7

Elaboration of Geoinformation Regional Monitoring Environmental System ("GERMES-I") Enriched by Artificial Intelligence Instruments

7.1 Introduction

Environmental problems as well as environmental and anthropogenic collisions in basins of Mediterranean Sea and Black Sea are closely linked with industrial, transport and agricultural activity and require considerable attention. We believe that one of the first protection and prevention measures to be taken today, while solving environmental tasks, is to combine the artificial intelligence (AI) means of information processing and decision making in uncertain situations – with new technologies in GIS, with new monitoring methods, aerospace remote sensing (RS) and some other techniques [Krissilov, 1999], [Krissilov et al, 2001], [Shutko et al, 1998, 2007], [Stepanov et al, 2001, 2003], etc. We call such intelligent system – "GERMES-I" (GEoinformation Regional Monitoring Environmental System-Intellectual).

It must be noted that talking risks assessments we mean at least 5-level interpretation or definition:

- 1st level: theory of different kinds of risks: risk structure, genesis of risk, the steps of danger development, theory of risk measurement, mutual influence and feedback links between different kinds of factors so on; it is new methodological and theoretical area now;
- 2nd level: concrete experimental studies of risks in condition of natural and man-made disasters;
- 3rd level: remote sensing application for risks determination by means of various sources (microwave radiometry, in particular, allows to obtain by practically direct way the risks assessments);
- 4th level: risks assessments in regional and/or national scale by means of advanced Geoinformation Environmental Monitoring System (examples – for Black Sea Region, for Aral Sea, GIMS for Bulgaria, others);
- 5th level: creation of state-of-the art technological monitor complexes for strategic determination of risks of hunger, another dangerous factors – throughout the World (e. g. by developing aerospace complex "RiceSAT" (rice satellite) with partners in Asia, America, etc.)

The problem of recognition and/or interpretation of monitored data occur in a lot of environmental tasks. All of them practically have similar characteristics: the objects and processes are complicated; features are both quantitative and qualitative, have various natures; one must take into account a lot of data, relations between them, etc. In addition, at the same time, we must use all this information for diagnostics, decision-making, and prediction; we have no other [Krissilov, 1999]. It is understood that without using certain arsenal of effective AI methods and algorithms we cannot make valid decision and solve agrotechnical, administrative, navigational, and environmental problems

[Stepanov et al, 2001]. Such tasks as measuring, recognition, estimation, considerable analysis and description of complicated objects and processes, etc. – may be solved by means of certain group of classification and evaluation methods, intellectual methods.

Therefore, planning and managing bodies must have full-scale, deep, and complex multilateral ecological monitoring.

At the same time any country and the Black Sea Region as a whole does not have general (common) big monitoring system. We have no interdisciplinary Expert-and-Analytical Center for collection and performance of OLAP (On-Line Analytical Processing) based on all information in order to save previous data, define and forecast the accidents and timely inform various users and agents in countries of the Region. There is no united and systemized database, as well as knowledge about links between parameters and probable results of its interaction. Almost all that we have now needs to be updated, is expensive, and cannot bring fast reaction.

Various forms of this issue were discussed in the framework of some events, some conferences of Balkan Environmental Association (BEnA), KDS events ("Knowledge – Dialog – Solution" Conferences and Schools), Danube and Black Sea round tables, GMES events, other scientific and public meetings, and included in certain Conclusions, etc. So far, administrative bodies in the basin and scientific organizations have unfortunately failed to get a grip on such Center creation. It is understood, that this work does not need a pot of gold, and new "Black Sea" Euro Region territorial unit can become both right way and right instrument for that.

We believe, that regional environmentally oriented monitoring and intellectual system GERMES–I can become the first step along this road (creation of such Center). Its general outlines and important special components are described in this chapter. As it can be seen, that in its algorithmic terms – a good deal of attention is paid to intellectual instruments for aggregation, evaluation, comparison, decision rules, – using original effective means [Krissilov, 1962], [Krissilov, 1984], [Krissilov et al, 2000], [Krissilov et al, 2001], [Krissilov A. and V. Krissilov, 2005], [Popov, 1971], [Krissilov V. et al, 1998], [Krissilov V. and A. Krissilov, 2000]. In measurement terms, major results of the long-term study and practical experience are presented [Shutko, 1982, 1987], [Shutko et al, 1995, 1998, 2007], [Stepanov et al, 2003], [Krapivin et al, 1996] and others.

7.2 Brief system description

The Black Sea and Mediterranean Sea basins and the coastal area of the region are a zone of extensive economic development with high capacity sea- and river ports, large industrial enterprises, heavy and growing traffic, owner-leased resource extraction on the shelf, and expanding recreational and agricultural uses of the shores.

These permanently acting factors, existing in a very complicated and vulnerable environment, require coordinated efforts and effective integrated management both of maritime and land economic activities. So the integrated environmental monitoring system can be seen as a tool of such management and risks prevention.

The following characteristics shall be monitored:

– environmental: direct survey and assessment of temporal and spatial data on oil pollution (where, what, how much, the dynamics); monitoring of all coastal areas as regards the outflow of waste waters and mapping of affected zones; detection of bilge water discharges; gas concentration surveys carried out above urban settlements and industrial zones, registering their wind drift and the nature of pollution; assessment of water turbidity, i.e. of practically all mineral suspended matter contained in water; assessment of chlorophyll concentrations (in other words – a self-cleaning capacity) in specific water reservoirs and water areas over the whole monitored basin, and a number of others;

- hydrological and meteorological: water temperature, presence and thickness of ice, wave characteristics, situation in straits, assessment of shore abrasion;
- land: assessment of water seepage in canals and through dams, the degree of soil pollution and salinity, the amount of swamping, assessment of crops conditions and that of the vegetation in general.

The system shall also deal with:

- detection and registering of various oil films: from a few micrometers to several centimeters thick;
- monitoring of general dynamics of the shore line (abrasion, landslides, building up and washout of sand bars, etc.) with high accuracy – of up to 2 to 5 m.
- agriculture activity; forestry, etc.

One can see that due to the range of characteristics having been monitored our System' objectives must be as following:

- collection and storage of current information on stationary and mobile pollution sources;
- detection and evaluation of risks presented by various critical and accidental situations in the technological, ecological, navigational and hydro meteorological spheres, taking into account the separate and cumulative effects of the considered factors;
- analyzing the background and current data in order to produce short- and long-range predictions for the observed objects and situations and collisions;
- presenting the current and predicted data in the form of maps describing temporal, spatial and material details;
- working out and justification of optimum technological and organizational solutions related to the prevention and combat against various dangers, and mitigation of the anthropogenic factor in the entire region.

So, instruments of "GERMES–I" system have provide to the administrative, economic, environmental bodies with reliable and fresh quantitative and qualitative data on the areas and objects, and compare them with the predicted data, etc.

In conformity with the set objectives and depending on specific conditions the monitoring shall be carried out:

a). regularly: a continuous observation and monitoring of assigned parameters over the whole land and water area and in specific sites;

b). as additional measurement and observation assignments required clarifying the situation (especially – the danger one) as regards the time, location, resolution, specified components, etc.

The work should be making on three levels: using satellite, air, and land means, with employment of a remote sensing system comprising optic, infrared and MCW instruments, as well as other appropriate equipment and software.

Basic parts of System are (Figure 106):

– block that realizes remote sensing (RS) of earth and water surface, by means of high technologies – Microwave Radiometry from planes or/and another platforms – for recognition and evaluation the green agricultural and forested (wooded) territories, overmoisted zones along the rivers, to contour it, to estimate leakage of the waters from the ponds, canals and pipelines, to define oil pollution, soil mineralization, iridizations, etc.;
– intellectual block, oriented to analyze data monitored, to assess various characteristics measured, to recognize and classify situations, objects and processes under the survey and control.

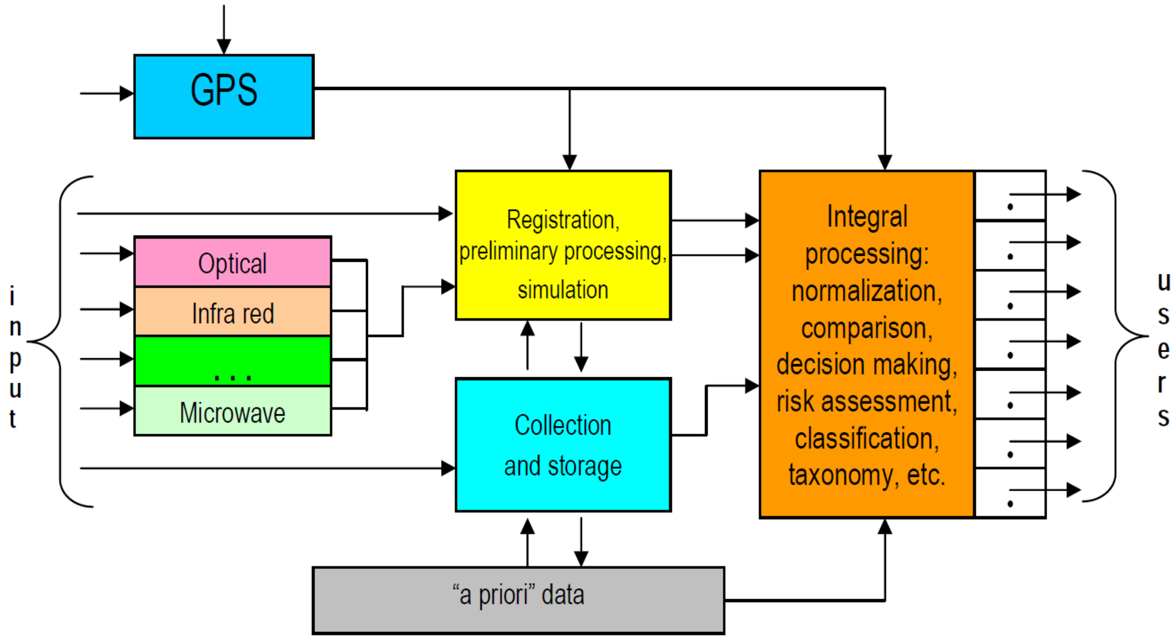


Figure 106. Preliminary version of GERMES-I structure

In our case a contour of GERMES–I includes some functional units [Krissilov, 1999], [Krissilov et al, 2001], [Haarbrink et al, 2007]:
– optical, infrared and microwave radiometers for data remote sensing;
– device for coordinates measuring (GPS – Global Positioning System);
– tools and instruments for various environmental, meteorological (etc.) parameters' measuring, registration and primarily processing;
– "a priori" data unit;
– unit for collection and storage of current data from various sources of pollution and accidents;
– unit for special intellectual processing of data measured.

