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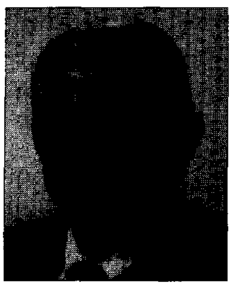
Terrorist Attack Emphasizes INMM's Mission



Just days before this issue was scheduled to go to press, the United States was struck by a devastating terrorist attack of unimaginable proportions. The attack was against the United States, but because of its social and economic impact, it has affected the whole world. Even though the media has been filled with information and discussion about the attacks, we felt that it was appropriate to also discuss it here. Most of us have experienced every human emotion since the attack. We have felt anger, sorrow, fear, compassion, patriotism, love, and concern for our fellow human beings. We share in the pain and grief of those affected, and on behalf of the Institute of Nuclear Materials Management, allow me to express our sympathy and concern for those who have been touched by the terrible and tragic events of Tuesday, September 11, 2001.

The greater INMM community has come together to support its members and share common feelings of sadness and concern. We are not aware that any of our members were killed or physically injured during the attacks that occurred. However, we all have been emotionally injured because it's so difficult to comprehend what has happened and the magnitude of the death and destruction.

Technology usually improves greatly during times of world crisis. We expect increased emphasis on intelligence gathering. Much of this will require advanced electronics and signal processing. Many of the personnel screening and personnel identification technologies will undoubtedly be improved and put into widespread applications, including those for the nuclear industry. Increased use should make them more effective, economical, and accepted.

We are gratified at the sense of national and world unity that is prevalent. We are gratified that the United States is seeking justice based on knowledge, not just on emotion.

Many questions remain. What effect will these attacks have on the nuclear industry in general and on the INMM in particular? For some time now the world has feared nuclear, biological, and chemical attacks. INMM members have been particularly active in helping to prevent nuclear proliferation. Either directly or indirectly, every technical area of INMM contributes to nuclear nonproliferation. We see heightened security at all government facilities, office towers, hospitals, power plants, oil refineries, sporting events, airports, reservoirs, public gatherings, and other infrastructure facilities. Those in every technical area are being called upon to be even more diligent and creative in developing and using procedures and technology to prevent terrorism. Many of our colleagues in the physical protection area are especially busy as they work to strengthen every aspect of physical security.

After the 1993 terrorist bombing of the World Trade Center, I was allowed to visit the site and view the damage and to assist in making it more secure. While we realized that an airplane could crash into the buildings, no one envisioned a deliberate attack that used commercial jets as missiles.

Much work remains to be done in managing nuclear material. We must continue our efforts and recruit those who will replace us. I will discuss the need to attract new people to our field in a future column. In the immediate future, we must increase our efforts to share our experience and expertise in protecting nuclear materials with those who are responsible for preventing biological and chemical terrorist attacks.

We thank all of you who have expressed love and concern during these days since the attack. Your calls, e-mails, letters, and other expressions of support are greatly appreciated. Many of us have been overwhelmed by the outpouring of sympathy and concern expressed by our friends throughout the world. As I write this, people are just beginning to regain a sense of normalcy in their lives. It will be a long process for many because of the difficult losses so many now face.

We will continue to work to promote the safe management of nuclear materials, a mission that seems more important than ever before.

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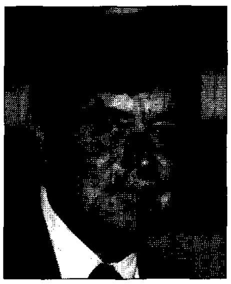
A New Emphasis



INMM President J. D. Williams notes in his message the new emphasis and effort that we the INMM community can bring to bear as the result of the September 11 terrorists' attack. Bringing our collective expertise to address antiterrorism is indeed a new mission, but one that I personally feel we can contribute a great deal to, particularly with the international flavor we have. Within the INMM community, there has been e-mail traffic, originated by Annual Meeting Technical Program Chair Charles Pietri, suggesting special sessions at next year's Annual Meeting. Charles always welcomes suggestions, so if you have any, contact him at cpietri@aol.com.

I was with several colleagues at the International Atomic Energy Agency at the Vienna International Center when the attacks occurred. In the ensuing days, during meetings as well as in walking the halls, condolences were expressed by colleagues from many countries. All of the opening speeches by ambassadors and dignitaries at the 41st General Conference of the IAEA emphasized the terrible nature of the attacks, and noted the increased posture and importance of the work of the IAEA. In response, the IAEA, at the Safeguards Symposium, scheduled for October 29-November 1, plans to have a one-day extension to hold a plenary session on antiterrorism.

You may note that in addition to Charles Pietri's summary article of this year's Annual Meeting, we have only three articles related to the Annual Meeting. Unfortunately, although our Managing Editor Patricia Sullivan did an excellent job in making ready the article on the Roundtable interview with our plenary speaker Robert Kuckuck, the review by his office was interrupted by the terrorist attack. Also, the feature article on the closing plenary session was likewise impacted. We hope to have these articles, along with Kuckuck's plenary address in the next issue of the Journal.

The three articles in this issue cover a broad range of topics with varying technical content. In the article 240Pu Effective Mass of 238Pu and 242Pu in Relation to Passive Neutron Coincidence and Multiplicity Counting, authors Croft, Bourva, Weaver, and Ottmar take us into the highly sophisticated filed of neutron multiplicity counting, comparing experimental work with theoretical calculations. In Civil Remote-sensing Satellites and a Fissile Material Cutoff Treaty: Some Case Studies on Verifying Nonproduction, Hui Zhang of the Kennedy School of Government provides a historical review of the FMCT, as well as suggests the role that civil satellites might play in verifying one facet of such a treaty, namely the verification that facilities declared as shut down remain so. In the third article, Dr. Jim Brown of Sandia National Laboratories provides a brief overview of the 11th International Arms Control Conference held in Albuquerque, New Mexico, U.S.A., April 20-22, 2001. Topics considered at this conference included, *inter alia,* "Homeland Defense: Is it Real?" At the time of the conference, the answer to this question was not as universally agreed upon as it is now.

Please note that the INMM Executive Committee will meet on November 14 and 15. I am sure the topic of antiterrorism will be on the agenda. All of us have ideas on what the INMM should do, ranging from creating a new technical division on antiterrorism to having special sessions at the Annual Meeting, or even on having a workshop devoted to the topic. I ask that you share any ideas on the INMM response to the terrorists' actions with INMM President J. D. Williams prior to the next executive committee meeting.

Should you have any comments or suggestions, please feel free to contact me.

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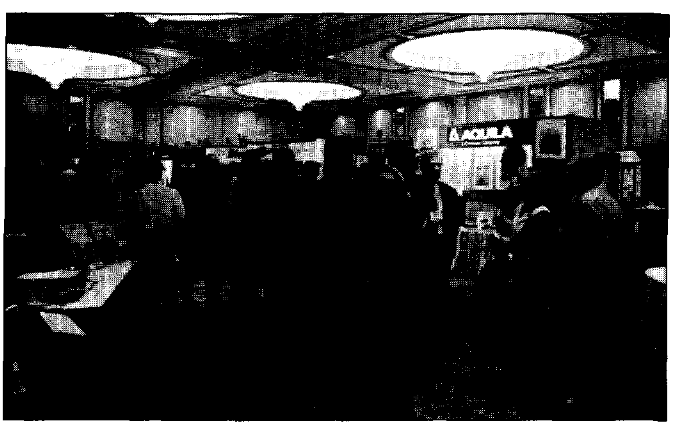
42nd INMM Annual Meeting—Full of Surprises

"It's the best I've ever had!"
"It was overwhelming!"
"Such a splendid surprise!"

Are these responses to the 42nd INMM Annual Meeting held in Indian Wells, California on July 15-19, 2001? I only wish they were. Instead, these were the almost-unanimous reactions from attendees and their companions to the Annual Meeting banquet prepared by the gifted Chef Sarah Bowman of the Renaissance Esmeralda Resort.

I'm looking for ways to entice Bowman to our banquet next year at the Renaissance Orlando Resort in Orlando, Florida—don't laugh, I'm serious. For surprises, the banquet even beat out the pocket meeting schedule, a hit in its own right.



Attendees congregate in the Annual Meeting Exhibit Hall. Twenty-three exhibitors had booths in the hall.

Of course, the true highlight of the meeting was the technical program with its sidebar meetings and discussions.

My belief is that INMM has great annual meetings because you folks have a lot of good ideas, and some crummy ones, too, and we listen to them all. We heard lots of good words about our newly formatted final program and unanimous praise for the pocket meeting schedule. (We've been planning this latter treat for several years now and Rachel Airth, our newly promoted executive director, was instrumental in working to get it laid out and published. I fully expect suggestions that next year we include the abstracts! Maybe a mini-final program is in the making but then it wouldn't fit in a pocket.) The pocket meeting schedule is one of the ideas that many of you have suggested.

If you were at last year's meeting in New Orleans, you may have heard about the near disaster when most of the boxes of meeting materials (including award plaques, flags, ribbons, and related items) being shipped by truck never arrived. The INMM HQ staff found replacements for us without most of you even knowing what happened. This year we had no such crisis. But just **two days** before the meeting a deluge of cancellations started and concluded with a total of thirty withdrawn papers by the end of the meeting, thirty-seven since the final program went to press three weeks before the meeting, and forty-eight since the preliminary program was printed in April.

We had to issue three meeting addenda to accommodate these later withdrawals along with some speaker and session chair changes. It made Swiss cheese out of our newly formatted and beautiful final program. In fact, Joe Indusi (BNL), the stalwart he is, as chair of one of the decimated sessions, presided over the sole remaining paper out of the original eight — then he went for a dip in the pool to cool down!

We had several other papers that were withdrawn in the months prior to the meeting. Most authors were courteous and professional and contacted me in a timely manner with some reasonable explanation for their withdrawal. Credit goes to some of the session chairs, such as Dave Swindle (EG&G, Inc.), who

INMM Vice President John C. Matter explains the newly formatted pocket meeting schedule at the opening plenary session.

initially had to opt out at the last minute but then immediately recruited a most suitable surrogate in Steve Goldberg (NBL). (The irony of it is that Dave was able to attend his session—but his initial action is noteworthy.) As I have pleaded for in the past, please do us all a favor: if you are not serious about presenting a paper, or do not have the funding or management support have little chance of getting such support, have conflicting schedules, or have any other significant uncertainty, please think very carefully before submitting an abstract for consideration. Frivolous abstract submittals usually result in late withdrawals that disrupt the program. If you need management or security classification approval for your presentation, please assure yourself and INMM that it is confirmed well in advance of the meeting. Since INMM is an international organization with broad visibility, it reflects very poorly on national, corporate, institutional, and individual sponsors when a paper is withdrawn especially within the last few weeks or even days of the meeting. (Would you believe I had an e-mail notice of withdrawal from one speaker about three hours before he was to give his paper? I guess he didn't want to get on one of my two infamous blacklists—this one the **No Show Blacklist.**) As I've said previously the INMM Annual Meeting program is not a trivial matter—it needs to be well thought-out and well planned. Changes are costly not only in terms of money, time, and scheduling, but also in the impact on speakers and attendees.

The Feedback

I do read your meeting evaluation forms! Others do, too! (Did you think that the INMM, even collectively, was smart enough to come up with all these cool ideas and innovations?) I even try to answer specific comments individually (if an address is provided) although most of the responses are to be found in this report.

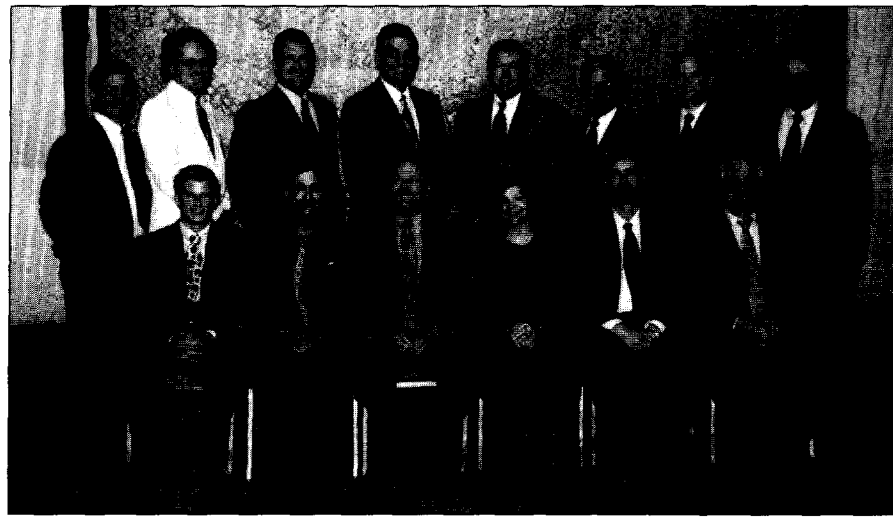
We received meeting evaluation forms from only 6 percent of attendees this year. That's up from only 4 percent last year. Significant results include:

Pre-meeting process: 97 percent good-excellent; 3 percent rate it is as poor-fair

Technical information exchange: 80 percent good-excellent, 20 percent good-fair

Again, I'll assume that those who didn't respond were so satisfied with the meeting that they felt no need to comment formally. We did get a lot of informal positive comments in conversations with attendees. Even so, it looks as if INMM needs to review further the quality of the presentations and their scheduling, the division meetings, and plenary speakers' topics. Suggestions as to how this review should take place effectively are welcome. Please e-mail me at cpietri@aol.com.

Several attendees had concerns about the excessive number of withdrawn papers as we all did—a significant disruptive element in a program prepared with excruciating detail by INMM. We had mostly favorable comments from our exhibitors—only a few written reports but many verbal responses.



INMM's Sustaining Members
Sustaining members of INMM were out in force at the 42nd INMM Annual Meeting in Indian Wells, California. Shown here are: back row (left to right): Rich Wyant, Wyant Data Systems Inc.; Ed Sadowski, Westinghouse Savannah River Co.; Bret Simpkins, Pacific Northwest National Laboratory; Mike White, Aquila Technologies; David Swindle, EG&G Inc.; Carter Hull, NucSafe; Ben Watts, Haselwood Enterprises Inc.; Mike Sheaffer, Lawrence Livermore National Laboratory; front row (left to right): Michael Whitaker, BWXT Y-12; Rick Seymour, NucSafe; Larry Avens, Los Alamos National Laboratory; Jill Cooley, International Atomic Energy Agency; Markku Koskelo, Canberra Industries; Gennady Pshakin, Institute of Physics and Power Engineering. For a complete list of INMM sustaining members, see page 8.

Logistics for the meeting were also rated as good-excellent but again a few attendees expressed disappointment with the hotel meal functions and the hot weather.

INMM chooses out-of-season hotels to keep lodging costs low and meeting amenities high—that means we have our meetings in most places at the times that others would avoid.

We meet in 2002 at the Renaissance Orlando Resort and return there in 2004. In 2003 and 2005, we have selected a brand new and elegant Marriott Desert Ridge Resort in the Phoenix area.

But, once again, regardless of the location, most attendees recognize that the Annual Meeting is a great opportunity to meet colleagues from around the world, participate in valuable private meetings and discussions, hear some really outstanding papers, and broaden one's perspective.

Let me share with you a few additional comments taken from this year's evaluation forms:

- "Need more time for questions and discussion."

  We get this comment every year. INMM has provided two meeting rooms that session chairs can arrange to use for such discussions. Some of the sessions are not full and any remaining time after the last paper has been presented can be used for discussion. Some sessions already have been structured to use the last hour (three paper slots) for a panel discussion. Occasionally, a paper is withdrawn from a session after the final program has been printed

42nd INMM Annual Meeting—Full of Surprises

Message from your Secretary

This year, after thirty-one consecutive years, I was unable to attend the Executive Committee meeting or the INMM Annual Meeting. That I was privileged to attend the meetings all those previous years was due to the members who placed their confidence in me to represent them on the Executive Committee and re-electing me secretary each year. I hope that I have justified their faith in me.

I had every intention of being at the meetings this year, but at the last moment my wife was diagnosed with cancer and immediate surgery was necessary. I am happy to report that the malignancy was totally removed and subsequent tests indicate that, currently, she is free of cancer. I wish to thank those members of the INMM and the INMM headquarters staff who were kind enough to send flowers to my wife.

The duties at the Executive Committee meeting and the Annual Meeting are many and varied. I wish to apologize to the Executive Committee, the Membership Committee, Fellows Committee, the Government/Industry Liaison Committee, Golf Committee, Charles Pietri, and Rachel Airth for having to struggle through without me. If the members are willing, I will start a new string next year and will attempt to surpass my record. I should be able to do this if I manage to live as long as my maternal great grandmother who lived for 107 years.

My sincere appreciation goes to Obie Amacker and Ron Hawkins who were kind enough to administer the Annual INMM Golf Tournament and a special thanks to Obie Amacker for assuming the duties of the secretary at the Executive Committee meeting and the Annual Business meeting. Now he realizes how difficult and frustrating the job can be.

Additionally, I wish to thank everyone who took time from their golf games and other busy schedules at the meeting to sign the huge card that was sent to me. The card hangs prominently on the wall in my den. As I read each name and wondered how I could thank each one, I became progressively frustrated. How should I do it? Random sample? No, couldn't determine right population size. Throw darts at the card to see whom I would personally thank? No, could be misconstrued if someone found out about it. Neither plan would get everyone so this message seemed much easier and quicker. All I had to do is prepare this message and all you had to do is read the *Journal*.

Thanks, gang! I missed you too.

Vince DeVito
INMM Secretary

and we have encouraged session chairs to use this period for discussions. So there are a number of realistic options for attendees to use—be creative!

- "Too many good papers are given in parallel sessions but can't get to hear them."

  You all know the answer to that one!

- "Need to restructure the poster session into multiple, half-day sessions rather than just one day and request that formal papers be submitted for the proceedings just as is required for oral presentations."

  This suggestion by Taner Uckan (ORNL), for the second year, merits consideration. An informal poll of poster presenters made by Sharon Jacobsen (BWXT Y-12), posters/demonstrations chair, indicated agreement. INMM plans to study this proposal for next year's meeting.

- "Speakers should practice their talk so that it falls with the allotted presentation time; they should also improve the quality of their transparencies and learn how to position them for better viewing by the audience."

  We are in total agreement.

- "INMM should provide LCD projectors for speakers to use."

  The use of expensive LCD projectors at INMM meetings is not a simple matter. INMM will study the cost of purchasing, renting, or leasing such equipment including maintenance, transport, obsolescence replacement, spares, and other factors. In addition, speakers will have to learn how to load and handle LCD projectors in an efficient manner that does not impact on their presentation time. In the *meantime, INMM urges those wishing to use LCD projectors next year to plan to bring their own or arrange to share such equipment.*

- "The hotel was limited in the variety of restaurants available and meals for those attendees who could not get offsite were relatively costly."

  Noted. We have passed this comment on to our meeting planner who will take this into consideration when making arrangements for hotel meals at future meetings.

To keep the statisticians in INMM happy, here are the meeting statistics for this year: there were 647 total attendees plus 145 companions. We had 285 papers (including 22 posters chaired by Sharon Jacobsen), and forty-seven sessions. (For comparison, last year we had 582 attendees, 125 companions, 291 papers including fifteen posters, and also forty-seven sessions.) Unfortunately, Thursday morning sessions, as noted by several attendees, were visibly less populated—no doubt exacerbated also by the significant withdrawals. The Technical Program Committee plans to fix that next year.

Noted Absences

We also note that Vince DeVito, long standing Secretary of the Institute, its corporate memory, and one of the original members of INMM, could not attend this meeting due to illness in the family. Vince had not missed an Annual Meeting in 31 years. See Vince's note to members to the left.

Another Annual Meeting regular participant and *JNMM* Associate Editor Bernd Richter (JRC), became unexpectedly ill and could not attend the meeting either. We hope to see them both next year.

Plenary Sessions

Gen. John Gordon, administrator of the National Nuclear Security Administration (NNSA), was slated to give the keynote speech in the opening plenary session but late breaking events in Washington unfortunately precluded his visit. Robert Kuckuck, NNSA's acting principal deputy administrator, was able to make the presentation on behalf of Gordon. Kuckuck elaborated on NNSA's mission to assure global threat reduction from nuclear proliferation through science and technology. He also felt that there was a role for the INMM to play in promoting the value of nuclear materials safeguards for nonproliferation. His speech can be found in an upcoming issue of the *Journal*. The follow-up interview conducted at the INMM Roundtable by *Journal* Technical Editor Dennis Mangan, representatives of the INMM Executive Committee, and *JNMM* associate editors provided some additional insight into NNSA policies and direction. In particular, the ever-diminishing scientific and technical capabilities at our national laboratories and other facilities and what to do about it was addressed. INMM was called upon to assist in focusing on this issue.

