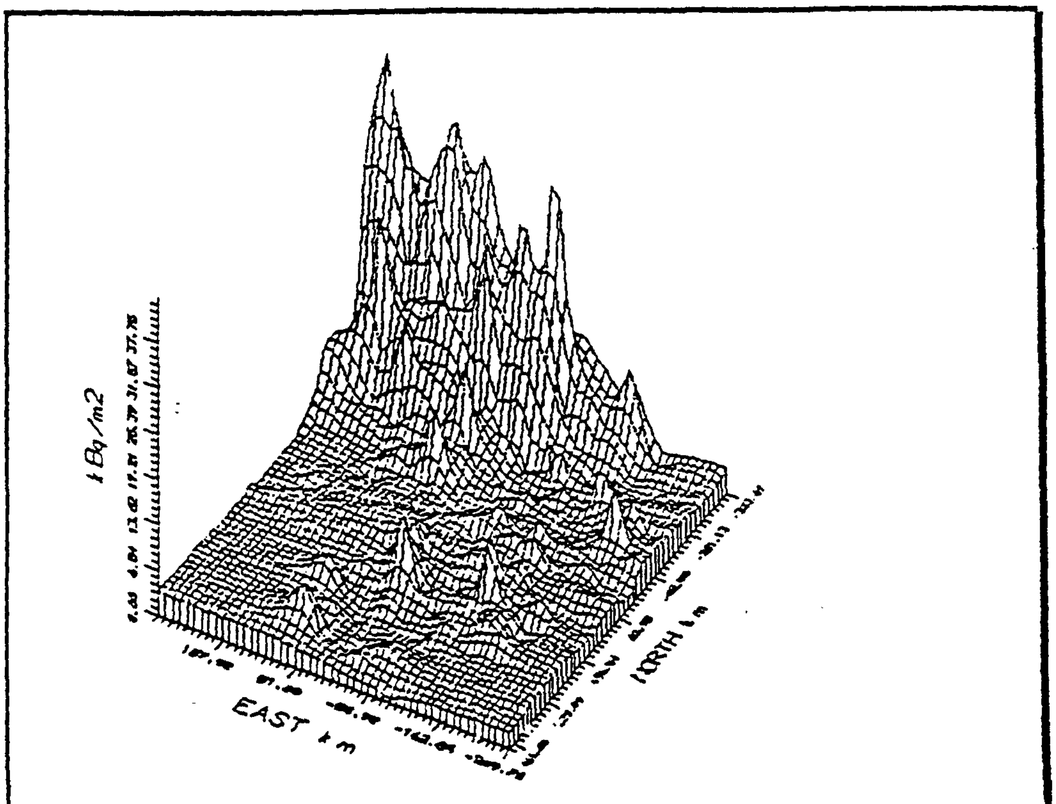


GOMEL REGION, DZERAHINSK, 144X75, Cs137 (IAC BANK)



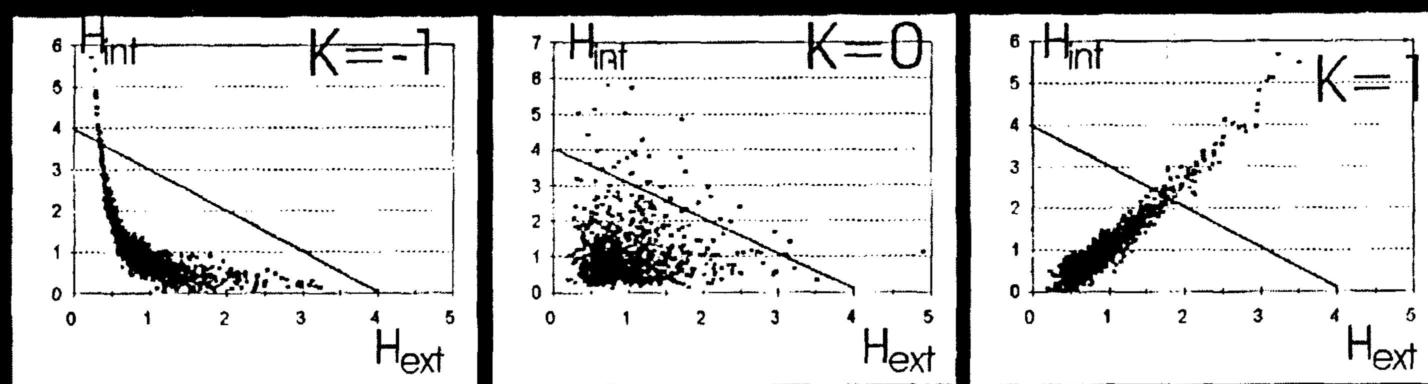


Gomel Region,
CS137



FRG, Cs137.

The necessity to account for the conflict between the "threshold" values of regulative rules and broad distribution functions of actual parameters



Distributions of cummulative dose depending on correlation (K) between external and internal exposures at

$\overline{H}_{int} = 1 mSv/y$, $\overline{H}_{ext} = 1$ mSv/y, $\overline{H}_{ths} = 4$ mSv/y

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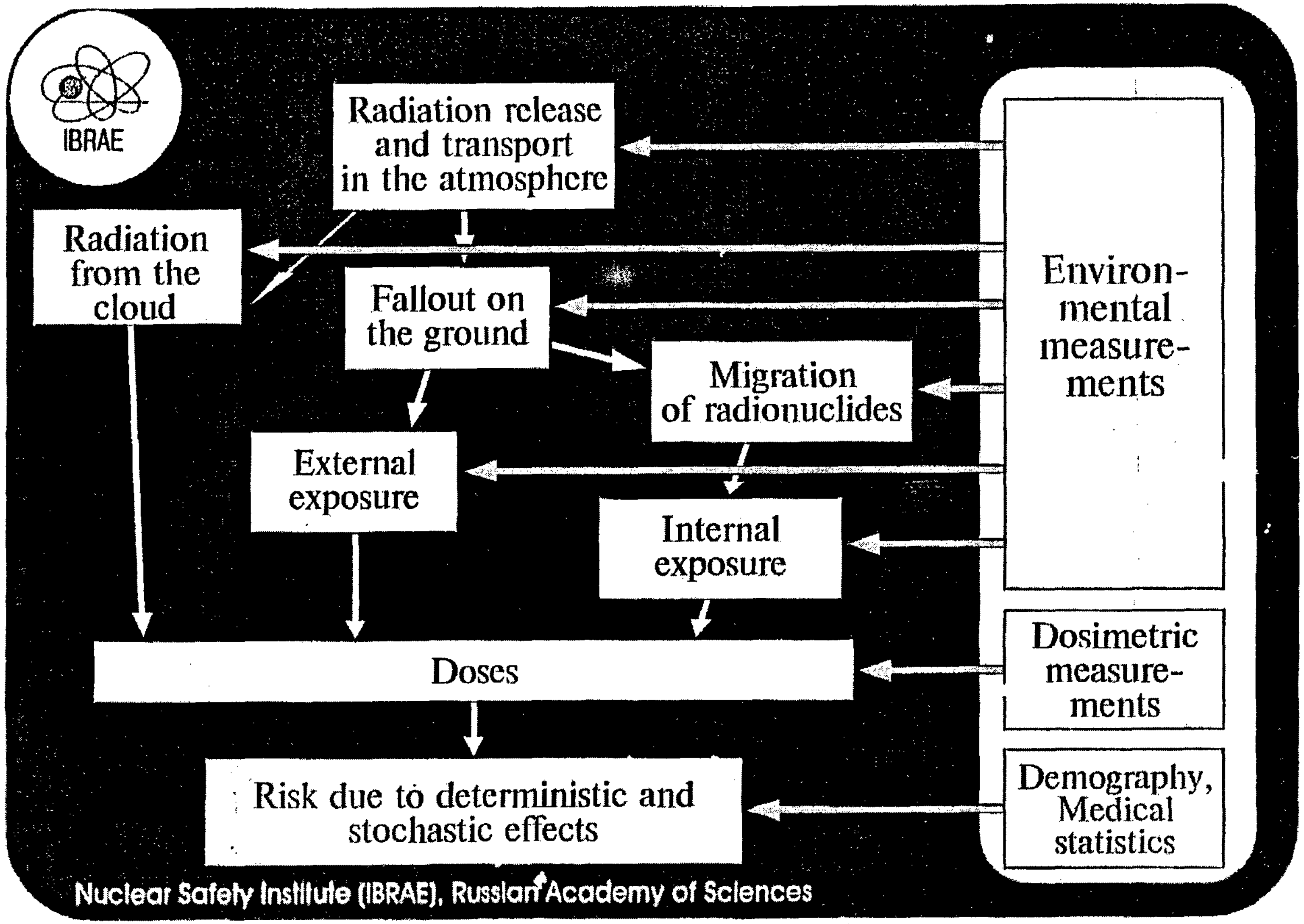
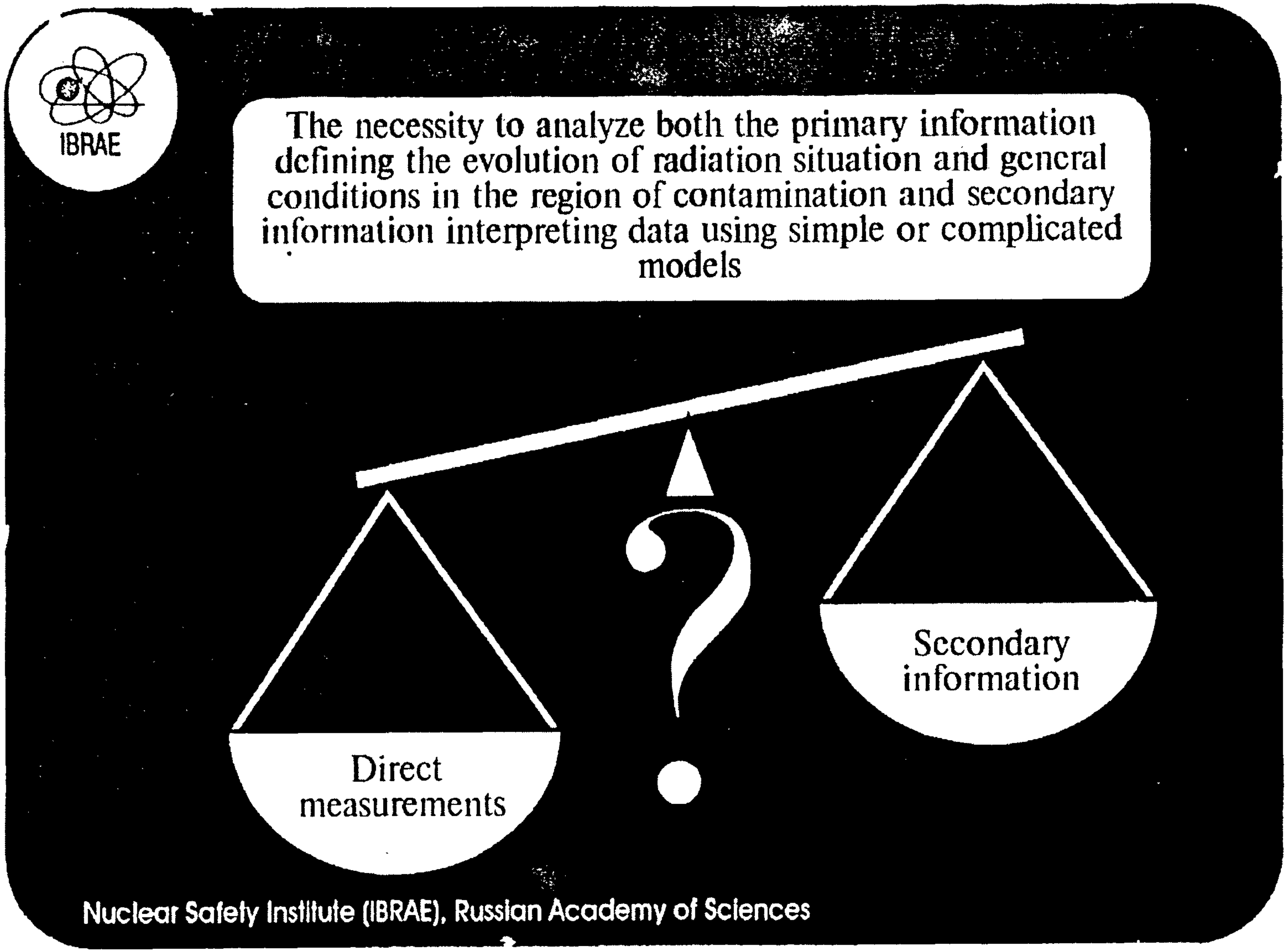
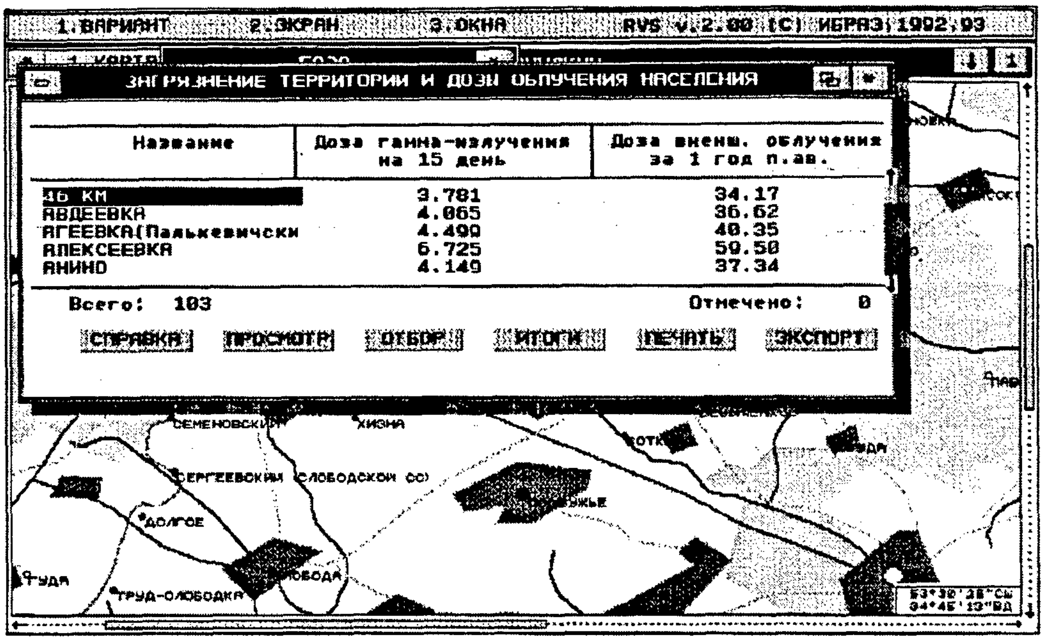
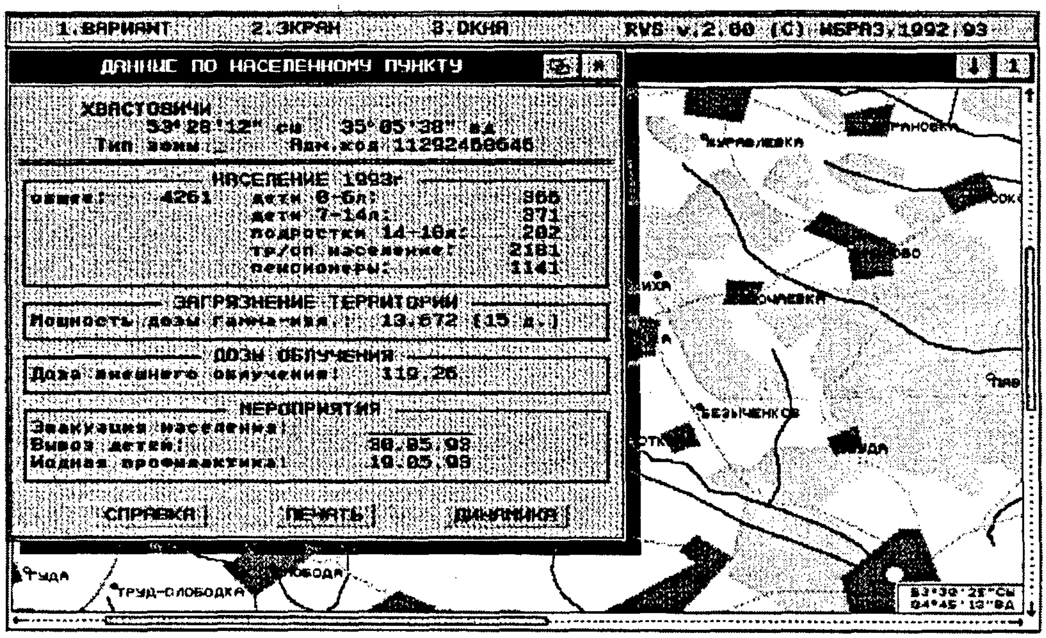
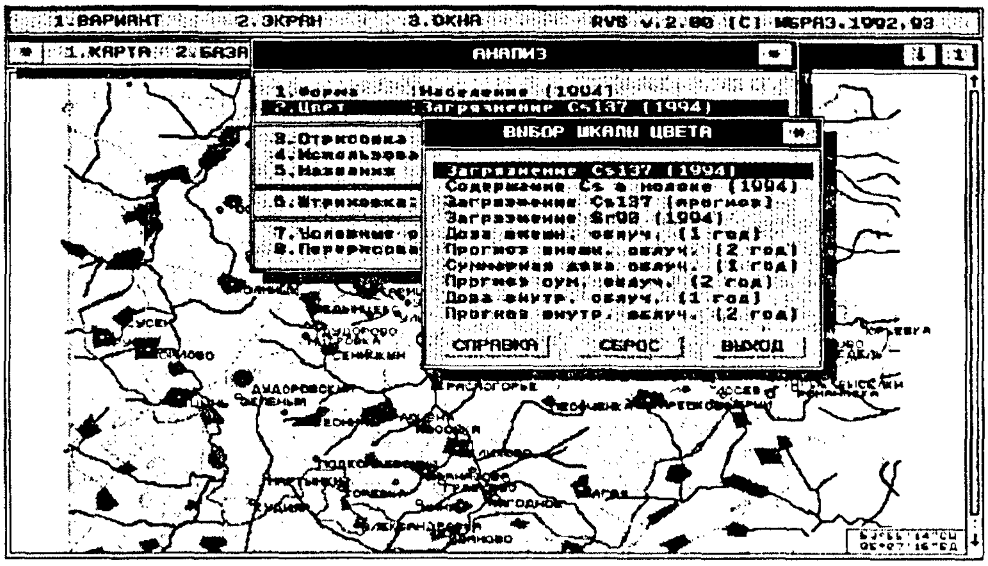

IBRAE
Radiation release and transport in the atmosphere
Radiation from the cloud
Fallout on the ground
Migration of radionuclides
External exposure
Internal exposure
Doses
Risk due to deterministic and stochastic effects
Environ-mental measure-ments
Dosimetric measure-ments
Demography, Medical statistics
Nuclear Safety Institute (IBRAE), Russian Academy of Sciences

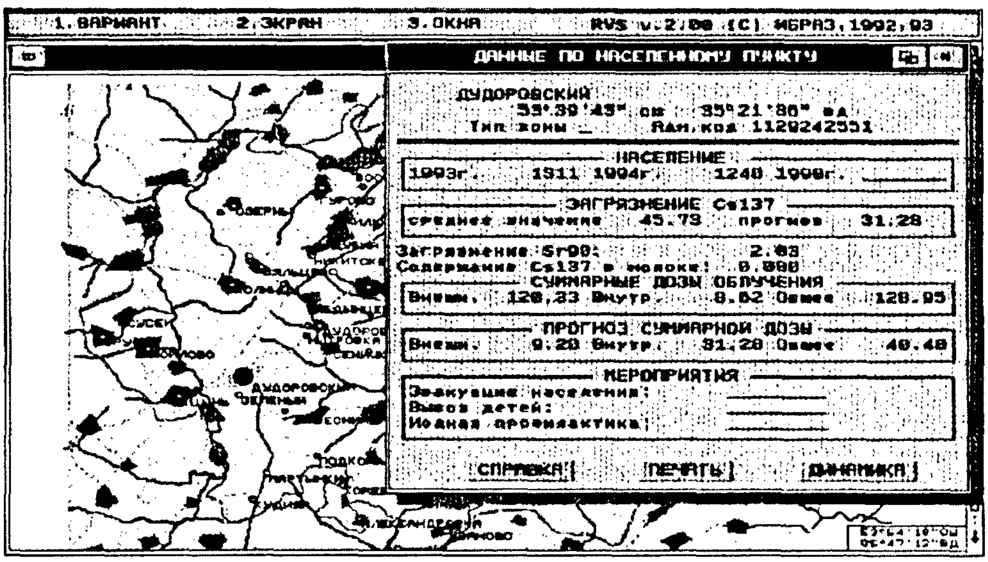

IBRAE
The necessity to analyze both the primary information defining the evolution of radiation situation and general conditions in the region of contamination and secondary information interpreting data using simple or complicated models
Direct measurements
Secondary information
Nuclear Safety Institute (IBRAE), Russian Academy of Sciences



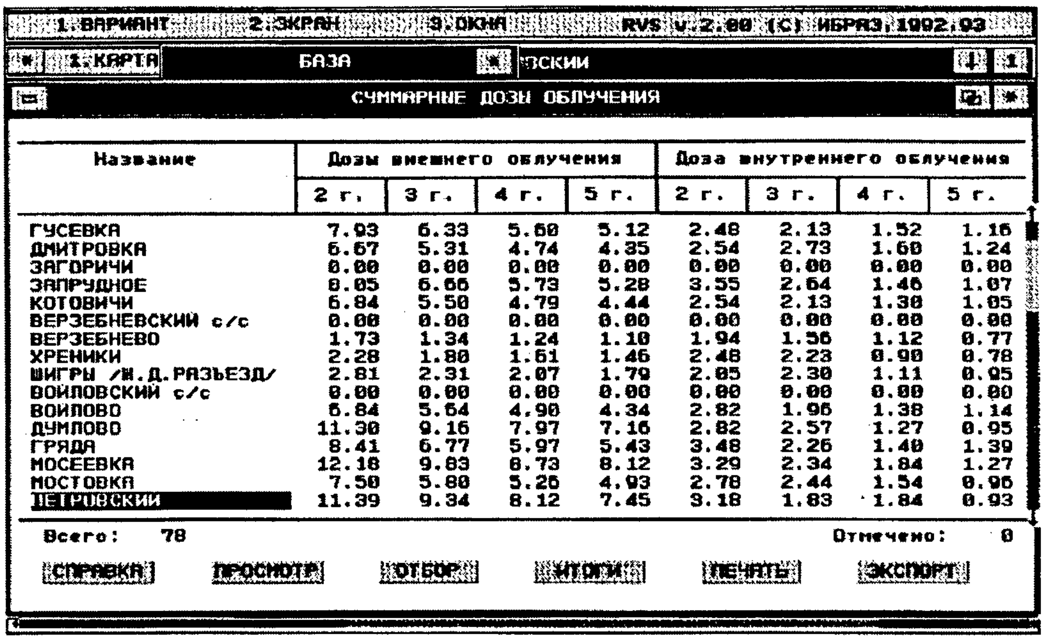


Examples of the data presentation on the 1 day of the exercise.





Example of the data presentation for 2 day of exercise.



1. ВАРИАНТ 2. ЭКРАН 3. ОКНА RVS v.2.00 (C) ИБРАЭ,1992,93

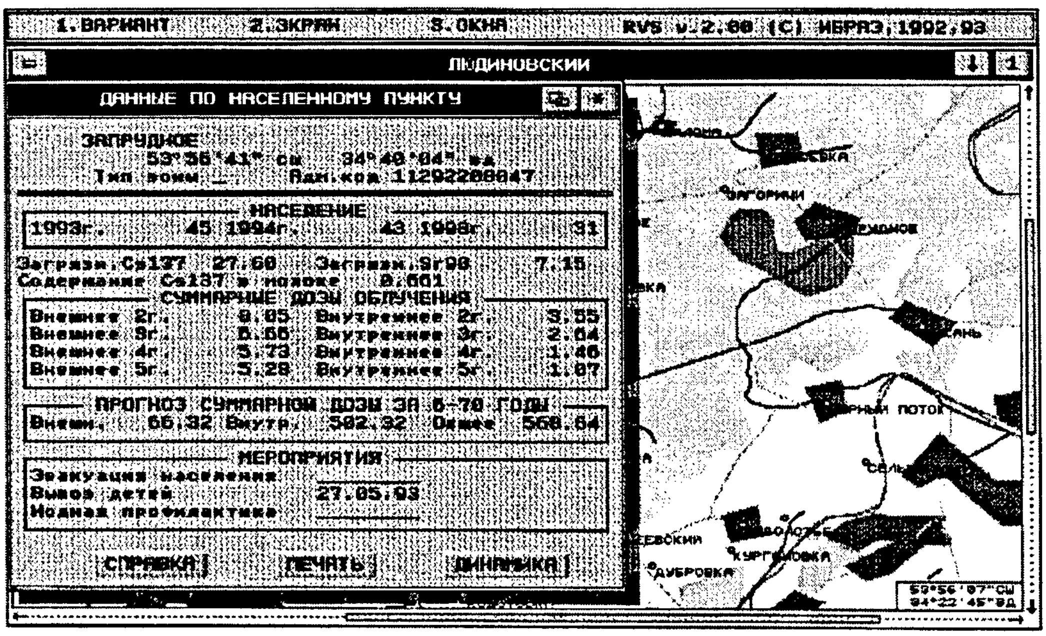
1. КАРТА БАЗА ЗСКИЙ

СУММАРНЫЕ ДОЗЫ ОБЛУЧЕНИЯ

Название	Дозы внешнего облучения				Доза внутреннего облучения			
	2 г.	3 г.	4 г.	5 г.	2 г.	3 г.	4 г.	5 г.
ГУСЕВКА	7.93	6.33	5.60	5.12	2.48	2.13	1.52	1.16
ДМИТРОВКА	6.67	5.31	4.74	4.35	2.54	2.73	1.60	1.24
ЗАГОРИЧИ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ЗАПРУДНОЕ	8.05	6.66	5.73	5.28	3.55	2.64	1.46	1.07
КОТОВИЧИ	6.84	5.50	4.79	4.44	2.54	2.13	1.30	1.05
ВЕРЗЕБНЕВСКИЙ с/с	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ВЕРЗЕБНЕВО	1.73	1.34	1.24	1.10	1.94	1.56	1.12	0.77
ХРЕНИКИ	2.28	1.80	1.61	1.46	2.48	2.23	0.90	0.78
ШИГРЫ /Ж.Д.РАЗЪЕЗД/	2.81	2.31	2.07	1.79	2.05	2.30	1.11	0.95
ВОЙЛОВСКИЙ с/с	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ВОЙЛОВО	6.84	5.64	4.90	4.34	2.82	1.96	1.38	1.14
ДУМЛОВО	11.30	9.16	7.97	7.16	2.82	2.57	1.27	0.95
ГРЯДА	8.41	6.77	5.97	5.43	3.48	2.26	1.40	1.39
МОСЕЕВКА	12.18	9.83	8.73	8.12	3.29	2.34	1.84	1.27
МОСТОВКА	7.50	5.80	5.26	4.93	2.78	2.44	1.54	0.96
ПЕТРОВСКИЙ	11.39	9.34	8.12	7.45	3.18	1.83	1.84	0.93

Всего: 78 Отмечено: 0

СПРАВКА ПРОСМОТР ОТБОР ИТОГИ ПЕЧАТЬ ЭКСПОРТ



Data on doses of external and internal radiation for inhabited settlements in the Kaluga region (3 day of the exercise).

Real Time Support.

- Network architecture, parallel processing of the modules:
  - control
  - source
  - meteorology
  - prognosis
  - countermeasures
  - representation

- Many variants

- Space-time scaling
  near zone (30 km, several hours)
  middle (100 km, 5-15 hours)
  far zone (1000 km, several days)

- Working regimes
  service
  training
  accident

- From DATA INPUTTING - to SCENARIOS SELECTION

BANK OF MODELS OF EXPERT GEOINFORMATION SYSTEMS

BANKS OF MODELS

Radionuclides migration in nature

Atmosphere, soil, food chains, surface and ground waters

Dosimetric models

1

Risk models

BANKS OF MODELS

Analysis of countermeasures and their effciences

Analysis of social-economic consequences

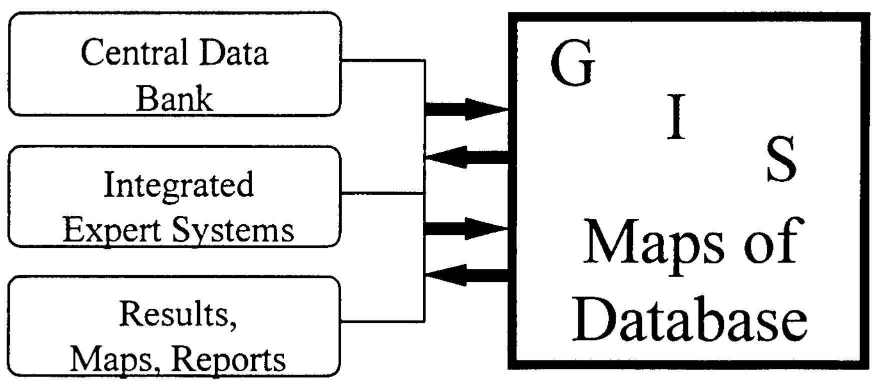
Statistics, geostatistics

2

Interpolations, fractals

EXPERT GEOINFORMATION SYSTEM (GIS)

MAJOR STRUCTURAL BLOCS OF EXPERT GEOINFORMATION SYSTEM



Purposes and tasks of expert geoinformation system:

1. COMPATIBILITY WITH DATABASE OF STATE COMMITTEE ON CHERNOBYL.

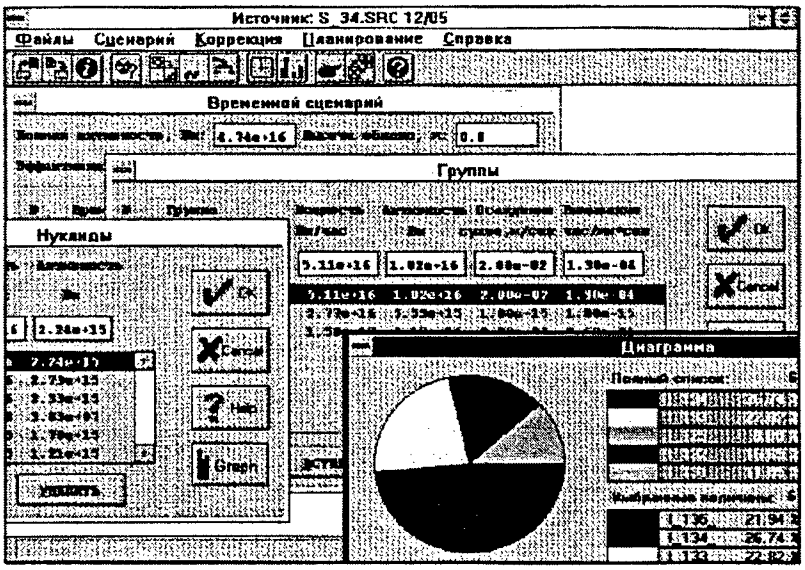
2. CREATION OF DATABASE WITH SPATIAL DISTRIBUTION AND TIME DEPENDENCE, MODELING AND PROGNOSIS RESULTS. COMPARATIVE ANALYSIS PERFORMANCE.

3. PREPARATION OF MAPS FOR DECISION ADOPTION.

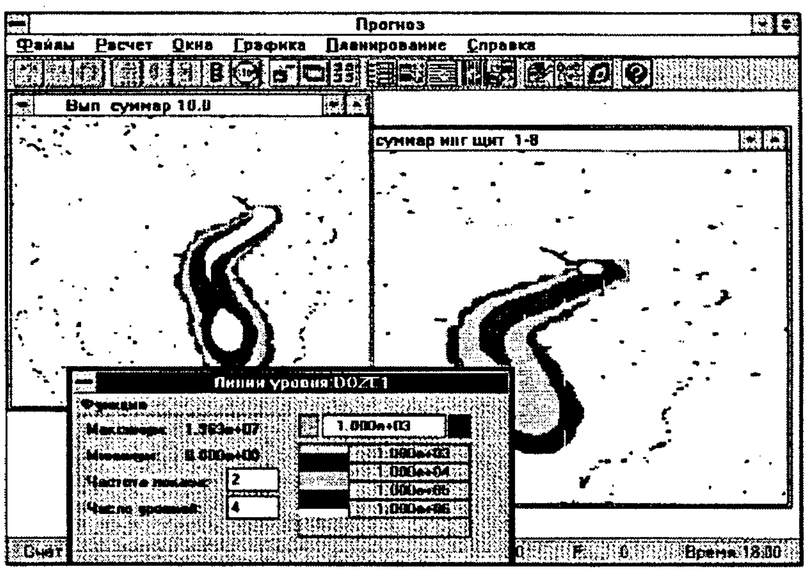
4. SUPPORT OF DECISIONS ON LEVELS OF INTERFERENCE AND COUNTERMEASURES, ESTIMATION OF ECOLOGICAL AND ECONOMIC CONSEQUENCES.

5. CARRYING-OUT OF RADIOECOLOGICAL EXAMINATIONS, SCIENTIFIC AND APPLIED INVESTIGATIONS.

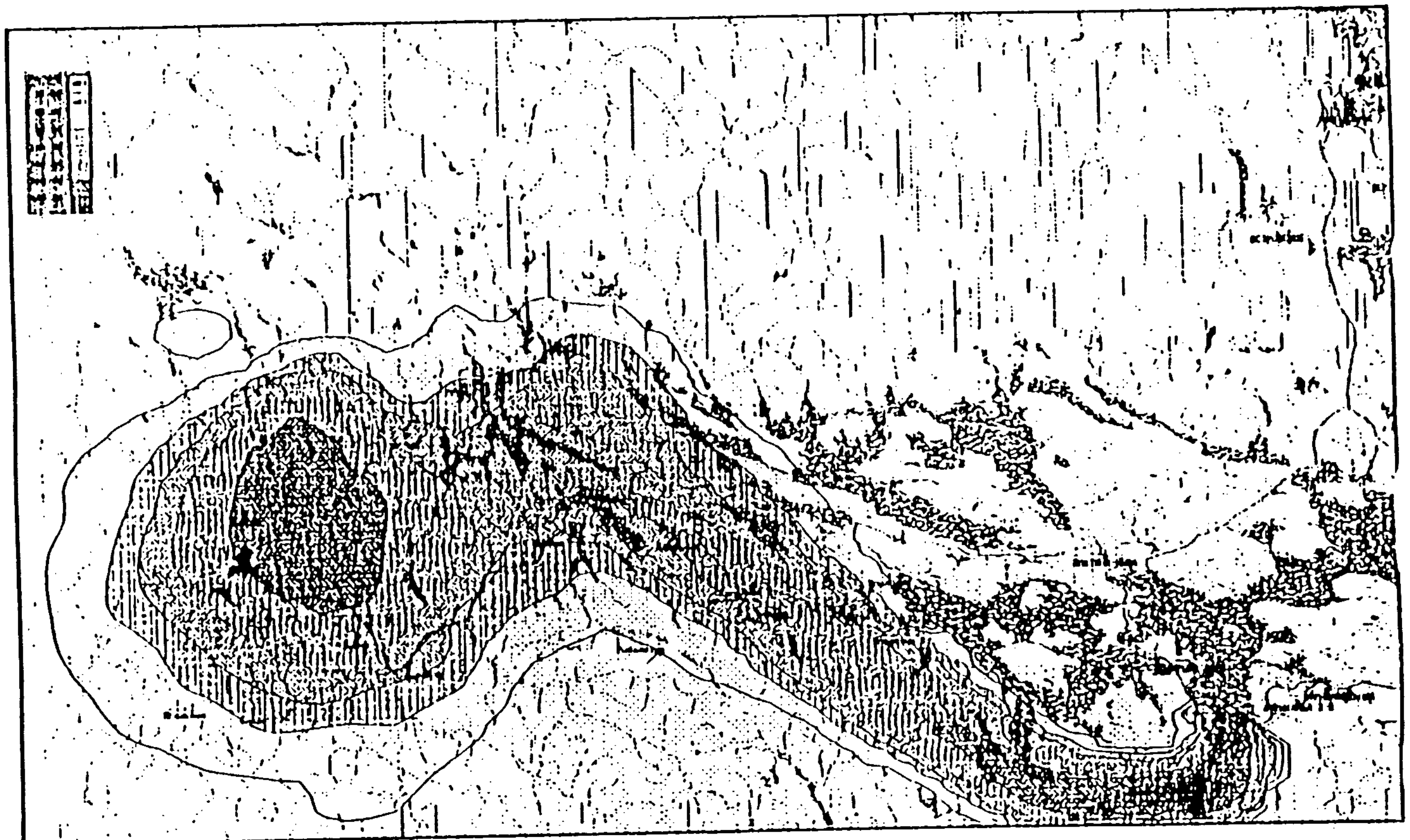
6. TRAINING OF EXPERTS.



NOSTRADAMUS. Subsystem "Source". Task notes fallout changes by time, dispersion and nuclide composition.



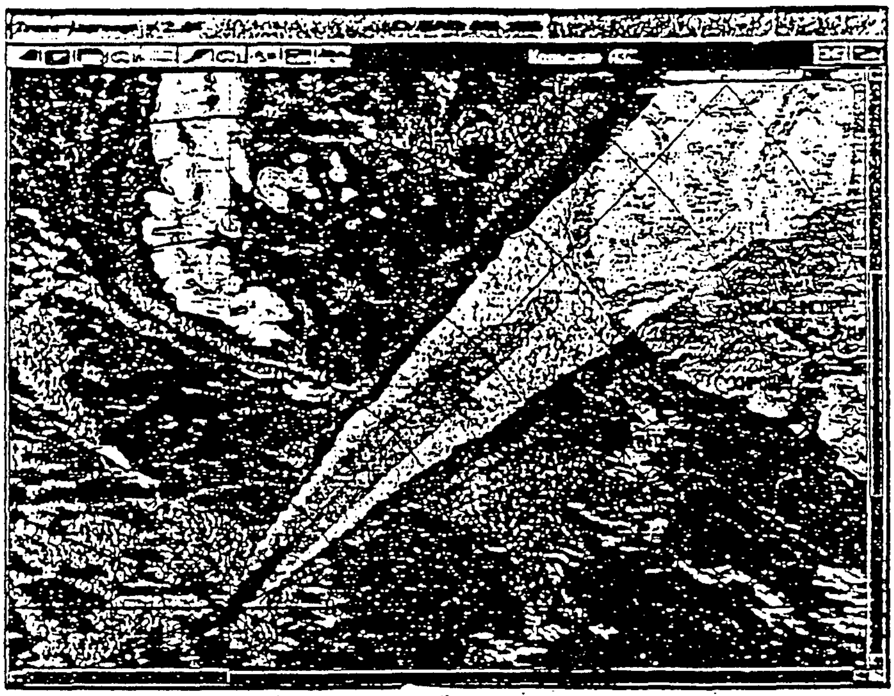
NOSTRADAMUS. Subsystem "Prognosis". Representation of radiation situation at time of calculation.

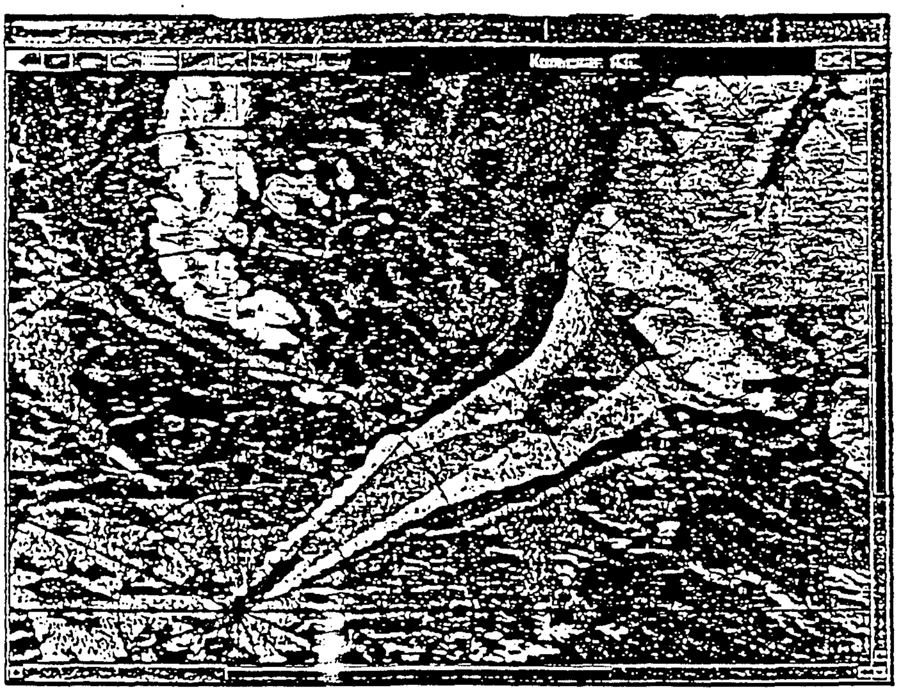


Contamination plots from fallout of I^{131} after day 1.

Lines of levels of 50, 100, 200, 500, 1000 Ci/km^2.

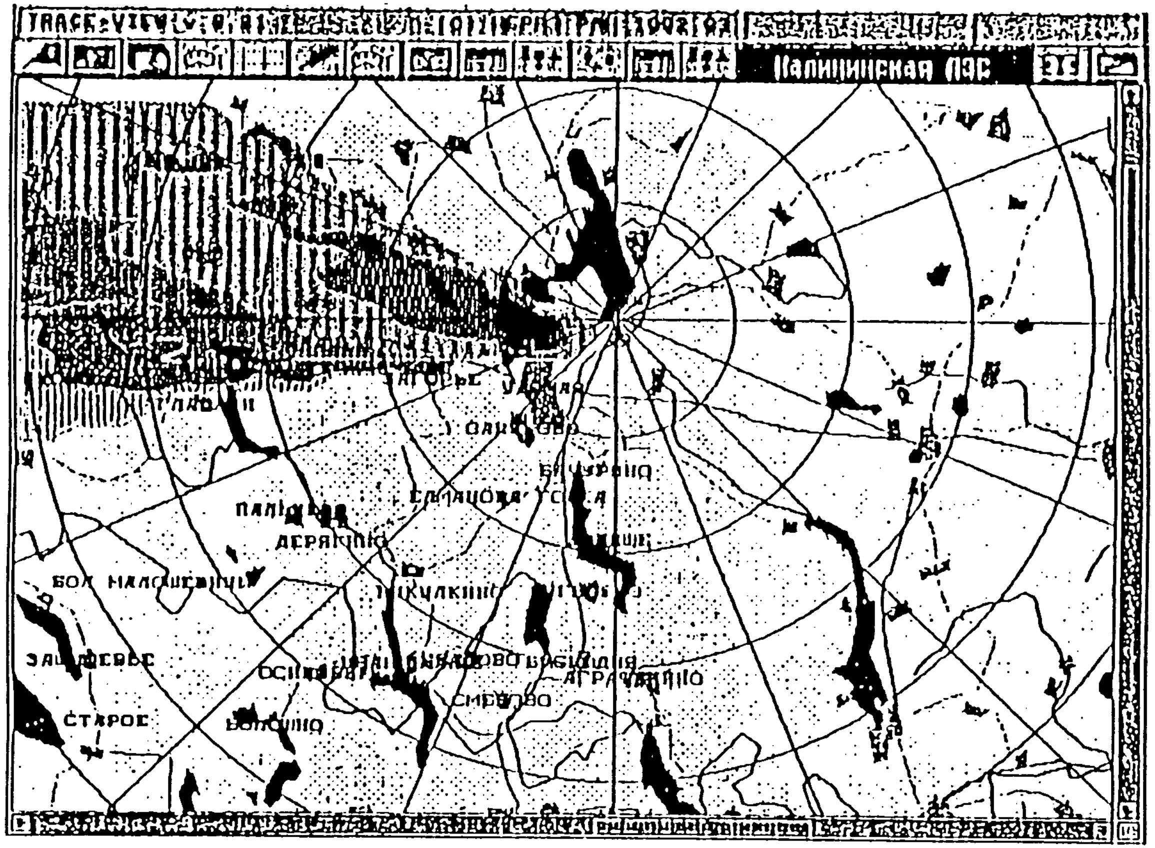
Orography





Nostradamus. Modeling results with wind adaptation to orography (lower picture) and without one.

Command Headquarters Training
EMERCOM RF
November 1994

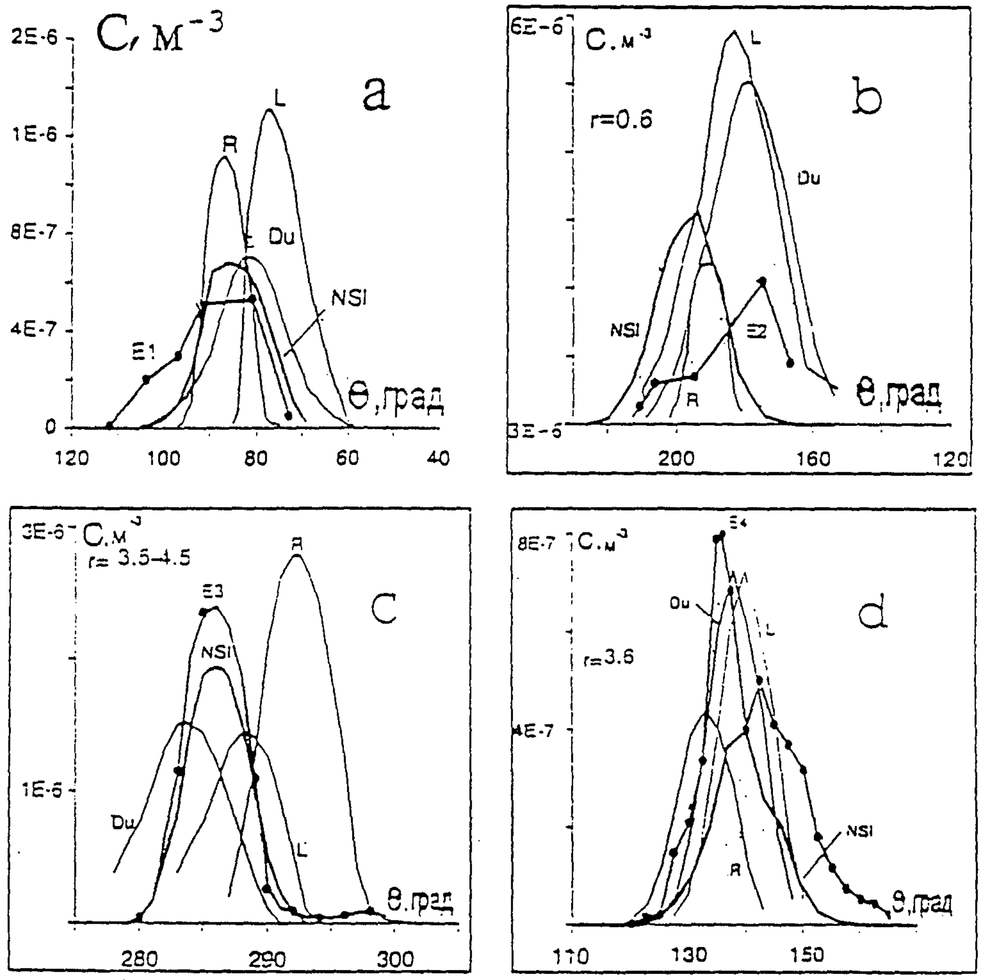


Inhaled doses to the thyroid (children 1-3 years)
(prognosis)

Variant NZ_R Emergency Actions Center, Institute of Nuclear Safety, Russian Academy of Sciences

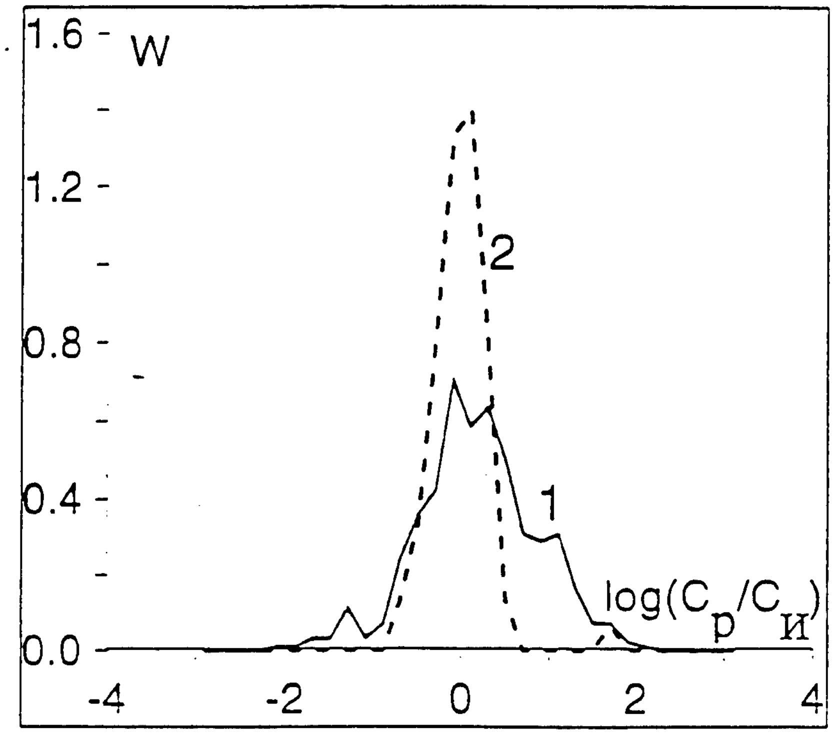
Comparative analysis of the nine European models with four ground tests.

