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INMM Grows to Address New Challenges

By Nancy Jo Nicholas
INMM President

Nuclear technologies and the issues that accompany them have grown immensely in the past few years and greater changes loom on the horizon. A renaissance in the nuclear power industry in developed and developing nations has spurred expansion of nuclear engineering and research programs. At the same time, the threats of nuclear proliferation and terrorism have compelled technology providers and policy makers to action. The INMM and its members are addressing many of these global challenges.

The INMM continues to grow to meet these challenges. INMM's first two student chapters were formed recently—at Texas A&M University and at Mercyhurst College—and another university is in the process of establishing a student chapter. The excitement of those involved in these student chapters is inspiring. I hope their enthusiasm reminds us of our own motives for entering the field and reinvigorates our work. Last year a regional INMM chapter was established in California, and planning has begun for potential international INMM chapters in Europe and Asia. In addition, our six technical divisions are expanding their scope to include nuclear security and illicit trafficking of nuclear and radiological materials.

INMM's Largest Annual Meeting to Date

The 47th INMM Annual Meeting in Nashville, Tennessee, brought together nearly 1,000 attendees and guests. It was a record-breaking success. During the opening plenary session, Jill Cooley, a dedicated and active INMM member, presented remarks by IAEA Deputy Director for Safeguards Olli Heinonen on IAEA Nuclear Safeguards: Staying Ahead of the Game. The technical program's quality directly reflects the contributions to the field by INMM members and annual meeting participants and the dedication of the volunteers who support Charles Pietri on the Technical Program Committee. I'm also grateful for the contributions of the Registration Committee, chaired by Glenda Ackerman, and the Poster Session, chaired by Taner Uckan. I was extremely pleased at the number and quality of this year's student papers and posters. Yvonne Ferris, Chad Olinger, and the members of the Memorial Education and Outreach Committee deserve praise from the entire INMM for their diligent work in judging student papers and posters for the J. D. Williams Student Paper Award. (Read the winning paper beginning on page 29.)

Sharing Global Best Practices

Last year, in his opening plenary address at the INMM Annual Meeting, Nuclear Threat Initiative (NTI) President Charles Curtis challenged INMM to do more to promulgate best practices. A committee of INMM Fellows evaluated options and recommended that the INMM Executive Committee work with NTI to create a World Institute for Nuclear Security, or WINS. The Fellows have established an ad hoc WINS Steering Committee, chaired by John Matter, and continue to collect input and ideas from interested parties. This fall they will help coordinate an international experts meeting where they will provide information about the WINS concept, gather input, discuss possible WINS activities, and prepare for a larger stakeholders meeting.

Leadership Development Opportunities

We held an INMM leadership orientation course, the Friday before the Annual Meeting, designed to educate potential future INMM leaders and officers about the history, mission, and structure of the Institute; the roles and responsibilities of the officers; and the annual meeting planning process. Debbie Dickman planned the course, which was taught by the current officers and the Annual Meeting Technical Program Committee chair. The course was developed a few years ago during the leadership development thrust of the INMM strategic planning initiative, led by J. D. Williams. We plan to hold similar sessions for future leaders every few years.

INMM is a volunteer-driven professional society. We leave plenty of opportunities for interested members to get more involved. I highly recommend and encourage members to participate in regional chapter activities such as technical workshops and seminars. A number of INMM committees could use some enthusiastic volunteers. Many of our committees meet once a year during the INMM Annual Meeting and conduct the rest of their work via e-mail and teleconferences. The Registration Committee conducts the bulk of its work during the annual meeting, and it's a great way to meet attendees and network. The Student Activities Committee and Communication Committee are both actively engaged in raising the profile of INMM. Submitting papers for publication in the peer-reviewed *Journal of Nuclear Materials Management* is another attractive option that should appeal to members. I've been an active volunteer and always thoroughly enjoy the time and energy I invest in this Institute and I'm that confident you will enjoy it as well.

If you have comments, ideas, or questions about INMM, I encourage you to e-mail me at njnicholas@lanl.gov or n.j.nicholas@earthlink.net or contact INMM headquarters at inmm@inmm.org.

The Flavor of INMM

By Dennis Mangan
Technical Editor

I am personally proud of this issue of the *Journal.* It does a beautiful job of capturing the essence of the 47th INMM Annual Meeting and the Institute itself. It addresses many of our reasons for our existence: it provides the flavor of our organization from, *inter alia,* the opening plenary speaker's presentation, to the intense efforts we have to develop the participation of young, needed students, and to the rather impressive *documentary* on a favorite topic of a dear friend of mine, Cecil Sonnier, and his long desire of chasing the simple word *transparency.* As you read this issue, these are what I call powerful thoughts and efforts.

Charles Pietri provides an excellent overview of our record-breaking Annual Meeting in Nashville. He identifies many of the highs, discusses the results of the meeting survey. One certainly gets the feeling that Charles is not going to rest on his laurels, but will continue to strive to improve. As you read his report, you will find interesting the effort being put forth by Mark Leek and others in nurturing our student population.

I encourage you to read the Opening Plenary Address by Olli Heinonen, deputy director general and head of the Department of Safeguards at the International Atomic Energy Agency. In his paper, *IAEA Safeguards—Staying Ahead of the Game,* he makes several thought-provoking comments. Two in particular were interesting. In discussing the scope of IAEA verification, he notes that since both the safeguards agreements and the Additional Protocol are focused principally on nuclear material, "…the IAEA's legal authority to investigate possible parallel weaponization activities is limited, unless there is some nexus linking the activity to nuclear material." I don't believe many people appreciate this limitation on what some refer to as "the international nuclear watchdog." Further on he states, "Another key to making verification effective is sufficient resources. IAEA verification today operates on an annual budget of about $120 million—a budget that would be comparable to that of a professional baseball team, or the police force of a large city, or half the price of a single jet fighter." I suggest that when considered in this context, the IAEA does a rather impressive job of being the international nuclear watchdog.

Jill Cooley, director of concepts and planning in the IAEA's Department of Safeguards, actually presented Heinonen's paper. Jill, who has long been associated with our institute and is one of our Fellows, in the opinion of many made a rather persuasive presentation of the paper. She also participated in the INMM Roundtable following the opening plenary. As you read this Roundtable, I believe you will find her to be extremely competent and her answers to the questions are very straightforward. She is to be congratulated, and we definitely owe her our appreciation.

A summary of the closing plenary is provided by Amy Whitworth, chair of the Government-Industry Liaison Committee, the committee responsible for this session of the Annual Meeting. As you read the summaries of the three speakers, you will gain insights into the U.S. Department of Energy/NNSA Defense Nuclear Security Program, the U.S. Nuclear Regulatory Commission's Regulation of Nuclear Facilities in the Post-9/11 Security Environment, and the IAEA's Nuclear Security Plan 2006-2009.

As has become the custom with the fall issue of the *Journal*, we publish the student paper that judged the winner of the J. D. Williams Best Student Paper Award. This year Andreas Enqvist of the Chalmers University of Technology in Goteborg, Sweden, presented the winning paper. The paper, *The Number Distribution and Factorial Moments of Neutrons and Gamma Photons Generated in a Multiplying Sample,* addresses issues associated with determining the mass and isotopic compositions of unknown samples.

The final paper in this issue is one written by the INMM's International Safeguards Technical Division in memory of its beloved "founding father" and its first chair, Cecil Sonnier. Cecil, who I was fortunate to have a colleague and friend, had a passion to explore and attempt to get international consensus on new (and sometimes old) international safeguards issues. One of those issues was the use of the word *transparency.* If I recall correctly, Cecil brought the discussion of transparency into the technical division's meeting at the 1994 Annual Meeting. Of the thirty or so attendees at that meeting, I believe a dozen provided their definition of transparency. The meeting was quite lively, and no consensus was attained. I remember commenting to Cecil after the meeting that he acquired as many definitions of transparency as he had volunteers to offer one. James Larrimore, Myron Kratzer, John Carlson, and Bruce Moran (all friends of Cecil's) were instrumental in this paper in Cecil's honor, *Transparency and Openness: Roles and Limitations in the Nuclear Nonproliferation Verification System.* I believe it will be the benchmark and most referenced paper on this topic in the future.

If you have any question or comments, don't hesitate to contact me at dlmanga@sandia.gov or dennismangan@comcast.net, or contact INMM headquarters at inmm@inmm.org.

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Report of the 47th INMM Annual Meeting: A Record-Breaker by Any Standard

by Charles Pietri
Chair, Technical Program Committee

INMM does not go out of its way to make or break records for the Annual Meeting—we just try to provide the most professional forum we can for our eager constituents thirsting both to reveal and to learn the best there is in the nuclear materials management community. And then to incrementally improve on this posture each year.

So it pleased and surprised us that we broke so many records at the 47th INMM Annual Meeting, July 16–20, 2006, in Nashville, Tennessee:

- Highest-ever meeting attendance—953 (including seventy-nine companions)
- 361 papers
- 51 sessions
- 30 posters and more than 100 poster session attendees
- 29 student papers
- 47 student attendees

But above all, it is reported that overall the quality of the papers and their presentations were best. We get all this information from data compiled from our evaluation surveys, session chair reports, INMM HQ staff observations, verbal comments at the meeting, and written comments after the meeting. Very little opinion goes into this report and none of my personal thoughts unless I specifically identify them. We'll look at this year's Report Card later on.

So why the significant growth and obvious enthusiasm at this meeting? We don't really know specifically but INMM plans to keep doing all it can to ensure continuing success. In fact, Charles Curtis, president of the Nuclear Threat Initiative (NTI), in his August 8 letter to President Cathy Key stated, "I want to congratulate you on another successful INMM Annual Meeting and express my appreciation for your personal leadership of INMM throughout this last year."

However, not all went well this year. Two days before the Annual Meeting we received notice that our Plenary Speaker Olli Heinonen, deputy director general, and head of the Department of Safeguards at the International Atomic Energy Agency (IAEA), would not be able to participate in the Annual Meeting because of urgent matters at the IAEA. (A month after the meeting he informed me that "…turbulent times seem also [to] be in front of us.") But INMM folks came through. With the help of Jim Larrimore, Jim Tape, and Leah McCrackin we were able to get a copy of Heinonen's speech from Vienna, track down Jill Cooley, director of concepts and planning at the IAEA, who we proposed would give the talk, and then get approvals to have the paper presented. Of course, Jill gave a most interesting talk on the very timely topic of *IAEA Safeguards—Staying Ahead of the Game,* (Olli Heinonen, author). It was evident to all that Jill was not merely reading the text but rather she thoroughly understood the meaning and impact of the paper. The talk focused on the need for change within the system to be able to find innovative solutions and avoid further proliferation of nuclear weapons and the clandestine means to produce them. (I was personally pleased to have such a knowledgeable expert make the presentation.) We were all smiles.

A happy conclusion: Jill Cooley, IAEA, (right) with Charles Pietri, INMM (left)

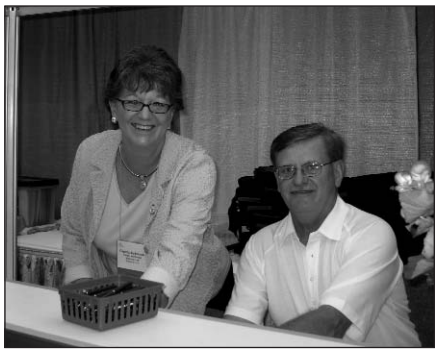
After the Opening Plenary Session, an interview was conducted at the lunchtime INMM Roundtable by *Journal* Technical Editor Dennis Mangan. There was the usual lively discussion on several topics that you can read about in the Roundtable interview on page 16 in this *Journal* as well as Olli Heinonen's complete paper; the paper also will be found in the *Proceedings of the INMM 47th Annual Meeting.*

Denny Mangan's Journal *Roundtable Luncheon: (left to right): Cathy Key, Jill Cooley, and Nancy Jo Nicholas*

In general, there did not seem to be major concerns at this meeting (after resolving the Opening Plenary)—no unexpected excessive paper withdrawals after the meeting had started and no significant defaults in attendance by country or facility, or anything else. We were told by many that the 47th Annual Meeting was another success and to "…keep it up." We did have some exciting firsts beyond the record breakers, one of which was our increased student participation that we'll review later on. On the downside we also had a record-breaking withdrawal of fifty-nine papers! Can you believe that we started off with more than 420 abstracts submitted this spring? It was very interesting to note the unusually high number of abstracts submitted along with the equally high number of withdrawals. INMM is still trying to

make some conclusions about these events.

And how would we ever survive, much less thrive, without Glenda Ackerman and her award-winning Registration Committee. (See details later.)



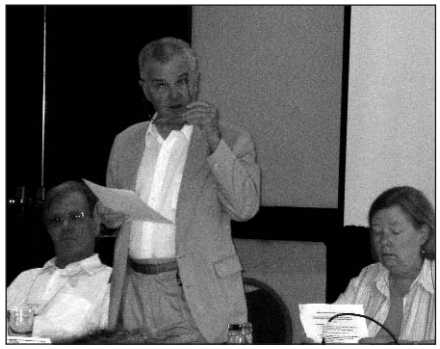
Glenda Ackerman and Mike Suwala—They were still smiling on the last day, too!

This year our faithful INMM HQ staff consisted of Leah McCrackin, our executive director, who knows everything; Lyn Maddox, our conference director; who can and does fix everything; Madhuri Carson, our conference administrator who makes order out of chaos—usually; Patricia Sullivan, the *Journal* managing editor, doing what needs to be done to help the meeting run smoothly; and, this year, Natalie Freeley, a new face substituting for INMM Administrator Kesha Bunting who decided to stay home to have her baby—poor planning I say! (Don't fret—Kesha will be back soon!)

On Saturday morning, before the official opening of the 47th Annual Meeting, two significant events took place: the INMM Executive Committee met to discuss worldly activities of interest to INMM including the proposal status of the World Institute of Nuclear Security (WINS); and the Annual Meeting of the New Brunswick Laboratory Measurement Evaluation Program. One of the values of the Annual Meeting is the opportunity for many attendees to "piggy-back" their meetings here. Many have told us that without INMM's meeting it would be otherwise difficult to get the time, place, and attendees for their side meetings. After all, the INMM Annual Meeting is where everybody is! (The day before an orientation session related to INMM history, processes, and activities for interested parties was held to more fully acquaint those individuals on the inner workings of the Institute.)

The hard-working, hard-thinking INMM Executive Committee

The long-established time for the six INMM Technical Divisions to meet and discuss issues and topics of importance is Sunday afternoon—a forum where the most knowledgeable professionals in the nuclear materials management community are assembled. As I visited each meeting I found that they were well attended and hopefully some good issues were developed further and others resolved satisfactorily.



Jim Larrimore (center) pointedly addressing the International Safeguards Division with Gotthard Stein (left) and Diana Langner (right)

Sunday is also the traditional time for the ANSI/INMM 5.1 Analytical Chemistry Laboratory Measurement Control Committee to meet. This ANSI N15 Committee has just completed the draft document N15.51 *Measurement Control Program—Nuclear Materials Analytical Chemistry Laboratory* and its renewal by ANSI is being processed. Another Sunday pre-meeting event was an early morning information gathering session: NNSA MC&A Implementation Panel Meeting chaired by Amy Whitworth.

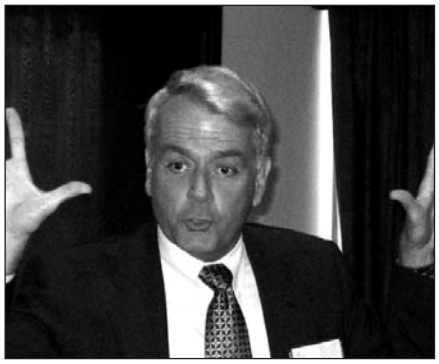
A fitting way to end the first official day of the meeting was the President's Reception on Sunday evening. This is the occasion for meeting colleagues and friends in the nuclear materials management community in a relaxed atmosphere. It's also a good way to prepare for the formal sessions starting early next morning. It was a very active evening complemented by food, beverages, and fellowship.

Attendees gather in the exhibit area at the President's Reception.

For our exhibitors, we try to plan events, such as the President's Reception and coffee breaks, in locations that give visibility to the exhibits and an opportunity for the meeting attendees to visit with these exhibitors. Some of the attendees actually want the exhibitors to stay longer so that they will have a better opportunity to see more of the exhibits. Our exhibitors deserve a lot of recognition for the way they spend a few days of their lives setting up displays and meeting with interested individuals who gain some insight into the practical applications and the innovative technology available for use. This year there was plenty of space for the exhibits and for the attendees to easily roam the various booths. If this year was good, next year in Tucson will be a delight for the exhibitors— and attendees, too.

The Awards Banquet took place on July 18 and ended with live (and loud) music (after all, Nashville is the home of country music.) The following awards were pre-

John Feng, Taiwan Power, the internationally known country and western karaoke singer, with Charles Pietri, visiting the exhibits.



Professor Paul Ebel and his frenzied, passionate exhortations to the speakers

sented: Meritorious Service Award to Scott Vance, and Special Awards to Leroy (Lee) Leonard and Connie Hall. Resolutions of Respect for several of our deceased members were read: Tohru Haginoya, Richard A. Schneider and Fred H. Tingey.

This is the fourth year that Professor Paul Ebel has conducted his fabulous and internationally recognized speakers' and session chairs' tutorial following the speakers breakfast each day. (I've been told that the attendees come to hear him rather than get instructions from me.) This year Ebel provided a brief summary of the past tutorials and then followed with a new series of helpful, even critical, pointers. (Now if only all of our speakers would follow Ebel's advice we would have exceptional meeting presentations—and put Ebel out of business.)

INMM HQ Staff relaxing a bit at the annual meeting banquet (left to right): Patricia Sullivan, Madhuri Carson, Leah McCrackin, Lyn Maddox, and Mike Hinchman.

LCD PowerPoint© projection systems for speaker presentations appear to be managed well once again with very few issues. INMM thanks Ebel and the technical division chairs and their colleagues for continuing to make the process work successfully.

As we said previously, a variety of means were used to evaluate the Annual Meeting.

The Report Card this year was better than previous years with some notable exceptions that were mostly very positive. We must be doing something right. I'll bet it's because we listen to all the comments our attendees offer and take action on those that are sensible and within our control to do so.

Here are the ratings:

The responses we get from the electronic survey is never very large. For example, only 29 percent of the attendees responded to the survey. In 2005 it was 25 percent, 2004 (31 percent), 2003 (5 percent—last year of the written survey). So, be aware that these findings may not be typical of the entire group of participants but only those who took enough interest (constructive comments or complaints) to respond.

Once again this year the **Overall Annual Meeting process** was rated similar to last year's—mostly as **good-excellent** with **excellent** commendations for the **Call for Papers, Online Abstract Submission process, Preliminary** and **Final Programs,** the **Online Program,** the **Technical Program Committee** and the ever-effective and gracious **INMM HQ Staff.** The **Pocket Schedule-at-a-Glance** again had the highest rating with the **Registration Process** following closely. We had a great **student** turnout and the papers and their presentation were **good**. The **Opening Plenary** session was rated as **good+**. Unfortunately, there were not a significant number of responses for the **Closing Plenary** to make an exact judgment.

The **Technical Information Exchange, Logistics,** and **Exhibits** areas were also rated highly **good-excellent** (mostly good). In fact, about 90 percent of the responders thought that the papers and their presentations were **good-excellent** despite some individual comments to the contrary.

The **Hotel** and **Facilities** were not rated as high as last year's Phoenix site—this year it was given a good-excellent rating by 70-85 percent of the responders. (Wait until next year: if you liked Phoenix, you'll love Tucson—not including the weather, over which we have no control!) **Once again, regardless of any other factors, nearly 94 percent of the respondents indicated that the INMM Annual Meeting met their needs and expectations!**

INMM continues to receive good meeting evaluations from those attendees that took the time to respond. INMM reviews all comments provided; some of them are addressed below while others are of an administrative nature (handouts, pocket schedule, coffee breaks, LCD projector details, etc.) that will be taken into consideration by the Technical Program Committee and INMM HQ staff. Please note that these comments may not be entirely representative of attendee sentiment. Nevertheless, we take the opportunity to provide some responses to comments that appear to warrant further discussion:

Overall, another well-prepared, well-implemented and well-attended Annual Meeting. Congratulations. *We just put this one in to set the tone!*

Excellent meeting, well organized and conducted and beneficial. The speakers'

breakfast and use of the TPC (preparation and monitoring) in conjunction with the Technical Divisions contributes significantly to the overall success. Many issues are ironed out, which in turn makes the flow of the meeting transparent. *Another kudo—INMM really tries hard.*

❖

Papers of interest—consider developing a Web-based capability that will allow attendees to build and print a "papers I want to see" itinerary to facilitate switching between sessions to catch different papers. *Good idea— INMM has already started to plan for this feature.*

❖

Too many long talks at Awards Banquet; need to shorten up the length of award presentations. The awards banquet was too drawn out and dramatic. It needs to be crisp. *INMM will take this point under consideration.*

❖

Too many parallel sessions of interest and some overlapping make it difficult to attend all sessions and always losing time going from one session to the other. But no real suggestion to improve it unless you stretch the conference on the whole week? Too many papers and too many sessions. Consider extending the meeting or reducing the number of papers/ sessions. I think the meeting was excellent. Where I have indicated 'Good' is only because the meeting had the aspect of a three-ring circus—meaning that there were so many good presentations being given in different sessions—it was hard to catch them all. I don't know how this can be corrected. I would hate to eliminate presentations. *We hear this comment each year and it is somewhat of a paradox because each attendee has his/her own concept of what papers they would like to hear. We know it's no real consolation to the individual but we have urged our attendees to impress on their management the need to send more staff to the Annual Meeting to cover all of the papers of interest. Extending the week by even one day does not seem to be viable based on many comments that even four days (five days if we include the Sunday meetings) is overload.*

❖

I found Nashville to be rather uninviting. Needless to say the area around the Renaissance was not the most conducive to bringing families and for enjoying free time. I noticed this year a paucity of families at the meeting. The meeting was great but leaving the hotel was a bit depressing in that Nashville's downtown is typical southern urban decay and sprawl. *On the other hand we find a different perspective:* Venue was very good being downtown in a vibrant city. *And:* The hotel location was bad. It was not feasible to walk to any reasonable restaurants. *And yet more:* This was a nice meeting but the location (Nashville) was great for me but I would think if someone took their family, there would not have been enough for them to do. *And again:* All in all it was a good conference and the hotel was very nice. Having so many restaurants within walking distance was also nice. *So, once again we have a diversity of opinion about the venue for the meeting. In the past we have been urged by a significant number of attendees to have a "city location" rather than a "resort." We tried it—and some like it, some don't. INMM had a record-breaking attendance—was it the location or the program, or both? Or did the location not matter that much?*

❖

Suggest in the future that INMM go ahead and pay for projectors in every room so we don't have to worry about this. We will bring the laptops. The requirement that volunteers deal with getting audiovisual equipment should be reviewed. If it isn't cost prohibitive, using the services of the hosting conference center should be considered. *The cost is the deciding factor and it has been evaluated each year—currently it is prohibitive but we will do our annual review on this topic again for next year.*

❖

More notices could be given out sooner for submissions and an early time frame for acceptance of papers should be given. The whole process is during the busiest time of the work for our government and an earlier notification of papers could be given out in March. The final paper submission could be given by end of June. *The problem of final paper submission is a growing concern to INMM. Each person who presents a paper makes a firm commitment to provide a final paper—this year the due date was June 16. Yet, we were missing about 5 percent of the papers at that time — up from less than 1 percent for the past several years.* **(INMM will not accept papers for presentation from these individuals next year.)** *We start notifying potential authors monthly at least nine months in advance of the meeting. We also include that information in the Call for Papers in October of each year, in the Speakers Manual, and in the confirmation notice and letter sent for abstracts accepted.*

❖

Closing Plenary speakers need to be identified EARLY, so that attendees can plan around the closing. Many left early because they had no notice on who was speaking, and they could not justify the extra day to management because they could not show benefit from extra day. This really needs to be fixed, and identification of Closing Plenary speakers given as much attention as Opening Plenary. For the past few years that the Opening Plenary speaker frequently is not present and someone else reads their speech. The Closing Plenary speakers appear to be selected on an ad hoc basis. The stature and quality of the plenary speakers has gone down significantly over the years and requires attention. Richard Rhodes was

the last impressive plenary speaker. *INMM realizes this is an issue and it has tormented us for years. One way to avoid the disappointments is to solicit speakers through a speakers bureau at a cost not acceptable to anyone ($50,000 to $150,000). Richard Rhodes spoke to us for a relatively small pittance because of long-standing personal relationships—he was a friend and highly interested in INMM and what it stands for. I would, once again, solicit any specific input on Plenary Speakers for our Annual Meeting.*

Start presentations as scheduled. I attended one presentation that started ten minutes early. Do not reverse the order of presentations. I attended one session in which the one I tried to attend had been re-ordered (and not changed on the schedule). Interpreters for attendees should sit at a distance from the rest of the audience. It is very annoying to hear talking in the background when you are trying to listen to a speaker. Papers should be presented in English only. Having the speaker present in a foreign language and an interpreter represent to the audience more than doubles the time to present information. Do not allow speakers to run over the time limit. This makes it impossible to get to another session if it is not in the same room. *One of the problems facing INMM is how to get some of our session chairs and presenters to read, listen, and understand the instructions for successfully managing a session. INMM explicitly, on many occasions, and in several media, instructs the session chairs and presenters to start and end on time and never to rearrange the talks. Yes, we need to address the interpreter issue and the resulting crosstalk. As for translations, there are only a very few speakers who really require a translator; it would be better to resolve this issue by allowing a double session so as to give the speaker and translator sufficient time to make a sensible presentation. INMM needs to discuss this and other approaches further.*

❖

Posters should run two days or have an entire session dedicated because it's very difficult to attend both oral and poster sessions. Each year I never get enough time to peruse the posters. *We had outstanding poster presentations this year and many of them. INMM will discuss the practicality of extending poster sessions for two days next year.*

❖

Some of the rooms were overcrowded and didn't allow for enough space—especially items that would be more in the political arena and high on the agenda. Some rooms tended to be overcrowded, confining, and hot while others had less attendance. *Each year when the Technical Program Committee reviews the abstracts and places papers in sessions, the committee is asked to determine the size of the room needed for each session based on potential attendees. Occasionally, we guess wrong—it is sometimes difficult to know what the makeup of attendees will be and their interests. Our apologies.*

❖

We often lack time to take notes during the presentations/conference. Perhaps the speakers could prepare some printed papers (more developed than the abstracts) for the people attending their presentation. It would permit attendees to keep in mind the major points of their presentations. *For many years INMM has strongly urged presenters to bring copies of their papers, or surrogates, to their session for distribution to interested parties. There has been only a small response to these requests.*

❖

The space provided for exhibitors was too small. It seemed that the exhibitors were crowded. *And yet we received other comments:* A few more booths would be good, but it was a nice number, not too crowded. With the exhibits closing on Wednesday it makes the conference feel like it too is over that day and not Thursday. *Maybe we need to encourage the exhibitors to stay longer?*

The heat seems to be increasingly oppressive in the cities that are chosen for this event. *I always include this comment each year and the answer is always the same: INMM negotiates the best overall deal for meeting location, space, and amenities possible. This usually means that the weather is not the most attractive for tourism and we get the better deal. Even so we still get complaints that our hotels are above per diem! However, I can assure you that the weather in Tucson next year will be hot but much less humid—hopefully, the temperature will be in the low 100°Fs and not at the 115°F levels we have had in the past. (An alternative remedy: stay inside the cool hotel during the day and listen to papers.)*

Again this year the major issues facing INMM in managing the Annual Meeting program were excessive paper withdrawals, frequent speaker changes, and late/absent final paper submittals. INMM will continue to try to keep paper withdrawals and speaker changes under control but it requires significant contribution from all meeting participants to make the program what we all expect it to be—a well planned and coordinated event. We have addressed the final paper submission problem elsewhere in this report. But be assured that INMM continues to recognize all of you who cooperated so well to make the meeting a success.