INMM President J.D. Williams welcomes attendees to the opening plenary session of the Annual Meeting..

Robert Kuckuck, acting deputy secretary, National Nuclear Security Administration, addresses the opening plenary session of the INMM 42nd Annual Meeting.

Our closing plenary session, co-chaired by Jim Lemley (BNL) and Amy Whitworth (NNSA) of the Government-Industry Liaison Committee, featured three interesting perspectives for the nuclear community. John Todd of NNSA spoke on "New Directions in Nonproliferation and Security;" Laura Holgate of the Nuclear Threat Initiative, discussed "Public-Private Partnerships in Nonproliferation;" and, Diane Jackson of the Nuclear Regulatory Commission addressed "Future Reactor Activities."

The Nontechnical

Some of the nontechnical activities of the Annual Meeting gave us time to relax and to meet new attendees and get reacquainted with others. The President's Reception on Sunday, July 15, was very well attended. It was the best opportunity to meet everyone. We still got comments that ninety minutes was not enough time to socialize—many of us went across the atrium to the lounge to continue our conversations.

President J.D. Williams (Sandia) and Vice President John Matter (Sandia) continue to make this a very enjoyable event for everyone.

We also had a nice reception for new INMM members on Monday evening, July 16, where we met some very interesting young newcomers who we hope will be major contributors to the

INMM and the nuclear materials management community in the future. The Awards Banquet on Tuesday, July 17, with its outstanding meal, made that evening most pleasant along with the presentation of awards for the faithful who have contributed in so many different ways to both the INMM and nuclear safeguards. See our article on the award winners on page 43.

Last year we inaugurated the new Community of Science database for abstract submittal. This spring INMM changed to a custom-made program, the Conference Planning Program, developed by a scientist working in the chemical industry, that was more suitable, cost-effective and flexible for our type of meeting. It had many good features including uploading of final papers for the Proceedings and some interesting management tools. We continue to look for and make enhancements to this program for next year. I received very few negative comments about the program and plan to work individually with those who encountered difficulties. Hopefully, it just may be a matter of becoming familiar with a new program. Again, your comments on the INMM abstract and final papersubmittal processes are cherished.

Former INMM President Deborah A. Dickman, INMM Annual Meeting Technical Program Chair Charles Pietri, and Annual Meeting Closing Plenary Speaker Laura Holgate enjoy themselves at the reception before the Awards Banquet.

This is the second year that INMM has requested that final written papers be submitted by authors a week prior to the Annual Meeting. The Proceedings of the INMM Annual Meeting is an integral part of INMM's legacy as a contributor to the knowledge base and as an historical event. Last year's response was adequate but not satisfying. The response this year was somewhat spectacular. I didn't think so at first because at registration time on July 15 we still lacked forty-four papers out of the total of nearly 285—good but not perfect. (Several authors had requested extensions until meeting time and provided me with some creative, some heart rendering but very convincing reasons for me to grant them.) My second blacklist, **Delinquent Final Papers Blacklist,** subsequently was posted for public view at the registration desk. By Wednesday, there were only three papers not turned in—a fantastic response! We are well on our way to providing you with the Proceedings on CD by November. Thanks to all who cooperated.

Planning for Next Year

Each year I remind potential speakers for the next Annual Meeting to start preparing now. This is especially important this year because the Annual Meeting takes place **June 23-29, 2002—three to four weeks earlier than is customary.** The deadline for abstract submittal is February 1. Now is the time to plan your own presentation for the 43rd Annual Meeting—next spring will be far too late.

We are happy to report that our revised process for encouraging

INMM Sustaining Members

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Aquila Technologies Group, Inc.
Argonne National Laboratory
Australian Safeguards and Nonproliferation Office
BNFL Instruments Ltd.
Bechtel BWXT Idaho, LLC
Brookhaven National Laboratory
BWXT Y—12 LLC
Canberra Industries
EG&G, Inc.
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International Atomic Energy Agency
International Fuel Containers, Inc.
Institute for Physics and Power Engineering
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
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NAC International
Nuclear Fuel Services, Inc.
Nucsafe LLC
Pacific Northwest National Laboratory
PerkinElmer Instruments/ORTEC
Sandia National Laboratories
Senstar Stellar Inc.
Westinghouse Savannah River Co.
Wyatt Data Systems, Inc.

INMM meeting participants to organize special topical sessions of interest under the mentorship of a Technical Program Committee member worked well in all cases except one. Several such session organizers have already committed for the 43rd Annual Meeting: Garland Proco (NAC International), *Information Systems;* David Baran (NBL), *Environmental Measurements and Reference Materials;* Bruce Moran (NRC), *Nuclear Regulatory Commission Licensing;* Jim Tape (LANL), *Proliferation Resistant Fuel Cycles.*

Special sessions like these must be planned carefully and submitted in final form by February 1 for consideration and review by the Technical Program Committee. If you would like to arrange a special topical session, I need to hear from you very soon so that we can reserve space in the program for you. Please do it now!

In closing, I would like to thank you all for the kind comments about how to enhance INMM and the Annual Meeting. Even the very few unkind remarks, too—they are also revealing! INMM would also like to recognize those who helped make this year's Annual Meeting a success: the authors and speakers who, despite funding, management, and security restraints, continue to contribute papers and posters to the premier nuclear materials management forum, the Institute of Nuclear Materials Management. In support of the speakers, again this year, were the thirty-three members of the Technical Program Committee, the Executive Committee, the exhibitors and sponsors, the session chairs, our INMM/HQ staff, and Chris Hodge (SRS) and the Registration Committee.

Outgoing INMM Executive Committee Member at Large Paul Ebel and INMM President J.D. Williams.

Remember to start planning for the next Annual Meeting now. We hope to see you at the 43rd INMM Annual Meeting at the Renaissance Orlando Resort, Orlando, Florida, June 23-27, 2002. Don't forget—we meet earlier than usual in 2002. Bear in mind it's your meeting—you can make it a success by your efforts!

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^{240}Pu Effective Mass of ^{238}Pu and ^{242}Pu in Relation to Passive Neutron Coincidence and Multiplicity Counting

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■

Abstract
The nondestructive assay of plutonium mass by passive neutron multiplicity counting requires accurate evaluated nuclear data to be available. In particular, the coefficients of the ^{240}Pu effective mass of ^{238}Pu and ^{242}Pu, γ_{238} and γ_{242}, play an important role in the validity of the calibration procedure. A new evaluation of these quantities, both for double and triple coincidence counting, is presented following measurements of ^{238}Pu, ^{240}Pu, and ^{242}Pu enriched reference samples in a neutron multiplicity chamber. Empirical double and triple coincidence count rates have been corrected for neutron multiplication, detection efficiency, and mass of isotope, so that the γ_{238} and γ_{242} coefficients for both counting modes could be derived. The results obtained are sufficiently different from the coefficients routinely in use for them to affect significantly the results of assays performed on certain material streams. The measurements reported here have uncertainties, which are a factor of about two lower than those previously attained.

1. Introduction
Passive neutron multiplicity counting using shift register pulse train time correlation analysis is routinely used for the nondestructive assay of plutonium for international nuclear safeguards accountancy and other purposes such as waste disposal sentencing.[1, 2, 3] Using this technique, the total plutonium mass is determined from the measurement of the ^{240}Pu effective mass, m_{eff}, together with knowledge of the relative isotopic weight fractions of the ^{238}Pu, ^{240}Pu, and ^{242}Pu nuclides contributing to the spontaneous fission rate. The ^{240}Pu effective mass is determined by overlaying an interpretative model, grounded in the work of Böhnel.[4,5] For the three experimental count-rates resulting from the detection of Single, S, Double, D, and Triple, T, coincidence events in a neutron assay chamber, the experimental data are interpreted using the basic one energy group, prompt-neutron, point model, multiplicity equations developed by Cifarelli and Hage.[6] The task of this model is to relate instrumental parameters and basic nuclear data, such as detection efficiency; gate utilization factors of the multiplicity electronics; spontaneous fission rates, and fission neutron multiplicity distributions, to the three measured quantities. This leads to the following expressions for the three bias and dead time corrected neutron count rates. Note that the relations shown below differ slightly from the ones introduced by Cifarelli and Hage because of the choice of definition for the factorial moments of the neutron fission multiplicity distribution.

$$S=\varepsilon \cdot \frac{\nu_{S1}}{1!} \cdot m_{eff} \cdot g \cdot f_1 (1+\alpha) \cdot \phi_1 \quad (1)$$

$$D=\varepsilon^2 \cdot \frac{\nu_{S2}}{2!} \cdot m_{eff} \cdot g \cdot f_2 \cdot \phi_2 \quad (2)$$

$$T=\varepsilon^3 \cdot \frac{\nu_{S3}}{3!} \cdot m_{eff} \cdot g \cdot f_3 \cdot \phi_3 \quad (3)$$

In these three equations ε is the neutron detection efficiency, ν_{S1}, ν_{S2}, and ν_{S3} are the first three factorial moments of the prompt spontaneous fission multiplicity distribution of ^{240}Pu[7]; g is the specific spontaneous fission rate of ^{240}Pu[7]; m_{eff} is the ^{240}Pu effective mass present in the sample[8] and f_1 ($\equiv$ 1), f_2, and f_3 are the coincidence gate utilization factors of the multiplicity shift register (MSR) electronics for single, double, and triple coincidence counting respectively.[9,10] Also introduced in these expressions are, ϕ_1, ϕ_2, and ϕ_3, the signal enhancement factors brought about by the self-multiplication, or induced fission, taking place in the sample. These involve the first three factorial moments, ν_{I1}, ν_{I2}, and ν_{I3}, of the prompt induced fission multiplicity distributions of the fissile isotopes present in the sample. Expressions for ϕ_1, ϕ_2 and ϕ_3 are given below in Equations 4, 5, and 6

$$\phi_1=M_L \quad (4)$$

$$\phi_2=M_L^2 \cdot [1+ (M_L -1) \cdot (1+ \alpha) \cdot \kappa_{21}] \quad (5)$$

$$\phi_3=M_L^3 \cdot [1+ (M_L -1) \cdot (1+ \alpha) \cdot \kappa_{31} + 3 \cdot (M_L -1) \cdot \kappa_{32} + 3 \cdot (M_L -1)^2 \cdot (1+ \alpha) \cdot \kappa_{33}] \quad (6)$$

where M_L is the leakage self-multiplication factor,[11] α is the $(\alpha,n)/(SF,n)$ reaction rate ratio within the sample, also referred as random to spontaneous fission neutron ratio,[7] and κ_{21}, κ_{31}, κ_{32}, and κ_{33}, are the induced to spontaneous fission neutron multiplicity coefficients.[12]

Among the parameters affecting the accurate determination of the mass of plutonium present in a sample, the knowledge of the relative contribution to the coincidence rates from the three spontaneously fissile isotopes is of prime importance. This paper is therefore concerned with the expression of the ^{240}Pu effective weight fraction, w_{eff}, in terms of the individual ^{238}Pu, ^{240}Pu, and ^{242}Pu weight fractions w_{238}, w_{240}, and w_{242} respectively. This is shown in Equation 7 where the superscript i refers either to Single, S, Double, D, or Triple, T, coincidence counting.

$$w^i_{eff} = \gamma^i_{238} \cdot w_{238} + w_{240} + \gamma^i_{242} \cdot w_{242} \quad (7)$$

Having established w_{eff} the total Plutonium mass in a sample, m_{tot}, can be obtained from the measured m_{eff}, according to Equation 8.

$$m_{tot} = \frac{m_{eff}}{w_{eff}} \quad (8)$$

The γ-coefficients γ^i_{238} and γ^i_{242} introduced in Equation 7 are currently estimated using evaluated nuclear data for the specific fission rates of the nuclear species involved and their associated neutron emission multiplicity distributions. These values are quoted in Table I.

Isotope	g (fis · s^{-1} · g^{-1})	ν_{S1} (fis $^{-1}$)	ν_{S2} (fis $^{-1}$)	ν_{S3} (fis $^{-1}$)	γ^S	γ^D	γ^T
^{238}Pu	1169.80 (± 1.90%)	2.210 (± 3.62%)	3.957 (± 3.54%)	5.596 (± 13.51%)	2.527 (± 4.43%)	2.573 (± 4.37%)	2.645 (± 13.80%)
^{240}Pu	475.01 (± 1.70%)	2.154 (± 0.23%)	3.789 (± 0.29%)	5.211 (± 1.17%)	1	1	1
^{242}Pu	807.15 (± 1.00%)	2.149 (± 0.37%)	3.809 (± 0.95%)	5.349 (± 2.61%)	1.695 (± 2.02%)	1.708 (± 2.21%)	1.744 (± 3.47%)

Table I. Spontaneous fission nuclear data for ^{238}Pu, ^{240}Pu, and ^{242}Pu and the derived ^{240}Pu effective mass coefficients.

Efforts to improve the accuracy of Passive Neutron Coincidence Counting (PNCC) measurements have led[8] to a recent empirical determination of γ^D_{238} and γ^D_{242} to be performed for two passive neutron coincidence counting chambers, the EURATOM onsite laboratory (OSL) counter[14] and the Harwell Instruments Ltd. (HIL) N95 High-Efficiency Neutron Coincidence Counter (HENCC).[15] For the purpose of that work, a series of seven small plutonium

Chamber specific γ^D	OSL-Counter		N95 HENCC	Previously recomended values	IAEA recommended values
	T_g = 64 μs	T_g = 128 μs	T_g = 88 μs		
γ^D_{238}	2.707 ± 0.011	2.714 ± 0.011	2.718 ± 0.010	2.573	2.52
γ^D_{242}	1.658 ± 0.005	1.667 ± 0.005	1.664 ± 0.003	1.708	1.69

Table II. Results for the empirical γ^D-coefficients obtained for the OSL counter and HIL N95 HENCC.

T_g is the width of the coincidence gate used in the neutron coincidence counting measurements. Also shown are the recommended values for instruments of the general OSL/N95 type. For completeness, the last column shows values currently in use by the International Atomic Energy Agency for safeguards work.

oxide samples, highly enriched in either ^{238}Pu, ^{240}Pu, or ^{242}Pu, were manufactured and used to study chamber specific responses. By comparing the coincidence count rates obtained and applying sample dependent corrections, counter specific values of the γ^D_{238} and γ^D_{242} coefficients were obtained. The values resulting from this analysis are shown in Table II. The present work is an extension of this effort. Its aim is to derive values of the ^{240}Pu effective mass coefficients to be used for both coincidence and multiplicity counting (i.e. triples).

Consequently, both double and triple coincidence counting data recorded during the measurement campaign using the N95 HENCC and MSR electronics have been used to derive the γ^D_{238} and γ^D_{242} values for multiplicity counting; the OSL measurements were taken using conventional coincidence counting electronics so that multiplicity data was not available. This paper describes the acquisition technique used to obtain the multiplicity data along with the count rate corrections applied on the empirical results in order to derive chamber specific coefficients. The analysis is also extended to correct empirical γ-coefficients for neutron detection efficiency, that is for the difference in neutron emission spectrum among ^{238}Pu, ^{240}Pu, and ^{242}Pu, in order to extract the best estimates of the basic nuclear data ratios.

2. Neutron Multiplicity Analysis

Every event entering the multiplicity shift register (MSR) electronics interrogates the number of events in a coincidence gate twice. The coincidence gate is defined by a time interval or gate width, T_g, set after a pre-delay time, T_p. The first sampling scores counts in the so called "reals + accidentals" coincidence (R+A) gate, which covers a time interval $T_d + T_p \leq t \leq T_d + T_p + T_g$, where T_d is the arrival time of the triggering event measured from an arbitrary datum. The second sampling takes place at a much later time $T_L = T_d + \Delta$ after the triggering event where Δ is chosen to be much larger than the life time of neutrons in the system. This allows for all the genuine time correlations between events born together to decay, thus only recording random coincidence events in the so-called "accidentals" (A) gate. This is illustrated in Figure 1.

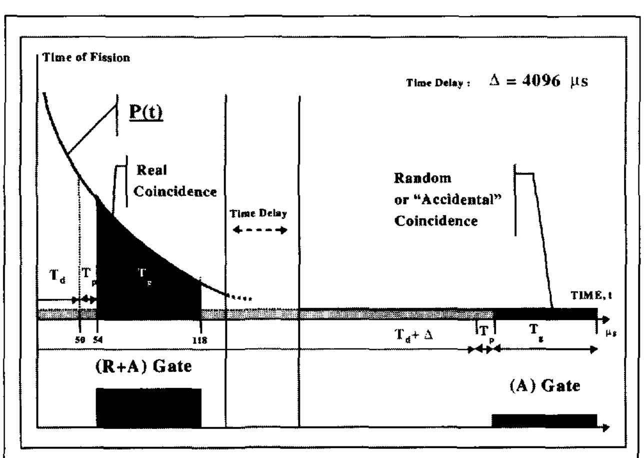

Figure 1. Neutron detection probability and the experimental gate timing for neutron coincidence counting.

The electronics used in the present work can sort multiplicities from 0 up to 255 and has a de-randomizing input buffer sixteen deep. The MSR output is therefore a pair of histograms RA(n) and A(n), n = 0 to 255, where RA(n) is the number of (R+A) gates inspected during the data acquisition period that contained n-pulses and A(n) is the number of A-gates inspected that contained n-pulses. From these two histograms, the dead time corrected singles (S), doubles (D) and triples (T) counting rates are calculated as follows:

$$S = TCF \cdot \frac{1}{t} \cdot \sum_{n=0}^{255} RA(n) - TCF \cdot \frac{1}{t} \cdot \sum_{n=0}^{255} A(n) \tag{9}$$

$$D = TCF \cdot \frac{1}{t} \cdot \sum_{n=1}^{255} \alpha_n \cdot \left(RA(n) - A(n)\right) \tag{10}$$

$$T = TCF \cdot \frac{1}{t} \cdot \left[\sum_{n=2}^{255} \beta_n \cdot \left(RA(n) - A(n)\right) - \frac{D}{S} \cdot \sum_{n=1}^{255} \alpha_n \cdot A(n) \right] \tag{11}$$

In these equations, t is the data acquisition period; TCF is the total (that is the singles or trigger) event rate dead-time correction factor that we choose to express according to the paralysable dead-time correction model.[17] Consequently, the TCF has been taken to be equal to $S = S_0 \cdot e^{a \cdot S}$, with a being the dead-time coefficient and S_o the observed singles rate. The α_n and β_n arrays in Equations 10 and 11 are functions of the dead-time coefficient-to-coincidence gate width ratio and expressions for them have been developed, within the framework of a paralysable dead-time system, by Dytlewski.[18] When the dead-time correction tends to zero α_n and β_n tend to n and n(n-1)/2 respectively and the dependence on the dead-time model assumptions become unimportant. At the rates encountered in this work, the uncertainty introduced into the final results as a consequence of the uncertainty in the dead-time corrections is not significant in comparison to other sources.

3. Experimental Set-up

The seven PuO_2 reference samples used in this work have been prepared by the Nuclear Material Division of AEA Technology plc and delivered with certification of their isotopic composition. A complete description of these samples can be found elsewhere.[8] Tables III and IV present the nomenclature and principal characteristics of these samples. The samples were encapsulated in standard X2 containers and had plutonium oxide masses in the range of 25 to 500 mg.

	Reference material		
Sample ID	AE8138/a, b, g	AE8138/c, d	AE8138/e, f
Main Pu isotope	^{238}Pu	^{240}Pu	^{242}Pu
	Weight percent		
^{238}Pu	89.88994 ± 0.06074	0.08399 ± 0.00578	0.00893 ± 0.00199
^{239}Pu	9.18161 ± 0.05513	0.01486 ± 0.00079	0.00755 ± 0.00357
^{240}Pu	0.88650 ± 0.00871	99.87468 ± 0.00787	0.02024 ± 0.00185
^{241}Pu	0.03336 ± 0.00053	0.00524 ± 0.00118	0.01635 ± 0.00152
^{242}Pu	0.00859 ± 0.00008	0.02123 ± 0.00144	99.94693 ± 0.00361

Table III. Certified isotopic composition of the AE8138 reference samples.

