RESULTS OF THE JOINT ESARDA/INMM WORKSHOP ON SCIENCE AND MODERN TECHNOLOGY FOR SAFEGUARDS

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Abstract

The Joint ESARDA/INMM Workshop on Science and Modern Technology for Safeguards was held in Arona, Italy, October 28-31, 1996. It was attended by some 120 participants, consisting principally of scientists from various disciplines and safeguards experts from the inspectorates. The Workshop provided a full discussion on the near and far term scientific technologies that may be applied to safeguards. In addition, there were extended discussions on the social and political aspects surrounding the areas of Nonproliferation, International Safeguards, and Regional Safeguards. The general opinion was that the Workshop met and exceeded its goals, setting the stage for future workshops of this type. One of the outstanding characteristics of this Workshop was the ample amount of time allowed for full discussion of each presentation, both for technical issues and social/political issues. This procedure was substantially different from the usual ESARDA and INMM meetings. This paper will discuss the organization and conduct of the Workshop, as well as the results as reported by the four Working Group Chairs and the Workshop Co-chairs.

Introduction

Safeguards play a central role in the nonproliferation of nuclear weapons. For this reason, close attention is paid to, and considerable effort is devoted to, the development of safeguards technology. The INMM and ESARDA institutions have long had an integrating and coordinating function in the process of improving safeguards technology. During the last two decades, the INMM and ESARDA have had a number of cooperative activities, including:

- 1978 - International Target Values (ITV) - ESARDA Destructive Analysis Working Group; later interaction with INMM Standards Working Group
- 1979-1980 - Special sessions in INMM Annual Meetings dedicated to ESARDA activities
- 1983 - ESARDA/INMM specialist meeting on Non-Destructive Analysis (NDA) statistical problems
- 1993 - Joint participation in International session of Japan INMM Chapter Meeting
- 1994 - INMM/ESARDA/ANS-ENS/RNS Joint sponsorship of IAEA Symposium;
- 1994 - Publication of Journal/Bulletin of each organization ITV material
- Continuing - papers by ESARDA and INMM officers in meetings of each organization

In pursuit of the advancement of safeguards technology, in 1995 ESARDA and INMM decided jointly to organize a Workshop on Science and Modern Technology for Safeguards. The purpose of the workshop was:

- to inform the safeguards community about selected sciences and advanced technologies that are currently available, or that will be available in the next few years, that could be used to support needed advances in international safeguards;
- to inform the practitioners of these sciences and technologies of the needs of the safeguards community for the implementation of technology in these areas; and
- to stimulate a continuing interchange between experts in various technologies and safeguards practitioners.

In organizing the workshop, priority was given to developing an approach that would further the interaction between scientists in advanced technical areas and safeguards experts. Priority was not given to providing a comprehensive representation of scientific possibilities; instead the agenda was limited to those areas that the technical organizing committee determined would offer realistic possibilities for application to safeguards. In this regard, the Workshop should be understood as the starting point for a further series of similar events that will be devoted to specific and limited fields identified from the initial workshop to be fruitful for safeguards applications. A further important aspect of the workshop was to sensitize scientists from universities and research institutions that were not previously concerned with safeguards technology to urgent problems in safeguards. The workshop was not expected to produce immediate products for safeguards application but rather to identify several areas into which research may be directed for future applications.

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DISCLAIMER

While it is important to recognize that the rapid progress of technology will no doubt produce results with application to safeguards, one has to be cautious not to allow our technology-trained minds run wild. In international safeguards, virtually nothing is purely technical. In almost all cases, implementation of modifications and advancements in safeguards is part technically based and part political or policy based. An example of this is remote monitoring. Television broadcast companies like BBC and CNN use this technology every day. But when this technology is applied to international safeguards there are a number of issues that must be faced including security, proprietary information, physical protection, states rights, and union rights.