Scott Vance, Membership Committee chair, notes that the New Member/Senior Member Reception was once again very well attended and, in my opinion, a great success. We had a good attendance of both new regular members and new senior members, and we also had a fantastic attendance of new student members. We not only had the usual opportunity to have them meet officers of the Institute but Debbie Dickman gave them a short, encouraging talk regarding the benefits of becoming involved in both their technical divisions and local regional chapters. The most apparent aspect of this year's reception is that there were a significant number of individuals who stayed for the entire hour and great interaction between the

Scott Vance, Membership Committee Chair, officiating at the New Member/Senior Member Reception

younger and more senior members.

This year, Mark Leek, chair of the Student Activities Committee (SAC), took a competent and comprehensive approach for this meeting. He organized the mentor program that matched INMM members with students to help personalize the conference for students and organize their time. This effort included an orientation meeting Sunday night to match members and students and a student initiative meeting Wednesday night for students to learn about career opportunities in nuclear materials management. This involved presentations by the chairs of each of the technical divisions. Further, in concert with INMM HQ staff, Leek arranged for two international students to attend the Annual Meeting, all expenses paid, under the auspices of the SAC and with funds provided by the INMM Executive Committee (EC). The two students were from Obninsk and Shanghai. (A third student from the Urals was unable to obtain a visa in time for the meeting). A block of six hotel rooms was reserved for use by twelve students, again under the auspices of the SAC and with funding provided by the EC. Two Texas A&M University (TAMU) students were recipients of INMM-supported air fare and hotel accommodations as first prize winners of the student paper competition sponsored by the TAMU INMM student chapter. Our student population is growing and their level of enthusiasm continues to spread.

As we said earlier, there was a very large turnout of students this year and

Mark Leek, chair of the Student Activities Committee, attending to his student flock

many presenting papers—a thrill for us. INMM continues to promote student participation in the Institute by, among other incentives, encouraging students to present the results of their research at the Annual Meeting. This is the fifth year of such an initiative and thirty papers were in competition for the J. D. Williams Best Student Paper Award. Many of our INMM colleagues, especially Chad Olinger, chair of the Memorial, Education, and Outreach Subcommittee, and others too numerous to mention, are responsible for making this student competition a success. First place in the competition went to Andreas Enqvist, Chalmers University of Technology, Goteburg, Sweden, and second place to Nicholas Smith, University of Nevada-Las Vegas, USA, while Josh Tackentien, Mercyhurst College, USA, took first place for the best poster presentation.

Happy Student Paper Award Winner Andreas Enqvist (holding the $1,000 check) with President Cathy Key (left) and Vice President Nancy Jo Nicholas (right)

Posters, posters, posters— thirty in all filled the spacious room and popcorn was served in the afternoon. There were plenty of visitors (and more wishing they had the time to visit). Taner Uckan masterfully orchestrated the process and even had a real card game going in the rear! *(IAEA Nuclear Inspection Simulator* presented by Josh Tackentien, Mercyhurst College—a student who won the Best Poster Award this year.)

The Government-Industry-Liaison Committee (GILC), Amy Whitworth, chair, presented three speakers for our Closing Plenary session's theme Nuclear Security in the Post-9/11 Environment: *NRC Regulation of Nuclear Facilities in the Post-9/11 Environment* by Mark Shaffer, Nuclear Regulatory Commission; The *NNSA Defense Nuclear Security Program* by Cheryl Stone, Defense Nuclear Security; and *The IAEA Nuclear Security Plan for 2006-2009* by Anita Nilsson, International Atomic Energy Agency.

In closing, if this Annual Meeting has been successful, if it met or exceeded your expectations, and if you enjoyed it, the credit goes to the nearly 400 speakers, the session chairs, the Technical Program Committee with their varied duties (especially the technical division chairs), and the INMM HQ staff. I've tried to give you just a slice of life at an INMM Annual Meeting and my apology if I've left out any individual, group, or event.

That covers the 47th Annual Meeting—let's talk about 2007 at the JW Marriott Starr Pass Resort in Tucson, Arizona on July 8–12.

JW Marriott Starr Pass Resort, Tucson, Arizona: Home for the 48th INMM Annual Meeting

Yes, it's one week earlier than usual. That means you have to start planning for it now. Complete your research, get your subject approved by management, write your

abstract and submit it by February 1, 2007, ***then write your paper and submit it early—certainly no later than the June 8, 2007 deadline.*** If you are planning to organize a special session, you need to think about it carefully and contact me or a technical division chair by November 27, 2006, or sooner—**no last minute ventures, please.**

INMM looks forward with much pleasure and anticipation for your presence at the 48th Annual Meeting next year—another gala affair. Let's do it!

Technical Program Committee Chair Charles E. Pietri can be e-mailed at cpietri@aol.com

Opening Plenary Address
IAEA Safeguards—Staying Ahead of the Game

47th Annual Meeting
Nashville, Tennessee, USA
Opening Plenary Speech
Monday, July 17, 2006

Olli J. Heinonen
Deputy Director General
Head, Department of Safeguards
International Atomic Energy Agency

Presented by Jill Cooley
Director of Concepts and Planning
Department of Safeguards
International Atomic Energy Agency

Note: Due to unforeseen circumstances, Mr. Heinonen was unable to make this presentation. However, INMM Fellow Jill Cooley, who serves as director of concepts and planning in the department of safeguards at the IAEA, made this presentation on behalf of Heinonen. The INMM extends its thanks to Jill Cooley for her gracious assistance.

The nuclear nonproliferation regime today faces a broad array of challenges. Some refer to the system as being in crisis; that may be too strong a statement, but the regime is certainly being tested. A number of vulnerabilities in the system have been exposed in recent years, and changes are clearly needed if we are to avoid the further proliferation of nuclear weapons.

Why Are These Changes Needed?

The answer is quite simple. The world is undergoing rapid changes on many fronts—socially, politically, and technologically. The Treaty on the Nonproliferation of Nuclear Weapons (NPT) was ratified more than thirty years ago. It should not surprise us that the solutions of 1970 are not a perfect fit to the challenges of 2006 and beyond. The problem is that we have not in all cases made the necessary adjustments to match these new challenges.

In particular, since the end of the Cold War, we have seen three developments related to nuclear proliferation: (1) the increased dissemination of nuclear technology and nuclear "know-how"; (2) a renewed drive on the part of a few states and extremist groups to acquire nuclear weapons; and (3) the emergence of clandestine nuclear procurement networks.

In addition to these trends, the renewed interest in nuclear power on the part of many countries—and the expectation for an expansion in new nuclear construction—makes it even more important that we have strong mechanisms in place to minimize the risks of proliferation. The international community will demand no less.

With regard to nuclear proliferation and arms control, the basic solution is clear: either we begin finding innovative solutions or the international nuclear safeguards regime will become obsolete.

First, a real commitment to disarmament—moving away from national security strategies that rely on nuclear weapons, which serve as a justification for other nations to acquire them.

Bringing multinational approaches to uranium enrichment and reprocessing would lower the risk of these materials to be used for weapons. A mechanism to ensure a reliable supply of reactor fuel would contribute to those ideals as well.

The third area of interest is how to deal with three major nuclear countries that remain outside of the NPT. Regardless how much we may wish it, none of them is likely to give up its nuclear weapons or weapon options in the foreseeable future, unless the security outlook for those countries changes. Treating such states as outsiders might not be a realistic option anymore.

Let me now discuss in more detail a number of suggestions on how the regime might be strengthened to meet these new challenges.

Better Control of Access to Nuclear Fuel Cycle Technology

The first question is how to better control access to, and ensure the appropriate use of, sensitive nuclear technology.

In recent years, far more countries have sophisticated engineering and industrial capacity, which is necessary for economic development, and should be welcomed. However, at the same time, nuclear technology has diversified, making it harder to track illegal or clandestine global procurement and sales. Electronic communication has made it easier to transmit component designs and other information. And many types of sensitive equipment and materials are classified as "dual use"—meaning that they could have both nuclear and non-nuclear applications—which makes it harder to maintain export controls.

As we all agree, under the NPT regime, there is nothing illegal about any state having enrichment or reprocessing technology. A relatively small number of countries have mastered part or all of the nuclear fuel cycle, enabling them to enrich uranium, produce fuel for power and research reactors, and reprocess spent fuel for re-use and waste disposal.

But as more countries gain this expertise, concerns have arisen regarding the margin of security resulting from this situation. The acquisition of highly enriched uranium (HEU) or separated plutonium is generally considered to be one of the most difficult steps towards making a nuclear weapon. By having access to nuclear material, or the capability to produce such material, a country has passed this step. Therefore, if a country with a full nuclear fuel cycle to produce enriched uranium or plutonium were to decide to break away from its nonproliferation commitments, a nuclear weapon capability could be within reach in a relatively short time.

For this reason, the IAEA and others have been exploring options for how the most sensitive aspects of the nuclear fuel cycle—uranium enrichment and plutonium separation—might be better implemented. The overall concept would be to move toward multinational arrangements for these types of operations. This would not happen all at once; as currently envisioned, it would progress as a series of measures:

- First, a mechanism would be developed to provide an "assurance of supply"; that is, a guarantee that reactor technology and nuclear fuel would be available for all bona fide users for peaceful civilian applications;
- The second step would be to call for a temporary moratorium (for example, for five or ten years) on new uranium enrichment and plutonium reprocessing facilities—at the very least for countries that do not currently have such technologies;
- Third, a similar framework would be created for managing and controlling the "front end" of the fuel cycle (i.e., enrichment and fuel production); and
- Fourth, we would work on establishing a framework for multinational management and control of the "back end" of the fuel cycle (i.e., spent fuel reprocessing and waste disposal).

The importance of assurance of supply is that, by providing reliable access to reactors and fuel at competitive market prices, the justification is removed for new countries to develop their own front end fuel cycle capabilities. But this means that the mechanism to assure supply must be reliable and credible.

A number of governments, industry groups and other organizations have been offering ideas and initiatives on how to facilitate progress with the assurance of supply. This coming September, at the IAEA General Conference in Vienna, we will hold a *special event* focused on developing a roadmap for moving forward in this area.

Ensuring the Protection of Nuclear Material

Another area of vital importance concerns the protection of nuclear material. Many international and regional initiatives are underway to help countries in this effort.

The importance of protecting such material has been elevated by the stated ambition of extremist groups to pursue nuclear and radiological terrorism. The frequency with which the IAEA's Illicit Trafficking Database receives reports involving nuclear or radiological material makes clear that vulnerabilities remain. Fortunately, only a relatively small number of these cases so far have involved high enriched uranium or plutonium. But this should not be a source of comfort. If an extremist group were to acquire nuclear or radiological material, we must assume they would not hesitate to use it.

Several agreements have been reached on how to enhance nuclear security. The UN Security Council adopted resolution 1540 in 2004. The International Convention on the Suppression of Acts of Nuclear Terrorism was adopted by the UN General Assembly last year. Both resolution 1540 and the convention call on countries to criminalize the illicit possession and use of radioactive material, and aim to enhance efforts to detect and combat illicit trafficking. And the parties to the Convention on the Physical Protection of Nuclear Material—for which the IAEA serves as facilitator and repository agency—agreed last year on major changes to better protect nuclear facilities and material. The IAEA has been supporting a number of initiatives—such as the regional seminar held in Quito, Ecuador, in April 2006—to encourage countries to implement these measures as fully and as early as possible.

Many countries have also been taking steps to convert their research reactors from high enriched to low-enriched uranium fuel, and to return the highly enriched uranium to the country of origin. But of the research reactors currently in operation, nearly 100 still use HEU enriched to 90 percent or higher—the level of enrichment needed for use in nuclear weapons.

So while it is clear that these and other steps are helping to reduce the risks posed by existing nuclear material, it is also clear that much work remains to be done.

Supporting Effective Nuclear Verification

A third area of importance is to provide the necessary level of support required to optimize the effectiveness of nuclear verification.

One key to the effectiveness of verification is the extent of

access that agency inspectors are given to information and locations. This access is governed by the legal agreements concluded between individual countries and the IAEA. In today's security environment, inspections that only verify what a country has declared under a comprehensive safeguards agreement are not likely to be considered effective enough, in terms of the degree of assurance they provide.

On the other hand, the expanded access provided by the Additional Protocol to safeguards agreements has, in recent years, clearly proven its worth. The Additional Protocol enables agency verification efforts to focus not only on what has been declared, but also on possible undeclared activities. The Model Additional Protocol was agreed upon in 1997, as a development that grew out of the case of Iraq's nuclear weapons program in the early 1990s.

As a side note, I should point out here, while discussing the scope of IAEA verification, that both safeguards agreements and additional protocols are focused principally on nuclear material. Therefore, the IAEA's legal authority to investigate possible parallel weaponization activity is limited, unless there is some nexus linking the activity to nuclear material.

The chief problem with the Additional Protocol is that it has not been universally applied. Today only about seventy countries have Additional Protocols in force. This limited number, nine years after the adoption of the Model Additional Protocol, falls well short of the agency's goal. The agency's verification efforts will not be regarded as "fully effective" as long as its inspection rights remain uneven from country to country. For the nuclear nonproliferation regime to be regarded as credible, it seems clear that the Additional Protocol must become the universal standard for how nuclear nonproliferation commitments are verified.

It is also important to consider that the central reason for verification is to build confidence. In recent years, we have seen that there are cases where proliferation concerns have created a confidence deficit, where even the access rights of the Additional Protocol may not be sufficient. In such cases, additional "transparency measures" may be called for.

Our verification work in Iran is a case in point. Over the past three years, agency inspectors have made extensive efforts to compile a detailed picture of most aspects of Iran's past and current nuclear program. But since parts of the program were concealed for nearly twenty years, this naturally has been a complex and labor-intensive effort, and a number of open questions regrettably remain unresolved. Therefore, the agency's Board of Governors has asked Iran to provide additional transparency measures—beyond even what would normally be expected under the additional protocol—to help to resolve these remaining questions, and thereby to provide the needed assurance about the peaceful nature of Iran's nuclear program.

The points I have outlined so far might sound somewhat negative. But at the same time I would note that, in the past few years, the agency has been able to make progress on the implementation of integrated safeguards. This includes reaching the conclusion—for states that have both a comprehensive safeguards agreement and an Additional Protocol in force—that there are no undeclared nuclear materials and nuclear activities in these states. In 2005, this conclusion has been reached for twenty-four states. And so far, integrated safeguards is being fully implemented in ten states, including Japan. This is a positive development, and should be welcomed. It is particularly significant in the case of Japan, which has the largest and most complete nuclear fuel cycle of any of the states in question. By reaching this conclusion in a given state, the agency is able to use its resources more efficiently.

Another key to making verification effective is sufficient resources. IAEA verification today operates on an annual budget of about $120 million—a budget that would be comparable to that of a professional baseball team or the police force of a large city, or half the price of a single fighter jet. With these resources, we oversee approximately 900 nuclear facilities in seventy-one countries. On the one hand, I am very proud of the professionalism and efficiency measures that have made this achievement possible. On the other hand, when I look at our growing responsibilities—as well as the need to "stay ahead of the game"—we are clearly operating on a "bare minimum" level of funding.

People and Technology: Planning for Increased Effectiveness

This brings me to the next topic and perhaps the most important: as we look to the future, what can be done to assure ourselves and our member states that the IAEA, as the international nuclear verification organization, will be "staying ahead of the game"? With the global reach of our responsibilities, and the continuous need to sift through vast amounts of information, how can we be sure that we are looking in all the right places? And how do we prioritize, using our limited resources to the best advantage?

Successful nuclear verification involves an interface between technologies, the professionals who use those technologies, and the institutions they represent. So far I have spoken mostly about ensuring the effectiveness of institutions and institutional measures. I would like to discuss workforce challenges and a number of aspects of verification-related technology.

During the last few years, we have been working on succession planning for the IAEA safeguards workforce. The average age of the agency safeguards inspectorate has been rising for more than a decade. The overall safeguards workforce has increased in number, but the largest percentage of that increase has been individuals between ages 55 and 62.

At the same time, we are finding recruitment more difficult. The pool of well-qualified candidates is getting smaller and the agency must compete with national governments and industry to hire fresh professionals with the proper expertise. Our salaries and compensation are not always competitive and our inspector positions often come with long hours and adverse travel schedules. On the other hand, the work is clearly rewarding, challenging, and of the greatest importance.

Let me now address a number of challenges we are facing in

verification technologies. Our objective is to provide credible assurances to the international community that states are honoring their safeguards obligations. In order to do so we have identified several key priorities:

- To develop, implement, and revise, as appropriate, safeguards approaches for new safeguards challenges (e.g., integrated safeguards), new facility types, and new operating conditions
- To optimize safeguards equipment and technology development with the view of further improving present detection capability and increasing the reliability of equipment while also ensuring the security of information transmission from the field and improving sustainability and timeliness
- To pursue R&D activities in the development of novel technologies for the detection of undeclared activities using, *inter alia,* member states support program mechanisms as well as internal resources and expertise
- To enhance capabilities in the area of environmental sampling (by expanding the capacity and capability of the network of analytical laboratories (NWAL))
- To increase and intensify efforts related to the collection, analysis, and evaluation of all available information on states' nuclear programs
- To maintain an efficient safeguards information infrastructure
- To enhance the agency's present satellite imagery acquisition and analysis capabilities to support the verification work of the agency

With these priorities clearly identified, we have also been identifying areas in which novel technologies are needed, based on either adapting existing technologies or conducting additional R&D. For example, in 2005 the department conducted a search for new technologies that would be capable of identifying nuclear fuel cycle process signatures. Sixty proposals were identified, and five proposals are being developed further.

We are examining a broad range of new technologies for their applicability in verification. These include:

Laser-induced breakdown spectro, nobel gas analysis, light detection and ranging for monitoring gaseous atmospheric pollutants, optical stimulation luminescence, and semiconductor sensors for UF6, (uranium hexafluoride). Additional suggestions will be required and more resources will be needed for the assessment and development of these novel technologies.

In the area of environmental sampling analysis, the NWAL remains essential to the agency's efforts. It is clear that the global FT TIMS capability should be expanded. And support will be required for the development of new environmental sampling methods, such as, for example to increase the sensitivity for determining particle location and to improve existing relocation techniques.

Finally, on a related note, we are working to improve our information analysis techniques. Information is at the heart of modern verification; in fact, we frequently refer to our work as being "information-driven safeguards." The conclusions in the annual Safeguards Information Report are based explicitly on the evaluation of *all information available* to the agency. However, with current resources and techniques, there are clear limits to how much information can be evaluated—and the amount of information available is constantly growing. New technologies offer the only solution for the collection and analysis of such large volumes of information. These technologies can quickly and automatically collect, extract, increase the signal to noise ratio of information, and present the results to the analyst in a readily digestible and convenient manner. In order to move forward, we will need to liaison with organizations capable of helping us in the development of these advanced information analysis techniques.

Conclusion

By entrusting to an impartial, independent IAEA inspectorate the task of verifying the peaceful use of nuclear energy, the international community has taken an important step toward improving the transparency of nuclear activities, and thereby indicated its strong support for international peace and security. Though we rely on an increasing amount of information and remote monitoring technologies, it is the physical access by IAEA inspectors to sites, information and persons that remain the pivotal points of the verification regime. Inspectors are, in fact, the "on-site eyes and ears" of the international community. This is a responsibility that we at the agency take very seriously. Every measure should be taken to ensure the effectiveness of our efforts. By adhering to their safeguards commitments, by taking prompt and responsible actions to correct problems, and by providing the IAEA with the resources necessary to do the job, states demonstrate the political will to ensure the effectiveness of the global nuclear nonproliferation regime.

Thank you.

INMM Roundtable

Monday, July 17, 2006
Nashville, Tennessee, USA

Opening Plenary Speaker
Jill Cooley
International Atomic Energy Agency

Dennis Mangan
JNMM Technical Editor, Chair of Roundtable

Patricia Sullivan
JNMM Managing Editor
Roundtable Coordinator

Participants:
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John Matter
INMM Immediate Past President

Nancy Jo Nicholas
INMM Vice President

Charles Pietri
INMM Annual Meeting Technical Program Committee Chair

Bernd Richter
JNMM *Associate Editor*

Gotthard Stein
JNMM *Associate Editor*

James Tape
INMM Past President

Dennis Mangan: Jill, I thought your presentation this morning was outstanding especially for someone who was a substitute. I was rather impressed with regard to the attitude you conveyed. It was almost like it was your paper. You just got right behind it and did a great job. Let me start off the questioning. One of the statements in the paper had to do with the amount of money that the safeguards organization gets. I found that interesting that it's about half the amount of an F-16. You also said it was about the average amount of money that maybe a police department in a city might spend, and here you guys look at, what, 900 facilities in seventy-one states? When I take those comments and I couple it with the fact that Anita Nilsson in IAEA's Nuclear Security does not obtain line-item budget of the agency but has to scramble for every dollar that she gets for the year and has to look for contributions. I wonder if this is reflective of the board of governors' attitude with regard to safeguards and the new mission of nuclear security.

Jill Cooley: First of all, thank you for your kind comments on my delivery this morning. I think the paper itself and the ideas behind it are supported by the whole of the Department of Safeguards and so it represents our collective view. With regard to the budget, one problem is that states' contributions to the work of the agency is part of a package of their support to the work of the United Nations. In general, states are supportive of nuclear safeguards and nuclear security activities, but they can't necessarily pull out a checkbook and make a contribution or increase the budget specifically for safeguards. Another issue is what is referred to as balance. Many developing countries call for any funding increase for safeguards activities to be balanced by an increase in funding for peaceful use activities (e.g., technical cooperation). There were some very tough discussions along this line in the board several years ago when an increase in the budget of the agency's verification program was being considered. We're in the middle of that same discussion now for Committee 25 and how its activities are going to be funded. A third issue regarding the budget is that many member states look at it in the context of their own budget issues—how they are cutting back and being lean-and-mean organizations. So you have countries such as Germany, Canada, and Japan that while they are very supportive of safeguards and verification they are always calling for more efficiencies in safeguards implementation. We constantly have to defend the scope and level of our verification activities as being essential for drawing credible safeguards conclusions. The Director General has stated repeatedly that the agency's first objective is, and has to remain, implementation of effective safeguards. Efficiencies are desirable but secondary. Bottom line—states are supportive, it just has to be seen in the context of support to the IAEA and to the UN as a whole.