Sample ID	PuO_2 Sample weight (mg)	(Main) Isotope weight (mg)
AE8138/g	25.31	(^{238}Pu) 19.277 ± 0.020
AE8138/a	101.27	(^{238}Pu) 77.129 ± 0.073
AE8138/b	501.02	(^{238}Pu) 381.586 ± 0.359
AE8138/c	105.28	(^{240}Pu) 92.187 ± 0.049
AE8138/d	505.11	(^{240}Pu) 442.295 ± 0.230
AE8138/e	103.23	(^{242}Pu) 90.728 ± 0.051
AE8138/f	502.55	(^{242}Pu) 441.688 ± 0.242

Table IV. Description of the AE8138 reference samples.

The N95 HENCC[15] is a passive neutron detection chamber equipped with 36 ^3He gas filled proportional counters. These are arranged in two concentric rings around a measurement cavity located in the middle of the polyethylene moderating body. Its detection efficiency was determined from ^{252}Cf measurements using a standard source calibrated at the National Physical Laboratory.[19] This resulted in a measured detection efficiency value of (42.37 ± 0.30) % for ^{252}Cf neutrons. All of the sources used in this work are geometrically small and the spatial variation of the detection efficiency was assumed negligible based on previous experimental sensitivity measurements. During the assays the chamber was used with an HIL neutron multiplicity counting electronics in NIM format based on the MSR circuit 950025-1.[20] This unit was operated with a predelay time of 4 μs and a coincidence gate width of 88 μs.

4. Empirical Multiplicity Counting Results for the N95 HENCC

All count rates were provided by the data acquisition software as uncorrected, background corrected and (background + dead time) corrected values. Background count rates were measured before each assay. Several measurements were performed on each sample. Each measurement was composed of a sequence of about thirty to fifty counting intervals of 100 seconds. This structure allowed a consistent statistical analysis to be performed on the data and provided data rejection capability in the case of high neutron multiplicity events due to cosmic ray interactions in the chamber. By distributing the measurements in time and by cycling between the different samples, any trending in the detection response or background that might be present was naturally taken into account. The empirical double and triple coincidence count rates, averaged over the total acquisition time, for the seven AE8138 samples are given in Table V.

Sample	Acquisition time (s)	Single count rate (s^{-1})	Double count rate (s^{-1})	Triple count rate (s^{-1})
AE8138/a ($^{238}PuO_2$)	77900	618.816 (± 0.02%)	19.743 (± 0.22%)	2.650 (± 0.46%)
AE8138/b ($^{238}PuO_2$)	60000	3035.742 (± 0.01%)	101.590 (± 0.20%)	14.092 (± 0.73%)
AE8138/g ($^{238}PuO_2$)	65000	154.831 (± 0.11%)	4.898 (± 0.23%)	0.652 (± 0.79%)
AE8138/c ($^{240}PuO_2$)	75000	45.983 (± 0.17%)	8.561 (± 0.18%)	1.139 (± 0.64%)
AE8138/d ($^{240}PuO_2$)	65000	220.042 (± 0.08%)	41.400 (± 0.14%)	5.624 (± 0.58%)
AE8138/e ($^{242}PuO_2$)	65000	66.134 (± 0.11%)	13.970 (± 0.18%)	1.839 (± 0.61%)
AE8138/f ($^{242}PuO_2$)	45000	320.934 (± 0.05%)	68.469 (± 0.083%)	9.116 (± 0.42%)

Table V. Empirical count rates for double and triple coincidences of the AE8138 samples measured in the HIL N95 HENCC.

5. Derivation of the γ^D_{238} and γ^D_{242}

In order to extract γ^D_{238} and γ^D_{242} coefficients from the experimental double coincidence count rates, evaluation of several parameters introduced in the model described in Section 1 must be performed. These parameters account for the different detection and neutron production mechanisms taking place in the detector and in the samples themselves. Some of these effects are therefore chamber specific, like the detection efficiency, ε, and the gate utilization factors, f_2, while others, like the neutron multiplication factor, ϕ_2, are sample dependent. The chosen approach was therefore to derive γ^D_{238} and γ^D_{242} by firstly accounting for all the sample specific effects so that neutron multiplication corrected count rates (per unit mass) could be derived. This also allowed for uncertainties in each of the parameters involved in the multiplication correction to be calculated, before fully corrected average $^{238,240,242}PuO_2$ double coincidence count rates per unit mass were evaluated. γ^D_{238} and γ^D_{242} values were eventually obtained by applying corrections due to isotope-specific and chamber specific-effects derived by Monte Carlo calculations.

The determination of the neutron leakage self-multiplication was performed using the MCNP™ [21] modelling of the AE8138 samples placed in the N95 HENCC. Particular attention was given in simulating the X2 encapsulation geometry. The plutonium oxide powder was modelled assuming a uniform density of 4 $g \cdot ml^{-1}$ and a cylindrical geometry.[22]

The determination of the α parameter for the AE8138 samples has been performed by comparing the experimental single to double count rates ratio obtained for the samples with that of a plutonium-gallium metallic alloy source, also encapsulated in a standard X2 container.[23] The 0.43g Pu-Ga metallic disc source is considered to have essentially no (α,n) activity, so that its nonmultiplying doubles to singles ratio, ρ_o is written as

$$\rho_0 = \left[\left(\frac{D}{S}\right)_{PuGa} x \frac{M_L^{PuGa}}{\phi_2^{PuGa}} \right] \qquad (12)$$

The determination of $M_L^{PuGa} = 1.0055$ by Monte Carlo coupled with a κ_{21} value of 2.17, derived from the work of Zucker and Holden,[24] led to a value of $\phi_2^{PuGa} = 1.0231$. These results, used in Equation 12 with the experimental count rates, S = 43.635 and D = 9.731, gave a ρ_o value equal to (0.2109 ± 0.0009). Then, taking equations 1 and 2 to form the D/S rates ratio of the AE8138 samples and using the expressions for ϕ_1, ϕ_2, and ρ_o, the resulting equation for (1+α) for the oxide samples can be written:

$$(1+\alpha) = \frac{M_L}{\left(\frac{D}{S} \cdot \frac{1}{\rho_0}\right) - \kappa_{21} \cdot M_L \cdot (M_L - 1)} \qquad (13)$$

Using the experimental single and double count rates of the AE8138 samples resulted in the α–values shown in Table VI. These were preferred to those derived from an analytical expression yielding α_{calc} based on the relative isotopic composition and the thick target O(α,n) neutron yield.[7,14,25] This is because of the possibility that low concentrations of low atomic number impurities are present in the oxide samples. This can significantly enhance the (α,n) production rate. For the purpose of propagating uncertainties, a rather generous uncertainty allowance of 10 percent on the experimental value of α given in Table VI was assumed.

Values of the κ_{21} coefficients were taken from the evaluation of Bourva, et al.[12] It includes the description of the (α,n) neutron energy spectrum effect on induced fission yields in the sample. Table VI summarizes all the numerical results of the parameters used for the evaluation of the neutron multiplication effects in the AE8138 samples.

The values shown in Table VI were used to correct the empirical count rates shown in Table V. The sample's count rates per unit mass were derived by dividing these by the amount of isotope present in each sample, as listed in Table III. This implies that the measured coincidence count rate from a sample is uniquely due to the isotope with the highest concentration. This hypothesis was tested by estimating the neutron production rate for each isotope in a sample using nuclear data of Table I. This confirmed that, even in the worse case, more than 99.6 percent of the measured response was from the principal isotope. Small corrections were nonetheless applied to correct for the presence of secondary spontaneously fissile nuclides in the final analysis.

Note that the values given in Table VI differ slightly from the results stated in a previous publication.[8] This is explained by the use of new evaluations for the M_L and κ_{21} parameters. Table VII shows the resulting corrected count rates per unit mass of specific isotope in the AE8138 samples. The errors relative to these count rates were calculated by estimating and combining errors on each parameter introduced in their derivation. Isotope specific values have then been obtained by simply deriving the mean count rates over similar sample types.

The ratio of the specific doubles count rates listed in Table VII give the empirical γ^D_{238} and

Sample ID	Leakage self-multiplication M_L	Random to SF ratio, α	Random to SF ratio, α_{calc}	κ_{21}	ϕ_2
AE8138/g	1.000460 ± (0.05%)	5.75 ± (10%)	5.33	2.207 ± (1.22%)	1.007783 ± (0.75%)
AE8138/a	1.001459 ± (0.05%)	5.75 ± (10%)	5.33	2.207 ± (1.22%)	1.024720 ± (0.76%)
AE8138/b	1.004642 ± (0.05%)	5.75 ± (10%)	5.33	2.207 ± (1.22%)	1.079086 ± (0.90%)
AE8138/c	1.000925 ± (0.05%)	0.1645 ± (10%)	0.1537	2.169 ± (1.41%)	1.004189 ± (0.16%)
AE8138/d	1.002970 ± (0.05%)	0.1645 ± (10%)	0.1537	2.169 ± (1.41%)	1.013493 ± (0.16%)
AE8138/e	1.000880 ± (0.05%)	0.0124 ± (10%)	0.02	2.169 ± (1.41%)	1.003697 ± (0.15%)
AE8138/f	1.002872 ± (0.05%)	0.0124 ± (10%)	0.02	2.169 ± (1.41%)	1.012092 ± (0.15%)

Table VI. Double counting multiplication factor for the AE8138 reference samples.

$\gamma^D{}_{242}$ coefficients for each sample. These are fully corrected for sample dependent effects. The average values over each sample type therefore provide the best estimates of the chamber dependent γ–coefficients. Note that because of the limited number of data points, the error estimation given in Table VII. on the averaged count rate values have been derived by considering the internal deviation rather than the external one (i.e. scatter). To obtain the best fundamental γ–coefficients estimates chamber specific corrections must be considered.

Sample ID	Corrected double count rate ($cts \cdot s^{-1} \cdot g^{-1}$)	Standard deviation	Relative error (%)
AE8138/g	252.11	2.04	0.81
AE8138/a	249.80	2.03	0.81
AE8138/b	246.72	2.31	0.94
Averaged $^{238}PuO_2$	**249.54**	**2.13**	**.086**
AE8138/c	92.48	0.24	0.26
AE8138/d	92.36	0.22	0.24
Averaged $^{240}PuO_2$	**92.42**	**0.19**	**0.20**
AE8138/e	153.41	0.39	0.26
AE8138/f	153.16	0.31	0.20
Averaged $^{242}PuO_2$	**153.28**	**0.29**	**0.29**

Table VII. Sample specific corrected count rates for the AE8138 samples and the derived average isotopic responses used for the determination of $\gamma^D{}_{238}$ and $\gamma^D{}_{242}$.

A possible dependence of the gate utilization factor value with source neutron energy was investigated by performing a series of calculations with the gate utilization factor Monte Carlo code, MCF.[9, 10] This analysis showed that no measurable difference could be observed for the different neutron sources. The gate factor f_2 was therefore assumed constant with a value of 0.577 for all samples and no corrections were carried out.

The efficiency correction was assessed by performing MCNP™ calculations, the results of which are shown in Figure 2. For this purpose, the neutron energy spectra used in the calculations were represented by Maxwellian distributions, X(E), of the form given by Equation 14.

$$X(E) \approx C \cdot \sqrt{E} \cdot e^{\frac{E}{\theta_t}} \qquad (14)$$

where E is the neutron energy in MeV and θ is the evaporation temperature. This parameter was taken as 1.38 MeV, 1.27 MeV and 1.21 MeV for ^{238}Pu, ^{240}Pu and ^{242}Pu respectively, as recommended by Walsh, et al.[26] Uncertainties on these were taken to be of the order 0.03 MeV. The mean neutron energy, <E> is given by $3 \cdot \theta/2$. X(E)·dE represents the probability for a neutron to have an energy within dE about the value E and C is a normalization constant such that the integral of X(E) over all positive energy is equal to unity.

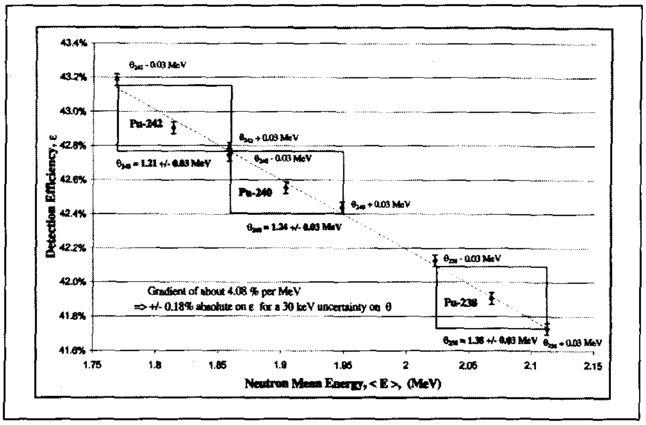

Figure 2. Detection efficiency of ^{238}Pu, ^{240}Pu and ^{242}Pu neutrons obtained from the Monte Carlo calculations performed for the N95 HENCC. Neutron energy distributions were taken as Maxwellian distributions with the given evaporation temperatures θ^{238}, θ^{240} and θ^{242}.

These calculations provided the detection efficiency values for the three isotopes ^{238}Pu, ^{240}Pu, and ^{242}Pu. The numerical values 41.92 percent, 42.58 percent, and 42.95 percent, respectively, are illustrated in Figure 2. Also shown in Figure 2 is the result of a sensitivity analysis that involved the recalculation of the detection efficiency for each isotope with θ adjusted both above and below its best estimate by one standard deviation. Based on this analysis, relative uncertainties on the efficiency values were estimated to be 0.43 percent. Further MCNP™ calculations for a ^{252}Cf source were also performed in order to derive a correction factor for these values to place them on an absolute scale.

Isotope	$\frac{\langle D^C_{2XX} \rangle}{\langle D^C_{240} \rangle}$	$\left(\frac{\varepsilon_{2XX}}{\varepsilon_{240}}\right)^2$	$\gamma^D{}_{2XX}$
^{238}Pu	2.7002 ± (0.88%)	0.9699 ± (1.22%)	2.784 ± (1.51%)
^{242}Pu	1.6586 ± (0.28%)	1.0156 ± (1.21%)	1.633 ± (1.24%)

Table VIII. The ^{240}Pu effective mass coefficients of ^{238}Pu and ^{242}Pu for double coincidence counting. The 2XX notation was adopted to describe quantities relative to the ^{238}Pu or ^{242}Pu response.

Comparison with the experimental detection efficiency of the N95 HENCC (see Section 3) showed that, for this purpose only, a factor 1.0394 ± 0.0073 should be applied to the MCNP™ results. For relative measurements, no scaling is needed.

The γ^D_{238} and γ^D_{242} coefficients corrected for isotope differences in detection efficiency were obtained by forming the ratios between the corrected specific count rates for ^{238}Pu and ^{242}Pu, R^C_{2XX}, with the corresponding ^{240}Pu response, R^C_{240}. These were then combined with the MCNP™ calculated detection efficiency square ratios, as shown in Table VIII.

The derived value of γ^D_{238} is 8.3 percent higher than the value estimated on the data of Holden and Zucker (see Table I). On the other hand γ^D_{242} is lower by 4.8 percent when compared with the similar data for ^{242}Pu. These new values therefore represent a significant change. The uncertainties in the present values are lower than those based on the literature values and in that sense represent an improvement. However for practical applications, it is the empirical γ–coefficients (i.e. uncorrected for detection efficiency) that matter. For the N95 HENCC, and similar counters, this work represents an accuracy improvement over and above that achieved for the fully corrected values, as the relative efficiency correction is limited in accuracy by the uncertainty in the emission spectra involved. It also quantifies the importance of allowing for the energy dependence of the detection efficiency.

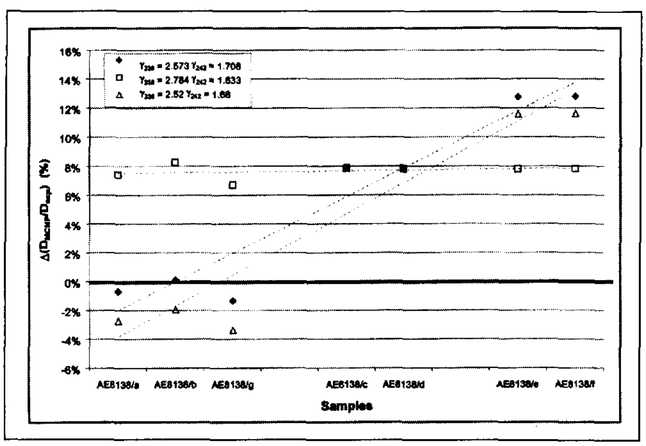

Figure 3. Comparison between double coincidence experimental count rates obtained for the AE8138 samples when measured with the N95 PNMC chamber and count rates derived from MCNP™ calculation and the various values of the γ^D_{238} and γ^D_{242} coefficients.

In order to investigate the validity of the new γ^D_{238} and γ^D_{242} values, the MCNP™ derived values for M_L, ε and f_2 have been used, as per Equation 2, to estimate the double coincidence count rates, D_{MCNP}, of the AE8138 samples. For these calculations, the spontaneous fission rate, γ, and ν_{S2} value were taken as 475.01 $fis.g^{-1}.s^{-1}$ and 3.7889 fis^{-1} respectively.[7] Different combinations of γ^D_{238} and γ^D_{242} values were then used in the expression of m_{eff} in order to compare their effect on the predicted count rates. The results for three sets of γ^D_{238} and γ^D_{242} values have then been compared with the experimental double coincidence rates, D_{exp}. The relative ratios for each type of sample are plotted in Figure 3. The three γ–sets correspond to the values derived from Reilly et al. (γ^D_{238}= 2.52, γ^D_{242}= 1.68),[16] Holden and Zucker (γ^D_{238}= 2.573, γ^D_{242}= 1.708)[7, 13] and the present work. Figure 3 clearly shows that results obtained using the new set of γ^D_{238} and γ^D_{242} values return consistent count rates, that is with no trending from sample to sample, with an average bias of 7.68 ± 0.49 percent above the measured results. The reason for the bias is a combination of uncertainties in the absolute value of $\gamma \cdot \nu_{S2}$ product for ^{240}Pu, error in the MCNP™ ^{240}Pu(SF,n) detection efficiency and the error in the f_2 estimate.[10,27] The bias can easily be removed by normalization as part of the system calibration. On the other hand, the two other sets present strong trends between ^{238}Pu, ^{240}Pu, and ^{242}Pu results.

In practical terms, using the γ^D_{238} and γ^D_{238} values derived in this paper corresponds to changes in the w_{eff} mass up to 0.25 percent depending on the type of material, when compared with value obtained with the Holden and Zucker set. This is illustrated in Table IX for a representative range of plutonium isotopic compositions and material types. For safeguards application aiming at bias-free accountancy verification measurements with an accuracy of 0.2 percent or better, it is clear that this level of previously unidentified systematic error is unacceptable.

Sample	w_{eff}(%) Previous evaluation	w_{eff}(%) New evaluation	Difference (%)
PuO_2 LWR low burnup (SM1)	6.413	6.413	0.01
PuO_2 LWR high burnup (SM4)	37.877	37.801	0.20
IRMM MOX pellet	35.214	35.162	0.15
SAL MOX pellet	37.366	37.281	0.23

Table IX. Comparison of w_{eff} values obtained using different sets of γ^D_{238} and γ^D_{242} coefficients for various types of nuclear material assayed at the OSL laboratory.

6. Derivation of the γ^T_{238} and γ^T_{242}

The calculation of γ^T_{238} and γ^T_{242} followed a similar approach to the one used for the derivation of γ^D_{238} and γ^D_{238}. The sample specific effects were first taken into account to derive the corrected specific triple coincidence count rates, shown in Table X. The resulting ϕ_3 values, also shown in

Table X, were evaluated using the leakage self-multiplication values and the α values of Table VI along with newly evaluated data for the triples counting κ coefficients.[12]

Sample ID	ϕ_3	Corrected triple count rate ($cts \cdot s^{-1} \cdot g^{-1}$)	Relative error (%)
AE8138/g	1.0160±(1.57%)	33.340	1.77
AE8138/a	1.0511±(1.55%)	32.736	1.63
AE8138/b	1.1659±(1.66%)	31.719	1.83
Averaged $^{238}PuO_2$		**32.598**	**1.75**
AE8138/c	1.0140±(0.60%)	12.188	0.88
AE8138/d	1.0454 ±(0.59%)	12.163	0.83
Averaged $^{240}PuO_2$		**12.176**	**0.70**
AE8138/e	1.0129 ±(0.57%)	20.009	0.84
AE8138/f	1.0424 ±(0.56%)	19.800	0.71
Averaged $^{242}PuO_2$		**19.904**	**0.64**

Table X. Sample specific corrected count rates for the AE8138 samples and the derived average isotopic responses used for the determination of γ^T_{238} and γ^T_{242}.