The workshop also provided a forum for the presentation and discussion of selected fields of science and modern technology that have not, as yet, been considered or have not been fully exploited by safeguards institutions. An example of such a technical field is technology developed for the implementation of the Treaty on Open Skies. No one would suggest that there should be an IAEA air force established at Schwechat in Vienna; but, just as in the commercial satellite field, the information gathered by such means might well have application to international or regional safeguards. The Workshop helped to determine the extent to which this and the other selected technologies might be used to improve safeguards in the future.

Workshop Organization

To enable appropriate interchanges between the technology experts and the safeguards experts, while keeping the Workshop to an acceptable length, the program was organized around four working groups. The working group topics were: 1) Physics and Chemistry Data Generation, 2) Computing Technology, Data Collection and Organization, 3) Mathematics, Statistics, and Decision Support, and 4) Socio-Political Aspects of Safeguards. These working group topics were not intended to be unique or exhaustive, but were decided upon by the organizing committee as providing a reasonable spectrum for the division of the technical topics to be discussed.

Within this structure, the invited technology experts presented papers describing their areas of expertise and current applications for their technologies. Then, with the help of a moderator, the safeguards practitioners and other technical participants were allowed to engage the speaker in active discourse regarding the technical subject and the possible application of the subject to safeguards. This interaction helped to inform the technology experts about opportunities that might be available in the future for applying their area of expertise to safeguards. This interaction also helped to inform the safeguards community about the applicability and limitations of each specific technology. By allotting one hour per subject, including a twenty minute presentation and a forty minute question and answer session, it was not necessary to terminate questions and interrupt the discussion. This format is unique in technical meetings, as far as the organizers are aware, and was one of the major innovations of this Workshop.

The Workshop was held in Arona, Italy, on the banks of Lago Maggiorie, from October 28-31, 1996. The workshop was co-chaired by Gotthard Stein of ESARDA, and Cecil Sonnier of the INMM. As originally planned, this Workshop was to have had an attendance of some 50 Technology Experts and Safeguards Specialists. However, when it took place, some 120 participants attended. This indicates the great interest that the Workshop engendered in the community, but the response created a rather large administrative problem for the JRC-Ispra staff that supported the meeting. The staff performed wonders, however, and the program events, which included a social gathering on the evening of the first day, and a banquet in the evening of the second day, were all conducted successfully in the grand European tradition. Carrying this tradition a step farther, Marc Cuypers of JRC-Ispra spent the evening of the second day of the workshop clearing the clouds that had persisted in the first two days of the week, and on the morning of the third day -- voila! -- the view was beautiful.

Working Group Findings

Following are brief summaries of the findings of each of the Working Groups. These have been extracted or paraphrased from the reports of the Working Group Chairmen as published in the workshop proceedings. Many of the comments offered by the chairman of a particular working group actually applied to all, and these have been collected at the end of this section.

Working Group 1 - Physics and Chemistry Data Generation

Twelve papers were presented in Working Group 1. Although there was some overlap among the topics presented, four papers addressed satellite or aerial platforms, and eight involved ground or near ground measurement instrumentation. Of the latter eight, three were related to nuclear measurement or instrumentation, and five involved chemical or environmental measurements. In many cases the application to safeguards of the methods, technologies, or procedures discussed was reasonable, possible, and more or less obvious. The participants in Working Group 1 believed that there were potential safeguards applications for all of the technologies discussed. The following papers were presented:

- Possible use of Satellite Technology for Safeguards: Potentials, Developments, Perspectives - H. J. Mieth