Hamburg Univ.	Germany	Eulerian and Gaussian models
EIR	Switzerland	Gaussian model
NRPB	England	Gaussian model
Riso	Denmark	Gaussian model (puff)
KFA	Germany	Gaussian model
KfK	Germany	Gaussian model
Battelle-Inst	Germany	Eulerian model
IABG	Germany	Lagrangian model



Integral of ground-level tracer concentration:
a - experiment E1, b - E2, c - E3, d - E4.
NSI - NSI model, R - Gaussian puff-model (Denmark),
L - Lagrangian model (IABG), Du - Eulerian model
(Germany).

Comparison with KfK experiments (700 cases). Probability density distribution.

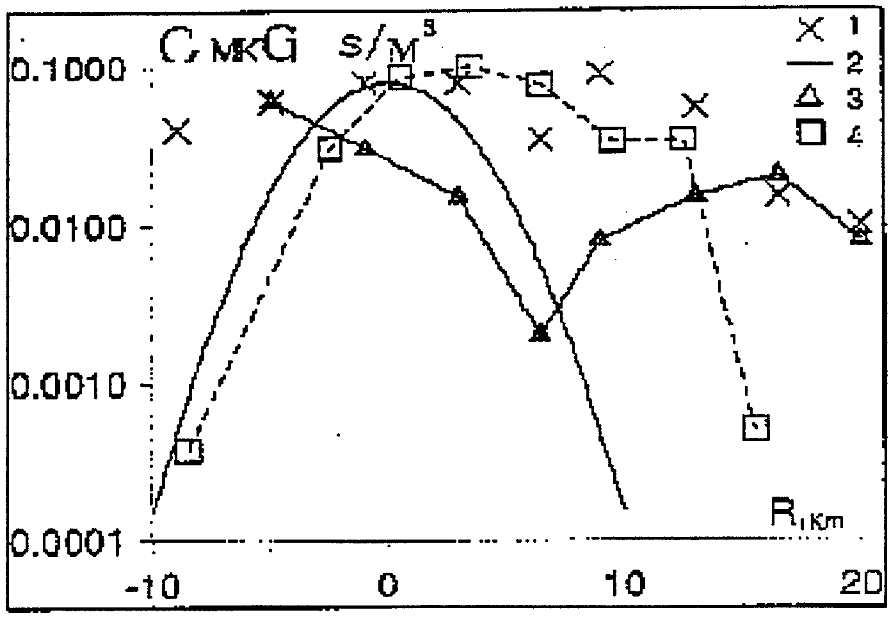


Probability density distribution.

1 - logarithm of ratio of model ground-level concentration to measured one for various distances from the sources and various time instants.

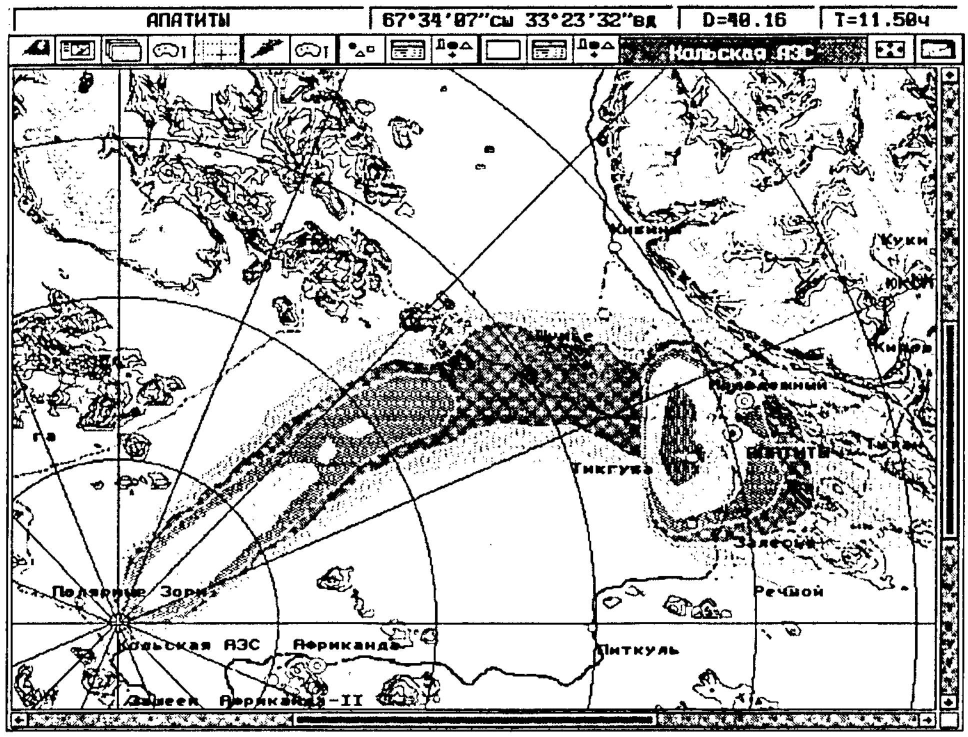
2 - logarithm of ratio of maximum model ground-level concentration to maximum of the measured one for various distances from the sources.

Comparison with INEL (Idaho National Engineering Laboratory) models and experiments

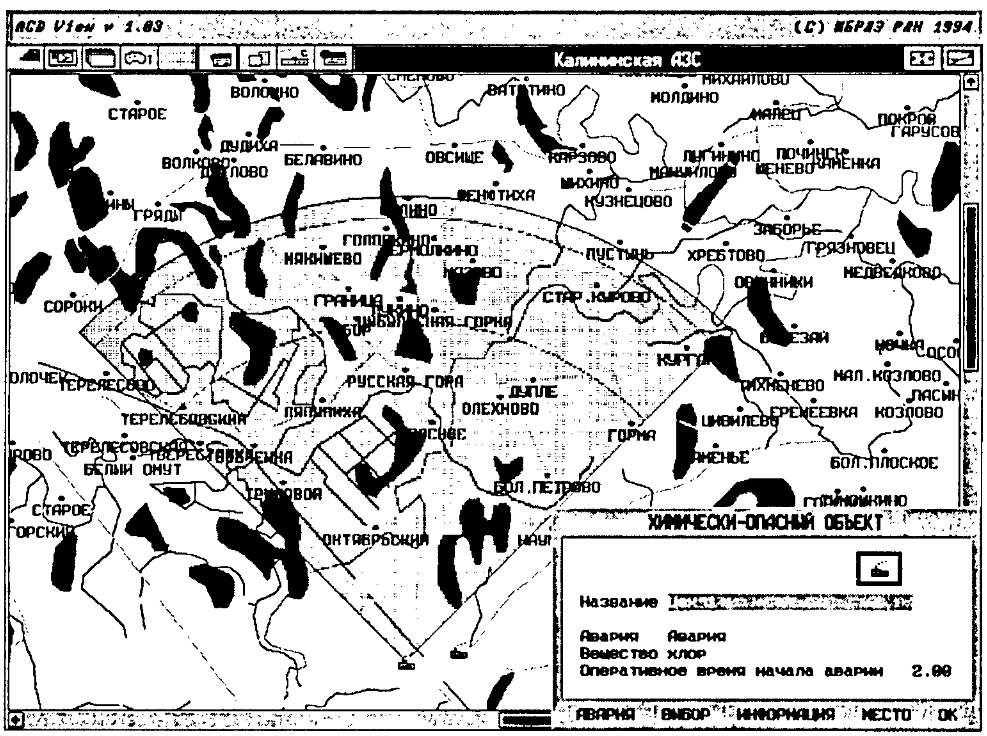


Integral of ground-level concentration of I^{131} at the distance of 60 km.

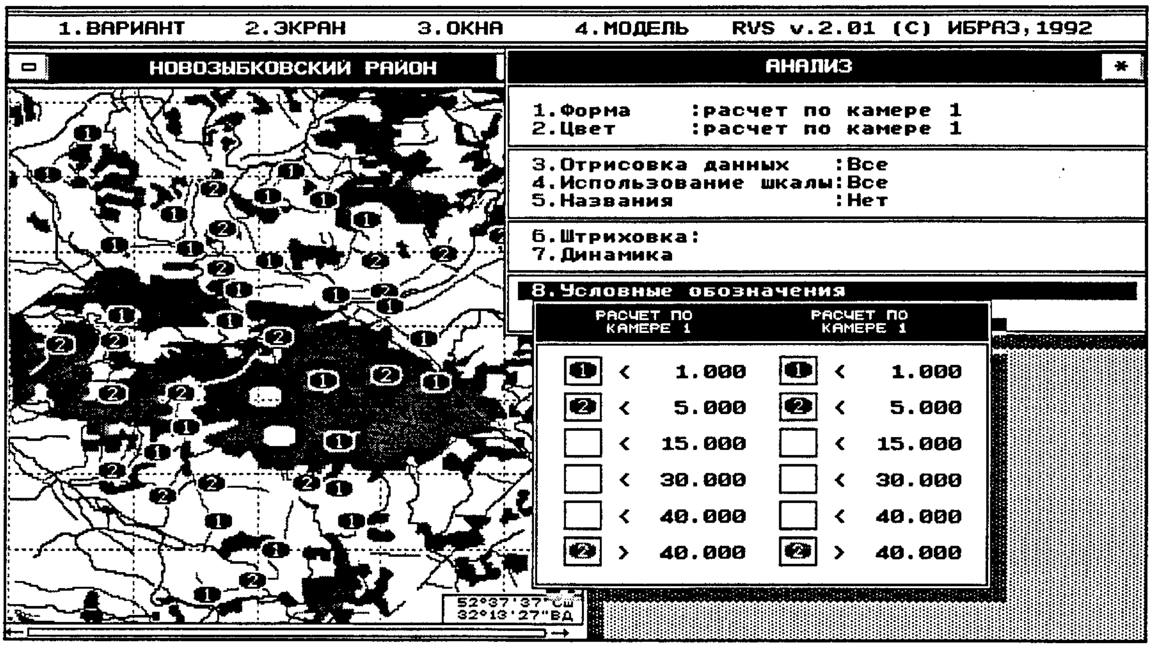
1 - measurement data.
2 - Gaussian model of Livermore laboratory.
3 - ADPIC model.
4 - NSI model.



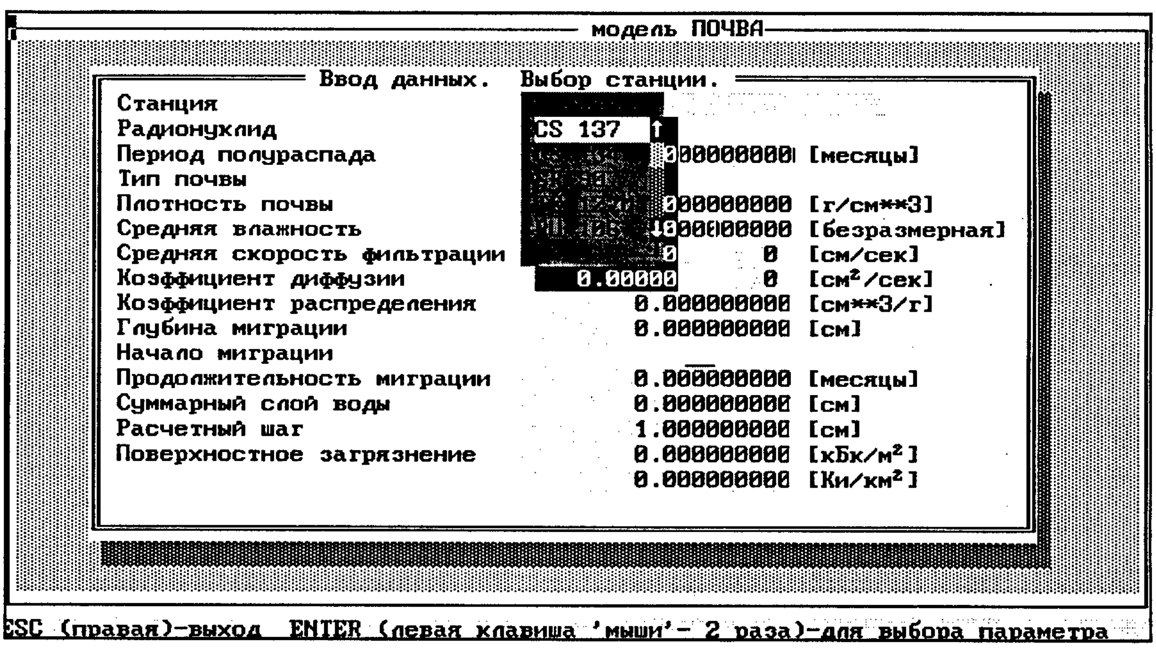
Example of presentation of information about accidents from radiation hazardous objects. (Skolsk region AES)



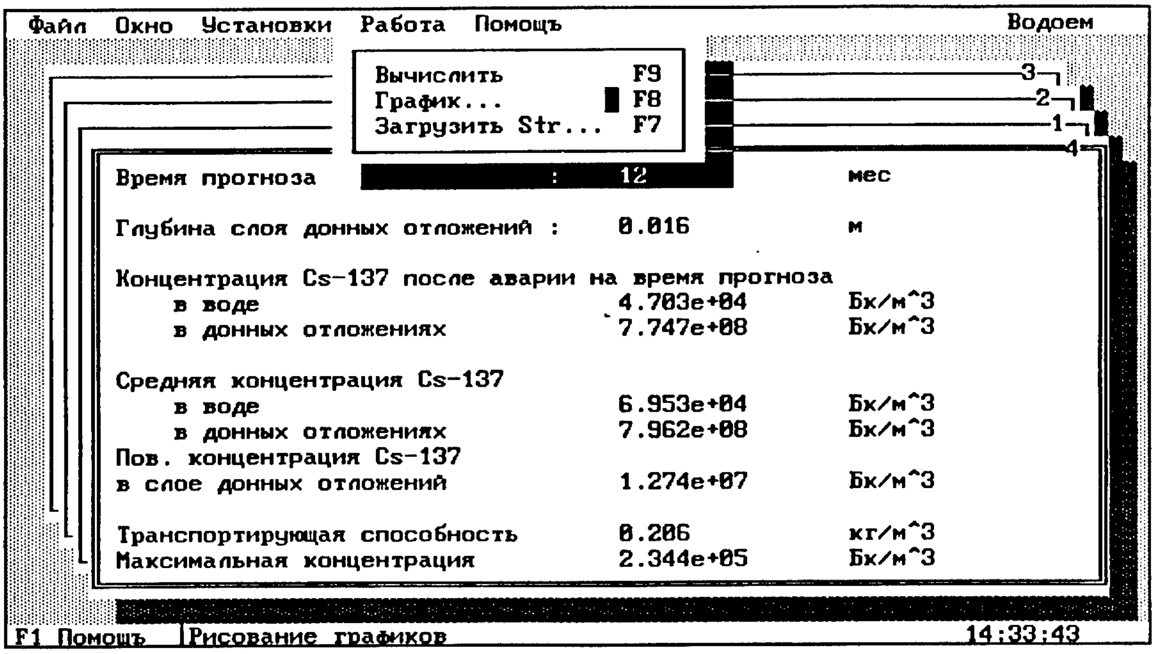
Example of presentation of information about accidents from chemical - hazardous objects.



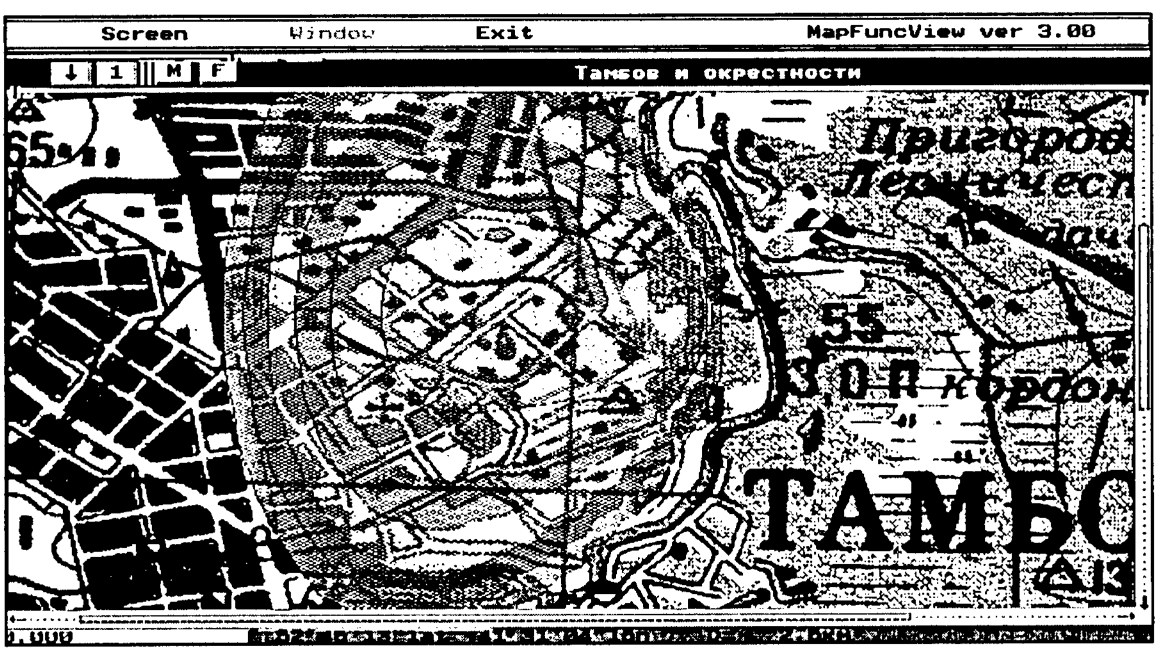
Examples of data presentation with use of "RSOIL"
(Radionuclides migration in soil) software.



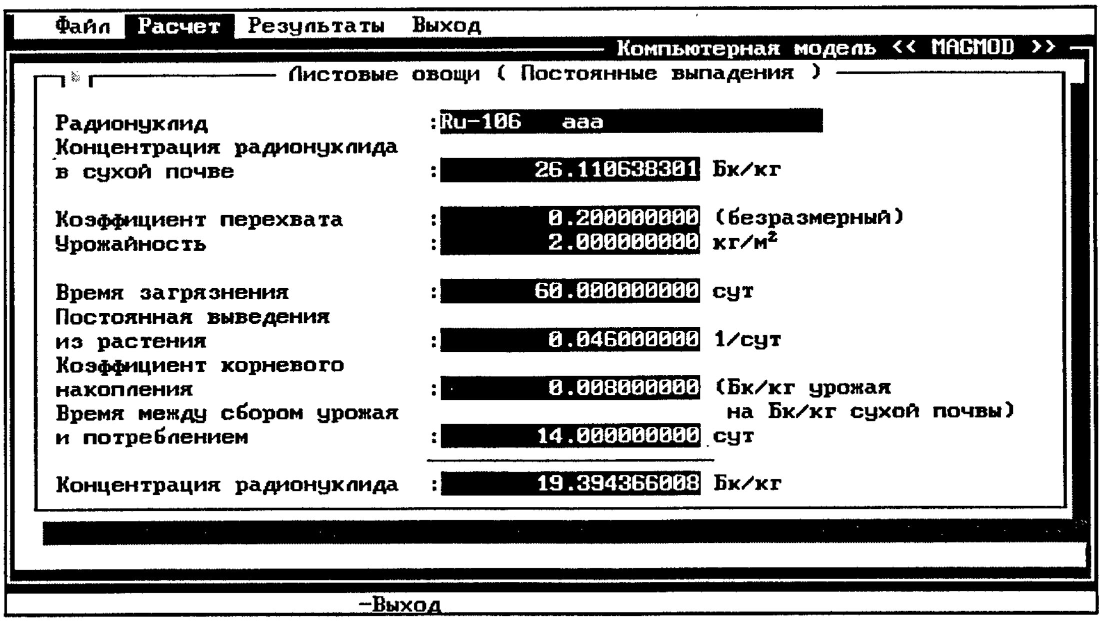
Advection-diffusion model of radionuclides migration in soil "MODEL_AD".
Choice of Radionuclide.



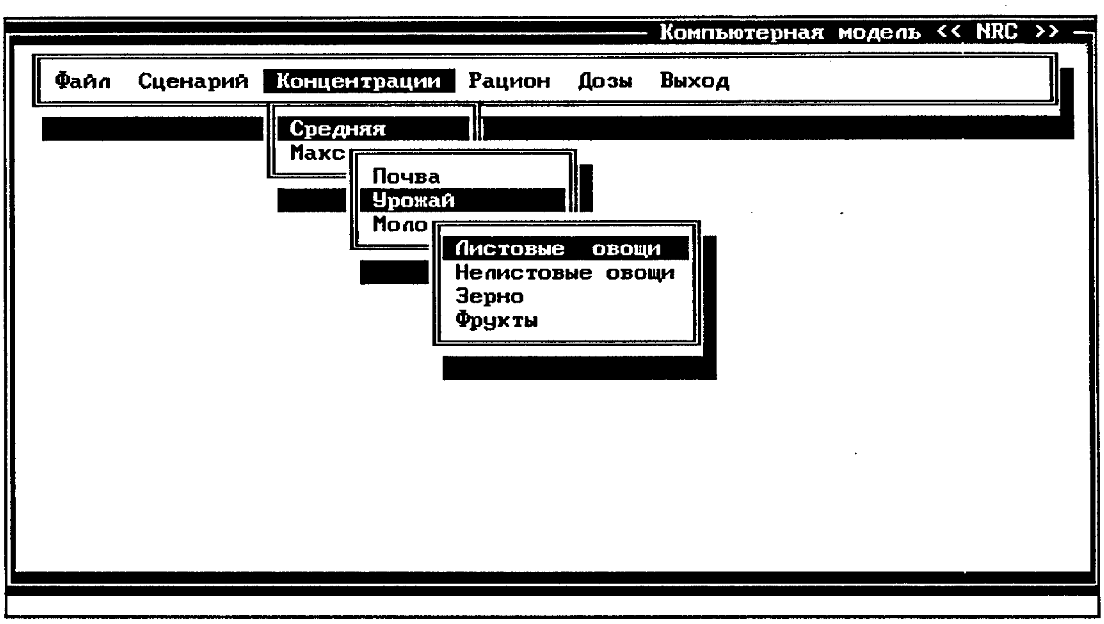
Computer model "DROP" - radionuclides dispersion in surface water.
Example of calcuation.



Examples of data presentation iwth use "GWATER" software.
(Radionuclides dispersion in underground water)

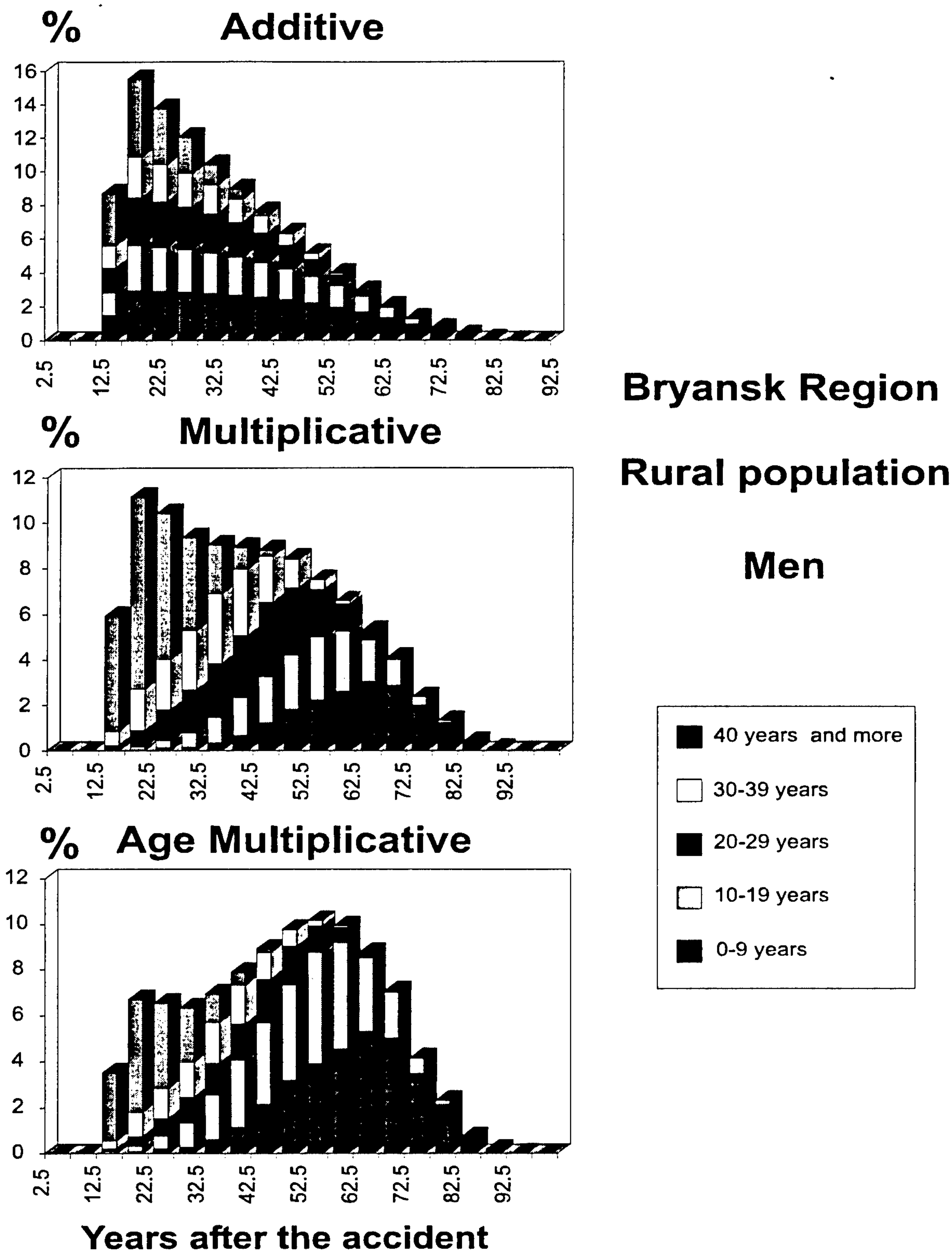


Food Chain "MAGMOD" -(IAREA - methodics).
Example of calculations.



Example of screen food chain model "NRCMOD".
(USA NRC methodics)

Dynamics of additional death-rate growth caused by alimentary-canal cancer



Comparision of Spontaneous and Possible Additional Radiation-Induced Mortality from Cancers in JKKT

(Acronym for the male rural population in the contaminated regions of Briansk Oblast.)

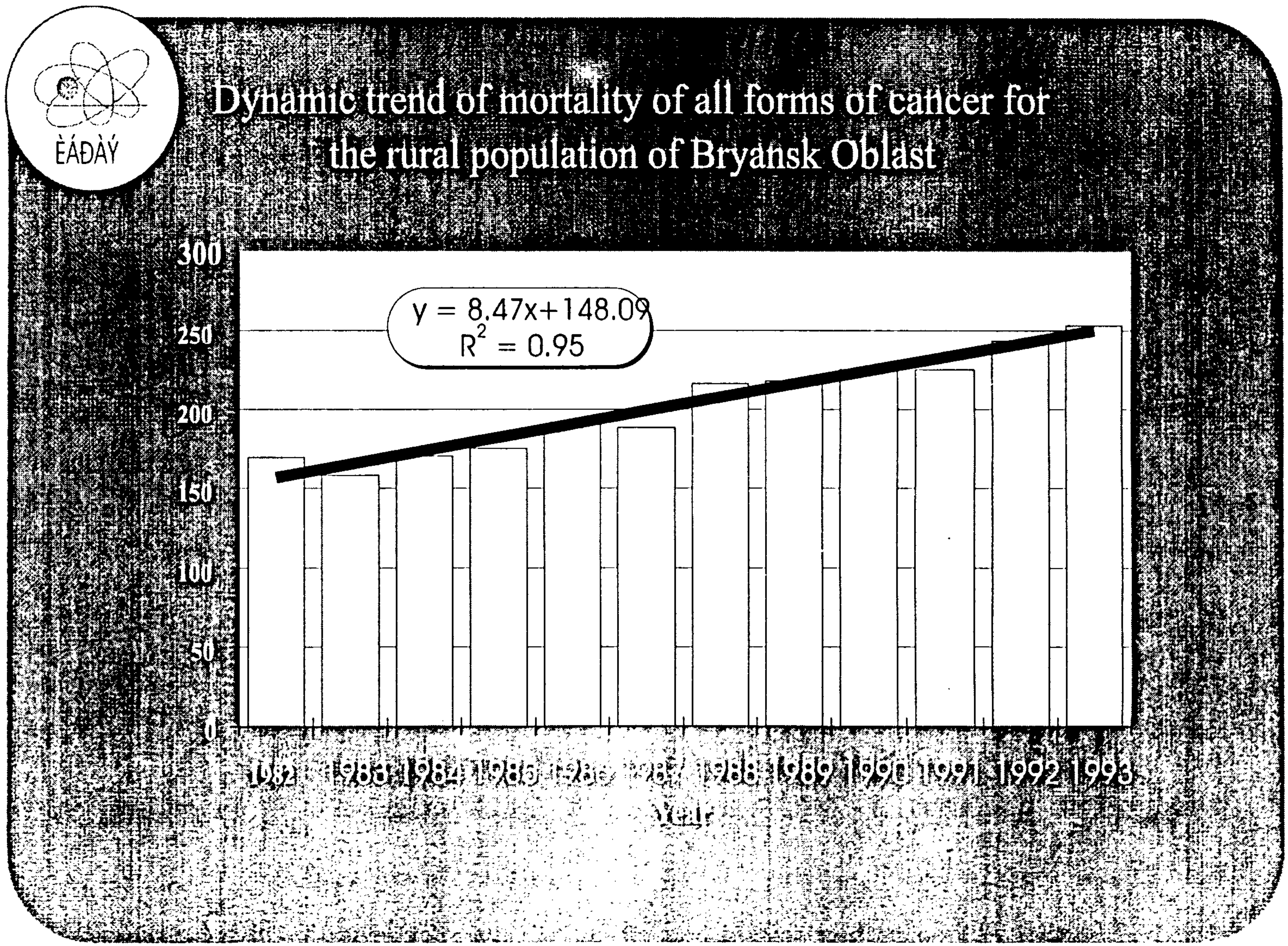
1. **Size of male population--$50,000**

2. **Spontaneous mortality rate –60 cases/year**

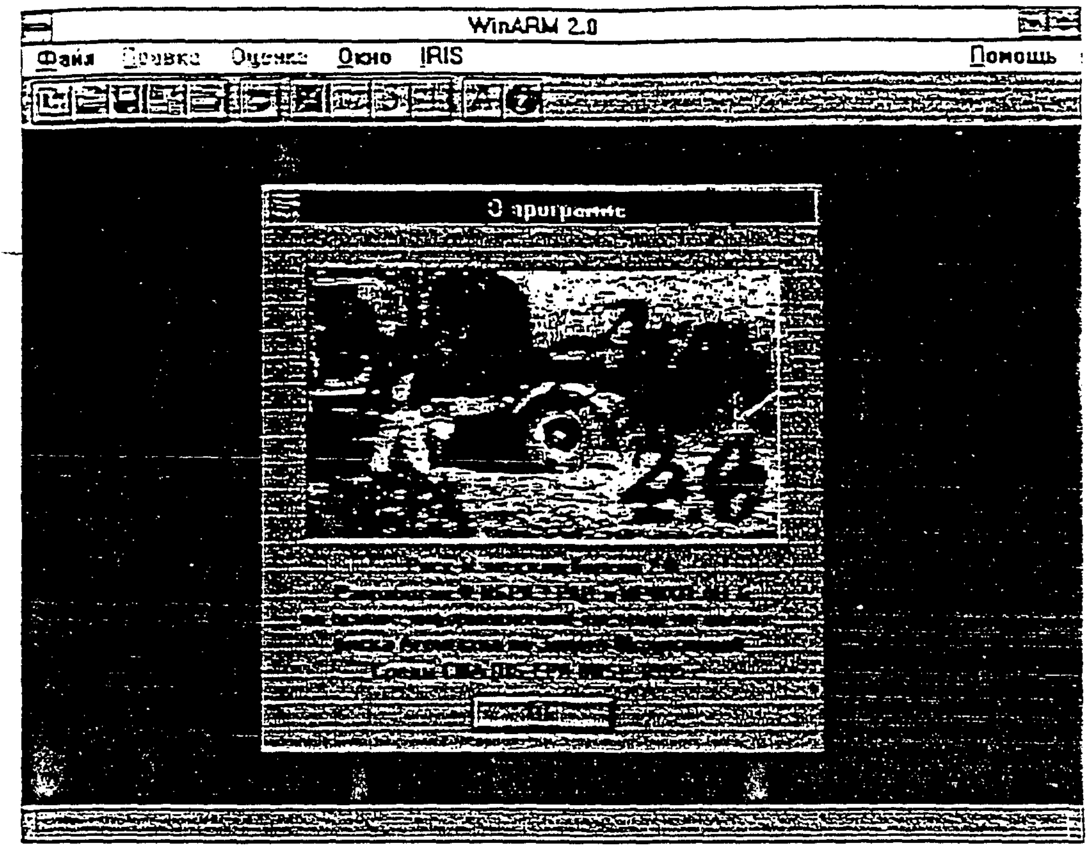
3. **Growth trend in spontaneous mortality rate -- ±1.5 cases/year**

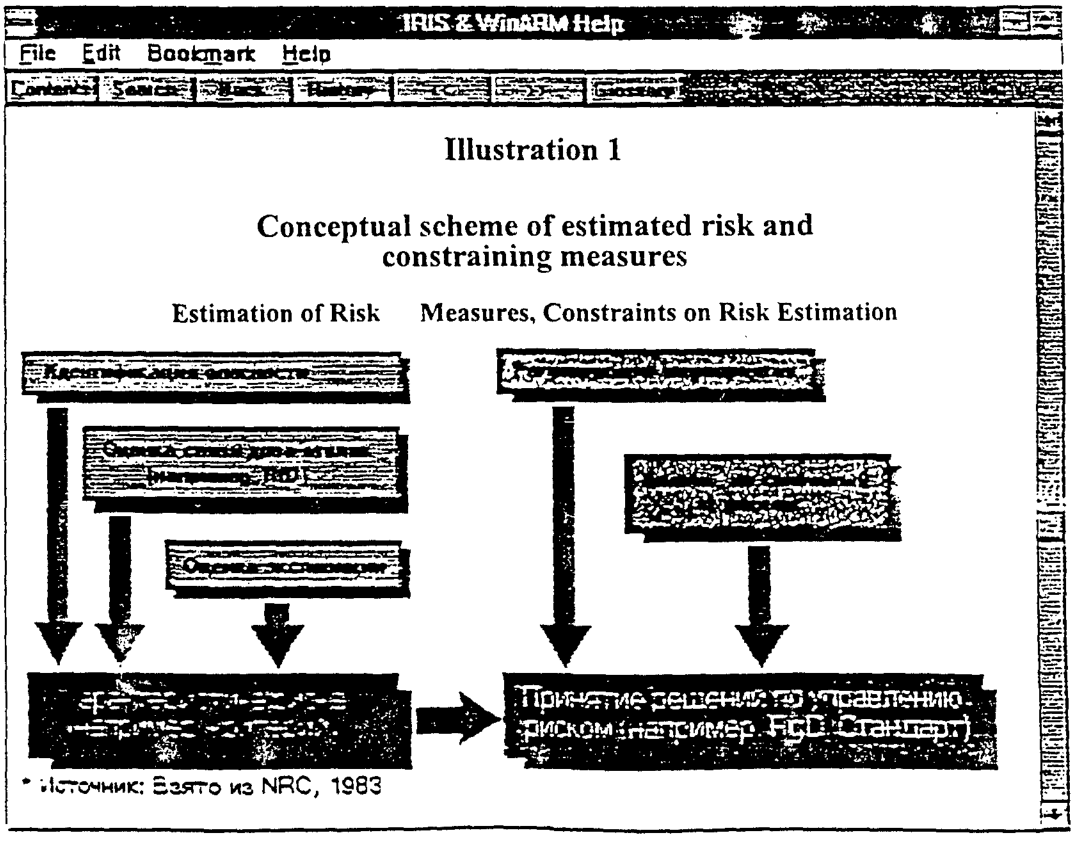
4. **Confidence interval of spontaneous mortality rate minus trend-- ±1.5 cases/year**

5. **Prediction of additional mortality from cancer in JKKT**
   -additive model–0.14 cases/year
   -multiplicative model–0.32 cases/year
   -age-adjusted multiplicative model–0.50 cases/year

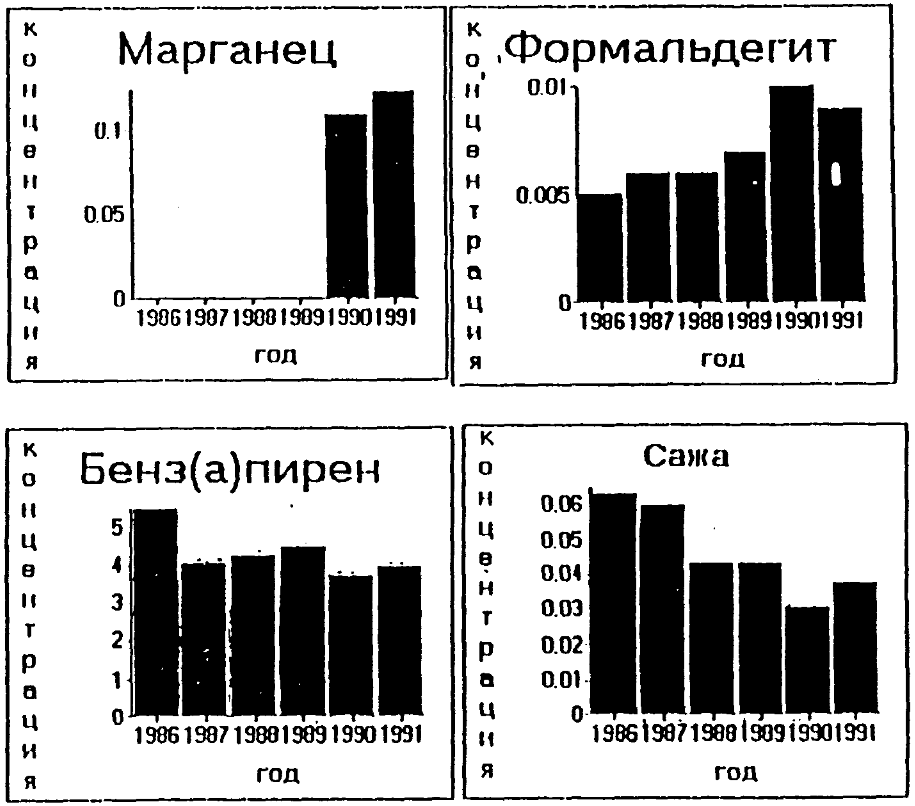

Dynamic trend of mortality of all forms of cancer for the rural population of Bryansk Oblast
ÈÁĐÀÝ
y = 8.47x+148.09
R^2 = 0.95
300
250
200
150
100
50
0
1982
1983
1984
1988
1989
1990
1991
1992
1993
Year

КОМПЬЮТЕРНАЯ ИНФОРМАЦИОННО-ВЫЧИСЛИТЕЛЬНАЯ СИСТЕМА
ПО ОЦЕНКЕ РИСКА ДЛЯ ЗДОРОВЬЯ ОТ СИСТЕМНЫХ ТОКСИНОВ
И КАНЦЕРОГЕНОВ WinARM





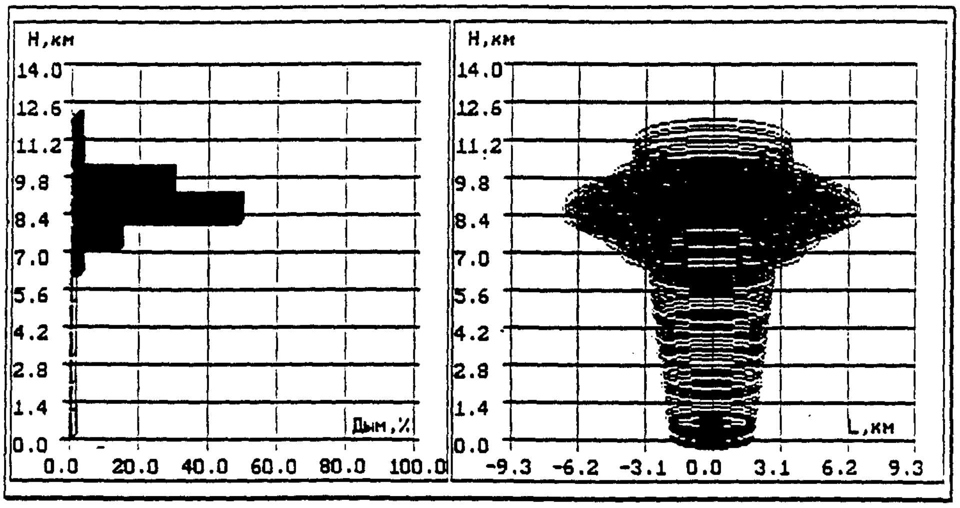
Примесь	Qcr	Qmax
ДИОКСИД СЕРЫ	0.0256667	0.71
СУЛЬФАТЫ РАСТВО	0.01	0.07
ОКСИД УГЛЕРОДА	1.2	24
ДИОКСИД АЗОТА	0.0100333	0.73
ОКСИД АЗОТА	0.05	0.52
ФЕНОЛ	0.002	0.04
САЖА	0.0366667	0.9
АММИАК	0.0366667	0.52
ФОРМАЛЬДЕГИД	0.00925	0.212
АКРОЛЕИН	0.015	0.34
ВОДОРОД ХЛОРИСТ	0.2	4.85
БЕНЗОЛ	0.005	0.05
ТОЛУОЛ	0.02	0.52
КСИЛОЛ	0.015	0.16
ЭТИЛБЕНЗОЛ	0	0.035
СТИРОЛ	0.007	0.095
ХРОМ	0.07625	0.31
СВИНЕЦ	0.161111	2.1
МАРГАНЕЦ	0.1225	1.25
МЕДЬ	0.11375	0.34
НИКЕЛЬ	0.0375	0.16
ЦИНК	0.38375	3.32
ЖЕЛЕЗО	2.4575	17.52
КАДМИЙ	0.005	0.03
КОБАЛЬТ	0.005	0.04
БЕНЗ(А)ПИРЕН	3.925	18.4



Date from the city of Ekaterinburg

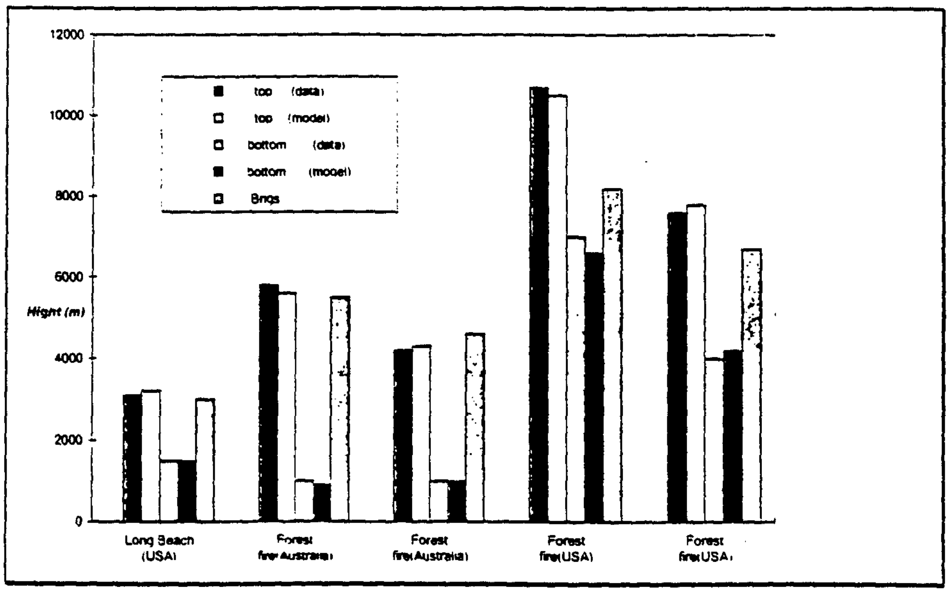
Effective release height over the fire

Modeling



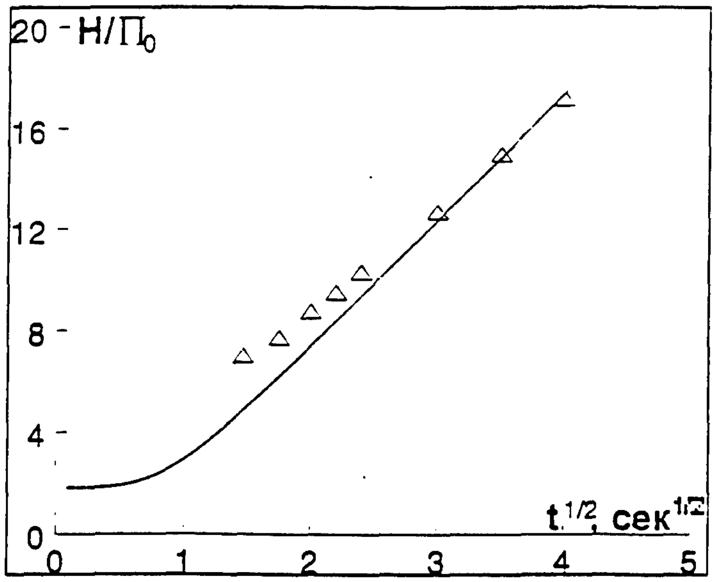
The view of smoke column and smoke propagation with height for Hamburg fire.

Comparison with the natural data



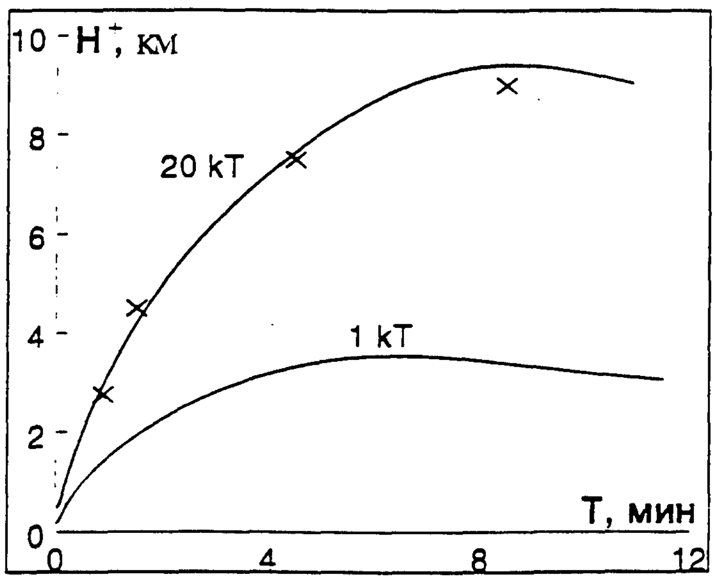
Effective release height after the explosion

Small scale experiments (30 kg of powder)

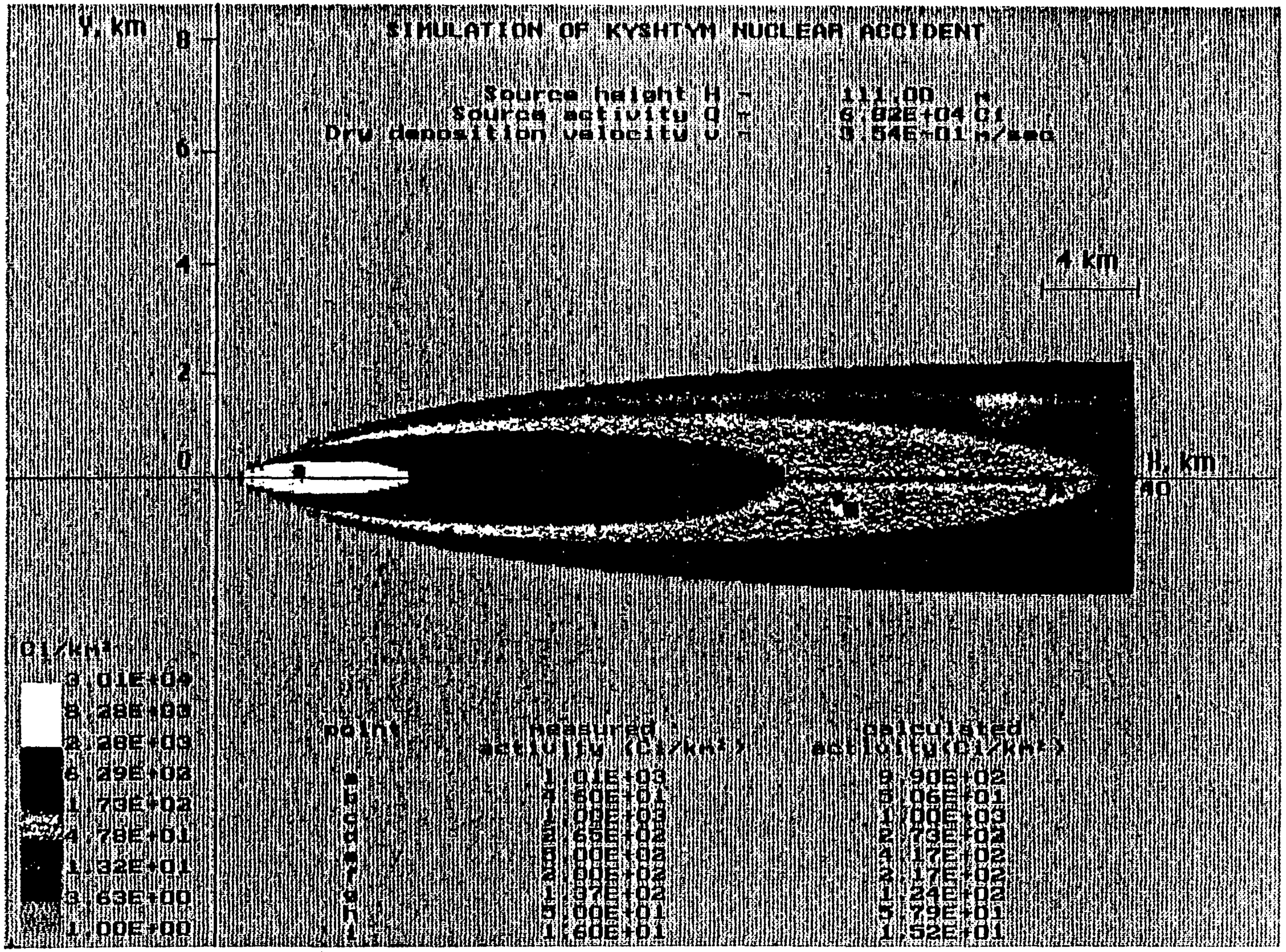


Selfsimilar regime of thermics rising.
$\Pi_0 = (Q\beta g/2\pi\rho_0 C_p)^{1/4}$. H is height, Q is charge energy, β is coefficient of thermal spreading. The points are the Gostintsev's experiments

Large scale experiments (1 and 20 kt).