The main attention in description below will be paid to first and last points, especially to remote sensing possibilities (MCW radiometry, see Chapter I), and to aggregated (integral) assessment methods, and to original effective decision rules. In addition, it must be underlined that last unit in our scheme is not simply mathematical one; it fulfils certain "mental" intellectual functions.

7.3 Some examples of practical MCW monitoring and risk assessment

It is needed to say several words about idea of "risk", referring particularly to Preface. As a rule, the risk related publications are discussing theoretical aspects of "risk assessment", "risk management", "risk development", "risk of artificial intellect utilization", "risk analysis", "risk theory and security", etc. One of the conclusions is: for obtaining the most representative "risk concept" definition, in the environmental situations especially, it is necessary, first of all, to reveal the most essential parameters of environmental objects or their models and patterns and, secondary, to determine the boundary characteristics for parameters under examination. It must be noted, that these two steps are completely adequate to the procedure of microwave radiometry data verification, validation and calibration. The team of the Institute of Radio engineering and Electronics, Russian Academy of Sciences, is working in this scientific and practical field more than 30 years (last decades – with certain collaborators, esp. "Miramap", Netherlands) and has accumulated a huge data bank on "what is microwave radiometry and what is an information content of measurements conducted by the microwave radiometers in different bands, from different heights, under different spatial resolution". Few examples of this methods and techniques application in various countries are placed below in this paragraph.

In addition, it must be clear, why just MCW methods and techniques can play the first fiddle among other sensors and methods.

What happened physically and historically, is that the objects to be remotely sensed in optical and infrared bands, namely, soils, vegetated areas, snow and ice, are characterized with big time constant, which varies within weeks–months and decades-centuries.

At the same time, water as it is (in stormy condition and in condition of chemical pollution), water on land surface (in condition of flood) and water inside the land surface (caused by rains and artificial watering) manifests as the most dynamic parameter of environment with the time constant of minutes-hours and days-months.

Fortunately, there exists a mighty remote sensing method of practically direct measurements of radio-physical water and moisten soil parameters under small dependence of parameter accuracy on surface roughness and a soil type, that is method of microwave radiometry (Figure 107). Main information can be found in [Shutko et al, 1998, 2007], [Krissilov, 1999], etc.

Devices for microwave radiometry are special (very high frequencies) radio-receivers perceiving by means of antenna the self-radiation of surface (objects) below in certain range of wavelength. These devices are able to determine the following soil, water and vegetation related environmental parameters and conditions:

- surface soil moisture,
- underground moistening,
- depth to a shallow water table (down to 2 meters in humid areas and down to 3-5 meters in arid/dry areas),
- located on the surface and shallowly buried metal objects of a reasonable size under the conditions of dry ground,
- contours of water seepage through hydrotechnical constructions (levees, dams, destroyed drainage systems, different kinds of leaks),
- biomass of vegetation above a water surface or wet ground,
- increase in temperature in land, forested and volcano areas,

- changes in salinity/mineralization and temperature of a water surface,
- water surface pollution, oil slicks on a water surface,
- on-ground snow melting,
- ice on a water surface and on the roads, runways.

Some figures below illustrate various kinds of application MCW-technique in different tasks during last decades.

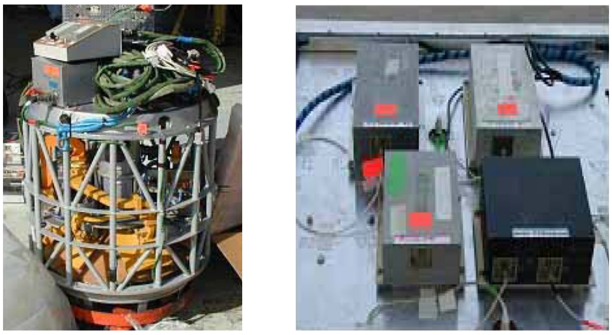


Figure 107. Scanning and non-scanning MCW-radiometers ready to work

Figure 108 shows the 5 micrometers film on the water in Odessa port area; left arrow indicates polluted piece from port Juznyj, the right one – from port Illichevsk. There was nice weather, no waves nor wind, we see background picture.

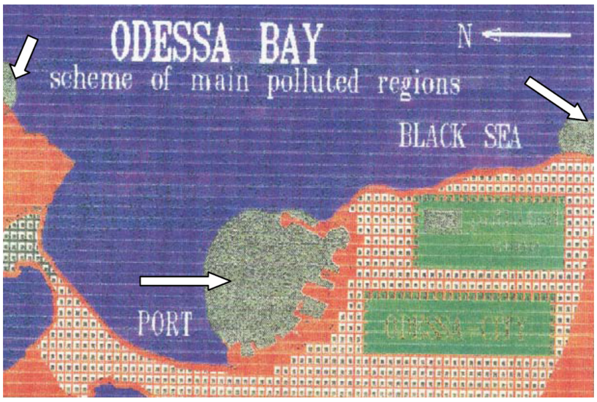


Figure 108. Thin oil-film recognition in Odessa harbor (end of 80s)

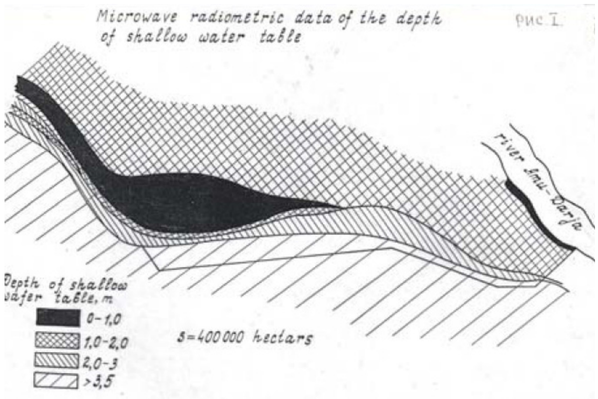
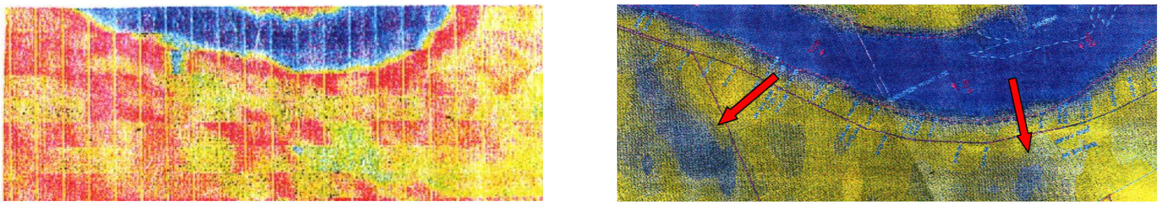


Figure 109. Map of underground water, Middle Asia (early 80s)

On the Figure 109 one can see that the boundary of moistened territory is situated in hundred kilometers from channel. This experiment and many other similar experiments indicating water seepage from existing canals pushed Soviet leaders to stop the Project devoted to turning some water from Siberian Rivers to Middle Asia and finally the project was declined.

Very interesting and demonstrative result of MCW measurement is presented on the Figure 110. Both pictures were taken at the same place on the bank of river. Left picture shows the surface of bank as dry territory (soil moisture levels are marked in colors – red and yellow indicate dry soil – water is absent). On the other hand, on the right picture, we can see two underground lakes just at the same place – the blue color indicates them. For obtaining such results, the measurements had to be made in different parts of MCW range.



(a) *(b)*

Figure 110. Illustration of surface state (a) and underground water table (b) measured in different bands (red and yellow colors indicate dry surface)

The accuracy of measurement one can see on the Figure 111: In its lower part, the vertical segments indicate results of hand-made in situ contact measurement, and dotted line – remotely sensed MCW data, from plane platform.

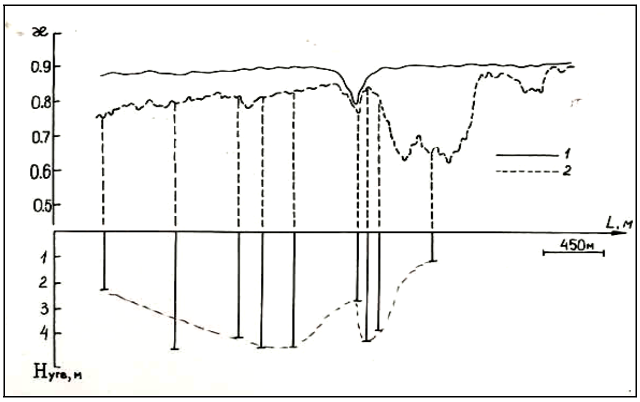


Figure 111. Experimental comparison of contact and remotely sensed data.
Upper Part: changes in emissivity at the wavelengths of 2 cm(1) and 30 cm (2)
Lower Part: "in situ" data of the depth to water table

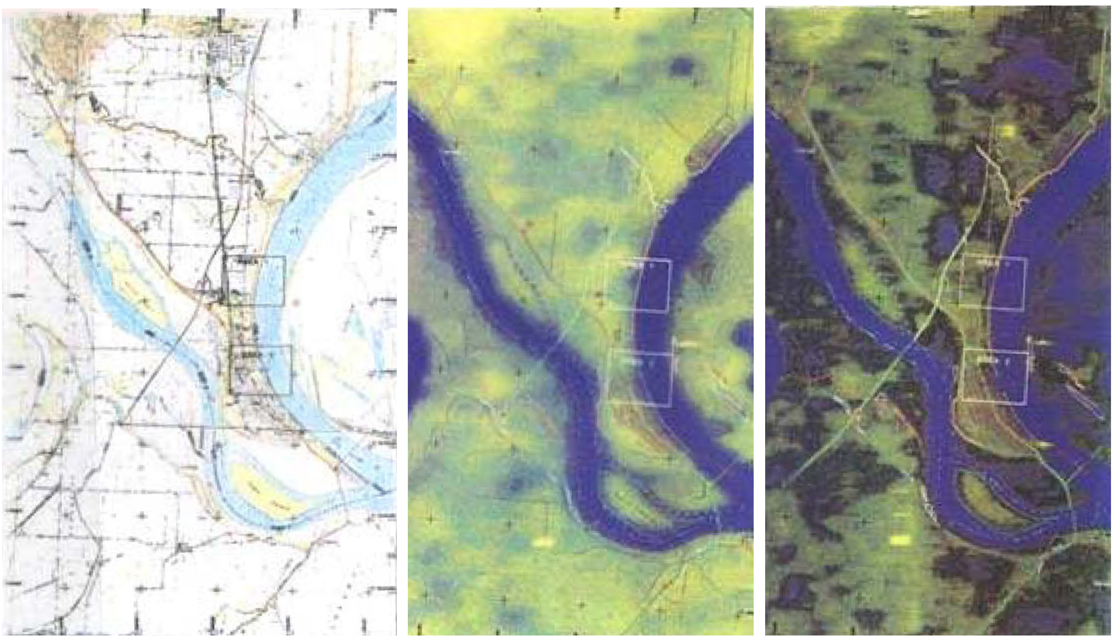


Figure 112. MCW monitoring in the region of Mississippi and Ohio Rivers, USA, end of 90s

Figure 112 demonstrates dual-wavelength procedure of water seepage/leakage determination through levees/dikes. The left picture is the map of the area, center – data at 5-cm wavelength, right – 21-cm data.