Isotope	$\frac{<T^C_{2XX}>}{<T^C_{240}>}$	$\left(\frac{\varepsilon_{2XX}}{\varepsilon_{240}}\right)^3$	γ^T_{2XX}
^{238}Pu	2.6773 ± (1.88%)	0.9551 ± (1.83%)	**2.803 ± (2.63%)**
^{242}Pu	1.6348 ± (0.95%)	1.0235 ± (1.82%)	**1.597± (2.05%)**

Table XI. The ^{240}Pu effective mass coefficients of ^{238}Pu and ^{242}Pu for triple coincidence counting. The 2XX notation was adopted to describe quantities relative to the ^{238}Pu or ^{242}Pu response.

The values for γ^T_{238} and γ^T_{242} given in Table XI have been determined with better precision in this work than they can be estimated from basic nuclear data in the literature (see Table I). In the case of ^{238}Pu the improvement is a factor of about five times in the relative standard deviation. These γ^T_{238} and γ^T_{242} values represent the ^{240}Pu-effective mass coefficient to be used if accounting for the specific detection efficiencies of the three plutonium isotopes. These were used in a predictive count rate study, similar to the one performed for the double coincidence coefficients. This is shown in Figure 4. This analysis also shows that the values

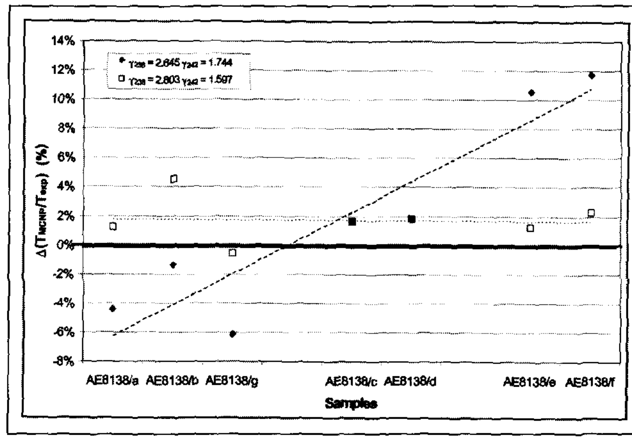

Figure 4. Comparison between triple coincidence experimental count rates obtained for the AE8138 samples when measured with the N95 PNMC chamber and count rates derived from MCNP™ calculations and the previous values of the γ^T_{238} and γ^T_{242} coefficients.

derived in the present paper return a constant bias between MCNP™ calculations and experimental measurements.

In practical applications, when the detection efficiency is assumed independent of the neutron's isotopic origin, the empirical $\frac{<T^C_{2XX}>}{<T^C_{240}>}$ values are what matters. These include the inherent behaviour of the neutron chamber, particularly the efficiency variation with nuclide. To date, it has been assumed that these ^{238}Pu and ^{242}Pu mass coefficients for double and triple counting are equivalent. The present results show that for the N95 HENCC, and generically for similar type of instruments, this assumption is reasonable within the limits of the present experimental uncertainties. For the N95 HENCC chamber, a suitable choice of γ–values would be 2.696 and 1.657 in the case of ^{238}Pu and ^{242}Pu respectively, based on weighted mean of the doubles and triples values.

7. Conclusions

This work has shown how to derive from experimental data the ^{240}Pu effective mass coefficients of ^{238}Pu and ^{242}Pu for both double and triple passive neutron coincidence counting. The results obtained for γ^D_{238} and γ^D_{242} represent an improved precision by a factor of two compared to values derived from nuclear data. These newly recommended values lead to changes in the ^{240}Pu effective mass of typical high burn-up materials by up to 0.25 percent. A better agreement between Monte Carlo calculations and experiment was obtained when the new γ–values were used in the calculations, rather than when previous estimations of the γ–coefficients were used. The calculated γ^T values also showed improvements on the precision by a factor of five. These results confirmed within experimental uncertainties that the γ^D and γ^T values are equivalent.

It is recommended for passive neutron coincidence counters similar in design to the N95 HENCC that the empirical γ–values reported in this work (γ^D_{238}= 2.696 and γ^D_{242}= 1.657) should be used in calibration and assay work where high level accuracy is required. For systems that are of significantly different design, the fully corrected fundamental γ–coefficient reported in this paper (γ^D_{238} = 2.80 and γ^D_{242} = 1.59) should be used but adjusted according to the method described to account for the variation in neutron detection efficiency.

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References

1. Stewart, J.E., H.O. Menlove, D. R. Mayo, K. E. Kroncke, F. A. Duran, B. S. Cordova, D. G. Langner, and C. D. Rael. 1999. The epithermal neutron multiplicity counter (ENMC), faster plutonium assay by factors 5-20. *Proceedings of the 40th INMM Annual Meeting.*
2. Lambert, T., J. L. Dufour, N. Lethuaire, and B. Thaurel. 1999. Mesures des quantités de plutonium dans les fûts de déchets par comptage neutronique passif (FUNE). *Proceedings of the 21st Annual ESARDA Symposium.*
3. Chard, P.M.J., S. Croft, I. G. Hutchinson, D. J. Lloyd, and C. G. Wilkins. 2000. Measurement of the plutonium content of intermediate level waste in the Sellafield Drypac Plant by passive neutron coincidence counting. *Proceedings of the Seventh Nondestructive Assay Waste Characterization Conference.*
4. Böhnel, K. 1978. Die Plutoniumbestimmung in Kernbrennstoffen mit der neutronenkoinzidenz-methode. *Kernforschungszentrum, Karlsruhe.* English Translation AWRE TRANS 70 (54/4252).
5. Böhnel, K. 1985. The effect of multiplication on the quantitative determination of spontaneously fissioning isotopes by neutron correlation analysis. *Nuclear Science and Engineering*, 90, 75-82.
6. Cifarelli, D.M. and W. Hage. 1986. Models for a three parameter analysis of neutron signal correlation measurements for fissile material assay. *Nuclear Instruments and Methods in Physics Research*, A251, 550-563.
7. Croft, S. and P.M.J. Chard. 1993. Neutronic Characterisation of Plutonium Oxide Reference Samples at Harwell. *Proceedings of 15th ESARDA Symposium.*
8. Ottmar, H., P. Van-Belle, S. Croft, P. M. J. Chard, L. C-A. Bourva, and U. Blohm-Hieber. 1999. An empirical measurement of the specific ^{240}Pu effective mass of ^{238}Pu and ^{242}Pu. *Proceedings of the 21st Annual ESARDA Symposium.*
9. Bourva, L. C-A. and S. Croft. 1999. Monte Carlo calculations of the neutron coincidence gate utilization factor for passive neutron coincidence counting. *Nuclear Instruments and Methods in Physics Research*, A431, 485-508, (1999).
10. Croft, S. and L. C-A. Bourva. 2000. The measurement of passive neutron multiplicity counter gate utilization factors and comparisons with theory. *Nuclear Instruments and Methods in Physics Research,*
11. Ensslin, N. 1985. A simple self-multiplication correction for in-plant use. *Proceedings of the Seventh Annual ESARDA Symposium on Safeguards and Nuclear Material Management.*
12. Bourva, L. C-A., S. Croft, and D. R. Weaver. 2000. Evaluation of the Induced to Spontaneous fission neutron multiplicity distribution coefficients for passive neutron multiplicity counting of plutonium and MOX. *Proceedings of the 41st INMM Annual Meeting.*
13. Holden, N. E. and M.S. Zucker. 1985. A re-evaluation of the average prompt neutron emission multiplicity (Nubar) values from fission of uranium and transuranium nuclides. Nuclear Standard Reference Data, IAEA-TECDOC-335.
14. Davidson, D., J. Verplancke, P. Vermeulen, H. O. Menlove, H. G. Wagner, B. Brandalise, and M. Stutz. 1993. A new high accuracy combined neutron/gamma counter for in-glove box measurement of PuO_2 and MOX safeguards samples (OSL-counter). *Proceedings of the 15th ESARDA Symposium.*
15. Chard, P. M. J., S. Croft, and P. B. Sharp. 1995. Characterisation of the Harwell N95 High Efficiency Passive Neutron Counter. *Proceedings of the 17th Annual ESARDA Symposium.*
16. Reilly, D., N. Ensslin, H. Smith Jr., and S. Kreiner (Ed.) 1991. Passive nondestructive assay of nuclear material. 1991 Nuclear Regulatory Commission publication NUREG/CR-5550. Also known as LA-UR-90-732, ISBN 0-16-032724-5, Chapter 16. Principles of neutron coincidence counting by N. Ensslin, 457-491.
17. Croft, S. and A. R. Yates. 1999. The characterisation of NMAS-12; A passive neutron coincidence counter for use at Dounreay. *Proceedings of the 21st Annual ESARDA Symposium.*
18. N. Dytlewski. 1991. Dead-time corrections for multiplicity counters. *Nuclear Instruments and Methods in Physics Research, A305, 492–494.*

19. Certificate of calibration of a californium neutron source, serial number 8761 NC. Reference N526, National Physical Laboratory, December 22, 1998.
20. Croft, S., G. Wakefield, P. M. J. Chard, K. P. Lambert, and D. J. Lloyd. 1993. Aspects of neutron multiplicity counting at Harwell. *Proceedings of the 15th Annual ESARDA Symposium.*
21. Breismester, J. F. Ed. 1997. MCNP™ A general Monte Carlo N Particle transport code (Version 4B). *Manual LA-12625-M.*
22. Wiltshire, R. AEA Technology Harwell. Private communication.
23. Crossley, D., S. J. Firkin, J. J. Green, and J.A Lee. 1993. The preparation of characterised encapsulated plutonium alloy foils for use as calibration standards for NDA techniques. *Proceedings of the 15th Annual ESARDA Symposium.*
24. Zucker, M. S. and N.E. Holden. 1987. Neutron multiplicity for neutron induced fission of ^{235}U, ^{238}U and ^{239}Pu as a function of neutron energy. *IAEA-SM-293/122, 329-347.*
25. West, D. and A. C. Sherwood. 1982. Measurement of thick target (α,n) yields from light elements. *UKAEA Harwell Laboratory Report* AERE-R10502.
26. Walsh, R. L., G. Chircu, and D.G. Madland. 1991. Calculation of fission neutron spectra for spontaneous fission of ^{240}Pu, ^{238}Pu and ^{242}Pu. *Nuclear Science and Engineering*, 108, 109-115.
27. Bourva, L. C-A., S. Croft, H. Ottmar, and D. R. Weaver. 1999. MCNP™ modelling of a combined neutron/gamma counter. *Nuclear Instruments and Methods in Physics Research,* A426, 503-517.
28. Ottmar, H. ITU Karlsruhe, Private communication, August 1999.

Civil Remote-sensing Satellites and a Fissile Material Cutoff Treaty: Some Case Studies on Verifying Nonproduction

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Abstract

A universal fissile material cutoff treaty (FMCT), which bans the production of fissile material for nuclear weapons, has long been seen as a key building block in nuclear disarmament and nonproliferation. There remains strong support for the prompt negotiation and conclusion of an FMCT, as demonstrated by the 2000 NPT Review Conference's call for the Conference on Disarmament to commence negotiations immediately with a view to their conclusion within five years. The principle focus in negotiating the FMCT will be verification. FMCT verification would focus in the first instance on the past military nuclear production facilities in the five nuclear weapon states and the three *de facto* nuclear states. After an FMCT, most of these facilities would be shut down. This paper explains how civil remote-sensing satellites would be useful in verifying the shutdown status of plutonium production reactors, reprocessing plants, and uranium-enrichment plants used to produce fissile material for weapons in the past. The satellites considered are the new-generation satellites with fine spatial resolution images in the visible and near infrared band (VNIR). It is concluded that high-resolution commercial satellite VNIR imagery would play a valuable role in monitoring, nonintrusively, the shutdown status of these nuclear facilities under an FMCT.

Introduction

Fissile material, in practice plutonium and highly enriched uranium (HEU),[1] is the fundamental ingredient in all nuclear weapons. It is also the most difficult and expensive part to produce. A fissile material cut-off treaty, which bans the production of fissile material for nuclear weapons, is therefore one key building block in a comprehensive strategy to limit the proliferation of nuclear weapons and eventually eliminate them. Proposals to achieve a fissile material cut-off agreement can be dated to the mid-1950s. Since then various diplomatic efforts have been undertaken. In 1993, the United Nations General Assembly adopted a resolution calling for the negotiation of a nondiscriminatory, multilateral, and internationally and effectively verifiable treaty banning the production of fissile materials for nuclear weapons or other nuclear explosive devices.[2] In March 1995, the Geneva-based Conference on Disarmament (CD) agreed to a mandate to begin negotiations on an FMCT. After several years' delay caused by debates over scope and linkage to nuclear disarmament measures, the CD agreed on August 11, 1998, to convene an *ad hoc* committee to negotiate an FMCT. However, the negotiations quickly ended when the CD failed to agree on renewing the committee's mandate. There remains strong support for the prompt negotiation and conclusion of an FMCT, as demonstrated by the 2000 NPT Review Conference's call for the CD to commence negotiations immediately with a view to their conclusion within five years.[3] At the time of writing, however, the CD remains deadlocked over the resumption of negotiations. And the situation is unlikely to change soon, if U.S. national missile defense goes forward.

A primary goal of an FMCT will be to have the five declared nuclear weapon states (the United States, Russia, the United Kingdom, France, and China) and the three *de facto* nuclear weapon states (India, Pakistan, and Israel) become parties. Almost all other countries will already in effect be subject to its requirements by virtue of being party to the NPT as nonnuclear weapon states (NNWS). Under an FMCT, the eight nuclear nations would end production of nuclear weapon-usable fissile material for weapons purposes. Any weapons-usable material that was subsequently produced would be under international safeguards to ensure that it was used only for nonexplosive uses allowed under the treaty.

The principle focus in negotiating the FMCT will be verification. The scope of verification will depend on the facilities and activities subject to an FMCT. In principle, all facilities and activities that produce, use, or store weapons-usable fissile material would be subject to FMCT verification: reprocessing facilities, uranium enrichment facilities, uranium-fueled reactors, tritium production reactors, naval power reactors, uranium and plutonium storage facilities, and fuel-fabrication facilities. However, the scope of verification is open to negotiation, and many options have been proposed.[4] Whatever the scope, FMCT verification must cover the following three classes of facility: declared production facilities that continue to operate; declared production facilities, which have been shut down; and undeclared production facilities.

Appropriate verification measures should be applied in each case. The basic FMCT verification measures will include safeguards at declared facilities similar to those administered by the IAEA, including onsite inspections to determine the accuracy and veracity of the accounting system; challenge inspections involving managed access; environmental monitoring; and remote sensing involving satellite imagery.

For the detection of undeclared production facilities, an FMCT verification system would require the use of the IAEA safeguards system, environmental monitoring techniques, and satellite imagery. In May 1997, the IAEA Board of Governors adopted an additional safeguards protocol to expand existing safeguards agreements and improve the IAEA's ability to detect the undeclared production of fissile material.[5] This new system has opened the door for the IAEA to use all types of information, including commercial satellite imagery. The IAEA is now studying the use of such satellite imagery to strengthen safeguards.[6]

Most importantly, FMCT verification would focus, in the first instance, on the eight nuclear states' past military nuclear-production facilities. After the FMCT enters into force, all these facilities should be declared. Some would continue operating to produce civil nuclear power or to produce fissile material for nonexplosive military uses. For example, reactors might continue to operate for research or isotope production along with necessary hot-cell or reprocessing facilities; HEU may continue to be produced for naval propulsion or possibly for research reactors. For these operating facilities, satellite imagery would be less useful for verification. The verification measures necessary for these facilities would be primarily strengthened IAEA safeguards, as currently being applied to NNWS under the NPT.[7] It is expected that the activities safeguarding such operating facilities will require most of the resource available for the FMCT verification. However, most of the nuclear states' production facilities would be declared and shut down. Thus, one important task of the FMCT verifications will be to affirm the status of these closed facilities. This paper will focus on the verification of those shutdown facilities.

The verification will generally require both onsite and offsite inspection. However, some of the eight nuclear states may resist onsite inspections at their more sensitive production facilities and sites as being too intrusive. An FMCT is likely to permit the retention of undeclared stockpiles from past production and the use or processing of fissile material already produced for sensitive military activities. In addition, the permitted sensitive production facilities and activities could be colocated with past nuclear production facilities. Some states may worry about potential loss of sensitive information at such sites. Some onsite safeguards and environmental sampling might be seen as too intrusive and might not be permitted. Less intrusive verification measures, such as satellite remote sensing, would therefore be preferable. In this article, I will explore how civil remote-sensing satellites could be useful in verifying the shutdown status of reprocessing plants, plutonium production reactors, and uranium-enrichment plants. This article will focus on the new roles of remote-sensing satellite imagery at VNIR wavelength in such verification. It should be noted that once nuclear production facilities are operating, in a number of cases, the heat signatures would be detected by satellite infrared imaging as well.[8]

The Status of Past Military Nuclear Production Facilities

Plutonium production reactors. The United States has shut down all fourteen of its plutonium production reactors. Russia has similarly shut down ten of its thirteen graphite-moderated plutonium-production reactors. Russia's remaining three plutonium-production reactors operate only to produce heat and electricity for nearby towns.[9] Britain operates eight small plutonium-production reactors to generate electrical power and tritium.[10] France has shut down three production reactors; two others continue to operate to produce tritium for nuclear weapons.[11] France also operates the Phéonix demonstration breeder reactor that may in the past have produced plutonium for weapons. However, all plutonium separation activities in Britain and France are now subject to Euratom and IAEA safeguards.

China is believed to have built two medium-sized graphite-moderated, water-cooled plutonium-production reactors: the first at Jiuquan and the second at Guanyuan. Each has its own dedicated reprocessing plant. Chinese officials have indicated that China's production of plutonium for weapons was halted in 1991.[12] This should mean that the production reactors and associated reprocessing plants have been shut down. In the future, Israel, India, and/or Pakistan may shut down reactors currently producing plutonium for weapons.[13]

Reprocessing plants. The United States has shut down its military reprocessing plants at its Hanford and Idaho sites formerly used, respectively, for plutonium production and the recovery of HEU from spent naval and research reactor fuel. Russia's military reprocessing facilities at Tomsk-7 and Krasnoyarsk-26 are still operating, separating spent fuel discharged from the three operating plutonium production reactors. However, the plutonium separated from the two reprocessing plants would be monitored by a U.S.-Russian still-to-be-fully implemented agreement.

There are four reprocessing facilities in Britain. The B204 plant at Sellafield is shut down. The B205 reprocessing plant is already under Euratom safeguards when handling civil fuel. The Thorp and Dounreay reprocessing plants are also under Euratom and IAEA safeguards. France has three reprocessing plants. UP1 at Marcoule is shut down. The UP2 and UP3 plants at La Hague are partially under IAEA safeguards. China has two reprocessing plants at Jiuquan and Guangyuan respectively. As previously mentioned they are likely to have been shut down. Under a production moratorium, India could shut down its Tarapur reprocessing plant and not commence reprocessing operations at its Kalpakkam plant. The Trombay reprocessing plant could be shut down as well.[14]

Uranium-enrichment facilities. All known military uranium-enrichment plants in these eight states are either gaseous diffusion or gas centrifuge plants. However, R&D on laser enrichment is well advanced in a number of countries. Between 1943 and 1956, the United States constructed three gaseous diffusion plants (GDPs) at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. The Oak Ridge plant has been shut down. The United States also has shut down the HEU portion of Portsmouth GDP and now produces only low-enriched uranium (LEU) for fueling commercial nuclear power reactors. The Paducah GDP is also operating to produce LEU for civilian purpose. The U.S. Enrichment Corp. (USEC) hopes to replace these GDPs with more energy-efficient enrichment plants.[15] Russia's uranium-enrichment facilities are located at four sites: Sverdlovsk-44 (Novouralsk), Krasnoyarsk-45 (Zeleznogorsk), Angarsk, and Tomsk-7 (Seversk). GDPs were built at all sites between 1949 and the end of the 1950s. During the following three decades, all four facilities were converted to more energy-efficient centrifuge enrichment plants (CEPs). All sites now produce LEU for power reactors.

