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Technical note

# Irradiation applications for homeland security

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**Abstract**

In October 2001, first-class mail laced with anthrax was sent to political and media targets resulting in several deaths, illnesses, significant mail-service disruption, and economic loss. The White House Office of Science and Technology Policy established a technical task force on mail decontamination that included three key agencies: National Institute of Standards and Technology with responsibility for radiation dosimetry and coordinating and performing experiments at industrial accelerator facilities; the Armed Forces Radiobiology Research Institute with responsibility for radiobiology; and the US Postal Service with responsibility for radiation-processing quality assurance and quality control. An overview of the anthrax attack decontamination events will be presented as well as expectations for growth in this area and the prospects of other homeland security areas where irradiation technology can be applied.


*Keywords:* Anthrax; Dosimetry; Homeland security; Irradiation; Luggage; Mail



## 1. Introduction

The tragic events of September 11, 2001 revealed that the average American was enjoying a false sense of security. On that day the porous, fragile nature of our shield against those who threaten the United States was frightfully obvious to all. Most unsettling was the uncertainty surrounding what would happen next. Those who experience an earthquake also experience the uncertainty of wondering if they had survived the worst, or just the prelude to a more devastating event to follow.

Unlike the events in New York, the evening news items that would soon be linked together as a coordinated anthrax attack trickled in slowly. When the association was clear, it was also obvious that the United States was firmly on a course it had never had to navigate before. Within the Federal government, the anthrax attacks unleashed a flurry of activity aimed simultaneously at remediation of the exposed areas and searching for prevention/mitigation methods to halt any further attacks. Government agencies were scrambling for information that was needed to address the current emergency as well as for guidance in formulating long-term policy changes. Many realized that ionizing radiation was well suited to eradicate the anthrax dispersed in the nation's postal system. The Ionizing Radiation Division (IRD) of the National Institute of Standards and Technology (NIST) was uniquely positioned to bridge the gap between industry and government. As a Department of Commerce agency, NIST's mission to promote and develop measurements, standards and technology enables it to have a close working relationship with their industry stakeholders. In this role, the IRD offered to guide other Federal agencies to the irradiation technology best suited to its needs. The IRD's established trust and credibility with the private sector would also aid in the coordination of the people and facilities required to sanitize the mail in rapid fashion.

## 2. Mail sanitation

NIST quickly ascended to a leadership role in a rapid succession of meetings organized by the President's Office of Science and Technology Policy (OSTP) and the

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US Postal Service (USPS). Several NIST staff were assembled to brief a broad range of Federal agencies. NIST's intimate knowledge of the irradiation industry led to invaluable guidance in assessing a safe and cost effective course of action. Since the IRD operates a calibration service that routinely certifies industrial irradiation facilities, it was able to attest that they were fully capable of sanitizing the mail with the highest level of quality possible. Moreover, NIST was also able to identify those in industry with the highest technical competence to eradicate the anthrax safely a high degree of confidence.

Once the sanitation process had started in late October 2001, NIST recommended that a series of test mail letter boxes be prepared to validate the protocol. As the USPS and the OSTP Director requested that time was of the essence, NIST dosimetry experts partnered with spore biologists from the Armed Forces Radiobiology Research Institute (AFRRI) the next day to design the tests. Test boxes were assembled with NIST dosimeters and AFRRI spore indicators, flown to the irradiation facility, processed and returned. After a required analysis period, exactly 1 week from presenting the initial project concept, NIST and AFRRI reported to the OSTP and USPS that the tests left no doubt that the process was safe. With these supporting data, the OSTP Director endorsed the process and suggested it continue as long as NIST actively monitored the activity (US General Accounting Office Report, 2002).

Operating in emergency mode from the onset, mail irradiation did not enjoy the normal period of planning, design and testing that would optimize the process from the perspectives of the irradiation process and product quality. To facilitate this, NIST acted as an intermediary between the processors and the packers. To achieve product consistency, NIST worked with the USPS to gather feedback on the product quality to formulate packing guidelines, and then coordinated this with industrial irradiation facilities by setting acceptance criteria for letter trays. Some of the early inconsistencies in packing coupled with conservative irradiation settings led to over-irradiated product. The chemical degradation produced undesirable physical effects with some of the more sensitive mail recipients. NIST-improved packing guidelines coupled with revised irradiation settings derived from a battery of new NIST on-site tests remedied the byproduct irritant problem. This cooperative effort between NIST, IBA and the USPS led to protocols for the processing of parcels with high-energy X-rays (from electron beam conversion). In all, several million articles of contaminated mail were sanitized and safely delivered to their destination. About this same time, a team of Federal government and industry representatives drafted a documentary standard that set requirements for validation and routine control of the decontamination process. Some Federal government mail (defined by zip code) continues to be treated with ionizing radiation. By the end of 2003, about 4000 tons of letter mail and 200 tons of parcels will have been sanitized.