Results of superposition of different images (concerning the same object) are shown in the pictures below.

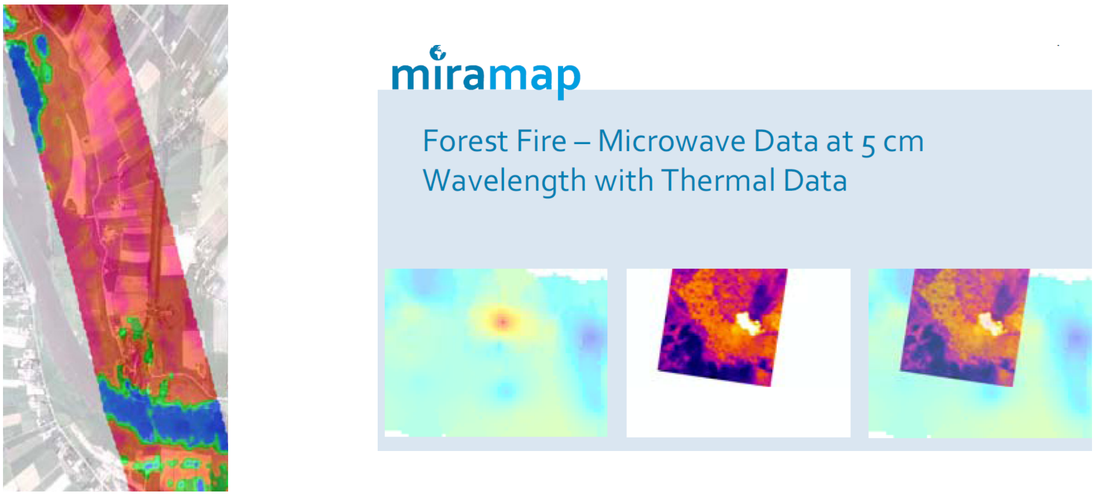


Figure 113. The complex (synthesized) pictures: left – area of water seepage detection in the Netherlands, 2005; right – forest fire in Bulgaria, 2007

Right part of Figure 113 contains three images: image of forest fire as seen by 5-cm wavelength microwave radiometer (left) and thermal infrared camera (center); the overlaid images are shown on the right.

Significant result can be seen in the figure below. Figure 114 is satellite multispectral picture with details of Mexican Gulf coastline. Figure 115 presents thematic maps obtained by MCW remotely sensed (from plane!!) data: surface soil moisture, depth to water table and vegetation index – different colors indicate different parameters. Both of these images are not "operational ": first one has no thematic information, the second one doesn't contain any geographic detail.

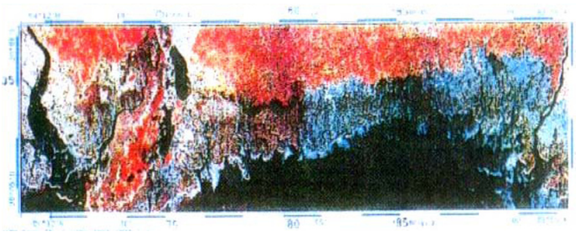


Figure 114. Satellite multispectral picture of Mexican Gulf coastline

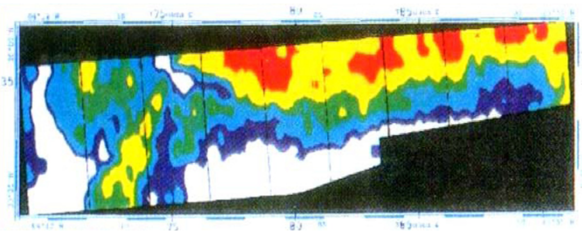


Figure 115. Thematic maps obtained by MCW remotely sensed data

On the initiative of the IRE RAS the National Wetlands Center in Lafayette synthesized all information available for this area and presented it in Figure 116. Almost all needed information together with surface geographic material is presented on it.

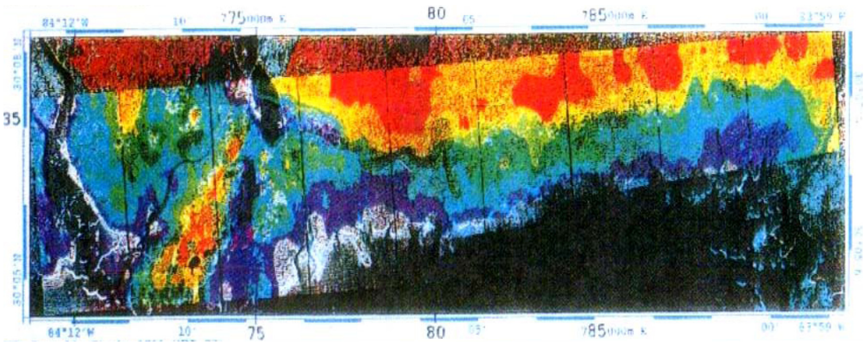


Figure 116. Mexican Gulf coastline synthesized picture, end of 90s

Some practical examples (from Bulgaria – 2007 expedition) devoted to the risk assessment of hydrotechnical construction leaking and of readiness to forest fire appearance and development will be presented below.

At the end of this brief review of some technical instruments and practical risk measurement and assessment, we want to say following. At first, the possibility for emergency response mapping, integrated with GPS and GIS technologies and special modeling and original algorithms, facilitates the monitoring and control of areas of water seepage through irrigation constructions, levees and dykes as well as revealing areas with dangerously high groundwater level. The passive microwave radiometry, used in GERMES-I system, is based on spectral measurements (own surface radiation receiving) in the millimeter to decimeter range of wavelengths. Moreover, comparing with other RS tools, such as color or infrared photography, thermal images and lidar, MCW radiometry is the only one taking measurements under the earth’s surface and therefore is very well suited for any hydrological parameters monitoring in a fast and reliable way.

And, second, it can be seen, that all these kinds of activity, all monitoring tasks and problems are needed the aggregative assessment, quality evaluation, effective and right decision making, – whole advanced arsenal of intellectual data processing.

7.4 Artificial intelligence approach proposed and main principles of estimating/classifying model creation

There are some reasons in environmental studies to elaborate the Decision Support System for Complex Objects Evaluation now (it is understood, an estimated "object" is a very general concept, which can refer to a situation, an alternative, an action, a product and so on).

These reasons are as following:

- the fast increasing of diverse and combine information, which can be analyzed only with great difficulties if preliminary aggregation, classification, generalization etc. are absent;
- necessity to make analysis of complex objects with different nature in various fields of human activity (science, management, industry, and so on).

There are many advanced approaches to solve different AI tasks, such as Bayesian estimation, Fuzzy Sets Theory, Neural Network Theory and other. However, some tasks, such as decision-making, choice, classification, judgment, and pattern recognition, have similar nature and can be solved by means of certain common tools, in definite unified way.

This statement has following grounds:

- each task mentioned above is proceeded from the system of local parameters with various nature (quantitative and qualitative);
- solving process includes certain considering and transforming the primary features;
- all tasks are knowledge based;
- all of them consist such operation as calculating, selection, quantitative grounding.
- their principal dissimilarity has different types of result (numeric and symbolic).

So, we propose in our system to unify different methods and to consider AI tasks mentioned above from one point of view [Krissilov A. and V. Krissilov, 2005], [Krissilov V. et al, 1998], [Krissilov V. and A. Krissilov, 2000]. It becomes possible if one takes into account the aim of concrete environmental (protection, prevention, administrative, managing) task. Only formal aim's description permits to get high-quality results. The main point of approach presented is the aim-oriented vector model of evaluation task.

Evaluation of object is based on the aggregated characteristic calculating. The aim-oriented vector model permits to describe different AI tasks and to solve them in terms of complex object' evaluation (Figure 117).