Change of rise of upper cloud level in time for energies Q=20kT и Q=1kT.



Reconstruction of source parameters for Kyshtym nuclear accident.

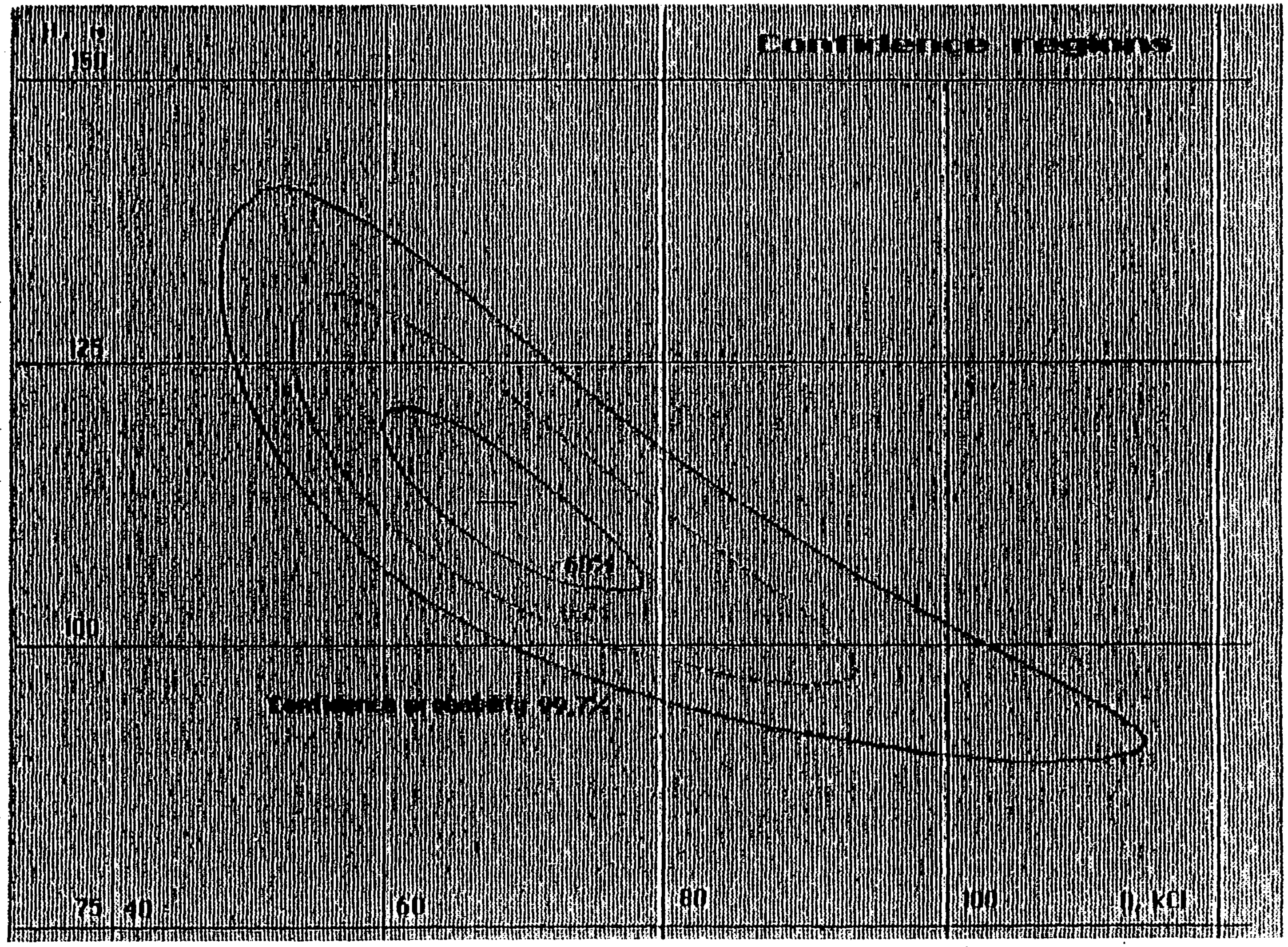
RECONSTRUCTION OF PARAMETERS OF THE RADIOACTIVE POLLUTION SOURCE FROM DATA ON THE MEASUREMENTS OF THE SURFACE ACTIVITY FIELD.

Method.

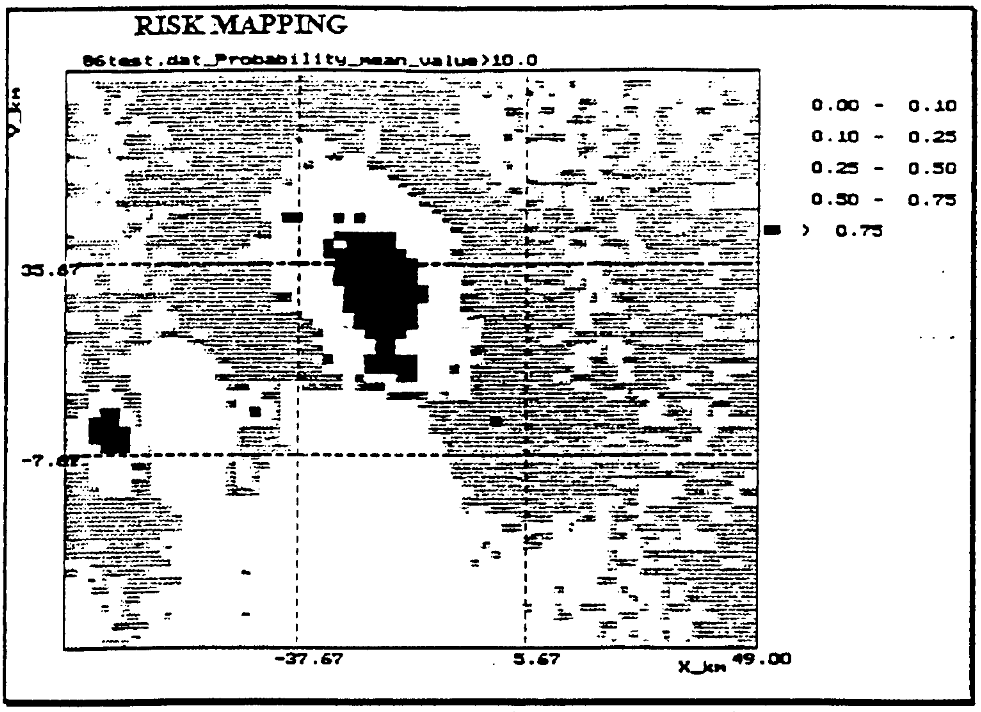
For the set of experimental values A_i, minimization of function $F = \Sigma(A_i\text{-}a_i)(A_i\text{-}a_i)$ leads to the solution of linear equations for unknown coordinates of parameter vector beta.

Output data.

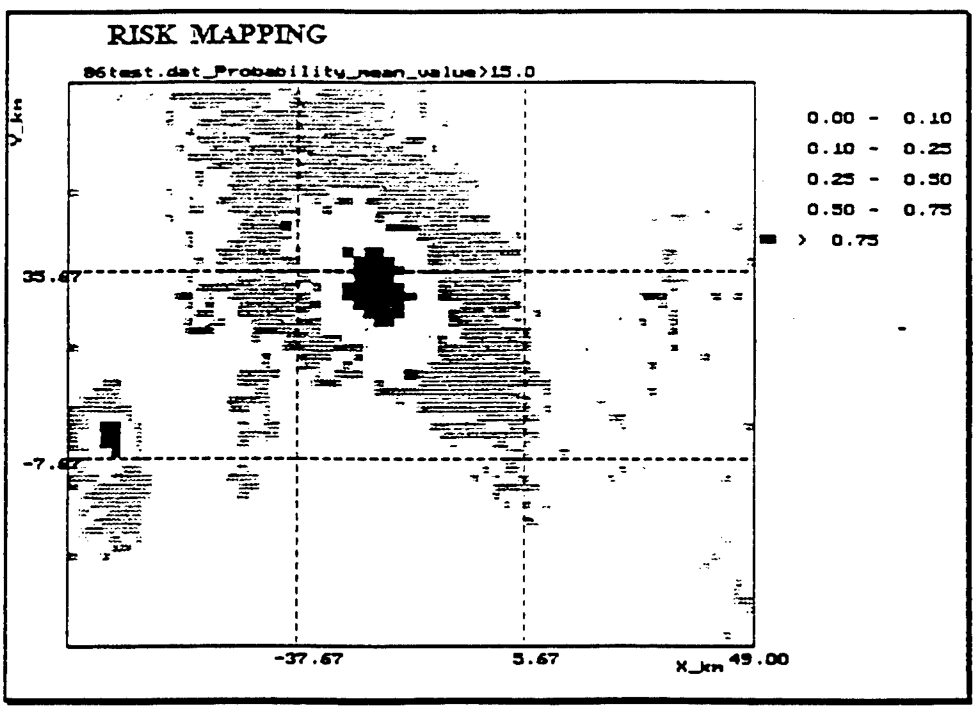
Source height H, source activity Q and deposition velocity v . Confidence region on parameters: H, Q and v lie in the region with assumed confidence probability. Calculated field of surface activity.



Confidence regions on H and Q parameters. V=0.35 m/sec.

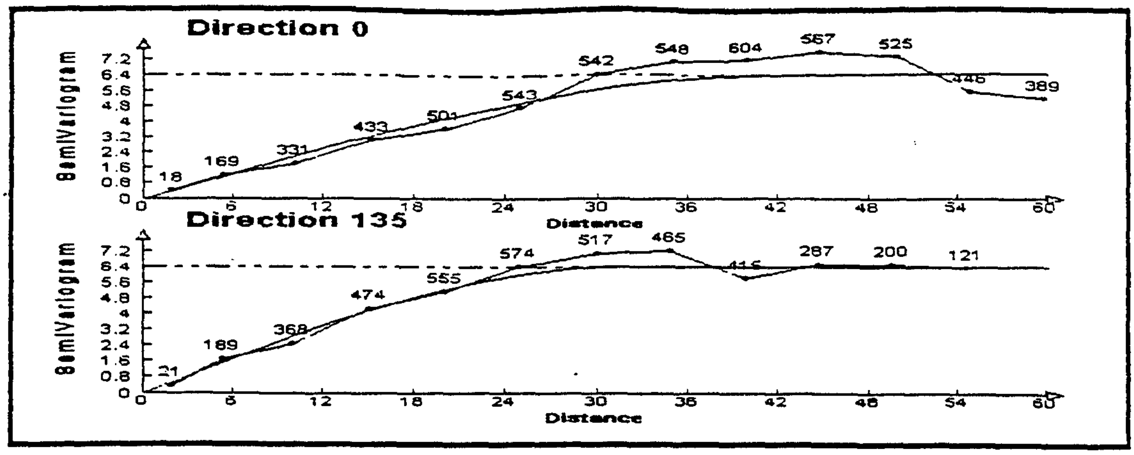


Sequential gaussian simulations (Simple Kriging). Risk map: probability that mean value of 100 realizations exceeds 10 Ci/km2.

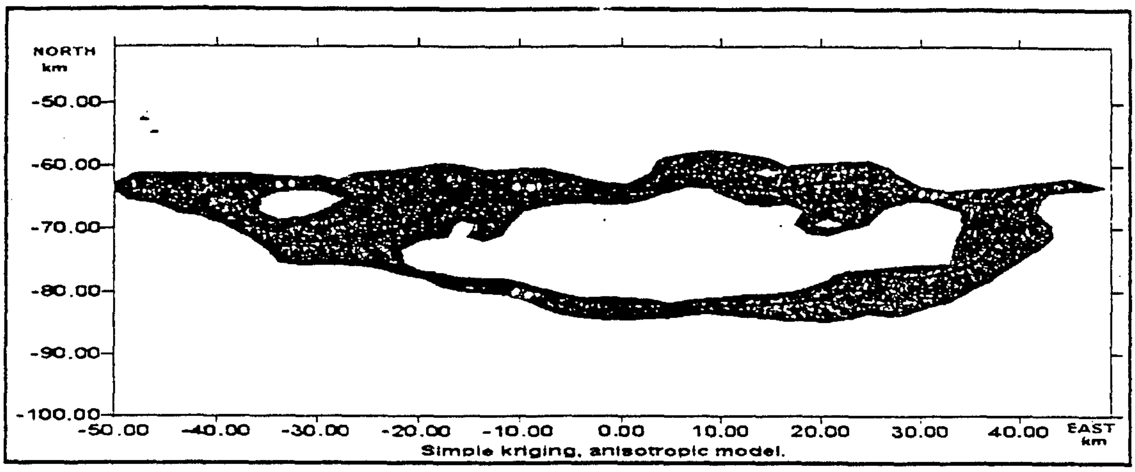


Sequential gaussian simulations (Simple Kriging). Risk map: probability that mean value of 100 realizations exceeds 15 Ci/km2.

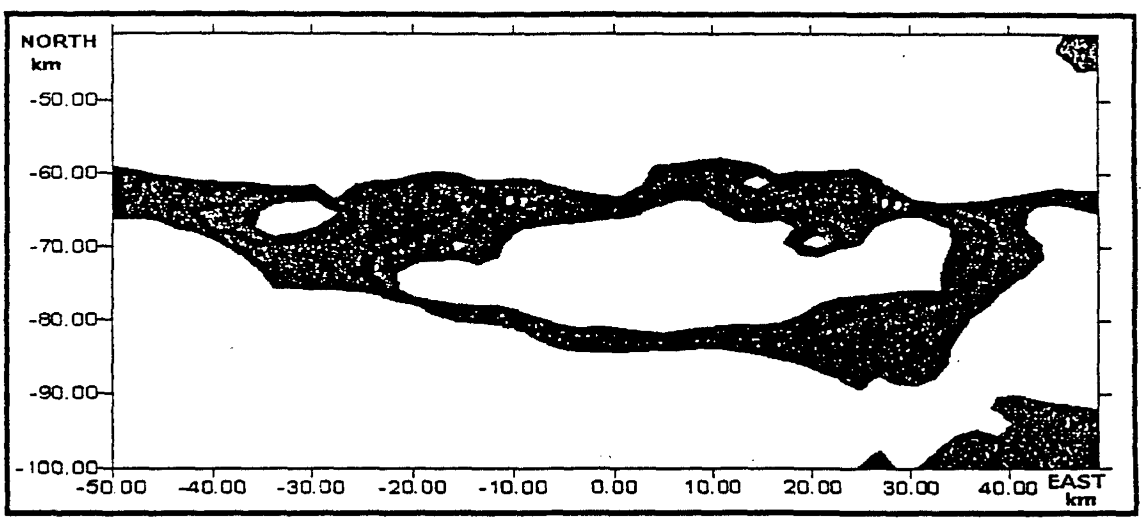
UNCERTAINTY OF ESTIMATION OF CONTAMINATION
OF CESIUM-137



EXPERIMENTAL VARIOGRAM AND ANISOTROPIC
MODEL FOR KALUGA OBLAST

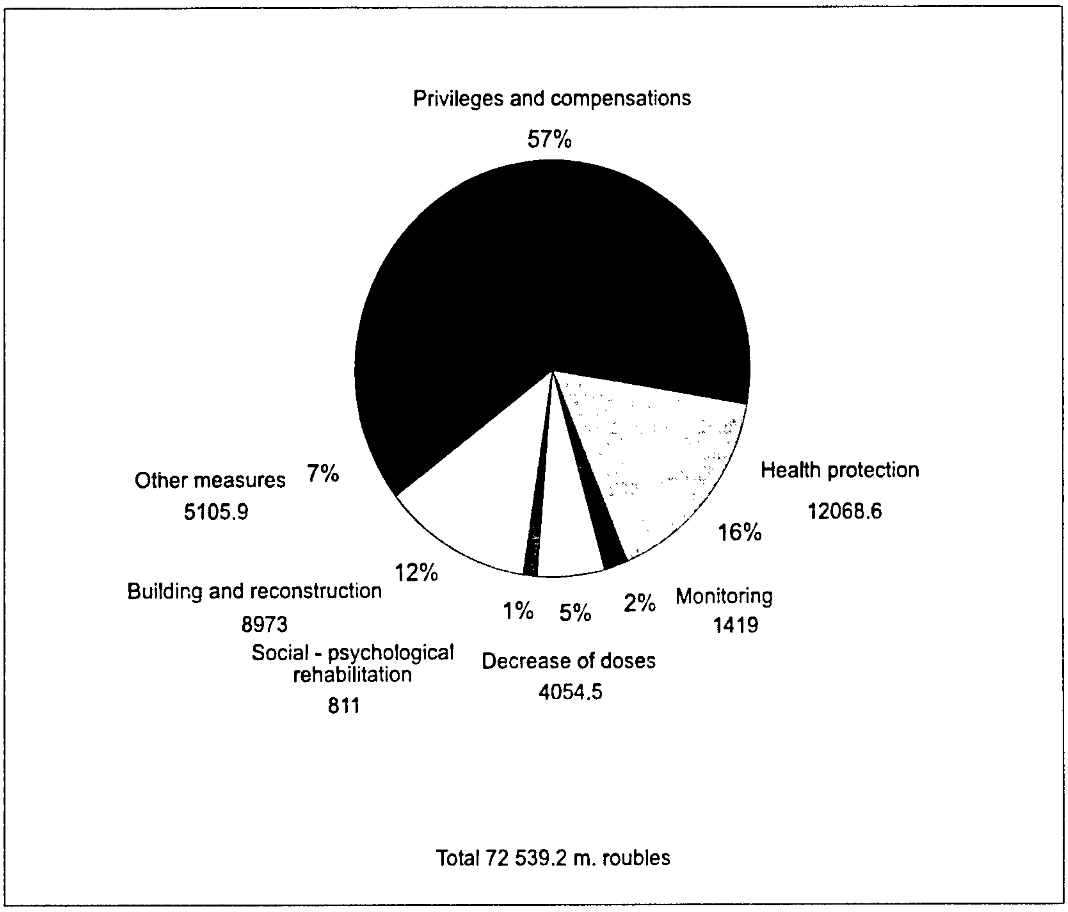


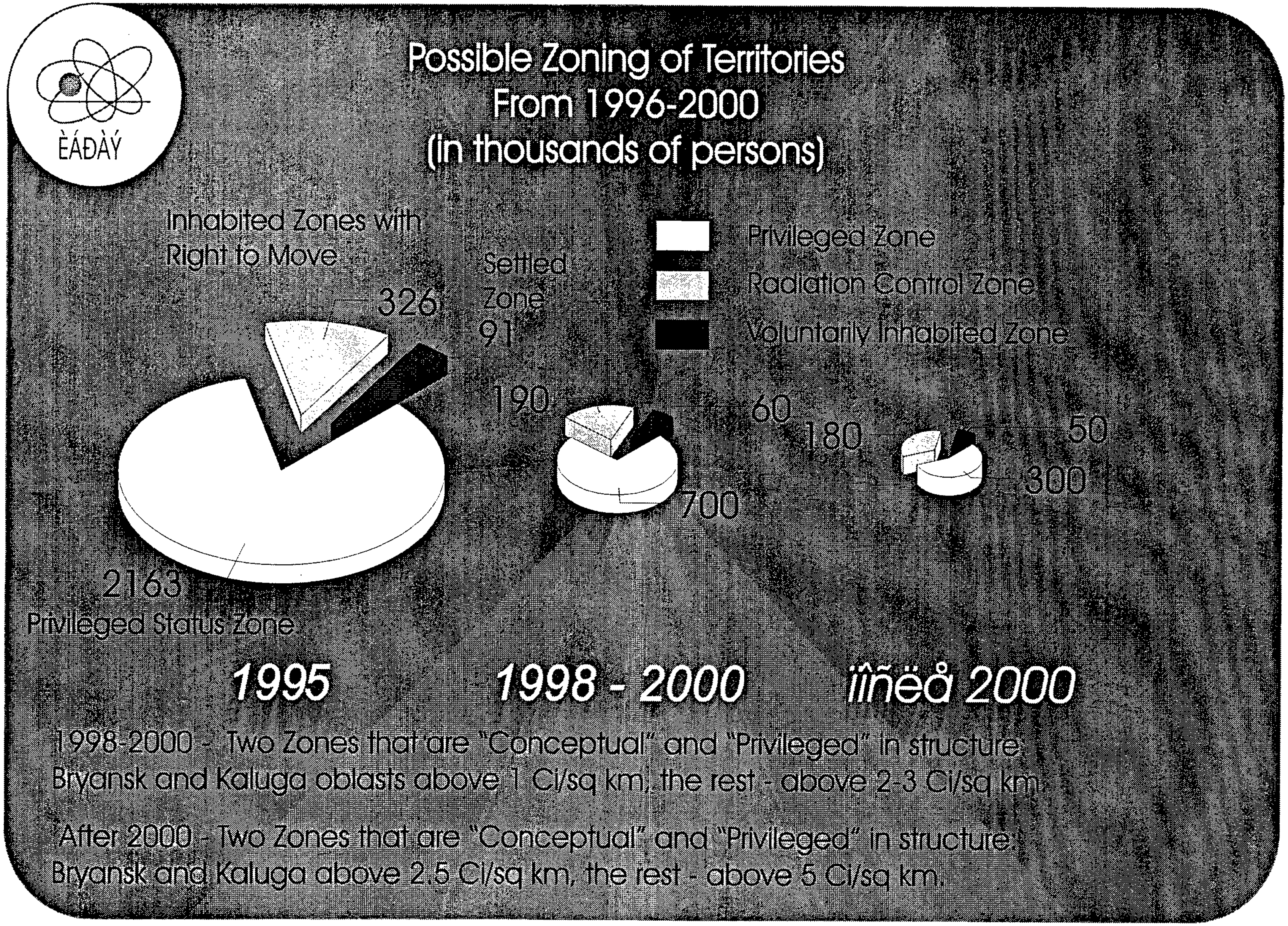
UNCERTAINTY OF ESTIMATION OF CONTAMINATION
ORDINARY SIMPLE KRIGING KALUGA OBLAST



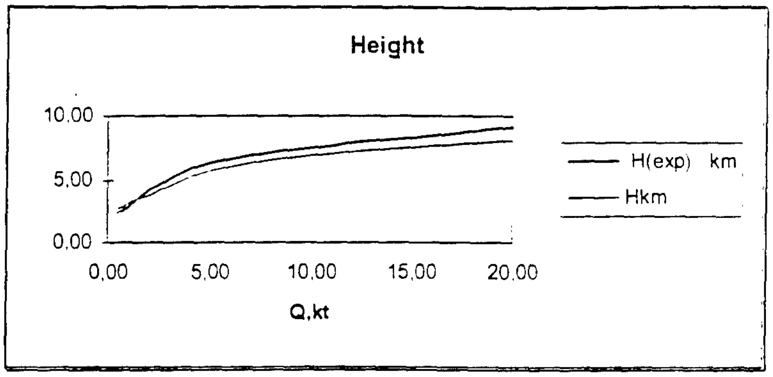
UNCERTAINTY OF ESTIMATION OF CONTAMINATION
ORDINARY USUAL KRIGING, KALUGA OBLAST

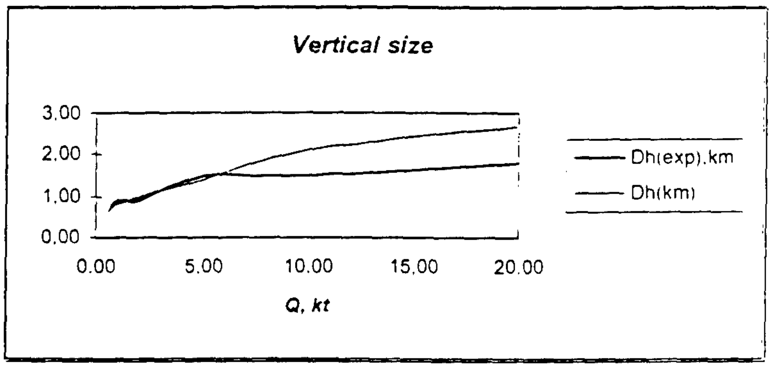
The Structure of Allocations for Measures Forseen in State Program to Protect the Population of Russia from Infuence of Chernobyl Catastrophy Consequences till 2000.

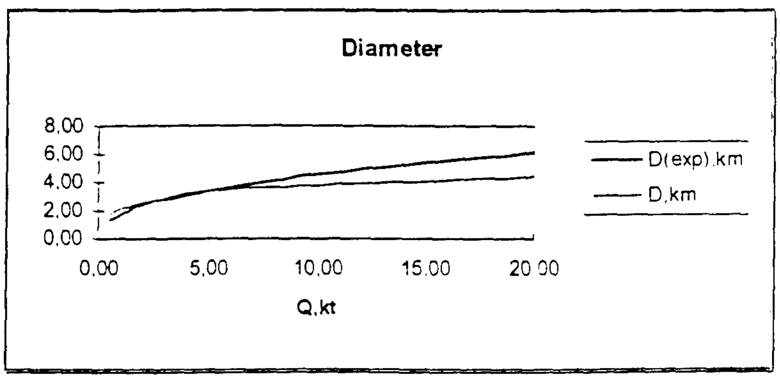


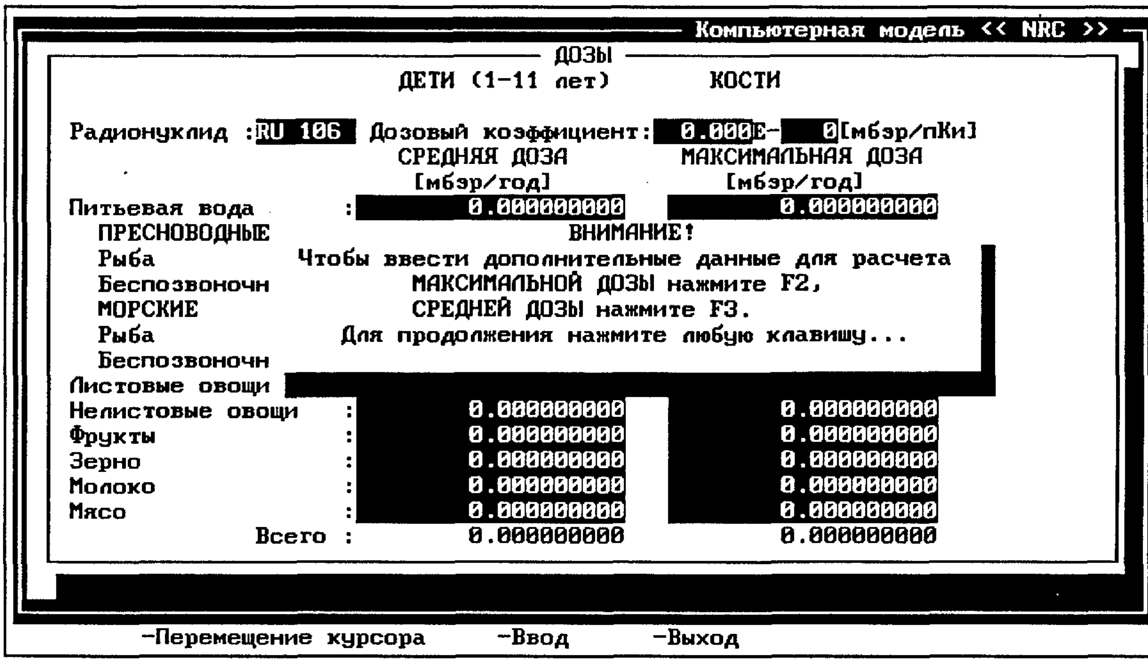

ÈÁÐÀÝ
Possible Zoning of Territories
From 1996-2000
(in thousands of persons)
Inhabited Zones with Right to Move
326
Settled Zone
91
Privileged Zone
Radiation Control Zone
Voluntarily Inhabited Zone
190
60
180
50
300
700
2163
Privileged Status Zone
1995
1998 - 2000
ïîñëå 2000
1998-2000 - Two Zones that are "Conceptual" and "Privileged" in structure:
Bryansk and Kaluga oblasts above 1 Ci/sq km, the rest - above 2-3 Ci/sq km.
After 2000 - Two Zones that are "Conceptual" and "Privileged" in structure:
Bryansk and Kaluga above 2.5 Ci/sq km, the rest - above 5 Ci/sq km.

Cloud dimensions dependence with charge energy.
Comparison NSI model with the natural data.

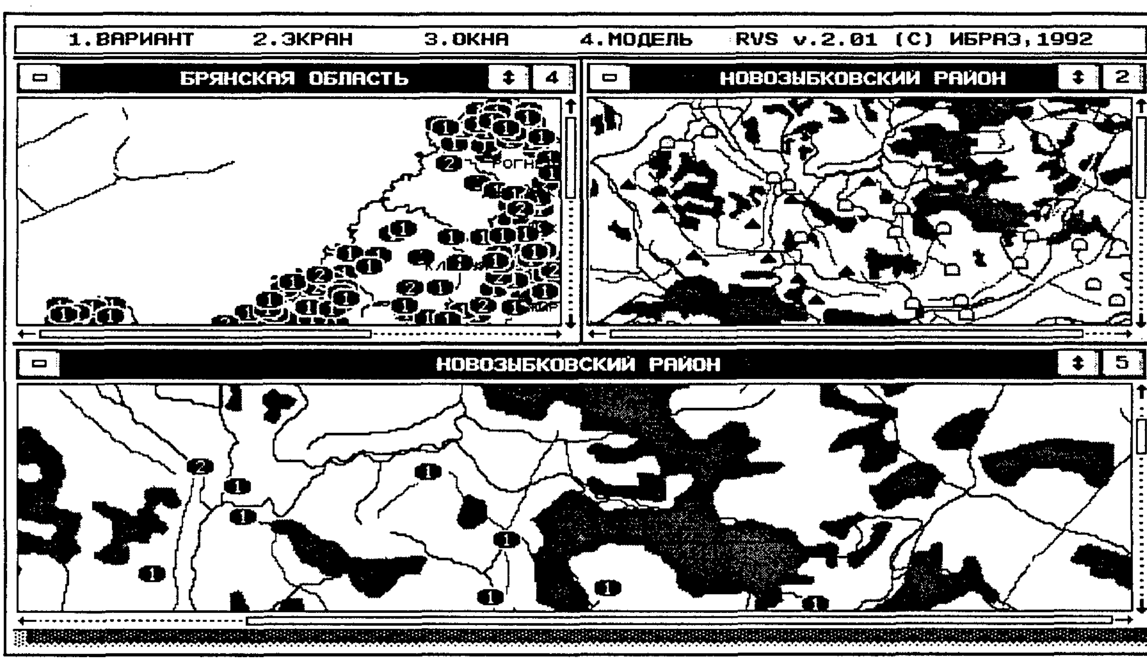






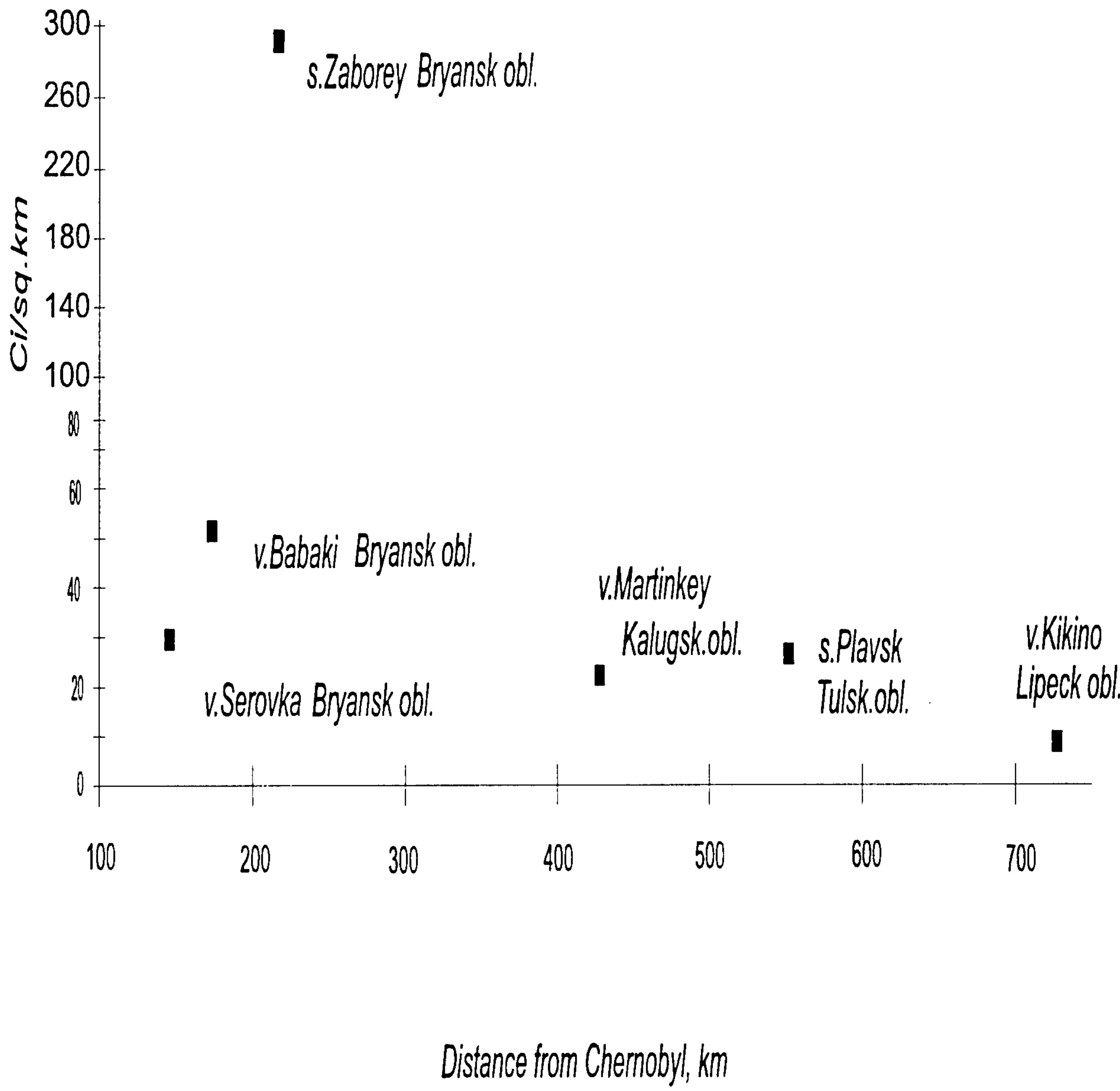


Dosimetric part of "NRCMOD" computer model.



Multi-screen system for radionuclides migration modeling analyses on maps.

Maximum values Densities of Cs - 137 in populated points situated at different distances from Chernobyl on Russian Federation Territory



MINISTRY OF RUSSIAN FEDERATION
ON SITUATIONS OF EMERGENCY

RUSSIAN ACADEMY OF SCIENCES

IBRAE

NUCLEAR SAFETY INSTITUTE

COMMANDING AND HEADQUARTERS TRAINING

Guideline Materials

NOVEMBER 22–24, 1994

MOSCOW

IBRAE

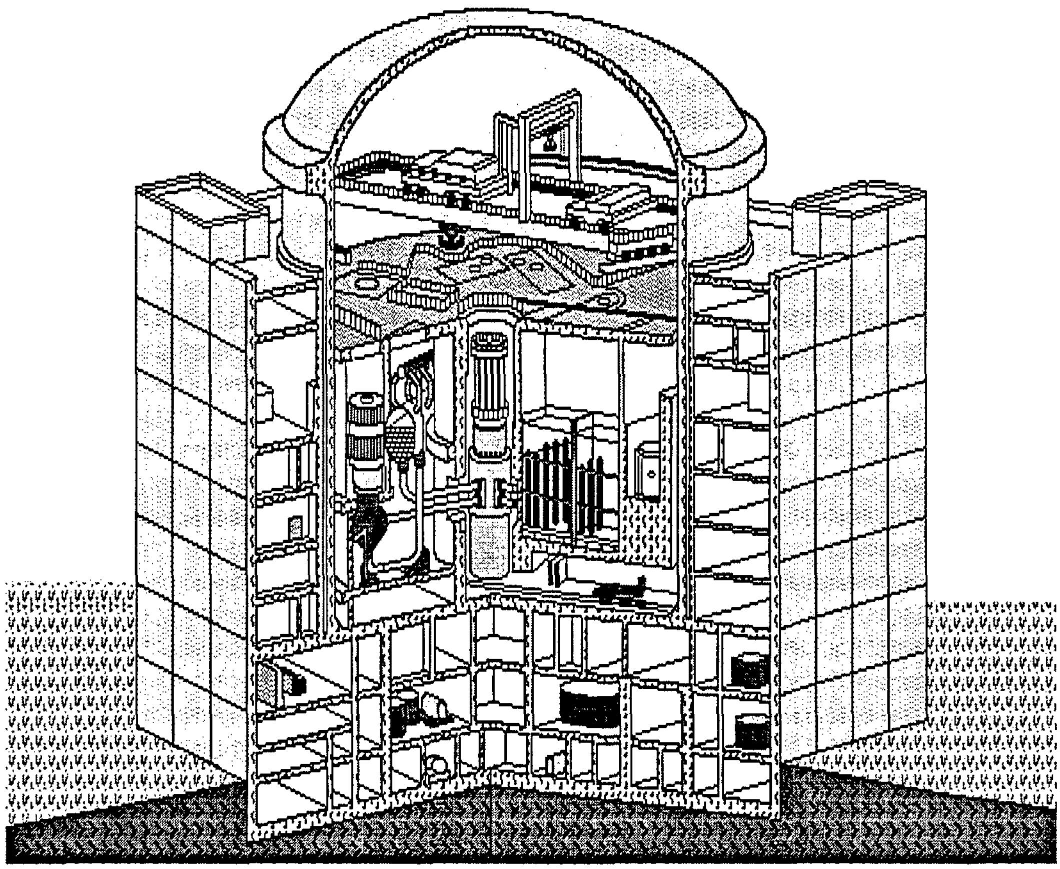
I. Accident and Release Scenario

The accident scenario and radioactivity release prediction have been prepared by the specialists of "ROSENERGOATOM" concern and NSI RAS.

The scenario is based on detailed modelling of a hypothetical accident at an arbitrary power unit with a VVER−1000 reactor assuming that failures of all the principal and backup active safety systems are "superimposed" for a long period up to 4 hours.

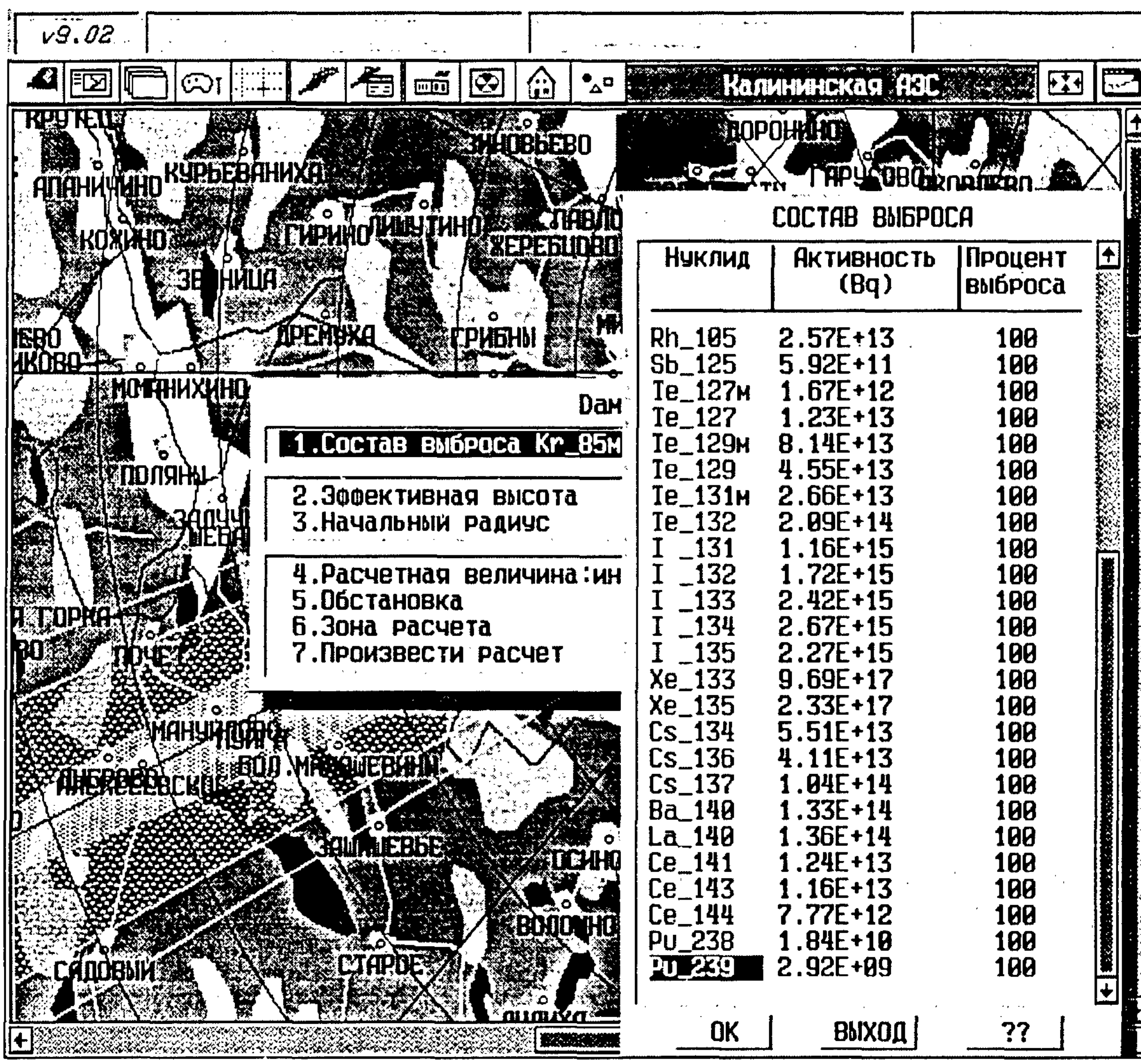
The dynamics of the hypothetical accident has been analyzed using the codes for severe accidents, which had been developed at NSI RAS, and the integrated code of the Nuclear Regulation Commission of the USA.

Command Headquarters for Training
EMERCOM RF
22-24 November 1994



Block Section at Kalinin AES

Moscow, 1994


v9.02
Калининская АЭС
СОСТАВ ВЫБРОСА
Нуклид
Активность (Bq)
Процент выброса
Rh_105 2.57E+13 100
Sb_125 5.92E+11 100
Te_127м 1.67E+12 100
Te_127 1.23E+13 100
Te_129м 8.14E+13 100
Te_129 4.55E+13 100
Te_131м 2.66E+13 100
Te_132 2.09E+14 100
I _131 1.16E+15 100
I _132 1.72E+15 100
I _133 2.42E+15 100
I _134 2.67E+15 100
I _135 2.27E+15 100
Xe_133 9.69E+17 100
Xe_135 2.33E+17 100
Cs_134 5.51E+13 100
Cs_136 4.11E+13 100
Cs_137 1.04E+14 100
Ba_140 1.33E+14 100
La_140 1.36E+14 100
Ce_141 1.24E+13 100
Ce_143 1.16E+13 100
Ce_144 7.77E+12 100
Pu_238 1.84E+10 100
Pu_239 2.92E+09 100
OK
ВЫХОД
??
1.Состав выброса Kr_85м
2.Эффективная высота
3.Начальный радиус
4.Расчетная величина:ин
5.Обстановка
6.Зона расчета
7.Произвести расчет
ЗИНОВЬЕВО
КУРЬЕВАНИХА
АПАНИЧИНО
КОЖИНО
ГИРИНО
ЖЕРЕБЦОВО
ГРИБНЫ
САДОВЫЙ
СТАРОЕ

IBRAE

Stage 1

A prompt primary prediction is performed on the basis of primary estimation of the release amount and simplified characteristics of the meteorological situation in the NPP area, which is, in its turn, based on the data provided by the "ROSENERGOATOM" concern.

The primary analysis and exposure prediction allow to estimate rather approximately the incident danger and to give preliminary information to the Crisis Situations Center of MSE RF.

IBRAE

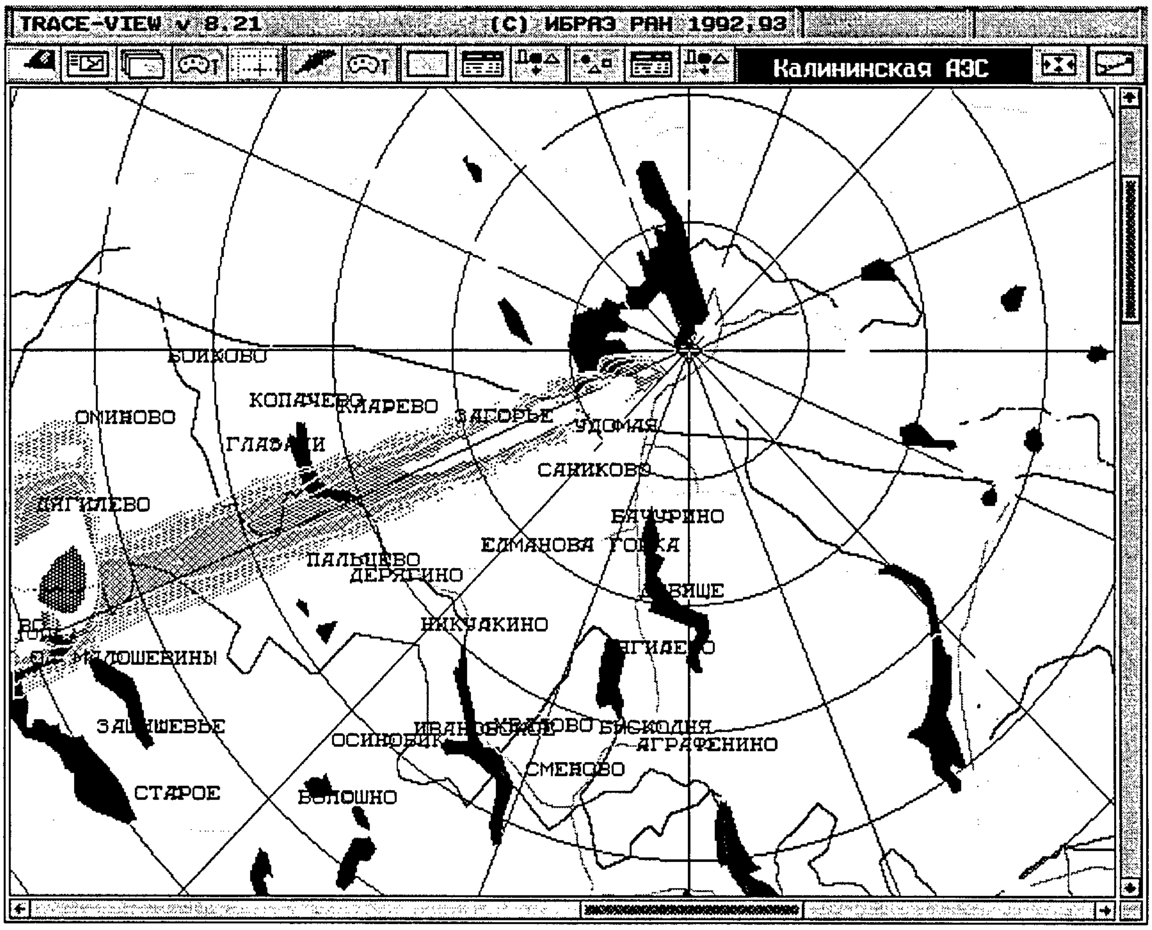
Stage 2

On the basis of primary information on the parameters of the power unit in a state of emergency and precalculated, more detailed characteristics of a probable release (this is performed using up–to–date codes for severe accidents), more accurate prediction of the radiation situation is performed with taking into consideration the refined data on the meteorological situation obtained from the Committee of the Russian Federation for Hydrometeorology.

