RADIONUCLIDE SOFTWARE INSTALLATION AT THE UNITED STATES NATIONAL DATA CENTER

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ABSTRACT

The United States (US) Army Space and Missile Defense Command (SMDC) has contracted Veridian to develop, test, and install Version 5.1 of the Radionuclide Monitoring System (RMS) software at the US National Data Center (NDC) located at the Air Force Technical Applications Center (AFTAC). The NDC currently uses RMS 5.0 to store and analyze atmospheric radionuclide data received at their facility. Veridian installed this version of software in August 2002. RMS 5.1 is scheduled to be installed in the fall of 2003. This paper describes the improvements and additions included in RMS 5.1. These enhancements can be grouped into three categories and include:

- Data Analysis Tools
  - The **Coriant** software used in the interactive analysis of three-dimensional beta-gamma coincidence data (*e.g.*, ARSA) was matured and hardened to increase usability and functionality of the software. The most notable modifications were the addition of three-dimensional graphing capability, noncoincidence graphing capabilities, and a help menu.
  - Software was added to automatically and interactively process data from the Russian ARIX xenon detection system.
  - The **Radionuclide Ratio Analysis Tool** (RRAT) was enhanced to allow calculations of estimated concentrations for fission products among nuclides that should be present in a sample given a concentration of any single nuclide, a date range, or a scenario.
- Data Management
  - An algorithm was placed at the front end of the RMS software pipeline to only assign samples that meet some intelligent criteria to analysts.
  - The error tracking of the RMS data pipeline was consolidated into a single log allowing pipeline engineers to find and resolve problems more efficiently.
  - A database archiving utility was built to reduce the volume of information stored in the database and to move relative and historic data off-line to a backup system.
  - The **Quality Assurance Tool** (QAT) was added to facilitate the quality control of reviewed radionuclide samples.
- State-of-Health (SOH) Tools
  - The **SOH Viewer** was added to allow users to read and to graphically and tabularly display raw (flat file) SOH data. The **SOH Viewer** can be used either in the field by a station operator or at a data center.
  - **Trendvue** was enhanced to display radioxenon detection system SOH data and to display reports generated at other data centers and received at the NDC (*e.g.*, IDC data). **Trendvue** is used to analyze trends in raw and processed data.
  - A utility was added to automatically and periodically generate and distribute HTML-based reports describing the SOH of the radionuclide component of the International Monitoring System (IMS).
  - A utility was added to automatically and periodically generate and distribute HTML-based reports describing discrepancies between the NDC and the International Data Center (IDC) analysis results.

OBJECTIVE

This paper describes Version 5.1 of the Radionuclide Monitoring System (RMS) software developed at Veridian's Nuclear and Radiological Technology Department that is scheduled to be installed at the Air Force Technical Applications Center (AFTAC) in October 2003. RMS 5.1 contains many improvements to the previous version currently in use at the data center. The enhancements to the RMS software include improvements and additions to many tools plus an expansion of Cascade Summing Correction (CSC) software and additional functions in the Forensic Event Tools (FET) that were added to the RMS suite with version 5.0 (Robbins et al., 2002). In the following sections the new components of the RMS software will be described and the differences between the R5.0 and R5.1 software will be summarized. To keep this paper within the limits for this seminar the functions of the software will be discussed only at a high level.

RESEARCH ACCOMPLISHED

Data Analysis Tools

Coriant is the software application that analyzes coincidence β-γ spectra collected by the Atmospheric Radioxenon Sampler/Analyzer (ARSA). Additional functions were added that make the tool easier to use for analysts. The analysts can now add general comments about samples, view the sample log, and access a help page on the 2-d graph commands. These additional functions will allow more efficient and timely processing of samples. Other capabilities that were added include:

- Capability to review non-coincidence data
- The ability for an analyst to concurrently review data related to a sample histogram
  - Gas background
  - Detector background
  - Most recent prior result
- Capability to calculate gross, net, and critical level counts from a configurable region-of-interest
- Spectrum manipulation commands were improved and documented
- Three-dimensional graphing capability for beta energy versus gamma energy, shown in Figure 1.
- An Open Sample window that displays pertinent, configurable, and sort capable data