- The Way Forward in Multispectral Instrumentation for Reconnaissance Satellite - W. Teuchers
- Signatures to be Provided by Modern RADAR Systems - A. Sieber
- Treaty on Open Skies Sensor Technologies with Potential International Safeguards Applications - M. Sandoval
- Detection of Shielded or Hidden Nuclear Material - W. Rosenstock
- Core Inventor Verifier for Research Reactors - U. Filges
- Nuclear Instrumentation for Safeguards - T. Prettyman
- Applied Spectroscopies: Point and Remote Chemical Sensors - A. Sedlacek
- The Use of Atmospheric Dispersion Models in the Identification of Unknown Nuclear Emissions - G.Graziani
- Environmental Sampling and Analysis for Safeguards - J. Toole
- Detection of Covert Nuclear Activities by Determination of Traces of Radionuclides and Organic Compounds in Environmental Samples - R. Rosenberg
- The Power of Nuclear Signatures - P. de Bievre

The comments were varied and wide ranging and the interaction was lively. Regarding possible satellite application to safeguards, it was recommended that a data utilization program be established and user needs be defined. Economic stimulus is driving ever increasing capabilities and these can be used to benefit safeguards. Modern radars offer an opportunity for design verification and other applications. Aerial monitoring can cover large areas quickly and be coordinated with on-site inspections. Advanced ground instrumentation and sample analysis techniques, for traditional safeguards or for environmental monitoring, can expand confidence in safeguards measurements and inspections if they are used in a properly organized and standardized program.

Working Group 2 - Computing Technology, Data Collection and Organization

Working Group 2 discussed subjects that were at the interface of Working Group 1 (data generation from video, measurement, monitoring) and Working Group 3 (Data analysis and decision support). The papers covered : (a) Data Collection and Transmission, and Remote Monitoring; (b) Relational Data Base Management; (c) Distributed Networks, Internet, and Multimedia; and (d) Virtual Reality. Each paper was discussed and analyzed according to the guidelines prepared by the Workshop organizers. The following papers were presented:

- Data Flow in Safeguards - G. Neumann
- A Prototype Remote Monitoring System for IAEA Safeguards - J. Whichello, et al
- Near Real Time Data Collection, Transmission and Evaluation in Future Integrated Monitoring Systems - U. Hacker
- Aspects of Relational Data Base Management and its Future Challenge - A. Rezniczek
- Cyberspace - Prospects of Agents in Cyberspace - U. Kotte
- The Role of Multimedia in Safeguards Training - J. Loeschner
- Advances in Multimedia and Internet Technology - C. Best
- Applications of Virtual Reality to Nuclear Safeguards and Non-Proliferation - S. Stansfield
- Application of Laser Distance Measurements to Safeguards - J. Goncalves
- Bringing the IAEA Instrumentation Program into the 21st Century - D. Rundquist (Presented by K-J. Gaertner)

Most of the techniques described in the papers: (a) have been developed and are in routine industrial, administrative, commercial implementation; (b) are under evaluation for some safeguards application, or (c) are waiting for specific applications. Some techniques, however need further development. One major concern is the *security aspect* related to remote data transmission and the use of distributed networks currently not considered secure. Standardization was also recognized as most important; however, the official standards are going to be defined by the mainstream of development, which is not in the safeguards field. Most of these technologies will not implemented immediately, but will be gradually introduced. Regional and global transmission of data was considered a medium- to long-term issue for safeguards. In the area of virtual reality, some demonstrations are being made and other specific applications could be envisaged over the next few years.

Working Group 3 - Mathematics, Statistics, and Decision Support

In working group 3 there were twelve papers presented. These can be divided into six basic groups: Non-cooperative game theory; Modeling of data; Inexact reasoning; Artificial Intelligence; Latent Failure Detection; and Remote Sensing. The following papers were presented:

- Inspection Games in Arms Control - R. Avenhaus, et al
- Game Theory Applied to Nuclear Non-proliferation - P. Goutal
- Statistical Methods of Combining Information: Applications to Sensor Data Fusion - T. Burr
- The Theory of Neural Networks for Classification - M. Canty
- Neuronal Algorithms for Full Information Spectural Analysis - V. Vigneron, et al
- Comparative Investigation of Neural Networks and Statistical Classification Methods in