Britain has shut down its Capenhurst GDP, which was used to produce HEU for weapons and naval-reactor fuel in the past. Two CEPs have been built at the same site. Both are now used for commercial purposes and are under both IAEA and Euratom safeguards. France also has shut down its military GDP at Pierrelatte that produced HEU for weapons. The Eurodif GDP at Tricastin, which started operation in 1979, produces LEU for nuclear power reactors.

China began producing HEU in 1963 at a GDP located near Lanzhou and, in the mid-1970s, started production at a second GDP in Heping. It has been reported that both GDPs stopped HEU production in 1987 and that the Chinese government is preparing to decommission a number of military nuclear material processing facilities, including the Lanzhou GDP.[16] The Heping GDP may also be shut down, as China is building enough CEP capacity to supply its LEU needs.[17] This CEP capacity, which is being built for China by Russia, is to be under IAEA safeguards. Pakistan has a CEP at Kahuta which began operation in the middle of 1980s and, according to 1987 press reports, was building a CEP in Golra as well.[18] Both Israel and India have reportedly carried out research and development on centrifuge enrichment, but there is no public report they have yet produced a significant amount of weapon-grade uranium.

The Current Capability of Civil Remote-sensing Satellites

Since the early 1960s, the USSR/Russia and United States have used military reconnaissance satellites (as part of their so-called national technical means (NTM) of verification) to identify and monitor each other and other countries' nuclear facilities and activities. The current capabilities of these systems are estimated to have a ten-centimeter resolution. However, not all countries have access to such capabilities, and those that have them are not willing to share widely the resulting information.

However, lower-resolution observation satellites have become available for civilian purposes, starting with the launch of the U.S. Landsat-1 (with eighty-meter resolution) in 1972. Landsat-4 and -5, with a resolution of thirty meters, were launched in 1982 and 1984 respectively. Landsat-7, launched in April 1999, has begun providing fifteen-meter resolution panchromatic images, in addition to thirty-meter-resolution multispectral images. In 1986, France launched SPOT-1 with a resolution of 10 meters in panchromatic mode and 20 meters in multispectral mode. SPOT-5, scheduled to be launched in 2002, will have a resolution of three meters. Since 1990 the USSR/Russia has marketed imagery from its KVR-1000 satellite with a resolution down to five meters. India's IRS-1C and IRS-1D were successfully launched into orbit in December 1995 and September 1997 respectively, each with a resolution of 5.8 meters. Now Russia's SPIN-2 (Space Information-two meters) also provides two-meter-resolution images dating back to 1970s.[19] In addition, a larger number of older images of nuclear facilities with about two-meter- and three-meter resolutions have recently become available as a result of the declassification of U.S. Corona panchromatic satellite images taken by the U.S. KH-4 intelligence satellites from 1960 to 1972.[20]

The capabilities of commercial observation satellites are being dramatically improved and a new space race in this field has begun. On March 9, 1994, the U.S. government decided to allow U.S. companies to build and launch private observation satellites that can obtain imagery with one-meter or better resolution.[21] On September 24, 1999, the U.S. firm Space Imaging launched the first such satellite—IKONOS—with a one-meter-resolution panchromatic sensor and a four-meter-resolution multispectral sensor. Also, the Russian firm Sovinformsputnik has started recently to sell Russian one-meter ground resolution satellite images to customers all over the world. Other companies, such as the U.S. companies Earth Watch and Orbimage, and the Israeli firm West Indian Space, plan to launch their high-resolution commercial imaging satellites soon. It is expected that a dozen or so such satellites from several different countries will be in orbit over the next few years. All of these new-generation commercial observation satellites have one-meter resolution and relatively short revisit intervals (one to five days).

It will be shown (in the following sections) that, unlike the previous generation of commercial satellites with medium-resolution satellite images,[22] the new high-resolution commercial satellite images can detect and identify the major visible characteristics of nuclear production facilities and sites and provide a useful means to monitor their shutdown status.

Case Study I: Monitoring the Shutdown Status of Plutonium-production Reactors

One major characteristic feature associated with a reactor is its cooling system. While the reactor is operating, and for a time after shutdown, removal of heat from the reactor core is essential to prevent a meltdown of the reactor fuel. A variety of cooling systems for dissipating the waste heat into the environment exist, including the use of cooling towers and once-through condenser cooling with river or seawater.

Reactors using cooling towers most often use the "wet" type, in which cooling is caused mainly by evaporation from drops or films of water to a flow of air. In all types of towers, the heat is removed by an air flow. The flow may be caused by mechanical means (e.g. by a fan) or by making use of natural-draft. In practice, there are two common forms of wet towers, mechanical-draft towers and natural-draft towers, which differ in the manner in which the air flow (or draft) is produced. Mechanical-draft wet cooling towers consist of a number of individual units. Each unit generally covers a ground area of a couple of hundred square meters and is more than ten meters high. At the top of each unit is a vent with a fan, roughly of several meters in diameter.[23] As far as we know, among these military plutonium production reactors only Pakistan's Khushab reactor and Israel's Dimona reactor[24] use mechanical-draft cooling towers. Other production reactors with cooling towers use natural-draft hyperbolic cooling towers. To produce sufficient draft, the natural-draft hyperbolic cooling towers are typically very large: several tens of meters high and more than ten meters in diameter at the top. Most important for verification, in most cases a plume should be visible above the tower when the reactor is operating.[25] Since the diameter of the vent or tower exit is generally more than several meters, the plume should be easy to detect with one-meter-resolution satellite images. Since it requires at least several weeks' irradiation to produce a practical concentration of plutonium in reactor fuel,[26] the revisit time of several days for current commercial satellites should be adequate detecting such operation of the plant.

Figure 1 shows a one-meter-resolution IKONOS satellite image (acquired in February 2000) over Pakistan's Khushab plutonium-production reactor. The sizable reactor containment (dome), the mechanical draft cooling tower (with eight vents), the high, narrow stack (for safe disposal of leaks of radioactive gases from failed fuel elements), and the security fence are clearly visible. It is reported that this unsafeguarded reactor was completed in 1996 and started operating in 1998. This reactor is likely to make an important contribution to Pakistan's nuclear weapons program, in addition to its older Kahuta uranium-enrichment facility. The reactor power is estimated at 40-70MWth, capable of generating enough plutonium for one to four nuclear weapons annually.

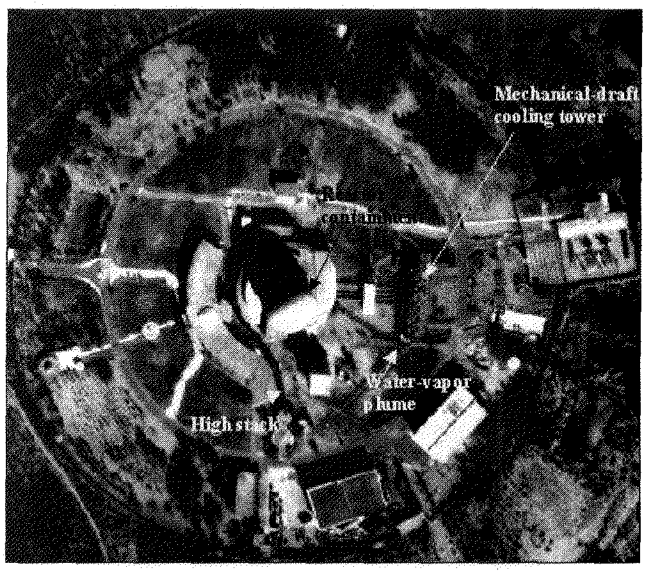

Figure 1. *One-meter-resolution IKONOS satellite image of Khushab reactor, Pakistan. This image was taken in February 2000. The reactor containment, high stack, and mechanical-draft cooling tower with eight vents on the top can be clearly seen in the image. Also visible is a trace of water-vapor plume coming out of the south end vent of the tower. Credit: Spaceimaging.com.*

Most importantly in the image, one can see clearly a trace of water vapor plume coming from the cooling tower, which means that the reactor was operating when the image was acquired. Under an FMCT, if the reactor is shut down, there should be no water vapor plume coming from the cooling towers. It should be noted that this one-meter-resolution image also shows much more detail of the reactor facilities than a ten-meter-resolution SPOT image acquired on May 21, 1992, over the same site that cannot permit identification of the dome, the cooling towers, or the high stack, (the most visible features of a reactor). So the medium-resolution images provide less direct and convincing evidence for the presumed reactor site and thus the operation of the reactor.

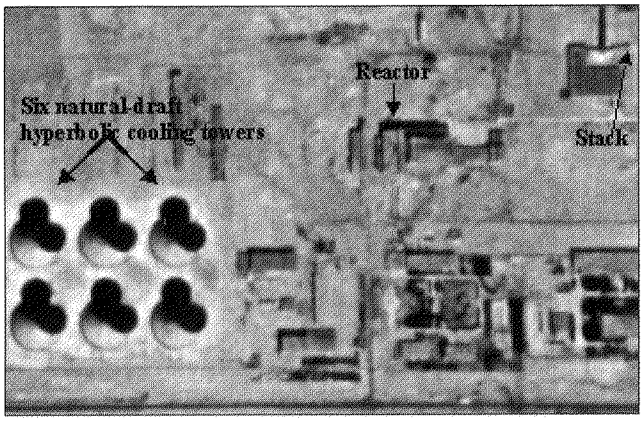

Figure 2: *A declassified U.S. Corona satellite image of cooling towers associated with two Russian plutonium-production reactors at Seversk (formerly Tomsk-7) (September 15, 1971, KH-4B system with six-foot spatial resolution).*

Figure 2 shows a Corona satellite image of an area containing two Soviet/Russia plutonium-production reactors then operating at Seversk (Tomsk-7). In this 1.8-meter-resolution image, the physical structures of the natural-draft cooling towers, and the vapor plumes at some of their tops, can be seen clearly. The clarity of a commercial satellite image with a one-meter resolution should be sharper. The two reactors associated with the cooling towers were decommissioned in 1990 and 1992. Therefore, now there should be no vapor plumes coming out of the cooling tower. The same technique could be used to verify the shutdown of China's first plutonium-production reactor in the Jiuquan complex, which has six large cooling towers and reportedly was shut down in 1984.[27]

It should be noted that it is generally assumed that the thermal signature from the towers should be detected by satellite thermal infrared (TIR) images.[28] However, detection could be complicated by a number of factors, such as the capability of the TIR, the size of towers, the power of the reactors, and the ambient conditions. The inability of the Landsat-4, -5 TIR detectors to detect plumes from some towers is therefore not surprising.[29] Also it is estimated that the current satellite TIR sensors, such as that of Landsat-5 and -7, might not be able to detect the warmer water vapor plumes from the towers associated with the Khushab reactor and Dimona reactors.[30] Finally, unlike the case of cooling towers, some production reactors using a "once-through" cooling system, such as C and L reactors at the U.S. Savannah River Site, discharged their hot water through streams and swamps into the Savannah River. The Hanford reactors discharged their hot water into the Columbia River. India's Dhvrua and Cirus research reactors at Trombay discharge their hot water into a bay. For such cases, a number of studies have shown that the discharged hot water would be highly visible at thermal infrared imagery—even at low resolution.[31]

Case Study II: Monitoring the Shutdown Status of Reprocessing Plants

To obtain separated plutonium for nuclear weapons, a reprocessing plant must be built where plutonium is chemically extracted from the spent fuel discharged from a reactor. Reprocessing plants can be identified using satellite imagery because of their distinctive physical structures. Figures 3a and 3b show one-meter resolution IKONOS images of India's Trombay reprocessing plant used to support the Indian nuclear weapons program. The reprocessing building and the high stack (for discharge of gaseous fission products released during reprocessing) are clearly observable. This medium-scale reprocessing plant was commissioned in 1964. It reprocesses spent fuel from the Cirus and Dhruva reactors, with a capacity of about fifty metric tons per annum. It is believed that this facility provided plutonium for India's nuclear explosions in both 1974 and 1998. Also the image shows clearly the trucks/

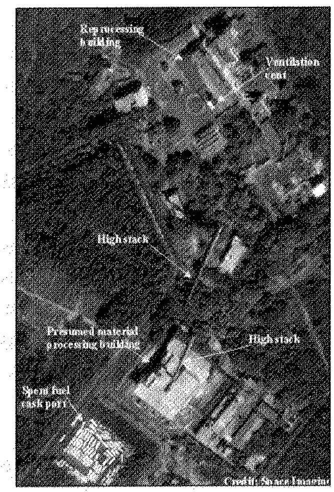

Figure 3a: *A IKONOS satellite image over India's reprocessing plant at Trombay. This 1m-resolution image was taken on February 27, 2000. The reprocessing building, high stacks, and spent-fuel cask port can be clearly seen in the image.*

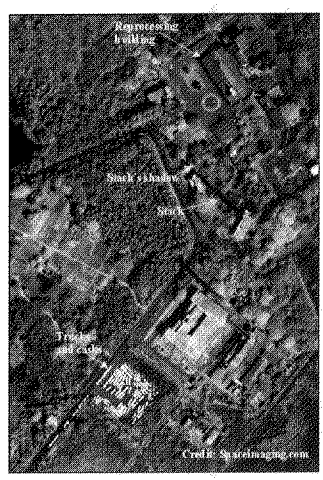

Figure 3b: *One-meter-resolution IKONOS image (in April 2000) of the reprocessing plant at Trombay, India. Comparison with figure 3a, one can observe the number and positions of trucks/casks on the road and the port have some changes. This could indicate some shipment activities occurred during this period.*
Credit: Spaceimaging.com.

casks in the road and the shipment port. These trucks are presumably used to ship cut spent fuel rods from the Cirus reactor. The reprocessing building at the Trombay site is smaller than that, for instance, at Seversk (Tomsk-7) in Russia.[32]

For satellite monitoring of the status of a reprocessing plant, the most likely observable characteristics would be the activity level. When a large reprocessing plant is operating, there will be many shipments of various forms of nuclear material. If the plant is closed, activity levels should be very low or absent. For example, there should be no shipments moving at the railroad cask portals (the portals for rail-mounted shipping casks from the reactor), no activity at the shipping dock (loading point for plutonium product), and no activity at the cold feed loading point (reprocessing requires a periodic feed of fresh chemicals). For these activities, transport vehicles, such as trucks, should be big enough to be detected by one-meter-resolution images from satellites.

Similarly, the activity level at a medium-scale reprocessing plant should be monitorable. As shown in figures 3a and 3b, the trucks/casks used to ship spent fuel from the reactor site to the reprocessing plant are clearly seen in the road to the port. Comparing Figures 3a and 3b we can see the number and positions of trucks on the road have changed, which could indicate some shipment activity during this period. If a reprocessing plant is closed, the activity level should be very low or nonexistent.

However, it would be too difficult to monitor the cases of using an underground transport tunnel between reactors and reprocessing plants or the reactor connected with the reprocessing facilities. In addition, shipments could be made at night. A reprocessing plant would have no evident thermal signatures for commercial satellite TIR imaging to detect. Satellite imagery could however be supplemented with other verification measures, such as offsite sampling of the air for the Kr-85 released when spent fuel is dissolved.

Case Study III: Monitoring the Shutdown Status of Uranium-enrichment Facilities

Under an FMCT, most of past military GDPs will shut down, because they are energy inefficient and therefore much more costly to operate than the uranium-centrifuge enrichment plants with which they are being replaced. A GDP cannot operate without a cooling system because it consumes huge amounts of electrical energy and more than 90 percent of the electrical energy is converted into compression heat which is dissipated by cooling towers or into a local water body via cooling water. Most GDPs, other than those in Russia, have wet-cooling towers, such as the three U.S. GDPs (at Oak Ridge, Paducah, and Portsmouth). China's GDP (at Lanzhou) uses mechanical draft cooling towers. The UK's GDP at Capenhurst uses a natural-draft cooling tower.

As discussed in the case of reactors, when cooling towers of a GDP are operating, white water vapor plumes will ordinarily be seen emerging from there tops. Similarly, such water vapor plumes would be seen in the satellite VNIR images. Because of their large inventory of in process UF_6, the time required for a GDP producing 90 percent U235 to reach equilibrium is about two to three months. A satellite revisit time of several days and one-meter resolution should therefore be adequate for detection of GDP operation.

Figure 4 shows a Landsat-5 VNIR image of the U.S. uranium GDP at Portsmouth, Ohio, taken on March 12, 1994. The enrichment "cascade" is contained in three large, two-story buildings identified as X-333, X-330, and X-326. Each process building has its own cooling system that dissipates the waste heat into the environment through mechanical cooling towers. Even though the spatial resolution of the image is only thirty meters, the plume from the towers can be seen clearly. The plume images would be much clearer in a one-meter-resolution satellite image. We also expect that the same approach would be applicable to monitoring a medium-sized GDP such as China's GDP at Lanzhou. In addition, it should be noted that the hot roofs of the enrichment buildings of a GDP would be detectable by the modern satellite TIR detectors.[33]

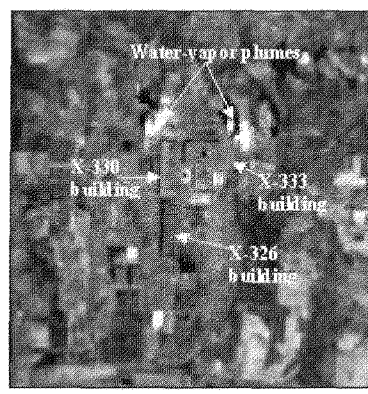

Figure 4: *Landsat-5 TM image at visible and near infrared bands taken March 12, 1994. This false-color image was combined with band 2 (green), band 3 (red) and band 4 (near infrared). The water-vapor plumes from the mechanical cooling towers at the northwest and northeast corners of the process building are clearly visible in the image. Source: U.S. Geological Survey.*

Monitoring a small CEP, such as that operated by Pakistan at Kahuta, would, however, be much more difficult. There are few observable operating signatures for VNIR images. Because of their small size and relatively low energy intensity, these plants do not require special cooling systems such as cooling towers. A recently released one-meter-resolution IKONOS image of the Khuhuta CEP provides much more detail than the ten-meter-resolution SPOT images did.[34] The enrichment buildings at south and north production area are clearly seen. But there is no visible operational evidence in the image. Also the TIR imaging system on current generation commercial satellites could not measure the roof temperature increase associated with their operation. Verification of the shutdown status of these nuclear facilities with few visible and thermal signatures would most likely require other less-intrusive monitoring measures.

Conclusion

FMCT verification would focus in the first instance on the past military nuclear production facilities in the five nuclear weapon states and the three *de facto* nuclear states. After an FMCT, most of these facilities would be shut down. High-resolution commercial satellite VNIR imagery would play a valuable role in monitoring, nonintrusively, the shutdown status of these nuclear facilities.

Water vapor plumes from cooling towers associated with reactors or GDPs will be visible in the high-resolution satellite VNIR images for most cases when these facilities are operating. The shutdown status of larger or medium reprocessing plants might be monitored by VNIR imagery through the activity level at the site, including shipments of the vehicle transports, but not for all cases. Finally, there might be no evident signatures either for VNIR or TIR imagery from a small CEP, such as Pakistan's Kahuta CEP.

The new generation of commercial observation satellite imagery will play a valuable role in confirming the shutdown status of nuclear production facilities. The verefication authority could use commercial satellite imagery to help select targets of verification or confirm information from other sources for use in triggering onsite inspections. Using satellite imagery to monitor the shutdown status of past military nuclear production facilities will reduce the frequency of onsite inspections.