James Tape: I wanted to second Denny's kudos for the job you did this morning. It was really impressive. I happen to know how much warning you had that you

were going to be asked to do this and it was not much. In the question you just answered you mentioned Committee 25, and you had a question about Committee 25 this morning. I think it would be very useful for this interview if you could again provide some background about Committee 25, its status, and where it's going.

Jill Cooley: Committee 25 refers to the new advisory committee on safeguards and verification that was established by the Board of Governors in June 2005 with the mandate to consider ways and means to further strengthen the safeguards system and make relevant recommendations to the board. The last comprehensive review of the system was done in the early 1990s in the aftermath of Iraq. Strengthening measures were put in place to address a number of issues and this effort culminated with the approval of the Model Additional Protocol in 1997. But clearly things have changed in the last nine years. Circumstances are different and we have new issues and challenges, in particular the emergence of clandestine nuclear supply and procurement networks. And so this committee was established.

The committee has met three times to date. The initial meeting took place in November 2005 where Olli Heinonen [Deputy Director General, Head of the Department of Safeguards, International Atomic Energy Agency] presented some general areas where the committee could start its considerations, specifically uniform legal authority, availability of information, enhanced analytical capabilities, and use of new tools. At the January 2006 meeting, the Secretariat prepared a report focused on enhancing the agency's analytical capabilities specifically in the areas of environmental sampling, satellite imagery, and information provided by states on nuclear procurement and supply. At that point committee members requested an overview and status report of the various safeguards strengthening measures that had been put in place throughout the 1990s to get everyone up to speed. The idea was to describe what's worked and what hasn't, to identify gaps, and to make recommendations for filling the gaps. So two technical papers were prepared for the third meeting in May, one presenting this summary overview, describing some gaps and identifying eleven recommendations for further strengthening; the second was a paper on satellite imagery with six additional recommendations. During discussion at the May meeting and following consultations in June, there was a call for recasting these recommendations and clearly distinguishing between legal (i.e., mandatory) and voluntary measures reflected in the recommendations and for clarifications regarding the technical, legal, and financial aspects of the measures. We are currently working on that paper. We will continue the consultations this summer and at the next meeting, scheduled for late September. We hope the committee will formulate a work program to look at one or more of these recommendations with a view to taking recommendations to the board. I'm hopeful that we can focus more on technical issues as the discussions to date have been frankly more on the administrative and financial aspects of the committee. And, in this case, I anticipate that there will be support from the international safeguards community represented in the INMM.

Bernd Richter: Jill, I have a question regarding the United States/India arrangement. Is the agency preparing in any way for that, i.e., for implementation of what India will be doing? What would be the impact of that arrangement on IAEA safeguards and on the role of the NPT (Nonproliferation Treaty)?

Jill Cooley: I'll answer to the extent possible. When the arrangement was first announced, just about a year ago, the Director General almost immediately went on record indicating his support for the plan. I believe he called it "out of the box thinking" for a practical step forward for advancing nuclear arms control, nonproliferation, safety, and security. At that point the agency did an initial assessment of the potential effort involved in safeguarding India's civilian nuclear facilities and the options for the required safeguards agreement (e.g., INFCIRC/66-type, voluntary offer agreement). Since then I believe it's been announced that fourteen nuclear reactors will be classified as civilian and come under this arrangement. Several of them are already under safeguards and so, from this standpoint, we can estimate quite well the safeguards effort required. It is not clear whether other civilian facilities will be covered. As well, the required safeguards agreements will be the item-specific INFCIRC/66-type. Our understanding is that there are still some major hurdles in the U.S. Senate and House and so we are not anticipating anything before 2008. We are waiting for India and the United States to come to us with their final plan and then the safeguards agreements, budgetary arrangements and timescale can be addressed.

Gotthard Stein: Thank you again for your excellent presentation. You mentioned, in the political part of your speech, perspectives and visions of the agency in connection with growing global nuclear markets e.g., multinationalization in the nuclear fuel cycle, etc. It seems that those cross-cutting factors and elements that are of concern not only for the Safeguards Department gain growing importance. I will mention in this connection also environmental monitoring and sampling, research activities, proliferation resistance and the overall complex of information collection and analysis. How will the agency deal with this development? Are there ideas to build new in-house structures to cope with these new challenges?

Jill Cooley: Let me ask for clarification. When you say is the agency looking at reorganization, are you talking about the entire agency?

Gotthard Stein: Yes, yes.

Jill Cooley: OK. First of all, I agree with everything you are saying—and I think this came up in a question this morning—you really can't just focus on one facility or just the safeguards aspects of the fuel cycle. You have to look at how this interacts with all the other issues, and I think we're seeing more and more of that. This comes under the Director General's one-house policy concept; there are a number of cross-cutting issues and projects that involve two or more departments. Now with that said, the Department of Safeguards is the largest of the technical departments of the agency and we're different from the others in that our activities are mandated. So we really can't set priorities for our mandated tasks; everything has to be done in some sense. But because we have limited resources, we are constantly looking at ways to be more effective and efficient.

In terms of the department and reorganization—if we look at safeguards ten, twenty years ago, the focus was on declared nuclear material at declared facilities with inspection activities defined by the safeguards criteria. Now we have shifted to what we call our state-level approach where the planning, implementation, and evaluation of safeguards activities is done for each state individually using all the relevant information available about the state. The Department of Safeguards is being reorganized to support implementation of this approach. Last year the operations divisions were reorganized where instead of having units responsible for specific facility types, for example a group inspecting reactors and a group inspecting enrichment plants, the operation divisions are now aligned according to states where the same team is responsible for safeguards in a state. We are in discussions with regard to reorganizing the support divisions to be able to interface effectively with and support the operations divisions. In terms of the rest of the agency, I'm not aware of any major reorganization discussion ongoing. Although with that said one area that is of particular relevance is the Safeguards Analytical Laboratory (SAL) at Seibersdorf. SAL is under the Department of Nuclear Applications but, because it works entirely for the Department of Safeguards, some feel that when it comes to SAL's budget and human resources they are not a high priority for Nuclear Applications. So there is talk about if there is some better way to organize or at least have the priorities of SAL recognized, but beyond that I can't speak to any other plans.

Cathy Key: Jill, I truly appreciate you stepping in and speaking at our opening plenary session. You are certainly a long-time member of the INMM and part of the family, and we appreciate you doing this for the organization. You did a great job, as we knew you would.

Listening to your talk, you pointed out the key to the success of the IAEA was effectiveness of verification. You stated this would be determined by three specific topics. You discussed the universal standard that had to be adopted. You also discussed the work force challenges, and having to have sufficient resources to be successful in effective verification. It seems that all three of these are very closely tied together to assure effectiveness of verification. Does the IAEA have a specific implementation plan, which addresses those three topical areas to assure full success?

Jill Cooley: We've just finished preparing the Department of Safeguards strategic objectives for 2006 to 2011, which covers the next three budget cycles. Let me describe the hierarchy. At the top level is the medium-term strategy of the agency that covers this period of 2006 to 2011. Then there is the agency's program and budget for implementing the medium-term strategy. The Department of Safeguards has taken the initiative on developing its own strategic objectives that spell out more explicitly the implementation of the medium-term strategy. The seven priorities that I described in the talk this morning are activities straight out of our strategic objectives for enhancing our detection and information evaluation capabilities. The next step is to go one more level down and translate these departmental strategic objectives to divisional objectives. We also need to incorporate them into our R&D plan where we are looking for support from member states. So we are developing a cohesive approach to ensure success that embraces all levels of the organization as well as external support. There are several ways that we are trying to approach it. I think it addresses all three things you indicated in terms of the tools, the people and the financial aspects.

Cathy Key: What is your feeling on the potential success to make that happen?

Jill Cooley: I think one of the more difficult issues is trying to find the right performance indicators to measure success. This is one of the comments that SAGSI (the agency's Standing Advisory Group on Safeguards Implementation) had when they reviewed the departmental strategic objectives at their meeting in spring. They were of the view that the objectives should be more specific and measurable so that in 2011 there could be a clear indication to what extent the objectives were achieved. There's still work to be done in this regard. Of course there's always the problem of coming up with meaningful performance indicators—not ones that are just easy to count or tick off but ones that are meaningful in terms of being able to evaluate if you have been effective.

Cameron Coates: The IAEA could be described as a material accounting and control sentry. However, nuclear security is getting more emphasis worldwide in recent times such as with what you see in the news every day. This could seem to imply a shift in the direction of including physical protection. How is, or is, the

IAEA working toward the integration of physical protection and material accounting and control in a safeguards context? And do you foresee a time when physical protection is included in safeguards?

Jill Cooley: Simple answer to both questions: no. Obviously physical protection is more in the nuclear security vein than in safeguards and it's the responsibility of individual states. International safeguards addresses proliferation by the state whereas physical protection addresses threats from non-state actors. With that said, physical protection of nuclear material and facilities is an important element of the nonproliferation regime. However, there is no international verification regime for physical protection measures applied by states, and no such regime is planned. The international Convention on the Physical Protection of Nuclear Material establishes, among other things, rules for the protection of nuclear material while in international transport. Last year, state parties to the convention agreed on several important amendments to the convention, including a broadening of its scope to include obligations regarding domestic use, storage and transport. This amendment now awaits ratification by states. The agency facilitated and supported the series of meetings required to negotiate the amendment. As well, the agency supports and facilitates implementation of the convention by establishing guides on physical protection measures and conducting evaluation missions. These missions are at the request of states and have as their objective to review and, as appropriate, recommend improvements of the physical protection measures being implemented.

Debbie Dickman: Thank you for speaking and filling in. It did seem exactly like your own speech. I very much enjoyed it. You brought up an issue this morning relative to assured fuel supply issues and the importance of a steady and affordable source of reactor fuel for countries who use this for their energy source. I was curious if since the agency is going to post some kind of stakeholder involvement if there is—if the agency is looking at its own perspective in terms of what kind of a role it could fulfill in the long term in helping create this infrastructure that would have the credibility, as you mentioned this morning, in being able to serve the community and deter some of these countries from developing a nuclear fuel cycle.

Jill Cooley: This whole area of multinational approaches to the nuclear fuel cycle, with assurance of supply as the first step, is a pet project of the Director General. I think I mentioned this morning that in 2004 he established an independent expert group to identify issues and options relevant to multilateral approaches to the front and back ends of the nuclear fuel cycle both to improve controls over fuel enrichment and reprocessing while ensuring access to nuclear fuel for power generation. I believe he was hoping that things would move a little quicker than it has but, as everyone is aware, there are a lot of issues and concerns on all sides on how this will be done. Just the fact that it's being discussed seriously by a number of states seems to bode well for progress. The Director General continues to see the agency as having a major role in this, such as a broker where the agency would administer a nuclear fuel reserve as a back-up supply. I believe Russia has announced its willingness to hand over ownership of some nuclear material to the agency as the first stock in this fuel supply reserve. I believe they were trying to get all the arrangements in place before the G8 Summit so that it could be announced. I don't know what the current status is but the Director General will continue to be proactive on this issue. As I indicated in the presentation this morning, in September at the General Conference in Vienna there will be a special event to work on developing a roadmap for moving forward with assurance of supply.

Debbie Dickman: It seems to me if the agency took that role there is a whole set of resources that are needed at the agency to manage that kind of an effort.

Jill Cooley: Yes, of course. The Department of Nuclear Energy is taking a lead role in looking at these issues and how it would go forward. I don't know all the details and what has been discussed to date, but I know the Director General is very keen on this.

John Matter: Jill, I would also like to thank you for your outstanding presentation. The question I have relates to the call to action we had at last year's opening plenary session by Charles Curtis. I am aware that you have been part of at least one informal meeting with the INMM, IAEA, NTI, and DOE discussing the concept of a World Institute of Nuclear Security (WINS). My question has two parts. First, in your opinion is there a need for such an initiative and supporting infrastructure? And second, what suggestions do you have for the Institute regarding how to engage the IAEA and the broader international community in this concept?

Jill Cooley: I think it's clear that there is a definite need for this kind of activity and that there is enough work to go around. The concerns that I know have been raised from the IAEA's standpoint, specifically from the nuclear security program, are the need to avoid duplication of already existing activities and competition for sources of funding. As was mentioned in the first question by Dennis, Anita Nilsson has to go out and beat the bushes every year for the funding for her activities. If WINS approaches the same sources for support, it will make Anita's job that much more difficult. With that said, I think there is an opportunity for a WINS-type organization to have a complementary role by filling niches that are not addressed by the agency's nuclear security

program, for example, direct support to facility operators or assistance for nuclear material control and accountability in nuclear weapon states. Anita has clear activities and a program plan of action that addresses best practices, documentation, and training for non-nuclear weapon states. Dialogue with the IAEA needs to continue in terms of how this is set up and what activities are conducted. The agency does want to be involved both with the small experts group meeting planned for the late fall time frame as well as with the bigger stakeholders meeting planned for spring. I think we just need to continue the dialogue and determine what is the best match. There is enough work for everyone.

Charles Pietri: Jill, many heads of state would probably like the answer to this question that I am going to pose, so it may never appear in the *Journal,* but does the agency really know the goal or goals of, say, Iran and North Korea as far as the nuclear issue? If they do, why is there such a problem? And if they don't know, how is IAEA going to deal with these issues?

Jill Cooley: The agency is not in a position to know the goals or intent of these states. One thing that has to be kept in mind is that the agency is a technical organization that presents the facts. It's up to the member states of the Board of Governors to determine what these facts support. Do they support a case of a state not fully meeting its safeguards obligations, a case of noncompliance or intent for a nuclear weapons program? The agency can only be in the position to put forward the technical facts. Every time there is a board report written, it's always this balance between what we know is fact as opposed to speculating on states' goals or intents.

Obie Amacker: Jill, you may have touched on this to the extent that you can, but one of the points you talked about earlier today had to do with staff, the aging workforce, however you want to refer to it, but are there specific plans or ideas to address the human capital or workforce realignment activity? It appears to be recognized and needed at the agency.

Jill Cooley: We're trying to tackle it from a number of fronts. I briefly mentioned the department's succession plan in my presentation this morning. We've been working hard on succession planning in the context of identifying skills needed in different positions, staff development to attain these skills, and timely recruitment in light of retirement of senior staff. Specifically we are looking at all section head and unit head positions to identify qualified candidates that could assume these positions through rotation or promotion in the near time as well as recruitment needs. Work plans are developed for individuals to reflect the experience and training required to assume these key positions. Skill sets are also being identified for the different level of inspectors (P3, P4, and P5) so that it's clear to all what knowledge and experience are necessary to be considered for the next level. In parallel, we are looking at our training program to support the development effort. It's a lot of work but really quite exciting. Now with that said, we have some built-in problems. One is the agency's rotation policy. At the agency, the normal maximum tour of duty is seven years. The idea is to get in fresh talent. So in this respect, the agency is not a career opportunity. And so putting effort into all this succession planning and related staff development when you know a number of people will be rotated out of the organization is an added level of complexity—and frustration. As well, our compensation package is not always competitive. You have to count on people wanting to work at the agency because the job is exciting and rewarding and because Vienna is a beautiful place to live. In terms of recruitment, relevant professional organizations, such as the INMM, are being targeted to find and attract new talent. Catherine Monzel, head of IAEA recruitment, is here this week spreading the good word about working at the IAEA. Anyways, it's an ongoing challenge for the Department of Safeguards to remain fully staffed with well-qualified people.

Nancy Jo Nicholas: Jill, this may not be a fair question either but I'll compliment your talk first. Following up the last remarks, I think one of the hiring/recruiting issues that the agency faces is this two-body problem or nepotism if you will. It's sort of difficult to bring a husband and wife team in to work. A lot of us have working spouses. Do you know if there is going to be any change on that front?

Jill Cooley: It's not an agency rule that a husband and wife team cannot get hired, however, each one would have to be well-qualified for positions located in different departments and make it through the competitive bid process on their own merit. I think the agency needs to start considering "package deals," so to speak, if it is serious about recruiting well-qualified staff. I think the only couples you will find in the Department of Safeguards are those who met and married after they both joined individually. The issue is certainly understood by the Recruiting Section, especially as they try to increase the number of women professionals in the organization. The problem is compounded by the fact that Austria has strict rules regarding employment of non-EU citizens so spouses have limited employment opportunities outside the agency (for example at missions or one of the international schools). With regard to recruiting women, the focus has been on creating a family-friendly work environment. And so

they have instituted flex hours, half time, working from home, on-site day care. Of course that sounds like old hat for the United States but in terms of Europe, and the agency in particular, it's a major step forward. So perhaps spousal employment will be the next step.

Bernd Richter: First of all, I have to apologize because I still owe you a great compliment. In your presentation, you also mentioned export/import control, and in some way or other you are dealing with that, and you are cooperating with states, with member states. Do you feel that that cooperation has to be intensified? And I also would like to mention that the EU Commission is looking into this and has some kind of legislation on the European level. As a European I would like to ask you also, whether you cooperate with the Commission of the EU, not only on a bilateral basis with EU member states.

Jill Cooley: To answer your first question, yes, I think cooperation needs to be intensified. Imports and exports of equipment and non-nuclear material is clearly an area where we can get so much more relevant information about states' nuclear programs and plans. The agency can also provide assistance to states in terms of their own controls. Now with that said, it is a sensitive subject. Expanding the annexes of the Model Additional Protocol which specify the manufacturing activities and exported items that states have to report on is one of the recommendations the Secretariat proposed to Committee 25. Many states don't want to see any more mandated controls and are strongly opposed to amending the annexes. We've also proposed a recommendation for voluntary provision of relevant information on exports, procurement enquiries, and export denials. Even though it is voluntary, many states consider any endorsement by the board as making it mandatory for all practical purposes, so it is still being discussed. About a year and a half ago, a nuclear trade analysis unit was established within the Department of Safeguards to centralize the analyses of all procurement network-related information available to the Secretariat. There is effort in expanding the sources of information; for example, there's been renewed contact with the NSG (Nuclear Suppliers Group) for information. At this point, we are getting information from individual states on a bilateral, voluntary basis. I really can't speak to if we are working directly with the EU on this issue.

James Tape: Just a follow-up to Bernd's question and the discussion. You talked about an information-driven safeguards system and that sharing of export information would be part of that. To what extent is this a two-way street? Is there an obligation on the part of the agency to share information on a selective basis with member states before it is reported to the board? Is that something under discussion?

Jill Cooley: It certainly is not an agency obligation to share information with member states except by official means, i.e., board reports. Of course, consultations are conducted with relevant parties in preparation for a board meeting so that no one is caught by surprise and reactions can be measured and appropriate. This is just good diplomacy to ensure constructive board discussions and decisions. Since the DPRK issue some fifteen years ago, the Director General has repeatedly told states that when they have information on suspect activities it is their obligation to bring it to the attention of the IAEA. This is then qualified with the statement that states should not expect information in return, i.e., it is not a two-way street. This is a very sensitive subject and whether there is room for discussion for select information sharing, I'm not in a position to say.

Dennis Mangan: I have another question Jill. In your presentation you mentioned a renewed interest in nuclear power and I found it interesting that the Waste Management Division of INMM this morning had a session on waste management and reprocessing and the room was packed. I mean people were actually standing out in the hallway. It was a very interesting session. I got to thinking. It did have a paper on the new initiative in the United States called Global Nuclear Energy Partnership (GNEP) that President George W. Bush announced I believe in February. It is basically addressing have a closed fuel cycle and advanced reactors but right up front is proliferation resistance very loud and clear. I wonder, was there any reaction at the IAEA when this initiative was announced or has there been any kind of discussion within the IAEA on this initiative?

Jill Cooley: I recall that when GNEP was first announced, I believe in early February, the Director General convened a small internal working group to review the U.S. proposal and develop an agency view. There were technical experts from nuclear energy, safeguards, nuclear safety, and security involved in this review. I believe the agency is generally supportive of the GNEP strategy. A number of elements are certainly consistent with the Director General's initiatives on multinational approaches to the fuel cycle including assurances of supply. And there are a number of IAEA activities relevant to GNEP. An example in the safeguards area is the work we're doing for INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) and GIF (Generation IV International Forum) in the development of an assessment methodology for proliferation resistance. But it was recognized that implementation will take many years, a great amount of money, substantial development, and a lot of international support. I believe the agency is awaiting more details from the United States.

Debbie Dickman: We had a question about creation of the generation of folks who are going to have to retire and it reminded me that I had heard not very long ago that the Department of Safeguards intern program was going to be discontinued, and I was wondering, first of all, if it was true, who funds it, and if there is any chance to get that kind of a program back or something like it so that you have fresh younger folks.

Jill Cooley: The answer is it's true. It was recently decided that the Department of Safeguards cannot host interns because of their employment status. Basically, they are not considered employees of the agency and therefore are not subject to the agency's confidentiality regime. All staff members, including cost-free experts, and consultants, have to sign a confidentiality undertaking which obligates them to protect confidential information. Because of the confidential nature of most of the Department of Safeguards work, it was determined inappropriate for interns to be working in the department. Interns will continue to work for other departments in the agency. With that said, the Department of Safeguards is replacing interns with junior professional officers (JPOs) who are considered staff members. There are several support programs, including the U.S. Support Program, that are funding such JPOs for safeguards. I understand that the U.S. Support Program will only be able to fund half as many JPOs as interns (basically because they get paid about twice as much) so we lose out in that regard. But we are still getting the benefit of young, enthusiastic talent. The main areas that the interns have been contributing to are in information technology and technical services. I assume the JPOs will continue along the same line. The department just went through the JPO list from the United States a week ago and forwarded our request to the U.S. Support Program.

Vince De Vito: I want to thank you again for filling what could have been a big void this morning. I have a question regarding a comment that you made during our dialogue here and that was about the Russians providing material to the agency. It is a two-part question. One, is material going to be physically transferred to the agency? And two, if it is, wouldn't you have to then have all the rest of the protective measures that you normally have? My other part of the question is, do you know what type of material it is, whether it is HEU, LEU, plutonium?

Jill Cooley: My understanding is that it's a virtual stockpile, so it's not physically being transferred. It's LEU because it is material intended for power reactor fuel. It is supposed to be the first installment of this material.

Vince De Vito: So in this case it would be in the agency's name but stay in place in Russia.

Jill Cooley: Right.

Vince De Vito: Do they intend to increase?

Jill Cooley: That's the idea—to get additional contributions, either money or actual material, from more and more states. I believe the United States through NTI has already indicated its intent to contribute. I just don't know the status of the discussions and arrangements.

John Matter: Is this part of the assured fuel supply concept? How would this virtual stockpile interface and interplay with the commercial market? Would this be a last source of supply if there was not a commercial source available to a particular state?

Jill Cooley: I believe that's what it is—a back-up mechanism of last resort in the event of a fuel supply problem for a state that is in good standing nonproliferation-wise. This would be a safety net when such a supply problem couldn't be resolved through normal commercial means.

Dennis Mangan: No more questions? Well, Jill, I want to thank you very much. This interview was very interesting from the standpoint that your answers to the questions provided a lot of insights into the workings of the IAEA that I actually did not appreciate.

Jill Cooley: Uh-oh. That doesn't sound good.

Dennis Mangan: But I do want to thank you for taking the time and I think it was evident from all the people here that you did an excellent job this morning.

Jill Cooley: My pleasure. I wouldn't have let the INMM down.

A Summary of the Closing Plenary Session of the 47th INMM Annual Meeting

Amy Whitworth
Chair, Government-Industry Liaison Committee

Introduction

No one can deny that the events of September 11, 2001, changed not only the course of United States history, but of the world. 9/11 changed our reality, both personally and professionally, in our collective responsibility for protecting what is potentially the most dangerous material on earth.

Before 9/11, the terrorists' threat was a reality to the security world; a threat we acknowledged as credible and a threat we protected against. Critics challenged the expenditure of funds for protection against what was considered an imaginary threat. Effective prevention is intangible—how do we know what we prevented, as opposed to what might not ever have happened?

Post 9/11, our security mission was brought to the forefront. The adequacy of our threat analysis was questioned and our ability to protect special nuclear material was scrutinized.

As we approached the fifth anniversary of this horrific event, it was important that we take the time to reflect upon where we are, ensure that our approach to security is balanced and defensible under the scrutiny of our stakeholders and immune from the needless drain on resources that typically accompanies uninformed second-guessing:

In planning this year's Closing Plenary program, the Government-Industry Liaison Committee wanted to focus on the progress to date in protecting special nuclear material in the post-9/11 era. It was our hope in sharing advances, accomplishments, and challenges that we continue to work collaboratively as a community to identify and implement innovative and creative approaches to nuclear security.