Geographical Remote Sensing and Possible Applications to Safeguards - D. Klaus, et al
- Fuzzy Logic Applications in Nuclear Research Areas - D. Auan
- Application of the Transferable Belief Model (TBM) for Diagnostic Problems - P. Smets
- Grey Analysis - G. Cable
- Artificial Intelligence as a Support to Decision: What Future in Safeguards - F. Werkoff, et al
- Detecting Latent Failures: A Statistical Approach to Diagnosis of Hidden Safety Problems Applied to Nuclear Safeguarding - P. Hudson
- Space-Based Monitoring of Proliferation of Weapons of Mass Destruction - B. Jasani, et al

As an abstract analytical tool, non-cooperative game theory offers an ideal, if not the only, framework for unifying such basic concepts as assurance, deterrence, optimal resource allocation, etc. Most of the papers presented in the "Modeling of Data" category emphasized neural networks in one form or another. The presentations addressing Inexact Reasoning were not as all-encompassing as data modeling. Fuzzy logic is a mature and standard engineering tool, which is considered cheap and fast, and allows the inclusion of expertise in decision systems. The Transferable Belief Model (TBM) appears to be nearing application, and avoids "artificial probabilization," making use only of information really available. Grey logic is relatively unknown outside its land of origin (China), and still lacks a critical comparison with other methods.

In the category of Artificial Intelligence, the Working Group discussed rule-based or knowledge-based expert systems. It was noted that AI has never really lived up to the expectations of some years ago. In the Latent Failure Detection category, the Working Group was presented with a simple, intuitive, and structured methodology for "heading off disaster." This technique is used routinely in the oil industry. Latent failure detection perhaps could be used as a methodological alternative to more formal procedures for aggregating evidence. Finally, Remote Sensing was discussed, in full recognition that this subject was not strictly within the mathematical-statistical framework of this Working Group. It was agreed that such information should be seen as complementary to other sources. It was concluded that the use of commercial satellite data for safeguards was indeed promising.

Working Group 4 - Socio-Political Aspects of Safeguards

Nine papers were presented and, very lively discussions followed each. The topics that were covered encompassed very wide areas, including social and political sciences related to the problems of non-proliferation and safeguards, philosophical approaches on verification, non-proliferation and international safeguards, and efforts to strengthen IAEA Safeguards. The following papers were presented:

- Strategies of International Social Control: Beyond Carrots and Sticks - R. Mitchell
- Networks in Interaction: Change Management and the Contribution of Game Theory - W. Siebe
- The role of Verification and Monitoring in Building Security - P. Lewis
- Social Science Theory and Non-Proliferation - W. Fischer
- Technological Development and Military Use Trends and Diffusion - R. Botzian
- Future Significance of Nuclear Weapons - E. Haeckel
- Safeguards and Transparency in the Future - M. Rosenthal (Presented by L. Hilliard)
- Detection of Non-Declared Activities Towards Nuclear Proliferation - A. Schaper
- New Challenges for an Expanding Non-Proliferation Regime - P. Ley

There have been significant developments and changes throughout the Nuclear Non-Proliferation Regime in recent years. However, a new equilibrium has not been reached, and may never be achieved. Demands for change originate from a wide range of sources, such as: political demands to strengthen the nuclear nonproliferation regime; the consequence of the NPT review process; a call for the IAEA to restructure to extend its activities to detect undeclared nuclear facilities; a need to achieve better use of the resources available to the international inspectorates by further rationalizing the activities of the inspectorate; and the need to interpret accurately, assess, and address the concerns of the public about nuclear proliferation and safety.

The members of WG 4 had expertise in a wide range of different fields, including social science, political science, mathematics, arms control, non-proliferation and verification, safeguards, and nuclear plant operation. The Chair believed that the deliberation in WG 4 by these experts was quite successful and extremely important and useful for the efforts of the international community to strengthen international safeguards and the non-proliferation regime. It was recommended that this kind of discussion be repeated in the future.