It should be noted that, under an FMCT, some of these production facilities might continue to operate for purpose that would not be proscribed under an FMCT. In such cases, satellite imagery could be less useful. Other verification measures involving onsite inspections, offsite sampling and ground-based remote monitoring would be required, based on the characteristics of specific facilities and national security interests. Under an FMCT, other facilities such as undeclared nuclear facilities would also need to be dealt with. To strengthen the ability of safeguards to detect undeclared production facilities and activities, the IAEA is currently studying the potential use of commercial satellite imagery. In any event, commercial satellite imagery should be taken as one useful tool, but not the stand-alone monitoring tool for FMCT verification. Finally, one of the greatest obstacles to using satellite imagery could be the financial costs of acquiring larger amount of images; e.g. Space Imaging currently charges several thousand dollars for each one-meter-resolution image. This problem is likely to be reduced as increased competition reduces prices in the future. Furthermore, in a wide range of applications the value of using commercial satellite imagery to verify an FMCT would be well worth the cost.

Notes and References

1. The plutonium could be any isotopic composition (except that containing 80 percent or more of the isotope plutonium-238). HEU is defined as uranium enriched to over 20 percent in the isotope uranium-235. As far as we know, no deployed nuclear weapon uses uranium-233. We do not discuss this fissile material further.
2. Prohibition of the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices, United Nations General Assembly resolution 48/75L.

3. NPT. 2000. Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons. Final Document. *NPT/CONF.2000/28* (Vol. I, Parts I and II), paragraph 15.3 under article VI.

4. E.g., the proposed scope ranges from focused verification to wide verification. Focused verification would concentrate on only sensitive fissile-material production facilities, i.e., reprocessing and enrichment facilities, and fissile materials produced after an FMCT enters into force along with the facilities where these materials are present. A wide-scope approach would also cover a variety of less-sensitive civil facilities such as fuel-fabrication plants and civilian power reactors. See details in "Fissile Materials: Scope, Stocks and Verification," UNIDIR Disarmament Forum 2. 1999. http://www.unog.ch/UNIDIR/E-DF2.htm.

5. International Atomic Energy Agency. 1997. INFCIRC/540: Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards. Vienna, Austria. See http://www.iaea.org/worldatom/infcircs/inf501-600.html.
6. See e.g. IAEA. 1998. IAEA *Safeguards 1998: Sources and Applications of Commercial Satellite Imagery*, Report Version November 18, 1998, IAEA, Vienna; Bhupendra Jasani. 1999. *Commercial Satellite Imagery and Safeguards: Some case studies using multi-spectral and radar data: An Executive Summary.* King's College London, Department of War Studies, University of London, August; Federal Republic of Germany Safeguards R&D Programmes, SRDP-R266/JOPAG/05.99-PRG-293/Task JNT D00988; Canadian Safeguards Support Program. 1999. Potential Application of Commercial Satellite Imagery in International Safeguards. *CSSP Report No.122*, October, CSSP Task ID IR 07X/IAEA Task ID D01142; Christer Andersson. 2000. IAEA Safeguards: Implementation Blueprint of Commercial Satellite Imagery, Ph2 Final Report. *SKI Report*, 00:11, January.
7. International Atomic Energy Agency 1972. The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. *IAEA Information Circular* INFCIRC/153 corrected, June 1972. http://www.iaea.org/worldatom/infcircs/inf101-200.html.

8. It should be noted that the capabilities of civil remote-sensing satellite imagery of thermal infrared are also

improving, and they would also play valuable roles to monitor nuclear operating. See The Application of Commercial Observation Satellite Imagery for the Verification of Declared and Undeclared Plutonium Production Reactor, by Hui Zhang and Frank von Hippel, *PU/CEES Report*, No. 319, 2000; Using Commercial Observation Satellites to Verify that Uranium-Enrichment Gaseous Diffusion Plants are not Operating, by Hui Zhang and Frank von Hippel, *PU/CEES Report*, No. 325, 2000.

9. Under a bilateral agreement between the United States and Russia, the plutonium that the three reactors produce is to be subject to American monitoring to verify that it is not used for weapons.
10. Four reactors are at Calder Hall and four are at Chapelcross. Two near Calder Hall were shut down in 1957 after an accident.
11. The three Magnox plutonium-production reactors at Marcoule were shut down by 1984. The two Celestin heavy-water production reactors at the site are reported to producing only tritium since 1991.
12. Norris, Robert S. et al. 1994. *Nuclear Weapons Databook Volume V: British, French, and Chinese Nuclear Weapons*. Westview Press, 1994.
13. It is expected that, under a FMCT, these countries could shut down their previous military nuclear facilities, which would protect design and capacity secrets of the nuclear facilities. (See e.g. , Steve Fetter and Frank von Hippel. 1995. A Step-By-Step Approach To a Global Fissile Materials Cutoff. *Arms Control Today*, October.) Otherwise they should accept more intrusive IAEA safeguards to verify that these facilities are not producing fissile material for weapons or purposes unknown.
14. Ibid.
15. A gas centrifuge enrichment plant was built at Portsmouth but it never became fully operational. The U.S. Department of Energy is again proposing to build a CEP at Portsmouth. See, e.g., Michael Knapik. 2001. Bush Administration, Congress Reviewing SWU Issues; Will Utilities Play A New Role? *Nuclear Fuel*, February 5, 2001.
16. Hibbs, Mark 1999. China Said to be Preparing for Decommissioning Defense Plants. *Nuclear Fuel*, May 17, 1999.
17. China's planned total nuclear capacity for 2005-2006 is about 8.6 Gwe. (See China: Romancing the Dragon. *Nukem Report*, Fall 1997, p.19) Except Qinshan-4, 5 heavy water reactors (2X675MWe), all the other reactors (about 7.25 GWe) require LEU. To supply LEU for this much capacity will require up to 1 million SWU/y enrichment capabilities. It is projected that China will have a total gas centrifuge enrichment capacity at Lanzhou and Hanzhong CEPs of about 1.5-million SWU/y by around 2005. (See Mark Hibbs. 1999. China Moved Centrifuge Complex to Keep Enriching U at Lanzhou. *Nuclear Fuel*, May 17, 1999).
18. Albright, David et al. 1997. *Plutonium and Highly Enriched Uranium 1996-World Inventories, Capabilities and Policies*. Oxford: University Press.
19. See http://www.spin-2.com/.
20. See e.g. http://www.fas.org/nuke/guide/.
21. U.S. White House. 1994. *Fact Sheet on U.S. Policy on Foreign Access to Remote Sensing Space Capabilities*. March 10, 1994.
22. Through 1980s and 1990s, based on analysis of a number of commercial satellite images (with resolution of 5 meters to 30 meters), it was estimated that the medium-resolution satellite imagery would have very limited and moderated roles to identify nuclear facilities and monitor nuclear activities. See, e.g. Michael Krepon, et al. 1990. *Commercial Observation Satellites and International Security*. New York: St. Martin's Press, Inc.; Michael Slack, et al. 1990. *Open Skies-Technical Organizational, Operational, Legal and Political Aspects* . Toronto: York University; Michael Krepon, et. al., 1992. *Open Skies, Arms Control, and Cooperative Security*. New York: St. Martin's Press, Inc.
23. Glasstone, Samuel and Walter Jordan. 1980. *Nuclear Power and Its Environmental Effects*. Illinois: American Nuclear Society.
24. From a recently aquired 2-meter-resolution IKONOS image (acquired on July 4, 2000) of Israel's Dimona nuclear complex, the reactor containment and a mechanical-draft cooling tower with two vents on the top are clearly identifiable. Also some declassified CORONA satellite images of this site are put on FAS Web site (see http://www.fas.org/nuke/guide/). It should be noted that, based on a U.S. policy issued in 1997, U.S. commercial satellite companies such as Space Imaging are not able to provide 1-meter-resolution satellite images of Israel's nuclear facilities at the moment.
25. Zhang, Hui and Frank von Hippel. 2000. The Application of Commercial Observation Satellite Imagery for the Verification of Declared and Undeclared Plutonium Production Reactor. *PU/CEES Report*, No. 319.
26. For a commercial light-water power reactor, the typical specific power is about 30MWt per metric ton of fuel. Production reactors usually have much lower specific powers. Achieving a typical burnup of 1,000 MWd/Mt to produce weapon-grade plutonium would therefore require more than thirty-three days.
27. See http://www.fas.org/nuke/guide/china/facility/.
28. The capabilities of thermal-infrared images of civilian satellites are also improving somewhat. In April 1999, Landsat-7, with a 60-meter spatial resolution, i.e. half that of Landsat-5, was launched. In December 1999, ASTER, with a 90-meter spatial resolution but better temperature accuracy, was launched.

29. Zhang, Hui and Frank von Hippel. 2000. The Application of Commercial Observation Satellite Imagery for the Verification of Declared and Undeclared Plutonium Production Reactor. *PU/CEES Report*, No. 319.
30. In fact, a preliminary analysis on a Landsat-7 TIR image taken in July 1999 of this site concluded that it cannot use that image to make sure whether the reactor was operating or not (see http://www.isis-online.org). This conclusion is consistent with our analysis.
31. It can be expected that the current commercial satellite TIR sensors could detect the discharged hot water from larger reactors around the exhaust port. In fact, even with the relatively poor resolution TIR images of Landsat-5, the hot water into the lake and rivers from the reactors have been detected. See details in Zhang and von Hippel. 2000. The Application of Commercial Observation Satellite Imagery for the Verification of Declared and Undeclared Plutonium Production Reactor. *PU/CEES Report*, No. 319.
32. From an image taken by a CORONA satellite on September 15, 1971, of the Tomsk-7 reprocessing plant, the more than 800-meter long canyon-like building (typical of large reprocessing plants) and the very high stack (readily distinguished by its long shadow) can also be clearly seen. See http://www.fas.org/nucke/guide/russia.
33. Zhang, Hui and Frank von Hippel. 2000. Using Commercial Observation Satellites to Verify that Uranium-Enrichment Gaseous Diffusion Plants are not Operating. *PU/CEES Report*, No. 325.
34. http://sun00781.dn.net/nuke/guide/pakistan/facility/kahuta.htm.

The 11th International Arms Control Conference

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Some 275 experts from the United Nations, North Atlantic Treaty Organization (NATO), the Comprehensive Test Ban Treaty Organization (CTBTO), and the International Atomic Energy Agency (IAEA), and more than thirty-five nations, including China, France, India, Israel, Kazakhstan, the Republic of Korea, Pakistan, Russia, and South Africa, gathered in Albuquerque, New Mexico, April 20-22, 2001, to discuss this year's cutting-edge issues in arms control and nonproliferation.

The forum for these deliberations was the 11th Annual International Arms Control Conference "Looking Ahead: New Horizons and Challenges in Arms Control," sponsored by Sandia National Laboratories and its national security and nuclear weapons programs.

This annual event was first organized in April 1990 by then-Senator John G. Tower and Jim Brown, colleagues in the political science department at Southern Methodist University. Since Senator Tower's untimely death in April 1991, Brown has continued to organize, chair, and seek financial support for this event.

In 1995, Brown and the conference moved to Sandia National Laboratories. At its first meeting in 1990, seventy-five individuals participated and only three countries were represented. Today, this annual arms control and nonproliferation conference is a premier international event.

At the 2001 conference, five panels explored issues such as national missile defense, cooperative U.S.-Russia threat reduction efforts, North Korea's nuclear ambitions, biological weapons proliferation, and homeland defense.

In the opening address, Ambassador Abdallah Baali, the permanent representative of Algeria to the United Nations, and chair of the 2000 Non-Proliferation Treaty Review Conference (NPT), described the success of the Review Conference in "reaffirming the importance of the NPT as the world's primary multilateral diplomatic instrument for the pursuit of nuclear disarmament." Baali went on to say that the review conference "underscored the unequivocal undertaking by the nuclear states to accomplish the total elimination of nuclear weapons—a task no longer described as just an 'ultimate goal.'" This commitment by the nuclear states will be tested, according to Baali, "by the progress in unilateral measures to reduce the nuclear arsenal" and thus "making nuclear disarmament irreversible."

A keynote address by Ambassador Wolfgang Hoffmann, executive secretary of the CTBTO, detailed the ongoing measures that the CTBTO is taking to construct a technologically advanced verification system in support of the Comprehensive Test Ban Treaty. Hoffmann noted that 200 individuals and seventy countries are involved in developing the international monitoring system, which, when completed, will be capable of detecting clandestine nuclear tests forbidden under the treaty. The system should be operational in 2005.

He further noted the universality of the CTBT, with 160 state signatories, and with seventy-one states having ratified the treaty. A cautious chord was struck by Hoffmann who stated that in order "to keep the momentum forward toward the treaty's early entry-into-force, it is essential that the two remaining nuclear weapons states also ratify."

Ballistic Missile Defense

Ambassador David Smith of Global Horizons, Inc. in Annandale, Virginia, vigorously defended the Bush Administration's proposal to develop a national missile defense (NMD) system, which he described as consisting of three essential elements: "globality, layering, and evolution." As Washington proceeds, Smith noted, "America should consult its allies, explain its missile defense plans, act transparently, and cooperate with any interested country. ... But our view of the ballistic missile threat to our country, our role in the world, and our consequent defensive response are not matters for debate."

In sum, Smith argued that "it is time to recognize that Cold War strategic arms control was a tool to manage enmity. ... It is time to move from a strategy based on nuclear destruction to a more balanced strategy that includes defenses, which, after all, harm only attacking missiles."

A European perspective was proffered by Guillaume Parmentier of the Institut Francais des Relations Internationales in Paris, France, who called for a more balanced approach to deterring and responding to aggression. The geography of Europe, coupled with its historical memories of defensive measures to contain aggression, "create widespread skepticism and even encourages criticism of the American plans. ... The illusion of vulnerability could create much misperception, and be the cause for disastrous decisions." The Europeans, Parmentier noted, prefer a combination of offensive measures and diplomacy to address their security concerns. "Defense is seen in Europe as a supplement to offense and diplomacy. It is not and cannot be a substitute."

Jack Mendelsohn of Lawyers Alliance for World Security of Washington, D.C., noted that those supporting the deployment of national ballistic missile defenses to protect the United States from long-range missile attack by rogue states ignore one critical factor. "The United States and Russia (as well as China) have not truly abandoned their commitment to deterrence." He goes on to note that as long as the United States and Russia are in a potentially "adversarial relationship," both will continue to maintain the ability to deter through threat of retaliation. To transition from this deterrent posture, Mendelsohn proffers that the United States' political relationship with Russia (and China) must evolve to one of cooperation "similar to the U.S. relationship with the UK or France," otherwise, "the unilateral, unagreed introduction of NMD will be more provocative than protective."

Cooperative Threat Reduction Efforts

According to B.G. Thomas Kuenning (Ret.), director of the Cooperative Threat Reduction Program (CTR), the CTR program has achieved "remarkable results" in U.S.-Russian efforts to pullback from their Cold War posture. Thus far more than 5,000 warheads have been deactivated, more than 600 ICBMs/SLBMs have been destroyed, and 360 silos and 330 submarine launchers have been eliminated through this program.

Laura Holgate of the Nuclear Threat Initiative pointed out that there are still several worthwhile efforts that ought to be undertaken: warhead and infrastructure dismantlement and fissile material inventory. She noted that now these issues are "too hard, but should not be abandoned." Other challenges facing U.S.-Russian cooperative programs, according to Holgate, are access to Russian facilities, transparency of weapons-related activities, and the limits of U.S. government assistance and expertise.

In a corollary presentation, Victor Mizin, diplomat-in-residence at the Monterey Institute of International Studies cautioned against the proposed U.S. cutbacks in funding for the CTR projects, which he indicated have reduced the "danger of the massive proliferation from the ex-USSR territory." However, he noted, Russian leaders at times take the cash flow from the United States for granted, and that many in Russia interpret the CTR programs as U.S. meddling in Russian security issues. "Russian officials will do nothing if U.S. leadership and most important, lavish financial support is not assured."

The Proliferation Game and North Korea

At no point has the IAEA "been able to conclude that the Democratic Peoples' Republic of Korea (DPRK) has complied with its obligations" under the NPT regime according to Piet de Klerk, director of policy coordination at the IAEA. "It looks likely that the situation will continue for some years to come." De Klerk notes that the IAEA would welcome a normalization of its relations with the DPRK, but this can only happen when "it returns as a member state." It is the IAEA's hope that the DPRK begins to "show a willingness to start cooperating beyond the freeze." That, according to de Klerk, "would be high time."

Gary Samore of the U.S. State Department argued that the strategic dilemma facing Washington on its North Korean policy has not changed with the new Bush Administration. "On one hand, a strategy of carrot-and-stick engagement provides assistance and improved bilateral relations" to Pyongyang in "exchange for restraints on its nuclear and missile programs." This aid assists the regime but "with no guarantee that it will ever give up those capabilities in the end."

Ren Xiao of Fudan University in Shanghai, China, suggested that Washington should offer to North Korea more financial incentives, because a "new missile deal is worth being made," and it is only through diplomacy and negotiations that North Korea will be out of the "proliferation game."

From the perspective of the Middle East, Dyugu Sezer of Bilkent University in Ankara, Turkey, opined that North Korea undermines international stability, but more importantly, contributes to the instability in the Middle East by its exports of missiles and missile technologies. Most disturbing, according to Sezer, is North Korea's sale of medium-range No Dong missiles to Iran, thereby increasing the vulnerability of Israel, Turkey, and Saudi Arabia. If North Korea, she hypothesized, introduced advanced Taepo Dong-2 missiles into this region, most of Europe, Russia, and India would be within range, adding further to international instability and vulnerability.

Homeland Defense: Is It Real?

In the final session on homeland defense, David Kay of Science Applications International Corp. asserted that from all the commissions and reports that have been generated "it would be reasonable to conclude...that the American homeland is a very insecure place, the actual temper of the times seems to show otherwise. Little seems to be falling from the sky." Kay suggests that the "empirical evidence for believing that there is a threat of weapons of mass destruction, terrorism seems to be elusive as the challenge of preparing for it is daunting." He proposes eight guideposts for assessing such danger (e.g. capabilities, motivation, intent, vulnerabilities, etc.), and added "even a quick scanning of these against easily available open source information is disquieting." Kay concludes, "that mass casualty terrorism looms as a real possibility."

In a companion piece, Amy Smithson, of the Henry L. Stimson Center, forcefully questioned the effectiveness of programs to respond to a mass-casualty terrorist attack on U.S. soil. "In the years ahead, domestic preparedness must graduate to a program that puts as much emphasis on public health and hospital preparedness as on disaster scene rescue capabilities." Smithson went on to say that "A sign of maturity in the program would be its transformation from an inside-the-Beltway justification for a spending carnival to preparedness standards and capabilities that are institutionalized and sustained over the long term. ... Bluntly put, an absurdly small slice of the funding pie has made it beyond the Beltway."

A more challenging issue that Smithson raised in her presentation is "modernizing local, state, and national policies and laws regarding the enforced evacuation, isolation, or quarantine orders," that pertain to the spread of a contagious disease. She called for a national conference to be held to address these vexing problems before it is too late, and the country is devastated, as it was in 1918, when a virulent strain of influenza surfaced. "Such an occasion is no time to be caught flat-footed, which is exactly where the country is today," she said.

Conclusion

This very successful two-day international event not only allowed for the creative exchange of ideas, but it further resulted in opportunities to establish and enhance valuable relationships among the distinguished members of the global arms control and nonproliferation communities.

Jim Brown is a principal member of the technical staff at Sandia National Laboratories and a founder and the chair of the Annual International Arms Control Conference.

The views expressed by these presenters are not intended and should not be considered to represent the views, attitudes or policies of the Department of Energy or Sandia National Laboratories. Sandia is a multiprogram laboratory operated by Sandia Corp., a Lockheed Martin Co., for the United States Department of Energy under contract DE-AC04-94-AL85000.

Upcoming Event

For information on the 12th Annual International Conference in Albuquerque, New Mexico, April 18–20, 2002, contact Evangeline Clemena, conference coordinator, Sandia National Laboratories, P.O. Box 5800, MS 1203, Albuquerque, New Mexico, U.S.A. 87185-1203. Her e-mail address is: edcleme@sandia.gov.

Awards Committee

The Awards Committee met on May 21, 2001, with no controversial issues on the agenda. One recipient of the Distinguished Service Award was chosen. No Meritorious Service Award recipient was chosen. Two Resolutions of Respect were prepared. Unfortunately, there were no student paper entries. After selecting the recipient, the committee discussed Scott Vance's proposal for the definition of and criteria for a "student." This was an agenda item at the July 14 Executive Committee Meeting.

Awards Committee member Don Six has resigned. He is very knowledgeable concerning. the many disciplines of nuclear materials management and will be sorely missed. The chair wishes this gentleman much success and happiness in his future pursuits.