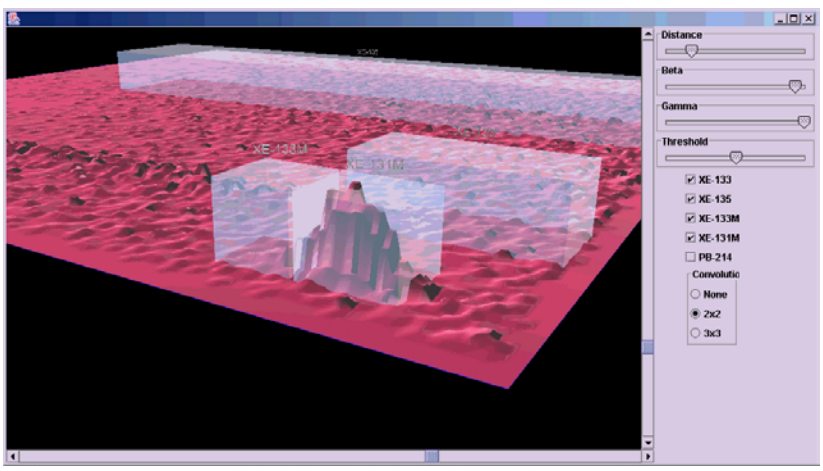


Figure 1. Three dimensional β-γ plot generated by Coriant.

The ability to remove identification flags from nuclides from analysis results was also added. Certain conditions cause the automatic analysis program to falsely identify xenon isotopes as present in a spectrum. The analyst has been given the ability to manually change the flag on selected isotopes to 0, not identified.

ARIX Data Processing

The Russian designed and built radioxenon sampling and measuring system known as ARIX will soon go into service and that data needs to be analyzed. Vladimir Popov and Sergei Bogachev from the Khlopin Radium Institute in St. Petersburg, Russia, visited the Space and Missile Defense Center for Monitoring Research (SMDCMR) from 23 July to 23 October 2002 as part of the visiting scientist program. During their visit, Popov and Bogachev developed, tested, and documented the automatic and interactive data processing software for the ARIX noble gas detection system (Popov and Bogachhev, 2002). This software was integrated into the RMS software, installed at the SMDCMR, and will be delivered to both the Russian NDC and the data center.

The Radioxenon Detection Software (*rms_arix_DataBase*) begins by reading the processing parameters and 2-D spectral data for a FULL sample spectrum and its corresponding background and preliminary (PREL) spectra. Each spectrum is divided into regions of interest (ROIs) defined by the γ-ray energies. The gross counts in each ROI are calculated by summing the counts per channel. The net counts are calculated by correcting the gross counts for the effects of the Compton continuum background or detector background and interference from other nuclides. The calculated air concentration and minimum detectable concentration (MDC) for each nuclide are determined using the net counts and the processing parameters.

The results of the analysis are stored in the Radionuclide Monitoring System (RMS) database for later use by the Radioxenon characterization software and by interactive tools such as the ARIX graphical user interface (GUI). The analysis results and errors are also written to a log file located on the UNIX file system. Analysts can view this log file or query the database to determine the status of the analysis.

Coincidence Summing Correction

The **Coincidence Summing Correction** (CSC) corrects for the phenomena in which two photons with different energy and from the same source enter the detector and are counted as one photon with the sum of their energies. The algorithm requires a total efficiency calibration for the detector being used. Because it is often difficult to measure the total efficiency of a deployed detector system, the software allows the use of modeled values inserted into the database. Included in RMS 5.0 were modeled values of a generic HPGe detector. RMS 5.1 will include Monte Carlo N-Particle (MCNP) modeled total efficiency calibrations of deployed RASA systems.

In addition, the IDC uses a technique for calculating CSC correction somewhat different than the technique designed for the data center. This technique requires modeled coefficients that will be distributed by the IDC when they get deployed into IDC operations. The options of using the IDC method, the data center method, or no CSC correction now exist as a choice for the user. Results of the various methods may then be compared.

Radionuclide Ratio Analysis Tool

The **Radionuclide Ratio Analysis Tool** (RRAT) is a tool that aids analysis of fission products detected in environmental samples. It uses the ratio of isotopes as evidence for whether the fission products originated in nuclear reactor processes or in the detonation of a nuclear weapon. It was formerly called the Ratio – Source Discrimination Tool.

