NTI Efforts to Encourage Replacement of Cesium-137 Blood and Research Irradiators with Effective Alternative Technologies

The National Academies of Sciences
Radioactive Sources: Applications and Alternative Technologies Meeting
January 30-31, 2020

Ioanna Iliopulos
PRESENTATION OUTLINE

• Background
• Models for Action
  • International
  • US
• NTI Report - Recommendations
THE NUCLEAR THREAT INITIATIVE PROTECTS LIVES, THE ENVIRONMENT AND OUR QUALITY OF LIFE NOW AND FOR FUTURE GENERATIONS.

Every day, we work to prevent catastrophic attacks with weapons of mass destruction and disruption—nuclear, biological, radiological, chemical and cyber.
## NTI Program Focus – Advocacy for Cesium-137 Substitution

<table>
<thead>
<tr>
<th>Application</th>
<th>Isotope</th>
<th>Commercially Available Alternatives?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Irradiation</td>
<td>Cs-137</td>
<td>Yes: X-ray—2 FDA approved devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial: UV Pathogen Reduction—FDA approval for platelet &amp; plasma systems, ongoing R&amp;D for red blood cell systems</td>
</tr>
<tr>
<td>Research</td>
<td>Cs-137</td>
<td>Partial: X-ray Irradiators for most research</td>
</tr>
<tr>
<td>Irradiation</td>
<td>Co-60</td>
<td>Partial: X-ray Irradiators for most research applications</td>
</tr>
<tr>
<td>External Beam Radiotherapy</td>
<td>Co-60</td>
<td>Yes: Linear Accelerators (LINACs)</td>
</tr>
<tr>
<td>Industrial Sterilization</td>
<td>Co-60</td>
<td>Yes: X-Ray, E-beam, LINACs</td>
</tr>
<tr>
<td>Radiography</td>
<td>Ir-192</td>
<td>Yes: X-ray</td>
</tr>
</tbody>
</table>

“The Committee recommends that the U.S. government take steps in the near term to replace radioactive cesium chloride radiation sources, a potential “dirty bomb” ingredient used in some medical and research equipment, with lower risk alternatives.”
International Models for Action: A Range of Approaches

- Norway
- Japan
- France

“...In order for us to construct and detonate a radiological bomb, we must acquire radioactive material by stealing it or buying it through legal or illegal channels. Possible RDD material could come from millions of radioactive sources used worldwide...”

- from the terrorist manifesto
• Pool Re and NTI hosted a joint conference in London (April 2017)
• Pool Re currently underwrites more than £2 trillion of exposure in commercial property to terrorism risk across the UK mainland – including chemical, biological, radiological and nuclear (CBRN).
• Awareness raising led to U.K.‘s internal discussions (via Home Office) to evaluate replacing all cesium-137 irradiators.
METHODOLOGY

**National Measures:** National measures in place to manage and secure radioactive sources.

**Global Norms:** A country’s international commitments and support for global norms around radioactive source sources.

**Alternative Technologies:** The country’s capacity for introducing alternative technologies.

**Risk Environment:** The risk environment and its potential effect on the security of radioactive sources.
Assessment of national policies, commitments, and actions governing radioactive sources to:

• Build awareness of importance of radiological security
• Catalyze a dialogue about priorities
• Promote progress in securing radioactive sources and promoting alternative technologies
• Highlight leading practices in radiological security
• Set baseline understanding of global radiological architecture
• Promote reporting, information sharing, and benchmarking
Preventing a Dirty Bomb: Case Studies and Lessons Learned

BY IOANNA ILIOPULOS AND CHRISTOPHER BOYD
WITH FOREWORD BY LAURA S.H. HOLGATE

US Models for Action
Report: Preventing a Dirty Bomb: Case Studies and Lessons Learned

Major Urban City - NYC
State-Wide University - UC
Medical Institution – Emory University

NTI
BUILDING A SAFER WORLD

Emory University
1. Identify Local Advocates and Build Support Networks

Who has the authority to make the decision?

- Federal Government/National Policy
- State and City Stakeholders
  - Governor offices, Health Commissioner’s office, Mayor’s Office, Dept of Health, LLEA’s
- Regulators
  - NRC, State Regulators, Congress (via Legislative Action)
- Operational Decision Makers
  - Medical and Research Senior Leadership (CEO/COOs)
- End Users
  - Researchers, Blood Bank Operators

Environmental Health & Safety, Security, Radiation Safety, and Risk Managers
2. Seek Consensus Among Stakeholders

- Management
- Administrators
- Researchers
- Faculty
- Medical professionals
3. Identify Funding and Support at the Institutional and Federal Level

- Commitments to implement a successful transition required securing funding at the institutional and federal levels.