The Awards Committee gratefully acknowledges the assistance of headquarters staff in arranging the conference call for the Awards Committee meeting.

Yvonne M. Ferris
Chair, Awards Committee
GEM Technology
Germantown, Maryland, U.S.A.

Fellows Committee

During the Executive Committee meeting held in March 2001, three issues were discussed that were ultimately steered to the Fellows for further review. They were:

1) increasing corporate sponsorship of the Institute;
2) technical paper quality and the selection criteria; and
3) the expectations of committee and technical division chairs.

Further dialogue and exploration of the first two were pursued with the third set aside to become an agenda item at the Fellows Luncheon at the 42nd INMM Annual Meeting. Specifics of the Fellows' review of items 1 and 2 are provided.

The committee also vetted three nominations submitted for 2001 Fellow induction and provided a recommendation to the Executive Committee for action. The results were announced during the Annual Awards Banquet during the Annual Meeting. (See Member News, pg. 43.)

The Fellows met on Wednesday, July 18, to address the issue of expectations of committee and technical division chairs, and other issues that arose during the Executive Committee meeting on July 14. The Fellows Committee stands ready to support the Institute in any manner possible and continues to welcome new challenges and opportunities from the Executive Committee and membership.

Obie P. Amacker Jr.
Chair, Fellows Committee
Pacific Northwest National Laboratory
Richland, Washington, U.S.A.

Government-Industry Liaison

The Government-Industry Liaison Committee (GILC) organized the closing plenary of the 41st Annual Meeting. The two speakers were Eugene Habiger, director of the Office of Security and Emergency Operations, U.S. Department of Energy, and Michael D. Rosenthal, director of multilateral nuclear affairs, U.S. Department of State. As customary, GILC coordinated publication of accounts of their presentations and ensuing discussions for the fall 2000 issue of *Journal of Nuclear Materials Management*. The offices of both speakers provided written texts of their remarks and, at their request, only these versions were used officially by INMM. GILC provided a luncheon for the invited speakers immediately before the session.

GILC held its annual committee meeting immediately following that session. The format of the closing plenary was reviewed, and ideas regarding speakers, topics, and organizations for next year's closing plenary were discussed. GILC remains interested in sponsoring a workshop, in cooperation with a technical division and/or regional chapter, possibly related to implementation of Integrated Safeguards by the IAEA if an opportune time can be identified. We discussed the desirability of increased participation by representatives of the nuclear industry in INMM activities and agreed that we should consider the interests of industry members when selecting speakers.

Through the year, GILC members continued to discuss by e-mail possible topics, speakers, and organizations for the closing plenary at the 42nd Annual Meeting in Indian Wells, California. Three people accepted our invitations to speak at the closing plenary:

- Laura Holgate, vice president for Russia/NIS Nuclear Programs, Nuclear Threat Initiative
- John Todd, chief, Defense Nuclear Security, U.S. National Nuclear Security Administration
- Diane Jackson, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission

GILC revised the description of its interests and responsibilities to appear on the redesigned INMM Web site. A number of substantive suggestions were made.

GILC members attending the annual meeting met immediately following the closing plenary session. INMM members with interest in GILC responsibilities are invited to join or work with us.

Current GILC members are Chair Jim Lemley, Vice Chair Amy Whitworth, Pierre Aucoin, Robert Behrens, Vince De Vito, Tohru Haginoya, John Matter, Bruce Moran, Anita Nilsson, Terri Olascoaga, Brian

Smith, Joseph Stainback, Meggen Watt, and Mike White.

James Lemley
Chair, GILC
Brookhaven National Laboratory
Upton, New York, U.S.A.

Amy Whitworth
Vice Chair, GILC
National Nuclear Security Administration
Germantown, Maryland, U.S.A.

Membership Committee

The membership status of the Institute of Nuclear Materials Management as of July 1, 2001, is as follows:

Regular Members	651
Senior Members	92
Fellows	30
Student Members	3
Emeritus Members	17
Sustaining Members	25
Honorary Member	1
Total Membership	**819**

The goal of the Membership Committee is to provide quality service to INMM members. The Membership Committee is composed of Chair Nancy Jo Nicholas, Jill Cooley, Obed Cramer, Bob Curl, Vince DeVito, Al Garrett, Michelle Kazanova, Larry Kwei, Bruce Moran, Takeshi (Ted) Osabe, Don Six, Grace Thonpson, and Scott Vance. Key services provided by the Membership Committee include:

- updating and issuing the annual Membership Directory;
- reviewing and approving new member applications;
- coordinating a reception for new and new senior members;
- overseeing the yearly membership renewal program; and
- administering the senior membership program.

The Membership Committee has begun coordinating input for a newly expanded Member News page in the *JNNM.* Now, not only do we list new members in the *Journal,* but we also feature events in the careers of our members. Please contact anyone on the Membership Committee or the *JNMM* staff directly with news to be spotlighted on this page.

We congratulate the following members who have been granted Senior membership status this year:

Trevor Barrett
Steve Dupree
Tadatsugu Ishikawa
Chris Pickett
Joe Rivers
Scott Vance
Dennis Wilkey

We are also working with the INMM Fellows, Awards, and Communications committees to develop a fresh marketing approach to attract student members. We are drafting and making plans to distribute a new student-oriented brochure for prospective student members (enrolled full-time in a college or university and have no other full-time employment).

Members of the INMM who are interested in serving on the Membership Committee should contact the membership chair directly.

Nancy Jo Nicholas
Chair, Membership Committee
Los Alamos National Laboratory
Los Alamos, New Mexico, U.S.A.

N15 Report

The N15 Standards Committee underwent its first audit by the American National Standards Institute (ANSI) in November 2000. As might be expected for a first audit, a number of discrepancies were identified by the auditor. We formally responded to ANSI with our acceptance of the audit findings and our corrective action plan. We were notified by ANSI that they were satisfied with our response and they had closed the audit. Those items that were identified as deficiencies will be reviewed at the next periodic audit which will take place around 2005-2006.

We will begin reviewing current standards to determine if they should be reaffirmed or rewritten, and will develop internal operating procedures to enable us to better comply with ANSI requirements.

Anyone interested in working on the N15 Committee should contact Chair Joe Rivers at joe.rivers@hq.doe.gov.

Joe Rivers
Chair, N15 Committee
Science Applications International Corp.
Germantown, Maryland, U.S.A.

Central Region Chapter

The Central Region recently completed an election of new officers. This completes the process of bringing the Central Region back to being an active chapter within INMM after nearly five years of dormancy. The Central Region held a very successful annual meeting at the Garden Plaza Hotel in Oak Ridge, Tennessee, in October 2000. The meeting was attended by fifty-two people representing ten sites or organizations. The meeting was opened with technical presentations and concluded with the business meeting. Plans for the 2001 meeting will be announced.

The newly elected chapter officers are:

Chair:	Chris Pickett
Vice Chair:	Larry Satkowiak
Treasurer:	Debbie McNeilly
Secretary:	Teressa Reed
Members at large:	Bob Ceo
	Terry Lewis
	Michael Whittaker
	Gary Kodman

Chris Pickett
Chair, Central Region Chapter
Oak Ridge Laboratory
Oak Ridge, Tennessee, U.S.A.

Japan Chapter

The Japan Chapter's 22nd Annual Meeting will be held November 7-8, 2001, in Tokyo.

As of May 21, 2001, the Japan Chapter has 131 regular members and twenty-two sustaining members.

T. Osabe
Secretary, Japan Chapter
Nuclear Material Control Center
Kanagaw, Japan

Northeast Chapter

The Northeast Chapter's dinner meeting originally scheduled for May 23, 2001, was cancelled because of conflicting schedules. It was to have included a panel discussion on the adequacy of safeguards in connection with the transportation of spent nuclear fuel. It will be rescheduled.

A meeting of the chapter members who attended the INMM Annual Meeting in Indian Wells, California, U.S.A., was held the evening of July 18. The next meeting of the chapter will be held at Brookhaven National Laboratory in Upton, New York, U.S.A., on October 18, 2001.

E.R. Johnson
Chair, Northeast Chapter
JAI Corp.
Fairfax, Virginia, U.S.A.

Pacific Northwest Chapter

The Pacific Northwest Chapter held its annual summer barbecue in September 2000 at Leslie Groves Park in Richland, Washington. As usual, this event was a big success with a good turnout.

A summer picnic/dinner meeting was held in July 2001 to host several visitors from the Japan Chapter. The event was held at the Canyon Lakes Golf Club in Kennewick and was well attended. The "First Annual PNW INMM Putting Contest" was held with about twenty-three participants. First place went to Tony Wooldridge, our new student intern at DOE-RL, second place went to Bret Simpkins of PNNL, and Hiroki Shiotani, one of our guests from Japan, took third place. A good time was had by all.

Glenda Ackerman
Vice President, Pacific Northwest Chapter
Pacific Northwest National Laboratory
Richland, Washington, U.S.A.

Southwest Regional Chapter

The Southwest Regional Chapter held its annual meeting May 4, 2001, in Taos, New Mexico, U.S.A. Attendees totaled twenty-four, and included representatives from Los Alamos and Sandia national laboratories, the University of Texas, the Nonproliferation and National Security Institute, Innovative Technology Partnerships, and Aquila Technologies Group. Formal presentations were given on a variety of topics, followed by a group discussion in the afternoon.

Jack Jekowski of Innovative Technology Partnerships discussed the aging of the nuclear professional community, and the various steps proposed to attract younger engineering and scientific professionals to pursue a career in nuclear technologies.

Larry Avens of Los Alamos gave an update on the cooperative effort to design and implement a storage plan for thirty-four tons of plutonium at the Mayak facility in the Russian Federation. Among the participants are DTRA, Bechtel, the Army Corps of Engineers, and Russian contractors.

Robert Martinez then presented the results of Sandia's work in international tracking and monitoring of nuclear spent fuel.

Brian Scott from Los Alamos National Laboratory talked about game theory and how to apply it to the decision making process for material inventory and protection.

The next presentation was from Feng Pan, a graduate student from the University of Texas. The Southwest Chapter provided financial support to Pan to offset his travel costs. He presented an approach to interdiction at border points in the Russian Federation ("Second Line of Defense"). He discussed probabilities of detection and how to determine the probability of detection.

Roger Johnston of Los Alamos National Laboratory gave the final presentation. He discussed the vulnerabilities associated with various types of tags and seals. He contended that successful exploitation of most seals would be a simple process, using readily available physical tools, under common conditions of seal usage. He stated that all tags and seals are vulnerable, and that these vulnerabilities need to be mitigated (e.g. through post-mortem analyses, procedural changes in application and checking of seals, or enhanced training of practitioners).

The afternoon discussion explored some ways to attract more qualified replacements for the soon-to-be retiring nuclear professionals. A number of suggestions were proposed, among them:

- Increased attention to math and science at the high-school level
- Re-opening the labs for field trips and tours at the middle-school level
- Increased recruitment of Navy nuclear personnel, made available by service downsizing
- Presentations at the middle- and high-school levels of the role of nuclear power and arms control in history and in society
- Increased emphasis and recruitment at the university level for physics and nuclear engineering, and adding incentives to pursuing such programs
- Use of retired nuclear engineers and physics professionals in teaching positions or in assisting teachers (at all levels) to develop more effective curricula.

The group reached a consensus on the need to continue to stimulate cooperative research and partnerships between the labs, universities and commercial industry.

Due to the positive response by the membership to the dinner meeting held in January, the Southwest Regional Chapter is planning another dinner meeting this winter. The chapter hopes to attract another high-level speaker who will be of interest to the membership.

Lawrence K. Kwei
Secretary/Treasurer
Southwest Regional Chapter
U.S. Department of Energy
Los Alamos Area Office
Los Alamos, New Mexico, U.S.A.

TECHNICAL DIVISION REPORTS

International Safeguards Division

The INMM International Safeguards Division met twice last year; once at the INMM 41st Annual Meeting in New Orleans, Louisiana, USA in July 2000, and once in May 2001 in conjunction with the 23rd ESARDA Annual Meeting in Brugge (Bruges), Belgium. In addition, the ISD served as the INMM agent for support of the Third Joint INMM/ESARDA Workshop on Science and Modern Technology for Safeguards. This workshop was held in Tokyo, Japan, in November 2000.

At the 42nd Annual Meeting, eleven international safeguards sessions, including two sessions were dedicated to recognizing twenty-five years of member state support to IAEA safeguards, and a joint ISD/Nonproliferation and Arms Control Division session on the Trilateral Initiative.

The success of the Third Joint INMM/ESARDA Workshop again reflected the importance of ongoing research programs to the future of international safeguards. ESARDA and ISD are considering holding another workshop in two years.

At the ISD meeting held in conjunction with the INMM 41st Annual Meeting in July 2000, the main subject discussed was the ongoing work on implementation of the new Additional Protocol to safeguards agreements and the development of integrated safeguards by the IAEA. This subject has remained a topic of great interest and concern in the international safeguards community. It is recognized that meshing the new with the old, and achieving full and proper implementation of the new system, will continue to be a challenge. As usual the topic engendered a lively discussion. An informal outline of the current efforts at the IAEA was presented by Pierre Goldschmidt, deputy director general and head, Department of Safeguards. Discussion covered a wide range of topics including the cost of safeguards and the IAEA budget, cooperation with regional and state systems of accounting and control, and the importance of communications between the international safeguards community and government organizations, facility operators, and opinion makers.

At the May meeting in Brugge, the program focused on the future of international and regional safeguards. To start the discussion we had two invited speakers present some ideas on this topic. Wilhelm Gmelin spoke on "International and Regional Safeguards: A Continuing Necessity;" Hans Hermann Remagen presented a talk titled "Ad Fontes." As usual, there was a lively exchange of views on issues raised in the presentations and topics brought up by participants.

ISD has continued its tradition of periodically sponsoring papers addressing important and current topics in International Safeguards. The summer 2001 *JNMM* was a special issue on the topic of progress toward the integration of INFCIRC/153 and INFCIRC/540. Papers from eight national and two regional safeguards organizations were presented, along with a foreword from the IAEA. These papers were discussed at the July 2001 ISD meeting in Indian Wells, California, U.S.A. In addition, the authors presented their papers and participated in a panel in the international safeguards technical sessions of the Annual Meeting.

Since its inception, the ISD has offered a forum for the exchange of information on the continuing development of international safeguards within the nonproliferation regime, and for the enhancement of a broad understanding of the implementation and effectiveness of safeguards. ISD meetings provide an opportunity for informal and mutually cooperative communication of problems and issues related to or raised by various parties involved in, or having an interest in, international safeguards. The success of this endeavor has in no small part been due to the leadership of the founder and charter chairman of the ISD, Cecil Sonnier.

At the ISD meeting in July 2000, Cecil announced that that would be his last ISD meeting as chair and that he was going to turn the office of chair over to Jim Larrimore. As indicated in the technical division reports published in the spring 2001 *JNMM*, the transition of chairmanship is now complete and the ISD management looks forward to maintaining the important role of ISD with continued support from the international safeguards community.

Jim Larrimore
Chair, International Safeguards Technical Division
Del Mar, California, U.S.A.

Gotthard Stein
Vice Chair, International Safeguards Technical Division
Juelich Research Center
Juelich, Germany

Steve Dupree
Secretary, International Safeguards Technical Division
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.

Materials Control and Accountability Division

The past year has been one of anticipation and new beginnings for the national MC&A program. It has been a year when the role of the Institute of Nuclear Materials Management has been constrained by gradually emerging organizational and personnel changes within the Department of Energy and the new National Nuclear Security Administration.

In response to national security concerns at the national laboratories, the U.S. Congress mandated the formation of the National Nuclear Security Administration, a new semiautonomous agency within the Department of Energy. It was not initially clear what role MC&A would take within this new agency. The picture gradually became clearer after the NNSA announced that it had selected a senior technical advisor for MC&A, Amy Whitworth. She has taken an energetic approach to defining NNSA's MC&A responsibilities, and toward defining relationships with NNSA contractor sites and with the Departments' Policy, Standards, and Analysis Division.

For most of the year, the MC&A program within the Policy, Standards, and Analysis Division of the DOE (SO-21) did not have a formally appointed program manager. A decision was made recently, naming James Crabtree as the new program manager. He assumed this responsibility at a time when a moratorium on new departmental directives is in force. The long-term effects of this moratorium on SO-21's programmatic objectives (and on a long-anticipated revision of the MC&A manual) remain to be seen.

These slowly emerging organizational issues do not mean that the MC&A community has been inactive. One of the more significant activities has been the completion of a comprehensive review of DOE Manual 474.1A, *Manual for Control and Accountability of Nuclear Materials* by a team of MC&A experts, many of whom are long-standing INMM members. The review resulted in a number of recommended changes. The recommendations are categorized as "major issues" having a high impact on MC&A programs, "implementation or interpretation issues," and "minor issues." At present, these recommendations are under review by a safeguards and security steering committee and it is unknown whether or when they will be implemented.

While the organization of the DOE/NNSA MC&A programs and associated requirements is being sorted out, the Institute of Nuclear Materials Management's main contribution has been the considerable expertise offered by its membership. More structured contributions, such as workshops on new MC&A policies, have not occurred.

Dennis Brandt
Chair, Materials Control and Accountability Technical Division
Los Alamos National Laboraty
Los Alamos, New Mexico, U.S.A.

Nonproliferation and Arms Control Division

The Nonproliferation and Arms Control Division conducted a workshop—Russian Nuclear Security—Priorities and Alternatives—in Washington, D.C. on May 16, 2001. The keynote speaker was Rep. Ellen Tauscher, (D-California), and the luncheon speaker was Senator Pete Domenici, (R-New Mexico). Lloyd Cutler, co-chair of the Secretary of Energy Advisory Board Task Force on Evaluation of DOE's Nonproliferation Programs with Russia, and task force member Robert Hanfling provided a brief summary of the task force's findings and led an open forum discussion. Other presentations included:

- Ken Luongo, Russian American Nuclear Security Advisory Council
- Matthew Bunn, Belfer Center, Harvard University
- Jim Fuller, Pacific Northwest National Laboratory
- Phil Sewell, United States Enrichment Corp.
- Jon Wolfsthal, Carnegie Endowment for International Peace
- Tom Cochran, Natural Resources Defense Council
- John Gerrard, National Nuclear Security Administration
- Leonard Spector, Monterey Institute of International Studies

We heard a number of new ideas on how to advance the nonproliferation cooperation between the United States and Russia. The main theme of the discussions was the importance of a coherent strategy for coordinating all the programs of cooperation. A secondary theme was the need for public outreach and increased public awareness of nonproliferation activities to facilitate financial support. At the risk of leaving someone out, I would like to express my appreciation for their help in making the workshop a success to Larry Satkowiak, Teressa Reed, Jim Lemley, Elly Melamed, and Wayne Ruhter.

We are still looking for volunteers for division officers. We need a secretary and leaders for each of the three standing committees. Our new charter was approved by the INMM Executive Committee at their last meeting. Thanks again to all those who provided input.

Steve Mladineo
Chair, Nonproliferation and Arms Control Division
Pacific Northwest National Laboratory
Washington, DC, U.S.A.

Physical Protection Technical Division

The Physical Protection Technical Division is planning a workshop for early 2002. Details will be announced when they are finalized.

The Physical Protection Technical Division worked very hard to solicit good papers for the 2001 Annual Meeting. Key personnel were identified to develop sessions in specific areas of physical protection. Rebecca Horton, Sandia National Laboratories, identified papers in access control and contraband detection. Laura Thomas, Oak Ridge National Laboratory, solicited papers on information security. Boris Starr, Sandia National Laboratories, screened papers on intrusion detection. As a result of their efforts we have four strong sessions on physical protection at the Annual Meeting. I would like to see these areas as well as vulnerability assessments become standing committees within the Physical Protection Technical Division.

Physical protection is a critical part of any nuclear facility in addressing nonproliferation issues. We expect to see new and novel technologies being developed in this area as more and more countries begin to turn to nuclear energy to meet their basic needs. There will be new opportunities and challenges to continue to assure the general public that nuclear technology is safe and secure. There will continue to be challenges in providing security technology that is nonintrusive to operations and that is cost effective. Opportunities for the worldwide security community to leverage off of each other's solutions and successes in the physical protection arena will continue to grow. Physical protection will continue to play a major role in accepting nuclear power as a viable source of energy for the world. I challenge members of INMM to continue to lead the way in physical protection development and application.