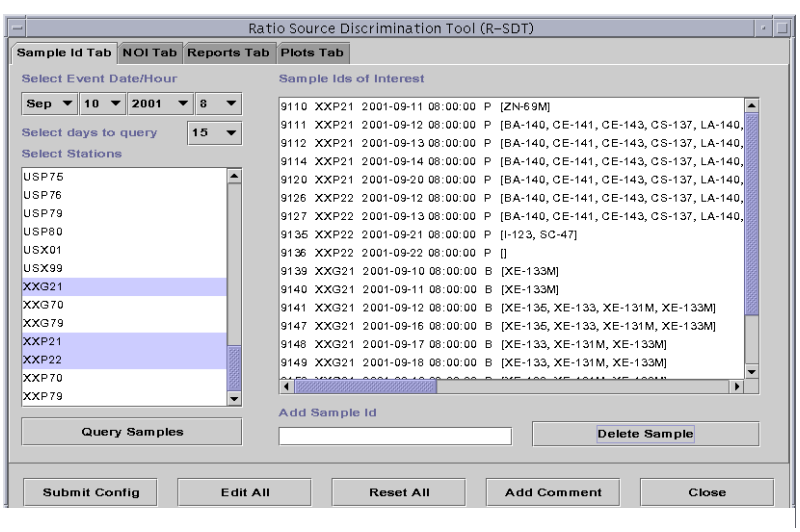


Figure 2. RRAT Sample selection tab

The RRAT (GUI shown in Figure 2) was enhanced to allow the calculation of estimated concentrations for fission products among nuclides that should be present in a sample given a concentration of any single nuclide, a date range, and a production scenario.

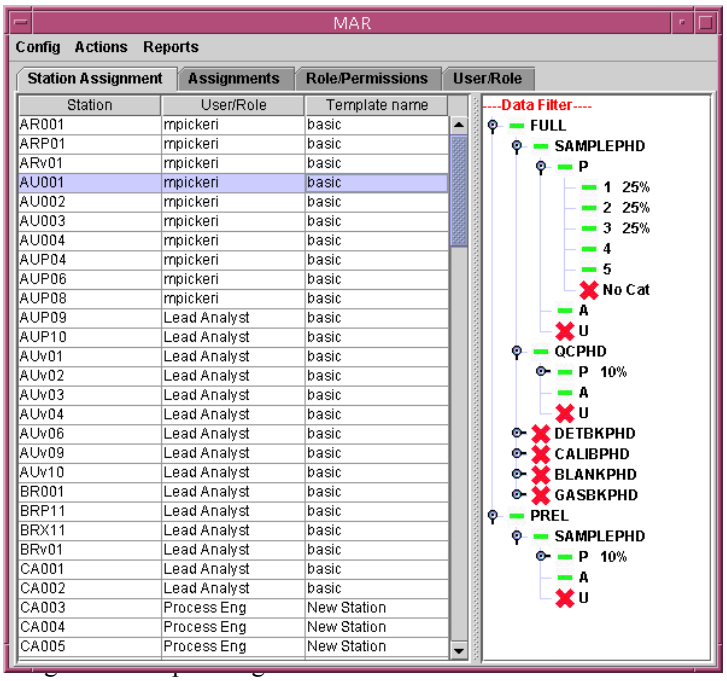
Experience has shown that sometimes, one or two fission product isotopes are found in one or more environmental samples. Either a nuclear explosion or large scale release of radionuclides from a nuclear reactor are expected to result in environmental samples with several isotopes present. The discovery of one or two isotopes immediately raises the question of what other isotopes ought to be in the sample above the minimum detectable concentration (MDC) given the presence of those seen.

The additional function in the RRAT allows the user to select an origin date and time, a period in days after this date and time to search for samples and execute the calculation, and stations in the International Monitoring System

(IMS) network. The tool will produce a list of all samples from these stations during the specified period that contained one or more fission products. If only one or two fission products appear in one or more samples, the user may select one or both of these fission products, a production scenario from a list (plutonium fueled bomb, uranium fueled bomb, light-water reactor operated for one year, and light-water reactor operated for less than a month), and a set of radionuclide ratios. The tool will then perform a simple equation, multiplying the isotope concentrations in the samples by the applicable ratios to find what the concentration of the other isotopes should be in the sample given the selected production scenario. The user can then compare these expected concentrations to the MDCs. While one cannot prove a negative, the lack of multiple fission products in environmental samples when analysis indicates that they should be measured strengthens the argument against the analyzed scenario having occurred. The new tool added to the RRAT allows this analysis to be conducted much more quickly.