Workshop Results

Because of the high quality of the presentations, and the luxury of not having to watch the clock, the participants in the Working Groups thoroughly enjoyed themselves. The presentations were relaxed and the discussions lively and prolonged. Optimistic forecasts were made on how some technologies could, in the future, change the face of safeguards. There was a feeling that a real dialogue was taking place between experts in disparate fields, each of whom was trying sincerely to understand the other's discipline. The general conclusion was that everyone profited from this atmosphere.

From a psychological viewpoint, new thinking is required in order to implement many of the new technologies discussed. One can, however, foresee gradual, step-wise introduction of simple applications of new technologies, followed by the continuous refinement and expansion of these technologies in the safeguards world. Research and development have an increasing role to play in the future of safeguards; namely, to contribute to the introduction of advanced technologies to increase the efficiency and effectiveness of safeguards. But is it clear the new technologies will have to be adapted to the framework of the basic safeguard principles and agreements.

Final Plenary - Conclusions - Future Plans

The Final Plenary featured a discussion panel consisting of the working group chairmen and a group of safeguards leaders. A report and statement was given by each Working Group Chair, followed by statements by the IAEA, Euratom, JRC-Ispra, and ESARDA principals. The Final Plenary was chaired by D. R. Wilkinson, Director of the ISIS Institute of the JRC, Ispra. Participants included personnel from the IAEA and Euratom Safeguards Directorate, the European Community, the Russia Federation, Japan, Canada, and the USA. Important points made in the statements and by the participants in the panel discussion included the following:

- As expected, some of the workshop presentations were on topics that focused on the present and near term; however, many were focused on the future. We all recognize the difficulty in dwelling on the future with so many problems in the present; however, the future should not be forgotten in the crush to meet near-term needs. In any case, all topics considered at the workshop were judged to be appropriate and clearly to provide the basis for furtherance of this type of forum.

- One of the outstanding characteristics of this workshop was the ample amount of time for full discussion allowed for each presentation. This procedure was substantially different from the usual ESARDA and INMM meetings. This workshop has set the stage for similar workshops in the future.

The conduct of a workshop such as this cannot be successful without the dedication of many persons. At the risk of forgetting some, the principal personnel that organized and provided services for this workshop included:

- Scientific Committee - Wolf Lauppe, Bernd Richter, Steve Dupree
- Organizing Committee - Steve Dupree, Carlo Foggi, Ule Kotte, Wolf Lauppe, Bernd Richter, Dirk van der Eecken, and the two Workshop Chairs
- Organizing Secretariat - Carlo Foggi, Fernanda Genoni, and the Public Relations Service of JRC Ispra

Conclusions

The 1996 Workshop on Science and Modern Technology for Safeguards provided a full and wide-ranging discussion of near- and far-term scientific technology that may be applied to safeguards. In addition, there were extended discussions on the social and political aspects surrounding the areas of Nonproliferation, International Safeguards, and Regional Safeguards. The general opinion was that the Workshop met or exceeded its goals, and set the stage for future Workshops to build on the results of this innovative first undertaking. It was also agreed that the next Workshop on Science and Modern Technology for Safeguards would be held in the USA in 1998. Plans have identified Albuquerque, New Mexico, as the location. The time of the work shop has not been fixed, but it is anticipated that it will be in September or October.

We hope that, in consequence of this Workshop, a network of research organizations and individuals will result among the different disciplines, preferably on a multinational level, and that such networks will lead to synergies in science and advanced technology for application to safeguards. While some cross fertilization has occurred in the past, the interactions offered by the Workshop should improve and enlarge this cooperation. We now have a cornerstone on which future activities can be based. We are convinced that the appropriate bodies in ESARDA and INMM will take the results of this workshop and use them for planning of their future conferences, workshops, and activities.

We look forward to seeing many of you at the next INMM meeting in July in Phoenix, Arizona, USA and at the next Workshop on Science and Modern Technology for Safeguards in 1998 in sunny Albuquerque.