This year's Closing Plenary program met that mark. We were fortunate to have three very distinguished individuals presenting this year: Mr. Mark Shaffer, U.S. Nuclear Regulatory Commission; Ms. Cheryl Stone, National Nuclear Security Administration; and Ms. Anita Nilsson, International Atomic Energy Agency. In this issue of the *Journal*, we publish summaries of these presentations.

Attendance at this closing session remained at a record high with close to 400 conference attendees present. It is the goal of the Government-Industry Liaison Committee to maintain this high level of quality for future closing plenary sessions.

The NNSA Defense Nuclear Security Program

Ms. Cheryl Stone, Deputy Associate Administrator for Defense Nuclear Security, National Nuclear Security Administration

Ms. Cheryl Stone, Deputy Associate Administrator for Defense Nuclear Security, presented the protective posture of the National Nuclear Security Administration (NNSA). The Office of Defense Nuclear Security (DNS) was created in June 2004 and reports directly to the NNSA Administrator on equal footing with the heads of other major programs. The office consolidated NNSA security functions except for Cyber Security, which is located in the Office of the Chief Information Officer.

The NNSA shares a common charter ensuring that the U.S. nuclear stockpile remains safe and secure—against any threat. Since the inception of the Manhattan Project to present, the NNSA and its predecessors were successful in that charter. Ms. Stone stressed that this legacy of responsible stewardship must continue, through continuous improvement, and a security philosophy that remains flexible enough to adapt to ever-changing operational and threat environments.

The NNSA complex encompasses a diverse range of facilities, diverse with geography, operations, and materials. Ms. Stone stated that these diverse facilities, operations, and materials must be protected against the Design Basis Threat (DBT). The Design Basis Threat is a classified document that delineates the number and characteristics of adversaries the United States must protect against. There is separate, but related, guidance which identifies the capabilities potentially used by the adversary. Ms. Stone noted the significant increase to the pre-9/11 Design Basis Threat and the 2003 Design Basis Threat requiring compliance by the end of 2006. NNSA sites have already begun reviewing their protection strategy for the 2005 Design Basis Threat, implemented by DOE Order 470.3A.

To address the challenges of protecting diverse facilities in an evolving threat environment, Ms. Stone stated that the NNSA has undertaken many different initiatives. These initiatives include establishing an "Elite Force," increasing deployment of technology, consolidating materials, identifying policy efficiencies, sharing information with our colleagues, and employing vulnerability assessment tools coupled with risk management principles.

Elite Force

To address the evolving adversary characteristics, the Department of Energy (DOE) created the "elite protective force" concept for DOE facilities possessing Category I or II quantities of Special Nuclear Material (SNM). The Department's intent for an "elite protective force" is to further enhance the knowledge, skills, tactics, and physical abilities of protective force personnel defending certain targets and enabling them to respond more effectively to a wider range of violent terrorist threats. Modern protective forces must move, shoot, and communicate quickly and effectively as part of a coordinated small unit. With the establishment of an "Elite Force," Ms. Stone noted that the NNSA is transitioning from a para-law enforcement to a para-military mindset.

Technology Deployment

It was also stated that every challenge for protecting SNM cannot be effectively addressed by increasing the protective forces alone. To face the more determined, more capable threat of the 21st Century, even an elite protective force must have technological superiority to achieve and maintain a tactical advantage. Both high- and low-tech solutions have been deployed at the NNSA facilities.

The NNSA is working to effectively integrate technology and response. All the technologies the NNSA is deploying combine to create an integrated system to deter, detect, assess, delay, interrupt, and neutralize the adversary before they can accomplish their mission, whether it be theft or the detonation of an in-situ device. To ensure effective design, implementation, operation, and integration of new security systems at NNSA sites, DNS chartered a Security Systems Engineering Team (SSET). This integrated advisory team includes representation from, various Department of Defense (DoD) entities, Nuclear Regulatory Commission (NRC), the Technical Support Working Group (TSWG), the United Kingdom, DOE and NNSA site stakeholders. The SSET performs a number of key functions in the deployment of new technologies including identifying needs, gaps and supporting the development of requirements; and promoting and coordinating security information exchanges on successful technology development and deployment.

Materials Consolidation

Clearly from a security perspective it makes sense to have fewer locations to protect in order to focus NNSA's limited security assets on those fewer targets. However, as Ms. Stone noted, in order to accomplish the primary mission of the NNSA—ensuring that the nuclear warheads and bombs in the U.S. nuclear weapons stockpile are safe, secure, and reliable—multiple facilities are required.

Defense Nuclear Security is working with Defense Programs to incorporate security at the ground level on new building projects in addition to consolidation of SNM to reduce the footprint and strengthen NNSA's protective posture to ensure the security and safety of materials, information and safety of the general public as part of Complex 2030. "Complex 2030" is the NNSA's future path to establish a smaller, more efficient, Nuclear Weapons Complex that is able to respond to changing national and global security challenges. By 2030, NNSA will employ a smaller, safer and more secure nuclear weapons stockpile that has assured reliability over the long term, and is backed by the industrial and design capabilities needed to respond to changing technical, geopolitical or military needs. NNSA's plans for the future will achieve the President's vision of the smallest stockpile consistent with U.S. national security needs. In 2004, President Bush directed that the size of the nuclear weapons stockpile be reduced by nearly 50 percent by 2012. At that point the stockpile will be the smallest it has been since the Eisenhower administration.

Policy Efficiencies

Ms. Stone noted that the NNSA is in the process of examining the security topical areas to determine where efficiencies could be achieved. An example of this effort is the Safeguards First Principles Initiative that NNSA is undertaking. The Safeguards First Principles Initiative will develop a principle-based standard for Nuclear Material Control and Accountability (MC&A) Programs. The standard will establish fundamental principles around which the NNSA expects its management and operating contractors to develop and implement their MC&A programs; support standardized implementation of effective and efficient MC&A programs that are tailored to a well-characterized risk; facilitate consistent implementation that is defensible from a risk management perspective with measurable performance; and provide a basis for designing MC&A Programs in the context of the nuclear material inventory holdings and missions at the site. The objective of the Initiative is to prepare a standard for developing, implementing, and evaluating Nuclear Material Control and Accountability Programs to be adopted NNSA-wide. The model will be tested at the Y-12 National Security Complex and the Nevada Test Site and independently evaluated by the NNSA Office of Program Evaluation and the Office of Security and Safety Performance Assurance. Under this Initiative, the NNSA has already advocated and obtained policy changes that saved approximately $1M annually by eliminating requirements that did not reduce risk to the security program. It is expected that the NNSA will achieve a more streamlined MC&A program at the NNSA facilities by 2008.

Collaboration

Ms. Stone identified collaboration with counterparts within the U.S. government as well as allies in other countries and international organizations as key to continual improvement for protection programs and systems.

Defense Nuclear Security (DNS) collaborates with the Nuclear Regulatory Commission and the Department of Defense on their respective Design Basis Threat policies, as well as tech-

nology deployment to ensure consistent application of security for similar assets. This collaboration provides an ideal forum for sharing lessons learned and leveraging other agency's efforts.

Defense Nuclear Security and the United Kingdom's Ministry of Defense have much in common relative to challenges and potential rewards; such as recommendations to improve security practices while reducing costs, exchanging technology reviews and procurement information, and acting as a fresh set of eyes looking at old challenges.

With regards to the International Atomic Energy Agency, DNS provides subject matter expertise to support the revision to INFCIRC 225 (International Physical Protection Guidance).

Defense Nuclear Security is also active with Physical Protection Bilateral Consultations. The NNSA assists on visits to other countries in protection of U.S. origin SNM. Recent missions include trips to Japan, Belgium, Germany, and Australia. Defense Nuclear Security, the DOE Office of Security and Safety Performance Assurance, and Defense Nuclear Nonproliferation participated with their respective Russian security counterparts to discuss Security Best Practices and Nuclear Security Culture as part of the Presidents Bush and Putin Bratislava summit follow-on.

Risk Management

Ms. Stone stated that Defense Nuclear Security is using risk management principles to guide and identify protection strategies and supporting technological solutions for deployment. The focus is on improving early detection and initiating response further from target locations and delaying adversaries with enhanced barriers and increased exposure to protective force weapons systems. Risk management will be used to prioritize upgrade investment dollars—targeting high-risk/high-consequence operations.

Conclusion

In conclusion, Ms. Stone stated that she had covered a few of the many efforts underway to enhance security across the Nuclear Weapons Complex. Defense Nuclear Security shares the unique and challenging mission for protection of special nuclear security with the Institute of Nuclear Materials Management; a mission that leaves no room for failure. Sharing amongst the larger security community, through events such as the INMM Annual Meeting, is critical to global security and success.

NRC Regulation of Nuclear Facilities in the Post-9/11 Security Environment

Mark Shaffer, Deputy Director for Material Security, Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission (NRC).

Mr. Shaffer presented a brief overview of the NRC's recent activities related to security in the commercial nuclear industry in the United States, with primary focus on the enhanced security measures to control radioactive sources at industrial, medical, and academic research facilities.

In April 2002, the NRC consolidated its security elements, creating the Office of Nuclear Security and Incident Response (NSIR), whose mission is "to prevent nuclear security incidents and respond to safety and security events." NSIR provides policy, evaluation, and assessment of issues involving security at nuclear facilities, and serves as the NRC's safeguards and security interface with the U.S. Department of Homeland Security (DHS), intelligence and law enforcement communities, the U.S. Department of Energy (DOE), and other agencies. NSIR also directs the NRC's program for response to incidents, including Emergency Preparedness and Incident Response interface with other federal agencies.

Commercial nuclear power plants and manufacturing facilities were security conscious and well-protected long before 9/11. These facilities had comprehensive security programs, including measures for physical security, such as barriers; detection and assessment systems; access controls; alarm stations; response strategies; and personnel security measures, such as background checks, fitness-for-duty programs, and access authorization. These facilities were also robust structures with redundant safety systems.

Since 9/11, the NRC has taken aggressive steps to further enhance security at nuclear power plants and other nuclear facilities. In short, barriers have been enhanced, security forces have been increased, training has been improved, search procedures have been intensified, and communications with law enforcement and intelligence agencies have been strengthened. The NRC moved quickly and aggressively to enhance the security of nuclear power plants and has comprehensively re-evaluated security requirements with the events of 9/11 as the context. Today there are numerous additional rule-making activities underway, including actions in the areas of cyber-security and the safety/security interface.

The NRC participates in DHS's Comprehensive Review, which is a cooperative government, community, and private sector analysis of high-consequence critical infrastructure and key resources to prevent, mitigate, and respond to catastrophic all-hazard events. The goal of this important initiative is to reduce the United States' vulnerability to terrorism by developing and coordinating plans to protect critical infrastructure and key resources.

NRC has also aggressively undertaken initiatives to control radioactive sources. The traditional focus of safety programs for

radioactive sources has been on the prevention of exposures to workers and the public from normal use and accidents. Security and control over the material was a component of these programs, but primarily from the perspective of preventing inadvertent and unintentional unauthorized access and common theft for monetary reasons. Before 9/11, these programs generally were not focused on the potential for the material to be used in a malevolent act by terrorists. Nonetheless, as a result of prior incidents involving orphan sources and loss of control events, there was recognition of the need to improve the control over risk-significant radioactive sources. The regulatory community was taking responsible actions to address these issues prior to 9/11, but there was not a sense of urgency. The terms radiological dispersal device (RDD) or "dirty bomb" and radiation emission device (RED) were foreign to most radiation protection professionals.

Urgency increased somewhat following the fall of the former Soviet Union, when large amounts of radioactive material could not be accounted for, presenting both an orphan source problem and a potential terrorist weapon. A number of source control efforts were ongoing both nationally and internationally. IAEA was developing the Code of Conduct for the Safety and Security of Radioactive Sources and a risk-based categorization of sources. IAEA had also developed a program to assist member states in enhancing or developing their source control programs. Domestic efforts were also primarily focused on preventing lost sources or on responding to lost source events.

NRC's fundamental goal of protection of the public health and safety and the environment remains unchanged. Following 9/11, the NRC recognized the need to address the threat of potential malevolent use of radioactive material, and to ensure the secure use and management of radioactive materials. Indeed, this is one of NRC's strategic goals. Meeting this goal necessitated increased efforts to identify the elements needed to enhance security and control of sources.

Having to consider the potential for malevolent unauthorized access to licensed radioactive materials is a significant culture change for many licensees. Addressing this culture change has required a cooperative effort of all involved stakeholders, and a willingness to consider new, and sometimes unfamiliar, approaches for addressing the potential threat. The NRC has worked with other government agencies and the regulated community in an effort to identify realistic approaches for enhancing security. Throughout the process, the regulated community has been willing to work with the NRC and has been a key part of that effort.

Security enhancements for materials facilities include orders for improved security measures, which have been directed toward large panoramic irradiators, manufacturing and distribution licensees, transporters of radioactive material quantities of concern, and others. As with previous security orders, the issuance of security orders to these types of facilities, was done based on the quantities of radioactive materials. The purpose of these orders is to enhance control of radioactive materials in quantities greater than or equal to the Table-1 values contained in the IAEA's Code of Conduct. More specifically, the objective of the orders is to enhance control of material to prevent unauthorized access, prevent malevolent use of material, and mitigate potentially high consequences that would be detrimental to public health and safety. The emphasis is on prompt enhancement using practical measures. NRC also has formed a Materials Security Working Group comprised of NRC and U.S. State Department representatives that continues to work to identify areas for enhancing security.

Source tracking and material accountability systems are in place. The Nuclear Materials Management & Safeguards System (NMMSS) has collected and reported data on possession, use and shipment of nuclear materials since the 1950s. However, not all nuclear materials are tracked by the NMMSS. In May 2003, NRC, DOE and Agreement States issued a Report on Radiological Dispersal Devices, identifying materials of concern and recommending the development of a national source tracking system. The National Source Tracking System was established, which ultimately will initiate and continue full-time tracking of materials of greatest concern, establish import/export tracking and meeting of international commitments, and assist with future policy decisions based on data from the system.

To obtain data the NRC conducted a voluntary survey of NRC and Agreement State licensees. Approximately 2,600 licensees were contacted and just more than half possessed Category 1 and 2 sources. (Category 1 sources are typically used in practices such as radiothermal generators, irradiators, and radiation teletherapy. Category 2 sources are typically used in practices such as industrial gamma radiography and high and medium dose rate brachytherapy.) This information is updated annually—with a portion of licensees updating each quarter.

The system is being designed to satisfy the IAEA Code of Conduct and address the RDD recommendations. The system will include sources from NRC and Agreement State licensees and DOE facilities and will provide a national repository of licensee and source information. The system will improve source accountability and give better information to decision-makers. The system is primarily Web-based, but the data is "Official Use Only." Finalizing the system will require rule-making and a proposed rule is currently out for consideration.

The Energy Policy Act of 2005 has an enormous impact on the NRC, and multiple other federal agencies. Title Six of this act focuses on nuclear security. This legislation affects the design basis threat, use of automatic weapons, force on force evaluations, federal security coordinators, source protection and tracking, and fingerprinting and background checks. Additionally, in the materials area, this legislation provides NRC with the regulatory authority over certain types of non-byproduct radioactive material, such as accelerator-produced material, which are currently regulated by individual state radiation control programs. The NRC believes this act will greatly enhance the safe and secure use of nuclear mate-

rials at commercial nuclear facilities in the United States.

Clearly the work of the NRC involves partnership with many other organizations, both state and federal. Some of these include the Organization of Agreement States and the Conference of Radiation Control Program Directors. The NRC has had long-standing relationships with these groups. Following 9/11, the NRC worked closely with these organizations to ensure a clear and consistent regulatory approach to safety and security at all facilities, whether they are NRC licensees or Agreement State facilities. The NRC continues to work closely with DHS, DOE, the U.S. Department of Transportation (DOT), the FBI, and the intelligence community. One of our successful partnerships has been DHS's Domestic Nuclear Office (DNDO). The DNDO is a jointly-staffed, national office established to improve the United States' capability to detect and report unauthorized attempts to import, possess, store, develop, or transport nuclear or radiological material for use against the United States, and to further enhance this capability over time. Some of the work being done by DNDO is the development of the global nuclear detection and reporting architecture. The NRC maintains on-site representatives at DNDO, and this partnership has proven to be a valuable resource for all participating agencies involved. NRC also has a long and extensive history of partnering with the IAEA, other international organizations, and individual countries to promote and ensure the safe operation of the world's nuclear power plants; and the control of radioactive source world-wide. NRC will continue these nuclear safety and security outreach activities and looks forward to continued partnerships with other state and federal agencies and the international community. The NRC values these relationships and will continue to work closely with these partners to improve nuclear security worldwide.

Mr. Shaffer closed with a discussion of the July 15, 2006, announcement by U.S. President George W. Bush and Russian President Vladimir Putin to create "The Global Initiative to Combat Nuclear Terrorism." The initiative will build the capacity of willing partner nations to combat the Global Threat of Nuclear Terrorism. This cooperation will include efforts to improve accounting, control, and physical protection of nuclear material and radioactive substances, as well as security of nuclear facilities; detect and suppress illicit trafficking or other illicit activities involving such materials, especially measures to prevent their acquisition and use by terrorists; respond to and mitigate the consequences of acts of nuclear terrorism; ensure cooperation in the development of technical means to combat nuclear terrorism; ensure that states take all possible measures to deny safe haven to terrorists seeking to acquire or use nuclear materials; and strengthen our respective national legal frameworks to ensure the effective prosecution of, and the certainty of punishment for, terrorists and those who facilitate such acts. The United States Nuclear Regulatory Commission looks forward to continued partnerships with other state and federal agencies and the international community, and in particular, the working relationship the NRC has with the International Atomic Energy Agency (IAEA). The NRC values these relationships and will continue to work closely with these partners to improve nuclear security worldwide.

The Nuclear Security Plan 2006-2009: Meeting the Threat of Nuclear Terrorism

Anita Nilsson, Director, Office of Nuclear Security, International Atomic Energy Agency

The prevailing nonproliferation challenges have been a recurring theme through the various sessions of the INMM Annual Meeting, dealing with proliferation threats by states and non-state actors. The 9/11 events opened the eyes of the international community to the disasters that could be the result, should nuclear or other radioactive materials come into terrorists' hands. The nuclear terrorism threat had to be adjusted to cover not only the theft of a nuclear device, but also the threat of making an improvised nuclear device (IND), a radiological dispersal device (RDD), sabotage of a nuclear facility, location, or transportation for the purpose of causing radiological harm to people, property, or environment.

It had also become evident that radioactive materials can no longer be considered self-protecting in the light of the suicidal sacrifices that were evidenced in recent terrorist events. It was recognized that terrorist groups with the knowledge and availability of nuclear materials would not hesitate to use an improvised nuclear device, and that unimaginable consequences could follow. Likewise, while much less destructive, an RDD would also present a powerful terror weapon, which would be more readily obtainable than an IND. Most major cities would stand unprepared for such an event that, as a minimum, would cause long-term health effects and high decontamination costs. The concern remains high; there are no indications of diminished threat. Since 9/11 the world has witnessed a number of serious terrorist events, last year in London and this year in India.

In September 2005, the International Atomic Energy Agency (IAEA) Board of Governors approved the Nuclear Security Plan for 2006-2009. The plan outlines, in a comprehensive manner, activities that must be implemented to reach the long-term goals of prevention, detection and response. The implementation of the plan is dependent on voluntary funding at a level of a minimum of approximately $15M annually. Through the plan, the IAEA develops recommendations and guides for nuclear security, offers assessment and evaluation services, technical advice and assistance, and promotes human resource development, *inter alia* through a comprehensive training program. It further promotes the exchange of information and the establishment of regional centers for education and training and for nuclear forensics support.

The Nuclear Security Plan recognizes that the international community has taken important steps towards the protection

against nuclear terrorism by approving, in 2005, an amendment to the Convention on the Physical Protection of Nuclear Materials. The approval of the UN General Assembly of the Convention on the Suppression of Acts of Nuclear Terrorism is another important achievement. More than 100 states have already signed the Convention. UN Security Council Resolutions 1540 and 1373 add to the corpus of multilaterally negotiated legal instruments against the spread of weapons of mass destruction. The IAEA, through its Nuclear Security Plan, facilitates the implementation of these international instruments, and provides assistance to states for the establishment of the necessary technical and administrative systems.

The Number Distribution and Factorial Moments of Neutrons and Gamma Photons Generated in a Multiplying Sample

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Abstract

An analytical derivation of the full probability distribution was demonstrated for the number of neutrons and gamma photons generated in a fissile sample with internal multiplication. The formulae for the probability distribution *P(n)* are derived in a recursive manner, and the results are compared with Monte Carlo calculations. We calculate the probability distribution up to values of n where *P(n)* becomes negligible. By introducing modified factorial moments of the number of neutrons and gamma photons generated in fission, the resulting probability distribution is formally equivalent with the expressions for factorial moments of the total number of neutrons and photons generated in the sample. These calculations are in very good agreement with Monte Carlo simulations. The results show that with increasing sample mass, the probability distributions change by acquiring a tail for higher *n* values.

Introduction

The number distribution of neutrons and photons generated in a finite sample with internal multiplication has been studied both with analytical methods and Monte Carlo simulations in the past. The motivation behind these studies is the fact that knowledge of the statistics makes it possible to determine, by coincidence and multiplicity measurements, the mass and isotopic composition of an unknown sample. The distributions will change and the derivation of them becomes more complex if the sample is multiplying. Due to induced fission, the distributions are shifted towards higher neutron and photon numbers. This effect will be more pronounced in samples of larger mass where these chains will grow in length and have a noticeable effect on the number distribution.

The starting point of this study, as well as earlier ones, has been the probability generating functions (PGFs), derived from master equations describing the behaviour of the neutrons and photons. Generally, these calculations were motivated by the search to find the dependence between the multiplicities of neutrons and the sample mass.[1, 2, 3] The multiplicities of the photons[4] have also been calculated for a multiplying sample. The equations for individual moments are fairly simple and can be derived recursively so that the equations are linear in the highest order and only contain powers of lower orders that have already been calculated in previous steps. Conversely, for the probability distribution, the algebraic equations of the relevant PGFs are usually highly nonlinear and a compact analytical solution cannot be derived. This issue is addressed here by using the symbolic calculation language Mathematica.[5]

The purpose of this work is to derive analytical formulas as well as to obtain quantitative results for the probability distribution *P(n)* and for the factorial moments. These quantities are derived from the corresponding master equation in a recursive manner for increasing *n*. For the probability distribution it will not be sufficient to just find a few values of *P(n)* for low values of *n*, instead we need to find all *P(n)* up to where the values become negligible and the cumulative probability is close to unity. For a sample with high internal multiplication (i.e., high sample mass), *P(n)* needs to be calculated up to $n = 100$ in extreme cases, especially when considering photons. The procedure of finding algebraic equations for $P^{(n)}$ is straightforward and involves calculating the nth order derivatives of an implicit nested equation.

One motivation for finding analytical expressions of this kind is to provide insight into the influence of the sample mass on the full probability distribution. Analytical expressions can easily be re-evaluated with a relatively low processor (CPU) time when compared to the time needed to run Monte Carlo simulations. Another advantage of using analytical expressions is that the statistical scatter, that is common for higher-order terms in Monte Carlo calculations when the number of occurrences becomes relatively low, can be avoided.

The probability distribution contains full statistical information on the process. Once this distribution is known it can be easily used to find the factorial moments, at least numerically, up to orders much higher than normally calculated so far from the equations of factorial moments themselves. We also noticed that with the introduction of some modified factorial moments of the number of neutrons and photons generated in a spontaneous and induced fission event, the number distribution takes on a form that is formally equivalent with that of the corresponding factorial

moments. This fact was used to calculate a larger number of factorial moments in a simple manner from the expressions received when deriving formulas for the probability distribution. Numerically, the accuracy of the moments calculated by this direct way is also more accurate than the calculation via quantitative values of the probability distribution.

Theoretical Treatment

The master equations mentioned above, also known also as Chapman-Kolmogorov equations, which are needed for the calculations of the probability distribution, have been derived earlier.[1,4] In these works it is assumed that the probability for a first collision before escaping the sample for an arbitrary neutron, *p,* is known. Furthermore, the model contains no absorption, hence the probability *p* will be equal to the probability of induced fission per neutron. For this reason, the quantity we calculate corresponds to the number of neutrons (or photons) *generated* in the sample, as opposed to the number of particles *emitted* from the sample. Accounting for absorption and detection is an extension that we plan to address in future work.