Stephen Ortiz
Chair, Physical Protection Technical Division
Sandia National Laboratories
Albuquerque, New Mexico, U.S.A.

Waste Management Technical Division

Arrangements have been completed for the next Spent Fuel Management Seminar to be held at the Loews L'Enfant Plaza Hotel in Washington, D.C. U.S.A. on January 9–11, 2002. Details and registration information are available on the INMM Web site at http://www.inmm.org.

Five sessions dealing with spent-fuel management, waste measurement, and packaging and transportation were organized fro the INMM 42nd Annual Meeting July 15-19, 2001. The Waste Management Division met on Sunday, July 15, 2001, at the Annual Meeting.

E.R. Johnson
Chair, Waste Management Technical Division
JAI Corp.
Fairfax, Virginia, U.S.A.

Newly Redesigned INMM Web Site Launched, More Improvements Planned

The newly redesigned INMM Web site —http://www.inmm.org—was launched Friday, July 13, just in time for the INMM Annual Meeting in Indian Wells, California, U.S.A. The site, which sports a new look and easier navigation, was greeted with praise from Annual Meeting attendees.

The site will continue to undergo changes in coming months. All INMM members are encouraged to explore the newly designed site and make suggestions for further improvements.

Possible improvements include:

- A members' only site
- A secure, searchable online membership directory
- Online membership renewal
- Online submission of articles to *JNMM*

Other suggested changes will be considered.

Contact Communications Chair Jim Griggs at james.griggs@pnl.gov to make your suggestions.

INMM Names New Executive Director

Rachel Airth, who has served as INMM's administrative director since June 1998, was named the Institute's new executive director at the INMM Executive Committee Meeting Saturday, July 14.

Airth replaces outgoing Executive Director John Waxman, who will continue to be active in Institute management as a consultant.

Airth joined the INMM headquarters team in 1998 as administrative director and has assumed increasing responsibilities, working closely with Waxman.

"I'm honored to serve in this role for this important organization. We will continue to provide the high level of service that our members have come to expect," Airth said.

She is available via e-mail at rairth@inmm.org, or by calling 847/480-9573, Ext. 245.

Author Submission Guidelines

The *Journal of Nuclear Materials Management* is the official journal of the Institute of Nuclear Materials Management. It is a peer-reviewed, multidisciplinary journal that publishes articles on new developments, innovations, and trends in safeguards and management of nuclear materials. Specific areas of interest include physical protection, material control and accounting, waste management, transportation, nuclear nonproliferation/international safeguards, and arms control and verification. *JNMM* also publishes book reviews, letters to the editor, and editorials.

Submission of Manuscripts: *JNMM* reviews papers for publication with the understanding that the work was not previously published and is not being reviewed for publication elsewhere. Papers may be of any length.

Papers should be submitted in *triplicate*, **including a copy on computer diskette**. Files should be sent as Word or ASCII text files only. Graphic elements must be sent in TIFF format in separate electronic files. Submissions should be directed to:

Dennis Mangan
Technical Editor
Journal of Nuclear Materials Management
60 Revere Drive, Suite 500
Northbrook, IL 60062 USA

Papers are acknowledged upon receipt and are submitted promptly for review and evaluation. Generally, the author(s) is notified within 60 days of submission of the original paper whether the paper is accepted, rejected, or subject to revision.

Format: All papers must include:

- Author(s)' complete name, telephone and fax numbers, and E-mail address
- Name and address of the organization where the work was performed
- Abstract
- Camera-ready tables, figures, and photographs in TIFF format only
- Numbered references in the following format:
  1. Jones, F.T. and L.K. Chang. 1980. Article Title. *Journal* 47(No. 2):112–118.
  2. Jones, F.T. 1976. *Title of Book*, New York: McMillan Publishing.
- Author(s) biography

Peer Review: Each paper is reviewed by two or more associate editors. Papers are evaluated according to their relevance and significance to nuclear materials safeguards, degree to which they advance knowledge, quality of presentation, soundness of methodology, and appropriateness of conclusions.

Author Review: Accepted manuscripts become the permanent property of INMM and may not be published elsewhere without permission from the managing editor. Authors are responsible for all statements made in their work.

Reprints: Reprints may be ordered at the request and expense of the author. Contact Patricia Sullivan at psullivan@inmm.org or 847/480-9573 to request a reprint.

IAEA Board of Governors Appoints ElBaradei to Second Term as Director General

The Board of Governors of the International Atomic Energy Agency (IAEA), appointed Mohamed ElBaradei to a second four-year term as director general of the IAEA when his first term expires at the end of November 2001. The appointment was approved by the IAEA General Conference.

ElBaradei, who has served as director general since December 1, 1997, has been a senior member of the IAEA Secretariat since 1984, holding a number of high-level policy positions. He was the legal adviser before heading the division of external relations, and becoming assistant director general for external relations in 1993.

ElBaradei was born in Egypt in 1942. He earned his bachelor's degree in law in the 1960s at the University of Cairo, and subsequently earned his doctorate in international law at the New York University School of Law between 1971 and 1974.

He served as ambassador in the Egyptian Ministry of Foreign Affairs and has served in the permanent missions of Egypt to the United Nations in New York and Geneva.

DOE and French CEA Sign R&D Agreement

The U.S. Department of Energy and the French Commissariat a L'Energie Atomique in July 2001 signed a bilateral agreement to jointly fund U.S.-French research in advanced reactors and fuel-cycle development.

The agreement is part of the DOE's International Nuclear Energy Research Initiative (I-NERI) launched this year by the department's Office of Nuclear Energy, Science, and Technology. I-NERI will foster international collaborative research and development of nuclear technology, focusing on the Generation IV advanced nuclear system technologies. The joint research funded through this agreement will enable the United States and France to move forward with leading edge generic research that can benefit the range of reactor and fuel-cycle designs anticipated in the future.

With France, the DOE is developing a Generation IV technology roadmap that, when completed next year, will serve as the research and development plan for advanced reactor and fuel-cycle system development. In addition to France and the United States, other countries participating in the roadmap are Argentina, Brazil, Canada, Japan, South Africa, South Korea, and the United Kingdom.

This is the second bilateral I-NERI agreement signed by the U.S. DOE this year. In May, the department signed a similar agreement with the Republic of Korea's Ministry of Science and Technology to conduct joint U.S-South Korean research in the areas of advanced instrumentation, controls and diagnostics, advanced light-water reactor technology, advanced light-water reactor fuels and materials, and advanced computational methods.

ASTM Names New VP

The American Society for Testing and Materials (ASTM) has appointed Kathleen Kono vice president, global cooperation. In this position, Kono is responsible for leading ASTM's international outreach efforts and coordinating ASTM/U.S. government relations.

Kono joined the ASTM staff in 1975 in the developmental operations area. She has been editor of ASTM *Standardization News*, executive director of the ASTM subsidiary, the Institute for Standards Research, and most recently, a Washington representative.

Progress on Additional Protocols

The IAEA reported at the 42nd Annual INMM Meeting in July that its board has approved fifty-seven Additional Protocols (AP) since the Model Additional Protocol to the IAEA Safeguards Agreement was adopted in May 1957. Fifty-one of these are with nonnuclear weapons states, five are with a nuclear weapons state, and one is with a state with an INFCIRC/66-type agreement. Of the fifty-seven states, nineteen had entered into force as of July 2001. For seven of the nineteen states with an AP in force, the IAEA had been able to conclude in its Safeguards Implementation Report for 2000 that it had found no indication of the presence of undeclared nuclear materials or activities in those states, and no indication of the diversion of nuclear material placed under safeguards. Therefore, the IAEA concluded that in 2000, all nuclear material in those states had been placed under safeguards and remained in peaceful nuclear activities or was otherwise adequately accounted for.

Regarding the adoption of the AP by the nonnuclear weapon states of the European Union, the IAEA has received notification from six of the twelve states that their requirements for entry into force have been met. However, that AP will enter into force only when the IAEA receives notification from all twelve states and Euratom.

ElBaradei Reports to General Conference

The director general of the International Atomic Energy Agency, Mohamed ElBaradei called for stronger cooperation to meet new challenges in the fields of nuclear technology, safety, and verification. ElBaradei reviewed nuclear developments from IAEA's vantage point in a statement to the IAEA General Conference September 17.

Ministers and senior government officials from the 132 IAEA member states attended the weeklong meeting at the Austria Center in Vienna.

ElBaradei cited important achievements in recent years that have strengthened the safe and peaceful use of nuclear technologies. At the same time, he emphasized interrelated challenges that, he said, "illustrate how much remains to be done."

He focused on the IAEA's three main functions—as a catalyst for progress in the peaceful applications of nuclear technology; as an objective authority on nuclear safety; and as the inspectorate for verifying that safeguarded nuclear materials and activities are not used for military aims.

In his statement, ElBaradei expressed concern over the lack of progress among states in concluding and bringing into force comprehensive safeguards agreements and the Additional Protocols. He also pointed out that the IAEA remains ready on short notice to resume its nuclear inspections in Iraq, which along with other United Nations Security Council-mandated inspections, were suspended in December 1998. The present situation does not enable the IAEA "to provide any assurance that Iraq is in compliance with its obligations under relevant U.N. Security Council resolutions."

In North Korea, the IAEA is continuing to monitor the freeze on facilities under the 1994 Agreed Framework between the United States and North Korea but the agency is unable to verify the completeness and correctness of North Korea's initial 1992 declaration of its nuclear program.

ElBaradei reported continuing progress through a Trilateral Initiative to submit nuclear material released from the military programs of the United States and the Russian Federation to IAEA verification. Talks are now seeking agreement on the scope of the verification measures, the nature of the material subject to verification, and the duration and nature of verification measures under the agreements, he said.

The full text of ElBaradei's statement is accessible on the IAEA's WorldAtom Web site at http://www.iaea.org.

DrumScan supplied to NESCA

BNFL Instruments has supplied and commissioned a unique state-of-the-art DrumScan system to NESCA, formerly the Atomic Energy Corporation of South Africa. The system, which was delivered on time and within budget, is licensed to assay a number of waste streams at NESCA's Pelindaba site just north of Johannesburg. To date, more than 3,500 drums have been classified and categorized for disposal by the DrumScan, which integrates with a conveyor incorporating a drum painting system.

Drum painting allows easier visual recognition of the disposal route—a novel and practical method that BNFL Instruments believes will be taken up by other nuclear facilities.

To improve data storage, the DrumScan system is also equipped with a bar code reader allowing measurement and characterization results to be integrated with NESCA's centrally controlled database.

The DrumScan's operation is fully automatic and requires no operator interface during routine assays.

Application Notes Available Free

Two application notes may be downloaded at no charge from the ORTEC Web site at http://www.ORTEC-online.com.

The notes are AN59 How Statistical Controls Detection Limits and Peak Protection and AN61 How Counting Statistics and the ADC Sampling Interval Control Mass Accuracy in Time-of-Flight Mass Spectrometry.

AN59 examines the contribution of counting statistics to the uncertainty in determining the peak area, and in controlling detection limits. The methodology is applicable to spectrometers that count single events. The results show that it is important to maximize the peak-to-background ratio, the event counting rate, and the counting time.

AN61 investigates and defines the relative importance of the random error caused by ion counting statistics, and the systematic error caused by the sampling interval, when determining the position of a peak in a spectrum that has been recorded by a digital signal averager. The results reveal that the systematic sampling error is virtually always negligible compared to the random error from ion counting statistics. It also demonstrates that interleaved 2-GS/s sampling with a single 500-MS/s ADC yields the same statistical precision as 2-GS/s sampling with four parallel 500-MS/s ADCs, but at a fraction of the cost.

New Members

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New Senior Members and Fellows Named

Seven members of the INMM were granted senior member status at the INMM 42nd Annual Meeting in July. Senior member status is awarded through application, recommendation by the Membership Committee, and approval by the Executive Committe. Senior members must be at least thirty years old, have ten or more years of active experience in nuclear materials management and/ or safeguards, and be a member of the Institute for at least five consecutive years.

The 2001 new senior members are:

- Trevor Barrett
- Steve Dupree
- Tadatsugu Ishikawa
- Chris Pickett
- Joe Rivers
- Scott Vance
- Dennis Wilkey

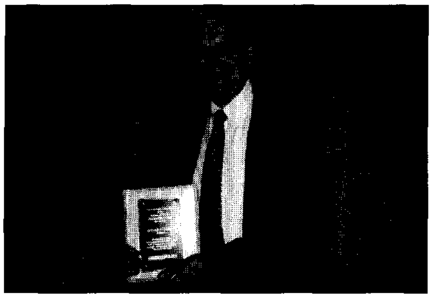
New Fellows

In addition, three new Fellows of the Institute were named at the meeting. Senior members who have attained distinction in the field of nuclear materials management may be honored with the rank of Fellow through nomination by their peers, recommendation by the Fellows Committee, and approval by the Executive Committee.

Congratulations to the Fellows of 2001 on their achievements:

- Deborah A. Dickman
- Hiroyoshi Kurihara
- Takeshi Osabe

INMM President J.D. Williams poses with newly named Fellow Takeshi Osabe.



Former INMM President Deborah A. Dickman is congratulated by current INMM President J.D. Williams on being named a Fellow of the Institute.

Congratulations also go to Gotthard Stein, recipient of the 2001 INMM Distinguished Service Award. The Distinguished Service Award is given to individuals for a distinguished level of accomplishment in and service to nuclear materials management.

This award focuses on long-term noteworthy service to the nuclear materials safeguards and management profession.

JNMM Associate Editor Gotthard Stein, recipient of the 2001 INMM Distinguished Service Award, with INMM President J.D. Williams.

Career Notes

Lawrence K. Kwei recently joined the U.S. Department of Energy's National Nuclear Security Administration at the Los Alamos Area Office (LAAO), where he is responsible for oversight of material control and accountability programs at the Los Alamos National Laboratory. He comes to LAAO from DOE's Rocky Flats Field Office, where he spent thirteen years involved in various programs, including facility safety oversight, weapons production program management, implementation of international safeguards on excess fissile material, and oversight of MC&A programs at the Rocky Flats Environmental Technology Site. Kwei received his bachelor of science degree in materials engineering from the New Mexico Institute of Mining and Technology in 1988. Kwei is active in the INMM, serving as secretary/treasurer of the Southwest Regional Chapter for the last two years, and on the INMM Membership and Registration committees since 1997.

Chad T. Olinger was selected by Los Alamos National Laboratory to lead its Safeguards Systems Group NIS-7. The Safeguards Systems Group solves problems of national security interest in domestic and international safeguards, nonproliferation, and arms control through research, development, and implementation of advanced systems and methods. Olinger received a Ph.D. in physics in 1990 from Washington University in St. Louis, Missouri, and has been involved in safeguards, arms control, and Russian nonproliferation programs at Los Alamos since then. He is an INMM senior member and served from 1997 to 1999 as vice president for the Southwest Regional Chapter and as president of that chapter from 2000 to 2001.

Don't be modest!

Keep us up to date on your promotions, awards, retirement, and other career news.

Send your news and photos to: Managing Editor Patricia Sullivan, at INMM Headquarters, 60 Revere Drive, Suite 500, Northbrook, IL 60062 U.S.A., by e-mail at psullivan@ inmm.org, or by fax to 847/480-9282. Be sure to include a daytime phone number and e-mail address.

Calendar

October 17–18
Nuclear Decommissioning (DECOM 2001) International Conference, London, England. Organized by British Nuclear Energy Society/ImechE. Contact: Maureen Carter, conference office, Institution of Mechanical Engineers, 1 Birdcage Walk, London, SW1P 3JJ; phone, 44 (0) 20 7222 7899; fax, 44 (0) 20 7222 4557; E-mail, m_carter@imeche.org.uk; Web site, http://www.imeche.org.uk.

October 29–November 1
Symposium on International Safeguards: Verification and Nuclear Material Security, Vienna, Austria. Sponsor: International Atomic Energy Agency in cooperation with ESARDA and INMM. Contact: Regina Perricos, Conference Service Section, Division of Conference and Document Services, IAEA; phone, 42 1 26000, Ext. 21315 or 21311; E-mail, R.Perricos@iaea.org; Web site, http://www.iaea.org/worldatom/Meetings/Planned/2001.

November 5–9
International Conference on Radioactive Waste from Nonpower Applications, Malta. Sponsored by the International Atomic Energy Agency. Contact: IAEA, Wagramesrstrasse 5, P.O. Box 100, A-1400, Vienna, Austria; E-mail, official.mail@iaea.org; Web site, http://www.iaea.org.

November 11–15
2001 ANS Winter Meeting, Reno Hilton Hotel, Reno, Nevada, U.S.A. Sponsor: American Nuclear Society. Contact: Leon Walters, general chair, Argonne National Laboratory; phone, 208/533-7384; fax, 208/533-7340, E-mail, leon.walters@anl.gov; Web site, http://www.ans.org.

December 5–6
6th BNES/BNIF Nuclear Congress Conference and Exhibition, London, England. Organized by British Nuclear Energy Society/ BNIF. Contact: Andrew Tillbrook, secretary, BNES, 1 Great George St., London, SW1P 3AA; phone, 44 (0) 20 7665 2241; fax, 44 (0) 20 7799 1325; E-mail, andrew.tillbrook@ice.org.uk.

December 11–13, 2001
8th Annual Environmental Management Nondestructive Assay (NDA) Characterization Conference, Adams Mark Hotel, Denver, Colorado, U.S.A. Cosponsored by the TRU and Mixed Waste Focus Area, the Department of Energy Idaho Operations Office, and the Institute of Nuculear Materials Management. Contact: Technical Chair Greg Becker; phone, 208/256-9003; E-mail, gkbl@inel.gov; Web site, http://badlands.inel.gov/tmfa/nda/overview.htm.

January 9–11, 2002
Spent Fuel Management Seminar XIX, Loews L'Enfant Plaza Hotel, Washington, D.C. U.S.A. Sponsor: Institute of Nuclear Materials Management. Contact: INMM, 60 Revere Drive, Suite 500, Northbrook, IL 60062; phone, 847/480-9573; fax, 847/480-9282; E-mail, inmm@inmm.org; Web site, http://www.inmm.org.

January 23, 2002
Nuclear Fuel Supply Forum, Willard Inter-Continental, Washington, D.C., U.S.A. Sponsored by the Nuclear Energy Institute. Contact: Suzanne Phelps, Nuclear Energy Institute, 1776 I St. NW, Suite 400, Washington, DC 20002; phone, 202/739-8119; fax, 202/785-4019; E-mail, srp@nei.org.

April 14–17, 2002
NEI Fuel Cycle 2002, Westin River North, Chicago, Illinois, U.S.A. Sponsored by the Nuclear Energy Institute. Contact: Suzanne Phelps, Nuclear Energy Institute, 1776 I St. NW, Suite 400, Washington, DC 20002; phone, 202/739-8119; fax, 202/785-4019; E-mail, srp@nei.org

April 18–20, 2002
12th Annual International Arms Control Conference, Albuquerque, New Mexico, U.S.A. Sponsored by Sandia National Laboratories. Contact: Evangeline Clemena, conference coordinator, Sandia National Laboratories, P.O. Box 5800, MS 1203, Albuquerque, NM 87185-1203; E-mail, edcleme@sandia.gov.

April 30–May 1, 2002
North America Young Generation in Nuclear, The Ritz-Carlton at Tiburon, Naples, FL, U.S.A. Sponsored by the Nuclear Energy Institute. Contact: Sonja Simmons, Nuclear Energy Institute, 1776 I St. NW, Suite 400, Washington, DC 20002; phone, 202/739-8042; fax, 202/785-4019; E-mail, sss@nei.org.

May 1–3, 2002
Nuclear Energy Assembly, The Ritz-Carlton at Tiburon, Naples, FL, U.S.A. Sponsored by the Nuclear Energy Institute. Contact: Lisa Steward, Nuclear Energy Institute, 1776 I St. NW, Suite 400, Washington, DC 20002; phone, 202/739-8006; fax, 202/293-3056; E-mail, lis@nei.org.

June 23–27, 2002
43rd INMM Annual Meeting, Renaissance Orlando at SeaWorld, Orlando, Florida, U.S.A. Sponsor: Institute of Nuclear Materials Management. Contact: INMM, 60 Revere Drive, Suite 500, Northbrook, IL 60062; phone, 847/480-9573; fax, 847/480-9282; E-mail, inmm@inmm.org.