Data Management Tools

SmartMAR



The Multiple Analyst Review (MAR) tool (sample assignment tree shown in Figure 3) allows the management of sample analysis through the assignment of spectra to analysts. The version in RMS 5.0 has been improved and renamed the **SmartMAR** in RMS 5.1. The capability to custom configures parameters for sample assignment was added. This allows samples to be assigned:

- Based on sample status, spectral qualifier, data type and auto categorization;
- Based on stations of interest; and
- Randomly for quality control purposes.

Pipeline Diagnostics

Pipeline diagnostics were added to the data processing software. The input processing errors for data files that fail to process are now stored in the database for easier retrieval. Previous input logs are consolidated into one log file, rms. log, with improved error messaging, timestamp, and process identification listings. The pipeline upgrades will allow the pipeline engineer to find and resolve problems more quickly, easily, and efficiently.

Quality Assurance Tool

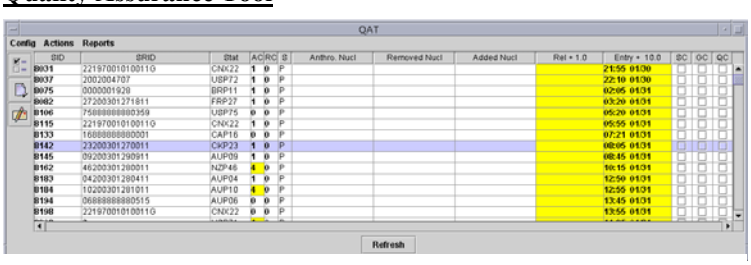


Figure 4. QAT manual review GUI window.

The **Quality Assurance Tool** (QAT) was added to facilitate the quality control of reviewed radionuclide samples (GUI shown in Figure 4). The QAT is the primary facilitator of quality control (QC) review of radionuclide samples. The QAT provides the Review Officer (RO), the Unit Head (UH), and other users the ability to manually review information about reviewed samples ready for release prior to their release. The QAT is broken into three components:

- **QAT GUI**: Provides the ability to manually review information about samples that have been released by the analyst but have not been released by the QAT Auto Tool. Notification messages can be sent to

selected recipients during the QC review. During this process, samples can be reassigned to the "Processed" status, which reinserts the sample back into the reviewing analyst's assignment queue. This facilitates the RO in executing his oversight responsibility and streamlines the review process

- **QAT Auto**: The QAT Auto automatically releases samples that fall under the categories that do not need to be reviewed by the RO or UH.

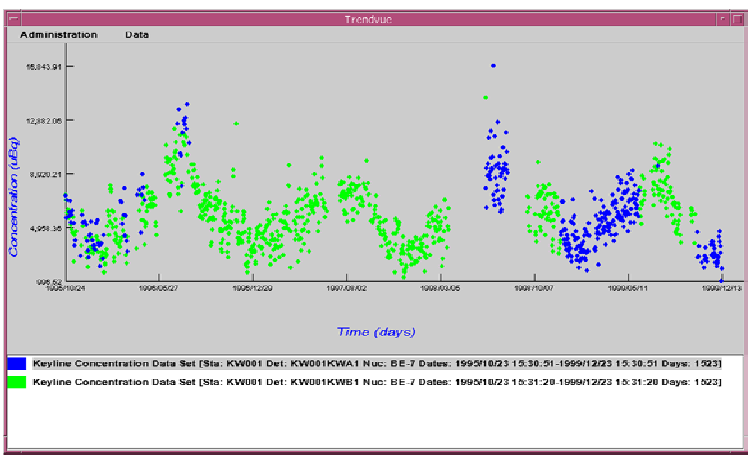
- **QAT Report**: The QAT reports the RO and UH actions. It automates the record keeping process, ensuring accurate records of the QC review process.