On having the meteorological data files obtained, the forecast for the near area and mid–area (up to 300 km) is refined using the "NOSTRADAMUS" computer code.

The refined forecast is transferred to the Crisis Situations Center of MSE RF.

Moscow, 1994



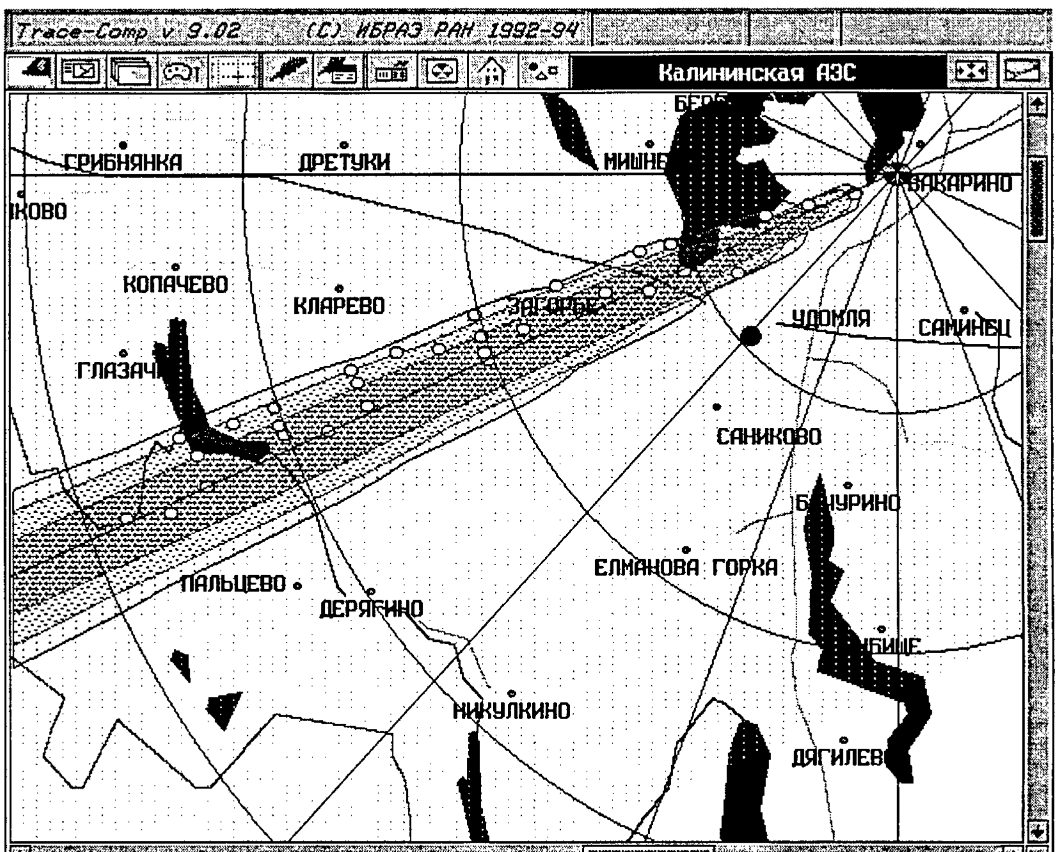
TRACE-VIEW v 8.21
(C) ИБРАЗ РАН 1992,93
Калининская АЗС
КОПАЧЕВО
ЗАГОРЬЕ
УДОМЛЯ
САНИКОВО
ДЯГИЛЕВО
ПАЛЬЦЕВО
ДЕРЯГИНО
НИКУЛКИНО
СМЕНОВО
АГРАФЕНИНО
СТАРОЕ
ВОЛОШНО

IBRAE

Stage 3

The data of actual dose–rate monitoring having been obtained, the parameters of the release source are corrected using the "REVERS" computer code. On the basis of the release source parameters (acivity, effective cloud ascent altitude) adjusted, the repeat prediction of the radiation situation and population radiation exposure is performed, and recommendations on population protection measures are worked out.

Command Headquarters for Training EMERCOM RF 22-24 November 1994



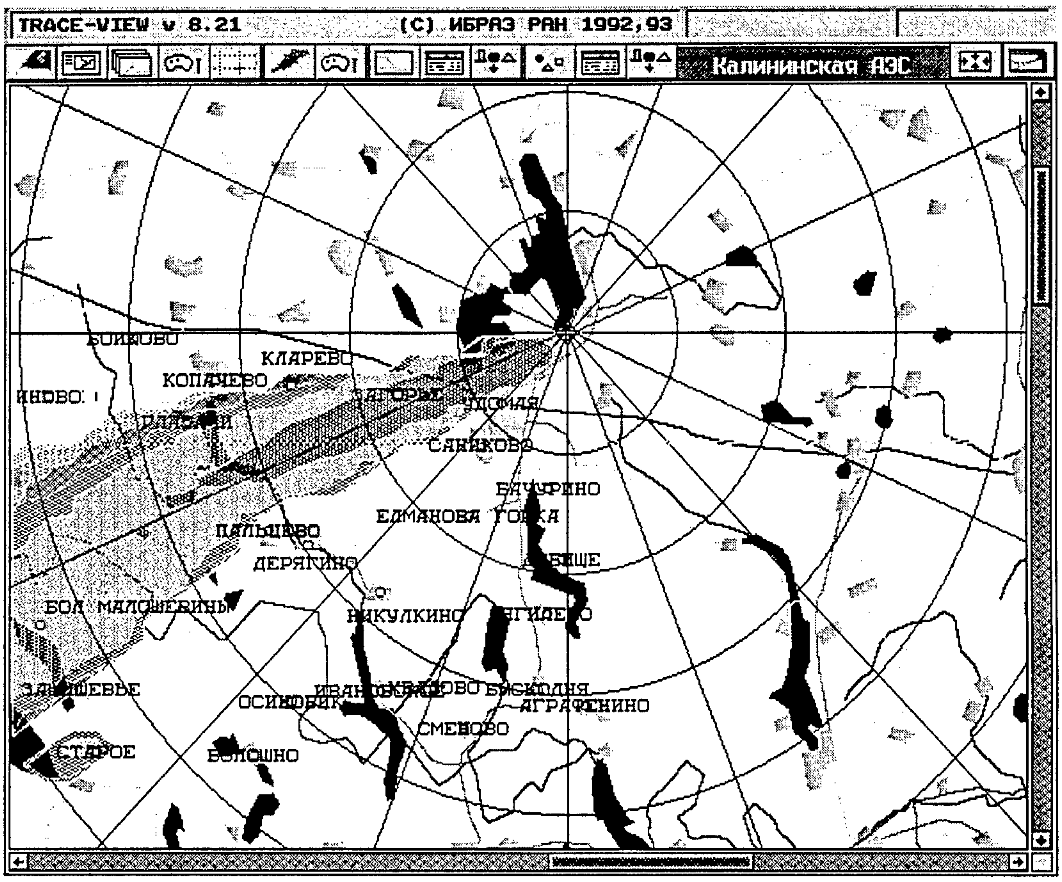
Map of measured points, using corrected source information
EAS, IBRAE RAS NS

IBRAE

Stage 4

As more detailed information on the radiation situation and isotopic composition of land contamination or radionuclide concentration in the air becomes available, successive correction of the source parameters and radiation situation forecast, including with population exposures, is carried out.

Command Headquarters for Training
EMERCOM RF
22-24 November 1994



Inhaled dose to the thyroid gland (children 1-8 years) (projected dose)
Variant NZL   EAS, NSI, RF

IBRAE

Stage 5

At ensuing stages, the Information and Analytical Center of NSI RAS which is a leading organization of the Chief Administration of MSE RF on overcoming the radiation catastrophe consequences accomplishes estimation and prediction of medium–term effects with the aim of working out primary recommendations on population protection at an intermediate stage after the radiation accident.

Apatity (Murmansk region), 1995

Practical Game with the framework of the "Polyarniye Zori-95" Command and Headquarters Exercise (EMERCOM of Russia, UN DHA, IBRAE RAS)

- about 50 participants and 100 observers from 26 countries and International organization;
- Phases: 3, 15 and 30 days after the accident at hypothetical NPP

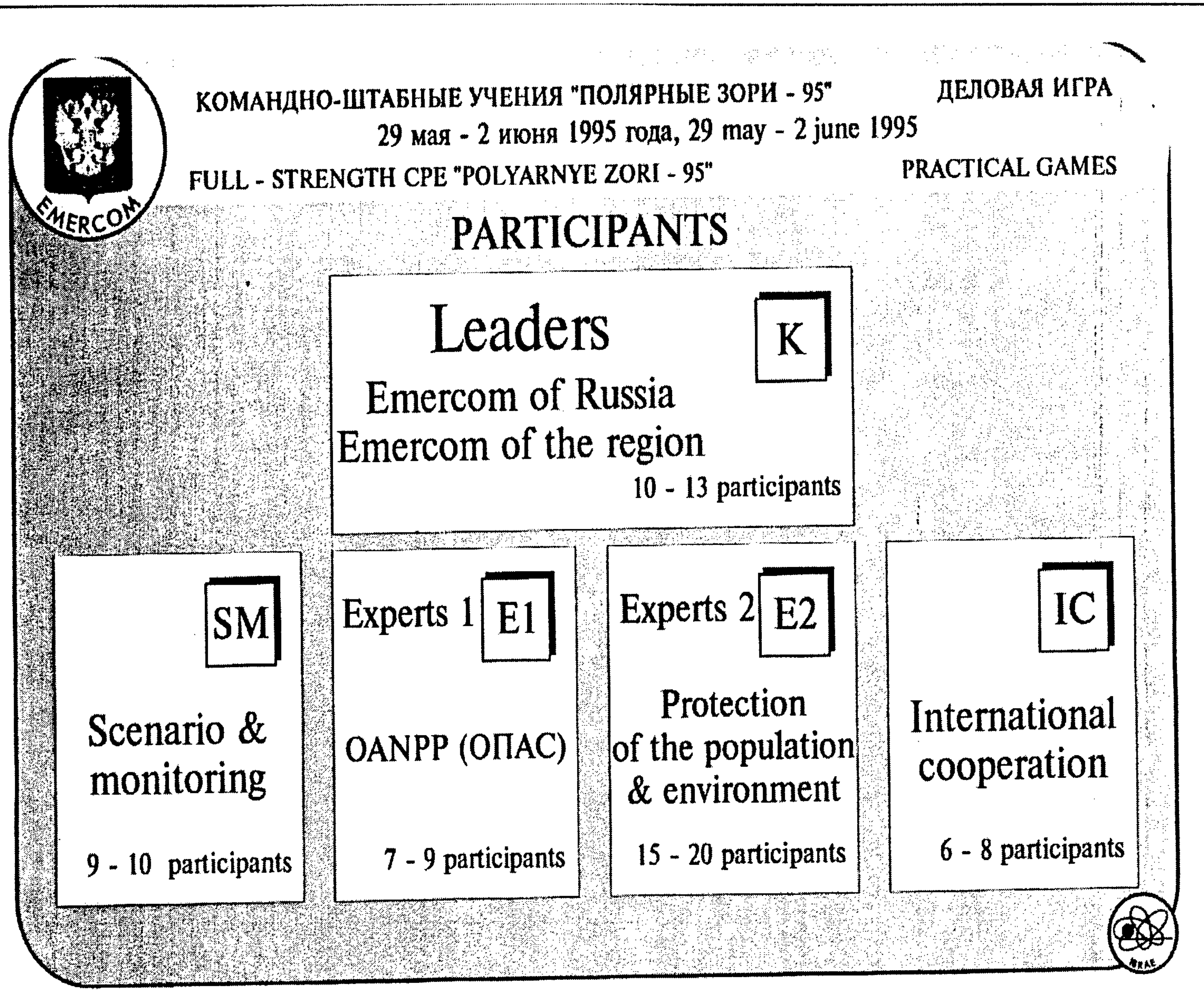
EMERCOM

COMMAND AND HEADQUARTERS TRAINING

PRACTICAL GAME

PRACTICAL MEASURES

IBRAE



КОМАНДНО-ШТАБНЫЕ УЧЕНИЯ "ПОЛЯРНЫЕ ЗОРИ - 95"
ДЕЛОВАЯ ИГРА
29 мая - 2 июня 1995 года, 29 may - 2 june 1995
FULL - STRENGTH CPE "POLYARNYE ZORI - 95"
PRACTICAL GAMES
EMERCOM
PARTICIPANTS
Leaders
K
Emercom of Russia
Emercom of the region
10 - 13 participants
SM
Scenario & monitoring
9 - 10 participants
Experts 1
E1
OANPP (ОПАС)
7 - 9 participants
Experts 2
E2
Protection of the population & environment
15 - 20 participants
IC
International cooperation
6 - 8 participants

КОМАНДНО-ШТАБНЫЕ УЧЕНИЯ "ПОЛЯРНЫЕ ЗОРИ - 95" ДЕЛОВАЯ ИГРА

29 мая - 2 июня 1995 года, 29 may - 2 june 1995

FULL - STRENGTH CPE "POLYARNYE ZORI - 95" PRACTICAL GAMES

FUNCTIONS OF PARTICIPANTS

K

- Coordination of practical game
- Formulation of the problem for experts
- Discussion of the recommendations
- Decision making
- Realization of the decisions on CPE

SM

- Generation of operative information
- Representation of the situation for the participants & observers

E1

- Information analysis
- Operative aid to NPP on localization of a accident
- Evaluation of the rediation sourse

E2

- Analysis, evaluation and forecast of the situation
- Development of recommendation on protection of

IC

- Realization of international cooperation and imitation of the cooperation

КОМАНДНО-ШТАБНЫЕ УЧЕНИЯ "ПОЛЯРНЫЕ ЗОРИ - 95"
ДЕЛОВАЯ ИГРА
29 мая - 2 июня 1995 года, 29 may - 2 june 1995
FULL - STRENGTH CPE "POLYARNYE ZORI - 95"
PRACTICAL GAMES

EMERCOM

Part 1
The third day after the accident
Tasks

Evaluation of the situation outside NPP

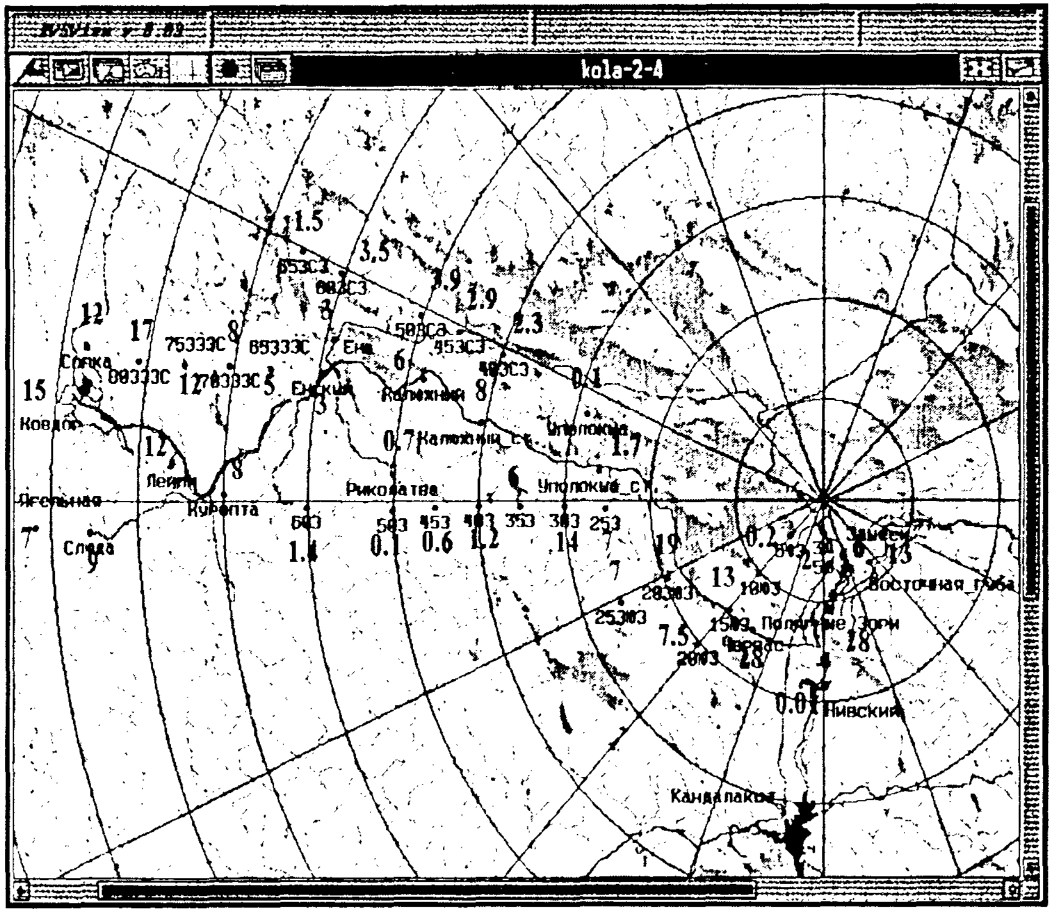
Development of recommendations on immediate actions:

radiation reconnaissance;
sheltering or evacuation of population;
iodine treatment

Refinement of the scale of transboundary transfer

Development of a request for aid

IBRAE



Мощности дозы гамма-излучения через 3 дня после аварии (мР/час)

Dose rate measures after 3 days after the accident. mR/h.

КОМАНДНО-ШТАБНЫЕ УЧЕНИЯ "ПОЛЯРНЫЕ ЗОРИ - 95"
ДЕЛОВАЯ ИГРА
29 мая - 2 июня 1995 года, 29 may - 2 june 1995
FULL - STRENGTH CPE "POLYARNYE ZORI - 95"
PRACTICAL GAMES

Part 2

Fortnight after the accident

Tasks

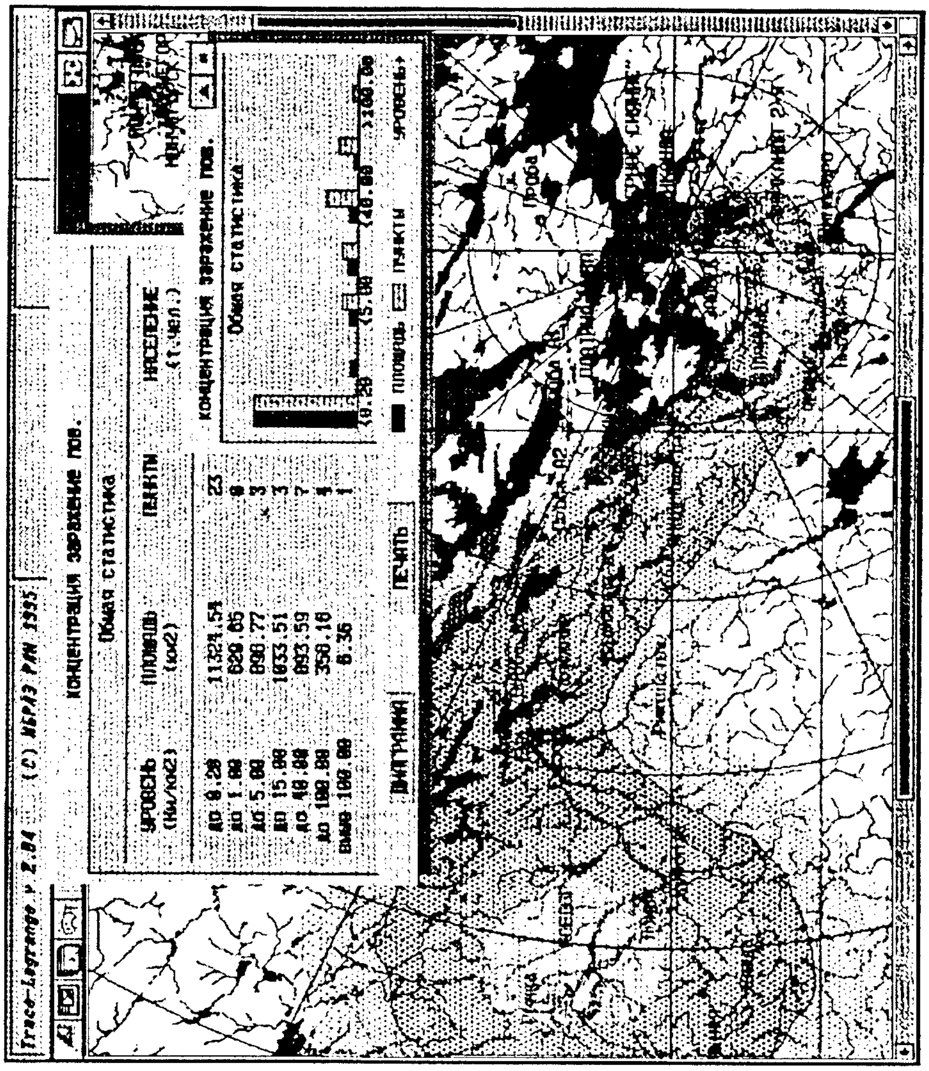
Redetermination of radiation situation

Evaluation of real exposure dozes for the population

Recommendations on protection & decontamination

Optimal utilization of the aid

Analysis of the consequences of transboundary transfer


Концентрация заражение пов.
Общая статистика
ПЕЧАТЬ

КОМАНДНО-ШТАБНЫЕ УЧЕНИЯ "ПОЛЯРНЫЕ ЗОРИ - 95"
ДЕЛОВАЯ ИГРА
29 мая - 2 июня 1995 года, 29 may - 2 june 1995
FULL - STRENGTH CPE "POLYARNYE ZORI - 95"
PRACTICAL GAMES

EMERCOM

Part 3

Month after the accident

Tasks

Recommendation on protection of the population & rehabilitation of the territory

Evaluation of the consequences of transboundary transfer

Evaluation of the efficiency of international aid and if necessary a development of the second request for aid

IBRAE

Desnogorsk (Smolensk region), 1996

Command and Headquarters Exercise in the Crisis Center of EMERCOM (EMERCOM of Russia, MAE RF, IBRAE RAS)

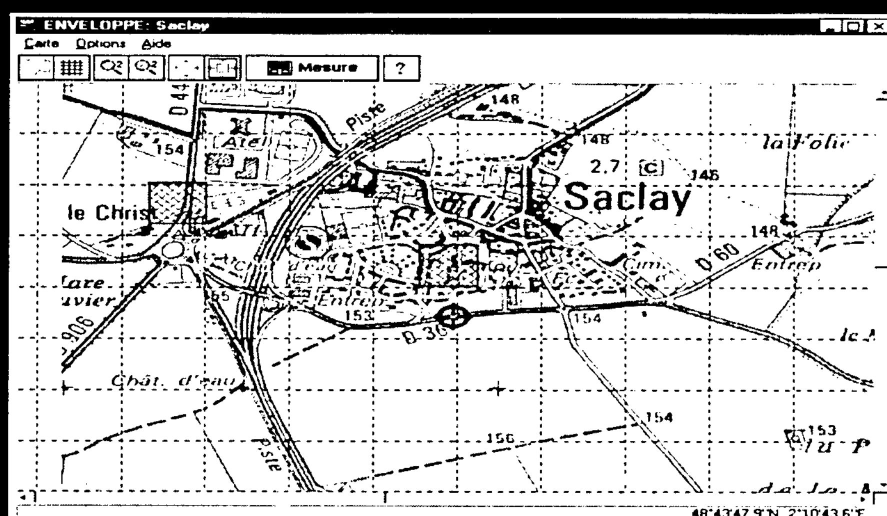
- about 80 participants from different ministries of Russia;
- Phases: Before and first day after the accident at the Smolensk NPP

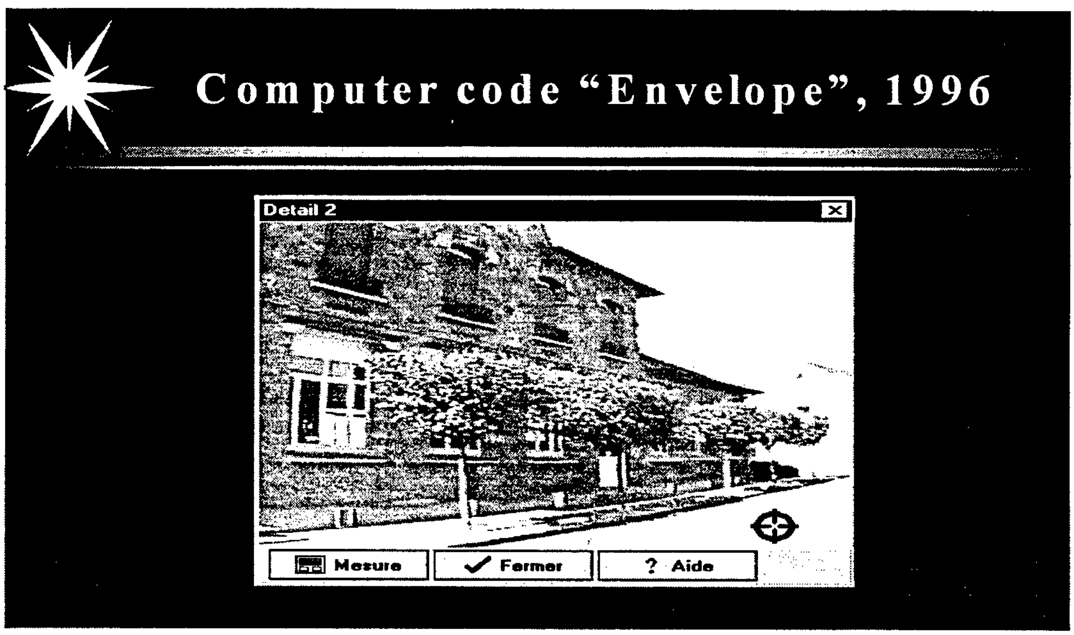
Saclay (France), 1996

Command and Headquarters Exercise in French Commissariat of Atomic Energy (Some Ministries of France, IBRAE RAS)

- about 500 participants from different ministries of France;
- Phases: First and 7 days after the accident at the reactor “Osiris” in the Saclay Nuclear Center

Computer code "Envelope", 1996

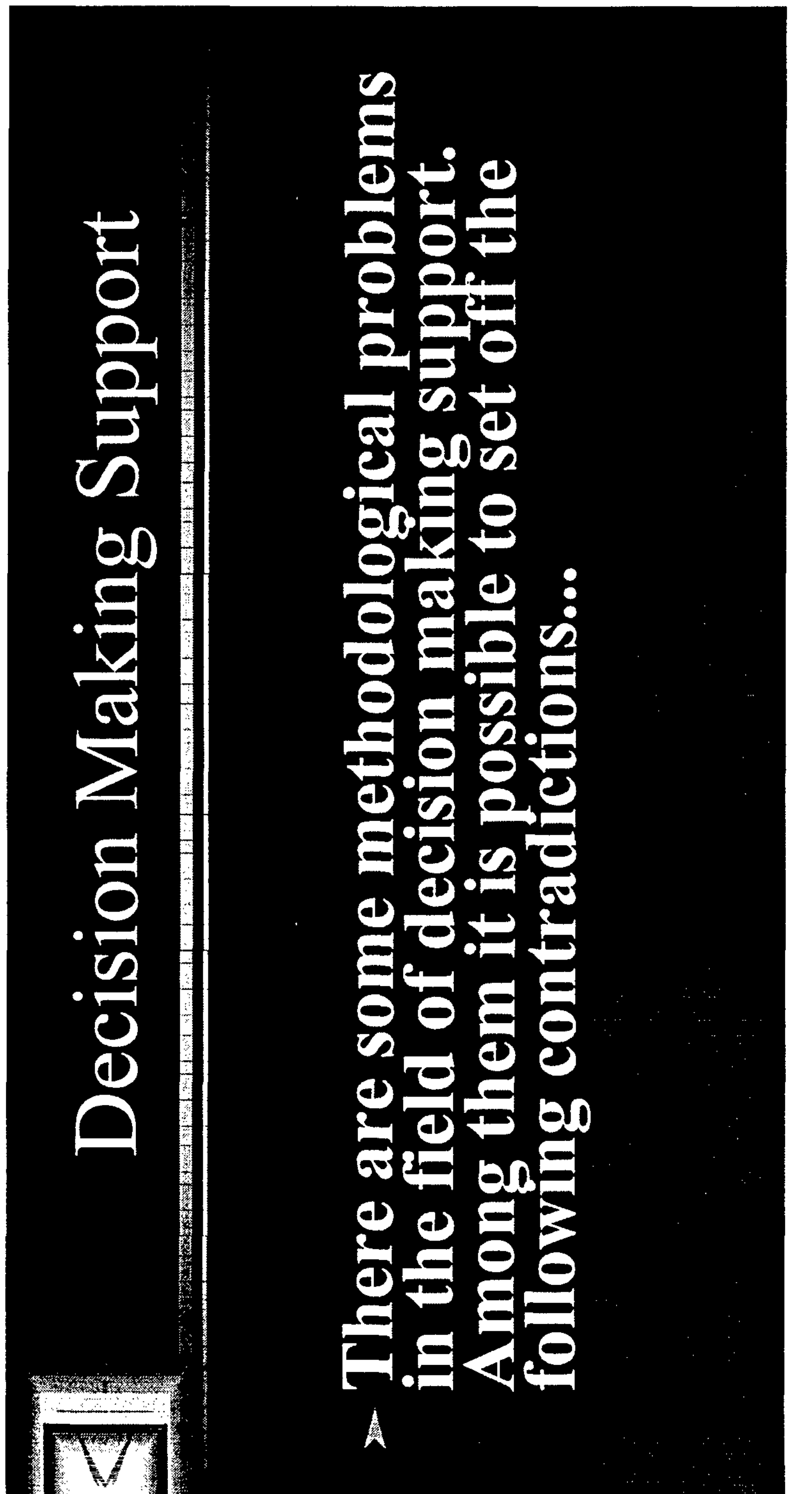


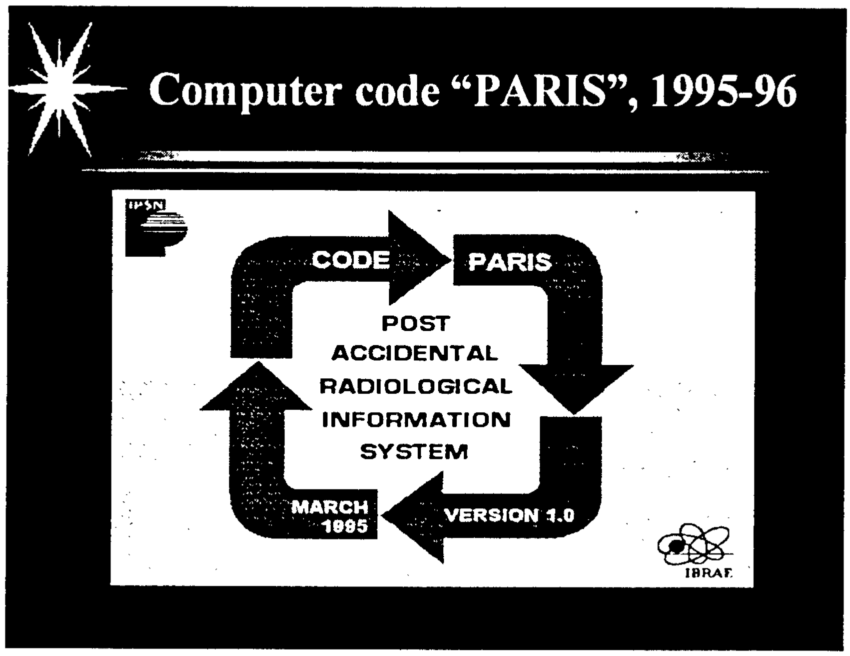

Computer code "Envelope", 1996
Detail 2
Mesure
Fermer
? Aide

Scientific and Technical Support for Decision Making to Protect Population at Radioactive Accidents:

Methods, Models, Information technologies

Rafael Arutyunyan
Oleg Pavlovski
Nuclear Safety Institute (IBRAE RAS),
Moscow, Russia

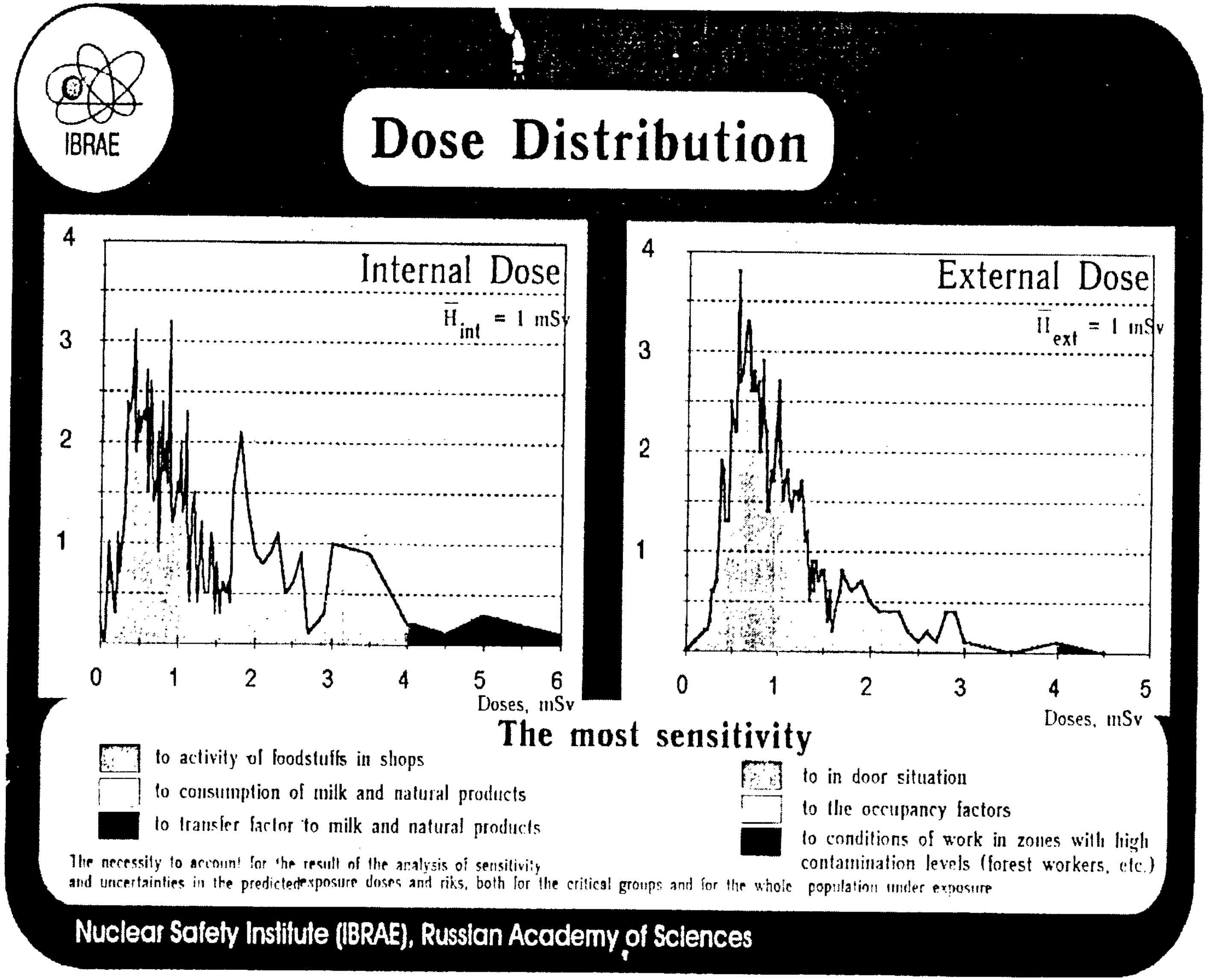

Decision Making Support
There are some methodological problems in the field of decision making support. Among them it is possible to set off the following contradictions...


Computer code "PARIS", 1995-96
IPSN
CODE
PARIS
POST
ACCIDENTAL
RADIOLOGICAL
INFORMATION
SYSTEM
MARCH
1995
VERSION 1.0
IBRAE

Decision Making Support

Contradictions between...

- actual distributions of analyzed data and threshold meanings of the norms;
- probabilistic estimations of radiological consequences and necessity of making deterministic decisions on protection of population;
- achievable efficiency of countermeasures and assessment of its actual efficiency from the viewpoint of population and mass-media


IBRAE
Dose Distribution
Internal Dose
$\overline{H}_{int}$ = 1 mSv
Doses, mSv
External Dose
$\overline{H}_{ext}$ = 1 mSv
Doses, mSv
The most sensitivity
to activity of foodstuffs in shops
to consumption of milk and natural products
to transfer factor to milk and natural products
to in door situation
to the occupancy factors
to conditions of work in zones with high contamination levels (forest workers, etc.)
The necessity to account for the result of the analysis of sensitivity and uncertainties in the predicted exposure doses and riks, both for the critical groups and for the whole population under exposure
Nuclear Safety Institute (IBRAE), Russian Academy of Sciences

Full-scale Practical Games

Specialists from IBRAE RAS organized and take part in the following practical games:

- St-Petersburg, 1993
- Moscow, 1994
- Apatity (Murmansk region), 1995
- Desnogorsk (Smolensk region), 1996
- Saclay (France), 1996

St. Petersburg, 1993

Decision-making exercise in post-accident situation in the case of radioactive contamination of large areas (EMERCOM of Russia, IBRAE RAS, IPSN-France)

- about 75 participants from Russia and France;
- local administration of the Kaluga Region;
- Phases: 15 days, 1 and 5 years after the accident at a hypothetical Russian NPP

BACKGROUND

IPSN

The experience of decision making exercises

Experienced experts

The Emergency Response Center work experience

NSI

The experience of providing of an informational support of the State Programs on the consequences elimination in Chernobyl and South Ural regions

The practical participation in the Expert Courtssessions on the problems of Chernobyl and South Ural affairs

Woking out of a software for decision making support

Kaluga region authorities

The administration experience
1 000 000 population
30 000 sq. km

The experience in people protection organization and rehabilitation of the territories affected by Chernobyl accident

SCENARIO

It was decided to produce a full model of the data on areas vital to the protection of the population and the rehabilitation of land, in particular the radiological and demographic situation, agricultural production and treatment of products, medical statistics and public opinion. Mid-May was chosen as the date of contamination because of its more serious consequences, while the persons involved in the exercise were to take their decisions at the 16^{th} day after the accident, then at one year after and finally at five years after it, in spring 1998.

SCENARIO

During the night of 16/17 May 1993, at an imaginary NPS near Kaluga region, radioactive gases and aerosols were released into the atmosphere. Dry radioactive deposits and precipitated deposits contaminated the soil an area of 1500 sq. km upper 15 Ci/sq km by Cs-137 in the nine cantons of the Kaluga region. The maximum contamination rate was approximately 100 Ci/Sq km. The Kaluga region authorities must take decisions to protect the population

Dr. Arutyunyan: Thank you very much. Now our next presentation by MAJ Rich Menchi of the Defense Special Weapons Agency.

Overview of consequences assessment tool set (CATS)

MAJ Menchi: I'll be giving a brief overview on the Consequences Assessment Tool Set (CATS). CATS is a joint project with FEMA and the Defense Special Weapons Agency. First, what is CATS? Simply put, CATS is a computer program that takes disaster models and combines them with databases inside of a GIS system. You can use ground base or satellite communications to send and receive real-time information, reports, and photos and send those back out to the emergency operations centers. There are two major parts of CATS. The first part, of course, is the models. Here's a list of some of the models in CATS and some of the agencies that are responsible for those models. We do not develop disaster models at DSWA for CATS. We integrate disaster models and provide the user with the models that he wants. The other portion of CATS, of course, is the databases. Here are some of the databases that are used in CATS. At FEMA headquarters, their CATS has well over 200 different types of databases. I guess the Achilles' heel of this program would be the databases. You need to have first of all accurate and up-to-date databases. Databases do go out of date very quickly. To meet the system requirements, you need the ARCINFO and ARCVIEW licenses; that's the GIS system. CATS works on a UNIX workstation. However we have been doing some work in accessing a UNIX-based workstation with a PC, using a Windows application. You need five gigabytes of memory, depending on how many databases you want to put into the system. Of course, you should have a dedicated communications line and a weather feed. Here are some examples of the output of the CATS model. Here is an output from Hurricane Emily. We went to CATS and asked, "What would be the damage to mobile homes when Emily makes landfall?" The nice thing about CATS is that, with appropriate databases, it tells you how many mobile homes are in the severe damage band, how many people live in those mobile homes, and then it prints out a resources list of how many tents, cots, meals, etc., you need to take care of those displaced people. It also lists the agency that would provide the resources. Here is an example of a storm surge from Hurricane Fran that occurred a couple of months ago. This is an earthquake that happened in Northridge, California, in 1994. Shortly after the earthquake, FEMA was sending out this image to local emergency operations centers (EOCs) in California. From this image, EOCs could get the scope of the damage and send the necessary help and resources to the areas most damaged. An assessment afterwards of all the 50,000 damage reports demonstrated that the ground truth matched quite well with the model, except for an area down in the south. Apparently, there was an unknown fault there, and that has been corrected in the databases. We also were able to do a run on Kobe, Japan. We had the databases, including the geologic database, and I understand that a high level official from the Japanese government was in Washington at the time, and FEMA presented this [slide] to them hours after the earthquake. Besides natural disasters, CATS can do technological assessments. This is a very busy slide of the street map of downtown Atlanta, Georgia. The red and yellow lines are major highways. The green line is railways, and, of course, the black lines are the streets. And in this case, we asked, "What happens if 3,000 gallons of hydrazine was derailed as it was crossing over into Interstate 75; what would be the results of that?" This is a very simple model. This is the Army's D2 PC model; it runs extremely fast and it gives you a quick image of what the disaster's like. We can also do radiological releases. In this case the background is Washington, D.C. It again allows you to look at population at risk. Here are some of the infrastructures; you've got two hospitals in the way of the release, and, of course, Union Station with the railways.

Still, CATS is still an R&D effort. It has been used in several actual emergency responses and numerous exercises, both civilian and military. Of course, we're rather proud of this. In this slide, you can see President Clinton. If you look closely, he has one of the CATS outputs from Hurricane Emily in front of him. CATS has been nationally recognized in the last few years, and this year we're one of the finalists in the Ford Foundation's Innovation for American Government Award.

For a quick recap, CATS can be used for both natural and technological disasters. It is operational now at FEMA and various other government agencies. It is available for civil and military emergency managers. We are continuing the R&D efforts to make it more user friendly for the customer. That concludes my overview of CATS. I can take some questions.

MAJ Mechi's slides begin on page 192.