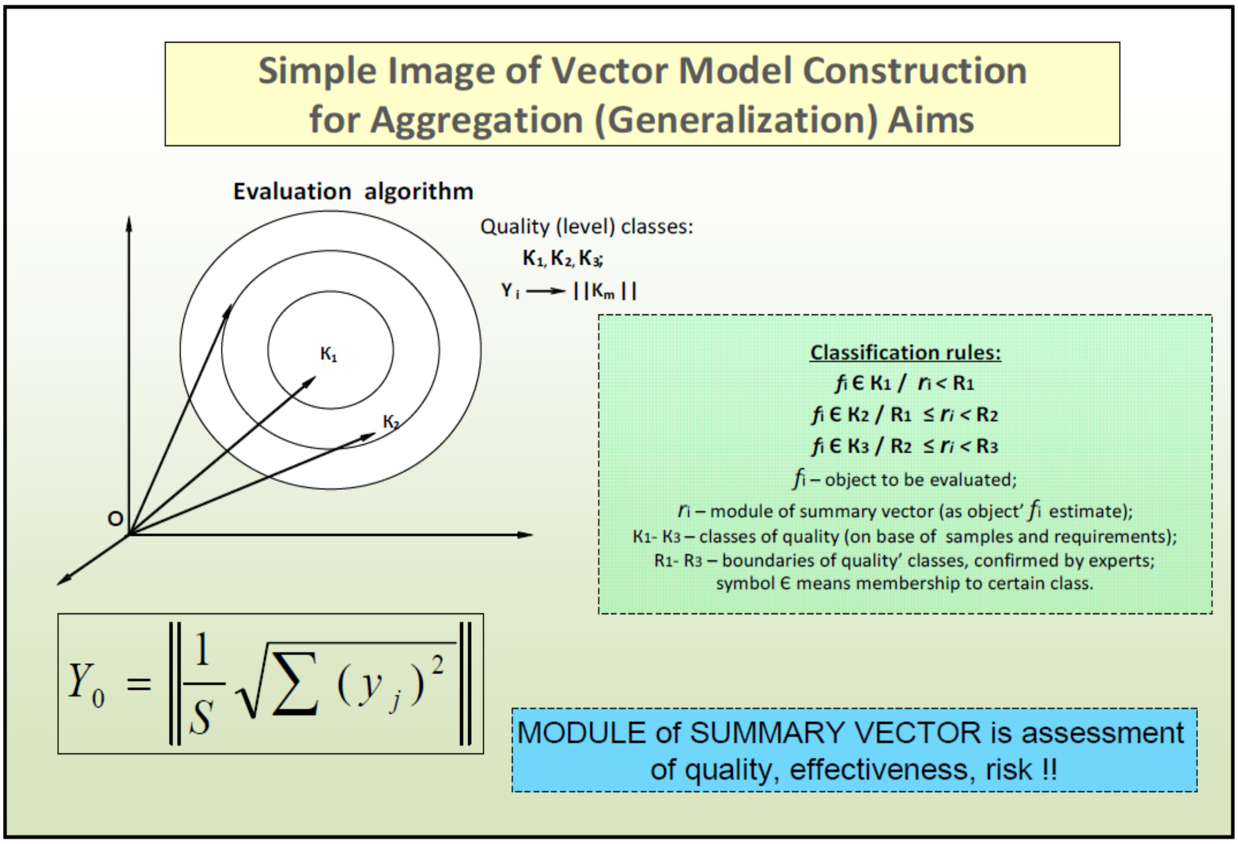


Figure 117. Presentation of vector assessment model

It may be shown that in essence all of AI tasks are based on evaluation with different goals. The resemblance of classification and evaluation can be demonstrated as example for proving it. Classification is the assignment of objects to groups within a system of categories distinguished by structure, origin, etc.

Usually the operations have been making by classification, by pattern recognition are following: comparison of concrete input object (in its feature' terms) with each sample of classes recognizing, the evaluation (calculation) of similarity level, and then the most coincident one' selection. So the classification can be produced substantially via evaluation.

Evaluation is a forming of an opinion or the approximate calculation of the qualities of an object. Thus, from that point of view, classification and evaluation are counterparts. The main difference is type of conclusion. Usually it is symbolic in classification and numerical in evaluation.

Analogously it can be shown that the pattern recognition, some kinds of decision making, choice, and judgment can be expressed in terms of evaluation.

Let us consider in detail the process of the evaluation, its participants, and component parts [Krissilov A. and V. Krissilov, 2005].

The correct evaluation process must be done with taking into account not only features of object, but also the requirements of subject, because the same object has to get different benchmark in cases of different requirements. In fact, the evaluation is formed as measure of correspondence (coincidence) between subject's requirements and object's features.

The object's properties can be both quantitative and qualitative, as it was told. Quantitative properties are characterized by possible maximum and minimum values. Qualitative properties are characterized by the set of their own values or description, – for instance, by means of so-called linguistic variable.

The concept of the requirement allows formalizing the aim of the concrete evaluation task. The requirements exactly should be attributed a certain weight factors in order to take into account the different importance of different factors (features). Thereby, forming the requirements means defining of ensemble of corresponding object's properties, and determination of the importance of the given requirement in respect to other requirements. Besides, presence of requirements determines necessity of forming of the set of dependent properties values, which the mostly satisfy to the given requirement. In general, it is possible to put these values as standards for given properties in case of concrete task.

7.4.1 Description of aim-oriented vector model

So, all this reasoning may be formulated as the main initial principles of vector model forming:

- there are two participants in every estimation process: object of evaluation and subject of evaluation;
- there are both quantitative and qualitative features;
- there is necessity of standard formation for every object's feature.

The vector model is intended for formalization of complex object evaluation with taking into account the purpose of concrete task.

The aim-oriented vector model composition

Let **S** is **n**-dimensional space of features. Each estimated object can be represented by a point $\mathbf{s'=\{s_1,\dots s_i,\dots,s_n\}}$ in this space.

Let **V** is **m**-dimensional space of requirements to objects. In general, **n** is greater or equal to **m**. The aim of every task is connected with point (or a zone) $\mathbf{v_O}$ in space **V**.

Example:	Demand:	Features:
	Good specialist	1. Education
		2. Experience
		3. Last place of job

Then there is point (or a zone) **E** in space **S**, which connected with $\mathbf{v_O}$ by the correspondence:

$$F:(V \Rightarrow S)$$

All objects from this zone satisfy all requirements on a 100%, -- so, it is a standard for this task. It is understood, that in case of classification task we have to form $\mathbf{v_O}$ and E for every classes.

The different requirements have different importance for concrete task (and/or for concrete experts). Moreover, each feature has particular influence to their demand. The vector of weight factors **P** is formed for taking into account the different importance of requirements and features.

In general case, the objects have quantitative and qualitative features. That is why all of features are presented as contribution function for identical treatment:

$$Z_i = f_i(X_i),\ i=l,...,n,$$

where $\mathbf{Z_i}$ is the contribution of the feature $\mathbf{S_i}$ to object evaluation producing and $\mathbf{X_i}$ is value (meaning) of feature $\mathbf{S_i}$.

The contribution function shows the influence of feature value (meaning) to final bench-mark for object. The contribution function must be defined for all feature $\mathbf{S_i}$ values (meanings) and it has maximum, which is the standard **E**. It is possible to say that every feature is exposed under the fuzzy transformation.

So, cortege **M = (S, V, F, P, Z)** is general context for evaluation task, and we propose name it aim-oriented vector model (AVM). Its view is shown on Figure 118.

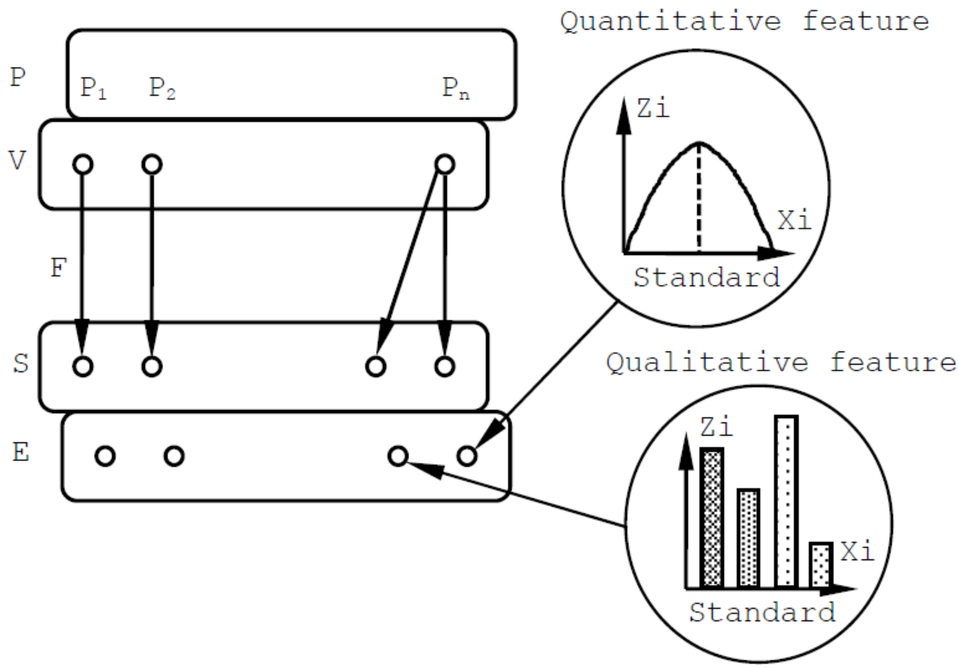


Figure 118. Relation between requirements (Vs) and features (S)

7.4.2 Solving of evaluation and classification task by means of AVM forming.

The aim-oriented vector model **M** allows calculating aggregated characteristic of the estimated object. The aggregated characteristic is:

$$K = ||PxF(Z'), Pxv_O||,$$

where x – sign of direct vector multiplication;

|| || – Euclidean metric in **V** space;

Z' – vector of z_i for point **s'**, which represents estimated object;

P – vector of weight factors.

The value of aggregated characteristic is defined as the distance between point **s'** (evaluated object) and point v_O (standard object, aim of evaluation) in transformed feature's space.

Analysis of the aggregated characteristics makes possible both estimation of objects and/or classification. It is possible to find out contribution of each feature and make retrospective analysis and determine which features raise the measuring level, which ones make it lower and which are indifferent ones (from point of view of the concrete requirement's list).

Now consider some especial aspects of classification task solving by means of the vector model proposed. In the first place, the task's context has to contain the set of classes must be recognized. Let us name it set **C**. Therefore, we have to form standards **E** and weight factors **P** for every class, and aggregated characteristic of classifying object is calculated for every class.

In the second place, the pattern recognition process is provided by means of some decision rule. One of them, namely the decision rule maximizing a right classification probability [Dubois et al, 1997] can be proposed for our problem solving. This decision rule is as follows:

$$s' \in c_j / R_1 = \max_j (K_j(s')),$$

where **j = 0, 1, …, L** is number of classes, and $K_j(s')$ is aggregated characteristic of object **s'** for class c_j.

This rule gives best result only in a case when the features are independent. There are many tasks where the objects are described by depending features. In this case, we propose to make special learning stage. Showing known objects from class c_j can measure for each **s'** the $K_j(s')$ and fix the probability $P(K_j(s')/c_j)$. Then the following decision rule may be proposed:

$$s' \in c_j / R_2 = \max_j (P(K_j(s') / c_j)),$$

The proposed approach allows getting correct solutions of classification tasks in case of depended features. This area of task will be described in details in fifth paragraph.

7.4.3 The stages of vector model forming

The process of aim-oriented vector model forming includes:

I. The stage of abstraction.

1) The feature set (space **S**) forming. There are possibilities to use both quantitative and qualitative features, but the measurable features are preferred.

2) The requirements set (space **V**) forming. It is understood; the requirements can be more general then features.