State-of-Health (SOH) Tools

SOH Viewer

The **SOH Viewer** opens and reads flat files containing SOH data for Radionuclide Aerosol Sampler/Analyzer (RASA) and ARSA machines. It sorts the data in the files, plots the data on graphs, and performs statistical analysis of the data selected by the user. The SOH Viewer gives scientists and technicians the capability to monitor performance of RASA and ARSA machines during installation, routine operation, and maintenance. It facilitates the prediction and identification of component failures, speeding repairs and improving system reliability. Message data may be reviewed and tabulated or plotted to reveal trends or significant events in the operating history of the RASA or ARSA.

Trendvue



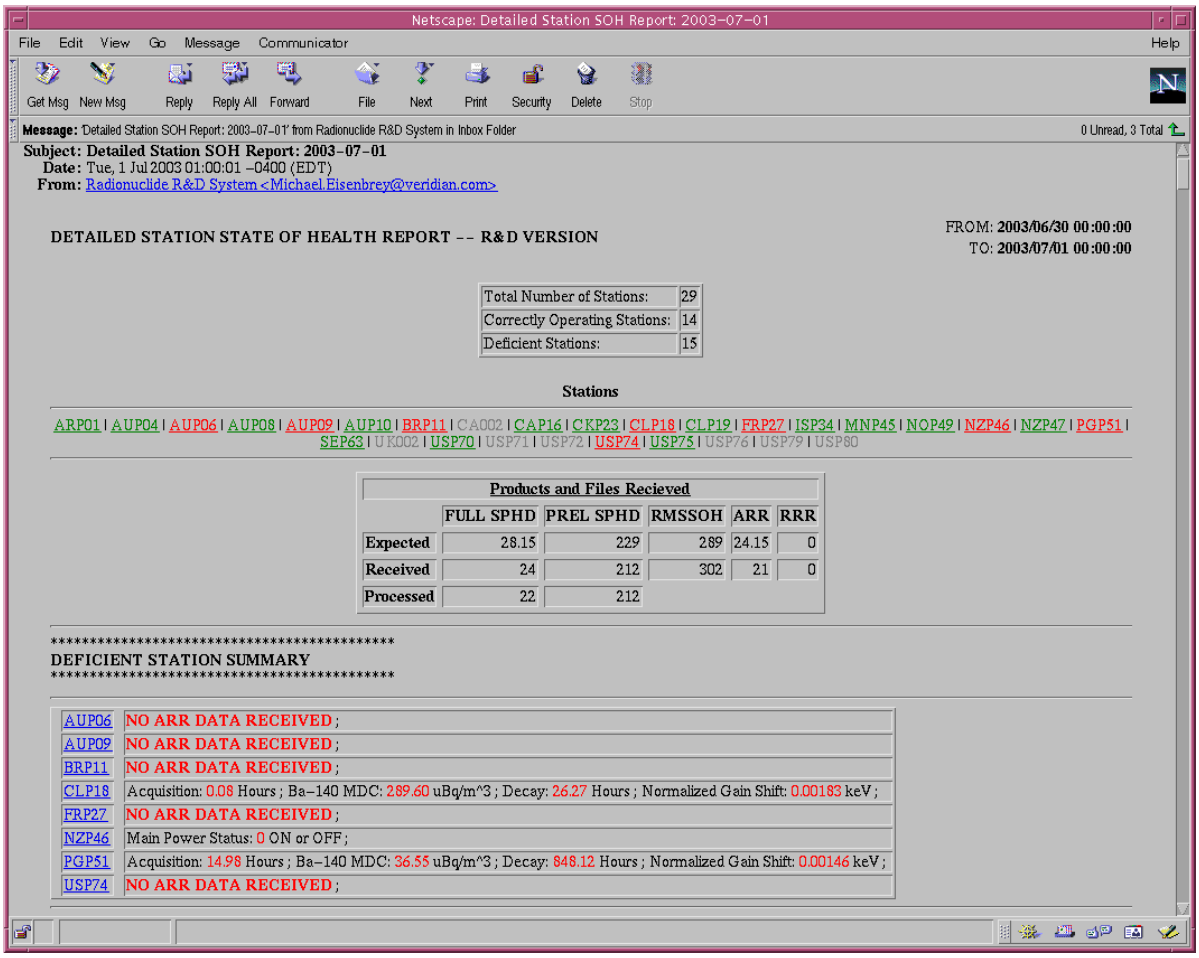
Trendvue is a program that allows the user to sort and plot various sample and SOH data from IMS stations. An example of data plotted on Trendvue is shown in Figure 5. Trendvue was enhanced as follows:

Figure 5. Example of Trendvue data plot.