- KEY INCENTIVE for facilities to participate.
4. Compare Cradle to Grave Costs

**COST AND LIABILITY ESTIMATES**

Learn about irradiator lifecycle costs and liability, and estimate the lifecycle costs of your irradiator using our worksheet.

**Irradiator Replacement Costs Estimate Worksheet Template**

<table>
<thead>
<tr>
<th></th>
<th>Cesium-137 Irradiator</th>
<th>X-Ray Irradiator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Purchase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Licensing and Registration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Facility Modifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Regulatory Compliance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Termination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Costs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Regulatory Compliance (Security Program)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Operating Cost (Utilities)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Maintenance Cost (Service Contracts)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Training Cost for Operators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Physical Security Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Insurance Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Costs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sum of Annual Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sum of Annual Cost Multiplied by Lifespan</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FULL LIFECYCLE COSTS OF OWNING AND OPERATING THE DEVICE</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Communicate Benefits of Cesium-137 Irradiator Replacements

- Protection of Public Health, Safety and Security
- Elimination of Terrorism Risk and Potential Liability
- Elimination of Costly Physical Protection and Procedural Requirements (10 CFR, Part 37) and Vulnerabilities
- Elimination of Costly Disposition (GTCC) at End-of-Life
- Elimination of Source Decay and Performance
- Enhanced Capabilities from X-ray Alternatives (Automated Dosimetry and Imaging)
6. Improve the Dissemination of Information

- Educate stakeholders
- Peer-to-peer outreach
- Comparative Studies
- NTI website: www.nti.org/cesium137
# Overcoming Technical Challenges

<table>
<thead>
<tr>
<th>Relative Biological Effectiveness (RBE)</th>
<th>X-ray</th>
<th>Cesium-137</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>There is a wide variation in RBE values in the literature for x-rays as compared with cesium-137. X-rays are more effective than cesium-137 gamma rays, suggesting that lower doses will be required to achieve the same biological endpoint.</td>
<td>There are fewer variations in the RBE values in literature for cesium-137.</td>
</tr>
</tbody>
</table>

| Machine-to-Machine Variation | X-ray irradiators produce different energies and spectra due to variations in x-ray tubes, energy settings, and filtration. While this allows for greater precision in calibration, it also requires more detailed reporting when comparing results from different x-ray machines. | With the single gamma-ray energy, cesium-137 devices yield less variation than x-ray machines. |

| Effectiveness | X-ray is generally better than cesium-137 for collimation, e.g., for partial body exposures, since it is easy to precisely collimate the x-ray point source with thin sheets of lead. X-ray offers advanced features and imaging that may be needed for some experiments. | Cesium-137 requires thicker collimation and casts a broad penumbra from the extended line source. |

| Conversion Factors | Each experiment needs to be individually calibrated when converting from cesium-137 irradiators to x-ray irradiators. Conversion factors depend on multiple inputs, including x-ray peak energy, x-ray energy spectrum (filtration), distance of the specimen from the source, field size, and biological system, among others. | Cesium-137 irradiator outputs (energy, dose distributions) are less variable than those of x-rays. |
7. Encourage Regulatory Changes for Cesium-137 Users to Accelerate and Standardize Permanent Risk Reduction

- Set Deadlines for Phasing out Cs-137 use
- Require Financial Assurances
- Require License Conditions (Justification Clause)
- Encourage National Policies that Support Risk Elimination

Cs-137 elimination
We Don’t Do This Alone

- Federal (e.g., DOE Office of Radiological Security, NAS, GAO, DOS, DHS, NRC)
- State and local champions
- Public-private partnerships (universities and hospitals)
- Insurance industry (Pool Re)
- Other governments
- IAEA
Contact Information
Laura Holgate, Vice President
Jessica Bufford, Program Officer
Ioanna Iliopulos, Senior Consultant

Materials Risk Management
Nuclear Threat Initiative
1776 Eye Street NW, Suite 600
Washington, DC 20006
Tel: +1 (202) 454-7741

www.nti.org/about/radiological/
https://www.nti.org/analysis/reports/preventing.dirty.bomb.case.studies.and.lessons.learned/

Follow:
@NTI_WMD

Thank you!