Consequences Assessment Tool Set (CATS)

For Natural and Technological Disaster Prepardness

MAJ Richard Menchi
Defense Special Weapons Agency

Models Utilized

U.S. GEOLOGICAL SURVEY

- Earthquake Ground Shaking (Evernden)

DEFENSE SPECIAL WEAPONS AGENCY

- Overpressure Damage Functions
- Hurricane Wind Damage
- Prompt and Protracted Radiation
- Casualty Estimation
- Hazard Prediction Assessment Capability

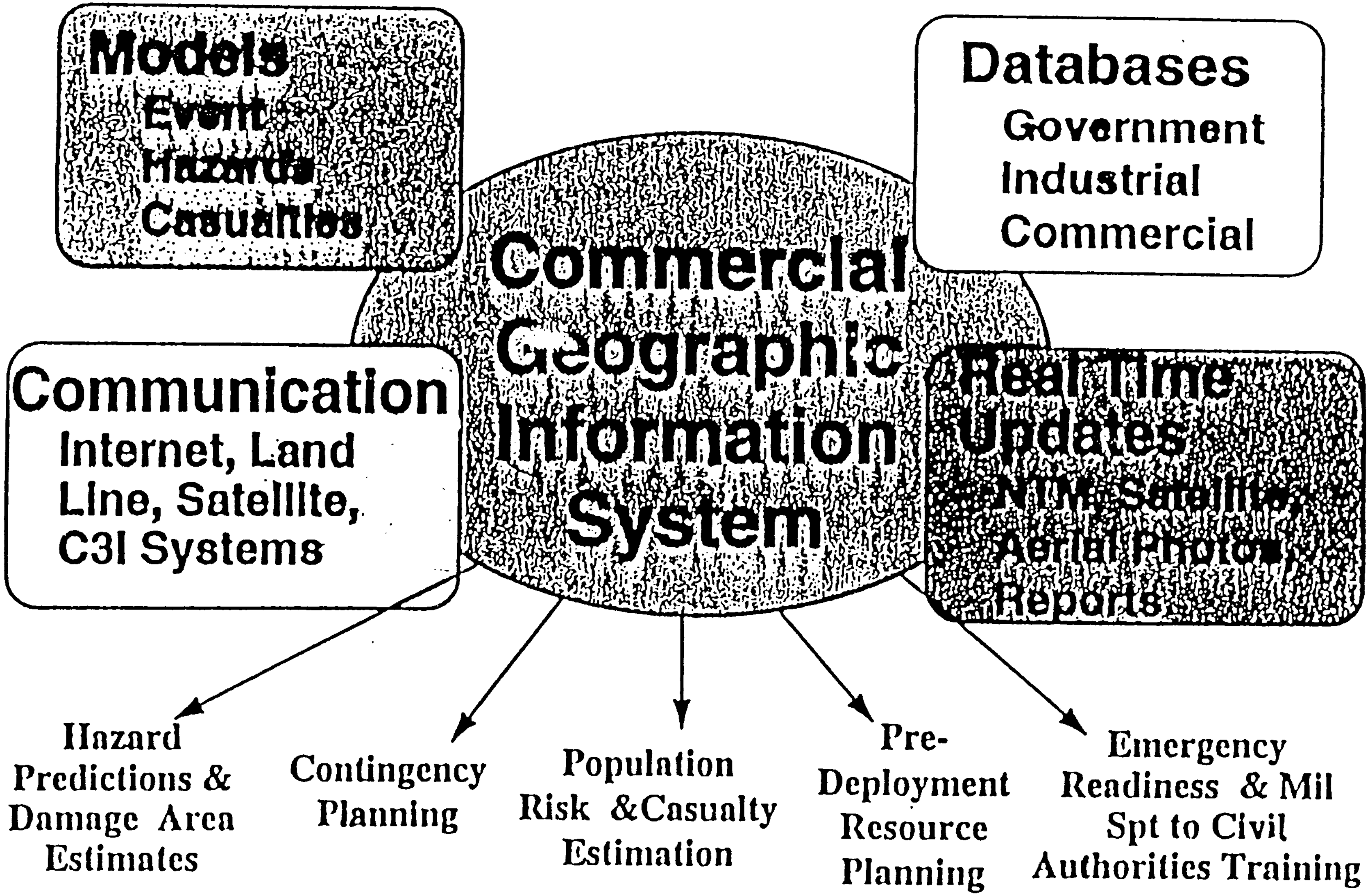
AUSTRALIAN BUREAU OF METEOROLOGY

- Huricane Wind Profile

CORPS OF ENGINEERS

- Flood Management

Program Concept



Infrastructure Databases Utilized

U.S. GEOLOGICAL SURVEY

- LAND USE/ LAND COVER (NATURAL & MANMADE FEATURES)
- DIGITAL LINE GRAPHS
  - HYDROGRAPHY
  - TRANSPORATATION (RAILROADS, ROADS, AIRPORTS)
  - ENERGY TRANSPORT (POWER LINES, PIPELINES)
- DIGITAL ELEVATION MODEL
- GEOGRAPHIC NAMES INFORMATION SYSTEM

ENVIRONMENTAL PROTECTION AGENCY

- RIVER REACH
- SEWAGE TREATMENT PLANTS
- WATER TREATMENT PLANTS
- MUNICIPAL/INDUSTRIAL POWER DISCHARGE POINTS
- WATER QUALITY MONITORING STATIONS

CENSUS BUREAU

- 1990 CENSUS POPULATION AND HOUSING DEMOGRAPHICS
- TIGER/ LINE FILES (STREETS, ROADS, HIGHWAYS)

Models Utilized

(Cont'd)

U.S. MARINE CORPS

- Wildland Fire Spread

NATIONAL WEATHER SERVICE

- Storm Surge
- Hurricane Track Uncertainty

FEMA

- Applied Technology Council for Earthquake Damage

U.S. ARMY

- D2PC Industrial Chemical Release

NUCLEAR REGULATORY COMMISSION

- Nuclear Reactor Release

System Requirments

- ARCINFO & ARCVIEW Licenses
- Unix Workstation (SUN SPARC 20 equivalent)
- 5 Gigabytes of memory for storage (10 desired)
- Optional
  - Dedicated communications line
  - Weather Satellite feed

Infrastructure Databases

(cont'd)

FEMA MASTER DATABASE

- AGRICULTURE
- TRANSPORTATION
- BUSINESSES
- COMMUNICATION
- MANUFACTURING

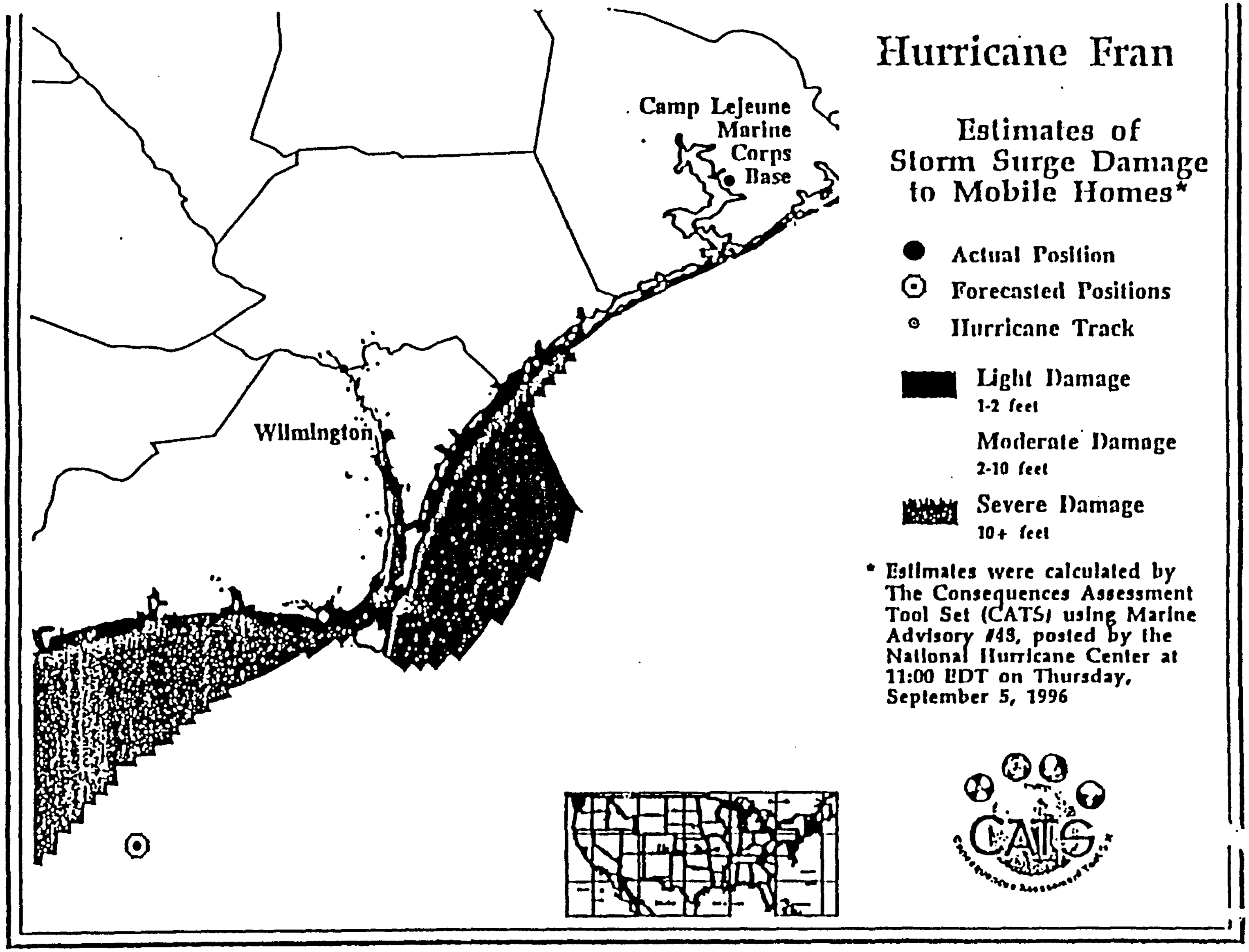
ENERGY
HEALTH
FINANCE
EDUCATION
GOVERNMENT

NATIONAL DECISIONS SYSTEMS/ EQUIFAX

- HOUSING
- POPULATION DEMOGRAPHICS ('90, '96, 01)
- BUSINESSES (10 MILLION)
- SHOPPING CENTERS

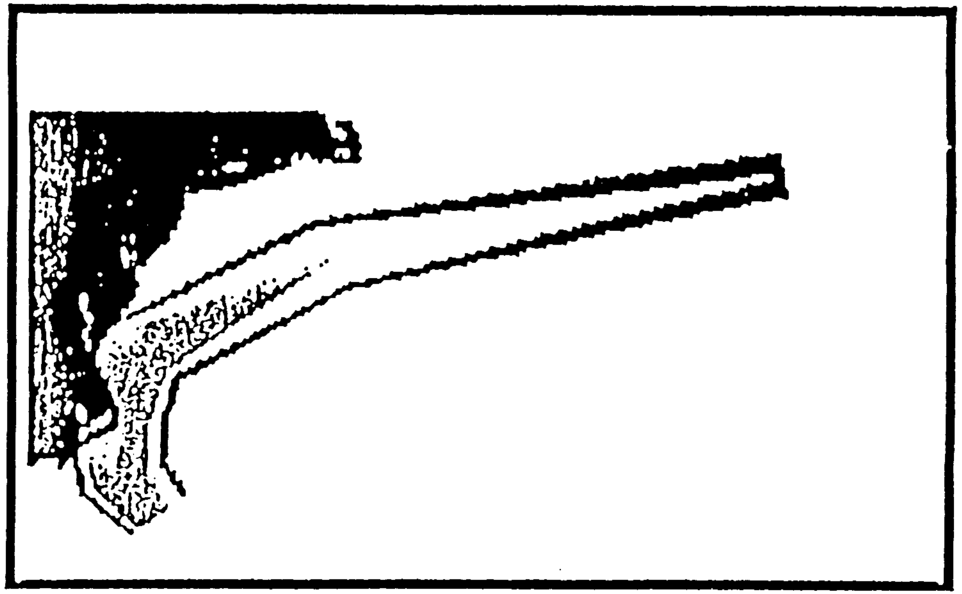
DEFENSE MAPPING AGENCY-CONUS/OCONUS

- DIGITAL TERRAIN ELEVATION DATA
- DIGITAL FEATURE ANALYSIS DATA
- NATURAL & MANMADE FEATURES
- DIGITAL CHART OF THE WORLD


Hurricane Fran
Estimates of Storm Surge Damage to Mobile Homes*
Actual Position
Forecasted Positions
Hurricane Track
Light Damage
1-2 feet
Moderate Damage
2-10 feet
Severe Damage
10+ feet
* Estimates were calculated by The Consequences Assessment Tool Set (CATS) using Marine Advisory #48, posted by the National Hurricane Center at 11:00 EDT on Thursday, September 5, 1996
Camp Lejeune Marine Corps Base
Wilmington
CATS

Pre-Deployment Resource Report

Hurricane Emily - 18 hrs prior to Landfall



Light Damage	Mobile Homes
Moderate Damage	Date: 8 31 93
Severe Damage	Time: 0900Z

Damage Estimation

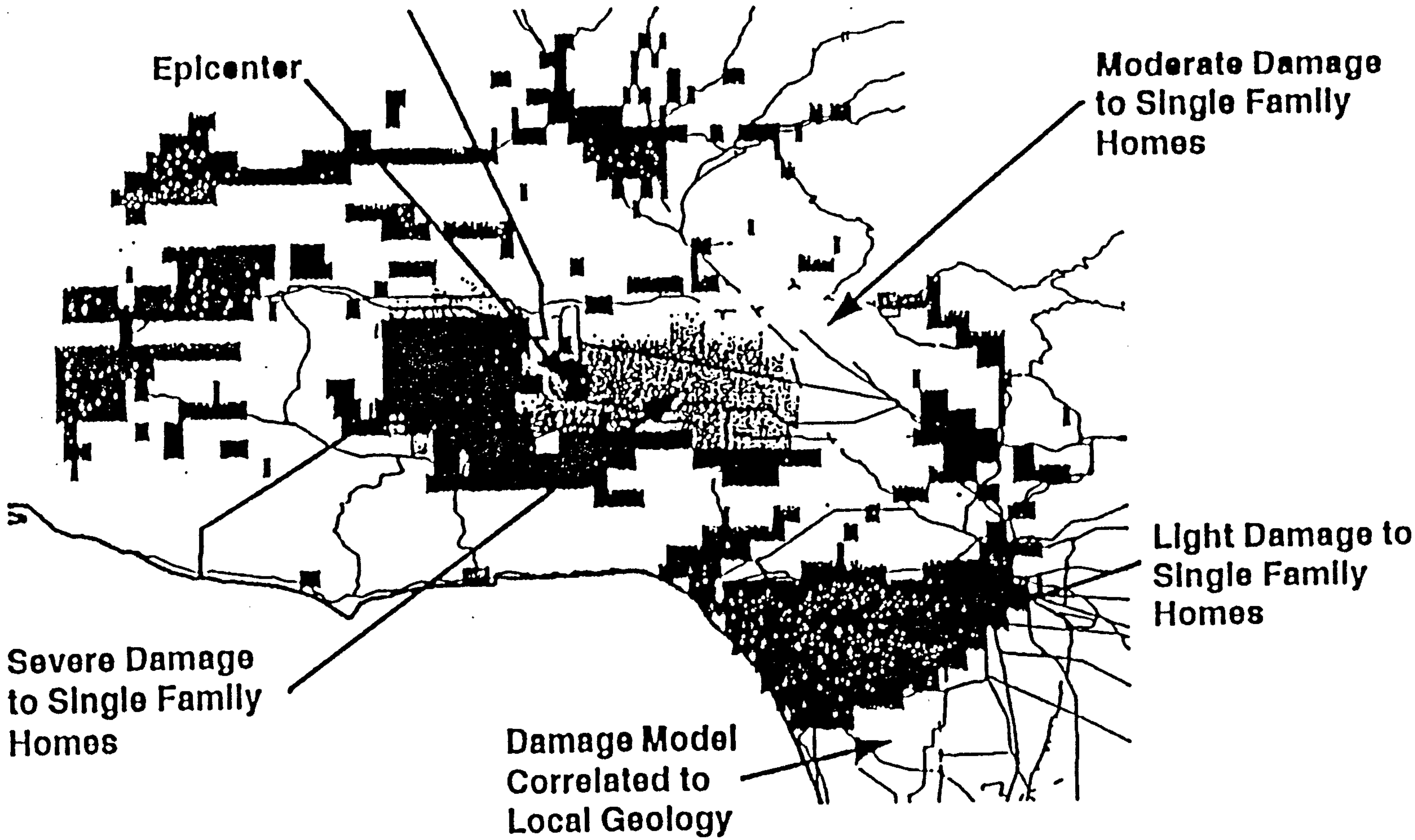
Housing: Mobile Homes
Damage: Severe

Value:	25202500
Units:	1759
Persons:	2683

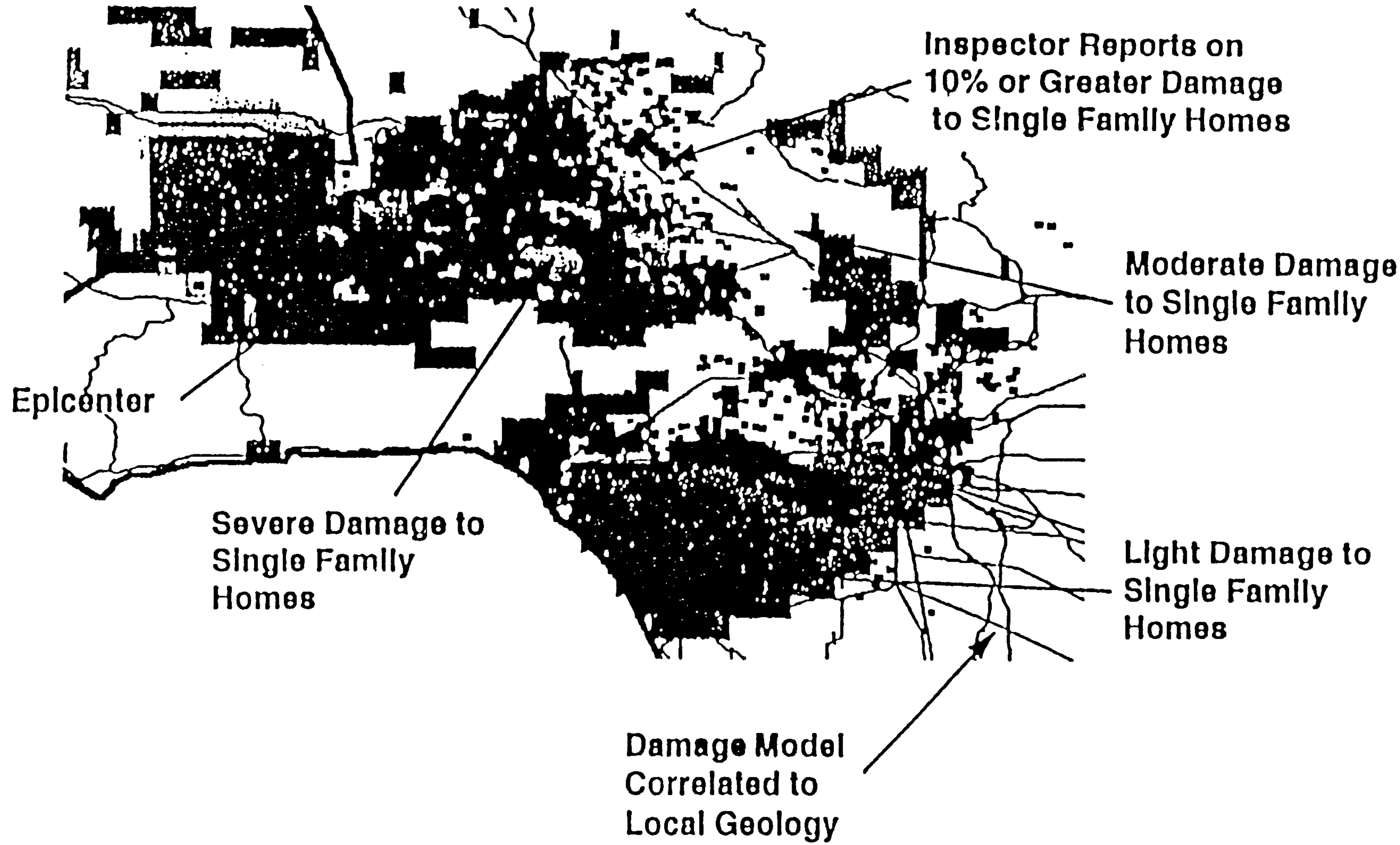
Deployment Package Resource List

Resource	Quantity	Agency
Meals	16098	DoD
Tents	268	DoD
Cots	2683	DoD
Blankets	2683	DoD
Water	5366	ACE/GSA
Portapotty	537	GSA
Ice Makers	283	DoD

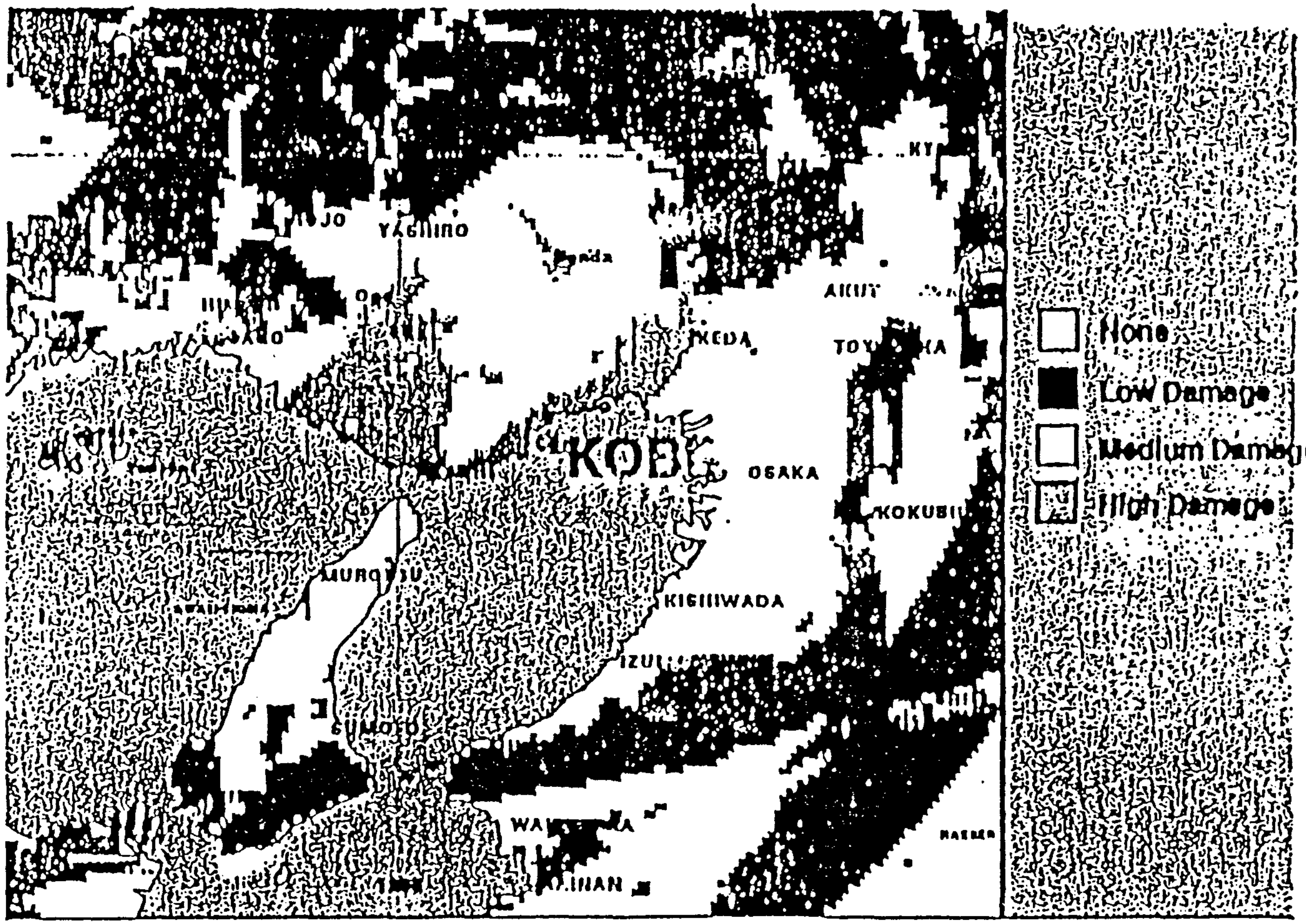
Earthquake Damage Assessment
Northridge, CA - 20 Jan 1994



Earthquake Damage Assessment

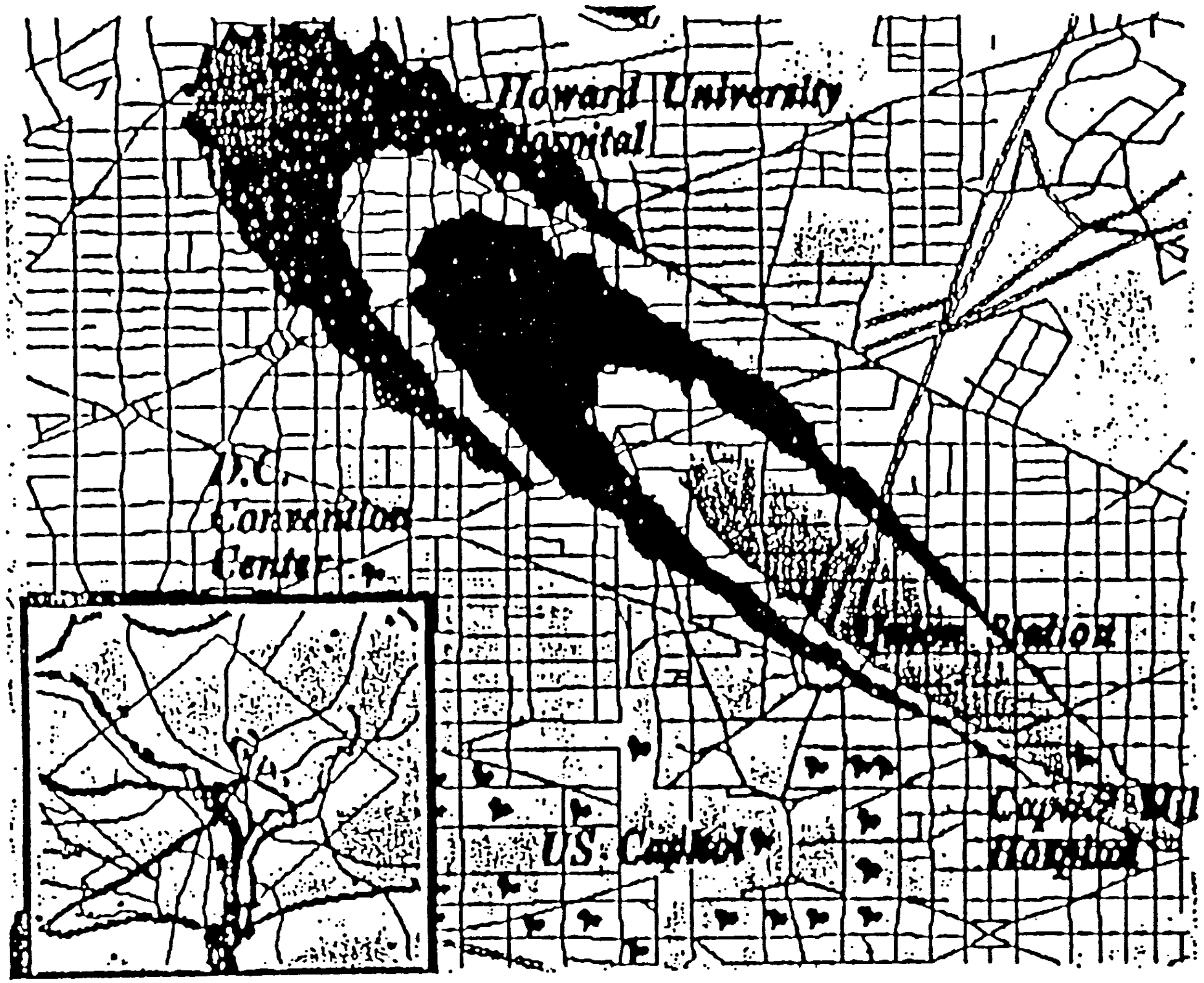


Damage Model: 1995 Earthquake in Kobe, Japan - Magnitude 7.2



Radioisotope Release

5000 Ci of Cesium, 100% aerosolized by a conventional explosion



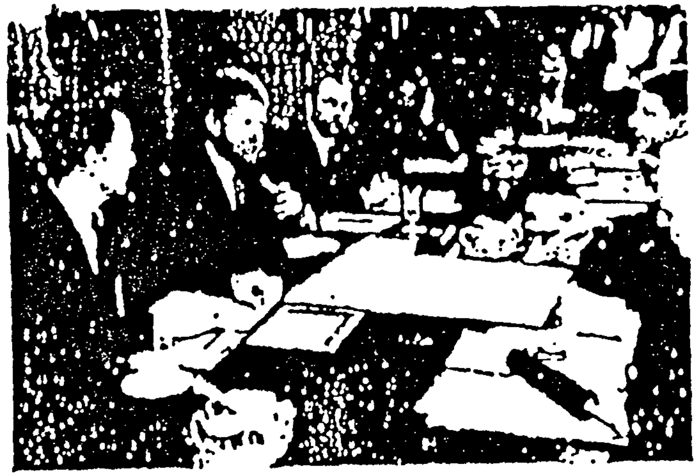
Pop 360,000
Housing: 220,000

Contamination
2-Hospital
31 miles of local streets
1 mile railroad

- 0.1 - 0.5
- 0.5 - 2.0
- 2.0 - 5.0
- 5.0 - 30
- >30 REM

How are the Information Tools being Used?

Emergency Response



- HURRICANES AND TROPICAL STORMS
  Aug 93 to Present (over 25 storms)
- EARTHQUAKES
  Northridge, Kobi
- FLOODS
  TX, FL, GA, CA, Midwest
- FIRES
  CA, CO, LONG ISLAND

Exercises

- RESPONSE 95
- New York
- Connecticut
- Florida
- CUSEC
- Puerto Rico
- Oregon
- JWID 94,95,96
- Hawaii
- III Wind
- Pacific Horizon
- Ellipse Circle
- Marine Corps Terrorist Response Team

CATS National Recognition

- 1994 *Federal Leadership Award*
- 1995 *Special Recognition Award for Public Service*
- 1996 Finalist, Ford Foundation's *Innovation in American Government* Award Program

RECAP

- DSWA and FEMA have developed a set of award winning tools to assess the consequences of natural and technological hazards
- Tools are operational and available for civil and military emergency management authorities
- Continuing R&D efforts are aimed at supporting customer requirements as identified

Dr. Arutyunyan: Thank you very much. Are there any questions?

Mr. Alston: There are several different programs to do all these assessments. Does CATS replace any of the programs that we've already seen, in terms of predicting what sort of casualties and so on that might occur? Is there any reduplication in all of these systems?

MAJ Menchi: Again, we aren't replacing any systems. We're a user of the different models that you have seen. As the models get more sophisticated, our job is to incorporate them into CATS. So it's really not duplication of effort. We just take the models and make them available for the customer.

Dr. Ainsworth: I would like to address this question to our Russian colleagues from the point of view of an administrator or policy maker. I would like to know if there is a connection between decisions to evacuate or taking of other action and projected health effects. What I am keen to understand is, what is the guidance given that politician or administrator in terms of the level of excess adverse health effects which must be taken into consideration in whatever evacuation decision is made?

Unidentified speaker: Well, the situation is normal. We do have a regulative document and regulations that determine the criteria whereby you make a decision to evacuate or to do other protective measures. Our task is to assess the situation, whether it's within the limits of the criteria for these decisions. Based on that, the administrator, using all these factors, makes an evacuation decision. He may even go beyond these criteria, for example dose criteria, and decide to evacuate according to the expected dose to the thyroid to children, pregnant women, etc. The evacuation decision is made according to these criteria and the situation that can dictate the necessity of evacuation even when the actual doses are lower than these criteria. Criteria are different as far as numbers are concerned, but they are similar, because during the accidents they are based on the dose; you make a decision based on the dosage, in an emergency situation.

Unidentified speaker: It is very important that we should distinguish between the role of scientists and administrators. Sometimes we tend to replace one with the other. If an administrator is a scientist but he is also the administrator, he must take into consideration more factors than a scientist would. A scientist should give you as much information as possible. He should not give an administrator a very simple answer like, "The dose is not going to be exceeded," and that's it. He should tell the administrator that there might be some further discharges, some contamination of foodstuffs, and also social and psychological factors. This is what we call the support of decision making, the topic we are discussing today. Thank you very much.

Emergency medical response at radioactive accidents and incidents: health concerns, internal exposure, combined injury, radiation burns

Col Reeves: This afternoon's session will be devoted to Emergency Medical Response at Radioactive Accidents and Incidents: Health Concerns, Internal Exposure, Combined Injury, Radiation Burns. Chairing this afternoon's session will be Dr. Shirley A. Fry of the Oak Ridge Institute for Science and Education (ORISE). Dr. Fry served until her recent retirement as Assistant Director of Medical Sciences at ORISE. Currently, she still serves as a part-time consultant at ORISE and is the acting scientific director of the International Consortium for Research on the Health Effects of Radiation. Dr. Fry...

Opening remarks of the session chairman

Dr. Fry: Thank you. Well, good afternoon, and welcome back from the lunch break. I'm very pleased to have the opportunity to be here and thank Dr. Reeves for the invitation. The topic for the afternoon, judging by the length of the title, is fairly complex. We're going to cover emergency medical response in radiation accidents and incidents, the health concerns, internal exposure, combined injury, and radiation burns. In this topic, we are coming now to the human consequences of accidents, emergencies, disasters, with the focus on the radiation components of such events. I think most of our attention, of the people on the panel this afternoon, has been given in the course of their careers to radiation accidents, but I think we should also take into account that, while we may be dealing with radiation as the primary feature of the accident, we also may be dealing with accidents of another nature, in which radiation is a component, so that we may have mixed types of health consequences as well as situations in which radiation health consequences are the major focus.

Our first presentation this afternoon is going to be given by Dr. Jim Smith, who is with the Center for Disease Control (CDC) and Prevention in Atlanta. Dr. Smith is currently chief of the Radiation Studies Branch and is involved in the Historical Dose Reconstruction Studies and in epidemiologic studies of radiation exposure, both to the general population and to other exposed or potentially exposed populations.

Acute and chronic public health concerns associated with radiation emergencies

Dr. Smith: Thank you, Dr. Fry. I appreciate the invitation to come and speak with you today. I've been involved to some degree with other aspects of the another project involving epidemiologic studies, and I'm glad to have a role in this part of JCCRER as well.

We often divide radiation emergencies into two broad categories--first, those dealing with the acute or critical phase. Initially, saving lives, treating injuries and burns, and preventing additional exposures have to be done very quickly and often with little information; but I want to focus this afternoon more on the second category, the chronic or extended phase. By that, I mean long-term follow-up of exposed people, both those that have received treatment as well as others who have been exposed or may have been exposed but have not received medical attention. Often the latter is a much less well-defined group. A basic message I want to deliver is: expect long-term follow-up of radiation emergencies, especially when many people are affected. In the U.S., we have found that no matter how small the exposure, there are frequently several issues that arise following radiation emergencies. The other point I would make is that much can be done during the acute phase to make the long-term follow-up easier.

Patients receiving treatment, whether the injury is due to radiation or something else, need medical follow-up. Today, however, I want to address the public health concerns that may lead to health assessments, epidemiologic studies or medical monitoring or intervention. Here radiation dose reconstruction plays an important role, and I will discuss that in more detail later. I will not talk about protective action guides, since you have already heard about these. I do want to mention, however, that they are important in long-term follow-up. Issues of evacuation and sheltering are important; also making decisions on returning home or to work after an area has been contaminated. We rely on protective action guides there, as well as, in preventing or reducing food contamination, as you heard from George Bickerton this morning. Developing protective action guides is one place where the federal agencies can be important because you cannot always expect the state and local authorities to have the resources to develop these guidelines.

Registries are always helpful, perhaps necessary, in long-term follow-up. Not only registries for emergency personnel, but also for people treated, including the medical personnel involved in the treatment, and a registry of people within the affected area, i.e., the area where people have been exposed. What we mean by registry is simply an official record of identifiable individuals associated with an event. It is important to know all of the individuals that were within the affected area or who have been monitored in some way. Sometimes we forget this, especially during the acute phase of the incident. Usually we get such information on the injured or treated, but often not on those who only get monitored.

What do we mean by "affected area"? Usually it is an area bigger than we think. In public health we normally use the linear- no threshold hypothesis, meaning that, no matter how small the exposure, there is some possibility of getting cancer. That makes it hard to define who the exposed people are and what the affected region is. We find it imperative to involve the public and the local health care providers as early as possible in those decisions.

Radiation dose reconstruction has been a topic of interest to us at CDC. Ususally these have been around historical incidents, mostly involving nuclear weapons facilities. We have been involved for a number of years now, in a large historical reconstruction at the Hanford Nuclear Reservation in Washington State. There were 700 to 800 thousand curies of iodine-131 released during the mid to late '40s at Hanford. Historically reconstructing what people's exposures were environmentally in the Hanford area have dealt with a number of complex issues. When we have a release, people can be exposed by direct inhalation. We are all familiar with the pasture-cow-milk pathway to people. The Columbia River that flows through the Hanford Nuclear Reservation and through Washington State, which has been a source of food for many people, especially the Native American Indian tribes in the Pacific Northwest. We have to consider the contamination of food and crops by this river pathway. The greatest issue is reconstructing what residents' exposures or doses were 40 or 50 years after the event, when given a radionuclide like iodine-131 with a half-life of only eight days.

What are some of the general requirements for dose reconstruction, whether we're reconstructing from events 50 years ago or an event that happened last week? First, we find that we rarely have enough data involving radiological survey and monitoring. Results of bioassays in people, and knowing who these people are or whom the survey or monitoring was done on, is important. Tracking of those who were evacuated or treated is also important. We know how tough of an issue that has been with the liquidators from the Chernobyl incident. Samples of clothing, jewelry, or body fluids are not always available, but whenever they are available, they can be helpful.

What is the alternative in the absence of data? Modeling. We are all aware of the shortcomings of modeling in reconstructing doses. Whenever we have hard data to base that modeling on, we are that much further ahead. Of course, any cytogenetic data that we have available would be useful. Internally incorporated radionuclides are often the most significant issue. We think of external exposure, which can be overriding on occasion, but, in most cases, radionuclides ingested or inhaled have been the most substantive issue.

What is the critical group, when we deal with environmental radiation exposures? Based upon the interactions we have had with people around the U.S., the answer is easy--infants and children. I cannot count the number of times we have heard mothers at public meetings stand up and say, "Look, we're really not so concerned with exposures that we got. What about my child, what about my three-month-old infant? What kind of exposures did they get, and what do they mean? What will be the risks from those exposures?" For these questions a lot of specific information is required. Personal identifiers are at the top of the list: names, social security numbers, addresses of people, no matter how insignificant it might seem at the time, certainly the location of the people at the time of the accident. Local weather conditions as we know play an important role, particularly with radionuclides, fallout, and washout rainout--fraction of time spent indoors versus outdoors. The route of evacuation and estimate of evacuation time can be critical in determining external doses. The medical condition of the person can be important; for example, if someone had asthma or some respiratory ailment at the time, this can affect whatever modeling we do with inhalation of radionuclides for that person. Of course, it matters whether or not the woman was pregnant or if there were any infants carried along. Was the person part of a special group, i.e., a nursing home that was evacuated?

I have presented a number of questions we need to consider. There is one tip that many of us have learned in situations like this. Anytime you can use tape recorders or whatever is new on the market--mini-recordable CDs, videocameras--any device that can collect information without us having to write things down--we have learned in our training exercises that these can be invaluable.

I would like now to discuss examples of long-term public health response for radiation incidents and accidents. I have already mentioned the Hanford Nuclear Reservation. There is apparently a dramatic increase in thyroid cancer in children, following Chernobyl. We have also noted that at least for parts of the region for which there have been significant fallout from Chernobyl there are corresponding regions that have chronic iodine deficiency. Given that chronic iodine deficiency may promote radiation-induced thyroid cancer, we have asked the question, "Might it be important to use as an intervention iodized salt, or some other means of correcting the iodine deficiency? Could that play a role in decreasing the risk of thyroid cancer?" We are also interested in demonstrating the value of building long-term relationships among institution in the U.S. and Newly Independent States for broad public health issues. We, therefore, plan to bring to the Gore-Chernomyrdin Commission some suggestions on putting together teams of Russians and others in the former Soviet Union with U.S. counterparts to explore the issue of chronic iodine deficiency in the region and what public health interventions might be done. In radiation accidents and incidents we often tend to focus on the physiological and medical aspects of treatment or follow-up for obvious reasons; however, it is important that we learn more about how to deal effectively with psychosocial issues, psychological trauma, perception of harm and related public health issues. Often in radiation accidents many lives are significantly disrupted. Three Mile Island reminds us of that here in the U.S. There was a great deal of disruption of many families since the Governor asked that all pregnant women and children be evacuated in the vicinity of Three Mile Island.

At CDC we have found that it is critical to involve the affected public as soon as possible in long-term follow-up. At the Fernald, Ohio, uranium facility, where we have supported radiation dose reconstruction, we have recently taken a new tack on communications with the public. We have "translated" technical reports into posters, on display, using lay terms, and invite community members to meet with us and discuss the science and the results. People who lived close to the Fernald area were exposed to uranium and to radon from historical operations at the facility. We always have a very active, interested public at meetings like this. Many members ot the public there "do their homework." They bring copies of the technical reports with them. They have them annotated, and ask many questions of the scientists and they are not always easy questions to answer. But the public gets heavily involved and early in the process. We have had 25 public meetings since 1990 in the Fernald area with people such as this, to bring them along throughout the entire process.

At Hanford there are nine American Indian Tribes and Nations that have been concerned that they were exposed in the past not only to radioactive iodine emissions, but also to other radionuclides released into the Columbia River. Fish has always been an important component of their diet and many from their Tribes historically migrated along the Columbia. We have been working with each of the Tribes (independently at their request) to see what issues they have and what studies we might do with their collaboration. To help promote this cooperation, we provide education and training in epidemiologic methods, public health, and radiation basics for interested Tribal members. This is what I mean by public involvement.

In conclusion, much can be done during the acute phase of any radiation accident or incident to prepare for long-term follow-up which almost always occurs. Furthermore, appropriate follow-up involves more than medical and radiation expertise. It is crucial to work with the public health officials, locally and federally, as well as the affected public in decisions about what activities are needed, including health studies, medical intervention, and clean-up.

Dr. Fry: Thank you, Dr. Smith. That was very interesting, a very broad spectrum of activities that are involved in responding in a public health situation. Are there any questions people would like to address to Dr. Smith at this time?

Dr. Julien Vanlancker, UCLA: Inasmuch as there's absolutely no evidence, at least that I know of, of iodine deficiency causing cancer, don't you think it is more likely that children that are deficient will absorb more of the radioactive material and that it's mainly a dose effect?

Dr. Smith: No question, that plays an important role. If they are iodine deficient at the time of exposure you would expect them to absorb more radioactive iodine. I'm not a physician, but it has been pointed out to me that it is biologically plausible for an iodine-deficient thyroid to play a role in cancer promotion as well.

Dr. Young: You said, and I have heard this said so many times it's almost become accepted, that there is an increase of thyroid cancer among the children in parts of Russia that have been looked at intensely, as well as Belarus and Ukraine. Have you at CDC looked at that to see if that's really true? Is it just simply that now that we are all looking carefully for thyroid cancers, we are seeing a lot more of them? Do we have adequate controls? I don't doubt that it could happen, but it seems to me that everybody's going along assuming that this is really the case, and I haven't seen the compelling information that really says that it is. So I thought that since we had representatives from all over here who know about this, I'd just raise this issue, and I look forward to being enlightened on the subject.

Dr. Smith: Well, Bob, certainly that is a good question. What we understand at CDC, is that there is an increase in thyroid disease among children in the region of Chernobyl. We are hearing that from our colleagues in public health on both sides of the Atlantic. Now, is that associated with radioactive iodine or other exposures? Could it be due to external radiation exposure? Is it associated with Chernobyl exposures? Is there a dose response relationship? I don't know. I do know that the National Cancer Institute is working with their colleagues in Belarus and Ukraine, trying to address these questions, by appropriate dose reconstruction and epidemiologic studies. I would like to wait for the results of that, but it is my understanding that there has definitely been an increase in thyroid disease among children in the region.

Dr. Young: Could I also get you to comment on something else that may be closer to your area of expertise? What is your assessment of how well we're doing in dose reconstructions with iodine? And a secondary question I'd like to raise, is anyone looking at something like a long lived radioisotope (e.g., iodine-129) as a marker that might still be hanging around, so that you could index it to iodine-131and get something other than a dose reconstruction in an actual physical measurement?

Dr. Smith: I think that dose reconstructions everywhere are being done much more carefully than ever before. Part of the reason is that a lot more resources are being provided to do that. As to your second question, iodine-129 might be a good marker for earlier I-131 exposures. You would expect that these isotopes go together biologically. How could the thyroid discriminate between the two? There certainly is I-129 in the environment that can be measured. A lot of that has been done around Hanford but, again, that's only a marker that tests the models. Given the uncertainties in the models and in the measurements, this is often not a clear test of model validation. Now, of course we cannot use iodine-129 in biopsy or autopsy tissue from the thyroid because of the biological turnover of iodine, within the thyroid on the order of 30 days. So you see, biologically iodine is removed rapdily even if the isotope is long-lived.

Dr. Vanlancker: Among your registries you didn't include tumor registries, and those are very important. If you'll remember in Hiroshima and Nagasaki there was no tumor registry until 1958, and the correct result appeared only after that period.

Dr. Smith: Absolutely, you are quite right. Thank you for pointing that out.

Dr. Fry: Thank you very much, Dr. Smith. Our next speaker is Professor Angelina Guskova who needs probably very little introduction to many in the room. Dr. Guskova is a doctor of medical sciences and a corresponding member of the Academy of Medical Sciences in Radiation Medicine in Russia. From 1974 to the present, she has been associated with the Clinic of the Institute of Biophysics of the Academy of Medical Sciences. Dr. Guskova will be focusing on the impact of radiation accidents on the medical community and particularly the hospital community.

Main principles of emergency medical help: analysis of experience of hospital activity at the Chernobyl accident

Dr. Guskova: Dear colleagues! For me, it is very important and I am very honored to share with you the experience we gained in working with the very varied groups of people who were involved in radiation situations, including those who endured exposure. I must say, that 10 years have passed since the Chernobyl accident. This is a good amount of time to be able to look at the past, to consider it critically, and to evaluate the successes and errors. We did this, at least it seems to me, rather quickly. Already in August of 1986, we told about our patients in a large report, about the illnesses endured, the first impressions, and about the effectiveness of the treatment measures undertaken. This has always been a tradition for us, even in the years when our countries were artificially divided.

In 1954, in Geneva, I presented the first two cases of severe radiation illness together with Dr. Baysogolov. In 1971, we wrote a book on radiation illness in humans, which, if I may, basically exhausted the experience in chronic radiation illness, since, afterward, these cases were already very rare, and exquisite. This book was translated in 1973 in the US Library of Congress, and so you've had close to 20 years to familiarize yourselves with our materials. On the other hand, I must say that we learned a lot, especially from our American colleagues. Today we gratefully note the names of Professors Bond, Cronkite, Burns, Blum, Lushbaugh, whose books and works were and still are our desk reference books, even to this day. Of the European scientists we gratefully remember Professor Jammet, who unfortunately is no longer with us, and Professor Dunster, who was a direct participant in the Windscale incident. We must combine our experience. It is still too small for each country to get by independently. I have in mind that experience which touches particularly on changes in the state of health, related to exposure. What does our experience consist of?

On the first slide, you see our experience with accidents over this entire length of time, including the number of situations, the number of exposed people. If the number of situations does not rise significantly, yet the number of involved people rises in particular, as can be seen in the last column, with the cross, of the, 134 patients had severe radiation illness due to Chernobyl. How do we categorize these situations? They are categorized by a series of factors, in the first place, related to the early stages, with the criticality of the accidents, and in the later stages, with a significant broadening of the radiation sources, the emergence of situations with gamma and beta sources, which are of special interest to us. Let's say we talk about what happened during those years with the situations of severe radiation illness. In the first place, the spectrum of radiation sources changed and widened. The number of people involved in the situation rose, including those among the general population. Dose reconstruction has improved, international cooperation has grown. In this slightly cartoonish figure, we present the main situations. Criticality accidents are in the lower left corner—gamma source. Faults mainly with personnel, [with non-uniform partial body exposure—Ed.]. But here is an atomic bomb explosion. At a large distance—this is a small person, with whole body irradiation. And finally, situations with gamma and beta sources, similar to the Chernobyl situation. What types of clinical forms arise in these situations? The multitude of forms can be presented with very few, really, with two extreme conditions: generally non-uniform exposure; very uniform exposure; or intake of radioactive matter, combined in a portion of cases with other, non-radiation factors.

An answer to these clinically severe forms of radiation illness, forms with reported injuries from the totality of radiation factors [literal translation; probably means whole body uniform irradiation—Ed.], and forms of non-uniform radiation of a small section. These two different forms also give different types of answers. Uniform exposure is very important for clinicians, because at Chernobyl it was precisely uniform, in terms of the gamma exposure. The clearly represented phase-like nature, the overt period of depression of hematological elements, the distinct recovery, coinciding with the prescription. However, here is another condition, with severely non-uniform exposure, when a series of waves of depression occur. The recovery period is also unstable. Combining localized and overall injuries really distorts the clinical picture. It brings about many difficulties in interpreting and evaluating the dose spectrum. For accidents with uniform exposure, you see a constant reduction in the period during which there occurs a drop in, in fact almost a total lack of, blood cells. Here patients are concentrated from a set of accidents with a higher dose level. I want to show you that being able to survive like this in this range of doses is also an effect of our combined efforts.

This [slide] is Chernobyl, the destroyed fourth block. This is a new era for us. This is a somewhat unusual situation given the characteristics of these injuries. Here, the main ones are exposure of personnel directly, who suffered during the time of the accident. First of all, these are the shift personnel who were there at the moment the accident occurred. These were the first people who were sent to analyze the situation, what happened, and the first to attempt to limit the accident. Finally, it is the people who were called for reconstruction work for permitted sections of the first-third blocks in July of 1986, and the beginning of 1987. All the subsequent situations are already somewhat different. We'll touch on them later. These are people who worked in the 30-kilometer zone, or who lived in the 30-kilometer zone. These are people who were evacuated for various periods of time, and finally, widespread populations who were located on territories with somewhat higher levels of contamination.

What are our main discoveries concerning Chernobyl? They are given here on this slide. This is our patient, known, probably, to the whole world, one of the firefighters, who took the first strike upon himself. But above all, there were 134 verified cases of severe radiation illness. When we were sorting things out at the site, 129 people came to us with suspicions of radiation illness. The preliminary diagnosis gave us 115, and the final verification, 104. Unfortunately, the situation was different in Kiev. Roughly the same group of patients received there, close to 150 people. Verified cases for only 30 people. One-a dangerous one-, and the rest were relatively light injuries. In all, we lost 28 patients. 27 in our clinic, mainly, with doses higher than 6 Gray, and some with doses from 4 to 6 Gray. In all cases there was significant beta exposure, exceeding the average whole-body dose by roughly 10 to 20 times. There was a very small intake of radioactive matter, I want to emphasize this, in only two cases. With thermal burns of the skin, the doses from internal exposure were comparable to the doses from external exposure. Another two people had intake of iodine with an 11-13 Gray dose to the thyroid. There were weak clinical indicators of thyroid dysfunction with favorable movement over 10 years after corrective therapy. Other consequences include radiation cataracts- 8 cases.

All cases with a dose greater than 5 Gray were in the facial area, plus an additional dose - this was an overall dose from beta exposure. There were firm changes in the skin in 8 to 10 people, with scars, ulcers, which needed repeated treatment. There were lesser changes in the form of unstable cytokines, I'll show you pictures, non-specific astheno-vegetative disorders, and in one group of patients, even the undoubted effect of psychological and social factors, of which the preceding presenter spoke. Features of the form. Relative to a wide range of doses, nearly half of the people with a dose, as I have said, of 10-20 times greater than the average per Kela (sic), had clinical emergence of skin injuries. Mucositis, enteritis, (transcript omission), starting mainly at the higher exposure doses. 7 cases of serious pulmonitis. Lethal outcomes, as you see, are in the highest dose range with a combination of syndromes-- 3-4 clinical syndromes for one individual. This explains the lack of effect of bone marrow transplantation. Here we demonstrate the relationship of gamma and beta doses, the typical distribution of burns in areas with the greatest contact with skin and semiquantitative curves which characterize the sub-dynamics of the symptom on skin in various burn injuries.

In addition, the volume of uniform exposure is of great significance. In this connection there is a very clear correlation for 500 neutrophils and the number of dicentrics. Similar characteristics can be presented and equations may be constructed, which we use in our expert systems, for predicting injury according to the number of neutrophils. The next figure characterizes one of the very important items which permitted us to reconstruct the exposure dose. The curves characterizing the number of dicentrics, and estimating the dose according to the number of equalized dicentrics [probably number of dicentrics normalized to background--Ed.] Next slide, please. A very important and simple diagnostic indicator is the number of lymphocytes in the peripheral blood, which was used in the initial, rapid sorting period. All the main clinical events are closely related to the external exposure dose, including the dose-time relationship of cytopenia and the spectrum of infectious complications. You can see that it is clearly implicated in a high level of dose, widening its spectrum, and taking up a large period of time, and infection occurs (transcript omitted), viral infections, and significant complications arise to interfere with the possibility of helping the ill in relation to these infectious complications.

I turn your attention to this slide, because discussions of lowering infectious immunity with doses up to 2 Gray, are absolutely unrealistic according to our experience. There can be no real clinical manifestations. Let's discuss recovery. Even in people who survived radiation illness, we especially show two patient groups: 1-2 Gray, 5-9 Gray. At 48 months of observation you see that the depth of the reduction in the severe period is different, while the recovery is practically always within the bounds of the norms. I really would like to tell you a lot about our experience. There are similar data relative to the number of thrombocytes. You see the drop, and the subsequent recovery. Thus, if you systematize those who survived, what did Chernobyl' leave behind? The first group: 134 cases-- early lethal outcomes for all with a dose of greater than 0.7 Gray (sic; most likely transcription error for 7.0 Gray—Ed.] The second group: the liquidators in the first months of operation. Especially from April to June, those who took an iodine hit: as a rule, they coincide also with the possibility of a 0.25 Gray increased dose. This group should be included in the higher risk group, which receives greater care when observing them. The remaining group of liquidators: with all methods of dose reconstruction, it still is located in the range of roughly 0.13 to 0.17 to 0.20 Gray. These are the liquidators for whom exposure-related changes are impossible. This is the group of liquidators who possess a higher risk of psychosomatic illnesses. All the studies must be conducted the same for all people, taking into account their heightened risk factors.