Neutron Distribution

The probability distributions of generating *n* neutrons in a spontaneous (source event) or induced fission event will be denoted by $p_s(n)$ and $p_f(n)$, respectively. Their generating functions $q_s(z)$ and $q_f(z)$ are defined accordingly

$$q_s(z) = \sum_n p_s(n) z^n \quad , \quad q_f(z) = \sum_n p_f(n) z^n . \tag{1}$$

These distributions and their generating functions are nuclear physics quantities that are known for the fissile isotopes of interest.

The master equation for the PGF of the number of neutrons generated in the sample for a single source emission event is of backward type, hence it is necessary to use two coupled equations: one for the distribution of the neutrons generated from a *single* neutron, and one for connecting to a *source* event, spontaneous fission, i.e., starting with several neutrons. We will denote with $p_1(n)$ the probability distribution of the number of neutrons generated by one initial neutron. Similarly, $P(n)$ will denote the probability distribution of the number of neutrons generated in the sample by one initial source event. Here we only consider spontaneous fission as a source event, but as noted by Böhnel,[1] (α, n) events can easily be incorporated into the same formalism. The PGFs $h(z)$ and $H(z)$ of $p_1(n)$ and $P(n)$ respectively, are defined as

$$h(z) = \sum_n p_1(n) z^n \quad , \quad H(z) = \sum_n P(n) z^n . \tag{2}$$

The coupled backward-type master equations of these generating functions read as follows:

$$h(z) = (1-p)z + p\, q_f[h(z)] \tag{3}$$

and

$$H(z) = q_s[h(z)] . \tag{4}$$

The principle behind equations 3 and 4 is straightforward. The first equation expresses the fact that $p_1(n)$ can be composed as the sum of two mutually exclusive events, namely the initial neutron either escapes without inducing fission and hence leads to one single *generated* neutron, or it will lead to a fission with probability *p*. In the latter case, a number of neutrons are generated that should each be treated as an independent neutron, therefore, we obtain the implicitly defined Equation 3.

One objective of this study is to determine the quantity $P(n)$. It can be obtained from equations 3 and 4 by noting that $p_1(n)$ and $P(n)$ are the Taylor expansion coefficients of $h(z)$ and $H(z)$, respectively:

$$p_1(n) = \frac{1}{n!} \frac{d^n h(z)}{dz^n}\bigg|_{z=0} \quad \text{and} \quad P(n) = \frac{1}{n!} \frac{d^n H(z)}{dz^n}\bigg|_{z=0} . \tag{5}$$

From Equation 5 one can see the reason why it is more complicated to evaluate the distributions $p_1(n)$ and $P(n)$ compared to the factorial moments. The factorial moments are evaluated at $z = 1$, for which we have $h(1) = H(1) = 1$, and the derivation of the equations for the generating functions will just lead to the appearance of the factorial moments of the numbers of neutrons generated in induced and spontaneous fission. In contrast, the expressions in Equation 5 have to be taken at $z=0$, for which case no similar simplification exists.

Calculating the derivatives of $H(z)$ requires, by virtue of equations 3 and 4, derivatives of the generating function $h(z)$, meaning derivatives of the implicitly given function $q_f[h(z)]$. It can be seen that higher-order derivatives will contain algebraic combinations of the lower-order ones. Calculation of $p_1(0)$ requires just inserting $z = 0$ into equations 2 and 3. This leads to an Nth-order algebraic equation, where N is equal to the maximum number of neutrons generated in an induced fission. In the quantitative section we will consider Pu-240 and that limits N to 8. We arrive at the following equation:

$$p(0) = (1-p)z + pq_f\left[h(z)\right]_{z=0} = pq_f\left[p_1(0)\right] = p\sum_{n=0}^{N} p_f(n)[p(0)]^n . \tag{6}$$

The eighth-degree polynomial in $p_1(0)$ has the probabilities $p_f(n)$ as coefficients. These data are also implemented in some Monte Carlo codes like MCNP-PoliMi,[6] which was used for the quantitative comparisons in this work. To facilitate comparison between the analytical model and the Monte Carlo simulations, we employ the nuclear data from this code to make sure that the

calculations are based on the same input data. The polynomial Equation 6 also contains the first collision parameter *p*. Hence the probability to induce fission will clearly affect the whole distribution in an important way. Once $p_1(0)$ is determined numerically, one obtains the source-induced probability, $P(0)$, from Equation 4 as

$$P(0) = \sum_{n=0}^{8} p_s(n) \cdot p_1(0)^n \tag{7}$$

We now have the initial terms needed to proceed to higher-order terms. To find $P(1)$ we use Equation 5 to get

$$P(1) = \frac{1}{1}\frac{dH(z)}{dz}\bigg|_{z=0} = \frac{dq_s(h)}{dh}\frac{dh(z)}{dz}\bigg|_{z=0}. \tag{8}$$

The solution requires calculation of the quantity $\frac{dh(z)}{dz}$ which can be found by derivation of Equation 3. A rearranging of the terms gives

$$\frac{dh(z)}{dz} = \frac{(1-p)}{\left(1 - p\frac{dq_f(h)}{dh}\right)} \tag{9}$$

The requirement that we are to evaluate the expressions at $z = 0$ gives some complications. In particular for $\frac{dq_f(h)}{dh}$ one has

$$\frac{dq_f(h)}{dh}\bigg|_{z=0} = \sum_n n\, p_f(n)[h(z)]^{n-1}\bigg|_{z=0} = \sum_{n=0}^{8} n\, p_f(n)[p(0)]^{n-1}. \tag{10}$$

Had Equation 10 been evaluated at $z = 1$, which is the case for the factorial moments, then instead of $p_1(0)$ one would have unity and the r.h.s. of Equation 10 simply reduces to the first factorial moment $\langle \nu_f \rangle$ of the number of neutrons generated in induced fission. In the present case, we get instead an expectation *weighted* by $[p_1(0)]^{n-1}$. To simplify notations we will denote this weighted sum with an overbar notation (i.e., as $\overline{\nu_f}$). With this notation we get in the general case

$$\frac{d^n q_f(h)}{dh^n}\bigg|_{z=0} = q_f^{(n)}(h)\big|_{z=0} = \overline{\nu_f(\nu_f - 1)\ldots(\nu_f - n + 1)}. \tag{11}$$

A similar notation will be used for spontaneous fission, i.e., for the weighted moments of $q_f^{(n)}(z)$. The terms P(1) and P(2) can then be written explicitly as

$$P(1) = \frac{dq_s(h)}{dh}\frac{dh(z)}{dz}\bigg|_{z=0} = \overline{\nu}_s \frac{1-p}{1-p\overline{\nu}_f}, \tag{12}$$

$$P(2) = \frac{1}{2}\left(\frac{1-p}{1-p\overline{\nu}_f}\right)^2 \left[\overline{\nu_s(\nu_s - 1)} + \frac{p}{1-p\overline{\nu}_f}\overline{\nu}_s\overline{\nu_f(\nu_f - 1)}\right]. \tag{13}$$

Apart from the modified expected values $\overline{\nu}_s$ and $\overline{\nu}_f$, the expressions for $P(1)$ and $P(2)$ are formally equivalent with the factorial moments $\tilde{\nu}$ and $\tilde{\nu}(\tilde{\nu}\text{-}1)$ respectively (singlets and doublets) generated in one source emission event,[1,4] the difference being that $\overline{\nu}_s$ and $\overline{\nu}_f$ replace ν_s and ν_f and there appears an additional coefficient $\frac{1}{n!}$ in the probability distribution. The parameter *p* will also have more influence for the latter, since $\overline{\nu}_s$ and $\overline{\nu}_f$ and also depend on *p*, while factorial moments only contain an explicit *p* dependence. The relationship can be expressed as:

$$P(n)\big|_{\overline{\nu}_f,\overline{\nu}_s} = \frac{1}{n!}\left\langle \tilde{\nu}(\tilde{\nu}-1)\ldots(\tilde{\nu}-n+1)\right\rangle\Big|_{\langle\nu_f\rangle\langle\nu_s\rangle} \qquad n = 1, 2\ldots \tag{14}$$

One difference in the calculations of the moments and the probabilities is that to find the terms in the probability distribution one has to start by finding $P(0)$, which includes finding $p_1(0)$ from a eighth-order polynomial. The factorial moments do not have an initial term that needs to be calculated, since the zeroth order factorial moments are equal to unity.

Finding all statistical information is preferably done by calculating the probability distribution. It has already been shown that this technique can be used to obtain the factorial moments. The inverse process, to reconstruct the probability distribution from the factorial moments, is also possible.[7] This is not as easy as replacing modified moments in a formula, as it requires a larger unfolding. Therefore, starting with calculating factorial moments is best suited for when one is looking for a limited number of factorial moments, and do not need any additional information on the statistics.

Finding higher order terms up to large *n* requires *n*th order derivatives of the implicit function 3. The *n*th derivative will contain all lower order derivatives, and will become increasingly complicated and time consuming to calculate. By using the symbolic computation code Mathematica,[5] we found a feasible way of calculating terms to high order and keeping the recursivity of the expressions helps to keep them from blowing up in size and complexity too fast.

Gamma Distributions

The derivations of the formulae and expressions for the gamma photon distributions are based on arguments similar to those for neutrons. We start with two coupled equations for the PGFs describing the gammas emitted from (generated in) the sample,[4]

$$g(z) = (1-p) + p\,r(z)\,q[g(z)] \tag{15}$$

and

$$G(z) = r_s(z)\,q_s[g(z)] \tag{16}$$

Here $q_f(z)$ and $q_s(z)$ have been defined earlier. We also need to introduce $f_s(n)$ and $f_f(n)$, the number distribution of the number of gammas produced in one spontaneous and one induced fission event respectively, and their PGFs as

$$r_s(z) = \sum_n q_s(n) z^n \quad , \quad r_f(z) = \sum_n q_f(n) z^n \tag{17}$$

These are known nuclear parameters and for the quantitative work we obtained their values from MCNP-PoliMi.[4] The generating functions of the number distributions are

$$g(z) = \sum_n f_1(n) z^n \quad , \quad G(z) = \sum_n F(n) z^n \tag{18}$$

Hence, what regards the probability distributions, once again we can identify the searched quantities $f_1(n)$ and $F(n)$ as Taylor expansion coefficients of $g(z)$ and $G(z)$ respectively:

$$f_1(n) = \frac{1}{n!} \frac{d^n g(z)}{dz^n}\bigg|_{z=0} \quad \text{and} \quad F(n) = \frac{1}{n!} \frac{d^n G(z)}{dz^n}\bigg|_{z=0} \tag{19}$$

To start a recursive formula with an initial value we substitute z = 0 into 15 and 16. We once again end up with an eighth-order polynomial to be solved for $f_1(0)$, much the same as we had for $p_1(0)$ for the neutrons.

$$f_1(0) = (1+p) + p\, r_f(0)\, q_f[f_1(0)] = (1+p) + p\, r_f(0) \sum_{n=0}^{8} p_f(n) [f_1(0)]^n. \tag{20}$$

Since branching is the process deciding what order the polynomial will be, we end up at an eighth-order polynomial once again due to the fact that branching only occurs in the fission process that is connected to neutrons and not gamma photons.

After having found $f_1(0)$ one can determine $F(0)$ from Equation 16 as

$$F(0) = f_s(0)\, q_s[f_1(0)] = f_s(0) \sum_{n=0}^{8} p_s(n) [f_1(0)]^n. \tag{21}$$

Continuing to higher order terms proceeds similarly to that for neutrons, and requires derivation of $g(z)$ and $G(z)$; thus for this reason also derivatives of the functions $q_\alpha(g)$ and $r_\alpha(z)$, $\alpha = \{s; f\}$ and their evaluation at $z = 0$. We shall again introduce shorthand notations for the occurring weighted sums, to show the similarity between the expressions of $F(n)$ and the corresponding factorial moments of order n (denoted $\langle \mu(\mu - 1)...(\mu - n + 1) \rangle$ as in [4]). We introduce the following notations

$$\frac{d^n r_\alpha(z)}{dz^n}\bigg|_{z=0} = n!\, f_\alpha(n) \equiv \tilde{\mu}_\alpha(n); \qquad \alpha = s, f; \tag{22}$$

and

$$\frac{d^n q_\alpha(g)}{dg^n}\bigg|_{z=0} = \sum_m m(m-1)...(m-n+1) \cdot p_\alpha(n) \big[f_1(0)\big]^{m-n} \equiv \tag{23}$$
$$\equiv \tilde{\nu}_\alpha(\nu_\alpha - 1)...(\nu_\alpha - n + 1) \equiv \tilde{\nu}_\alpha(n); \qquad \alpha = s, f;$$

Compared to the case of neutrons we see a change in the definitions of Equations 11 and 23, where the former is weighted by $p_1(0)$ and the latter $f_1(0)$. Also zeroth-order derivatives will occur due to product quantities such as $r_f(z)\, qf\,[g(z)]$ and $r_s(z)\, q_s[g(z)]$ in the equations for the generating functions. For factorial moments these are just unity, and hence are not explicitly shown in the corresponding formulas. This amounts to saying that it is easy to convert the expressions from the probability distributions to factorial moments, but the inverse procedure is more complicated because the zeroth-order derivatives are not shown in the expressions for the factorial moments.

As an illustration, we show the resulting probability distribution for $n = 1$

$$f_1(1) = \frac{p r_f'(z)\, q_f[g(z)]}{1 - p r_f(z)\, q_f'[g(z)]}\bigg|_{z=0} = \frac{p \tilde{\mu}_f(1)\, \tilde{\nu}_f(0)}{1 - p \tilde{\mu}_f(0)\, \tilde{\nu}_f(1)} \tag{24}$$

and

$$F(1) = r_s'(z)\, q_s[g(z)] + r_s(z)\, q_s[g(z)]\big|_{z=0} = \tag{25}$$
$$= \tilde{\mu}_s(1)\tilde{\nu}_s(0) + \tilde{\mu}_s(0)\tilde{\nu}_s(1) \frac{p \tilde{\mu}_f(1)\, \tilde{\nu}_f(0)}{1 - p \tilde{\mu}_f(0)\, \tilde{\nu}_f(1)}$$

This can be compared to the expression of the first factorial moment for photons:[4]

$$\tilde{\mu} = \langle \mu_s \rangle + \frac{\langle \nu_s \rangle p \langle \mu_f \rangle}{1 - p \langle \nu_f \rangle} \tag{26}$$

For large n it is once again necessary to resort to Mathematica to handle the calculations and derivations symbolically in the recursive manner earlier described.

Numerical Work

Number Distribution

The distributions derived analytically for the neutrons and gamma photons were evaluated and compared to Monte Carlo simulations using the code MCNP-PoliMi. The ability of PoliMi to tally the number of spontaneous and induced neutrons and gamma photons in a given Monte Carlo history enables it to give the number distributions as well as calculating factorial moments and coincidences.[4, 6, 8]

In Figure 1 (left) a comparison is shown between the numerical data from the Monte Carlo simulations and the results from the analytical calculations for three different sample masses and their corresponding first-collision probabilities. There is a very good quantitative agreement in the results. We see that with increasing sample mass, i.e., larger p, the number distributions change in such a way that the bulk of the distribution for low n values remains fairly unchanged, with only a small decrease in the amplitude, while a tail develops for larger n values. This behaviour displays itself in the increased factorial moments with increasing p. The phenomenon of a tail developing is a characteristic of the

Markov chains with renewal and regeneration. Higher p means that the Markov chain has a "longer life." For higher values of N there is statistical scatter for the Monte Carlo results connected to the low number of occurrences; in the analytical calculations this behaviour is not present.

Figure 1 (right) shows a more detailed view of the development of a tail with increasing p for large values of n.

The number distribution of gamma photons is interesting because these have higher fission multiplicities, which could lead to an increased sensitivity in measurements aiming at determining sample properties such as isotopic composition or mass. The calculation of the statistics of gamma photons are more involved because they depend on more kinds of nuclear data, and the spontaneous and induced fission gamma distributions need to be considered up to $n = 23$.

The quantitative results, Figure 2 (left), show an agreement with Monte Carlo simulations that is very similar to that of neutrons. Also for photons a tail develops for high values of n with increasing p. The dependence of the distribution on the parameter p is also shown with a surface plot, Figure 2 (right).

Factorial Moments

The expressions derived for the number distribution were also used to calculate the first ten factorial moments, which were then

Figure 1. (left) Comparison between the analytical results and Monte Carlo simulations for three different sample masses having composition 80wt% Pu-239 and 20wt% Pu-240. (right) The dependence of the neutron number distribution on the first-collision probability p.

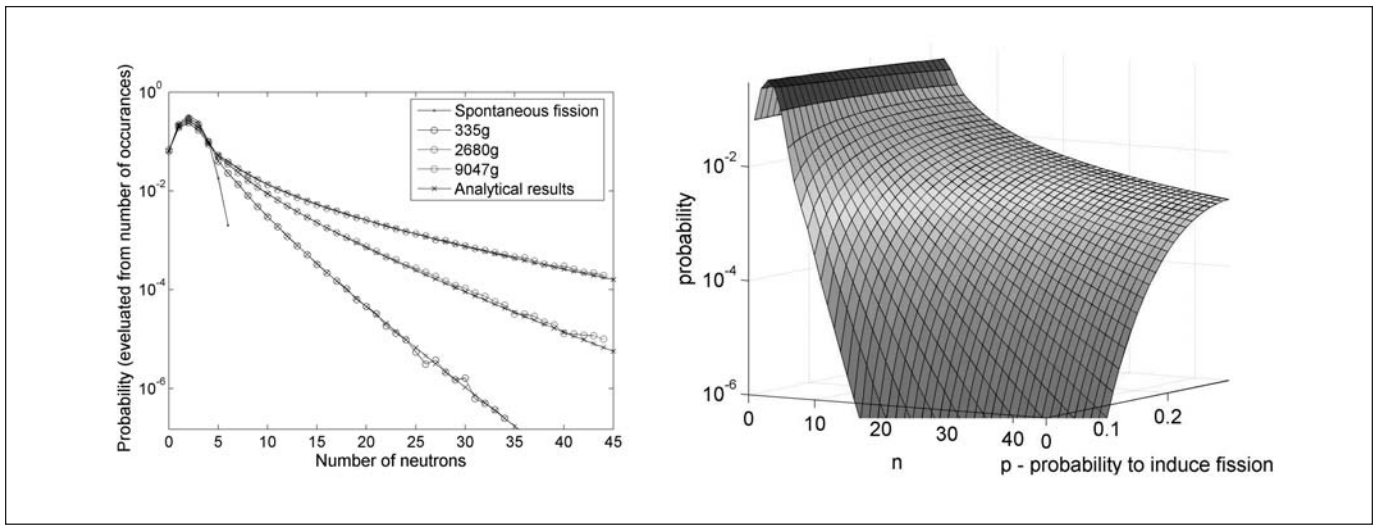
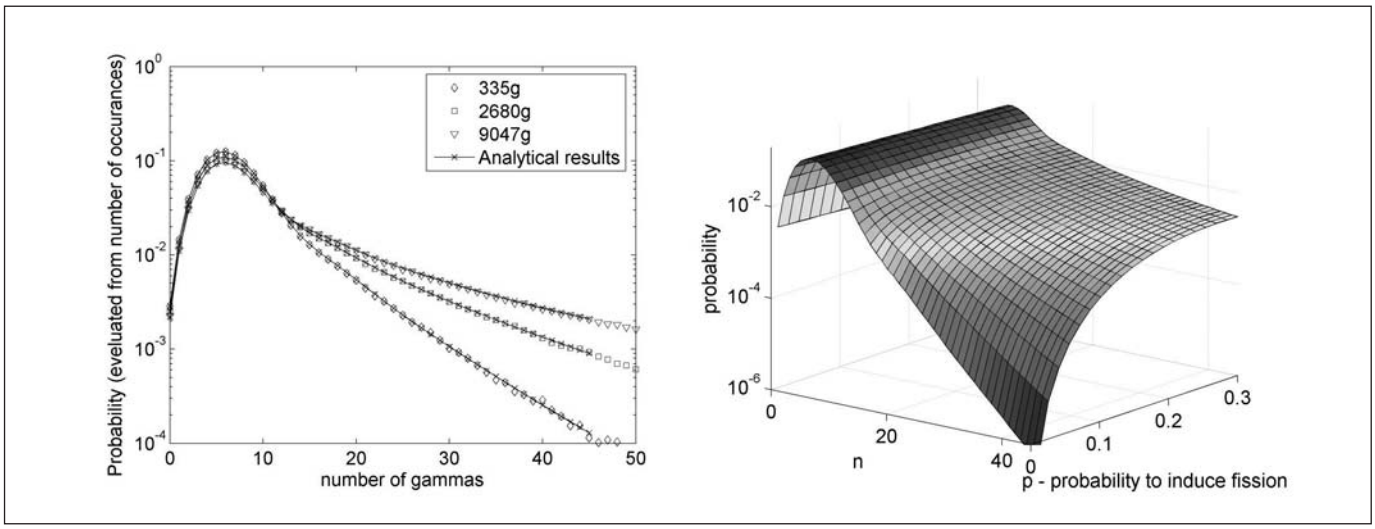


Figure 2. (Left) Comparison between the analytical and Monte Carlo results for the gamma photons from samples having composition 80wt% Pu-239 and 20 wt% Pu-240. (Right) The dependence of the number distribution of gamma photons on the first-collision probability p (analytical model).



compared with the same quantities calculated by MCNP-PoliMi. Figure 3 shows the result of this comparison for the neutrons. As can be seen, the agreement is very good, with some small differences for samples of higher mass, i.e., larger internal multiplication.

Figure 4 shows the factorial moments for gamma photons. Again, there is good agreement between the moments calculated via the analytical expressions and the corresponding Monte Carlo simulations. The numerical values for the factorial moments are given in Table 1. The greatest differences can be seen for heavier, more multiplicative samples. Higher factorial moments also show larger differences compared to lower ones, likely resulting from the fact that those high values are more sensitive to small variations in statistics and input data. For practical reasons, the data for the higher factorial moments are of less significance compared to singlets and doublets, etc., therefore the differences at higher moments will not have a large impact on calculations and predictions made for realistic samples.

The factorial moments show close to exponential growth for higher-order moments. The lower-order moments have a more irregular growth and will be hard to predict the values of in other ways than to use the kind of Monte Carlo simulations or analytical derivations used in this work.

Conclusions

The number distribution and the factorial moments for neutrons and gamma photons were calculated from master equations that were previously used for finding factorial moments. By applying symbolic computation, higher-order terms could be calculated in

Table 1. The first ten factorial moments for neutrons and photons for the 2680g sample of 80 wt% Pu-239 and 20 wt% Pu-240

Factorial moment	Neutrons		Photons	
	Analytical	Monte Carlo	Analytical	Monte Carlo
1	3.0941	3.0886	10.000	10.197
2	15.205	15.395	176.13	182.35
3	146.5	153.28	5966	182.35
4	2349.8	2574.5	3.3155e+05	3.6957e+05
5	52895	61371	2.5856e+07	3.0603e+07
6	1.5315e+06	1.9117e+06	2.5932e+09	3.3176e+09
7	5.4203e+07	7.4196e+07	3.1784e+11	4.4878e+11
8	2.2674e+09	3.4421e+09	4.6035e+13	7.2819e+13
9	1.0945e+11	1.8266e+11	7.693e+15	1.3616e+16
10	5.9879e+12	1.0627e+13	1.457e+18	2.8226e+18

Figure 3. The first ten factorial moments for neutrons calculated analytically and with Monte Carlo simulations. The same three sample masses are used as for the number distributions.

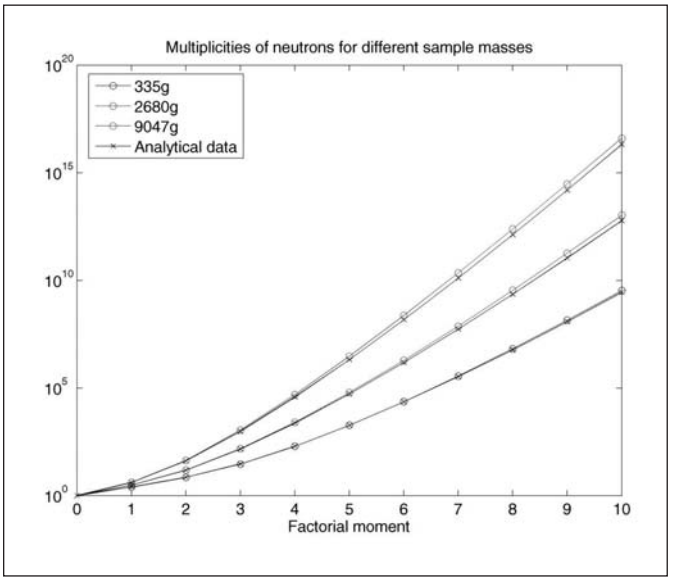
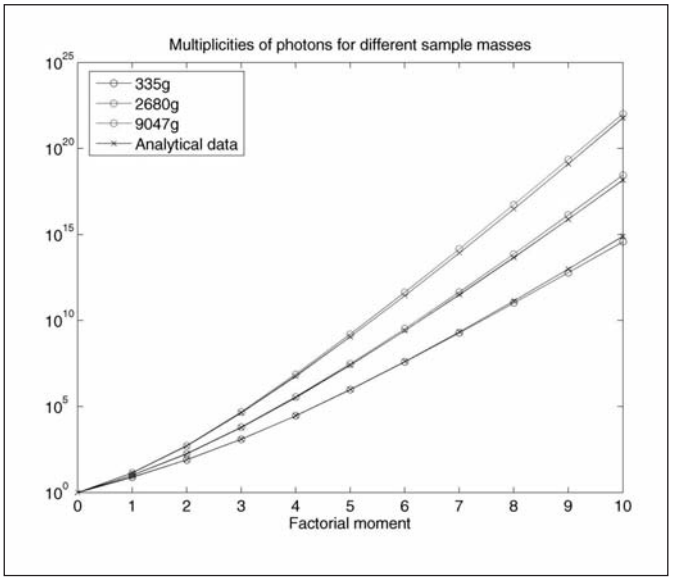


Figure 4. First ten factorial moments for gamma photons for three sample masses calculated analytically and with Monte Carlo simulations



a recursive and efficient manner. With the introduction of modified moments we showed that the expressions for the number distributions could be brought into a form equivalent to that of the factorial moments. The quantitative results show good agreement with Monte Carlo simulations performed with the code MCNP-PoliMi, both for the number distributions and for factorial moments. The results show that a tail develops in the probability distribution as the first-collision probability increases.