- Added the ability to simultaneously process, analyze and plot data from multiple detectors at the same station (for example, in the case of an ARSA which has 4 detectors per station)
- Added the ability to view Automated Radionuclide Reports (ARR) and Reviewed Radionuclide Reports (RRR) report data from other data centers.
- Added a Sensor plot to capture the process sensors block in ARSA SOH messages. This graphical tool allows an analyst to more quickly review the data and diagnose problems as well as identify peculiar trends and anomalies.

SOH Report

The **SOH Report** tool provides the capability to automatically and periodically send HTML formatted reports, shown in Figure 6, based on the status of the radionuclide network.



Netscape: Detailed Station SOH Report: 2003-07-01

File Edit View Go Message Communicator Help

Get Msg New Msg Reply Reply All Forward File Next Print Security Delete Stop

Message: 'Detailed Station SOH Report: 2003-07-01' from Radionuclide R&D System in Inbox Folder 0 Unread, 3 Total

Subject: Detailed Station SOH Report: 2003-07-01
Date: Tue, 1 Jul 2003 01:00:01 -0400 (EDT)
From: Radionuclide R&D System <Michael.Eisenbrey@veridian.com>

DETAILED STATION STATE OF HEALTH REPORT -- R&D VERSION

FROM: **2003/06/30 00:00:00**
TO: **2003/07/01 00:00:00**

Total Number of Stations:	29
Correctly Operating Stations:	14
Deficient Stations:	15

Stations

ARP01 | AUP04 | AUP06 | AUP08 | AUP09 | AUP10 | BRP11 | CA002 | CAP16 | CKP23 | CLP18 | CLP19 | FRP27 | ISP34 | MNP45 | NOP49 | NZP46 | NZP47 | PGP51 | SEP63 | UK002 | USP70 | USP71 | USP72 | USP74 | USP75 | USP76 | USP79 | USP80

Products and Files Recieved

	FULL SPHD	PREL SPHD	RMSSOH	ARR	RRR
Expected	28.15	229	289	24.15	0
Received	24	212	302	21	0
Processed	22	212			

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DEFICIENT STATION SUMMARY
****

AUP06	NO ARR DATA RECEIVED ;
AUP09	NO ARR DATA RECEIVED ;
BRP11	NO ARR DATA RECEIVED ;
CLP18	Acquisition: 0.08 Hours ; Ba-140 MDC: 289.60 uBq/m^3 ; Decay: 26.27 Hours ; Normalized Gain Shift: 0.00183 keV ;
FRP27	NO ARR DATA RECEIVED ;
NZP46	Main Power Status: 0 ON or OFF ;
PGP51	Acquisition: 14.98 Hours ; Ba-140 MDC: 36.55 uBq/m^3 ; Decay: 848.12 Hours ; Normalized Gain Shift: 0.00146 keV ;
USP74	NO ARR DATA RECEIVED ;

Figure 6. First page of Detailed SOH Report.

The properties of the report include:

- Displays station performance status as 'PASS' or 'FAIL' depending on tests performed on SOH messages and Sample Reports received from each station.
- Report can be generated and sent to subscribers
- Report can be generated based on sample and state of health data

The International Data Center (IDC) and the data center review the same spectra using the same software tools. The RRR and ARR from the two centers should be nearly identical, the only differences occurring due to small variations in calibration parameters used by them. The **SOH report comparison** tool provides the capability to automate comparison of the IDC and US data center RRRs and ARRs, comparing multiple parameters.

CONCLUSIONS AND RECOMMENDATIONS

The software suites described are effective and robust. It is recommended that the software suites enter into operational use at the data center, and that work continue on developing further capabilities and applications for the tools.

REFERENCES

Radionuclide Software Installation at the U.S. National Data Center, D.J. Robbins, J. Rynes, and K.F. Biegalski, *24th Seismic Research Review - Nuclear Explosion Monitoring: Innovation and Integration*, 2002, Ponte Vedra, FL.

Automatic and Interactive Data Processing Software for the ARIX Noble Gas Detection System, V. Popov and S. Bogachev, Space and Missile Defense Center for Monitoring Research, 2002