3) The correspondence **F:(V⇒S)** forming. Every requirement must be connected with one or more features.

II. The stage of scaling.

4) The vector **P** of weight factors forming. The weight factor takes into account the requirement importance and importance of feature for its requirement.

III. The stage of fuzzification.

5) The contribution function **Z** forming. The contribution function extremes are the standards for the feature.

In case of classification task, solving the steps 4 and 5 must be made for each class.

There are two fundamental ways to form the vector model: a) on a base of the statistical analysis; b) on a base of the expert's knowledge and opinion. Both of them were applied in the presented model.

The evaluating system above was realized with using certain effective decision rules and with calculating the aggregated estimations of objects/processes monitored. Moreover, in system described some original decision functions are used that allows operating with dependent features [Krissilov, 1984], [Krissilov et al, 2000], [Krissilov A. and V. Krissilov, 2005]. This property permits to solve complicated tasks with high accuracy.

Let us consider these interesting and original decision functions.

7.5 Decision making rules for situations both with independent and dependent features

7.5.1 Introduction notes

A lot of tasks, due to automatization and algorithmization different kinds of activity, deep computing and so on, – need now the effective decision rules application. There are dozens of works devoted to this problem, among them, particularly, [Banerji, 1978], [Schlaifer, 1979], [Zagoruiko, 1976], [Gladun and Vashchenko, 2000], many others. The neuro-computing methods and technologies also are used in the area of artificial intelligence (AI).

There are certain works describing data processing by means special spaces [Krissilov V. et al, 1998], [Krissilov A. and V. Krissilov, 2005]. It may be seen, that using geometrical explanation and imagination is very fruitful approach in various AI tasks and in processing of complicated data upon the whole.

A great many of decision functions and rules, that are applied in tasks of pattern recognition and support of the administrative decisions, are constructed in the assumption of independence of attributes (features) being used for description of analyzed and/or recognized objects. Desire to take into account dependence between parameters leads to the very large expenses of time and memory, or, at the best, comes to final fixing, for example, only of pair dependences, in nearest neighborhood. Besides, it happens seldom when users or developers have the information on real values of dependences features' presence or absence from each other in various processes, classes of objects, etc.

At the same time, it is difficult to imagine a task, in which the description of analyzed objects is made by means of parameters independent in aggregate. Especially it looks clear by putting medical diagnosis [Popov, 1971], in solving the environmental tasks [Krapivin et al, 1996], in realization of geoinformation monitoring, etc. In these last cases, e.g., analyzing a natural situation or estimating anthropogeneus influence, the expert operates with such characteristics, as moisture of ground, water table level etc., are dependent from each other certainly.

Then if we have the problem to build full-scale monitoring system (and while another tasks solving) alongside with other means of processing of the information, it is necessary to use decision functions, which are able to take into consideration relations and dependencies between the features without using a big system resources.

7.5.2 Decision functions (1st learning stage)

Let some *k*'s object, having evaluated or recognized, is described by *n*-dimensional vector [Krissilov, 1962, 1984]

$$f_k = \{\nu_1, \ldots, \nu_i, \ldots, \nu_n\}$$

where $i = \overline{1,n}$ is number of feature and v_i is the measured value of ***i'***s feature in the ***k'***s object.

Dealing with classification problem, we can obtain (as result of learning stage) the matrix

$$C_n = \|p_{ji}\|,$$

where *j* is number of class and p_{ji} is probability of *i*'s feature in *j*'s class.

Therefore, we see, that objects recognizing have statistical nature. First step in learning is shown on Figure 119.

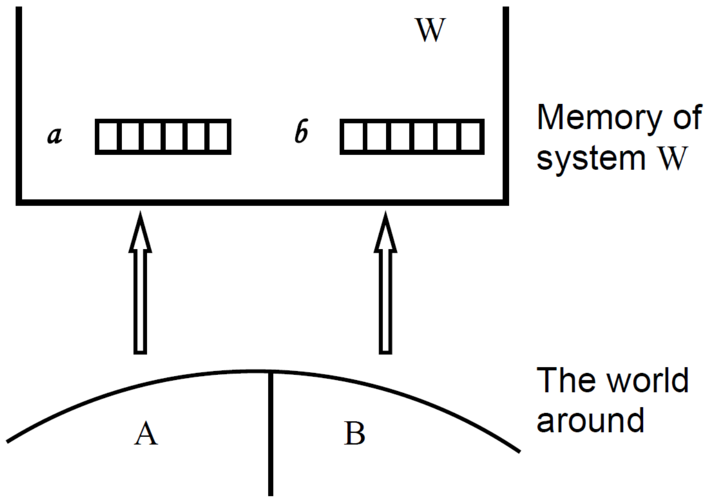


Figure 119. Creation of the memory (1st stage)

The pattern recognition stage is provided by means of some decision rules. One of them, namely the rule maximizing a right classification probability [Krissilov, 1984], [Krissilov et al, 2000] can be proposed for our problem solving. This decision function is as follows:

$$f_k \in M_j / R_f = \max_j P(M_j / f_k) = \max_j \prod_i^n p_{ji}^{(\nu_i)}, \quad (5.1)$$

where f_k is *k*'s unknown object, which must be classified;

– M_j is class with number *j*;

– $P\ (M_j / f_k)$ is probability of M_j when this concrete set of features f_k is presented;

– $p_{ji}^{(v_i)}$ equals to p_{ji} if v_t=1, and to $1-p_{ji}$ if $v_t = 0$. And it is probability of measured value v_t, if the feature is not binary.

In expression (5.1) the value R_f, being found as the maximum of the value $\prod p_{ji}^{(v_i)}$ for various classes (*j* changes from 0 (unknown class!) up to *S*), – shows the class that can generate the present vector f_k with the most probability, – in a case the features are independent each from another.

However, there are many tasks, as it was told, where depending features describe the objects. So we have to construct corresponding decision rule. For these purposes, the second learning stage must be introduced.

7.5.3 Decision function strengthening (2nd learning stage)

The curves of probability distribution of concrete characteristics of examined objects are applied to this task solution. These curves are obtained as a result of the additional training stage by means of the representative choosing of objects/classes should be recognized (Figure 120).

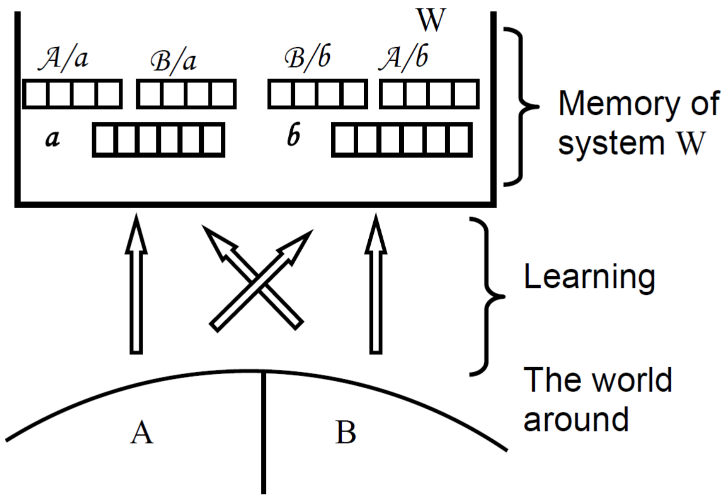


Figure 120. Second learning stage

Showing known objects from class M_j to recognizing system, we can find for each f_k the value $x_{kj} = \prod_i^n p_{ji}^{(v_i)}$ and fix the probabilities P(x_{kj}/M_j) and organize its memory consequently (see 0).

Then the following decision rule may be proposed:

$$f_k \in M_j / R_\Sigma = \max_j P(x_{kj} / M_j), \qquad (5.2)$$

Accordingly, this function of decision is made on the ground of a maximum probability of belonging the present input gamma of features (given f_k) to definite class, and comparing these probabilities for all classes. It needs to be noted, that we measure in this case the values of probability obtained by using only one line from matrix C_n, – for each class, i. e. using the sample of one class only.

The next our step can be generalizing this approach by means of extending the number of samples, of lines our matrix, being included in process, using for these purposes similar samples of classes and, lastly, all lines from matrix C_n entirely.

Then final version of decision rule looks as follows:

$$f_k \in M_j / R = \max_j \prod_{r=1}^{s} \left[P(x_{kr} / M_j) \right], \quad (5.3)$$

where $r = \overline{1, S}$.

Thus, we obtained the multidimensional decision function (MDDF) that allows using deeper data in comparison with previous rules of decision.

7.5.4 MDDF interpretation

Multi-Dimensional Decision Function' using and applying corresponding procedures form/build the memory of recognizing system in manner of holographic one, distributed and developed. Indeed, in cases when decision rule in expression (5.1) is realized, then each class' sample in memory unit contains information regarding that class. This information is represented by features' probabilities for objects belonging to given class.

When decision function expressed by (5.2) is realized, then the information, which forms each sample, becomes more complicated. It includes now the curve of probability' distribution of appearance certain values x_{kj} (results of evaluation) being measured/ weighed on definite line of matrix (with number *j*) by showing objects from corresponding class.

These curves of probability distribution (for all our classes), as it was told, are obtained as results of the additional training stage showing the representative sets of objects/classes should be recognized. In addition, we have for each class one curve only. Decision by (5.2) is made by means the finding maximum of evaluation found among classes compared, it is maximum probability of belonging just that combination of features (in this concrete recognizing object f_k) to given class.

Moreover, finally, when rule (5.3) is used, the sample of each class includes (in form of certain curves of probability distribution) the indices of estimates/assessments x_{kj}, which shows the results of weighing various objects from *given* class *on samples all other* classes. Just this result we obtain in 2nd stage of training. It looks as if just one object or situation is observed by means of several perception inputs, from different points of view, or is passed in parallel through various filters or prisms (see Figure 121 and Figure 122). It was found (some years ago, in certain neurobionic studies) that information from *each* mouse' vibrissa on its nose reflects (is sent) not only *in one* corresponding pull of neurons in mouse' brain, but it is in *all of them*; very close to the way being realized in holographic system.

We may say that increasing of grounding and quality of decision-making is got in this case in our decision or assessment system as result of more entire extraction of information about classes should be recognized, about interrelations between classes and latent links between its features. Besides it must be pointed out that such results are obtained due to some fuller and better disposing the knowledge mentioned above when Multidimensional Decision Functions in our AI-tasks and in various managerial and control problems are used, due to better use the "context information".