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References

1. Böhnel, K. 1985. *Nuclear Science Engineering*, 90 75.
2. Lu, M., T. Teichmann. 1992. *Nuclear Instruments and Methods Section A* 313 471.
3. Lu, M., T. Teichmann. 1993. *Nuclear Instruments and Methods Section A* 327 544.
4. Pázsit, I., S. A. Pozzi. 2005. *Nuclear Instruments and Methods Section A* 555, Vol. 1-2. 340.
5. Wolfram Research Inc. 2005. *Mathematica,* Version 5.2, Champaign, Illinois.
6. Pozzi, S. A., E. Padovani, and M. Marseguerra. 2003. *Nuclear Instruments and Methods Section A* 513 550.
7. Richards, P. L. 1959. *Manual of Mathematical Physics*, Pergamon Press, London.
8. Pozzi, S. A., J. A. Mullens, and J. T. Mihalczo. 2004. *Nuclear Instruments and Methods Section A* 524 92.

Transparency and Openness: Roles and Limitations in the Nuclear Nonproliferation Verification System

Contribution of the INMM International Safeguards Technical Division
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1. Introduction

While transparency has a long history of usage in arms control, the international safeguards community began to talk about "transparency and openness" in the aftermath of the discovery of Iraq's clandestine nuclear weapon program in 1992. In 1994 Cecil Sonnier brought that discussion into the Institute of Nuclear Materials Management (INMM) International Safeguards Division. In recognition of Sonnier's dedication to the division, which he founded and chaired for two decades, a memorial activity was initiated in July 2004, shortly after his death. It was felt that a reexamination of transparency and openness would be a suitable memorial discussion topic. This reexamination has taken into account important developments during the past two years in the role of transparency and openness in international safeguards and nonproliferation, driven by the "special verification case" of Iran.[1] This paper reports on the results of this memorial activity.

The first notable call for transparency and openness in the international safeguards area was by International Atomic Energy Agency[2] Director General Hans Blix before the Agency Board of Governors in February 1992 (see Section 1.1). This was followed by consideration in 1992-1993 by the Standing Advisory Group on Safeguards Implementation (SAGSI), reporting to the agency's director general (see Section 1.1). At that time the principal question addressed was whether and how transparency and openness could allow states to better demonstrate their nonproliferation credentials, through their interactions with the agency in the framework of their Nonproliferation Treaty (NPT) safeguards agreement. The possible role of transparency and openness in improving the efficiency of agency safeguards was also in consideration.

A role for transparency and openness with respect to undeclared nuclear activities was mentioned, but the concerns at that time were largely limited to the proven cases of Iraq and North Korea, although other potential trouble spots were recognized. Since 1994, the international community has had to deal with further noncompliance in North Korea and with the situations in Iran and Libya. And in late 2004, information came out about undeclared nuclear activities on a much smaller scale in South Korea (Republic of Korea)[3] and Egypt.[4] Discovery of the illicit nuclear proliferation network of A. Q. Khan of Pakistan[5] has added a further important challenge; the agency is reported to have discovered connections or contacts in more than thirty countries around the globe.[6]

Cecil and his wife Pat Sonnier

The main challenge facing the international safeguards community in the last several years has been reacting to and addressing questions about the noncompliance of Iran.[7] As the agency and its member states have struggled with how to build confidence in Iran's compliance, Iran has been requested to take "transparency measures" that have been characterized by the agency as going beyond its legal obligations under the NPT and its safeguards agreement.[8] This represents a significant extension of the role of transparency and openness in international safeguards and nonproliferation.

In this paper, we address the following important questions about transparency and openness:

1. What roles can transparency and openness play in cases where the compliance of a state with its nonproliferation and safeguards agreement obligations is in question?
2. What roles can transparency and openness play for states generally believed to be in compliance with their nonproliferation and safeguards agreement obligations?
3. How could and should the agency provide more transparency to its member states in order to increase the credibility of the assurances it provides?
4. What possibilities are there for further developments in transparency and openness in international safeguards and nonproliferation?

In the rest of Section 1, we review considerations of transparency and openness in international safeguards in 1991-94; transparency and openness in related verification regimes; and terminology related to transparency and openness. In Section 2, we address the first question above, which is perhaps the most important role of transparency and openness. In Section 3, we address the second and third questions, analyzing transparency between the agency and states in compliance, and transparency between the agency and states. In Section 4, we explore the fourth question, possible further developments in transparency and openness. And in Section 5, we present our conclusions and recommendations.

1.1 Transparency and Openness in International Safeguards and Nonproliferation, 1991–1994

Reaction to the Iraq clandestine nuclear program. Hans Blix, in his director general's statement to the February 1992 Board of Governors, placed openness and transparency in the forefront of safeguards and confidence building under the NPT:[9]

*Perhaps the broad objective of safeguards may be said to be the creation of a regime of **openness and transparency** and thereby to create confidence. There is no question of encroachment upon sovereignty. Verification activities are based on agreements freely made. To a state that respects a pledge given not to develop or acquire nuclear weapons, the strengthening of safeguards should be welcomed, provided it does not impede development or is very cumbersome—and this has not really been contended. The verification which occurs will result in a stronger—more credible—assurance about the peaceful nature of the state's nuclear programme.*

*It is important, I think, to retain the notion that **openness and transparency** about nuclear activities is the essential requirement to maintain confidence about their peaceful character and dispel any doubts in this regard. Full co-operation in implementing required safeguards is a way of achieving such **openness and transparency.** To create confidence a country may wish to go beyond the **openness** that follows from routine safeguards arrangements. It is reasonable to demand that the safeguards machinery should be sufficiently effective to detect violations—if any. By the same token, it is reasonable for governments to demand that it should be of use to dispel unfounded allegations.*

Blix's text seemed to clearly lay out the meaning and role of transparency and openness, and notably their relationship to confidence building. However, closer scrutiny generated much discussion. This was reflected by the statement in an unpublished paper written in 1994 as part of the INMM consideration that *"much confusion may exist regarding the use of the terms transparency and openness in the context of improved IAEA safeguards pursuant to the NPT."*

In this reexamination of transparency and openness, several points in Blix's citation were found to need clarification, if not modification. Blix's view on what was required to create confidence through openness and transparency was a starting point that has been built upon through international evaluations of what is required to meet recent proliferation challenges. International confidence is created through the agency's verification of the accuracy of the state's declarations and sufficient transparency of the state to provide assurance that activities have not been hidden from the agency and not declared. Openness of a state now includes bringing an Additional Protocol into force and permitting the agency to verify the nuclear fuel cycle-related activities identified by the state and to undertake additional measures to identify others that might not have been declared by the state. When compliance comes into question, routine safeguards arrangements are no longer viewed as adequate openness of a state.

A key clarification regards what Blix intended in saying a state "may wish to go beyond the openness of routine safeguards arrangements," which presumably meant the arrangements connected with routine reporting and routine inspections as provided for in comprehensive safeguards agreements based on INFCIRC/153.[10] A state *must* go beyond routine safeguards whenever the agency validly invokes either the special or ad hoc inspection authority of a comprehensive safeguards agreement. Also, in adopting an Additional Protocol based on INFCIRC/540,[11] states are now accepting the broader provision of information to and complementary access by the agency. But how "unfounded allegations" are to be dispelled remains a work in progress; this is taken up later in this paper.

Improving efficiency and effectiveness of agency safeguards—1991-1994.[12] In 1991 SAGSI[13] began focusing on how agency safeguards could be implemented more efficiently and effectively, in support of the agency's response to the board's call for "strengthening the effectiveness and improving the efficiency" of agency safeguards. Initially, SAGSI revisited the earlier idea of greater transparency of facility operation, coupled with an increase of transparency through non-routine activities to confirm the absence within a state of unsafeguarded nuclear material and activities. Transparency and openness were considered to be key elements in SAGSI's exploration of so-called alternative approaches to safeguards, explored in 1991-93 and incorporated in SAGSI's report to the director general in April 1993 on its reexamination of safeguards implementation.

At the director general's request, SAGSI further developed the ideas on transparency and openness and reported them in November 1993. SAGSI explained that the concepts of transparency and openness are complementary, with the formulation: "If they are compared to a house, transparency is like a glass house. One can see from a distance what is happening in it. Openness on the other hand is like a brick house in which one is allowed to enter."

SAGSI addressed transparency in international safeguards at the level of states and their nuclear programs, at the level of state systems of accounting and control (SSACs), and at the level of facility operators. It further noted that transparency is also required in the relations between the Secretariat, the Board of

Governors, and the member states. SAGSI suggested that these different aspects of increased transparency and openness might be a basis for enhancing the efficiency and effectiveness of the agency's safeguards system.

SAGSI noted that transparency is primarily related to providing information, and it listed additional information that a state might provide to the agency. This list was taken into consideration in the agency's Program 93+2, which was carried out between 1993 and 1995, and then was largely incorporated into the so-called expanded declaration in INFCIRC/540, adopted by the Board in 1997.

SAGSI noted that openness would be greatly improved by a state's willingness to permit wider access, and it pointed to the need for additional agency access to obtain assurances about the absence of undeclared nuclear activities. This idea was incorporated into the Model Additional Protocol as "complementary access."

As mentioned at the beginning, during 1994 the INMM International Safeguards Division pursued transparency and openness further, engaging in informal written and oral exchanges. That activity contributed to the general understanding within the international safeguards community, but did not generate published results given its informal nature.

In hindsight, it appears that discussions on transparency and openness in international safeguards had had their day by 1994. Approaches that were viewed as enhancing transparency and openness had been taken up in the agency's Program 93+2 and then in the Board of Governor's development of the Model Additional Protocol. But transparency and openness were destined to return to the discussions of safeguards and nonproliferation.

1.2 Transparency and Openness in Related Verification Regimes

In many areas of human endeavor, where there are calls for improvement, there are calls for transparency[14] and openness.[15] While it might be instructive and provide useful insights to look broadly at such usage, we limit consideration to a brief review of how transparency has been used in other international nuclear contexts. Openness has been used less frequently. We will suggest below that the term *openness* comes into play in the interactions of states with the agency under the NPT.

Transparency has long been central to arms control. As an example, recently in the context of START III negotiations the United states and Russia agreed that their experts would explore possible measures related to long-range sea-launched nuclear cruise missiles and tactical nuclear systems, including appropriate confidence-building and transparency measures.[16] The United Nations Institute for Disarmament Research (UNIDIR) has proposed a general definition of "confidence and security building measures" (CSBM): *"A CSBM seeks to introduce transparency and thereby predictability in relations between states by clarifying national intentions, reducing uncertainties about national activities, and/or constraining national opportunities for surprise."* [17] This juxtaposition of confidence-building measures and transparency, echoing Blix's 1992 statement, has been reflected in the agency Board of Governors considerations on Iran in late 2005 and in 2006. It is, in fact, the key to the role of transparency between states under the NPT.

1.3 Transparency, Openness, and Cooperation

Here we discuss the meaning of transparency, openness, as well as the related term cooperation. The combination "transparency and openness" has sometimes been used; when used together, transparency alone would often suffice. SAGSI suggested that, for international safeguards, transparency should mean the provision by a state of *information* allowing others to see more clearly what its activities and capabilities are, while openness should mean the provision by a state of *access* that would enable others to see for themselves or through an intermediary, i.e., the agency. Another characterization is that transparency refers to a state of being in which it is very difficult to conceal illegitimate activity, and openness characterizes a policy (by a state) that seeks to achieve this transparency. We develop those ideas further in this subsection and in the remainder of the paper. Our general recommendation on terminology is that *transparency* be considered the appropriate primary term, which can include openness, and *openness* should be used only when its separate meaning is intended.

Transparency

Transparency is a widely used term in many fields. Transparency involves a condition, or state of affairs, evident to an observer—in the safeguards and nonproliferation context, to another state and to the agency. A determination of transparency results from an assessment by others and thus is a perceived *virtue* of an organization, government, or state. A government or state cannot achieve transparency simply by proclaiming it.

For international safeguards and nonproliferation, the context in which transparency is used must be carefully explained and qualified in order not to mislead or over-promise the effectiveness of safeguards. The concept of transparency arises because states have a strong national security interest in gaining confidence about the nuclear activities of other states and, to the extent that they can be inferred from these activities, also the intentions of other states in the nuclear area. States and the agency gain confidence about other states through differing means.

As has been demonstrated by recent cases, the agency assesses transparency as a part of how it gains the confidence to draw safeguards conclusions about a state. The agency's assessment of transparency involves a number of factors: how the state complies with the obligations of its safeguards agreement and Additional Protocol; how it cooperates with the implementation of safeguards by the agency; whether information from open sources is consistent with the nuclear activities declared by the state; what voluntary reporting the state does to the agency when appropri-

ate; and what confidence-building measures the state undertakes when judged necessary to resolve outstanding issues. Some actions taken as confidence-building measures may be referred to as transparency measures between the state and the agency.

States also make an assessment of transparency as part of how they gain confidence that another state is meeting its obligations under the nonproliferation regime. A state's broader assessment of transparency may consider information it obtains independently from bilateral and multilateral contacts and from other sources, reports by the agency to its Board of Governors and annually to member states, open sources of information about the state,[18] and confidence-building measures undertaken by the state, including transparency measures and, if relevant, a state's voluntary constraints on sensitive nuclear activities.

Transparency in international safeguards and nonproliferation can be defined as: "the condition in which a state's nuclear programs, activities, facilities, capabilities, and intentions are known to other members of the international community, through explicit policies and actions of the state, by reason of its general climate and culture of openness, and by independent information available on the state."

The problem of completeness of transparency. When transparency is used, a qualifier is frequently added, often "full transparency."[19] This reflects one of the major problems with the term transparency—the tendency to think of it as complete, when it is unlikely to be complete given the many aspects involved. In fact, a basic limitation of transparency is that there is no way to verify whether it is complete. For the agency to assess whether a state's apparent openness and transparency are real and complete, the tools available are no more and no less than those provided in the relevant safeguards agreements, including the state's cooperation (see discussion later). The effectiveness of the tools may be limited by the effectiveness of countermeasures used to hide activities that a state does not want to be observed.

There may also be the expectation that full confidence requires complete transparency. On the contrary, not every detail needs to be available, only sufficient information, e.g., to see that technology is not being misused. Nevertheless, all information of safeguards relevance is useful and the limited transparency that corresponds to incomplete information is of value provided that the likelihood that it is incomplete and perhaps even inaccurate is recognized and given weight.

Without the agency being in effect the sovereign, it is difficult for it to achieve something close to full confidence. Safeguards cannot provide absolute assurance of the absence of undeclared nuclear activities for a state. "Every modern state maintains elaborate and costly programs to protect its classified national security information."[20] While large-scale clandestine nuclear activities, like the Hanford and Oak Ridge installations in World War II, can no longer be kept clandestine, nuclear activities that are small enough might be hidden. With proper understanding of this limitation, transparency can strengthen the agency conclusion that it has no indications of undeclared nuclear activities.

Calling for transparency. Calling for transparency—by states and/or the agency—can be a legitimate part of the rhetoric employed to exert pressure for compliance in cases where there are questions about a state being in full compliance with its undertakings. However, calls for transparency are inherently ambiguous and might be interpreted as displacing calls for compliance with the safeguards agreement provisions per se. This might tend to blur the meaning or even weaken the significance of compliance and thus might undermine the agency's rights to verify compliance. The question should be asked: "Why not call for compliance rather than for transparency?" If what appear to be positive responses to calls for transparency are given credence, or even the benefit of the doubt, the safeguards component of the nonproliferation regime will suffer. Care must be taken that making calls for transparency does not turn into a surrogate or substitute for the agency not asserting and making use of the rights that the agreements already give it.

Openness to the Agency

The concept of openness arises because the agency, under its statute and the NPT, has a unique mandate. The agency is charged with verifying whether states are fulfilling the obligations they undertake through their safeguards agreements with the agency. In order for the agency to properly carry out its mandate, states must comply fully with the obligations to provide information and access as set forth in their safeguards agreements. Openness in international safeguards and nonproliferation can be defined as the relationship between a state and the agency with respect both to the information and access that a state provides. Therefore, the objective of openness in international safeguards is to contribute to the agency's process of verification and thus its ability to draw correct safeguards conclusions. We call that "openness to the agency." For openness to the agency to contribute to transparency of the state, the information must be verified or the access performed so that the agency has confidence that what the state provides or offers is accurate and complete.

With respect to the agency verifying that declared nuclear material has not been diverted, a state's obligations for openness are defined in its safeguards agreement, including an Additional Protocol where applicable. The strengthening measures adopted in the 1990s within the legal authority of INFCIRC/153, and several of the provisions of the Additional Protocol have expanded openness by states in such areas as cooperating to facilitate inspections on short notice and the use of remote transmission of safeguards data.

With respect to activities performed by the agency to support a conclusion that undeclared nuclear material and activities are absent, the strengthening measures adopted in the 1990s within the legal authority of INFCIRC/153 and the provisions of the

Additional Protocol have expanded significantly the information and access routinely available. Explicit provision of access for the use of environmental monitoring in facilities, at nuclear sites and at other locations in a state is a new element of openness of states.

The openness of a state to the agency may be greater than its transparency to other states or the international community as a whole because of the agency's obligation to maintain the confidentiality of information provided by states.[21] Thus, the agency may require and receive some information from a state that it is not able to share with other member states. Giving the agency access to such information should be encouraged, provided that it is made clear that it is preferable that states allow to be made public information relevant to its nuclear activities that is not sensitive for nonproliferation or proprietary reasons.

A key question about openness is whether a state can never say no to an agency request for any information or access. There is a basis for the agency to take the position that there is no limit.[22] There is no explicit limit in paragraph 77 of INFCIRC/153 on the "information or locations in addition" to which the agency can request access, and demand it as a matter of right, if the Board determines that it is essential and urgent. This would include information that is not explicitly nuclear but is essential to provide the rationale for otherwise ambiguous nuclear activities, such as enrichment. The Board would make the decision as to whether the justification for the request is valid and politically acceptable.

Openness to the agency could mean even more than discussed above. An example could be the assembly and release of information that is helpful to the agency's task (or establishing arrangements that facilitate this). Of course, a state's ability to falsify information must be kept in mind, and the agency's ability to verify the accuracy and completeness of such information is limited. Nevertheless, information that is sufficiently diverse and independent in origin may be considered to have greater credibility than information solely from state sources—and this could be helpful for agency purposes.[23]

A further form of openness applicable to all states and independent of their safeguards agreement with the agency is to provide the agency information or to assist agency investigations about possible undeclared nuclear activities in other states, specifically regarding inquiries about purchasing specialized equipment or non-nuclear materials, exports and export denials, and use of ports for trans-shipment of such equipment and materials. Such information could be of great benefit to the agency.

Cooperation Between the State and the Agency

Cooperation is sometimes used where *openness* might be expected. Certainly openness requires a degree of cooperation, but cooperation does not assure complete openness. Therefore, it is helpful to address the meaning and usage of cooperation in relation to openness. There is a case for making a distinction between openness of a state to the agency and cooperation between a state and the agency.

Cooperation is a fundamental element in making any agreement work. One section of Part I of INFCIRC/153 is titled "Cooperation between the agency and the state" and this provision reads:

> *"The Agreement should provide that the agency and the state shall cooperate to facilitate the implementation of the safeguards provided for therein."*[24]

What was intended by *cooperate* in that INFCIRC/153 provision was something subjective and general, the state should not make unnecessary difficulties for the agency, and vice versa. To the contrary, by *openness* we mean something very concrete and objective: access to information and places. Either a state allows the access or it doesn't. If the agency has a right to the access and the state denies it, it is in noncompliance, regardless of how politely it says no.

However, a consequence of this legal provision in comprehensive safeguards agreements is that when cooperation is referred to without further qualification in an international safeguards context, it is reasonable to assume that it refers to agency-state cooperation to facilitate the implementation of the safeguards prescribed in the safeguards agreement (including an Additional Protocol, for states with one in force). If cooperation is intended to mean more than that, misunderstandings could occur. This problem can be avoided through the use of the term openness when appropriate.

There is also the matter of how a state responds to reasonable requests by the agency for additional information or other safeguards needs. It is open to a state to provide the agency greater information and access voluntarily when this appears likely to be helpful to overcome uncertainty. The fallback for the agency is that virtually complete access is required under the relevant safeguards documents, pursuant to a board finding that it is essential and urgent. If such information and access is freely and cooperatively given, that can carry with it a greater sense of validity, and a correspondingly higher degree of assurance than if the same information and access were obtained after delays and repeated requests, or only through the imposition of the agency's mandatory processes.

Finally, a new direction for cooperation of states with the agency has been raised in the Secretariat report on Iran for the November 2004 Board of Governors, in which cooperation is used many times. The "full and prompt cooperation with the agency of third countries" and "cooperation of other states" is called for.[25] That brings the actions of all states into play. Could it lead to the Secretariat naming those "third countries" that have, and perhaps those that have not, given it this additional cooperation? That may depend on whether the actions involved in this "additional cooperation" are intended to build confidence through *transparency* or provide confidential information to the agency, i.e., through *openness*.

2. Role of Transparency and Openness Where the Compliance of a State with its Nonproliferation and Safeguards Agreement Obligations are in Question

2.1 Recent Cases

The concept of transparency and the concept of openness to a lesser extent have again become prominent in the informal and formal discussion of international safeguards.[26] The usage has been in connection with the recent cases where there were questions about compliance, notably the cases of Iran but also of Libya. The most extensive usage has been with regard to the Iran case, both in official documents and in the media. In the media, in March 2005, one commentator referred to "Iran's customary brazenness…in its repeated snubbing of efforts by [the agency] to promote nuclear transparency…"[27] Another commentator reported "an unusual gesture of openness"[28] when Iran took a group of journalists deep underground to visit the Natanz uranium enrichment facility; the U.S. State Department commented: "If Iran were really serious about demonstrating transparency in its nuclear program, it should answer all of the [agency's] outstanding questions."[29] Iranian officials have declared that their "nuclear activities are transparent."[30] And, a senior Israeli official was reported to have said, "The way to stop Iran is by…sanctions as a tool and a very deep inspection regime and full transparency."[31]

When there are questions about a state's compliance, the formal usage is more important. If a state is in fact in compliance with its safeguards agreement but is nevertheless the subject of suspicion, transparency and openness can play a role as tools to aid the agency to verify compliance. Additional information and openness, i.e., access to locations, people and documents, might result in greater transparency and strengthen the confidence in the state's compliance.

When questions have arisen about the compliance of a state with its safeguards agreement obligations, the agency follows a process that, while particular to the case, is guided by relevant provisions of INFCIRC/153 and the agency statute. The threshold step is for the director general to report the case to the Board of Governors. The board, taking account of the Director General's report, can decide that the case should be reported to the UN General Assembly and Security Council. Once a case has been referred to the UN Security Council, the Security Council may reaffirm the agency's rights and urge a state to comply with resolutions of the Board of Governors. It may also give the agency a mandate to carry out activities under a council resolution, as happened with Iraq in 1992 and with DPRK in 1994.

However, certain measures lie in the agency's competence even if a case is referred to the UN Security Council, such as suspension of agency membership, call for return of nuclear material, and most importantly, continuation of safeguards. In this sense, the board is no different in principle from the UN Security Council—a tribunal of member states—and should be seen as a part of the same system of adjudication.