## 3. Luggage irradiation

The agricultural industry has always been vulnerable to foreign pests that threaten severe economic consequences. The US Animal and Plant Health Inspection Service (APHIS) defends against this threat every day at more than 80 international airports throughout the United States. Approximately 100 million passengers carry 150 articles of luggage through these ports each year. About 30% of this luggage is categorized as high risk. Inspecting upwards of 50 million articles of luggage is a formidable task. The new threats posed by terrorism have raised the level of concern for APHIS inspectors. Since increasing the number of inspectors is unlikely due to budget constraints, APHIS is considering a technological solution to mitigate these threats.

NIST has a study in progress (funded through the US government Technical Services Working Group) to examine the technical issues and barriers to the use of irradiation to mitigate common bioterrorism agents and insects in high-risk passenger luggage. The attractive features of this solution are:

- the individual pieces of luggage do not have to be physically opened and inspected;
- bioterrorism agents that are concealed, or not easily identified by an inspector, can be treated;
- the risk of contaminating inspectors or facilities using this treatment method is very low; and,
- radiation doses can be selected to neutralize a variety of bioterrorism agents, diseases and insects.

Most concerns regarding the sensitivity luggage contents are not an issue since a large number of common items (e.g., food) are prohibited. However, care should be taken to minimize the absorbed dose to luggage and its contents as not to destroy or render them unusable. And the irradiation equipment must be capable of processing luggage at a rate that does not significantly delay passengers. The purpose of this work is to develop irradiation specifications, procedures, and protocols that will ensure that broad classes of bioterrorism agents in passenger luggage will be neutralized without damaging luggage contents and inconveniencing passengers with long delays.

This work focuses on three areas: the assembly of critical input data, the development of a coupled computational-experimental verification approach for estimating the radiation dose that can be delivered to

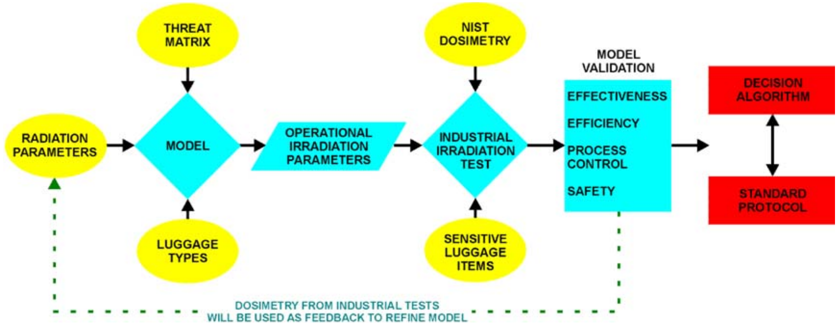


Fig. 1. Flowchart outlining the interrelationship of inputs final deliverables in the luggage irradiation project.

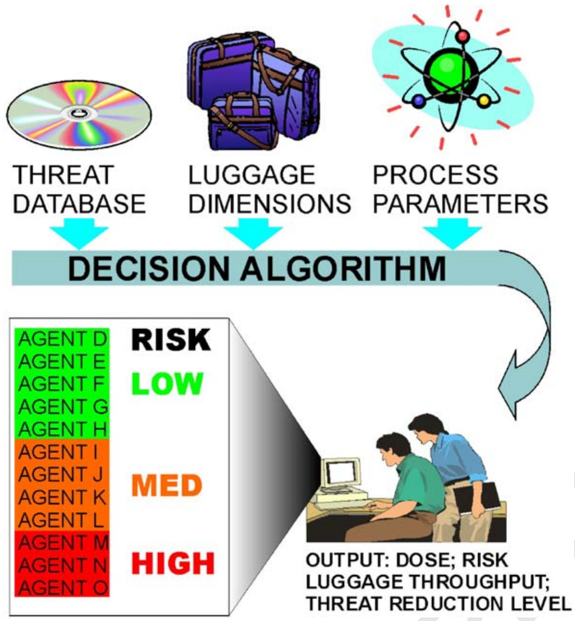


Fig. 2. An illustration of the luggage irradiation decision protocol.