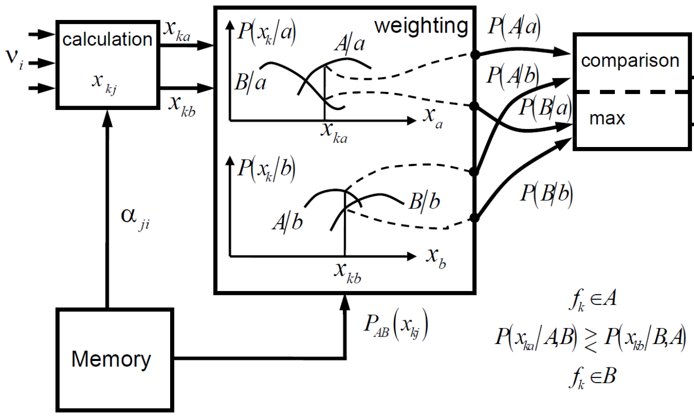


Figure 121. Using the probability distribution curves for advanced decision

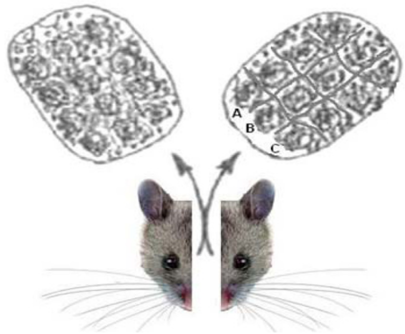


Figure 122. Structure of mouse memory belonging to the vibrissa's information

7.5.5 Some concluding remarks

Decision functions mentioned above was successfully used by solving various tasks:

- environmental tasks and radiometry data interpretation;
- risk assessment and estimation of various protective devices' effectiveness;
- recognition of printed and handwritten letters, either some voice commands;
- data interpretation in geophysical exploration (known task "Oil – Water Recognition");
- evaluation of the socio-economic level for some administrative territories (life quality);
- comparison of development level for south regions of Ukraine;
- medical diagnostics, staff management, and so on.

Interesting and hopeful results were obtained in all tasks listed above ([Krissilov et al, 2007], [Shutko et al, 1998, 2007] and others).

The system could recognize the different situations and objects, to make grounded decisions, is able to simulate monitored situations. Some important properties of outworked system were displayed:

- ability of work with qualitative and quantitative features;
- filling forecast information those of spatial-time intervals, where the measured data are absent;
- obtaining of aggregated, generalized evaluations for monitored processes, objects or situations in a case of action of various local or depending factors;
- ability of classification of the objects and situations, forecast variants evaluation, to provide support and quantitative decision-making.

Strictly speaking, we operate here with instruments that simulate the functions of intellectual processing of information.

7.6 Examples of intellectual data processing application in Bulgarian Expedition (2007)

7.6.1 Brief introductory notes

Probably, it is remarkable fact that Bulgaria became one of the first European countries for the last 10-15 years in which certain bodies have decided to spend multi-purpose monitoring environmental work with use of modern hi-tech means. This was done not at the level of private company, not for certain region or for narrow problem solving, but namely in the wide context and with the long-term purposes to obtain.

It is necessary to note that it was preceded by a long-term preparatory work at various levels: cooperation with the Bulgarian Academy of sciences, mass media publications, work with the profile parliament commissions, joint seminars, and conferences, etc.

In spring of 2007, the Bulgarian side has signed the contract with MIRAMAP Company, which has prepared for this purpose the international team with participation of specialists from Russia, Netherlands, Bulgaria, Ukraine, Australia, and United Kingdom. The Requirements Specification (Technical project) was developed together by both Bulgarian side and International team of scientists and engineers. Regions, problems, and terms were chosen as typical in order to show and to estimate the set of possibilities of applied methods and equipment and, on the other hand, to obtain an estimation of hydrological danger at the current environmental conditions. Owing to hot weather it has become actual to make the estimation of forest fires danger, and this problem also have been included into the program during fulfilling the work and was successfully solved.

It is necessary to tell some preliminary words about structure of the concepts connected with an estimation of risk, and about the role of information, of data – in this structure. Concept of risk is one of the widest and widely applied ones for the system representation of critical situations. As it was told, it belongs to number of badly formalizable concepts. However, some algorithms and methods, which appreciably overcome this difficulty, are entered into our monitoring system. They, anyway, make concept of risk operational, i.e. give the chance to operate with risk, in our case — to lower it that is essentially to be engaged in risks management.

The hierarchy of relations in system of the critical situations representations is following. At top level among other categories, there is a concept of risk. Further, one of the factors defining risk, namely degree of readiness for the prevention of a dangerous collision is situated (or readiness for minimization of damages at its occurrence from the uncontrollable reasons — a lightning stroke, flooding, at earthquake, etc.). Finally, degree of readiness for prevention of dangerous situations is appreciably defined by the knowledge factor. In a case the corresponding services have a few of data, dispose of the smaller information, then the more low degree of their readiness will be, the more poorly a measure on their prevention activity should be realized. It, in turn, leads to not optimum distribution of resources, to increase in risks and a possible damage.

The structural analysis of concepts risk and information (knowledge) and relations between them shows that they are connected by the quasi-hyperbolic relation (similar to curves presented on Figure 126).

Some considerations specify that these curves differ from one another by exponent of the hyperbola and distance from the axes. Presence of different curves is defined also by the fact that risks value depends on a number of factors: organizational ones, finance, personnel, other. However, appreciably exponent value (in the characteristic equation connecting risks with information!) and, consequently, the curve steepness, depends on parameter which we may to mark as quality of information. It is its completeness, system character, accuracy, etc.

It is obvious that for the best organization of readiness for the risks prevention (it conducts to reduction of risks and damages) — it is preferable to work with such curves for which in a transitive zone the insignificant increment of information conducts to considerable decrease in risk.

Last explaining introductory note is as follows. In order to describe quantitatively our situation we use concepts "risk classes» and "information classes». We shall consider risks low if they don't exceed 0,15 – 0,2, it will be I class of risks. Medium risks lie between estimations 0,15 – 0,2 and 0,45-0,55; it depends on variety of external and internal factors. Within these limits, there is a second class of risk. At last, all estimations above value 0,55-0,6 characterize III class, high risks. Approximately the same distribution is used by experts of insurance business. Classes of "volume" of information, with other borders of splitting, were analogously entered.

In Chapter 1 of the present monograph the short description of Bulgarian expedition is given. We would like only to emphasize the following examples of concrete use of "intellectual" algorithms of environmental data processing: for an estimation of protective properties of hydraulic engineering constructions and for an estimation of danger of forest fires. We want underline once again that our algorithms and methods are applied here neither for geophysical parameters interpretation, nor for increase of accuracy of measurements, but are used directly for modeling of abstract functions of a brain, for generalized concepts reception – regarding efficiency, risks, and similar to them.

Mentioned above examples of risk assessment of hydrotechnical construction leaking in the area of Rusenski Lom and of readiness to forest fire appearance and development in the area not far from Danube will be described below.

7.6.2 First example: assessment of dam hydro protective characteristics

On Figure 123 the dam near by the Nikolovo village (southwest from Ruse) is presented. The dam was constructed in the late fifties – the beginning of 60th, and has no clay inside basis. There is by-pass channel on right orthographical side, but its efficiency is insignificant. Because residential and administrative buildings are situated behind the dam, and due to some other reasons, the great attention was paid to the question: how high are hydroprotective properties of dam, does it hold water well or no, how much it is steady. This problem was especially important because of many residential buildings behind dam (on distance of 250 m and more) had had water in basements and cellars.

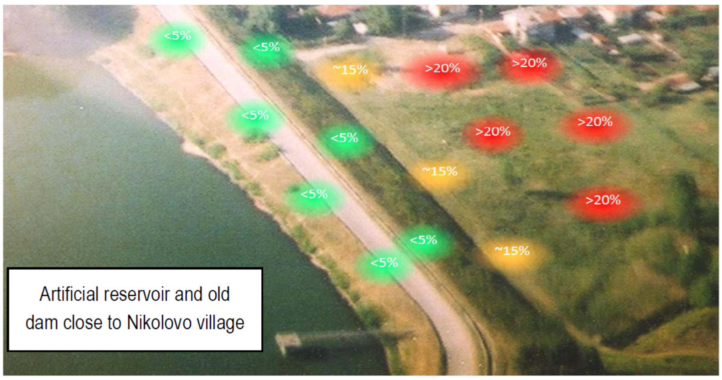


Figure 123. The dam nearby village of Nikolovo (from plane)

The figures put on photos, characterize humidity of a surface of the soil, measured by the radiometric equipment in the first day after long rains – about 5% on front side of a dam and more than 20% in territory behind a dam. This situation of the first day is presented on Figure 123.

The Dam first of all and surrounding area were covered by detailed RS measurement in the various conditions.

MCW maps with data measurements are presented on Figure 124 for dry and wet condition correspondingly. These maps contain the following parameters: both surface and underground soil moisture for dry and wet condition. Besides that: infrared assessments of surface temperature data in same area where the above microwave soil moisture assessments were collected; moreover, the lidar data of elevation were obtained in same area where the above microwave soil moisture assessments were collected.

In Figure 124a following colors are chosen for the following gradations of soil moisture in upper 0-5 cm thick layer in dry condition:

0.00 – 0.05 g/cc or 0 – 5% of volume (and forested areas) – dark green;

0.05 – 0.10 g/cc or 5 – 10% of volume – light green;

0.10 – 0.20 g/cc or 10 – 20% of volume – light blue;

0.20 – 0.30 g/cc or 20 – 30% of volume (and open water) – dark blue.