If the board decides to deal with a case within the agency framework, at least for a period, it may adopt one or several resolutions with requests to the state and to the Director General. The director general is asked to report to the Board of Governors whether a state is in or has come into full compliance with its safeguards obligations. The implications of such a request have been unfolding over the past several years in the Iran case before the agency Board of Governors. That case has broken new ground and established precedents in dealing with questions of compliance in international safeguards, also with respect to transparency and openness.

With respect to consideration by the board of a conclusion reported by the director general on agency verification activities, it is the process of verification itself that is crucial. This distinction is an important one. There are many times in the process of verification when the agency will have to make judgments to guide its own efforts in order to end up with a conclusion to present to member states, but states will make their own conclusion and they will reflect their judgment, not the agency's, in their decisions in the Board as to whether or not to refer a state to the UN Security Council. Transparency and openness of a state can play a role with respect to the actions member states take in the Board of Governors.

Iran. The situation with Iran provides a concrete example. If Iran had complied with the reporting and access requirements of its safeguards agreement, it could have done all the things it now claims its agreement allows it to do, including enrichment, without in any way violating its safeguards agreement or the NPT. However, in view of its violations, whether Iran can claim the full rights given by the treaty and safeguards agreements to complying parties has come into question. Moreover, the conduct of otherwise permissible activities if undertaken while R&D possibly connected with weaponization is also in progress would raise questions as to compliance with the NPT and safeguards agreements. Fuel cycle activities with the potential for the production of weapons usable material would raise the most serious questions. But, any nuclear activity of a scale and nature, including reactor construction and operation, that could contribute to weapons material production could come under suspicion and scrutiny. While the conduct of weaponization activities in the event that they are discovered or reasonably suspected thus has obvious relevance to the determination of compliance, it must be emphasized in the strongest possible terms that it is unnecessary that such activities be discovered in order for noncompliance with the provisions of safeguards agreements to be established, and appropriate corrective actions to be initiated.[32]

The director general has emphasized the importance for Iran to provide active cooperation and maximum transparency in order for the agency to gain full understanding of the extent and scope of its previously undeclared activities and to verify the correctness and completeness of its current declarations relevant to its nuclear program.[33] Additional openness and the resulting

transparency may reduce doubts, with the essential proviso that the completeness of the transparency will never be assured. However, when noncompliance has been established, as in the case of Iran, a high degree of transparency will be called for, which is perhaps not achievable in practice, leaving an uncertainty which safeguards alone may be incapable of resolving.

Other recent cases. Libya was another significant case, where the director general was able to report that the state, while in noncompliance for a substantial period, had given active cooperation and what is believed to have been full openness to the agency. Therefore, he concluded that Libya was taking the necessary corrective actions and being sufficiently open to the agency to come into compliance with its safeguards obligations. In the Republic of Korea (ROK) case in 2004, the director general stated that the failure to report certain sensitive nuclear activities was of "serious concern" but "the ROK has actively cooperated with the agency in providing timely information and access to personnel and locations, and has permitted the collection of environmental and other samples." This cooperation, in combination with the apparently limited scale of the activities that the ROK failed to report, allowed the director general to conclude that although continuing follow-up was needed, resolution of the issue could be handled through routine safeguards under the agreement and additional protocol.

2.2 Confidence-Building Measures

Transparency helps to engender confidence—e.g., if state X concludes that it understands the rationale for state Y's nuclear program, and is confident that it is aware of the details of that program—including what it believes to be the absence of research and development on production of weapons-usable fissile material, or an appropriate civil purpose for such R&D—then state X can factor those conclusions into its strategic assessments and decision-making affecting state Y. It must be clearly recognized, however, that state X's understandings in regard to the nuclear program and intentions of state Y may be incorrect and its confidence, therefore, may be misplaced.

In his statement for the November 2004 board, the director general introduced a new concept and term—"confidence deficit"—saying: "A confidence deficit has been created, and confidence needs to be restored. Iran's active cooperation and full transparency is therefore indispensable."[34] The introduction of the concept of confidence deficit at that stage in the Iran case reflects a maturing of thinking about how to address both nonproliferation concerns and safeguards compliance questions. A confidence deficit develops when noncompliance with safeguards obligations is coupled with incomplete transparency. The concept of confidence restoration/confidence building has been explicitly brought into the handling of this case. This is consistent with the United Nations Institute for Disarmament Research (UNIDIR) definition of a confidence and security building measure (see Section 1.2).[35] Intrinsically, confidence-building measures can only have a partial effect, as steps toward a restoration or achievement of full confidence.

For states with legally binding NPT safeguards obligations, confidence-building measures should not be used to describe actions that a state in noncompliance undertakes to remedy the noncompliance with those obligations. Other states are entitled to full compliance and should expect the agency to demand it. Therefore, it was good to see that confidence building and the confidence deficit concept were not used for the case of the Republic of Korea, also before the November 2004 Board of Governors.

Depending on the circumstances, however, building confidence—or coming back out of a confidence deficit—may require a state to provide the agency information and access beyond that which it has obligated itself to provide under its safeguards agreement, broad as those obligations are, and to take wider actions or accept limitations on its actions, such as the suspension of certain nuclear activities. The acceptance of such actions by a state falls in the area of confidence-building measures.

In the Iran case, the Board of Governors started in November 2004 to request Iran both to fully meet its obligations under its safeguards agreement and to take voluntary confidence-building measures, such as termination of all enrichment related activity, that a complying party is not legally obligated to take.[36] In February 2006, Iran was explicitly called to respond positively to confidence-building measures with respect to its declared nuclear program, namely to resuspend all enrichment-related and reprocessing activities, to reconsider the construction of a heavy water research reactor, to ratify its Additional Protocol and, pending ratification, to act in accordance with it. While Iran's noncompliance with its safeguards agreement does not in itself provide a legal obligation for Iran to take these actions, neither does Iran enjoy the legal right, as would a state in compliance, to continue these activities. It is in this sense that certain activities go beyond the legal obligations of the NPT and safeguards agreements. As additional confidence-building measures, specific openness actions, called *transparency measures* that extend beyond the formal requirements of the Safeguards Agreement and Additional Protocol," were requested of Iran, namely, to provide such "access to individuals, documentation relating to procurement, dual use equipment, certain military-owned workshops and research and development as the agency may request."[37] This application of confidence-building measures, which includes voluntary actions by the state and specific transparency measures between the state and the agency, provides a model for use in future cases. But care must be taken that calling for confidence-building measures does not lead to confusion between obligatory and voluntary actions.

Bilateral or regional cooperation between states could include establishment of nuclear transparency measures to increase confidence. A study of regional transparency measures covering nuclear safety, security and safeguards has been presented recently.[38] States might consider opportunities for developing

appropriate bilateral or regional transparency measures to complement safeguards, and where they do develop transparency measures, making the information from these available to the agency.

2.3 Transparency Visits

In the Secretariat's report on Iran to the November 2004 board, certain types of access for inspectors were called transparency visits "in the interest of confidence building."[39] While this is not a new concept,[40] it raises important considerations.

In the Model Additional Protocol, the concept of agency visits in the interest of confidence building was introduced in Article 8, which provides for a state to voluntarily "offer the agency access to locations in addition to those" otherwise provided for by the additional protocol and to request "the agency to conduct verification activities at a particular location." Such Article 8 access would seem to match the intent of the term "transparency visit."

Which side initiates discussion of such a visit is not important. It is clear especially in INFCIRC/153 but also in INFCIRC/540 that this additional access should be arranged cooperatively when possible. In many cases, a transparency visit would be voluntarily agreed to by the state. What is important is how the state reacts when the agency wishes to have additional access and the state does not wish to voluntarily offer it.

The key point here is that in states with comprehensive safeguards agreements, the provisions, even based on INFCIRC/153 alone, provide a strong basis for verification, without any additional openness. The agency has the right to go anywhere in the state "when it considers that information made available by the state is not adequate for the agency to fulfill its responsibilities under the Agreement." If the agency Secretariat asks and gets turned down by the state, which would represent a serious case, the agency board can invoke the "essential and urgent" provision to require the state to permit the access.

A transparency visit is in effect a special inspection that has not been formally requested as such. Using transparency visit as a label may be useful for smoothing the process. But care is required not to prejudice the agency's right of complete access by implying that these visits can take place only with the agreement of a state. Special inspections, whether viewed as *"transparency visits"* or formally designated as special inspections, can take place at the invitation of a state or at the initiative of the agency, and need not be authorized by the Board of Governors. If a state refuses a special inspection, the Secretariat will need to gain the support of the Board of Governors for further action.[41]

The Iran case provides relevant examples. The agency has been reported to wish access to two military sites.[42] In one case, the agency was reported to have made a request for a "transparency visit." Calling it a "transparency visit" may make the process easier for the state to agree, but the agency should make it clear that it has rights. In the other case, it was reported that the Iranians have said they will not grant the access unless the agency is able to present reasonable evidence of nuclear material on the site.[43] A reported Iranian statement was: "[The agency] should have evidence that there are nuclear activities," not just "We heard from someone that there is dual-use equipment that we want to see."[44] This raises the question of the limits, if any, on the agency's complementary access and special inspection rights.

The framers of the Model Additional Protocol did put limits on complementary access (Article 5). In particular, complementary access to "any location specified by the agency," other than places on a nuclear site or nuclear-related locations identified by the state, is in the first instance "to carry out location specific environmental sampling" (Article 5c), and is subject to denial if the state is "unable to provide such access," provided the state makes "every reasonable effort to satisfy agency requirements, without delay, at adjacent locations or through other means."

For a special inspection, there is a threshold requirement, but it is a very low one, viz., "if the agency considers that information made available…is not adequate to fulfill its responsibilities," the key one of which is to ensure that "safeguards will be applied on all material and to verify that such material is not diverted…" To do this, as made clear in the agency statute,[45] the agency needs and shall have "access at all times to all places and data and to any person…as necessary to account for [nuclear] materials." In other words, access by the agency can be needed to places where the evidence will show that safeguards do not need to be applied. Contrary to the Iranian assertion mentioned above that there must be evidence of nuclear activities at a location at which the access is requested, there need only be a nexus with nuclear material.[46] But what is sufficient *nexus* has not been defined. The degree of nexus being a matter of judgment, it may be questioned by the state. Obviously, the state possesses the power not to comply. It is then in noncompliance, and the processes for dealing with noncompliance must be initiated.[47]

Recently, a broader usage of transparency visits, beyond states with comprehensive safeguards agreements, has arisen. There have been reports of agency's requests made to Pakistan, a non-NPT state, in the course of the agency's investigation of the illicit nuclear proliferation network.

In summary, it is important to have a proper understanding of the concept of transparency visits in relation to complementary access and to Article 8 visits under an additional protocol and to the agency's special inspection rights of INFCIRC/153. The agency has rights of access that should not be diluted through the use of the euphemism of transparency visits.

3. Role of Transparency and Openness Under Routine Safeguards

While the transparency of states to each other or to the international community as a whole is the end objective and therefore the most important aspect of transparency, in this section we focus on the interactions between states and the agency under

routine safeguards and possible roles of openness to the agency and transparency measures. We also address voluntary provision of information to the agency by states (3.2) and the transparency of the agency about safeguards implementation in states (3.3).

3.1 Role for States with Different Types of Safeguards Agreements

Safeguards are implemented by the agency under three types of safeguards agreements: comprehensive safeguards agreements for NPT non-nuclear-weapon states; voluntary offer agreements for nuclear weapon states; and INFCIRC/66-type agreements for other states. For the NPT non-nuclear-weapon states, four situations of their comprehensive safeguards agreements can be distinguished:

- states with significant nuclear activities with an Additional Protocol in force
- states with significant nuclear activities in the process of putting an Additional Protocol in force
- states with significant nuclear activities that may choose not to accept an Additional Protocol
- states that (as far as known) hold such limited nuclear material that they have a so-called "small quantities protocol" (SQP) to their safeguards agreement, suspending inspections and other safeguards procedures that would otherwise apply.[48] These states can be subdivided into those that agree to accept a revised SQP (a model agreed by the Board of Governors in 2005) reinstating some verification activities by the agency, those that also include an additional protocol, and those that do neither of these.

A majority of NPT states with a significant nuclear program now have Additional Protocols in force. A comprehensive safeguards agreement (i.e., based on INFCIRC/153) with an Additional Protocol in force now represents the comprehensive safeguards norm. Once an NPT state has put its Additional Protocol in force, the agency carries out the activities it considers necessary to draw an initial conclusion on the absence of undeclared nuclear material and activities in that state. Then, safeguards implementation moves into so-called integrated safeguards. In principle, this process involves information and access called for in the safeguards agreement and Additional Protocol. In practice, the agency has found that the process for drawing the initial conclusion may raise issues that call for information or access beyond routine safeguards. One example is resolving questions about the history of nuclear activities in a state, which may require information and access that do not involve currently declared nuclear material, facilities, and locations. The state might say that to meet such a request, it must go beyond its obligations. The agency would respond that such information and access is necessary. With good cooperation between the state and the agency, in the sense of paragraph 3 of INFCIRC/153, such situations can be handled through additional openness and perhaps transparency measures, and resolved. The boundaries for this type of situation are still being established.

Regarding NPT states in the process of putting an Additional Protocol in force, some have stated the intention to sign an Additional Protocol but have not yet done so, and some have signed an Additional Protocol but have not yet put it in force. As a general rule, during the process of signing and putting the Additional Protocol in force, these states are treated similarly to states not having an Additional Protocol in force.

NPT states with a significant nuclear program that have a comprehensive safeguards agreement but do not have an Additional Protocol in force are a rapidly decreasing but important minority of states. As the number of states that may choose not to accept the new comprehensive safeguards norm diminishes, the agency's conclusions about these states are likely to attract increasing scrutiny. Such states remain subject to all of the obligations of the NPT and comprehensive safeguards agreements and may well constitute the most important group of states from the standpoint of safeguards implementation. Although the agency will not state a conclusion about the absence of undeclared nuclear material and activities in these states, other member states will expect the agency to do all that the safeguards agreements foresee, and perhaps more, to provide as robust safeguards conclusions as possible for these states. Therefore, it is likely that the agency will, from time to time, request information and access of such states beyond their legal obligations. How the state reacts and this process proceeds will be considered in the agency's evaluation. With good cooperation between the state and the agency, in the sense of paragraph 3 of INFCIRC/153, such requests can be met through additional openness, including perhaps transparency measures, and resolved.

In SQP states, which represent a majority of NPT states, agency activities are infrequent. The agency Board of Governors approved a strengthening in the approach to safeguards implementation in SQP states in 2005. SQP states are also invited to conclude an Additional Protocol (as of this writing, 30 have done so). It is possible that an issue may arise for an SQP state that leads the agency to request transparency measures by the state, e.g., information and access beyond the obligations in the SQP. How the state reacts and this process proceeds will be considered in the agency's evaluation. With good cooperation between the state and the agency, in the sense of paragraph 3 of INFCIRC/153, such requests can be met through additional openness and perhaps transparency measures, and resolved.

The agency does not draw state-level safeguards conclusions about the nuclear weapons states. It only reports on the results of the limited activities performed under the individual voluntary offer agreements. These states will have individually crafted additional protocols in force, under which the agency will receive certain information and, for three of the states, access. The agency may request transparency measures of a nuclear weapon state, e.g., information beyond its legal obligations in conjunction with the agency's investigations about another state. How the nuclear weapon state reacts and this process proceeds may influence how other states react to agency requests for transparency measures.

The agency does not draw state-level safeguards conclusions about states with INFIRC/66-type agreements (i.e., India, Israel, and Pakistan), it only draws conclusions on the results of the activities performed under the individual agreements. These states may put in force individually crafted Additional Protocols, under which the agency will receive certain information and perhaps access. The agency may request a transparency measure by any of these states, e.g., information or access beyond the legal obligations of the INFCIRC/66 agreements and Additional Protocol of the state in conjunction with the agency's investigations about another state.

3.2 Voluntary Provision of Information to the Agency

One form of openness of states to the agency is the voluntary provision of information beyond that called for in the safeguards agreement. In 1993, the so-called Voluntary Reporting Scheme (VRS) was introduced with Board of Governors endorsement.[49] It provides a mechanism for the voluntary reporting by states on nuclear material not required under an INFCIRC/153-type safeguards agreement and of exports and imports of specified equipment and non-nuclear material.[50] Export information is of special and unique importance because it may provide the agency with information that importing states would not provide on themselves. Much of the information to be provided under the VRS is included in the Additional Protocol; some is not, in particular equipment imports. States with an Additional Protocol in force could voluntarily provide such information to the agency.[51]

The agency has also established mechanisms for states to voluntarily provide information on neptunium and americium, and on incidents of illicit trafficking in nuclear material and other radioactive sources.

3.3 Agency Transparency

The transparency of the agency's safeguards implementation determines how much confidence member states gain from its verification activities. Reporting by the agency that it has found no indications of noncompliance is only partly useful to states. Member states need to know what the agency did to judge how much weight to put on the agency's conclusions. This is especially important in relation to undeclared nuclear activities. In fact, it is fundamental, since a statement that no undeclared activities were found or indicated could be made if the agency does nothing at all. Such a conclusion begins to acquire meaning and value if states know that the agency has performed substantial verification before reaching the conclusion.

But confidentiality has been a hallmark of reporting on the agency's safeguards implementation, and the general rule has been "no news is good news." The basis for this general rule is the statutory requirement that the staff "shall not disclose any industrial secret or other confidential information…" The use of this general rule has been generally interpreted to mean that if a specific state is not singled out in agency documents for the Board of Governors and member states, the agency has no substantive concerns with that state's compliance with safeguards obligations. However, the "no news is good news" custom means the agency is not required to disclose developing problem areas.[52]

This approach provides limited transparency for member states, and two forces have been working to modify it. One is from states that consider they are full and strong supporters of the NPT and fully comply with their safeguards agreement obligations. They would not be averse to getting public credit by being mentioned explicitly by the agency. The second is the number of recent cases of noncompliance or serious safeguards breaches, which have been reported explicitly to the Board of Governors and even publicly by derestricting documents and making them available through the agency Web site.

Starting with the November 2004 agency Board of Governors meeting, greater transparency of the agency Secretariat and board seems to have been established as standard practice. Not only were the Director General's Introductory statement to the Board, the Secretariat's report on Iran,[53] the Director General's November 29, 2005, statement to the board, and the resolution adopted on Iran[54] placed immediately on the agency Web site, also the Secretariat's report on the Republic of Korea (ROK)[55] and the Board Chairman's Conclusion[56] were made available on the Web site.[57]

With that transparency of the agency accomplished, the way would seem to be open for the Secretariat to be more transparent about all states, including states that are not special verification cases.[58] In assessing the degree of transparency that could be expected from the agency about its safeguards implementation, it should be recognized that while the agency is under a statutory obligation not to divulge state information, it is under no obligation, and indeed has only limited authority, not to disclose information on its own safeguards measures and their implementation. That type of information should be maintained confidential only when its disclosure would adversely affect the effectiveness of implementation of safeguards. Beyond this, the only statutory or agreement right or reason to maintain confidentiality is the pragmatic one of not discouraging states from cooperating and not giving states too much insight into how they are being safeguarded.

The primary document in which the agency reports to states on the safeguards results is the annual Safeguards Implementation Report (SIR). The annual safeguards statement is made public and published in the agency's Annual Report. With the introduction of the Additional Protocol, there is movement in the direction of increased reporting. Starting in 2004, the SIR Executive Summary, which presents background on the safeguards statement, has been placed on the agency Web site, and its contents have been expanded.

The naming of states in the safeguards statement and SIR is currently limited to states for which the second conclusion has been drawn, to the cases of noncompliance (Iraq and DPRK), and recently to cases reported by the director general to the Board of Governors (Libya, Iran). Safeguards results for individual states

could be reported in the SIR, and states could choose to make further information about the safeguards performed in their country public. For this to happen, the situation must evolve to where the agency is able and willing (i.e., requested by states) to make meaningful positive statements about states' compliance with safeguards obligations.

A reasonable level of transparency of the agency with respect to such states would include annual reporting about the measures applied and the results of safeguards implementation and the annual reaffirmation of the safeguards conclusions of no indications of diversion or of undeclared nuclear material and activities.

The challenge for the agency and for its member states is to extend the practice of increased reporting—not necessarily in same degree of detail, but still considerable detail—to all states. Further expansion of this transparency would be desirable in the interest of confidence building.

4. Possibilities for Further Developments in Transparency and Openness

In this section, we develop the idea raised in Section 3.1 that states might enhance transparency by offering greater openness to the agency than required by their safeguards agreement, suggesting specific actions that states might take. Then we briefly explore the possibility of moving toward formalizing transparency measures taken by states.

4.1 Possibilities for States with Different Types of Safeguards Agreements

For all states, a possibility would be to follow up the recent call by the agency director general for greater openness in the light of the nuclear black market of A. Q. Khan, by providing information to the agency on sensitive technology transfers to other states.[59] The following further transparency might be offered:

- Provide information to the agency on inquiries about purchasing specialized equipment or non-nuclear materials, export requests, exports and denials for export of nuclear equipment and technology. (States with Additional Protocols are required to report exports, but not requests and denials. For members of the Nuclear Suppliers Group, coordinated arrangements might be adopted.); and
- Provide information to the agency about illicit transfer by their nationals of sensitive nuclear technology to the extent and as promptly as possible under applicable law.

For NPT states with a comprehensive safeguards agreement and additional protocol, the following further openness to the agency and transparency might be offered

- Make public the measures employed under the safeguards agreement by the agency in the state and the results of those activities
- Provide information to the agency and assist agency investigations about possible undeclared nuclear activities in other states, particularly regarding specialized equipment or non-nuclear materials
- Accept other transparency measures if requested by the agency.

For states with a comprehensive safeguards agreement without an Additional Protocol in force, the agency has the same right and obligation to apply its safeguards to all nuclear material in all peaceful nuclear activities as in states that have adopted an Additional Protocol. It has in some respects less explicit authority to undertake safeguards measures designed to contribute to drawing a safeguards conclusion on the absence of undeclared nuclear material and activities. Therefore, in such states there is considerable scope for openness to the agency and enhanced transparency. In addition to putting an Additional Protocol in force, it is suggested that the following actions by such states might be adopted:

- If the state has signed an Additional Protocol, act as if it were in force pending its formal ratification, or participate fully in the Voluntary Reporting Scheme
- Provide the agency with a declaration of the state's nuclear activities beyond those covered by the comprehensive safeguards agreement
- Provide information and access to locations, provided for in the Additional Protocol to the extent that these are additional to those explicitly provided for in comprehensive safeguards agreements
- Permit the collection of environmental and other samples away from nuclear sites, in accordance with the provisions in the Additional Protocol
- Provide information to the agency on joint activities with other non-nuclear-weapon states such as research and development activities, uranium mining, and equipment and materials manufacturing
- Provide the agency to the extent feasible in light of security restrictions information about possible undeclared nuclear activities in other states and assist the agency in its investigations of such activities, particularly regarding exports to such states of the equipment or non-nuclear materials listed in Annexes 1 and 2 of the Model Additional Protocol

The above list deliberately does not include confidence-building measures involving modifying nuclear activities of a state. Such confidence-building measures currently under discussion include freezing sensitive nuclear development activities, such as an enrichment program, and participating in a multilateral nuclear arrangement (MNA) to obtain enrichment, spent fuel and high-level waste services. These measures are not considered to be transparency or openness.[60]

For the voluntary offers, there is scope for transparency by nuclear weapon states in the following areas:

- Reporting by nuclear weapon states of transfers of nuclear material to or from non-nuclear weapon states is important for supporting the agency's conclusions on the absence of

diversion of declared nuclear material in the non-nuclear weapon states. Therefore, full and timely reporting by nuclear weapon states to the agency on transfers of nuclear material to or from non-nuclear weapon states should be ensured

- Provide to the agency the information included in the Voluntary Reporting Scheme if included under the applicable Additional Protocol, in particular information on joint activities with non-nuclear-weapon states such as research and development activities, uranium mining, and equipment and materials manufacturing
- Provide to the agency any releasable information that can contribute to the identification of undeclared nuclear activities in a non-nuclear weapons state (NNWS) or otherwise help the agency with the job of resolving questions about the compliance of a non-nuclear weapons state.