passenger luggage, and the application of the computations to a larger variety of luggage configurations followed by the development of specifications, procedures, and protocols for the irradiation of passenger luggage. The flowchart in Fig. 1 shows the interrelationship of the proposed activities along with the final deliverable (specifications, procedures, protocols) that will result in the successful treatment of high-risk passenger luggage. When implemented, the selection of doses for specific threats will be determined from a decision algorithm (Fig. 2). The decision algorithm will be a dynamic utility developed from the computations and data of this work. It will allow real-time adjustments to the process that enable the operator to adapt to changing threats. The decision algorithm will operate in the following manner: operators will select desired inactivation levels from a database of possible threats (defined along with their respective $D_{10}$ values and theoretical loads), then select luggage parameters (i.e., dimensions, density, etc.) and define irradiation parameter ranges. The relative effectiveness of this selection against all agents listed in the threat database will be determined and displayed to the operator. From this output the operator can make intelligent decisions regarding risk versus throughput.

## 4. Other applications

Ship containers entering the country through several major US ports pose a significant smuggling risk. About 10 million (12–24 m long) containers enter the United States each year. Only about 2% of these are inspected. Truck sized portal monitors can be used to screen containers for radiological materials. However, a means to X-ray these containers to examine their contents that would not significantly reduce the throughput would aid security efforts. Neutron methods may offer some advantages. Some nuclear material-based weapons emit neutrons, or can be stimulated with neutrons to emit gamma photon signatures. Since US inspection agencies can set container guidelines to suit the inspection technology; all options are open to facilitate this type of inspection service.

The importation of products derived from natural sources (e.g., wicker items) has been recognized as a potential risk for the entry of foreign pests into the US agricultural system. An emerging area for the application of irradiation technology is in the treatment of fresh-cut flowers. There are approximately 62,000 shipments per year of cut flowers through US international airports each year. The traditional fumigation treatment, methylbromide, is scheduled to be phased out in 2005.

The threat of chemical and biological agent attacks on US military troops throughout the world is very real. There is a possibility that military materials or even cadavers may need to be decontaminated. Here, field deployed portable electron beam accelerators are a reasonable solution. Along these same lines, the decontamination of physical evidence should be considered; this application would apply to national and international law enforcement agencies as well.

## 5. Research opportunities

NIST provided critical dosimetry in establishing radiation-dose/agent-deactivation curves during the anthrax decontamination process. Radiation-dose/agent-deactivation curves were established for both electron and X-ray beam irradiation. NIST and AFRRI continue to collaborate to measure radiation inactivation of viral pathogens. The NIST dose measurements ensure that the dose/deactivation curves are traceable, with the highest degree of accuracy, to the national standards for radiation dosimetry. However, most of the data in the literature that cite $D_{10}$ values for pathogens are less reliable. The need for reliable data is strong.

The studies of volatile organic irritants and the degradation of paper resulting from the mail irradiation process underscores the need for radiation effects studies on common materials from a safety point of view. The National Archives, Library of Congress, and the White House records office are deeply concerned with the effect of radiation to prematurely age government documents that need to be archived for centuries. The radiation effects on certain sensitive materials such as magnetic media and their packaging material should also be examined.

Also an issue of safety is the consideration to improve irradiator throughput by raising the photon energy from 5 to 7 MeV; a risk assessment for induced activity should be undertaken.

The use of ionizing radiation to decontaminate materials questions the applicability of standard forensic tests used in law enforcement. A collaboration between the IRD and Biotechnology Division of NIST demonstrated that high doses of ionizing radiation (electrons and gammas) does not interfere with standard DNA profiling tests.

## 6. Support services

Growth in irradiation processing will spur demand for dosimetry systems and support services. A cost-effective approach to meeting the demand for services is an on-line calibration service in development at NIST (Desrosiers et al., 2002). Other new services are being considered as well. NIST may contract with other government agencies to offer quality control services aimed at ensuring the completeness of the mail treatment process.

## 7. Conclusion

Those who have spent their careers in the radiation-processing industry have long desired for significant interest and growth in this technology. It is unfortunate that these gains are accompanied by losses in the liberties we have enjoyed for so long.

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