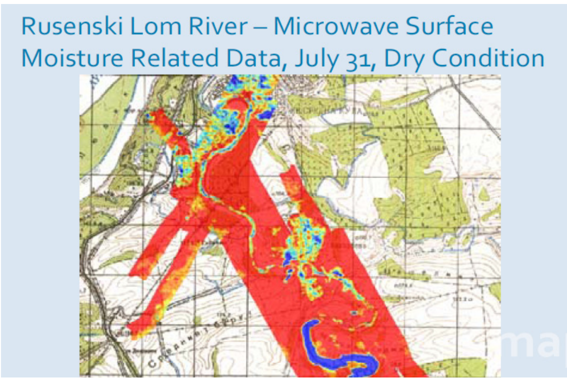
In Figure 124b following colors are chosen for following gradations of soil moisture in upper 0-5 cm thick layer in wet condition:

0.00 – 0.05 g/cc or 0 – 5% of volume (and forested areas) – red;

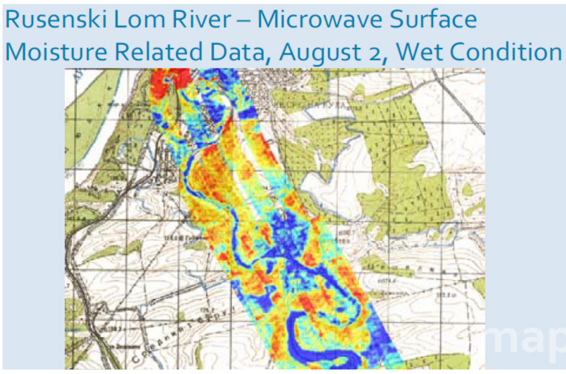
0.05 – 0.10 g/cc or 5 – 10% of volume – yellow;

0.10 – 0.20 g/cc or 10 – 20% of volume – light blue;

0.20 – 0.30 g/cc or 20 – 30% of volume (and open water) – dark blue.



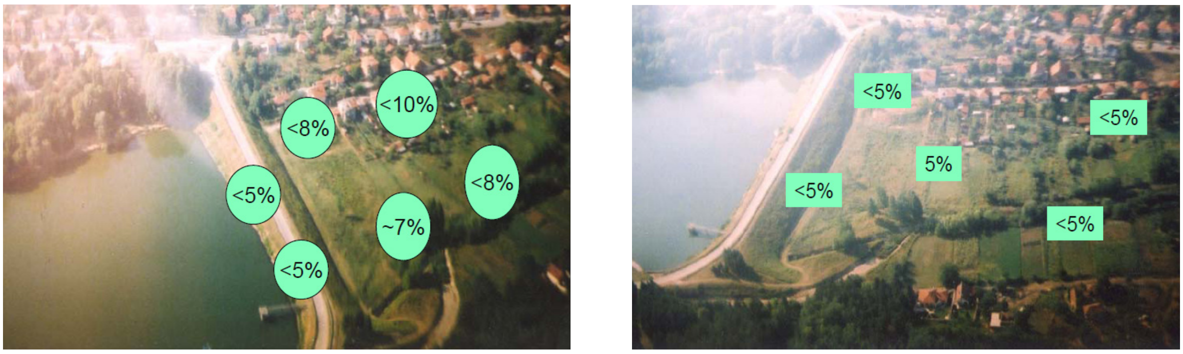
a) dry condition



b) wet condition

Figure 124. MCW maps with data measurements at the Nikolovo area for various conditions

The remote gouging spent through 4 day and some calculations have shown that integrated humidity in three – five times has decreased (Figure 125). These total characteristics have been received as generalization (by means of model) the data on controllable area (some hundreds of sq. meters), and also taking into account surface and underground water – to one and a half – two meters.



a) Third day after a rainfall b) Forth day after a rainfall

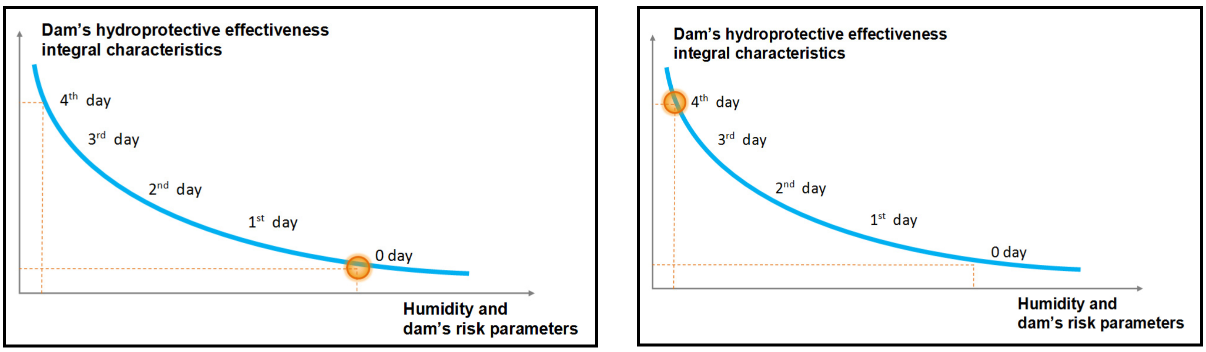
Figure 125. Situation with Nikolovo dam and area humidity after a rainfall

At performance of operation of generalization by means of the model described in given Chapter the certain weight factors have been used. In particular, at aggregation of the data of spatial distribution of humidity, estimation of this parameter for a back side of a dam were are taken with factors, on 30% by big, than for the front side and a dam surface; for slopes of underlying valley humidity of a surface of soil was considered with weight factor on 15% smaller, than for a ground part of this valley etc.

However, the account of the data mentioned above does not suffice for an estimation of efficiency of a dam as about its hydroprotective characteristics. It was necessary to consider: quality of road covering, age of the construction, first of all tixothropic properties of a ground (tixothropy is the set of its constructional characteristics and properties depending on a number of factors), and some parameters more.

The vector model described in paragraph 4 of the present chapter and solving rule (5.3) from paragraph 5 (in the modified kind) has been applied to construction of such generalized estimation of object quality (see Figure 126).

The conclusion has been made, as a result drawn, that hydro-protective properties of this dam are for today quite satisfactory; on Figure 126b the red circle indicates high level of hydro-protective effectiveness of the object assessed.



a) first view on effectiveness b) final assessment of dam effectiveness

Figure 126. Illustration of use both aim-oriented vector model and advanced decision rules (assessment of dam effectiveness)

7.6.3 Second example – assessment of forest fire danger

Different situation has been observed in the forest area close to Danube as related to risk of forest fire development. Figure 127 presents infrared photograph of the woodland with two control areas – A and B tested in order to determine the probability of fire risk occurrence. As it has been revealed from dynamic observations of thermal infrared and microwave radiometric data, locations A and B could not be corresponded to the certain zone of risks, though preliminary version was that they belong to the middle class: about 30% of risk for A, and about 35% – for B locations.

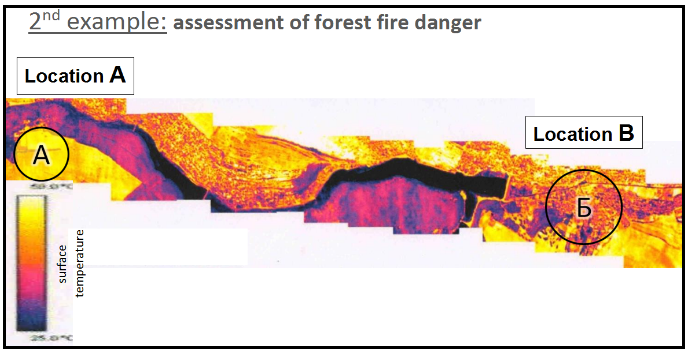


Figure 127. Infrared photograph of the woodland with two control areas – A and B

These preliminary calculation presented on the Figure 128 was based on the certain information. The expedition data bank contained the following maps:

- in situ data of soil moisture, temperature and precipitations (from Meteo) in selected areas,
- map of soil types from the text-books,
- map of surface relief from text books and from the lidar data
- map of brightness temperatures at 5 cm (most wet condition)
- map of brightness temperatures at 5 cm (most dry condition)
- map of brightness temperatures at 21 cm (most wet condition)
- map of brightness temperatures at 21 cm (most dry condition)

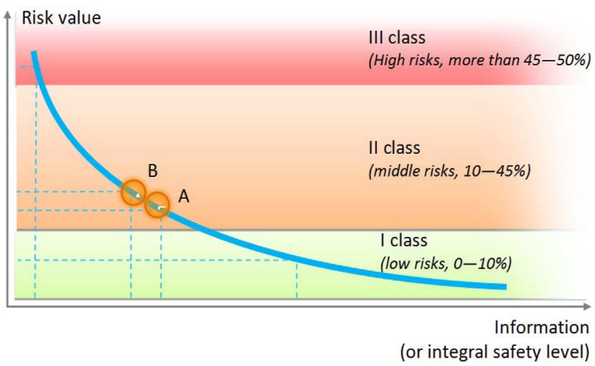


Figure 128. Preliminary assessment of forest fire danger for locations A (high risk) and B (low risk)

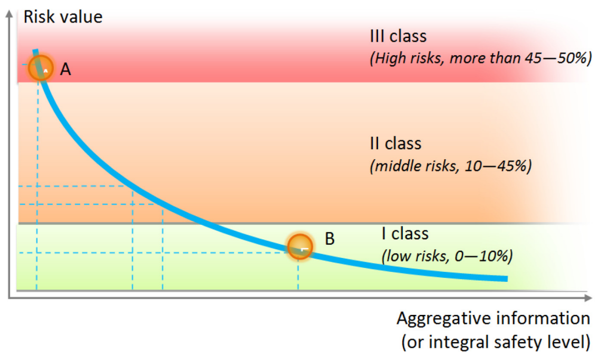


Figure 129. Final assessment of forest fire danger for locations A (high risk) and B (low risk)

None of that could give full picture in the forest. It must be known that deciduous or coniferous forest substrate (forest floor, pass-years leaves) plays a very important role.

Only having added data on a condition of a wood substrate, presence of dry trees and some points more; it has appeared possible to estimate danger of ignition really.

Then, according to the aggregate of parameters as mentioned above, total assessment of the fire risk occurrence for both areas was obtained. Upon the record of the temperature and other parameters of the forest floor it appeared that one of the areas is relatively safe (0,15 – I class), and as for the other one – the probability of ignition is rather high (0,65 – III class of risk) – which is presented at Figure 129.

7.7 Carrying platforms and some new technical points

In a problem of risk assessment as a whole, applied carriers of the metrological equipment play large practical role, from the point of view of efficiency, accuracy, and convenience of measurements carrying out.

According to various monitoring tasks and to different scales of objects under survey, a large variety of carrier platform for remote sensing are used. It looks fruitful when system "GERMES–I" being planned, to project system covering all levels of supervision: land (including water areas), from air – using planes and helicopters, and from space, using the data received from various satellites.

In Chapter 2 of the present monograph, the effective methods of various important information processing are considered in detail. These data are collected from a terrestrial surface, basically, by means of satellites and in situ regime. In the given Chapter, some examples of planes use as the basic carrier means have been mentioned.