For states with INFCIRC/66-type safeguards agreements, there is scope for openness to the agency and transparency with respect to activities in the state involving transfers of nuclear material, equipment or technology to other states. In addition to concluding an additional protocol, as foreseen in the Foreword to INFCIRC/540, it is suggested that the following actions by such states might be adopted:

- Participate in the Voluntary Reporting Scheme, in order to shed light upon the nuclear fuel cycles of other states, including providing to the agency information about the export of nuclear equipment and technology
- Provide information to the agency on joint activities with non-nuclear weapons states such as research and development activities, uranium mining, and equipment and materials manufacturing
- Provide the agency with information and assist agency investigations about possible undeclared nuclear activities in other states, particularly regarding specialized equipment, nuclear and non-nuclear materials
- Accept transparency measures beyond what is already subject to safeguards in the state, when requested by the agency, including transparency visits with environmental sampling and access to personnel.[61]

4.2 Towards International Norms of Transparency?

Further ideas for utilizing transparency in international safeguards and nonproliferation have been mentioned several times. In Blix's 1992 statement discussed in Section 1, he refers to "a regime of openness and transparency."[62] An unpublished paper written as part of the INMM consideration of transparency in 1994 contained the suggestion, "Greater efforts to encourage all nations to accept certain standards of openness against which their performance could be judged might not only improve transparency and enhance existing safeguards, but could also produce more efficient use of existing resources at the same time." In June 2004, ElBaradei proposed that limitations be placed on the production of new nuclear material through reprocessing and enrichment, possibly by agreeing to restrict these operations to being exclusively under multinational controls. He noted that these limitations, undertaken as confidence-building measures, would need to be accompanied by proper rules of transparency.[63]

In other arms control areas, transparency regimes or transparency measures have been negotiated between the parties. Despite the general interest and enthusiasm in the early 1990s, little has developed in the multilateral domain.[64] Would international norms for transparency further strengthen the nonproliferation regime?

A regime of transparency between states and involving the agency, within the framework of multilateral, bilateral, and unilateral measures of the nonproliferation regime, would need agreed international norms. The negotiation of norms for transparency between the states and the agency can be expected to be complex. The agency statute provision for access at all times to all places and the openness requirements contained in safeguards agreements and additional protocols establish a base-line norm. Internationally accepted definitions would need to be developed for transparency goals and measures. This might be done by the agency and SAGSI developing recommendations for review by the Board of Governors' Committee on Safeguards and Verification.

5. Conclusions and Recommendations

Conclusions

- Transparency in international safeguards and nonproliferation can be defined as: "the condition in which a state's nuclear programs, activities, facilities, capabilities, and intentions are known to other members of the international community, through explicit policies and actions of the state, by reason of its general climate and culture of openness, and by independent information available on the state."
- A determination of transparency results from an assessment by others and thus is a perceived *virtue* of an organization, government or state. A government or state cannot achieve transparency simply by proclaiming it.
- The agency assesses transparency in gaining the confidence to draw safeguards conclusions about a state. The agency's assessment of transparency involves, *inter alia,* how the state complies with its safeguards obligations, how it cooperates with the agency, and whether information from all sources is consistent with the declarations by the state.
- States make a broader assessment of transparency as part of how they gain confidence that another state is meeting its obligations under the nonproliferation regime. A state's assessment of transparency may consider information it obtains independently, reports by the agency, open sources of information about the state, and confidence-building measures undertaken by the state, among others.

- A simple explanation of *transparency* and *openness* in international safeguards is that transparency means the availability of *information* on a state that allows others to see more clearly what the state's activities and capabilities are, while openness means the provision by a state to the agency of information and access. Transparency should be considered the primary term, which can include openness. Openness should be used only with reference to information and access provided by a state to the agency.
- The agency is required by its statute and safeguards agreements to maintain the confidentiality of information received in confidence from member states. States may provide information of safeguards relevance to the agency that goes beyond that which the state is prepared to place in the public domain. Giving the agency access to such information should be encouraged, provided that it is made clear that it is preferable that states allow information relevant to its nuclear activities that is not sensitive for nonproliferation or proprietary reasons to be made public.
- The agency may receive, and should make use of, information provided by states on the nuclear activities of other states. In making use of such information, the agency should take all means within its capabilities to independently assess the validity of the information, but it cannot dismiss information provided by responsible sources solely on the basis of its confidential character.
- There can be no assurance that information obtained under the rubric of transparency is complete and accurate. On the contrary, its assessment and use as an aid to the drawing of safeguards conclusions either by the agency or other states must take into account the fact that all modern states maintain elaborate systems to protect information which they deem to be important to their national security and cannot be expected to disclose, in the interest of transparency, information which they wish to conceal.
- Requests for access to locations not explicitly subject to ad hoc or routine inspections under comprehensive safeguards agreements or to complementary access to declared locations under the Additional Protocol to such agreements, referred to in this report as "transparency visits," may, if acceded to by the state, contribute to the ability of the agency and other states to understand and thus have more confidence in the purpose and nature of the state's nuclear activities. In requesting such visits, however, the agency must use care not to undermine its rights of access to the locations in question under its special inspection or complementary access authorities, which provide for very broad access as needed to verify compliance with safeguards obligations.
- Calling for transparency is not a substitute for and should not be allowed to undermine demands for full compliance with the explicit obligations of safeguards agreements.
- Confidence-building measures, which may include voluntary actions by a state and additional openness of the state to the agency, are welcome and potentially important when a restoration of confidence is necessary. Confidence-building measures include actions by a state that go beyond the obligations of safeguards and nonproliferation agreements, such as refraining from particular nuclear fuel cycle activities that, while permissible if undertaken for peaceful purposes, can help contribute to confidence on the part of other states in the peaceful character of a state's nuclear programs.
- But care must be taken with confidence-building measures, first that calling for them does not lead to confusion between what is obligatory and what is voluntary. Actions that a state is already obligated to take under its safeguards and nonproliferation agreements, such as providing access that has been denied, should not be viewed as confidence-building measures. In addition, while confidence-building measures can contribute to confidence as to the absence of additional, undeclared activities, they cannot provide assurance on their absence.
- In order to make the agency's safeguards findings of maximum usefulness to member states, the agency should inform states in considerable detail of the measures that the agency has implemented in arriving at its findings. The provision of such information by the agency is of particular importance in respect to making judgments as to the absence of undeclared activities, since statements that no evidence was found of undeclared activities can be made even if no measures to determine their presence were undertaken. The agency has no statutory obligation to maintain the confidentiality of its own safeguards activities, although it has a limited right to do so when required to ensure the effectiveness of its safeguards implementation.
- Transparency, openness, cooperation, and confidence-building measures are of particular relevance and importance for a state whose compliance with its safeguards obligations has come into question. States with all types of safeguards agreements with the agency can undertake openness actions in order to assist the agency, build transparency, and enhance international confidence.

Recommendations

It is recommended that the following areas related to the use of transparency and openness in international safeguards be evaluated further, within the framework of or in coordination with the agency.

- Expanded transparency in agency reporting in the annual SIR, as discussed in Section 3.3
- Transparency and openness measures by states with different safeguards agreements, as discussed in Section 4.1

End Notes

1. This term was used in agency Director General's introductory statement to the Board of Governors of September 19, 2005, and in the Board Resolution adopted on September 24, 2005. Both documents are available on the agency Web site.
2. In this paper the International Atomic Energy Agency will be referred to as the agency.
3. Professor Eun Cheol Lee, Seoul National University, "Nuclear Transparency Efforts of the ROK & IAEA Inspection," responded to the information by referring to the government's "nuclear transparency policy". "As a confidence-building measure for the transparency, Korea government declared four-point peaceful nuclear policy on 18 September [2004]," *TCNC Newsletter,* October 1, 2004.
4. "Egypt said to run nuclear tests with possible links to weapons," Associated Press. Vienna, January 4, 2005; Dafna Linzer, "Egyptians reportedly took part in past nuclear experiments," *Washington Post,* January 5, 2005.
5. The Khan operation has threatened the nonproliferation regime by making it easier for would-be proliferants to obtain what they want and therefore has increased the likelihood that proliferation will take place, but it has not fundamentally affected the safeguards component of the regime as defined by the NPT and safeguards agreements. Whether a state clandestinely imports materials and equipment, or clandestinely makes them itself should not fundamentally impact the need for and ability of safeguards to detect their presence.
6. Broad, William J., and David E. Sanger. 2004. As Nuclear Secrets Emerge, More Are Suspected, *The New York Times,* December 26, 2004.
7. In the nonproliferation sphere, North Korea continues to be an important case.
8. It is important, however, that actions requested of a state that do not go beyond the legal obligations of its safeguards agreement should be characterized as compliance, and not transparency, issues.
9. This citation can still be found on the agency's Web site, www.iaea.org.
10. IAEA. 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, INFCIRC/153 (Corrected).
11. IAEA. 1997. Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards, INFCIRC/540 (Corrected)
12. Material in this section is based on the recollections of one of the authors (JAL), who worked with SAGSI during this period, and on limited distribution documents.
13. The Standing Advisory Group on Safeguards Implementation, reporting to the agency Director General.
14. An example was Jeffrey Sachs, head of the UN Millennium Development Project, calling for transparency and codes of conduct in a presentation on his book, *The End of Poverty,* at the World Bank on March 22, 2005.
15. An example is found in Paul Wolfowitz's farewell statement as ambassador to Indonesia in May 1989: "If greater openness is a key to economic success, I believe there is increasingly a need for openness in the political sphere as well," quoted in article by Alan Sipress and Ellen Nakashima, "Jakarta Tenure Offers Glimpse of Wolfowitz," *Washington Post,* March 28, 2005
16. Arms Control Association. 2003. The START III Framework at a Glance, Fact Sheets.
17. The claim for transparency would be more realistically stated as "lowering unpredictability, as a contribution toward clarifying national intentions," rather than achieving predictability.
18. A state that has a free and inquisitive press and is widely involved in international interactions would be assessed more positively than a state that does not have those characteristics.
19. For example, in IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Report by the Director General, IAEA Report GOV/2004/83 (November 15, 2004) [Derestricted November 29, 2004], paragraphs 87, 90, 96, 112.
20. Kratzer, Myron B. 2002. Integrated Safeguards: What's in a Name, *Proceedings of the 43rd INMM Annual Meeting.*
21. It has been reported that there is reluctance to give information because the agency is prone to leaks. Without confidence that confidentiality will be maintained, states will not be fully open to the agency.
22. INFCIRC/153 permits access anywhere and everywhere as required to verify compliance. In February 1992 the Board of Governors reaffirmed states' obligations to place all activities under safeguards and the agency's right of access, under special inspections, to any location in a state needed to verify compliance with this obligation.
23. For example, a state in which uranium mining takes place might (a) facilitate the availability of information on uranium production, that serves to cross-reference and aid in substantiating reporting provided to the agency, such as company reports and taxation/royalty reports, and (b) draw the agency's attention to these sources of information.
24. INFCIRC/153, paragraph 3. See Note 10.
25. IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Report by the Director General, IAEA Report GOV/2004/83 (November 15, 2004) [Derestricted 29 Nov 2004], paragraph 2, fifth bullet.

26. The terms transparency and openness have been used frequently in recent agency documents. Several uses are referenced in this article. Transparency is often qualified, most frequently as "full transparency." In agency board documents on Iran and Libya in 2003 both transparency and openness have been used, not always together.
27. Ramberg, Bennett. 2005. A way to break the nuclear impasse: Dealing with Iran II, *International Herald Tribune,* March 24, 2005.
28. Reuters. 2005. Reporters Shown Underground Iran Nuclear Plant, March 30, 2005.
29. Deputy State Department Spokesman Adam Ereli, presenting the views of the United States government in a *Voice of America* News Editorial, April 13, 2005, Iran's Nuclear Program: "If Iran were really serious about demonstrating transparency in its nuclear program, it should answer all of the [agency's] outstanding questions. If Iran were really serious about allaying the concerns of the international community, they would stop denying [the agency] full and unrestricted access to suspicious sites like the Parchin high-explosive facility. They would stop refusing [agency] requests to interview key officials associated with Iran's nuclear activities. They would tell the truth about the history of their advanced P-2 centrifuge program. They would tell the truth about their Lavizan facility before they bulldozed it to the ground. They would answer openly questions about past plutonium-separation experiments."
30. Foreign Ministry Spokesman Hamid Reza was quoted by the official IRNA news agency as saying: "Our nuclear activities are transparent and under the supervision of the IAEA." Iran Denies Smuggling Uranium from Monitored Site, Reuters, April 13, 2005.
31. Ritter, Scott. 2005. Sleepwalking to Disaster in Iran, *Aljazeera,* March 30, 2005.
32. The decision on the non-compliance of DPRK was taken without knowing the amount of plutonium diverted or discovering weaponization activities.
33. IAEA, Director General, Introductory Statement to Board of Governors, September 13, 2004.
34. IAEA, Director General, Introductory Statement to Board of Governors, November 25, 2004. He used the term again in his introductory statement to Board of Governors, September 19, 2005.
35. Confidence-building measures are particularly relevant when the parties involved, usually but not necessarily a two-state pair, have no binding legal obligations with respect to each other in a specific area of mutual interest. That is a different situation than in the nonproliferation and safeguards area.
36. IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Resolution adopted by the Board on November 29, 2004, IAEA Report GOV/2004/90 The phrase *confidence-building measure* appears four times, once qualified as *voluntary* and once as *voluntary, non-legally binding.*
37. IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Resolution adopted by Board on February 4, 2006, IAEA Report GOV/2006/14 (Derestricted February 4, 2006).
38. Hori, Keiichiro. 2006. Transparency of Peaceful Use of Nuclear Energy in East Asia, *Proceedings of the 47th Annual INMM Meeting.*
39. IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Report by the Director General, IAEA Report GOV/2004/83 (15 November 2004) [Derestricted November 29, 2004], *Transparency visit* is used in the title of Section B.2. An expanded form (in paragraph 96) is: "transparency visit in the interest of confidence building." Further requests for transparency visits have not occurred in agency documents during 2005-2006.
40. Examples of such visits are those made by Director General Blix at the invitation of North Korea to see the reprocessing research facility before a formal inspection visit, and invitations to the Director General to visit Iran, carried out by Deputy Directors General for Safeguards.
41. Board involvement would be required to decide that a special inspection is "essential and urgent" under INFCIRC/153 paragraph 18, as a matter of interpretation under INFCIRC/153 paragraph 21, or under the dispute resolution procedure under INFCIRC/153 paragraph 22. In the arrangements for a transparency visit, the modalities of the visit are established. This includes which personnel will perform the visit (e.g., the inclusion of specialists by the agency), whether managed access will be used at the request of the state, which facility/location staff and records are to be made available, which measures are to be performed and which equipment is to be used.
42. *The Tehran Times* reported on October 12, 2004, that Pierre Goldschmidt, then Deputy Director General for Safeguards, IAEA, referring to an agency request to visit a site, said, "We think it's good for Iran to show transparency so that everyone can be confident that there is no nuclear activity taking place at [the Parchin military] site."
43. An example of such reporting was "Under its mandate, the agency can inspect a site if it has indications that nuclear materials are present, and it needs to be able to offer proof if challenged," Carla Anne Robbins, "As Evidence Grows of Iran's Program, U.S. Hits Quandary," *Wall Street Journal,* March 18, 2005.
44. David Sanger, *The New York Times,* January 5, 2005.

45. The negotiating history of INFCIRC/153 directly ties the special inspection provisions to the agency statutory access provision. The authority under INFCIRC/153 is extremely broad and clearly extends to any place that the agency can make any connection with nuclear material.
46. The one questionable area is to a location, e.g., a military facility, where the agency makes no contention that it has information pointing to a nexus with nuclear material, but only information relating to possible intended future use of such material. If the state refuses an agency request, the inspection must be authorized either through arbitration or a Board determination that it is essential and urgent.
47. That is the explicit meaning of paragraph 18 of INFCIRC/153. If the board determines that an action by the state is "essential and urgent," the state must do it.
48. At the time of writing, sixty-three states have comprehensive safeguards agreements and eighty-seven states have SQPs.
49. IAEA, GOV/2629 (1993).
50. The list of specified equipment and non-nuclear material in the Voluntary Reporting Scheme is incorporated in Annex II of INFCIRC/540.
51. Although reporting of equipment imports might allow a cross check between export and import information, the difficulty in extracting import data from customs databases or from importers would likely result in missed reporting of imported items and thus inconsistencies.
52. In the past, there have been calls for the Director General to regularly state to the board that "there was no evidence of noncompliance with any safeguards agreement, except in the cases of X and Y."
53. IAEA, Director General's introductory statement to the Board, November 2004.
54. IAEA, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran, Resolution adopted by the Board on November 29, 2004, IAEA Report GOV/2004/90.
55. IAEA, Implementation of the NPT Safeguards Agreement in the Republic of Korea, Report by the Director General, IAEA Report GOV/2004/84 (11 November 2004).
56. IAEA, Chairman's conclusion on Item 4(c), Nuclear Verification, Implementation of the NPT safeguards agreement in the Republic of Korea, November 26, 2004.
57. Reports on the agency Web site now include: on Iran, Director General's reports to the agency Board of Governors, his introductory statements to boards, and Board Resolutions from June 2003 through March 2006; on Libya, reports dated September 18, 2004, and February 20, 2004; on Iraq, reports and statements to the UN Security Council from January 2003 through October 2004.
58. See note 1.
59. In 2004 the agency set up a covert nuclear trade analysis unit looking at covert procurement activities.
60. However, transparency may play a different role in such arrangements. Mohamed ElBaradei in an article for a UN review, as reported on October 29, 2004, by Agence France Press, called for placing "transparent limits" on processing of plutonium and weapon grade uranium as part of his call for a tougher, broader application of the NPT. ElBaradei, in a speech at Carnegie International Nonproliferation Conference, June 21, 2004, spoke of the need for proper rules of transparency in the context of proposed limitations on enrichment and reprocessing. ElBaradei convened an Expert Group on Multilateral Approaches to the Fuel Cycle in 2004; it presented its report in March 2005.
61. Reuters. 2005. Pakistan Considering Sending Nuclear Parts to IAEA, Reuters, Islamabad, March 25, 2005: "Pakistan's refusal to allow IAEA experts to take environmental samples inside the country has prevented the IAEA from verifying Iran's explanation."
62. Perhaps Blix was intentionally alluding to the recognition by the international community in those years of the importance of providing a greater degree of openness and transparency in the broad arms control and disarmament field. Evidence of this can be found in treaties and other measures agreed at the level of the United Nations and in several regional contexts. Of particular importance is the Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and Their Destruction (CWC). For reasons that are not clear, this trend halted following the conclusion of the CTBT in 1996 and the adoption of the Additional Protocol in 1997.
63. Mohamed ElBaradei, Speech at Carnegie International Non-Proliferation Conference, June 21, 2004
64. Walker, William. 2003. Some Reflections on Transparency in the Contemporary Security Environment, *Disarmament Forum,* no. 2, 55–60.

U.S. and Russia Sign Liability Protocol

In September 2006, the United States and Russia signed a liability agreement that clears a legal hurdle for an important nonproliferation program administered by the U.S. Department of Energy's National Nuclear Security Administration (NNSA). The United States and Russia successfully completed negotiations of the plutonium disposition program in 2005, and the Russian government recently completed its formal process approving it for signature.

The plutonium disposition program aims to eliminate a total of sixty-eight metric tons (about 150,000 pounds) of surplus weapons-grade plutonium in the United States and in Russia, and stems from a 2000 nonproliferation agreement between the two countries. Both countries will dispose of their plutonium by converting it to mixed oxide (MOX) fuel for use in nuclear reactors. Once the MOX fuel is irradiated, the plutonium has been converted into a form that cannot be used for nuclear weapons.

NNSA is nearing completion of site preparation activities for construction of a mixed oxide fuel fabrication facility at the Savannah River Site in Aiken, South Carolina. The agency is awaiting completion of the appropriations act for fiscal year 2007 before proceeding with construction.

International Partners Initial ITER Agreement

The United States, China, the European Union, India, Japan, the Republic of Korea, and the Russian Federation completed an initial agreement to construct ITER, an international fusion energy project. In FY 2006, the U.S. Department of Energy (DOE) allocated $25 million to ITER and President George W. Bush has requested $60 million for the project in FY 2007. The United States was one of the original participants in the early design and R&D for ITER.

As the host, Europe will contribute 45.4 percent of the construction cost, with the six other partners, including the United States, will each provide 9.1 percent. DOE laboratories will subcontract with industry to build the components of ITER for which the United States is responsible. The U.S. total contribution to the construction of ITER will be $1.1 billion.

By initialing the ITER agreement, the international partners agree to formally conclude negotiations and submit the agreement to their governments for final approval.

DOE's National Laboratory Directors Highlight Scientific Merits of GNEP

Directors of nine of the U.S. Department of Energy's (DOE) national laboratories in May announced their support for the Global Nuclear Energy Partnership (GNEP) and discussed the collaboration among the labs in carrying out the partnership. GNEP will support advanced technologies to recycle spent nuclear fuel and promote emissions-free nuclear energy in a more proliferation-resistant manner. President Bush has requested $250 million in fiscal year (FY) 2007 for GNEP.

The GNEP Technology Demonstration Program is based on a five-year technology plan, which is currently being developed in consultation with scientists from DOE's national labs. This detailed roadmap for GNEP technology development and demonstration process is focused on technologies that will:

- Separate the high-energy elements of spent nuclear fuel that can be recycled.
- Develop "fast burner" reactors that can convert these high-energy elements into electricity and shorter-lived isotopes, dramatically reducing the volume and toxicity of the waste.
- Integrate modern nuclear materials management concepts into each step of the fuel cycle to increase safeguards confidence.
- Close the nuclear fuel cycle through research and technologies for recycling fuel and fabricating fuel suitable for recycling.

For more information on GNEP, visit http://www.gnep.energy.gov/.

Radioactive Sources Recovered in Georgia

Two abandoned and potentially dangerous radioactive devices were successfully secured in July 2006 during the first three days of an effort to trace lost radioactive sources in Georgia. Such abandoned sources are known as orphan sources.

A Georgian Ministry of Environment and IAEA team, scouring the isolated alpine region of Racha, found a powerful source in a pile of dirt on the floor of a derelict factory. The team also found a second smaller source inside a house—in a tin of nuts and bolts above a work bench. Just a thin, wooden wall separated the source from the family bedroom.

In the village of Iri, where the first source was located, background radiation levels were elevated twelve times above normal in the village centre. In the second village, Likhaura, residents requested investigators to check their houses for possible sources after the discovery.

The radioisotope in both sources was Cesium 137, a powerful gamma emitter, among the most common radioactive isotope in industrial use for instrumentation to check materials for flaws and for industrial measurements. New, powerful, backpack-mounted instrumentation with which the search team was equipped helped reveal and locate both sources.

Because records are not available, search team leaders said they had no clear knowledge of the origin of the sources. The first source may have been overlooked when the factory was abandoned; the second was presumably picked up and taken to the house where it was found. Both would originally have been contained in shielded containers.

As many as 300 radioactive sources have been recovered in Georgia since the mid 1990s and there has been at least one death and many injuries to the public as a consequence.

A legacy of Georgia's sharp economic decline after the break-up of the Soviet Union was a loss of control of radioactive sources used in industry. The collection and sale of scrap metal from abandoned

factories has also provided a means of livelihood and some orphan sources have been found in shipments of scrap. Many orphan sources have also been found on former military bases.

Bombs Grade Spent Nuclear Material Removed From Uzbekistan

Spent nuclear fuel containing enough uranium to produce 2.5 nuclear weapons has been safely returned to Russia from Uzbekistan in a classified mission completed in April 2006. It is the first time that fuel used in a nuclear research reactor has been repatriated to Russia since the break-up of the Soviet Union.

Under tight security, sixty-three kilograms of spent highly enriched uranium (HEU) was transported to Mayak in Russia, in four separate shipments. IAEA safeguards inspectors monitored and verified the packing of the fuel for transport over the course of sixteen days.

The secret operation, six years in the planning, was a joint undertaking of the IAEA, the United States, Uzbekistan, Russia, and Kazakhstan as part of the Global Threat Reduction Initiative (GTRI). The aim of the GTRI is to identify, secure, and recover high-risk vulnerable nuclear and radiological materials around the world.

In Russia, the fuel will be processed so that it cannot be used for atomic bombs. Russia originally supplied the nuclear fuel to Uzbekistan for use in its ten megawatt research reactor. Located at the Institute of Nuclear Physics of Uzbekistan, thirty kilometers from Tashkent, the reactor is currently used for research and to produce isotopes for medical purposes.

The IAEA is now helping to convert the reactor to run on fuel that cannot be used to make a nuclear weapon. The agency is also developing lessons learned from this shipment to provide a basis for guidelines for future spent fuel shipments. This latest shipment follows the successful repatriation of nearly eleven kilograms of fresh highly enriched uranium from the Uzbek reactor in 2004.

Over the past three years the IAEA has supported similar operations in other countries including Libya, Romania, Serbia and Montenegro, Bulgaria, Uzbekistan, Latvia, and the Czech Republic to transfer HEU reactor fuel back to its country of origin.

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.

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  2. Jones, F. T. 1976. *Title of Book*, New York: McMillan Publishing.
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Calendar

November 12–16, 2006
Winter Meeting and Nuclear Technology Expo
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Hyatt Regency Albuquerque and Albuquerque Convention Center
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December 11–15, 2006
International Conference on LessonsLearned from Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities
Athens, Greece
Contact: International Atomic Energy Agency
Web site: www.pub.iaea.org/MTCD/Meetings/Meetings2006.asp

June 24–28, 2007
ANS Annual Meeting
"It's All About the People: The Future of Nuclear"
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July 8–12, 2007
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PATRAM 07
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