Next slide. There is a very interesting, small group of investigators, which to this day, is working on the sarcophagus, removing and analyzing fuel ejected out of the 4th block. Very high doses, but with a great, distinctive rhythm of onset. We see no clinical manifestations. High doses, identified from chromosome operation and tooth enamel in a few cases. The group is high risk, but it is very small in number. The general population may also be crudely divided into two large groups. The first is the southern strike, and this is the same group for which we predicted a lifetime dose of more than 0.35 (units not given in transcript). Those who required rapid, and timely evacuation, prohibition of using foodstuffs, special observations, especially the children's group. And finally, the second large group, for whom the leading factors are the social, psychological factors and an ordinary level of risk for all other illnesses. The thyroid. Professor Tsyb will talk about this in more detail. I just wanted to point out to you, that there is a definite latent period, there is a difference among three of our governments, which cannot be fully explained by the dose on the thyroid gland, maybe because we don't know these doses very well, and therefore comparing them must be done with great care. We also don't know everything about the other risk factors of these people. Was Chernobyl' the first such situation? What helped us to rather quickly orient ourselves, to say that it was overall radiation, that the beta component, mainly, affects skin and open sections of mucous membranes. There were many involved, but few who were ill.

Here is a compilation of these situations. Everywhere you see numbers like hundreds, thousands, and even hundreds of thousands. There were very few cases of acute radiation illness, fatality- there either was, or there wasn't. This is typical, these are complex cases, where a doctor must find a few people among a huge mass of people. The leading factor here is the external. It is very important that we also are supported by the other experience of our colleagues in the Southern Urals. This is a large group of professionals who were observed during the period of illness formation, together with Professor Baysogolov; observations were continued for 30-40 years in a wide range of doses. What do we know of the consequences to these people? In the formation period, there were up to 2000 cases of chronic radiation illness. Up to 150 cases of plutonium pneumosclerosis, 40 cases of acute radiation illness, particularly at this enterprise. And here are the outcomes. The first group had a total dose of less than 1.5 Gray, with an annual dose of less than 0.25 Gray. There are practically no long-term effects which are directly related to exposure. Here the dose is on the order of 2 Gray. Cases of chronic radiation illness are already possible. The time it takes to develop is determined only by the accumulated dose. At 4 Gray a majority, practically the entire group, develops chronic radiation illness with long-term consequences of increased cancer by roughly 2 times. Because of the lack of time, I won't talk about the effects of local injuries. Let's go over the "Mayak" personnel one more time, with their outcomes. I turn your attention to leukemia, mainly emerging in the first decade. The average dose level is 3.2 Gray. The annual dose is more than 1 Gray. Practically all of these people have a period of depressed hemopoiesis which precedes. Later, the rate is practically at the same as the control. Later, lung cancer. There is a significant frequency, especially in some contingents. There is some higher frequency of ischemic heart illness, as compared to the control, although it is statistically unreliable. There is no increased frequency of insult. This is a 40-year observation of personnel who worked during the most unfavorable time period. This includes data on people who began to work after 1960. Already, after 35 years, they do not differ from the control group.

Next, please. Thus we agree with those predictions which were made on the basis of observations and generalizations of materials one decade after Chernobyl'. The liquidators were evacuated from the high zone. The strict control zone: they remained in contaminated areas. There are predictions of these effects for liquidators: leukemia, considerable cancer and illnesses in newborns. These would be the materials of Doctor Abel Gonzales (sic; from transcript). We consider it very important, since it orients us on a more sufficient number of dispensary studies of these people and observations of them. So, on the whole, we can talk about the outcome of these situations, and why so many disturbing aspects occurred. I won't touch on the upper half of the slide, since I've already spoken about it. But above all, we say that we did not know everything about the health of these people before they were involved in the accident. There were many unidentified health problems with possible effects caused by psycho-emotional and physical injury. It is a very difficult social situation, complicated for these people by the loss of infrastructure, by their having to move, to work in different places, their fears for their children who suffered and who were already suffering from real thyroid cancer. We agree with the majority of international experts, and we spoke of this at a number of international conferences, that our attention must first of all be concentrated on these relatively small groups, and we subsequently reported on our experience in this regard in Geneva.

A total analysis of all radiation situations, in Minsk, with the problems of treatment and giving aid, in Israel, the sources for errors in determining the links in changes in health with these people. What leads to errors? We've seen many examples. There are thousands of publications in our country, in the Ukraine and other nations. But most of all it is a lack of information, as I had said, about the initial status of the patients. And further, lack of consideration for the very significant non-radiation factors of the accidents. This can be the professional incompetence not only of the patients, but of the doctors themselves who proffer the appropriate aid. There is a lack of very important information on the spontaneous risk values. I again want to thank our colleagues from the Institute of Radiation Safety for Atomic Energy, who turned our attention to these background values over a long period of time; it is only with comparison to these background values that we can come to a proper conceptualization. Finally, there is the known tendency on the part of patients to aggravate their condition, and the defenses of the medics against heavy social problems. Finally, without question, there is the irrational formulation and transfer of information sources.

The report preceding mine from Dr. Smith is very important. As difficult as it is, we need to work with society, with our possible future patients, with the mass media. And finally, I must say there are many defects in our legislation. First of all, it does not limit aid to a specific amount of time, thereby forming a feeling of constant victimization in the society. And secondly, it does not orient people to the fact that involvement in the event, being involved in the situation are the main reasons for changes in their health. And thirdly, these laws are not always made with sufficient expert consultation. What do we think we need to do in the future for this, in order to help these people for whom we have complete empathy? We must systematically, very responsibly, and very aggressively formulate these groups and work with them on an informative and medical basis. Only because we don't always do this, our recommendations do not always give a sufficiently positive effect in this regard. The coming second decade- is it a very important period for the epidemiological value of specific disease classifications? Form. Cancer, including thyroid cancer. Cardiovascular disease, psychosomatic illnesses. Standardization, and unification of the programs in the various regions and countries, is of the utmost value in order that we may be able to compare our results.

And finally, I would like to say, that radiation is now so widespread, and we will live with it for a long time, it is important that we develop an optimal plan of dealing with radiation in our patients and in ourselves. And from this point of view, I again turn your attention to the last part of the problem, facing the future. There is the need for very widespread, mutual, international cooperation, a good example of which is our meeting here. I thank you for your attention. (Applause)

Dr. Fry: Thank you, Dr. Guskova. You have given us a great deal to think about, and I can't help but think there must be some questions.

Dr. Steinhausler: Dr. Guskova, during the Chernobyl project we had one component that we were not able to verify, and that was the issue of hot particles. Have you seen anything in your medical follow-up that would indicate that there was a significant contribution from the hot particle issue?

Dr. Guskova: I want to answer you in the following fashion. First of all, there were 28 lethal outcomes with detailed investigation of the morphology of the lungs, including the distribution of hot particles. These are single particles in a large expanse of the lungs. It doesn't seem to us that they can have any significant clinical value. Evaluation of the dose on the lung (transcript interrupted)... dose on the lung in equivalent dose for the liquidators during the most unfavorable periods of work does not exceed 10-20% of the equivalent dose. I want to say that our publications are continuing. I will leave behind for my colleagues and my friends in the United States a book, in which there is a long chapter on our experience in diagnostics, sorting and treating patients in the severe period. A copy of this book will be given to Doctor Ricks, Oak Ridge, and to Dr. Reeves here. I wanted to turn your attention to the fact that in our country, there is a helpful (at least to me) journal published entitled "Catastrophic Medicine." Here is one issue which is specially dedicated to the Chernobyl' accident. I think that it would make sense for you to have this journal, and maybe on the basis of the abstracts, which are in every article in English, select some for translation.

I think that the Bulletin of Radiation Risk, which is published by Professor Tsyb, is very important. He finally succeeded in raising the issue, immediately, of an English version of several issues. I think this is a very helpful information exchange. And I would like to say, with pride, that two booklets we wrote before the accident were fully validated during the accident. We did not have to radically re-examine our positions. This includes chronicles and organization of population observations. Here is a severe radiation situation, to which we need add only a few words concerning Chernobyl'. These books are available in the United States and we will be very glad if they would be translated and used, as our first book with Professor Baysogolov was used. I thank you.

Dr. Fry: A great contribution to the English literature on the subject--thank you, Dr. Guskova. We now move on to the next speaker, Dr. Robert Boudagov. Dr. Boudagov is a Doctor of Medical Science and professor of radiobiology. He is assistant director of the Medical Radiology Science Center in Obninsk in the Russian Federation. His research interests focus on the pathogenesis of multiple radiation injuries as well as in developing methods of preventing and treating these injuries.

Triage and treatment of combined injury in mass casualty situations

Dr. Boudagov: Madam Chairman, distinguished participants, acute radiation sickness, which originates from high dose exposures following an accident or nuclear explosion, may be associated with thermal burns as well as different types of mechanical traumas. Actual difficulties of early-stage diagnosis and choice of valid therapy procedure for overexposed patients increase if combined injuries occur. Owing to previous numerous experimental studies, mainly in the USA, Germany, former USSR and recently in Russia, many problems of pathophysiology and management of combined injuries have been solved. However, physicians and especially surgeons need concrete information about common principles of the earliest possible diagnosis, outcomes prediction and the content of emergency medical aid. They need easily readable recommendations on how to act with increased work loads on medical personnel in mass casualty situations. Scientists have to recommend to them a course of action and effective utilisation of available resources in overloaded burn and surgical centres.

I am afraid we won't be able to give concise information concerning all of these physician's needs today, but we should really try to do it. At the same time I would like to stress our unsolved problems as concerning combined injuries (CI)

.As you know outcome of CI is worse than that of Acute Radiation Syndrome (ARS), thermal burns or mechanical traumas separately. Burns render the most apparent change for the worse. On the other hand, such variety of combined injury is expected more frequently. For this reason my presentation will address mainly radiation and burn injuries.

Considering known data on the severity of ARS or thermal burns, and taking into account their aggravating action, combined injuries may be classified into four categories.

Grade I includes superficial non-extensive burns (B-1) combined with total body irradiation up to 2 Gy (R-1). Prognosis for health is favorable for victims of Grade I.

The same burns combined with acute total body exposure to 2 or 3 Gy (R-2) comprise Grade II. Full-thickness burns up to 10% of body surface or extensive superficial burns from 10 to 40% (B-2) combined with mild irradiation less than 2 Gy applies to Grade II too.

Prognosis for health and survival is favorable as a rule but life-threatening complications may occur in 20% of victims if emergency medical aid is not rendered in time.

Severe combined injuries (Grade III) consist of the next components:

a) Superficial non-extensive burns plus 4 or 5 Gy irradation (R-3);
b) Full-thickness burns up to 10% of body surface or 10-40% superficial burns plus 2 or 3 Gy irradiation;
c) Full thickness burns from 10 to 40% of body surface or more than 40% superficial burns (B-3) plus irradiation up to 2 Gy.

Prognosis for health and survival is doubtful. About 50% of patients have chance to recover if complete surgical and therapeutically therapy is available in time.

Other combinations of acute radiation with thermal burns apply to extremely severe irreversible types of combined injuries - Grade IV. All patients died in spite of the most modern therapy. These victims need only symptomatic medical aid.

CLASSIFICATION AND PROGNOSIS OF COMBINED INJURIES

Categories of CI severity	*Component of burn*	*Component of radiation*	*Prognosis for health and survival*
Grade I	**B-1**	**R-1**	**Favorable**
Grade II	**B-1**	**R-2**	**Favorable as a rule**
	B-2	**R-1**	**(Life threatening complications may occur in 20% of patients)**
Grade III	**B-1**	**R-3**	**Doubtful**
	B-2	**R-2**	**(About 50% of patients have chance of recovery)**
	B-3	**R-1**	
Grade IV	**B-1 - B-4**	**R-4**	**Unfavorable**
	B-2	**R-3**	
	B-3	**R-2**	**(All patients die)**
	B-4	**R-1**	

The presented classification may be useful mainly for medical triage in mass casualty situations. The immediate estimation of the radiation damage extent is of great importance for a successful treatment strategy as concerning combined injuries. Emphasis should be placed on sorting out severely burned patients who need emergency medical care. The most difficult question for surgeons will be a distinction of such patients from those who were additionally exposed to high doses of radiation. Anorexia, nausea, vomiting, diarrhea, salivation, dehydration, fatigue, headache and hypotension are used commonly to define the severity of the exposure. However, predominant manifestation of burn shock can mask these clinical symptoms. Recommended biological markers of exposure to ionising radiation, such as chromosome aberrations of blood lymphocytes or dynamics of blood cell counts, are not practicable for urgent triage of patients with combined injury.

Our experimental study revealed that initial post-burn leukocytosis did not depend on the absorbed radiation does within the prodromal phase. Erythrocyte number, hemoglobin and hematocrit levels increased significantly in 3-6 hours after CI. However, the same degree of hemoconcentration is also observed after thermal burn without additional irradiation.

In other words, known early-stage burn-induced hematological features, such as leukocytosis and hemoconcentration, can not be useful for triage and outcome prediction of thermal trauma if combined radiation injuries occur.

Therefore, an approximate early estimation of radiation damage degree is mass casualty situations more probably will base:

a) on the historical data and duration of victims being in radiation area;
b) on the data of individual physical dosimeters (if possible);
c) on the non-accordance of more severe clinical state of patients to relatively mild degree of trauma.

I think we have to answer the next questions in the future for triage improving:

- Which simple methods of biological dosimetry would enable us to a rapidly estimate the radiation damage degree in patients with severe burn or other type of shocking trauma that is need of urgent surgical aid?

- How would we really sort out victims with severe trauma and shock "which are killed already (because of simultaneous high dose irradiation) but not dead yet"?

Management of victims following a nuclear disaster has to include the successive complex of surgical and therapeutic treatment. Life-saving standard emergency surgical procedures for nonradiation injuries and therapy of burn of traumatic shock are the first important step within 24-48 hours after CI. Antiemetic drugs, such as Ondansetron, Granisetron, Dimetcarb or Dixaphen, are useful for nausea and vomiting removal. Single tetanusanti injection is compulsory too. Antimicrobial therapy should start from the first day after CI of Grade II or Grade III.

All essential special surgical operations should be carried out before the beginning of the third phase of acute radiation syndrome - manifest illness. Operative treatment of extensive full-thickness thermal burn is not recommended until hemopoiesis recovery is complete. However, previous experiences and experimental studies indicate that patients with severe CI die during the first two or three weeks mainly due to bacterial endotoxicosis and gram-negative sepsis. Unfortunately, the available facts prove decreasing efficiency of antimicrobial therapy and some biological response modifiers for rather high dose exposure and open would trauma occurrence (publications of G.D. Ledney, G.S. Madonna, I. Brook and co-workers from the Armed Forces Radiobiology Research Institute, Bethesda).

The main scope of our recent experimental research for and selection of effective means for the preventive therapy of toxic and infectious complications of combined injury. Three groups of remedies were under study, which given at an early stage of disease, would be useful to improve efficacy of subsequent standard treatment schemes and to increase survival. The first group include biological response modifiers. Published data proved that these agents may increase macrophage activity and secretion of cytokines such as hemopoietic growth factors. Means of the second group used for decreasing of the initial "aseptic" phase of bacterial enteroendotoxemia and early post-burn intoxication. The third group included antibiotics for prophylaxis and preventive therapy of infectious complications.

Mice and rats were irradiated at minimal lethal doses. Non-lethal per se full-thickness thermal burn were inflicted immediately after irradiation by means of a powerful lamp light. Combined injuries were characterised by sharp decrease of 30-day survival of animals in comparison with separate ARS.

The next biological response modifiers used in our work: pyrogenal, prodigiozan, zymozan (10 mkg/mouse, i.p.), synthetic analogue of muramyldipeptide glycopin (5 to 50 mkg/mouse, i.m.), thymozin, thymotropin, thymogen (20 mkg/mouse, i.m.), different kinds of new yeast polysaccharides (20 mg/kg, i.p.) and others. Increase of survival and beneficial effects on blood systems state were used as indexes of this drug's efficacy.

According to the obtained results, bacterial polysaccharide pyrogenal, glycopin and thymus preparations did not modify the extremely low level of mice's survival. Single injection of prodigiozan, zymozan and three extra-cellular yeast polysaccharides in 1 h after CI resulted in moderate increasing of survival as compare with untreated mice. The best results were obtained when recombinant IL-2 or heat-killed Lactobacillus acidophilus were used (10^8 microbes per 1 ml growth media, s.c.). Increase of 30-day survival accordingly composed 42% and 53%.

Recombinant human G-CSF investigated for the ability to accelerate bone marrow regeneration and to decrease the severity of leucopenia after irradiation only or CI. Results demonstrated that G-CSF increased the number of bone marrow CFU's in the group of separately irradiated mice. When animals were exposed to CI this index did not change significantly. G-CSF did not modify lowered number of bone marrow nucleated cells and leukocytes score within the period of manifest illness.

We directed most attention to the therapeutic use of rhIL-1-B. It taken into account that IL-1 act as an essential molecular master switch for secretion of GM-CSF, G-CSF, IL-3, IL-6 and other important hemopoietic growth factors. Several authors reported that IL-1 given in 1-4 hour (50-100-200 mg/kg,s.c or i.p.) increased survival of mice exposed to radiation only.

Single injection of IL-1 in amounts proposed for acute radiation syndrome treatment (100 mkg/kg) in 4 h resulted in abrupt prognosis deterioration when dealing with CI. About 60% of "treated" mice died during the first 2-3 days after CI. The same results were obtained if dose of IL-1 reduced to 150 ng/mouse. Analogous data were received also when a single IL-1 injection was given in 24 h after CI.

Experiments in a rat model were made to study the ability of natural and artificial enterosorbents to eliminate gut derived bacterial endotoxins and to decrease burn toxaemia. All medicines were injected into stomach in 1 h and then in 24 hours. Indexes of absorbent efficacy were measured in 48 hours after CI. The following drugs were under study: enterodes, phosphalugel, kaolin, polymethylsillocsan, polyphepan, almagel and different kinds of carbon-contained absorbents.

The best results in the prevention of the early endogenous toxic syndrome were obtained when artificial carbon-mineral sorbent was used. Level of bacterial endotoxemia and blood total toxicity significantly decreased following two-fold administration of this remedy. It's important that the use of enterosorbent increased efficacy of the antibiotics doxycyclin or ciprofloxacin. More strong decrease of blood toxicity, correction of intestinal dysbacteriosis was revealed when antimicrobial therapy was combined with enteric toxins absorption. Survival of treated rats increased up to 80% while all rats from the control (untreated) group died during the first two weeks after combined injury.

Selection of optimal antibacterial medicines for preventive therapy was made among broad-spectrum antibiotics. Survival rate, possible side effects to hematopoietic system and lymphoid organs, enteric microbiocenosis and resistance to exogenous infection was recorded. According to the obtained results, beta-latams, aminoglycoside and rifampicins did not modify low survival value. The complex antibiotic sulacillin, which consists of ampicillin and the beta-lactamase inhibitor sulbactam, rendered strong prophylactic action during the first 8-10 days after CI but did not increase 30-day survival. Successful preventive therapy was the best when animals treated with two antibiotics: pefloxacin + sulacillin (treatment course 7-10 days, starting with the first day after CI). Percentage of survival following such antimictrobial therapy increased from 7% (untreated group) to 53%. Selective decontamination effect observed. There were no aggravating side effects from this anitbiotic complex to the radiosensitive systems.

Therefore, presented data indicate that early recommended treatment schemes may be complemented by some new effective means of preventive therapy. On the other hand, one can say that direct extrapolation of treatment techniques, recommended early for the acute radiation sickness alone, to combined injuries may be incorrect. Future investigations are needed for pathogenetically based improving of supportive and restorative therapy.

I think we should know much more about the mechanisms of early aggravating effect of thermal burn or wound trauma on ARS severity and outcome (oxidative stress, generation of free oxygen radicals, metallothioneins synthesis, "cytokine cascade" response, pathogenesis of early endotoxemia).

I would like to express the hope that we'll be able jointly work out much more effective strategies for CI therapy. In particular, by search for the most optimal combinations and dose scheduling of hemopoietic growth factors or other biological response modifiers.

I would like to express the hope that our workshop will start more active scientific co-operation between Medical Radiological Research Center in Obninsk and the Armed Forces Radiobiology Research Institute in Bethesda.

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LABORATORY OF RADIATION AND NON-IRRADIATION EFFECTS MODELLING, MEDICAL RADIOLOGICAL RESEARCH CENTRE, OBNINSK, RUSSIA

Budagov R.S., Nesterenko V.S., Makarov G.F. et al. Rationale for the methods of prevention and treatment of toxic infectious complications of combined radiation and thermal injuries/Med.Radiol., No 9-10, 41-44, 1992. (in Russian).

Ananyeva E.P., Budagov R.S., Eliniv N.P. et al. Use of Yeast polysaccharide glycan-Sph as mean of early therapy of combined radiation-thermal injury / Mycology & Phytopathology, v.26, No 4, 270-272, 1992. (in Russian).

Budagov R.S., Viadro M.M., Makarov G.F. et al. Experimental basis of the possibility to use sulacillin for the combined radiation-thermal injury's infectious complications prophylaxis / Antibiotics & Chemotherapy, v.37, No 11, 35-37, 1992. (in Russian).

Combined radiation injuries: the pathogenesis, clinic and therapy. Eds. A.Tsyb & M.Pharshatov. Moscow, 1993, 288 p.

Budagov R.S., Nesterenko V.S., Piskarev A.V., Chureeva L.N. Peculiarities of the development of bacterial enteroendotoxemia after the combined effect of radiation and burn/ Radiobiology, v.33, No 2, 271-275, 1993. (in Russian).

Chlopovskaya E.I., Budagov R.S., Suchareva N.N. et al. Application of drugs of protozoan origin as means of prophylaxis and early therapy in combined radiation-thermal injuries/Izvestia Academii Nauk. Seria biologicheskaia, No 2, 227-234, 1993. (in Russian).

Khlopovskaya E.I., Budagov R.S., Chureeva L.N. Radiaion- induced changes in metabolic and functional activity of adhesing macrophages / Radiobiology, v.33 No 2(5), 687-693, 1993. (in Russian).

Nesterenko V.S., Nasibov S.M., Budagov R.S. et al. Antitoxic efficiency of some enteric sorbents - chitosane derivatives - in combined radiation and thermal injury /Exper. Clin. Pharmacol., v.57, No 6,59-61, 1994. (in Russian).

Khlopovskaya E.I. Budgov R., Chureeva L.N. Modifying effect of thermal injury on radiation-induced changes in biochemical and functional activity of peritoneal macrophages / Radiobiology, v.34, No 1, 148-153, 1994. (in Russian).

Budagov R.S., Ashurov A.A., Zaichik V.E. Bloos's trace elements as indexes of radiation injuries severity/Radiobiology, v.34, No 1, 49-54, 1994. (in Russian).

Nesterenko V.S., Rachkovskaya L.N., Boudagov R.S. et al. Efficacy of using synthetic carbon-mineral sorbents in combined radiation-thermal injuries / Experimental and Clinic Pharmacolgoy, v.58, No 5, 65-67, 1995.

Tsyb A.F., Boudagov R.S. Drugs for the prophylaxis and early therapy of radiation injuries (review) / Med. Radiology and nuclear safety. Journal's Library. Moscow, 1995, . 144-147. (in Russian).

Makarov G.F., Boudagov R.S. et al. Estimation of pefloxacin's efficacy for combined radiation-thermal injury treatment / Antibiotics & Chemotherapy, No 8, 36-39, 1995. (in Russian).

Abakushin D.N., Khlopovskaya E.I. Boudagov R.S., Poverenny A.M. Antibodies to cardiolipin are realising from binded state binded state when burn shock develops/Bull. Exp. Biol. Med., v.122, No 10, 425-426, 1996. (in Russian).

Tsyb A., Boudagov R., Olianova L. Experimental studies to improve diagnosis and treatment of combined radiation/thermal injuries / Diagnosis and treatment of patients with acute radiation syndrome. Joint study project No 3. Final report. ECSC-EC-EAEC, Brussels - Luxembourg,, p. 82-91, 1996.

Boudagov R., Oulianova L. Therapy of combined radiation injuries with hemopoietic growth factors. /The radiological consequences of the Chernobyl accident. Proceedings of the First international conference Minsk, Belarus March 18 to 22, 1996. EUR 16544 EN. Brussels-Luxembourg, p.641-644, 1996.

Boudagov R., Uljanova L., Makarov G. Preventive treatment of combined radiation injuries / IRPA9. 1996 International Congress on Radiation Protection. Ninth International Congress of the International Radiation Protection Association. April 14-19, 1996. Proceedings /Volume 4.P.157-159.

Nesterenko V.S., Makarov G.F. Boudagv R.S. et al. Effect of the synthetic carbon-mineral sorbent and antibiotics on the development of combined radiation and thermal injury/ Rad.biol. Radioecol., 36, 5, 727-730, 1996. (in Russian).

Oulianova L.P., Boudagov R.S. Changes of hemopoietic system and hemoregulatory cytokines after acute radiation or combined radiation-thermal injuries / Rad.Biol. Radioecol. (in press).

Boudagov R.S., Oulianova L.P. Pospelova V.V et al. Biopreparation based in Lactobacillus acidophilus - new remedy for the early therapy of combined radiation and thermal injuries / Rad.Biol. Radioecol. (in press).

Oulianova L.P., Ketlinski S.A., Boudagov R.S. Study of interleuin - 1B efficacy for the combined radiation-thermal injuries treatment/ Rad.Biol.Radioecol. (in press).

Petrov V.N., Boudagov R.S. Alternations of tumor necrosis factor's activity level in blood serum after irradiation or combined radiation and thermal burn injury / Rad. Biol. Radioecol. (in press).

Chlopovskaya E.I., Boudagov R.S., Smoryzanova O.A., Rott G.M. Participation of metallothioneins in the regulation of macrophage activity at combined radiation and thermal injury, induced oxidative stress / Biochem. (in press).

Dr. Fry: Thank you, Dr. Boudagov. Dr. Guskova...

Dr. Guskova: How do you explain the negative effect of interleukin with the combination of burns and radiation damage, while interleukin is effective when there's only radiation injury?

Dr. Boudagov: This question at first puzzled us, and we had to repeat the experiment many times to make sure this is not an artifact, but the analysis of this problem demonstrated that the nonradiation effect, first of all from thermal burns, was itself accompanied by the activation of the discharge of interleukin 1 and interleukin 6. All this in general imitates the reaction of the acute phase, however, there must be some threshold of effectiveness where side effects prevail, the side effects of interleukin 1.

Dr. Auton, SRF: Will you elaborate a little bit on oxidative stress and cytokine cascade response?

Dr. Boudagov: This question would be suitable for future investigation. We know too little about the possible mechanisms and role of oxidative stress and cytokine cascade in response to the aggravating actions of some events. I do know that, in the case of combined radiation situations, otherwise relatively positive complex reactions, such as oxidative stress, may be harmful.

Unidentified questioner: Would you please comment on the appropriateness of marrow transplants, in particular cord marrow transplants in combined injury?

Dr. Boudagov: During the last two years we studied with some European colleagues in the framework of a special project therapy for radiation sickness. It was shown that in acute radiation syndrome bone transplantation has really few indications. Besides this, I know results of experimental studies that were made four to seven years ago where bone marrow transplantation for mice and rats was noneffective. Maybe the main cause of this is sepsis and action of bacteria and antitoxins. That's my opinion.

Unidentified questioner: Your comments concerning the antitoxin absorbent approach to things is very exciting. Have you thought about or have you applied the combination with G-CSF?

Dr. Boudagov: It may be very interesting, but now really we have no chance to realize these schemes without money!

Dr. Fry: We thank you, Dr. Boudagov. We seem to have to cut to the bottom line on many of these questions, unfortunately.

Dr. Fry: The second half of our panel discussion will be led off by Dr. Bob Ricks, Director of the Radiation Emergency Assistance Center/Training Site (REAC/TS) in Oak Ridge, Tennessee.

Summary of U.S. experience in medical accident response

Dr. Ricks: Thank you, Dr. Fry. First of all I have taken the liberty to change the title of this presentation just a little bit from what you have in your program. The reason for that is that I wanted to emphasize this is a summary of REAC/TS' medical experiences of response, because we have colleagues from the military who also have some experience in this and there are a couple of private groups in the United States that provide assistance to the commercial nuclear power industry, and they have experience as well. Usually one way or another REAC/TS gets involved in providing assistance, consultation, etc., with these other groups, but I certainly wanted to recognize that they have programs as well. The program at REAC/TS has a multiphasic mission. Our primary mission is to provide direct or consultative assistance on a 24-hour basis with medical and health physics support, following radiation accidents. The program has been in existence for a little over 20 years, and it was initially designed to provide for medical emergency decontamination, etc., for the Oak Ridge nuclear community. There are approximately 13,000 atomic workers at risk in Oak Ridge on a daily basis in government-owned facilities, and somewhere between 1000 to 1500 additional persons who work in private industries primarily associated with waste management. We also, as part of this program, maintain a data registry, which primarily contains medical information on radiation accidents and can be used as a basis for conducting medical follow-up on DOE or DOE contractor employees and radiation accident survivors in general. This program is funded entirely by the Department of Energy. We also use the program and the experience that we have in this program to share information with medical and health physics colleagues through conduct of training courses in radiation accident management. To date, our experience is approximately 4,000 health and health physics professionals trained in REAC/TS, not only from the United States but 41 foreign countries as well. We provide assistance to DOE contractor sites by conducting quality assurance evaluation for their emergency preparedness and also extend this assistance to state and local response groups, private industry, both foreign and domestic. We develop and refine cytogenetic techniques for biological dose assessment and also assist DOE and the NRC with forensic medical consultation on compensation cases where radiation is known or alleged to be associated with some specific disease, and then, lastly, REAC/TS is designated by WHO as a collaboration center along with about 10 other centers around the world. Our response capabilities include 24-hour emergency response and consultation. We can accept patients into the REAC/TS facility, which is a separate emergency department located within the community hospital in Oak Ridge. This hospital is a full-service 400-bed medical facility serving a widespread area in East Tennessee. We have 24-hour surgical decontamination capabilities. Our staff consists of consultant medical and health physics personnel, including a full-time physician, part-time physicians for expansion of our team, registered nurses, a paramedic, health physicists, and myself as a radiation biologist, and then all of the necessary support personnel to allow us to provide that assistance. Cytogenetic dose evaluations, whole body counting capabilities, and both fixed and portable whole body counters are available at REAC/TS as well as a very sophisticated set of whole body counters in existence in the community in Oak Ridge, both as part of ORISE and as part of the government-owned facilities in Oak Ridge. REAC/TS also coordinates the distribution and use of DTPA therapy in the U.S. through an Investigational New Drug agreement with the FDA. I mentioned to Dr. Fry that I would have a surprise announcement for her today. It's taken a while, Shirley, but as of today the FDA has assigned an IND to REAC/TS. We have a number and permission to start within 30 days on a program involving the use of Prussian blue in the U.S. in the event of cesium contamination. We have been pursuing that for several years, and I'm happy to say that we finally have it in place. And then, of course, we rely on a lot of interlaboratory collaboration with other DOE facilities, not only in Oak Ridge but on a nationwide basis as well. What is the facility? It's a very modern facility of about 700 square meters as part of the Methodist Medical Center of Oak Ridge, with a number of treatment rooms, classrooms, health physics laboratories, our laboratory, etc. Since we began this program in June of 1976, we have had 1,015 calls for assistance. This averages about 50 calls for assistance per year on the average, such that we are working a new radiation accident, real or suspected, each week. We have during that period of time seen 192 patients in our facility, and there have been 271 cytogenetic dose estimates performed in support of various requesters for assistance. I can tell you these numbers are already incorrect. They were current on Monday, but as of today the calls for assistance increases by one and the cytogenetic dose estimates increased by one, as a result of an accident discovered not too far from where we are today. The NRC requested for REAC/TS to provide cytogenetic dose estimates on one individual as well as a medical consultation for the individual's private physician. This involves a neutron density gauging device. I don't have a lot of other details about it at this time, having only learned about it within the last hour or so. As far as international experience is concerned, this slide (attached) summarizes that experience. You will note that the first two entries actually occurred prior to REAC/TS' coming into existence. Many of us who have been associated with this program over the years were working prior to the REAC/TS program in a medical division as part of Oak Ridge Associated Universities. That division was using total body radiation for treatment of various diseases, such as leukemias and lymphomas, and had gained a reputation prior to REAC/TS for having capabilities in managing radiation accidents. Since our designation as a WHO collaborating center in 1980, we've had a number of responses. They involve both the admission of patients to REAC/TS, on-site responses where we had a team requested and therefore mobilized to go to some foreign site, or where we simply provided consultation to the medical or health physics community involved in any particular accident. As part of this program, and indeed part of the REAC/TS Accident Registry, that medical data-base of information, we are able to ask and answer the question, "Where do radiation accidents occur?" (See slide.) We divide these into nine separate categories, from nuclear reactors or radiation facilities down to the last category that we commonly refer to as the question mark category. We emphasize that to impress to physicians and health physicists from all over the world that radiation accidents, and particularly serious accidents, occur where they least expect them to, involving members of the general public who have no idea that they are involved in such an accident, and, of course, the accident in Goyanya, Brazil, in 1987 is a very good example of that. If we use that experience to determine the frequency of radiation accidents, and thus the categories in which one would expect serious accidents, we can see that if we divide them into accidents with critical assemblies, accidents with radioisotopes, and those with radiation generating devices, sealed sources, or X-ray devices, that the majority of serious accidents occur with the use of radiation-generating devices or sealed sources. There has been a steady increase in this type of accident over the years, reaching a plateau in the mid '70s, and it appears that it is going to stay at that plateau for the foreseeable future. The reason primarily for this increase was the expanding commercial nuclear power industry and the increased use of nondestructive testing or industrial radiography. As a result of the OPEC oil crisis, as well as a decrease in the construction of nuclear power plants, we see fewer of these accidents. If we look at that distribution in a slightly different way and look at the number of serious accidents, which I'll define for you in just a moment, we see that of 389 well-documented accidents, 293 of them have occurred as a result of some accident with a radiation device, and you'll note that about half of the serious accidents in this data registry are the result of mishandling of sealed sources, such as radium-192, cobalt-60, or cesium-137. This slide summarizes the human experience in these major accidents, as part of our registry. Note that of the 389 accidents 239 of them occurred in the U.S. and 150 outside the U.S. The number injured in non-U.S. accidents is large, because of the number of persons in the 30 kilometer radius around Chernobyl and the nearly 11,000 persons involved in the accident in the Ural Mountains that you heard described yesterday. Very few persons have received a significant exposure. In our data registry there are 112 documented fatalities. I'd like to call your attention to the fact that REAC/TS has entered into an agreement with the Institute of Biophysics of the Russian Federation to assist the personnel at this institute in computerizing these accident data on acute radiation syndrome and then assisting our Russian colleagues in getting this information published in the medical scientific literature, and I want to emphasize "assisting" our Russian colleagues. It is not our intention to publish these data ourselves. It's our intention to provide assistance. The protocol for this project has been reviewed and approved by the JCCRER on the U.S. side. It has been reviewed and approved by members of the European commission and has the support of the Department of Energy. I mean that both literally and figuratively since not only are they paying for these efforts but they are very interested in seeing to it that these data become part of the medical record and increase worldwide knowledge of these types of accidents, their management, and how that medical management has changed from 1950 to the present. The dose criteria that we use to classify an accident as a significant exposure are summarized as follows: 250 mSv or greater to the bone marrow or gonads would classify an accident as significant; 6,000 mSv to the skin or extremities; 750 mSv to tissues or organs other than bone marrow or gonads, such as the eye or the thyroid; internal contaminations that equal or exceed half of the maximum permissible burden as defined by our National Council on Radiation Protection and Measurements. This is an area that is somewhat controversial and is not in line with ICRP recommendations, since this is a classification system as per agreement between the U.S. Nuclear Regulatory Commission and Department of Energy. We anticipate that there will be some change in the near future. Some of you may have heard me say that about two years ago, and it simply hasn't happened as of yet. And then, lastly, any medical misadministration that results in any of the dose criteria or conditions. And I want to emphasize that these numbers are strictly a numerical scoring system below which we say there has been a nonsignificant exposure, above which, a significant one. There is not necessarily an implication of serious medical consequence. I don't need to belabor that point to this group because you're very aware of the absence of medical consequences, for emergency response at least, for a 260 mSv exposure. As far as fatalities are concerned, in this data registry we divide fatalities into, first of all, nonradiation deaths. These are deaths associated with trauma in radiation accidents. More than likely, had the individuals survived their trauma, they would have succumbed to the radiation exposure or certainly have received significant medical consequences from this exposure. An acute death is one that occurs within 60 days postexposure, and an associated death is one that occurs between the sixty-first day and two years postexposure. I emphasize that this is not a database that we are using for epidemiological follow-up. The data are available for epidemiological follow-up, but that is not one of the missions of REAC/TS, and that's sometimes confusing or misconstrued by some individuals. As far as the 26 fatalities within the United States, I can tell you that few of those accidents are the result of acute radiation syndrome; many of them are associated deaths. Of the 26 fatalities, 21 occurred as the result of medical misadministrations, the last one being in November of 1992 at a hospital in Pennsylvania. There are a number of accidents in that Category 9 or "question mark" category I mentioned earlier that have occurred outside the United States. Examples would be Algeria, Brazil, Estonia, Mexico, and Morocco.

If we look at the database for serious accidents in a slightly different way and look at the number of accidents with fatalities and the number of fatalities in any particular accident, it appears that we are rather unsafe in this country. There are 13 accidents in which at least one person has died, and there are 30 fatalities, from acute, associated, and nonradiation deaths. The reason for that is that this database is primarily one that reflects accidents in this country. We are well aware there are other serious accidents, perhaps not with fatal outcomes, in other countries; we simply don't have access to this information. This is just another reason for international cooperation. We all need to share in letting everyone know what the real experience is with this type accident, particularly with regard to the medical management aspects. There are, however, some other important aspects to documenting these accidents. If we look at common causes of these radiation accidents, we see a variety of causes. It's been our experience at REAC/TS that there has not been a single underlying cause for any of these accidents. There are multiple causes, perhaps only two, maybe three, yet in almost every case the thing that almost always plays a role is human factors. We imperfect animals do some very predictably wrong procedures that oftentimes result in significant exposure. Now I would call your attention to the top box in the last slide that says that in this central registry at REAC/TS there are 1,588 entries for separate incidents or accidents. You'll note that I had a number earlier of 1,015 or as of today 1,016. The discrepancy there is due to the fact that there are data in this registry that are not the result of calls for assistance to REAC/TS. Many of them are anecdotal from that time period prior to REAC/TS becoming a program of the Department of Energy. There are also 1,110 cases where the individual(s) received a zero dose. I point out to you that that part of the registry where individuals received over 250 mSv is a small component. The majority of the data in this registry are of an incidental nature, are nonaccidents, or zero dose. I think that is becoming increasingly important and reflects back to comments we heard earlier about the psychosocial problems associated not only with serious accidents but with accidents that really didn't happen, where people suspected that they were involved. I can tell you that when the Secretary of Energy, Hazel O'Leary, made announcements about human experimentation with radiation in the United States, within a few days we began to get numerous phone calls of people who thought that whatever health problem they had and couldn't be explained, or perhaps couldn't understand the explanation, they thought it was associated with some type of radiation accident. I think that one of the big challenges now and for the future will be for the medical and health physics communities to demonstrate that an accident has not occurred, rather than to use all of those tools that we have talked about, all of those tools that are well established for documenting real and serious accidents. And I'd like to close by just reflecting on the fact, of which I'm sure you're all aware, that within six months after Konrad Roentgen published the paper on the discovery of X-ray, the first radiation accident occurred and was documented in the literature in *Nature,* as I recall, in 1896. From that point on, beginning with that first accident, we began as a society to accumulate information on the diagnosis and treatment of radiation injury. That has greatly expanded as the experience has expanded. I feel I would be remiss if I didn't point out to you that within this country all of that information was taken and put into a useable, easily readable form in a publication in 1964 by Dr. Gene Saenger, who's sitting here on the front. I think what we've done since that period of time in this country is to, in many ways, expand upon the ideas and concepts for training and sharing with medical and health physics colleagues that Dr. Saenger and his colleagues developed and published in 1964, and I'm happy to say that Dr. Saenger still participates in the training courses that we hold in Oak Ridge and is always available for consultation as well. Thank you very much.

Dr. Fry: Thank you, Dr. Ricks, for that summary of the experience of the REAC/TS program which constitutes a major basis in this country for the training of emergency response personnel to radiation accidents and much of the on-the-job training that physicians and health physicists have had in responding to radiation accidents. Are there any questions or comments people would like to address to Dr. Ricks at this stage?

Dr. Bill Blakely, AFRRI: In your selection criteria, where you have 250 mSv, is there a dose rate dependency for that (i.e., whether or not they absorb that dose over 20 years)?

Dr. Ricks: No, it's basically an acute dose.

Dr. Fry: One of the very important things in responding to radiation accidents and many of the questions that come to REAC/TS concerns exposure to radiation in the form of radioactive iodine. This was particularly true at the time of the Chernobyl accident, both from individuals in the United States and people who were thinking of traveling to the former Soviet Union or in that area.

We're very fortunate now to have Mr. William McNutt. Mr. McNutt is with the Federal Emergency Management Agency (FEMA). He currently is the senior policy advisor in the Radiological Emergency Preparedness Program of FEMA.

U.S. Policy on Potassium Iodide as a Thyroid Prophylaxis for Commercial Nuclear Power Plant Accidents

Mr. McNutt: Thank you Dr. Fry, and good afternoon to everyone. My topic this afternoon will be the development of a federal policy on the use of potassium iodide as a prophylaxis for the thyroid in radiological emergencies that might occur at commercial nuclear power plants.

The controversial issue of providing thyroid blocking agents for the public was discussed as early as the 1950's, although it wasn't until 1975 that the National Council on Radiation Protection and Measurements stated, in their Report No. 55, that potassium iodide is an effective thyroid-blocking agent, and should be administered when projected thyroid doses from a release of radioactive iodine exceed 10 red. This Report also noted the possibility of stockpiling the drug at locations near the nuclear power facility. That same year, the General Services Administration assigned certain radiological emergency responsibilities to the Department of Health, Education and Welfare, following which the Assistant

Secretary for Health tasked the Food and Drug Administration (FDA) with developing guidance for the emergency use of a blocking agent.

In 1978, the FDA concluded that potassium iodide (KI) is safe and effective as a thyroid-blocking agent under proper dosage, timing of dosage, and monitoring of side effects. For that specific use, the agency publisher a Request for Submissions of New Drug Applications from manufacturers, and gave Notice of Availability of Labeling Guidelines. Not a single application had been received when, a year later, on March 28, 1979, the accident occurred at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania.

Coincidental to the Three Mile Island accident was a Federal Executive Branch reorganization establishing the Federal Emergency Management Agency (FEMA) on April 1, 1979.

Later that year, FEMA was assigned lead responsibility for offsite radiological emergency planning and preparedness for all types of peacetime radiological emergencies. To implement their program FEMA published a regulation, 44 CFR Part 351, which (1) delineated each Federal Department and Agency's role and responsibilities in radiological emergency preparedness; (2) established an interagency group, the Federal Radiological Preparedness Coordinating Committee (FRPCC), with FEMA as Chair; and (3) charged the Department of Health and Human Services (HHS) (i.e., FDA) with providing guidance on the use of radioprotective substances and the prophylactic use of drugs to reduce radiation doses. Pursuant to this charge, in 1982 the FDA published its final guidance on the use of KI. The only change to the FDA's original 1978 guidance was the- threshold for use was conformed with the Environmental Protection Agency's Protective Action Guidelines at a projected dose to the thyroid of 25 rem. The FDA guidance also advised that each State is responsible for formulating its own policy and procedures on when, if at all, the public should be supplied with KI.

Initially, six States announced a policy of distributing KI to the public. (Now there are two States that do so.) Of these original six States, one State proceeded to pre-distribute the drug, and another stockpiled enough to administer at reception centers. (The remainder indicated they would incorporate the use of HI for the general public in their plans, but did nothing.) Discussion ensued on the value of having stockpiles at Federal, regional and/or State levels. FEMA received funding to accumulate stockpile(s) at Veterans Administration repositories, but was dissuaded from implementing the plan by the deliberations of the FRPCC. However, the FRPCC did establish an Ad Hoc Subcommittee on Potassium Iodide to review the available literature and make recommendations to the FRPCC.

As a result of the Subcommittee's deliberations, a July 1985 Federal policy statement was published by FEMAfor the FRPCC. The policy recommended that KI be stockpiled and distributed for emergency workers and institutionalized people, but that predistribution or stockpiling of KI for use by the general public should not be required in State and local emergency plans, and should be left as a prerogative of the States. Thyroid blocking for emergency workers and institutionalized people was recommended because: (1) they are more likely than the general public to be exposed to radioiodine in the event of an accident; (2) the number of people involved in such a distribution would be relatively small; (3) the storage, distribution, and administration of KI could be readily controlled; (4) the known sensitivity to KI of this limited number of people can be reviewed; and (5) sensitive individuals could be monitored for side effects. Opposition to stockpiling for the general public was based on: (1) the difficulty of effective distribution during an emergency; (2) a 1980 cost-benefit analysis, by the Nuclear Regulatory Commission (NRC), which recommended against stockpiling; and (3) recognition that other options such as sheltering and evacuation provided protection against all radionuclides, not just iodines.

In 1989, the World Health Organization (WHO) Regional Office for Europe prepared guidelines for iodide prophylaxis following nuclear accidents. The guidelines were not WHO stated policy, rather developed as a special project for the governments of the United Kingdom and Switzerland.

Stable iodine was recommended for the entire population in the immediate vicinity of the reactor if the projected dose to the thyroid from inhalation exceeded individual national intervention protective action guidelines. At distances where the ingestion pathway would be the principal contributor to dose, if the projected dose still exceeded national intervention protective action guidelines, stable iodine was recommended for lactating and pregnant women (i.e., 2nd and 3rd trimester), and children from the age of neonates to 16 years. Administration to persons aged 17 years and above was not recommended due to risk benefit factors, particularly in iodine deficient areas.

Also in 1989, the American Thyroid Association appealed to FEMA, as Chair of the FRPCC, and to the FDA for reconsideration of the Federal policy regarding stockpiling. FDA deferred to the FRPCC for response, on the basis that the interagency Committee was the proper forum for such a deliberation. The Committee, in turn, requested that HHS review the medical aspects of KI use prior to FRPCC discussion of policy issues. Acting for

HHS, the Center for Disease Control (CDC) convened a panel of experts in July 1990. The CDC report found no medical aspects affecting the status of the policy, and hence recommended no change in the policy. The report did recommend formation of an FRPCC Ad Hoc Subcommittee to review other technical and policy issues related to the Federal position.

The second FRPCC Ad Hoc Subcommittee on Potassium Iodide convened in February 1991 with representation from FEMA, CDC, the NRC, FDA, and the Conference of Radiation Control Program Directors, or CRCPD, the professional organization of State radiation control personnel. Items discussed as potential sources of information were: a proposed contractor update of the 1980 NRC cost-benefit analysis, funded by that agency; a FEMA contract with Argonne Laboratory for review of Chernobyl emergency experiences and monitoring of international literature; and a CRCPD survey of the States to determine current policy and supplies for KI.

The NRC's contractor report was scheduled for completion by April 1992 and a Draft Regulatory analysis was projected for Spring 1993. The report was completed as scheduled, but required further evaluation by the Agency. The KI Subcommittee tabled discussion of the Federal policy pending completion of the NRC study. Meanwhile the Veterans Administration again volunteered its four regional warehouses and 175 hospitals as storage and distribution centers. In March 1993, NRC staff reported to the FRPCC that the Agency was still evaluating the issues related to if and how the report should be employed.

On November 23, 1993, and March 29, 1994, the NRC staff presented its recommendations to the Commission to address the KI stockpiling issue. The staff's recommendation was that the NRC, in coordination with HHS and FEMA, revise the current Federal KI policy to make KI available to the States. The revised policy would read: "Although a reactor accident requiring KI is unlikely and KI is only effective as a protective measure for the dose to the thyroid from radioactive iodine, the cost to purchase and stockpile amounts sufficient to administer to populations within 5 miles of operating nuclear power plants is relatively low. Consequently, it appears prudent to stockpile KI for limited populations located close to the operating nuclear power plants.

Additionally, the staff recommendation included a commitment that the NRC staff would work directly with FEMA and HHS to revise the Federal policy regarding stockpiling KI for possible use in a radiological emergency. The revised policy would state that KI will be purchased by the Federal Government and made available through FEMA to the States. While NRC would encourage the stockpiling of KI, the decision to stockpile, distribute, and use KI would be the responsibility of the individual States' emergency planning authorities. At the option of the States, procedures incorporating the use of KI in State emergency plans would be developed and coordinated through FEMA.

The Commission's vote on the above staff recommendation was 2 to 2, and under NRC internal procedures, a tie vote on the proposal means that it fails. There was, therefore, no decision on the merits of the NRC staff's recommendation.