However, throughout last 20 years, enough wide experience has been collected in use of various carrier platforms of the radiometric equipment developed by IRE RAS and radio corporation VEGA (RF), and at their joint activity in different monitoring projects and with various collaborating organizations worldwide [Shutko, 1987], [Shutko et al, 1995, 1998, 2007], [Haarbrink et al, 2007], [Krissilov et al, 2000, 2001], [Krapivin and Phillips, 2001], [Borodin et al, 1996], [Kondratyev et al, 2002], etc. Some examples illustrating this work are described below.

a) manned mobile platform

b) unmanned helicopter

Figure 130. Illustration of various mobile earth and air platform

Figure 130a presents photograph of the manned "Rover" type mobile platform equipped with three portable microwave radiometers, operating at the wavelengths of 6 cm, 18 cm and 21 cm. It is equipped with a folding panel of 1.5 m x 1.5 m for instrumentation installation along with GPS receiver, data acquisition system and power supply battery and is oriented for research activities related to soil moisture determination. These experiments have been successfully spent together with NASA Center for Hydrology, Soil Climatology and Remote Sensing, Agromechanical University in Alabama, and NASA Goddard Space Flight Center.

Figure 130b illustrates unmanned aerial vehicle (UAV) helicopter "Microwave Autonomous Copter System" (MACS) equipped with a 6 cm radiometer (is shown by red color), data acquisition system, GPS receiver and power supply battery (Miramap Co.).

Figure 131 contains the assessment of accuracy MCW measurement made by rover platform: comparison of microwave estimates of soil moisture at 21 cm wavelength unit with *in situ* soil moisture in 0-1 cm, 0-3 cm and 0-6 cm layer.

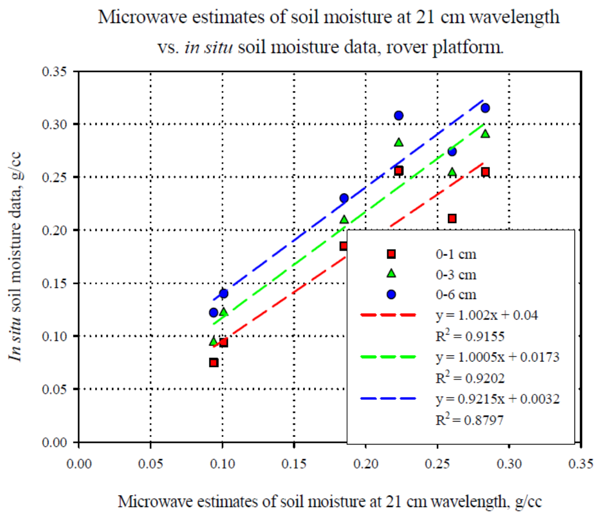
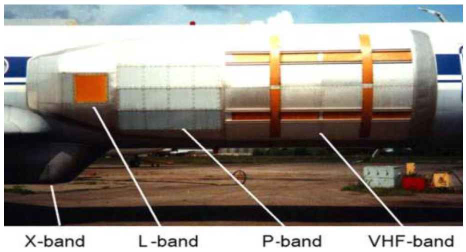


Figure 131. Comparison of remote sensed soil moisture with in situ data in 0-1 cm, 0-3 cm and 0-6 cm layer

Example of Airborne SAR system – IMARC, Vega Corporation, ("Flying Laboratory", SAR – Synthesized Aperture Radar) and allocation of certain kinds of antennas for different frequency bands one can see on Figure 132.

a)



b)

Figure 132. "Flying MCW Laboratory (a) and allocation of special antennas on the airplane (b)

In 2008, especially on Miramap request, Vega Radio Corporation designed and purchased the newest version of portable and light single-beam radiometers Ranet 6 (6-cm radiometer) and Ranet 21 (21-cm radiometer) (see Figure 133).

This is the newest generation of portable, autonomous microwave radiometers, which contain inside themselves radiometer, as it is, antenna, power supply unit, data acquisition system, and the GPS. The radiometer is designed for application in the laboratory conditions and inside a small cart for precise analysis of subsurface overmoistening or drought situation.

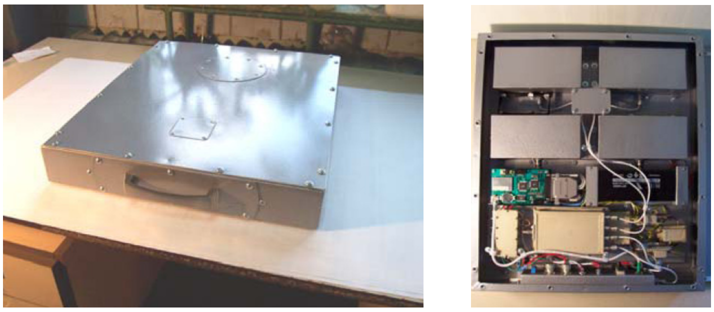


Figure 133. Ranet 21, the newest 21-cm radiometer design by Vega Radio Corporation

Last two examples from VEGA and IRE studies concern fifth level of works, according to the list in the first paragraph of the given Chapter: strategic international projects with use of high technologies for environmental monitoring, struggle against hunger, spontaneous and technogenic disasters. It can be power monitoring complex for strategic revealing and determination of various dangerous factors throughout the World, for instance creation and developing "RiceSAT" complex with partners in Asia and America, participation in GMES, so on.

On Figure 134 example of dual-frequency spaceborne radar with synthetic aperture is shown. This device has special antenna 12 x 3,3 m, two wavelength bands P (70 cm) with resolution 30 meters and L (23 cm) with resolution 3-30 meters. Originally, this complex is designed for:

- radar survey of Earth: land and water surface for Earth resources exploration, oceanography, geology, etc.
- monitoring of vegetation cover, particularly, index of vegetation;
- monitoring of emergent situations, etc.

The second example is shown on Figure 135. In this complex high resolution, radar is used – about one meter. Its wavelength is of 9,6 cm), antenna 12 x 3,3 m^2, exploitation period – 5 years.

Figure 134. Example of dual-frequency spaceborne radar with synthetic aperture

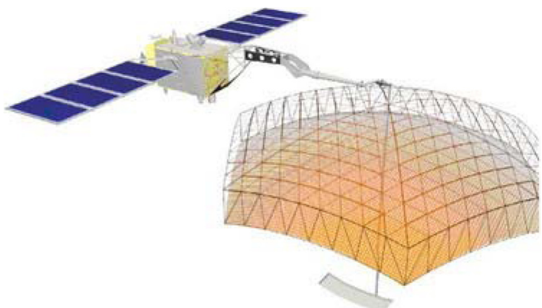


Figure 135. Example of high resolution spaceborne radar with synthetic aperture

Originally, this complex is designed for:

- Earth surface monitoring,
- geological and topographical mapping,
- ocean monitoring and ice patrol,
- environmental monitoring of sea and land surface,
- land use needs,

- emergency operative monitoring,
- navigation control.

Having such properties, this equipment can be the cream of the crop in risk revealing / assessment system.

7.8 Discussion

The description presented shows how joint use, definite combination of GIS-technologies, MCW-radiometry and AI methods should have looked like in multifunctional intellectual monitoring system – GERMES–I, and how they were successfully introduced in multiple projects and situations.

Important elements of this System are mostly implemented and its capabilities were examined in various areas in the World in a framework of projects similar to the System described.

Some of these works were performed for:

- monitoring and control of dangerous hydrological situations in dozens of countries;
- assessment of protection properties of some hydrotechnical constructions;
- risk assessment of forest fire appearance;
- determining the areas of underground moistening with shallow water table;
- detecting zones with high or low water level;
- detecting areas of water seepage from canals and through levees;
- evaluation of the environmental conditions in Bulgaria, Russia, Vietnam and Ukrainian southern regions;
- the geoecological and epidemiological mapping of the Earth, some others.

In sum, we can present the following considerations.

Risk assessment can be represented as process of study and analysis of environmental, technogenic, sanitary, epidemical and other dangerous effects – in order to quantify the probability of harmful environmental factors adverse effects on economic activity, public health, and socio-economic situation in general.

The internationally recognized methodology for risk assessment includes four stages.

1. Identification of risk (hazards): what factors in what levels and exposure pathways, from which media can have adverse effects on economic activity and on human health, how plausible and confirmed the links between factor and consequences are.

2. Evaluation of the exposition – description of pollution sources, routes of contaminants movement from source to man, to accident place, the path and impact point, the levels of exposure, etc. Currently, these objectives are widely used in various geoinformation systems (GIS) and are described in this monograph.

3. Establishing the "dose-reaction-response" correlation. For medical cases, it can be the connection recognition between health (for example, the proportion of individuals, who have developed a specific disease) and levels of exposure.

4. Risk profile and evaluation; that means: generalization and analysis of all data obtained in the descriptive, analytical and experimental studies of the risk estimates for similar kinds of situation, for population and its sub-groups; a comparison of risks of acceptable (suitable) levels, a comparative evaluation and ranking of the various risks in terms of their statistical, environmental, medico-

biological and social significance. The purpose of this phase is – the establishment of institutional and socio-environmental priorities and the risks that must be prevented or reduced to an acceptable level for a given society.

Note that considered in given Chapter algorithms and technical methods successfully work for each of these steps.

The work described and its objectives contribute to the scientific, technical, wider societal and policy objectives in the number of European programs, frameworks and EAS strategies, for example, 6th Framework Programme; Thematic Priority: 1.4 Aeronautics and Space; 2. SPACE; 2.3.2 Area: GMES; Application field: Risk management; etc.

Several years ago the ESA Book: "Down to Earth: Everyday Uses for European Space Technology" was published consisting of description of MCW measurements and application. Concerning this issue we could read short but significant and substantial opinion: "For me the message of the book is doubly valuable, as it shows us that the return on the investment that we make in Europe on space research is being significantly increased by the beneficial improvements in life it brings to us here on Earth" (Lord Sainsbury, Minister for Science and Technology in the UK Government). The time shows how right and correct these words were.

We hope that joint elaboration and international use of the system described will be fruitful and profitable for our countries, will promote and strengthen maritime and inland pollution control and prevention, will decrease existing risks.

It seems obvious that natural and anthropogenic risks are overlapping now more and more, and we are not on the horns of dilemma – we have no alternative: **the Flight to the Planet of Earth must continue; and Flight of the Planet of Earth must continue too.**