In September 1994, the Subcommittee on Potassium Iodide issued a Report and Recommendations to the FRPCC. The Report, which incorporated data from a second CRCPD survey of the States, and which reaffirmed the 1985 Federal policy, stated that the Subcommittee found no compelling justification for Federal stockpiling of KI because:

(1) To be effective, KI would have to be prepositioned in the immediate area of a nuclear facility with a plan for immediate distribution, or it would have to be predistributed to homes, schools, and work places--both processes which are logistically difficult to implement; and

(2) The majority of States with commercial nuclear power plants in their borders were against the creation of a Federal KI stockpile, citing evacuation as their primary and preferred protective action.

The Subcommittee's report was adopted by the FRPCC in a December 1994 meeting.

In October 1995, the NRC received a Petition for Rulemaking that requests the NRC to change its Rule to include "sheltering, evacuation and prophylactic use of iodine" as a range of protective actions for the general public. This change would require States to develop plans for the administration of KI to the general public as a protective action option. In order for this to be a viable option, KI would need to be purchased, stockpiled, and perhaps even pre-distributed to the public.

The FRPCC asked that another Ad Hoc Subcommittee on Potassium Iodide be established to review information provided to FEMA and other Federal agencies, including the Petition for Rulemaking; review the comments received on the Petition; and review relevant new information pertaining to the issues affecting the Federal policy on the purchase and stockpiling, and use of potassium iodide by the general public in a radiological emergency at a commercial nuclear power plant.

As part of its examination of the KI issue, the Subcommittee held a public meeting on June 27, 1996. At this public meeting, the Subcommittee heard testimony from representatives from the States, the nuclear industry, concerned public interest and citizens' groups, academia, the American Thyroid Association and the Petitioner.

After hearing the compelling viewpoints presented at the public meeting, the Subcommittee presented its report and recommendations to the full FRPCC. Taking into account factors such as the roles of Federal agencies, the interest of State and local jurisdictions, the over-the-counter availability of KI and recent government guidance on evacuation, the Subcommittee recommended:

(1) Without changing the Federal policy, the Federal government should fund the purchase of a KI stockpile for any State that decides to use it as a protective measure for the general public. If a State does choose to incorporate KI as a protective measure, they would then have to incorporate it into their emergency plans.

(2) The language in the 1985 Federal policy be softened to be more flexible and balanced; and

(3) That local jurisdictions who wish to consider KI as a protective measure consult the State to determine if such arrangements would be appropriate. If local governments have the authority or secure the approval to incorporate KI as a protective measure for the general public, they would need to include such a measure in their emergency plans.

In October 1996, the FRPCC adopted the Subcommittee's report.

Presently, the 1985 Federal policy is being revised to reflect the recommendations of the Subcommittee. The NRC, following its own regulatory process and internal procedures, is in the final stages of evaluating the Petition (and comments on it) and submitting its findings to the Commission for a decision.

Dr. Fry: Thank for that interesting review and for bringing us up to date, and in fairness I think we will take a couple of quick questions. Dr. Saenger...

Dr. Saenger: I certainly want to congratulate Mr. McNutt for giving us a steeplechase version of what happened. I was the chairman of the committee that put the issue in Report 55. And there were several aspects to this which I think are important. One was that we were the first report that ever got the FDA to revise downward the amount of material in one of their recommendations. The therapeutic dose of KI is 300 milligrams. We were successful in getting a dose of 100 milligrams for adults to be taken daily for, say, three to seven days, depending on the emergency, and 50 milligrams for an infant. The question of whether one should have mandatory stockpiling has been very moot as you have heard, mostly because KI has a shelf life of about seven years I believe, and at that point all the iodine has deliquesced. Iodate was recommended, I think by the British, but never found acceptance over here for reasons I don't really understand. I think it is interesting that the threshold has been elevated to 25 rem as compared to ours of 10 rem. I think this is one of those situations where whatever you do is always open to question. It would be interesting to see when the next switch is in the stockpiling of KI.

Mr. McNutt: I might add that the prescribed dosage now is 130 milligrams, and the Food and Drug Administration was about to issue, or extend the shelf life for potassium iodide; however, due to their massive reorganization, that has not been done. Right now it is still at five years.

Dr. Fry: One more question--Dr. Fong...

Dr. Fun Fong, Emory University: Has there been any discussion about the potential delivery of povidone iodine, something that's available in many hospitals? It has been proven in laboratory animals to effectively block the thyroid. You would always have a fresh supply of povidone iodine. Has there been any discussion in the committees about this form of iodine?

Mr. McNutt: No, there has not.

Dr. Fry: Thank you, Mr. McNutt. I think we'll go on to our last presentation. Tomorrow we'll have opportunity for more discussion and questions. Dr. Tsyb is an Academician of the Russian Academy of Medical Sciences. He's director of the Academy's Medical Radiological Sciences Center, located in Obninsk. He currently heads the Russian Scientific Committee on Radiation Protection and has authored a monograph, "The Consequences of the Accident at the Chernobyl Nuclear Power Plant."

Diagnosis and treatment of children exposed to radioactive iodine inhalation at the Chernobyl accident

Dr. Tsyb: Dr. Fry, dear colleagues, we have been here several days in this wonderful country of yours which has all these deep democratic traditions, and we're very grateful to you for giving us the opportunity to participate in this extremely important seminar. Thank you very much. And now a few words about what we know about the thyroid pathology after Chernobyl, about the diagnosis and treatment, and also about the risk factors for both malignant and benign tumors of the thyroid gland. I would like also to say that I'm going to talk not only about children and teenagers but also about the liquidators. First slide, please. This is the map of the density of radioactive iodine fallout in the Russian Federation, and you can see that the area where the density of contamination is more than 100 curies per square kilometer takes place in the Briansk Oblast, in Nolazipkoba and some other areas, and smaller densities, 25 to 50 curies per square kilometer, are in the Kaluga Oblast and in Tula Oblast. We're talking about radioactive iodine, not cesium, and so of course this has an approximate character, because we didn't have enough samples. One of the main institutions called Typhoon, which is responsible for assessing the radiation situation, came up with this map. Also I would like to say that exposure to radiation affected quite a few children, teenagers, and adults in Chernobyl as a result of the accident there, and when we asked the question, "What is to be done?", we had to develop a concept as to how to monitor the health condition of these children and teenagers. We worked out this screening concept, which consists of three stages. All these three stages can be seen on this slide. I would like to stress that we're talking about active examinations of children. The second stage is the verification of the diagnosis, and the third stage is treatment in the hospital of those children who have some thyroid gland pathologies or who got sick. This screening, of course, and other examinations cost a lot of money. We're talking about active examinations of many children and teenagers. They are examined by a pediatrician or therapist or endocrinologist, and also there are some ultrasound exams, studies of thyroid gland hormones, and other procedures. One of these exams, calcitonin, is done only after the patient is in the hospital and cancer is suspected. As far as the cytology, we sometimes do a puncture [needle biopsy] of the thyroid gland and sometimes we find some lesions there. We do the biopsy at the local hospital or clinic, and we also do the cytological exam. We have been doing this for 10 years, and every year we examine large amounts of children and teenagers. We already have sort of a permanent contingent of patients which we examine, which we monitor, and there is also a register of everybody who was exposed to radiation as a result of the incident at Chernobyl, including children and teenagers with thyroid problems. For example, every year we examine a contingent of 11,000 children in Kaluga; in part this also refers to Smolensk and Yaroslav Oblast. This contingent is greatest in Briansk Oblast because this was the most contaminated area. We're talking about 20,000 children there. And, as for Tula, we examined both children and adults. A number of cancers were identified as the result of active and direct examinations and not because these people came to the doctor, clinic, or hospital. In other words, we're talking about active examinations by special teams of physicians which include those experts I have mentioned before, and that always includes ultrasound examinations. And now I would like to show you a few slides which illustrate those changes which we detected when we researched the function of the thyroid gland. The first one is the T-3 hormone. The abscissa is the number of years after the accident, and the ordinate is nanomols, the units for T-3 hormone. I would like to draw your attention to the fact that only in the years 1986 and 1987 did we see an increase of T-3. The black column designates those children whose thyroid dosage is under 2 Gy and the white column, more than 2 Gy. And you can see that there is a difference between these two categories of children. In some cases there was a temporary increase in T-3. We have observed these children all these years. Ultimately the T-3 levels normalized. This is a similar slide for T-4, and we saw the same tendency, an increase of T-4 for children who had more than 2 Gy exposure, especially in '86 - '87. This is thyrotrophic hormone, TSH. I would like to point out that the level of TSH in the group of children with exposure of more than 2 Gy is lower than in the other group. In other words, there is an inverted ratio. What happens next is that TSH goes down in both groups and then it goes back up again. Why does this happen? Perhaps a slow normalization of the content of TSH of blood of those children has taken place. And an especially interesting issue is this: We examined a group of children, together with Professor Gosatkinam, in the Orel Oblast, which was also contaminated. There was also some exposure to the thyroid. We also had a control group. You can see that there is a verified difference between the levels. Thirty-three percent of those children and teenagers whom we have observed have a nine percent higher level. In other words, the difference is 2.5 times. These studies are the result of research made in '92 and '93. Very interesting data have been obtained with regard to the microsomal fraction. We're talking about children where the dosages were as shown on the slide, and, especially when we look at 1987 and 1988, these antibodies, 1800, 3000, and so on. And you can also see the percentage of children in whom we found an elevated level of antibodies of the microsomal fraction of the thyroid gland. You can see how many children had this increased level of antibodies. Then this level went down significantly, but in the years 91-93, there is a return to higher levels again. So it looks like this is a risk group. It looks like this is a group which had an increased content of antibodies and therefore needs constant observation and monitoring. We are doing exactly that. The overwhelming majority of these children did not show symptoms of auto immune thyroiditis. On the other hand, it could be a precursor of some disease. These children are members of a risk group, and we should monitor possible manifestations of any thyroid pathology. These are the same studies, with two groups of children. On the abscissa you have dose ranges of zero cGy; less than 30 cGy; 30-75 cGy; 75-200 cGy; 200-400 cGy; and above 400 cGy. The control group of children is an internal control group of children from those same three areas who in 1986 had zero measured exposure. In other words, they did not have any radioactive iodine in their thyroid. If you look at these dosages, you see that those groups of children who were exposed to more than 200 cGy had elevated levels of antibodies of the microsomal fraction of the thyroid gland. And we also obtained interesting data when we observed a group of patients which again had this elevated level of antibodies. We wanted to find out whether or not this leads to some hematological diseases, so we looked at this group of patients. They have B-12 deficiency anemia and also cytopenia and lymphoproliferative diseases. This is a control group which did not have any hematological diseases. And we have found that the titer of antibodies of the microsomal fraction is more often higher when a patient has either cytopenia or there is a lymphoproliferative disease such as lymphoma. In other words, this is a risk group which, if it has an elevated level of antibodies, then more often has some hemoblastosis. Now, as far as the autoimmune thyroiditis cases, we looked at 7,950 children. We not only looked at the antibodies, we also did ultrasound exams, and, if we found any lesions, then we did cytological studies in order to find out whether or not there was some lymphoid infiltration which might indicate autoimmune thyroiditis. The previous slide demonstrated that the level of antibodies was 4.6-4.8 percent higher, but when we looked at the ultrasound characteristics, when we looked at the zones that can be observed in the case of autoimmune thyroiditis, we found that the level of autoimmune thyroiditis cases is much lower. If you look at the abscissa, which is the age of children, for those younger than 16 or even 20 years of age, the incidence of autoimmune thyroiditis is 0.6 percent, but as age increases, the number of cases of autoimmune thyroiditis also increases, especially for people 40 to 60 years of age

There are 20,000 people that we have been observing in the Kaluga region and 7,000 in this other region; we examine them every year using the methods which I have mentioned. Let's look at the morbidity structure for these children and teenagers. This is a typical morbidity structure. It's typical for all four oblasts (Briansk, Kaluga, Tula, Orel) which were exposed to iodine radiation. We can see that nodular neoplasms are observed as often, no more than one percent of the cases, as with autoimmune thyroiditis cases and benign cysts, but more often we see diffuse goiters. Also, in this contingent we found 0.5 cancer cases per 1,000 for Kaluga Oblast. This slide shows the situations in the Briansk, Tula, and Smolensk Oblasts. The abscissa is the age groups of children; the number of nodular tumors goes up as the age goes up, but there are no verifiable differences between children in these three oblasts, despite the fact that Briansk Oblast is the most contaminated by cesium. We're talking about 30, 40 and even 50 curies per square kilometer, but we don't see any verifiable difference between these two oblasts with regard to nodular tumors. Now, this is the same for nodular goiter in adults. Again, the incidence goes up as the age goes up and is observed most often when a person reaches the age of 50 to 60 years. But again there are no verifiable differences between the areas with various degrees of contamination, including cesium.

Here we changed our approach and decided to take a look at the whole group of children and teenagers in four oblasts: Briansk, Tula, Orel, and Kaluga. We looked at children aged 0 to 17 years. In these four oblasts there are almost one and one half million children and teenagers, and you see their distribution according to age. And now the summary. You can see the number of cancers of the thyroid gland for children and teenagers of these four oblasts. We have separate data for girls and boys. All in all, there are 124 cases of thyroid cancer in the contingent where children are aged from 0 to 18 years old. In other words, as of today we have 144 cases of thyroid cancer for those four oblasts. In other words for one million and approximately 200 thousand children and teenagers, we have 144 cases, and you know very well that the spontaneous level of thyroid cancer is about one to two cases per million children. "These figures are taken directly from the transcript; the slides were not available, so we cannot explain these conflicting data." When we conduct active screening maybe we would get as many as 3 to 4, maximum 5 per million, which is identified when you do ultrasound studies. And the next slide shows the distribution of thyroid cancer for young women and girls. *[Break in transcript]* figure six times greater than the other one, and if we're talking about people from 0 to 18 years of age then the ratio is one to two. This graphically displays what happens to girls. The abscissa is the age of the girls, and you can see again the ratio between the expected and observed number of cancers and you can see that the greatest increase can be observed when the children were 0 to 1 year of age. It was this age that for some reason during that period the thyroid seems to be the most radiosensitive for girls, and we saw these differences quite clearly. For boys, you can see the number of boys and also the expected and observed numbers. Also I must say that girls have thyroid cancer much more often than boys. And here we have a much greater ratio, although the total number of cases for boys is 34 and for girls 90 and more. With the boys we don't see much the first two years, and then, when they're 2 to 3 years of age, you can see the peak of the incidence of such cancers. Here you can see the increase in the incidence of cancers. This was a big project which was done under the aegis of the WHO and IFECA (?), an international program. The work done by the Russian experts was done within the framework of the European Union project. We are also implementing now an international consortium project which actually is located in the United States, and I would like to demonstrate the contingent of children and teenagers, 834 people who had various pathologies. And here we have diffuse goiter, some nodular tumors, thyroiditis cases, and so on. This is the contingent which we diagnosed in 1992 and then observed in the years '92 through '94 and we are extremely interested to know what happens to those pathologies. Are they going to remain unchanged, or are they going to transform into other diseases? Of course, we delivered the appropriate treatment recommended by endocrinologists. There were a number of patients (110) suffering from diffuse goiters, and 10 cases of thyroiditis. Here we also have two cases of cancer, especially for those people who had diffused swelling or tumor in the thyroid gland. Some of those who had diffuse goiter were subjected to conservative therapy; 12 percent of them regained their health, but some goiters increased in size and some nodular tumors appeared. So it's very important to observe and examine and treat those conservatively treated patients in whom certain pathologies have been found. If we have the slightest suspicion that they're suffering from thyroid cancer, these children should be sent to highly qualified specialists in a well equipped clinic where refined diagnoses should be made and treatment should be conducted. I would like to demonstrate that the problem of cancer treatment and the problem of diagnosis are very difficult problems. Unfortunately, even today in the Russian Federation, we have different methodological approaches to this problem. Only now was a decree of the Minister of Health issued which basically mandates that treatment should be conducted in two clinics, the Institute for Children's Diseases and also Medical Radiological Scientific Center in Obninsk. I would also like to show what the situation is in our country. We found 35 cases of thyroid cancer. That was diagnosed preoperatively on the basis of a thorough examination. In these 35 cases of diagnosed thyroid cancer, different types of surgery were conducted but were followed up by histological studies done by the best experts in Obninsk and the Hertson Institute, Oncological Institute in Moscow. This was also done by other pathologists, no fewer than three, and what happened? Out of those 35 cases, in 23 cases cancer was confirmed, in 6 cases there were no cancer. In two cases there was thyroiditis and nodular tumors, so despite all these very thorough examinations by experts who had dedicated all their lives to these problems, nevertheless, we made these mistakes in a number of cases. Also in some cases we found goiters, thyroiditis, adenomas, and so on, and then after follow-up histological studies, out of 45 cases, in six cases we found thyroid cancer and you can see that in the chart. So I just wanted to point out that this is a very important, very difficult problem. I would really like to invite my American colleagues to participate in cooperative projects related to this problem. We, together with our Belarusian colleagues systematized and summarized all the materials for the last 10 years, and we put them out as a book. Unfortunately, it's in Russian, not in English, but we're working on a translation. But we have come to the conclusion there are many difficult problems that can be resolved only if we cooperate. And now I must say that after Chernobyl, there were many cancers in Chernobyl. After these patients were treated in hospitals and the extent of TNM staging was determined, we had 14 percent of metastases. As for T-4, when the capsule of the thyroid gland was involved, all patients had unilateral cervical node metastases. I would also like to show you how many cases there were of patients with thyroid pathologies who came to our clinics during the period of 1975 through 1985. I just wanted to say that our clinic has been dealing with the problem for a long time, and we have a special section which is unique in Russia, and we have radioiodine therapy of the thyroid. There have been 6000 patients who were treated there, both children and adults. This slide illustrates a problem faced by radioiodine therapy. We treated 2300 children and adults for cancer of the thyroid gland. We have a proposal here, because there is a problem related to the fact that in various areas of the Russian Federation some cases of thyroid cancer appear and immediate consultation is necessary, so we have to engage in long distance or distance treatment. We had two teleconferences in 1995, one in Hong Kong where a congress of pathologists was taking place and the second teleconference in Geneva. We were able to show them our histological specimens and also we were able to talk to experts. So this is one possible way to encourage cooperation between specialists, especially if we're talking about histology. It's very expensive to invite somebody, let's say from the United States, to come review our slides, but it could be done with the use of long distance treatment using teleconference. I simply wanted to point out this important aspect. Since we are very serious about radiation epidemiology, our center has another smaller center within its structure of radiation epidemiology which cooperates with the World Health Organization and it's headed by Victor Ivanov, who is a great expert in the area.

Again, we examined these cohorts of Kaluga Oblast children whose individual thyroid exposure doses we know for each child because we did the measurements during the first two or three weeks after the accident, and we compared the risks. This (slide) is the well-known Japanese cohort, and this is our Kaluga cohort. You can see the excess relative risks are very similar as far as the attributive risks for all noncancerous diseases or disorders of the thyroid gland. That risk for the Japanese is 16.4 and we had 12.1; however, these are preliminary data. This is a very important issue. In order to refine these coefficients, more effort is needed. Also the radiation exposure was different in Japan and Kaluga because the times of exposures were prolonged, some exposures were external, some were internal, dosages were different, etc.

More efforts are needed to define the coefficient for cancerous disease of the thyroid. Here you can see the case control methods that we utilized. For example, in Briansk Oblast, where there are some 120,000 children (we're talking about the southwestern regions, which are the most contaminated), we found 70 cases of thyroid cancer. We used case control methodology, and we did medical dosimetric studies of each cancer case and we selected pairs using this methodology that you are well aware of. We employed criteria, such as gender, age, and also the type of population center where that child lived. Using that methodology we determined relative risks and we found that it equals approximately seven, when the dosage for thyroid are 0.60 to 1.40 Gy. There are not many cases where the dose exceeds 1.40 Gy. When the doses are 0.50 to 0.60 Gy, we did not get any verified increase in relative risks. This is a very important question right now. We have 144 cancer cases, and in every case we do medical and dosimetric studies using specific methodology. We do this work within the framework of an international consortium. We also do a lot of work related to control cases. First of all, when we have 134 (sic) cancer cases we need to find 400 control cases. It means that we have to do a medical and dosimetric study for each child, and this is a huge task. This is one of the main components of our future work within the framework of domestic and foreign cooperative projects.

These are the new data for children and teenagers which we publish every quarter in our bulletin, *Radiation and Risk*, and our Professor Angelina Guskova talked about that. With the help of our American colleagues, we were able to publish two issues in English, which I have given to Dr. Reeves. As far as the data for liquidators, we have processed them recently and I wanted to show you the data for thyroid cancer for liquidators in 1986. The blue or purple line is what had been forecast on the basis of the model that you know well. This (slide) is what we really obtained, so the conformity is not bad. And now for the first time we can see this growth of cancer incidence for those people who were liquidators in '86. We should really separate the data for '86 and '87 because we're talking about different liquidators, but there is one detail which was introduced for the first time; we're talking about the screening coefficient. You see this line doesn't start from one; it starts at a different level because there is a latent period of two or three years. Using the screening coefficient, we get good conformity. In other words, if we do this screening we detect not one, but three to four cases per million. If you take that into account, and some works on that topic have been published, we're talking about five to six hundred percent increase of incidents of cancer for liquidators. This is the relative risk, and you can see it in these two charts. First of all, we compare the radiation risk of leukemia in the Japanese cohort and in our liquidators. The excess relative risk is 4.3 for the liquidators, and the Japanese have a different number, but there are differences in the cohort and in dose, and also the type of exposure is different, as well as the type of radiation. But if we look at the attributive risk and the percentages, it is 81-88 percent in Japan. As far as the risk of thyroid cancer, if we compare it to the Japanese cohort and determine excess relative risk, we have 5.3 and the Japanese have 8.x, and so on. You can also see the numbers for attributive risk, so right now we can talk about the increase of thyroid cancer cases and leukemia cases for liquidators in '86 and '87. I think that we should continue this research in order to confirm or perhaps exclude the conclusions. Thank you very much.

Dr. Fry: Thank you, Dr. Tsyb. The hour is late; the topic is hot. Are there any questions that must be asked tonight? I think we have a great deal to sleep on tonight and come back refreshed tomorrow with good questions for a good discussion. Thank you very much. Thank you, Dr. Tsyb.

Concluding remarks

Col Reeves: For this morning, we are going to conclude our conference by having each of the chairmen of each of the three panels comment about any further items they may have concerning their presentations. Then we will open the floor to the audience for questions that were still pending from yesterday or the day before. Finally, I would like the chairmen to just sum up what they think are the next steps they think we should take to further the work that we have been doing for the last few days. Dr. Arutyunyan, the Russian co-coordinator, and I will give the concluding remarks. Dr. Vladimirov, who chaired the first panel on Review of the Russian Experience and Liquidation of the Consequences of the Chernobyl Nuclear Power Plant and South Urals Accident from the Emergency Response Point of View, will open this morning's session.

Dr. Vladimirov: Dear colleagues, on Tuesday, Nov. 12, in the afternoon, we heard five presentations on the topic of the Experience of Liquidation of the Consequences of Radiation Accidents. In two presentations out of the five, details were given about the Russian experience of the emergency response in the South Urals area and the Chernobyl catastrophe. In two presentations, issues of the roles of the federal regulatory ecological monitoring were described and approaches to certain measures on remediation of contaminated areas. In the fifth presentation, experience on the development of the Russian system of emergency response, including the radiation accidents, was described. All those issues are very acute and urgent and it seems to us that the people present here were interested in them. We in Russia base our activity on one principle: we should always be prepared for the worst, then it will be easier for us to deal with better situations. Nobody today can say the Chernobyl catastrophe will not be repeated, both in the U.S. and Russia. A lot has been done to increase the safety of nuclear power plants. We are sure that during normal operations of our NPPs, the Chernobyl catastrophe shall not occur again, but of course we can come across terrorist attacks, earthquakes, and meteors which can cause certain accidents. God forbid if some mad man were to be able to start nuclear war. Then global contamination will occur. At the present time, as I described in my report, the situations at the majority of Russian areas that have suffered from the testing of nuclear weapons, the accident at the Mayak in the South Urals, and the Chernobyl catastrophe have been normalized. It may seem that we may be able to stop the work related to the liquidation of the catastrophe, but we are doing the contrary.

Number 1: We have to work with the suffering population and the territory; we should give them a chance to live on those areas without any restrictions or limits. Please understand me correctly. Huge areas have been contaminated in Russia in which an enormous number of people lived (30 million, about one-fifth of the entire population of Russia). To evacuate and resettle these people is impossible. To stop economic activity on this area means to lose a huge economic potential of the country. Thus we have to resolve the issues of how to make sure that these people live happily on this territory.

Number 2: As I have already said, this is a very good test ground, where, not in a laboratory but in natural conditions, one can and one must study the problems and issues that are of interest for human beings. The most urgent problems that we pay much attention to today are the following: first, reconstruction of exposure doses. You can imagine that nobody thought, after we had the last nuclear explosions into the atmosphere, what kind of doses the future population would receive; however, right now we have to deal with this problem, to reconstruct exposure irradiation doses in order to correctly assess the health state of our population. We are using various methods, both ceramics and tooth enamel electron spin resonance analysis the ratio of isotopes; we're searching for ways how to more correctly reconstruct the exposure doses of the population. The second problem is the problem of receiving clean products from contaminated areas. I said already in my report that today we can receive clean products, such as vegetables, fruits, and meat products, from many of these areas, but you cannot really take these products from a human being who lives in a rural area, in a village as we say. If you take these products from him, he has nothing to do in that village. We study the behavior of radionuclides in nature-- how they penetrate the soil, how the vegetation behaves, and some other problems that we are trying to solve in this direction. We are working towards the study and development of methods and ways for effective decontamination. And, finally, we exercise control over the health of those who suffered and how to treat them. You heard yesterday a report on this topic. Also, we are resolving a number of other issues. We think that our experience is needed. It will be necessary not only during global catastrophe but also during local radiation accidents. Another aspect of this problem--we think and believe that our works are very efficient as far as the population and population behavior are concerned. This work does not create additional radiophobia that many people are afraid of and talk about. On the contrary, people can see that we are next to them when they have problems, that we are searching and implementing new methods of their protection. They become more calm and they welcome this. We believe that our seminar, our workshop, was extremely useful. We have exchanged our experiences, we have assessed the state of problems and we have discussed what will make possible to develop the plans of our future cooperation. Thank you very much for your attention.

Are there any questions?

Dr. Ainsworth: I have a very general question, probably on dose reconstruction, that I think goes beyond the scope of your comments just now. The fundamental question that is being asked, at least here in the States, is how good must the dose reconstruction be if the question is epidemiological? To determine an excess cancer risk, an excess risk of other kinds of late problems, how good do these dose estimates have to be? Are the doses going to be reconstructed with a factor within 50 percent or a factor of 2 or 10? How good must they be? Maybe the epidemiologist can tell us that.

Dr. Vladimirov: Had we used the principle that dose reconstruction must be within 10 or 50 percent, perhaps we would not have even started this work. We are developing the methods that allow us, indeed, to restore the doses of population who suffered during catastrophes. In particular, the problem of reconstructing or calculating the doses for the people who suffered during nuclear explosions was very difficult, because, actually, the territories are clean; the areas are no longer contaminated; and to restore the doses using some parameters was extremely difficult. But we did find the methods. They were approved by our state, our national sanitary organizations. These doses are being reconstructed and restored and in the near future will be published. This year we are going to publish the doses, as I said in my report, for the population who suffered in the Chernobyl accident. We will calculate the accumulated doses over all the areas where people lived and suffered; moreover, we will give a forecast to year 2050. We hope that when we publish this data that in the main we will be able to resolve this radiophobia problem. The population must see what people have received and what they are going to receive. They should live happily on those areas and do their economic reconstruction. If we speak about the degree of risk, we are really continuing to develop these methods. The dose reconstruction that we are doing right now will give us the chance to more precisely assess the degree of risk during the all radiation accidents and catastrophes that might occur. We hope to assess the risk for the population who live near NPPs, near radiochemical facilities, research centers, etc.

Dr. Steinhausler: I would like to add on to the question of Dr. Ainsworth in two points. The first is the dose reconstruction for the people in the contaminated areas, and the second is the dose reconstruction for the liquidators. In the international Chernobyl project, we tried to assess the standardization and the quality control in assessment of the effects; that means what health effects were registered in Belarus and in Russia and in the Ukraine in the selected areas. And we came across the major obstacle, that is, the lack of interhospital, intermedical center standardization in the registration of health effects. This means that it was not convincingly assured that health effects registries in one area would be comparable to those of the next. My question to you is, is there any mechanism in place that you foresee the possibility that in the future this quality assurance and quality control in health effect registration will be addressed? The second question that I have was in regard to liquidator dose reconstruction. Is the technical difficulty that the term "liquidator" comprises a large number of different, let's say occupationally, exposed groups? We have looked at the liquidator numbers and activities between 1986 and 1991. We have been able to identify in this five-year period 47 different groups of "liquidators," so to speak, ranging from the early search and rescue parties before the arrival of the fire fighters to, for example, the divers who dived into the water underneath the reactor to open vaults. My question to you is, in your registry of liquidators, is there a possibility to define the exposure scenarios for all these different liquidator groups? I would appreciate your comments on that.

Dr. Vladimirov: Let me start with your second question, about restoring the pattern of all the work that the liquidators did. I told you that about 600,000 people were involved in the Chernobyl accident. We cannot restore entirely the picture of who worked where, when, and doing what. We cannot assess the dose reconstruction for each individual; it's extremely difficult; however, we do have control groups. Actually, in all our national documents, we divide liquidators into liquidators of 1986, of 1987, and of subsequent years. We base our notion on the fact that the effects were different, naturally. In the first case, there were a lot of nobel gases, iodine, very high levels of sulfur, and very high levels of irradiation, particularly when we cleaned up the area and gathered up the fuel elements and residues of the reactor. Then the level of the exposure dose was in the area of 100 rem during a 24-hour period. Let me cite you another example. You remember that we had a problem when the reactor was heated up. We were afraid that it would collapse down into the basement where there was a pool with water that had not drained, and we thought that maybe another, a second thermal explosion, could have occurred. So for two days we were going to resolve one problem, that is to make a pathway for engineers, so that the engineers would be able to go underneath the reactor and pump out the water. We were going in from the west, from the forest, from the industrial area, and the people who participated in this operation indeed had no less than 40-50 rem per 24 hours during this work. Many of those were relieved and sent home. It was a necessity; however, when we came closer to the wall, the engineers told us that an explosion should be made. They could not go through without an explosion; however, the structure would collapse if we made another blast. So the next day we approached the reactor from the south, and the radiation levels were lower even in the protected equipment. I personally was responsible for this work, and I was in the vehicle with a protection coeffecient of 40. I received 12 rem in the course of 3 hours, but we cleaned up the area so that the radiation level was no more than 1 rem per hour, and we provided for the passage of our experts, who were then able to pump out the water from underneath the reactor. Then immediately we started work with miners who were drilling near the reactor from another site, and it was a very useful operation. So if we attack this problem from this angle we approximately know who, where, and when, what levels of radiation, what types of radiations (which was also very important for all of us). So we know about such individual control groups and we can work on these groups. You know that a large amount of the radiation dose occurred during the cleanup of the roofs, when people cleaned the remainder of the fuel elements off the roofs and the radiation levels were hundreds of rems per hour. We didn't have any mechanized or automatic method to clean up. We sent robots to the roofs, but the robots did not work, because when you have these very high exposure doses the electronic parts did not work. We didn't have the robots that could work under these high radiation levels. It was also very difficult to do because the roofs were made of concrete and covered with bitumen, so we had to use manual devices to cut off some pieces of the roofs. The liquidators worked for a limited period of time, only a few minutes. We told them exactly how many minutes they should work, then they came back. It was just a single shot; they did not up go up to the roof again, but, again, we have the data that tell us that many of them got doses during this operation of over 25 rem. This is another group of people that we study, of course. These people left the irradiation zone immediately and were immediately sent home. Many people worked on decontamination of rooms in Unit Number 3 and Unit Number 4. Again, there were different levels of radiation. The most difficult group for assessment was that of the people who worked underneath the reactor. By that time we had provided for good dosimetric control, we took samples of both gases, aerosols, and controlled the air from one side. We knew the composition of isotopes and we knew the exposure levels, and so for this group we can also judge on the doses that they received during their work. By the way, these were scientific people in this group, and so I would like to emphasize again that there are certain groups that we can judge and speak about radiation doses.

Dr. Tsyb: I would like to discuss several problems. Number l: Dose reconstruction, not simply reconstruction but reconstruction of doses for serious epidemiological studies. These are our main tasks of today. In dose reconstruction, we have three groups: the reconstruction of doses for the entire body of the population who lived in the contaminated area, dose reconstruction for thyroids for the population and especially in the children, and the third group, dose reconstruction in the liquidators. Here we have to have separate approaches in order to resolve each of these three problems. As far as reconstruction of doses for the entire body of the population is concerned, let me tell you the following: as Mr. Vladimirov told you recently, this problem, today, has been basically resolved. Now we are not speaking about individual doses for individual people who lived on the contaminated area, we are speaking about the Russian Commission on Radiation Protection who has developed and approved two methods. One methodical approach is for the determination of the annual effective dose for the entire body in the population who live in the contaminated area, and the second methodical approach is for the determination of accumulated dose during the entire period after the accident. So today, we are speaking about a 10-year period of time. I think that we have not only the methodology, we also have certain results regarding the determination of doses using this methodology and we have a group of extremely highly qualified experts. First of all, these are experts from three institutions: from St. Petersburg, Moscow, and Obninsk. We believe that this year the results will be published. We are talking about average exposure doses for every population center, and we will also have the whole spectrum from minimum to maximum doses. We talk about epidemiological studies and look at them from this point of view, for example, when we talk about stochastic effects, especially malignant tumors of various organs and systems, in the population that lives in these areas. We are talking about excess relative risk, how many additional tumors will there be and within the frame-work of IFECA (?), the international program. We have implemented a three year-long pilot project. Especially serious epidemiological studies have been conducted with regard to leukemia and leukoses. I would like to draw your attention to the fact that the WHO right now has about 1,000 copies of a scientific report on this pilot project in English. It would have been nice if this report had become known to all experts in America, Europe, Japan, and so on. Such highly qualified experts as Bebeshko from Ukraine, Osechinsky from Russia, Ivanov from Belarus made these reports. They demonstrated quite clearly and they published the data that show that an increase of leukosis cases in the population that lived in contaminated areas did not happen; it simply did not happen. But naturally, it is necessary to continue studies in this area, taking into consideration the reconstruction of the doses that will be achieved. By the way, this work has been done very well in the Ukraine and Belarus. As far as reconstructing the doses for thyroid glands, especially in people who were children or teenagers at the time of the accident, I would like to say that we also have certain achievements in this area. For example, in Russia, we also do dose reconstruction for cohorts or contingents for epidemiological studies. For example, we formed such a cohort in Russia, consisting of 3,500 children from Kaluga Oblast, and we know for certain what the individual doses for thyroid glands are for each child. These doses are not approximate, they have been measured during the first couple of weeks after the accident. We examined 8,200 children and adults. We measured the doses for thyroid glands in these people. We have also signed an agreement with regard to a long-term project, which will last 20 years, to continue studying these children. The average dose for this cohort is approximately 25 to 27 rad for the thyroid gland. In other words, if we, at least over the course of 10 years, do real genuine cohort epidemiological studies then we would be able to answer the question, whether or not these low doses cause thyroid cancer in children and teenagers. As of today, in this group we only found four cases of thyroid cancer. The same direct measurements have been made in a sufficiently large cohort in the Ukraine. Professor Likhtarev has about 150,000 measurements, direct measurements, and this is a sufficiently large group. As far as I know, they are doing epidemiological studies and doing reconstruction of the doses. By the way, what I said about the relative risk for children, which is equal to 7, we are talking about thyroid cancer. Now Ukrainian colleagues recently published certain materials and their average risk is expressed by the same figure, 7. It was Likhtarev's and Gulko's studies; Gulko is now in Germany. Another serious problem is connected to the reconstruction of doses in Tula, Orel, and Kaluga Oblasts, because very few direct measurements were made there. There is only a small group who was involved, 3,000 people in Briansk, who were subjected to direct measurements, so we have our work cut out for us. Right now, we are actively working in this direction, we are implementing several projects. Right now, in fact, international cooperation is being implemented in three areas: with the European Union, the American International Consortium, and also we have some examples of bilateral cooperation. So I hope that whatever problems we have will be overcome. The third problem is the problem of the liquidators. This is probably the most difficult problem, from the point of view of doses, because right now we only know those doses which were included in specific legal documents dealing with liquidators. We are talking about 117,000 liquidators in the Russian Federation who have legal documents incorporating the doses, but we don't know to what extent the doses in these documents correspond to reality; therefore, the approach proposed by Dr. Vladimirov is probably the best way to go. We should form risk groups for liquidators. We do not need to try to reconstruct 600,000 doses. This is not doable. But to form a risk group is possible, and there are some good approaches with regard to forming such cohorts. We are taking into account the length of time the liquidators spent in the zone, the distance the liquidator was from the reactor, as well as such data as the gender, age, profession, and other parameters which allow us to verify the dose incorporated in the legal documents issued to the liquidators. The Institute of Biophysics headed by Academician Ilyin is doing a lot of work in this area, and so our Institute of Biophysics Center also cooperates in this area with the best experts of the United States, Europe, and Japan. Therefore, I believe that if we can form risk groups for liquidators and do these genuine epidemiological studies then we would be able to answer a lot of questions, which is necessary for both science and practice, but I would like to add that we really have to do more work, because after 10 years we are only doing the first steps in this direction. As of today, we do not have answers to many questions, and these answers are extremely necessary from both the scientific and the practical points of view. Especially, we must know what is happening in the low spectrum of these doses. Therefore, we're really happy with this seminar, we're really satisfied with it and I would like to say that we have registries in our country that are quite good and that touch upon different areas. They could serve as a good basis for this work. Thank you very much.

Dr. Vladimirov: Dr. Tsyb, basically I would like to say a few words and add something to the questions which were asked by our colleagues from Austria and the United States. These were very important questions. How are we going to deal with the assessment of the health of these groups? Definitely, I believe that the issues of the assessment of doses for liquidators for their clinical interpretation contain a lot of uncertainty. We have to decide what part of the cohort is affected by this uncertainty. Definitely we are not going to have 47 groups as you said--this is not realistic--but our experience shows that one would have many different routes toward the assessment of doses. One would compare that to relatively few direct measurements and try to reconstruct using biological methods. There are always differences and gaps. The character of these differences is very interesting. The workers' doses are much higher. As far as biologically calculated doses are concerned, many are close to direct measurements but are sometimes quite different. This is easy to understand because we are talking not just about exposure but also the effect of that critical biological system which we are studying. We believe that in these cases the following should be done: we should say that these high exposure dose cohorts are relatively small; therefore, one of the common errors is to assess the dose with respect to the cohort which was in the worst conditions, and then the result is transferred to the health condition of the group of which these people make up 5-7 percent. In other words, they're not the main indicators of the status of the group. Professor Tsyb already said in his presentation that we can see that some increase in frequency of thyroid cancer can be observed, but these liquidators have different exposure rates. We should really single out only those people whose dose is accurate and then try to see health connections only for those people, because we can either lose the effect if the other group is bigger or we can exaggerate this effect, having extrapolated it on the people who had not been subjected to this exposure.

The next very important consideration is, I believe that we should be very careful when we look at all the contingents of Chernobyl and when we assess the coefficients of excess risk. We don't know enough about the size of the doses so that we could convince ourselves that we will get some comparison, some similarities or nonsimilarities. We know the spectrum, the spread, and we know the distribution a little bit, but in this distribution, up to 80-90 percent is in the spectrum of very small doses which are very similar. There are two extremes in this distribution, a few people with high doses and very few people with extremely low doses, so, for epidemiological studies, these people should not be counted because they only interfere with our understanding of the problem. *[Part of transcript omitted here.]* on the extreme edges or else he belongs to the maximum distribution group. I have to reconstruct for him his exposure dose with the maximum accuracy. We had such examples. For example, there was a dosimetry expert who was in the corridor near the entrance of Unit 4, and he spent a long time there. He basically instructed other people not to come in, to put on special uniforms, and so on and so forth. So he had the maximum exposure rate. We confirmed that by studying chronological measurements of his lymphocytes and also post-mortem study of the enamel of his teeth and also with the help of a diagnosis of acute leukosis after three years, which we were able to connect with this individual's high exposure dose. This of course is not always the way out, but, in this particular case, this was the right way to go. Professor Vladimirov mentioned those people who were underneath the reactor and in the water. We looked at that group, and the greatest doses of exposure existed for soldiers who didn't go in but who were standing at the entrance, because they stood there for longer times. Those who came in and then went out knew about the danger, but the soldiers standing at the entrance didn't know about that. And the chronological data were much more severe. Therefore, once again I would like to say we should really be careful when we study these professional groups. We must use additional criteria when we reconstruct the doses, and we also have to work with a larger group, where the differences in doses are not great. We should also work with the edges of the cohort, but we shouldn't extrapolate their effects onto the whole group or whole population. From my clinical experience this is exactly what we should do; this is the moral way to do things. We also have certain obligations to these people; we should not exaggerate and yet shouldn't underestimate the effect.

Now in the Ukraine, what happened there? I believe that the most cancer cases took place in the zones where the exposure rates were the lowest. How did it happen? A large group in those regions received a large collective dose, so there is a connection to the large collective dose but it is not connected to the exposure rate of the thyroid on individuals. So we should really continue working on that and maybe do some corrections because we shouldn't really formulate rules. We should do it very carefully.

And the last--it is very difficult to reconstruct the doses for liquidators because unfortunately, for a group of people chronological studies of chromosomes were done for relatively small numbers of people when they were indicative of something, but Professors Solongais, Lloyd (?) and so on believe that these chromosome studies should not have been done. They were wasted, although they were expensive. At that time, we should have done stable operations which would be the basis, not for the reconstruction of the dose but for forming the risk group for specialized observation. During the first year, we looked at 1,000 cases of liquidators which did work at Unit 4 underneath the reactor and who worked at Unit 2 and Unit 3. We did not get more than 0.7 Gy in a single case. In other words, this dose was lower than the dose for deterministic effects, but it's realistic for forming the group at risk for distant consequences. So this is something that I wanted to add to what my colleagues had said. Thank you.

Dr. Fry: I just wanted to make some rather general comments following up on what John Ainsworth, Dr. Tsyb, and Dr. Guskova have commented on. Coming from a slightly different perspective, in more general terms, the degree of precision of the dosimetry depends to some degree on what question is being asked. I think this has been commented on by the other speakers. If you want to know whether the population as a whole has experienced some health harm, that can be done without very precise dose estimates, based on location and other nondosimetric factors. If you want to know if there is harm observed in the population of interest, and is that harm associated with radiation exposure, then you need a different and a more precise estimate of dose. If you are then looking at the magnitude of the risk from a given dosage of radiation, then you need an even more higher level of precision. This process is achieved by the system that Dr. Tsyb and Dr. Guskova have outlined in a process of a general population study, then more defined cohorts, and then into a case control mode. In a case control mode, where hopefully you would have the opportunity and resources, because you are dealing with smaller numbers of people, to collect more precise information about individuals, the concern is centered particularly in the low dose range, which is what we are interested in. What is unknown now, from a radiation protection standpoint, is what are the effects if any in the very low dose region. There are other factors that can influence the apparent effect of radiation, and in the case control mode you can also gather information about previous exposure to radiation, other types of hazardous materials, medical exposures to radiation. In the low dose range, the uncertainties of the dose from the accident or unexpected release of radioactive material or radiation can overwhelm the dose that is received. So we have to be very careful in the very low dose region of assigning doses to individuals without very carefully making them as precise as possible.

And in response to Dr. Ainsworth's question about what do epidemiologists want--we would like an individual dose that is clearly attributed to that individual to assess an exposure. And then we come down to the biological markers of exposure, which as Dr. Guskova has pointed out are not as sensitive as we would like. I think this is another area which is very strongly in need of support, the refinement of biological dosimetry for radiation exposure. We have now more advanced tools to develop these techniques, but effort and resources need to be put in that area. So ideally an epidemiologist would like the best dosimetry that exists, which is the individual dose to the individual person in biological terms. Thank you.

Dr. Vladimirov: Thank you. Any other questions?

Dr. Arutyunyan: I would like to raise a question that may be of interest for all of us to discuss. Within the framework of the Executive Committee of our Agreement, it seems to me that the experience of all the workshops, seminars, discussions with our Western colleagues have shown that it is effective, notwithstanding the fact that the last five years, both in Russia, Ukraine, and Belarus, a lot has been done and many publications have been issued. The Western scientists don't know this information. Of course we have issues to be studied in the future. We have certain projects, some things we don't know about, but there is a part that is very interesting when we speak about exchange of our experience. So it seems to me that within the Agreement of the JCCRER it would be interesting perhaps to publish in the English language something that in Russia has been known already for Urals and Chernobyl. We can do this kind of work jointly. The Russian scientists would prepare the material and our American colleagues would edit the materials as far as standards and framework that are used by American scholars are concerned. It would not be a very expensive program but very useful because pretty often you ask us the questions that we have known for a long time. We are surprised. How come our Western colleagues don't know about it? Perhaps it is because we have the situation that the Russian language exists only in the territory of the CIS countries. It would be interesting to think over if you agree with me. We can try to discuss this problem on the level of the Executive Committee and then the JCCRER. Thank you.

Dr. Vladimirov: Thank you. Any other questions?

Dr. Ainsworth: I don't speak for the Joint Coordinating Committee for Radiation Effects Research, I'm just one person who sits on the Executive Committee, but I strongly support as an individual, on behalf of the Department of Defense position, the approach that was just described. I think that would be an excellent idea. In fact, our little institute with Col Reeves playing a key role has tried to support some of the summaries of data collection on the chronic radiation syndrome and things of that nature, so I think that this is an especially important effective way to promote communication and to identify the kinds of extensive studies and accomplishments that are already in place, based on the work done in the CIS and particularly the Russian Federation.

Now I would like to change the subject. I will look to Col Reeves to tell me whether this is the right time to bring this up, but I would like to change gears altogether here and talk about Emergency Response Procedures. We have been talking about health effects largely and dose reconstruction. Our American colleagues have heard presented what our Russian colleagues do. And our Russian colleagues have heard about our processes and procedures. Now the question I have is, how can each of us benefit from the experience of the others, so that when this happens again we will be even better prepared, based on our joint experience to deal with these things? We have some differences in procedures and processes. It might be useful for us to discuss some of those, but the goal here, I think, is to try to ascertain how together we can do this even better.

Mr. Bickerton: I would like to make a just a couple of remarks on that. I certainly like the subject that you bring up. One of the thoughts that has gone through my mind in the last few days is we are hearing from our Russian counterparts things that where they have had the real experiences in responding to emergencies, especially Chernobyl obviously the number one. I referred to my talk the other day as a theoretical talk, because although we do have a lot of procedures and plans and such in place, we don't have the background, the experience to really have tested those out. We do tests and exercises and such, but I think certainly that is one area where having actual background and experience to rely on can be very valuable to us. Certainly one of the things I was very interested in getting would be copies of Romanov's and Vladimirov's presentations where they talked about some of the decontamination factors and things of that nature. We talk about those and we do have some theoretical information of our own, again, that we can rely on and we use in our own planning process, but I think we can certainly look to the vast experience of the Russians to assist us in some of our planning processes and help us learn and better understand some of the problems and concerns that we are going to run into in the real world environments. I certainly applaud that question and certainly would like to look forward to getting some exchange of information and techniques, experiences to help all of us in the process.

Dr. Vladimirov: I can answer your remarks. For today, we have extremely high possibilities. If you look at our cooperation that we are doing today jointly, it's a diverse cooperation. Our ministry is having very fruitful working together with FEMA. Annually we plan certain events. We have created a special joint committee that plans and organizes the execution of these measures and events. So within the framework of this cooperation and of this committee we can do exercises, workshops, seminars, and other events that would make it possible for both of us to fruitfully resolve this problem.

The second aspect of our cooperation within the framework of what we already have, within the framework of the Department of Defense and the Department of Energy of the United States, there is also a Joint Executive Committee that plans and organizes certain events. We can also cooperate in this direction in order to resolve all these problems. Moreover, we have cooperation with your ASME as far as safety is concerned and also discussed these problems. We also do some planning and execution of those issues, and so if we desire we can set up very fruitful cooperative work.

Mr. Alston: A very simplistic way of maybe answering the question of how--it would be very useful, I think, to the U.S. emergency response community, and hopefully also to our colleagues from the Russian Federation, if we could maybe get in a tabletop environment, where we might take a scenario of an emergency that has occurred and to compare how in each of our countries we would respond so that we could learn in this type of environment how each of us would handle it and then compare and contrast the ways so that we might be able to learn from each other. Certainly the vast amount of experience is with our colleagues from the Russian Federation, but we also may have some ideas that could be useful. I think this type of cooperative effort would not only be inexpensive but would probably be very fruitful for all of us.

Dr. Vladimirov: The Russian side agrees. During the entire workshop that we have during these three days, the Russian side is proposing exactly what you said. Let us cooperate. Let us do measures together, events together, so that our experience, our grievous experience, would be at the possession of all mankind.

Any other questions? Then, thank you very much. Our session work is completed.

Col Reeves: Thank you Dr. Vladimirov, Dr. Romanov, Mr. Chilton, and Mr. Bickerton. If Dr. Arutyunyan and the other members of his panel could come up and discuss the second topic, which was, as you may recall, "Scientific and Technical Support for Decision Makers Concerning Protection of the Population at Radioactive Accidents and Incidents."

Dr. Arutyunyan: Good morning. We will discuss certain summaries and our ideas of how we can work in the future on the topic of scientific and technological support of decision making and population protection during radiation accidents. Perhaps you will allow me to start with a few short remarks that I could not do during the session of our group because we didn't have any discussion at that time. We have discussed the modeling issues. We have seen various models that make it possible to forecast the consequences of radiation accidents. We discussed training and the procedures on how to develop scientific and technical recommendations for authorities who make decisions. I would like to emphasize again those elements that we tried to describe in our report. Our understanding that actually all existing models concerning the forecasting of radiation accident consequences have some drawbacks. That is, they're not very precise. If you want to make some decisions based on their forecasts, they are quite good for initially assessing the scale of the consequences. They are quite good in order to create the basis for developing emergency plans, but when we deal with this stage in the real-time mode, then we understand that there is some necessary lack of precision for direct forecast based on the models for decision making, with the exclusion of some certain situations when doses are very high or very low. In these cases the results of the forecast are useful. It is necessary to build an uncertainty factor into all these models with their databases; this is very important. Secondly, this kind of model must be added with the databases, which are based on the actual data for Chernobyl, South Urals, etc. This will make it possible to realize what is the ratio between the forecast and the realistic situation. The other problem is the fact that this model must take into consideration the actual data that are input during the accident. This kind of combination, where you adjust the model constantly, based on the actual data generated during the accident, makes it possible to achieve more precise results.

I would like to say that the key figure in the recommendation for decision making process is an expert. It is not a model, it's not the people who calculate using this model, it is an expert, a specialist in various knowledge, say agriculture, radiology, etc. Our experience and international experience show that the contemporary computers allow us to equip these experts in such a way that they will work more efficiently. It is extremely important when experts from various countries sit at the table together. They have various approaches, various expertise, and it is important whenever possible to provide them with real-time data and various calculations based on their requests. Those people who do the modeling make the calculations and give them to the experts. Then the experts can find easily the answers and address the situation, which is also a very important element. We were discussing the problem about where there is too much or too little information. Of course, in an emergency situation there can be too much information that is actually interfering with the real situation, but, if we want to develop recommendations for authorities for decision makers process, we cannot give simple answers as final answers. Although, based on my discussion, some people think that we do not want to give any recommendations but just give figures, you look at the figures and make your decisions. Of course this is wrong. We do develop recommendations regarding preventive measures, etc., but if we give only this kind of answers then the authorities cannot make decisions, say, in about one or two days after the accident, because additional information, such as new measurements or data, might cause him to think that the doses on which he based his decision were wrong. In this situation, we must have a lot of information. Besides calculating average doses we must take into consideration what is going to happen with the vegetation. Maybe there are spaces where the dose rate is higher than average. So everything should be estimated by us, and we must also show to the authority that we do understand everything and have taken it into consideration. Another element, which is very important, is that we cannot assume that all these problems exist only during severe, big accidents. Of course, severe incidents yield severe damages and we must be prepared to a maximum degree to do everything that we can to prevent damage, but our experience has shown that little, small accidents can give damage, even great damage. Small contaminations can lead to the situation where people begin to be excited about the situation, and this leads to greater damage. For example, the Chernobyl area. Actually, the money for Chernobyl problem is not going to the area with contamination but to the zone of one to five curies per square kilometer, the so-called "benefit status zone," where the rate is lower than 1 rem per year. "Well, maybe this is some of the drawbacks of the propaganda," some people say. No, this is wrong. At least at our institute we do believe that, until we take into consideration the fact that the radiation factor is a very acute element, we are going to have problems--plus, the fact that radiation has the peculiarity that it can be easily detected. That is why the population very quickly can learn that, for example, their background radiation levels are higher by 30 percent, which is impossible, actually, during other contaminations, but this leads to a very negative attitude, so the damage from small accidents can therefore be very high. We are prepared to react to many accidents and to give people very precise information. This is very important and useful to local authorities and other people who work with the population. We had an accident in Tomsk. The actual discharge was almost zero, but as a result we had a decree by the government that we had to pay several billion rubles to protect our population. So our experience in cooperating with the population has shown that people believe you more when you demonstrate the modern technology. We did show them computers, databases, models, and people started to believe in us and respect us. If you tell them we have made certain calculations, they may not believe you. When you tell them that you have 10-15 experts and international groups, for example in Belarus, we have people from various countries and they tell the population the real situation in real time, this is very important. So when we speak about our cooperation, it seems to me that it would be very useful for us to cooperate on the level of a human being, because we know the professional capabilities of both countries. It would not be just an expert, but somebody, a specialist, who would be able to give precise answers, which is a very important element. Let me cite you another example. During the exercise in Polyarni Zona, when we had experts from various countries, the local administration decided to evacuate the city of Cardor. The experts at that period of time said that there was no basis for evacuation, but we were working with the authorities and the local administration in our exercise. Their first reaction was that they would not change their minds but insist on their decision. It was a very tense time in a serious exercise. The local authorities had proved to us that they wanted to defend the population, but when they learn that 10 experts from various countries signed the same document, their reaction was instantaneous. The chief administrator sent his people, they learned the situation, and they did agree that under these circumstances, with this support, they did agree not to evacuate people.

Another element about exercises--the best way of education, of how to educate both the population and the authorities, the best way is through exercises. You may have all these documents, decrees, emergency plans on the table, but in real life the effect from them is much lower as compared to the administrator who has gone through an exercise. I mean, a business game or exercise, but it is very important that this exercise must be prepared for a long period of time, in our experience. We do realize that we must prepare any exercise for a long period of time. If you prepare the exercise for only a month, then you are not going to yield good results. If you prepare for a year and gather all pertinent information for this territory, create information systems, and experts of the administration constantly receive questions from the people who organize the exercise and give answers, then they can reconsider their documents and plans so that participation in these games becomes very useful for the administration, who will feel very confident in a situation where he must make real decisions. A simple scenario is dangerous, because people learn about things that have nothing to do with real life. It's the same as learning how to ride on a bicycle, and then you're in a fast track car all of a sudden. So we try to prepare full-scale scenarios with the consideration of all the details, particular features of the area, unexpected situations. So it seems to us that we should work on this problem together and develop certain mutual approaches. Well, perhaps this is all I wanted to add to my presentation and now I invite my colleagues if they have any questions or remarks.

Dr. Ainsworth: About two weeks ago I ended up being in charge of an evacuation of our institute as a drill. Now this was a very small-scale drill exercise, but you never know what' s going to happen until you stand there with command authority. Because we have a reactor in our building, these drills are routine and are well planned in advance. What I found, personally, is that five percent of the things that should have happened did not happen as the book indicates that they should. There are always the uncertainty and the last minute things that have to be dealt with, and you better be quick in dealing with those. So I only want to ratify the utility of a prior plan, then get in there and do it, and see what doesn't go as right as you would like to have it go.

Dr. Guskova: I would like to tell you about my experience. We have a hospital for 600 people and our clinics work with that clinic. We got information about a bomb threat, so during a very short period of time we had to evacuate our patients, have take all necessary documentation and then come back to normal life. Let me tell you this was a very serious test for us. Something did help us when we learned about the Chernobyl accident. I was one of the first people in the country who learned about the accident. At night, about two hours after the accident, I had a call from the medical unit that serviced the station, but the connection was very bad, perhaps it was because of secrecy. I had to go to another telephone set with the Ministry of Health Care and have a very stable connection with the medical unit at the station. So during this brief period of time, I learned that we have to receive not one or two individual patients in order to see what kind of illness they have but the entire group, 130 people. We had to locate them, to give them beds in small rooms, to provide for certain sterile modes, to reconsider planning of our physiotherapy unit in order to be able to wash people. We began this work at 6:00 A.M. By that evening, about 12 hours later, we were prepared for this kind of work. Again, all the patients were taken care of, all of them were sent home with the exception of the very serious hematological patients; we did not want to take the risk of sending them home. So in about 30-36 hours, this large flow came back. Of course, in these cases, you have very many unexpected factors. First of all, it was necessary to replan the hospital in accordance with the needs that existed at that moment. We lacked at that time simple things, such as, for example, for radiation pathology, it was necessary to create individual sets of all the medical instruments, from blood pressure apparatus to simple methods of monitoring patients. So if you have 500 patients, you had to have 500 sets, so that everybody would lead, so to say, an independent life. We needed a system of simple decontamination so that when somebody enters or exits the building, as well as separate compartments of the building, there was adequate equipment at dosimetric stations. Of course, we did not manage to do everything. For example, we contaminated the area that the patients were arriving at. We then invited military units in order to cut out the surface of the soil or the floors. These are simple things, but we did not plan for them.

Another element is also very important, and that is the possibility of contamination by radioactive materials of the place where you are going to send the patients. In this case, we use the assistant of the Kurchatov Atomic Energy Institute. We were lucky enough, since we are neighbors with the institute, so that we had shuttles and buses that would deliver contaminated materials from the area of our hospital. So it seems to me that these exercises or drills, for example, the preparation of hospital, how to receive large groups of patients, particularly for radiation profile, with contamination, are extremely useful drills and exercises and I advise our colleagues to do these drills and exercises, as much as possible. This is because we can detect many defects that we do not notice when we work every day.

Dr. Arutyunyan: I think it's clear that we must talk about how to train for practical measures; we cannot talk only about scientific and technical support, when we basically practice interaction and interoperablity of various branches and experts and so on. Dr. Vladimirov...

Dr. Vladimirov: I would like to stress two points. First of all, we mentioned evacuation. I would like to say that in Russia right now we are reconsidering this question. In the past, we used to think that evacuation is one of the main methods of population protection both in peacetime and in wartime, but now we are more critical and it's possible that very soon we will change the concept of this. We believe that in those accidents that we have encountered, evacuation may cause more problems than other attempts to protect the population. One has to choose a good moment for the evacuation so that the exposure rate would not be too high but would be as low as possible; therefore, this is one of the issues that has to be considered and certain decisions have to be made with regard to it.

I would also like to say something about the decision making process. I was part of the government commission on Chernobyl from day one. I must say at that time we did not have what we have now. We did not have computers, we did not have scientific studies with regard to how to assess the situation. In other words, we did every thing in the most common way; we would sit down at the table and start talking about the situation and make decisions. So many mistakes were made in Chernobyl, even the fact that we tried to....*(Tape ends here.)*

Dr. Arutyunyan: If we could, in a timely manner, do the assessment and give our advice, then we would have made fewer mistakes. The reason why I talk about this is that what we achieved during the exercise called Northern Lights, where a lot of experts from various countries participated, is that there were several discussions about the different approaches. We had to create a uniform approach. Each expert could basically ask other experts from his or her country and get some advice from them. That was extremely important and it's clear that we have to try to act when an accident happens, we have to somehow get together a group of international experts which would give us advice as to how to make decisions. Of course, each country must make the decisions by itself. We can tell our regional leaders, "You are the leader, you are the commander in your area. You are responsible for the measures to protect the population; we are here to give you advice, to support you, to assist you with resources and so on." In other words, the administrator on the local level still is responsible but he or she needs advice, and we should think this through on how to achieve this. Thank you very much.

Unidentified speaker: I just want to ask a question about one factor I don't think we really touched on much and that's public perception, and how that enters into the decision-making process, and how that may impact you in the technical arena. When we talk evacuation, for instance, in this country [U.S.], we commonly joke about the public "voting with their feet" and leaving whether or not we recommend it or not. I guess part of the question really becomes one of credibility, what credibility we've established with them and how they perceive us and our response to the accident. Perhaps you have a taste for what it is like here, but how does the Russian experience compare in that area? As far as dealing with public perception, are you perceived favorably, or would you expect a similar response perhaps, that they would "vote with their feet" rather than putting their faith in your recommendations?

Dr. Arutyunyan: Well, this is a difficult question, especially in Russia now, whether or not the population trusts anybody. Perhaps Dr. Vladimirov could talk about this, but the experience of 1986 showed that at the early stages the population basically did everything that the administration suggested. The evacuation of Pripyat was very orderly and Dr. Vladimirov can say something about this. This is a difficult question, and when I talked a couple of minutes ago I stressed the fact that we are now looking differently at the issue of evacuation. This is a difficult question for many reasons. I took part in organizing the evacuation of the city of Pripyat. It took us two and one-half to three hours to evacuate almost 50,000 people, and we believe that this was an ideal case when we were able to evacuate the population in such an orderly manner. We were able to designate the leaders in each building. We explained to them, having gathered them together, what to do, but in a way we were dishonest because we told them that a week or two later they will be back, so take only the most necessary things, let's say your documents, some money, and so on. Leave the rest. So we solved that problem, but a month or two or three later, we had to organize a trip for these people back to their homes where they could take the most valuable things that they were allowed to take. So we should really approach this on a case-by- case basis. We evacuated all-in-all about 112,000 people from the Chernobyl zone; we even evacuated cattle. We evacuated people, too, from villages, with all their possessions, with everything they could take. We just sent trucks there, and we took everything away from the contaminated area, but at that time we told them the truth. We told them you would not see your home again soon, and the people understood that and they would go. But what happened later? Today, even in the 30 kilometer zone, a lot of people reside there, because people went back by themselves despite all the problems that they're experiencing. They still live in that 30 kilometer zone, where the level of contamination is more than 15 curies per square kilometers and in some cases even more than that. Who are these people? These are not young people. These are elderly people who, as they say, have nowhere to go. They have their parents' graves there, and they want to end their lives there, and we have to supply them with bread and food, and once a week we have to supply them with the most necessary things, so that's what happened. And where contamination was not as great, more people came back because we built new settlements, new population centers in uncontaminated areas, but people abandoned those places, those settlements, and went back to their homes. So we believe that, as far as evacuation from contaminated areas goes, we have not solved this problem well. So I think that we should not have evacuated people from most of those areas. When we calculated the doses, it looks like nothing horrible would have happened, but now, because of that, we have a problem and we have to try to unravel it, to resolve this problem, and it's taking a long time. So, these evacuation problems are being discussed, and I think that we are going to develop and work out an approach. Well, a poll of some kind is always difficult. It's difficult to poll the population, and it's hard to say how the population would behave now. The other question is, do we take this into account when we conduct exercises and games and so on, especially of the long-term type. We definitely take into consideration the issues of public opinion, and we even, in St. Petersburg, had representatives of the population of Kaluga Oblast, but of course we cannot say that we understand this issue as well as some other issues. It's impossible to say how the population will behave. It depends on to what extent the population trusts their local authorities when the accident happens.

Dr. David Auton, SRF: I was interested yesterday in some of the presentations that were given about the modeling of precipitation scavenging. I've been peripherally involved with the U.S. efforts in this area for some 25 years, and, no, we haven't made much progress, although we've put a lot of effort into it. I'd be interested sometime in hearing some of the details of your modeling and what data you might have to back up the models that you've come forward with. Any remarks you might have on that would be useful as well.

Dr. Arutyunyan: Well, I think that first of all we have all this on computer and we have databases and we can talk more in greater detail about this, but the technology in general is that we verify every model we have with the use of all data we have. When I show, for example, the atmospheric models, we use all the literature available, American and German and Russian, to back them up, and you can see which models are good, which are bad, and so on. In some cases the margin of error is on an order of magnitude. Some are more accurate, but, of course, even the Gaussian model in some cases works well when we're talking about small distances and the weather is stable, so we can rely on that, too. So, when we talk about the databases that we have, it's important to look at the experiment. You have a model and you find the margin of error and uncertainty, and so on, but when we talk about the databases connected to the experience in Chernobyl and Urals, which are factual, we have sets of facts, numbers, data, which allow you to orient yourself to a real situation when you are not comfortable with the model. So this is some kind of a backup. When you then get some numbers from the model you at least can think what kind of distribution and spread you can expect. So you can see all that during the break. Dr. Pavlovski will be happy to help you with that.

Dr. Vladimirov: And also I would like to say a few words about the following. The first is about dry and humid air and precipitation. After Chernobyl, the picture of contamination was very diverse. The gradients were very high, and you saw that on the slides that Dr. Arutyunyan showed. We were trying to understand what the reason for that was, and of course the main contributor was again this pattern of dry and moist areas and precipitation. We were trying to find the amount of precipitation and residue, and what helped us was that in certain individual population centers they had special services which basically measured precipitation. We're talking about small meteorological stations which exist in Russia. In other words, in every village there is this person who is paid a very small amount of money, but he has this duty to use very simple equipment to observe precipitation twice every day. When we got this information regarding the small population centers, and when we tried to correlate it with real contamination in this area, we were able to improve our model for moist precipitation significantly. This is my first point, and secondly, regarding evacuation I headed a group of international experts that was mentioned. The problem that had arisen was connected to the standards and regulations that we had in Russia. The point is that the standards and procedures for evacuation depend on the accumulated dose; however, the guidelines don't say that we have to make a decision based on the dose that can be averted. And what happened in Kogdor was that part of the dose had been realized already, and slightly more could be added if the population had stayed; however, the accumulated dose could then be higher than the one mentioned in the regulations and guidelines for evacuation. The main part of the dose had been realized already, so it couldn't be gotten rid of. So, what happens is that the effectiveness of evacuation became very small because the averted dose was, let's say, only 10 to 15 percent, and when this was discussed by experts and when we told the administrators about this, the administrators truly understood that evacuation was not necessary, although formally the accumulated dose would have been higher than the one stipulated by the guidelines. This is very important because in the new guidelines, which are going to govern evacuation, the decisions should really depend on the averted dose. That's what I wanted to add. Thank you. Any other questions or comments?

Dr. Ainsworth: I want to understand this fully. By averted dose, do you mean that amount of fission product incorporation that was prevented? I'm a little confused by the use of that term.

Dr. Vladimirov: Well, what I meant was this. For example, the assessment of the external exposure dose, which is the first criterion for evacuation, for a given population center could be, let's say, 26 rem or cGy. This is higher than the minimum stipulated by the guidelines which suggest that one should evacuate, but out of this 26, by the time we make the decision to evacuate, 20 could have been realized, because the discharge cloud had passed and some time has passed. People have now lived in the contaminated area for some time. If we now take these people and resettle them in some noncontaminated area, then we will lower this dose by 6 cGy; however, they will have to pass through this contaminated territory and maybe get 10 more instead of maybe being protected in some strictly controlled sealed shelter, maybe some basement, where this six will become, let's say, 0.5 cGy. This is the idea. This is what averted dose is, and this of course includes the doses received by internal exposure, but this problem is simpler because you can ban local produce and you can quickly bring in clean products. This is an administrative issue and measure, and usually, even in a contaminated town, you can find clean foodstuffs. So, the main thing is the dose of external exposure, which you can fight somehow and prevent, realistically.

Mr. Bickerton: I'd just like to add a couple of comments to that. It's not always understood here in the United Sates, but the EPA protective action guides are based on exactly that same thought--that the avoided dose, or averted dose, is what you look at, not the total dosage received up to some point in time. The important point is how much dose will be avoided by evacuating personnel. You have to look at a couple of scenarios there, just as you indicate, as far as the exposure that might be accumulated during the evacuation versus the dose that might be received while they're sheltering, and try to balance the various scenarios off against each other to try to make that final determination. That's exactly what we do in the United States.

Dr. Arutyunyan: And now we're a little bit behind schedule. It was a very nice discussion but our bosses probably will ask us, "So what was the outcome, what was the upshot of your discussion?" Maybe we should talk about what should really become the subject of consideration, when we talk about material and technical support for decision making. I think we could try to conduct an exercise together, at least one exercise--in other words, experts from the United States and Russia, those who do modeling and those who are simply experts--and maybe do one exercise, one hypothetical situation and see what our approaches are. That would probably have helped us to realize what problems we have, what achievements we have made, because experience shows that this is probably the best form of cooperation of solving problems. Then we would see how we can develop our various models and methodologies and so on. This is what comes to mind on the basis of what I have seen. So I think that trying to start modeling together or develop some individual models, I think this is very complicated, always, but, in the course of an exercise like that, one has to use all of the existing models and when it becomes evident what exists, what achievements there are and so on. Any other ideas, questions, or comments? Well then, thank you.

Col Reeves: What we'd like to do for the remainder of the morning is to first summarize the panel Dr. Fry chaired, which was on the Emergency Medical Response at Radioactive Accidents and Incidents: Health Concerns, Internal Exposure, Combined Injury, Radiation Burns. She and her panelists will have the opportunity to sum things up, open it to the audience for discussion, then with some concluding remarks perhaps with what they think the next steps might be, and then we'll form the conclusions, after which we'll adjourn the meeting. Dr. Fry...

Dr. Fry: In reviewing what was discussed yesterday, it seems to me that there were concerns about emergency response with respect to radiation accidents and incidents and concerns about health, internal exposure, combined injury, and radiation burns, and our discussions fell into two main categories, I think. First, of course, the immediate factors of health concerns--what to do about internal exposure, particularly iodine, the need for early information about the types of exposure people had, so that the medical community could respond effectively early on and take proper actions that would be beneficial to people who had received acute injuries. Then, in each of those areas there were other divisions into what the needs of science are versus what the needs of the public are. Perhaps I shouldn't say "versus," but there are needs for science and there are needs for the public in both of these situations--the immediate post accident, post exposure period and in the longer term. In most situations there is obviously a need for preparation for the accident situation, and we are blessed and cursed in radiation accidents--blessed because these have been fairly infrequent situations, cursed because they are infrequent, and keeping people's interest up, and resources available, taking care to make sure that, during the turnover in the groups of people working in these areas, the new persons are informed and educated? They may be informed and educated today, but in six months you have a whole new crew of people on board whom we have to make sure are also informed and educated. So, with those two main divisions of immediate versus long-term needs in emergency response for the medical aspects and for the needs of science and the needs of the public, our discussions in each of the presentations, I think, fell into several categories that we could characterize as information and communication of the information that we have and of the information that we gather in the course of an event. We must bear in mind that these radiation events have some common factors, but each one also has some unique peculiarities. Then, discussion of interventions--by interventions, I also include treatment that Dr. Boudagov discussed as well as Dr. Guskova. The most important, probably, intervention to be considered at the immediate time of the accident is whether or not there's a need for the administration of stable iodine, and all the factors that go into that decision making process. Of course, when the accident happens, you don't have time to gather an expert group from around the world. The urgency is then and now and probably before the accident. The preparations for availability and the decisions about availability and when to give stabile iodine, etc., ideally should be firmly established before the need arises, because you don't have a great deal of time if the intervention is going to be really effective. As we learned from Mr. McNutt, this issue has a very protracted history in this country. We have not heard a great deal at this meeting about the experiences of our Russian colleagues and how their situation today is different from the time of the Chernobyl accident. What is in place now, what considerations have they made? Then the other two areas that I identified that seemed to be a common thread to our presentations were the needs for education, both of professionals and of the public, even in the medical community. This is a large, diverse community, and the plea that we heard was that medical professionals need to be educated in acute radiation health effects and the problems of triage. The public will have great concerns, and a large portion of that is due to lack of education. I think there needs to be, beginning at the grade school level, improved education of the general public about what radiation is and what it can do and what it doesn't do, with some degree of levels of concern. And then the last, but not the least, of the concerns is the need for continued and further research in each of these areas. We've identified psychosomatic issues, issues related to treatment, intervention; how do you educate the general public more effectively? Each of these areas has their own research questions to be addressed in considering emergency medical response. So that is a very brief, but I would hope comprehensive summary that will serve to start a discussion in terms of whether there are any unanswered questions from yesterday. Do any of our four panelists have opinions on these topics as well as other topics that you may feel still need to be addressed? Dr. Guskova...

Dr. Guskova: Madam Chairman, I think that you have touched a very important issue, that the element of knowledge regarding radiation pathology, as well as intensive immediate therapy of other injuries, must constantly be in the field of vision of each physician. This was demonstrated very well by the Chernobyl accident. We came across the fact that experts who were extremely qualified and very specialized, in certain areas of internal medicine and surgery, proved not to be prepared to render assistance to radiation injuries. There were deficiencies in their diagnosis, their treatment, and their understanding of the situation. For example, our Ukrainian colleagues came across radiation illness for the first time. They, without any grounds to do so, widened the differential diagnosis, since many elements of acute radiation syndrome are not specific and can be associated with other illnesses. I can recall in my personal experience a situation when somebody contracted scarlet fever when he was simultaneously exposed to a very low radiation level. All the elements were very alike. His temperature, vomiting, skin appearance, change of blood parameters were typical for scarlet fever. The small dose of radiation did not cause these symptoms, though a larger dose could have. This is a very difficult situation, even for experienced physicians, and especially for the people who saw this patient for the first time in their life. What did we do in order to immediately raise the level of knowledge? For example, the Department of Defense, every two weeks, would send to our clinic new groups of doctors. Then later on these physicians would work at the Chernobyl area. They did help us in our work because our work was very difficult, and at the same time they learned themselves, because they were only in the limited part of the cycle of the radiation illnesses. We told them what happened. They were with us during the two weeks and we told them what was going to happen with those patients later on. It was extremely useful because it was next to the bedside of actually sick people, and later on it gave them a support in their very difficult work in field conditions at Chernobyl. The second element as we realized, is the necessity of education. The first people who come into the area of an accident are not physicians or medical technicians, they are technical workers, but the limitations of the consequences of the accident depend upon the correct actions of these people. So to close the access to the damaged area, to cover skin, to give preparations, this is all available in the field, but we should deal with this in a correct manner. We also spoke with those technicians before the accident, but the most extensive work with the technical personnel of the Nuclear Power Plant (NPP) occurred after the accident. We developed special courses. Hundreds of people learned a lot at those courses, and we believe that later on they will act correspondingly if such a situation occurs near their workstation. I go to the next very important educational issue. It is very important that the information about treatment on the one hand will be updated by new scientific data, for example, as in Dr. Boudagov's presentation. And on the other hand we should develop a very simple and accessible set of measures to recognize the illness and treat it. This should be something we would be able to use in any conditions before the real difficult events occur that require the competence of highly qualified enterprises and facilities. That is why we need to have simple, understandable recommendations which we'll adjust or correct during our drills and exercises. We had the last version of instructions of 1986. This was useful, not for us but for those who for the first time had to deal with these issues. So, such recommendations and instructions must be updated periodically in order to check what has been updated with time, what items of usefulness have appeared, what is new, and what we can get rid of if necessary. Another important lesson--depending on actual conditions that we have, we can transform our tasks in some way. If we have many injured people, then in the first instance we should select those people who need treatment immediately. It is our opinion that these people needing treatment immediately should be sent to those facilities where they can be helped during the entire illness period and not create additional stages of evacuation. They should be sent immediately to a highly qualified facility. For the people with lighter injuries, they can stay at the initial site and undergo secondary triage and selection of the people; we maybe made a mistake regarding their sickness in the first stage. And I would like to emphasize again that, notwithstanding the attention that we must pay to internal factors, my personal experience is that the external exposure with its clinical consequences is the major component of injury, and the most part of immediate actions should be concerned with this component of the accident. The internal factor is also a very real component, but we do have sanitary measures of washing people and prevention of contamination, although it doesn't work that rapidly in the actual clinical setting. Here we have the reserve in clinics but not the resources for prevention measures. Preventive measures must start immediately, not based on clinical characteristics but on information about people and substances. Maybe it would be something in excess of necessary measures, but we must do it. Thank you.

Dr. Ricks: I have a question about the rotation of physicians through your hospital for a few weeks. Could you share with us the general criteria that were used in selecting who would rotate through your hospital and, more specifically, was the age of the physician considered in the selection process?

Dr. Guskova: First of all, our clinic must have certain full-time physicians, as in a good family, with a representation of all ages; those who can teach and those who must learn. Then we are going to have a harmonic turnover of the generations; however, in addition to these full-time people, we periodically select, for a short period of time, some people between accidents for special training. These people stay with us for several months. They do clinical studies, two years, postgraduate studies three years, and after that only part of the doctors remain in our clinics. We prepare them for other facilities, other clinics. Now my students are the heads of the branch of the Institute of Biophysics in the Urals. They work at the Urals Research Center of Radiation Medicine in Chelyabinsk, and in some of other cities and towns of Russia, but some of them remain in our clinics and then will take over after us the scientific and clinical expertise. Cases of acute radiation illness are not that frequent. We should think about the fact of what clinics should do between the accidents in order to be constantly prepared for accidents. I must have in my clinics a set of teams of clinical specialists that in the case of emergencies would be able to become heads of a unit of radiation pathology. What kind of unit is in my clinic? We treat leukosis with intensive programs. This is a model where we use whole body radiation exposure with chemotherapeutic measures that create depression of blood as well as other future consequences. So during the accident people from this unit become the heads of units of another hospital. There are units that in peacetime work on the issues related to the administration of radioactive substances and all those clinical forms that are possible from these radioactive substances, for example, the effects of plutonium or phosphorus or radium on lungs, liver, kidneys, bone marrow. So these people during their day-to-day operations learn on the issues related to clinical toxicology, how to assist in decontamination. The third unit that is very important in my clinic relates to the respiratory tract. We must know everything that is going on throughout the respiratory tract and the lung, so everything that we can know about the lungs, their functions, metabolism, measures of decontamination of the respiratory tract is very important. And also, people who do not die of infection die of lung problems. If we can treat pneumonia, pneumosclerosis, bronchitis, this is going to be very helpful during the acute radiation illnesses. And let's take a man or a woman as a whole human being. If he or she is ill, then his human being participates in his illnesses, sometimes it's helpful, sometimes it is not helpful for the doctor. Many illnesses have an accompanying vegetative functional disorders; we must understand them and correct them. So we have a unit of nervous illness and psychological expert evaluation. And Unit Number Five--people with local radiation damages need us more. If somebody has a radiation burn, then he is going to experience psychological effects of radiation illness, so after Chernobyl we established Unit Number Five, consequences of acute radiation injury. This is an individual topic, individual work. So in the course of the day-to-day operation we try to maintain a high level of our preparedness for acute situations, although together with you we wish we do not have such situations in the future. Thank you.

Dr. Ricks: The basis for my question is that it's been my observation in the United States and in many other countries that the expertise in management of radiation accidents, particularly in the medical arena, is in the hands of an aging population, particularly an aging male population--I would never say it's an aging female population! But this I think points out one of the great challenges that all of us who have some expertise in this field must meet, and that is that there is a great need to involve young scientists and physicians at every opportunity that we have in management of these accidents. The day will come when those of us who have this experience are only remembered for two things--the information we shared and the mistakes we made. Now, for an example of how involvement of the young scientist and physician works, I don't think there is a better example than Brazil. When the accident in Goiania occurred in 1987, those of us who responded, who provided advice and assistance, I think were initially surprised by the age of the average responder. The accident management fell into the hands of young, well-trained scientists and physicians, and as a sideline I'm happy to say that some of those persons had been trained at REAC/TS in Oak Ridge as well as by many of us in courses offered in Brazil. And so you have in Brazil now a group of individuals who certainly have the experience from managing one of the most major radiation accidents in the history of the use of nuclear energy, and those individuals are basically young, aggressive persons. The challenge is to them as well, to spread that information and to see to it that their colleagues also learn. To my knowledge they're doing this.

Dr. Fry: I think that raises two points I'd like to address--one is the importance of documentation and archiving of information from radiation accidents. As I say we are blessed that these situations do not happen very often; therefore, we have to take the maximum advantage of lessons learned in each of these situations so that people coming after can look back and benefit from what has been done, which may have been good or not so good, but they will at least have a background and resources that can help them in the new situation. The other issue is looking across the medical community, how the radiation medicine experts can remain experts in radiation accident management with the benefit of input from other disciplines, other specialties in medicine. I think we heard yesterday, from Dr. Boudagov, information that is beneficial to the management of a radiation accident victim, but a lot of that work is done in other fields, such as the management of immune suppressed patients, the treatment of people who had whole body radiation for therapeutic reasons. As important as it is to get our message out, we must also learn to look further afield to bring in additional information to keep the therapeutic applications up to date and benefit from the knowledge of specialists in other areas. Perhaps Dr. Boudagov and Dr. Tsyb would like to comment on how we might do that.

Dr. Boudagov: Thank you Madam Chairperson. I would like to use this opportunity to add a few words. We have this large spectrum of issues that we have considered in the course of these three days, in the course of this seminar. I think that the problem of combined injuries maybe is perceived by you as one of the particular, maybe not very important, issues, but I would like to say in this connection that it may be so from the point of view of the scale of injuries but, from the point of view of the readiness to render medical assistance in a timely manner, this is probably one of the most difficult issues in terms of urgent medical response. I would like also to say that I support the ideas of Dr. Guskova and Dr. Fry, meaning that we must constantly update our information and also use the most modern state-of-the-art methods and means of treating injured patients and use also other areas of medicine. I would also second the proposals that were mentioned today, that maybe it would have been good and not very expensive to try to update somehow the existing official documents dealing with this urgent medical assistance, including medical assistance to people who have combined injuries. I know that our colleagues, specifically AFRRI, have published such articles and monographs on this issue, and I would like to say that the official documents were also issued in Russia in 1993 on these issues. Maybe it would have been good to try to prepare on the basis of the existing documents and on the basis of the state-of-the-art knowledge of the physiological mechanism of this type of injuries. We need to create some kind of document accessible to the average physician which would detail the first steps that have to be made even before specialized medical assistance is rendered by specialized clinics and so on and burn units. I would also like to add that in my presentation yesterday I really wanted to talk not about what has been achieved but more about what has remained unsolved about such issues, and I think there are at least two challenges of this kind. First is the earliest possible diagnosis and prognostic assessment of the severity of the injury, which would have allowed us to optimize the organization of medical assistance and channeling this medical assistance first of all to those injured patients who have a chance of survival, and on the other hand it would allow us to optimize and rationalize the use of the existing resources and medical means, and I would like to mention combined radiation injuries in this connection. Even at the stage of this preliminary medical assistance we should have some kind of means of early preventive treatment, which may be done by a medical technician or nurse but which could, on the one hand lengthen the latent period of acute radiation sickness during which one could somehow suppress the nonradiation component of the injury, which would allow us to increase the effectiveness of consequent treatment of bone marrow syndrome, intestinal syndrome, and so on. In conclusion I would like first of all to express my heartfelt gratitude to the organizers of today's seminar who gave us, maybe for the first time, an opportunity to talk about combined radiation injuries and address this presentation to the people who include the representatives of AFRRI, with whose work we have been acquainted for a long time. Now finally we have had a chance to see these people and to talk to them face to face and maybe also establish some contacts that may be implemented in the future. And as far as proposals for possible areas of research in the area that I am talking about, I would like the member of our organization committee, Dr. Ricks, I hope that on Friday, if I'm not mistaken, when we visit AFRRI, I hope we'll be able to organize some kind of a roundtable with the experts in this area and maybe we would be able to have some specific discussion of the issues which have to be resolved and whose resolution could be done more effectively if we cooperate. Thank you.

Dr. Fry: I, in the last few minutes of this session I would like to give opportunity for our panelists to address interventions and specifically the use of stable iodine. We have two experts here, one at the administration end and one at the receiving end, who've had the experience of dealing with people who have been exposed to radioactive iodine. This is something for which we can at least ameliorate the effects if we have early intervention; it's something positive we can do. As you've seen from Mr. McNutt's presentation yesterday, this has been a very protracted exercise in this country, largely I think because one major factor is that it's not the squeaky wheel that gets the grease. If we had an accident tomorrow that had a release of radioactive iodine, you bet there would be something done, but in this situation as in many aspects of radiation accidents, it doesn't come to public perception very rapidly. So I'd like to invite comments from Dr. Tsyb and Mr. McNutt.

Dr. Tsyb: Yesterday we heard a very interesting presentation about the history of iodine prevention treatment in the United States, and this was the first time I was able to hear such an interesting story, which was accompanied by a very interesting discussion, however, it didn't have any outcome. There was no decision made at the end. As is well known, NPP accidents, and this was demonstrated by Chernobyl, are accompanied by massive iodine consequences, and if we had been prepared to conduct, in an appropriate manner, some iodine prevention procedures then we wouldn't have had such massive consequences that I talked about yesterday. Because as of today there are three countries, Russia, Ukraine, and Belarus, where there are about 1,000 cases of thyroid cancer in children and teenagers. Even if half of those cancers are connected to radiation, then it still is a significant medical problem; therefore, since we did not talk a lot about how this iodine prevention should be conducted and also because there are some organizational and administrative problems of great magnitude and also there are some specific medical problems, too. But what do you do with an infant younger than one year old? How much iodine and what kind of iodine and how to administer it? And these decisions have to be made quickly because these babies feed on milk, and usually milk is a very good pathway for radioactive iodine-induced disease. Then the second question arises, when we talk about these iodine prevention procedures, when we look at how it was done in these three countries. There are many different methods which are difficult even to imagine. For example, sometimes the iodine solution (five percent, three percent solution of iodine) was administered and now the question arises: does this stable iodine, especially its long, protracted use, doesn't it also contribute to the incidence of thyroid cancer, because in the process of ingesting it some free radicals are created, just as during exposure to radiation? Therefore, I would like to propose that maybe we implement some cooperative activities and ventures in the future. I'm talking about the optimization of iodine prevention procedures. It would have been good if some kind of a joint cooperative document could be created which would be functional both for our two sides and for the international community. I already said that in our country, and I can say this with all certainty, that if another accident happens then this iodine prevention procedures will be conducted approximately the same way as it was done in Chernobyl, because these issues remain unresolved. And today there is another serious issue. Wouldn't it be possible to develop some kind of methods to prevent thyroid cancer in those people who have been radiated, whose thyroid glands have been exposed? We're talking about really basic research, specifically on the study of molecular, biological, radiobiological, and cellular characteristics of radiation-induced thyroid cancer. And this could lead to methods and maybe pharmacological means which would prevent this rather severe disease, especially in children and teenagers. I would like also to say a couple of words if we have time. I would like to say that the mitigation of consequences of radiation incidents should cover not only the acute phase. We're talking about very long-term problems, and right now we are in this phase at this stage in our country. And the second proposal I would like to advance, as far as our future cooperation is concerned. We have developed two concepts, we have prepared two documents which have been approved by our government. The first document is the concept of radiation protection and economic activities in contaminated areas. I'm talking about radiation protection of the population and the population's economic activity. And the second document is basic elements of radiation protection of the population exposed to the radiation from the accident. We're talking about the distant stage of the accident, distant in time, and we have some experience in that area which we would like to share with our colleagues, and, of course, also we would like to learn about their expertise and experience in this area and what they would suggest that should be done. Sometimes at international seminars and conferences I hear that the population that lives in contaminated areas have the same exposure that we receive when we take the trip from Moscow to Washington and back in an airplane. This of course is a very simplified consideration of this issue because we have very difficult, very hard problems connected to protecting people who have been living in these contaminated areas for many, many years. These are beyond all norms and guidelines for radiation protection and safety. Thank you very much.

Dr. Fry: Mr. McNutt, would you like to make a few comments on the U.S. experience and how the Russian and U.S. groups may benefit from shared experience?

Mr. McNutt: Yes, thank you. The offer of the federal government to fund the purchase of stockpiling KI for the states is viewed by most, including the American Thyroid Association, as a step in the right direction; however, the decision lies with the states and since the federal government has taken at least the burden of funding away, these public interest groups' next move would be to petition the states to include it in their plans and make it available in the event of a radiological emergency in a power plant; however, the concept of the squeaky wheel I think is a valid one in that we haven't an accident since TMI, and the pressures with commercial power industry, the utilities, the financial pressures, and also the funding problems in the state, and at the federal level, the so-called reinvention syndrome, streamlining, have all resulted in a sort of a ground swell for cutting back on certain activities, including preparedness in support of planning for nuclear power plant accidents. We're undergoing that at this particular time, and I would hope that we would not be caught with our guard down if we lessen our preparedness. There is an effort with the federal government that I'm at liberty to mention, and that is the possibility of stockpiling potassium iodide across the country for incidents other than those associated with commercial nuclear power plant accidents. If this planning and preparedness actually occurs, obviously initial indications are that nuclear power industry would be in favor of it, because it would have no direct relationship, at least theoretically, with their power plants. That's where we are today, with this issue. I mentioned yesterday it is controversial in this country. I personally believe it's a prudent step for states to include it in their planning and to have a stockpile. The drug is quite inexpensive and FEMA is going to request the Food and Drug Administration to speed up any review for the shelf life to make it even less expensive. With that, I just want to thank everyone for the opportunity. I enjoyed being here.

Dr. Fry: Thank you, Mr. McNutt. Maybe I missed it yesterday but I'd just like to clarify, does proposed federal funding include maintenance of the supplies, changing out when the shelf life expires?

Mr. McNutt: Yes, it would include the maintenance of a stockpile.

Dr. Kumar, AFRRI: I would like to raise the issue which Dr. Boudagov has brought up, that is the prophylactic and the therapeutic measures. Dr. Boudagov has aptly pointed out that AFRRI has doubled the lab database on both of these aspects, prophylactics as well as therapeutic measures of radiation treatment. In the prophylactic respect, it might be something which is worthwhile for those people who are going into an emergency rescue operation because there is a possibility that those people are aware of the nature of the radiation field in which they are going and so they would be well prepared ahead of that with the drugs which may be protecting them against radiation. In the case of therapeutic measures, it is good for those that are already exposed to the radiation, and in both of these areas, prophylactic as well as therapeutic, we have a large number of drugs, mostly in the prophylaxis area. In that aspect maybe many of you are aware of the work of AFRRI on antioxidants and some nutritional factors and sulfhydryl compounds which will be very useful as prophylactic agents. In therapeutic aspects we have both a large number of hemopoietic factors like the G-CSF which Dr. Boudagov expressed yesterday and also GM-CSF as well as the PIXY compounds. All this large area of compounds can be considered for both prophylaxis and therapeutic purposes. Only one other problem--these drugs are useful in prompt or acute exposures. What is lacking now is the development of these drugs into either a new drug delivery mechanism so that it may be useful for chronic exposure scenarios and also for probably protracted and therapeutic exposure scenarios. And the other aspect I want to address is what Dr. Tsyb has brought out about the thyroid metabolism which is very, very important. I think we do not have any very good animals models in this respect. All that we have are epidemiology data of thyroid cancer, but, to understand the molecular biology as well as metabolic aspects of the thyroid gland, some animals models have to be developed in that respect. I was very happy to see what he has presented to us today about the antibodies of thyroid microsomes. It might be something which is worthwhile to pursue further in the animal models. It is important because the microsomal peroxidases may be what is incorporating the iodine into the thyroxine and triodothyroxine molecules, so these two aspects are something which are worthwhile to pursue, the molecular biology as well as the metabolic aspects of thyroid glands. Thank you.

Dr. Fry: Thank you very much. Those are very useful comments. Dr. Ainsworth, do you want the last word?

Dr. Ainsworth: I have two questions. Following up on what Dr. Kumar has said about protectants, in emergency response planning in Russia is there any inclusion of the use of radioprotective agents under circumstances like the firemen, where you know that someone is going to go in? Secondly, Dr. Young and I and others in this country have been asked repeatedly about the use of radioprotective agents at Chernobyl, and we have no specific information about that. So if someone from the Russian side could comment, we would greatly appreciate that.

Dr. Tsyb: Dear colleagues, this last question is extremely important and we have not discussed it at all. This is the question of creating prolonged action radioprotective agents, and a lot of scientific institutions are working on this problem. I would like to say that certain achievements have been made by the Institute of Biophysics, headed by Academician Ilyan. Recently he showed me a book which he just published, called *Radio Protector B,* which is the agent that was used in Chernobyl, B-190 specifically. And I would like to second the opinion of my American colleague, this problem must be a topic for discussion. This is a very important issue. It's extremely important because, if everybody who starts to respond to an incident could get these radioprotective agents, if we could thereby reduce exposure by 30 percent even, that would be wonderful. If we can reduce it by 100 to 150 percent, that would be fantastic. We're working on this problem at the Institute of Biophysics. This is a very relevant, very urgent issue. Radioprotective agents, radioactive iodine uptake prevention procedures are the most important measures of acute response, of immediate response. Thank you very much.

Dr. Kumar: I'm very happy to hear your comments about radioprotection. I think it might be something worthwhile to pursue a combination of radiation protectors because those which we use today are, as you know, very toxic if used alone, but if you lowered down the doses of them and used them as combinations, maybe even the combination of iodine and other radioprotective agents, this would be worth pursuing.

Dr. Fry: Thank you. I'd like to thank the panel members and all the participants. I think this session and the presentations we heard yesterday have identified clearly some areas for future directions which are going to be discussed at the end of this meeting--areas in information and communication as I mentioned at the beginning, areas in intervention and treatment, education and research, in support of improving emergency medical preparedness for dealing with radiation accidents and their consequences. Thank you everybody.

American representative

Col Reeves: Let me sum up briefly if I can. I take copious notes, but I find it beneficial to then reduce things to two or three simple statements. I'd like to mention a couple of the most important things that I learned from the first panel, which is the importance of dose reconstruction and its relationship to health effects, especially concentrating on the high risk groups, secondly, the importance of rehabilitation of the land for habitation and especially economic productivity after an accident. If I have one take-home lesson from Panel Two on the scientific and technical support, that would be the necessity of our next step perhaps being the performing of a table-top exercise or business game. That way both sides, and other nations too, can compare their notes on how to respond to radiation accidents. While some nations have had more experience than others in dealing with radiation accidents, all of us have theories and plans and all of us have a need for planned response procedures and for improving how we do things. And if I could sum up in three words the third panel, which Dr. Fry so excellently chaired, that would be teach, train and do research. The goals of a university or of any training institution are primarily twofold. Number one is to generate knowledge, and number two is to disseminate knowledge. I think we've had quite a bit of experience along line number two, where we have been able to learn from one another during these conferences. It brings us to what our next steps should be. It is of prime importance to do a table-top exercise, a business game, that will actually test our plans and procedures. I think all of you remember Mr. Alston's and LCDR Thompson's presentation the first day on what Partnerships for Peace has already achieved along these particular lines. Secondly, proposals for future work, biomedical bench research--Dr. Boudagov mentioned some of the challenges in the fields of molecular biology, molecular correlates, that will perhaps help us to understand how better to treat combined injury. As was pointed out, we're getting a pretty good handle now in handling the complications of the bone marrow syndrome, sepsis resulting from cytopenia induced by radiation. It appears now that one of the most critical organs, which will then determine survival at the next higher range of what is now becoming survivable dose levels from prompt radiation, may be the lung. And of course the one problem that we've had that has been very clearly documented epidemiologically, after Chernobyl, has been the increased incidence of thyroid cancer. What are the steps that we can take to ameliorate this problem once iodine has been incorporated as well as of course prophylactic measures, and then what other use can we do with the voluminous amounts of existing databases with human data? I think as Dr. Fry pointed out it's very important to record and document the lessons learned from accidents. This is one of the hardest things for those of us who have served as physicians. It's very difficult to remember that you've got to sit down and record and write notes, but that's so important, not only for your current patient but also for the persons who hopefully will be helped by your experience in the next accident. And then, finally, there should be collaborative research between institutions at all levels. Of course a primary problem is resources. I know that is in the back of all of our minds to a greater or lesser degree, not only resources needed but resources available. *[Tape changeover here.]* We are required to report to the Executive Committee and subsequently to the entire Joint Coordinating Committee for Radiation Effects Research on what were results and what are the next steps stemming from this workshop. One note, and I will close on this--the JCCRER framework for the ones familiar with it has recently been loosened to allow it to become more of a coordinating rather than a controlling commission. Now we are being encouraged to do institution-to-institution collaboration to whatever degree and whatever area that both institutions would like to do. Of course, this doesn't preclude several institutions working together on a particular focused problem, but cooperation can take place at any level.

Finally, I would like to thank those of you who have come. First of all, those who have chaired our panels, Dr. Victor Vladimirov, Dr. Rafael Arutyunyan, and Dr. Shirley Fry, for taking the time and preparation to coordinate and particularly to summarize the works of their panel. Secondly, I would like to thank the 20 individual participants who spoke. Thirdly, I would like to thank those of you in the audience, particularly those of you from the international community, besides Russia and the U.S., who have attended the workshop. The whole point of such a workshop is to foster international and national contacts and future collaborations. Again, thank you all for coming , and we do appreciate the attention that you have given. Before I finally close, let me ask my colleague, Dr. Rafael Arutyunyan, who is co-coordinator for this workshop, for his final remarks.

Russian representative
Dr. Arutyunyan: Thank you, Glen. The only thing I want to add is I understand that we already know we have to report about our workshop in our groups. I think by fax you can send us more precise proposals, then we will coordinate them together, Glen and I, to set up a table to forward to the Executive Committee. You are absolutely right that our Joint Committee is now operating under another format of work. There is no need to coordinate with all the agencies involved for projects, so if we have two sides that understand how to bring the money to the project, then the Executive Committee will make a decision that the agreement is necessary, useful, and should be organized. Directions 1 and 2 of the JCCRER are currently well underway and are being funded. The third topic, upon which Glen and I coordinated this workshop, has been discussed all the time, but I like the idea that it has now gone beyond its own framework; this means that you and I have created the correct atmosphere as a minimum. So, we should get some funding to shift toward our third direction. Thank you very much. Thank you for your hospitality. Glen, thank you very much. I know that it was very difficult to organize and coordinate this workshop, and I am very grateful to all the participants.
