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IN A NEW YORK MINUTE: ECONOMIC IMPACTS OF A RADIOLOGICAL DISPERSAL DEVICE

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Abstract

In the Fall of 2015 the Office of Radiological Science (ORS) began working with Sandia National Laboratories (SNL) to use enhanced data, new models/methods, and informal expert elicitation to improve upon past studies and produce a better understanding of the full range of economic consequences of an RDD event. The paper explores in detail the consequences and impacts associated with an RDD detonated in a major metropolitan area.

1. INTRODUCTION

It has long been recognized that the primary impact of a radiological dispersion device (RDD) incident is economic, that the disruption occasioned by dealing with a large urban area that is uninhabitable until remediation is complete can be very costly. This view is supported by the history of dealing with radiological accidents such as Chernobyl, Goiania, and Fukushima. To determine the economic impact and understand the factors affecting the impact, the DOE Office of Radiological Security, (DOE/NA-212), funded Sandia National Laboratories to conduct a rigorous study of the effects of a major RDD incident in a metropolitan area. The paper will concentrate upon detailing the method of analysis and showing the large scale of the impact. Estimating the economic impact of a terrorist attack involving a RDD is a complex process that involves unknown factors and limited historical data. We use enhanced data, methods, and recently published studies of Fukushima impacts to improve upon earlier studies and produce a better understanding of the full range of economic consequences of an RDD event.

2. APPROACH

The basic approach used in the analysis is shown in Figure 1. The analysis is broken into three distinct steps. The first is the analysis of physical impacts. This captures the physical dispersion, immediate health effects, and disruptions to critical infrastructure. This includes the conceptual design of the incident scenario, including the size of the release, the location, and weather. These details serve as the input to the aerosol dispersion code QUIC (Quick Urban Industrial Complex Dispersion Modelling System). QUIC is a Los Alamos National Laboratory developed tool that models aerosol dispersion and calculates deposition on the ground and buildings. Given the urban area of the scenario, it is important to properly represent how urban canyons will affect dispersion, which QUIC can do. This phase also includes the utilization of SNL developed models to determine the physical impact to critical infrastructure such as transportation and electric power. Last in the analysis, a SNL model for indoor infiltration, Probabilistic Anthrax Risk Assessment Tool (PARAT), is employed to determine the extent of contamination inside the buildings in the path of the radiological dispersion.

The second step of analysis is the response, which is focused on how policy and human decisions will drive recovery. The team utilized informal expert elicitation to outline the response scenarios. Additionally, we had the privilege of having the cooperation of the New York City Office of Emergency Management. This provided the analysts with an opportunity to apply a real response plan to our scenario instead of generating a hypothetical response. One last advantage of having the cooperation of NYC was their sharing of detailed building data. This was significant when determining clean-up activities and debris estimation. The team again deployed SNL developed models to estimate clean-up costs and timelines during the long-term recovery: Prioritization Analysis Tool for All-Hazards/Analyzer for Wide-Area Restoration Effectiveness (PATH/AWARE), and Resource Estimation and Scheduling Tool for Optimized Recovery (RESTORe).

The last step of the analysis is focused on monetizing the actions that occur in the previous steps and estimating a net economic impact. The analysts used a combination of economic accounting, input-output models, and dynamic forecasting economic models to estimate economic impacts.

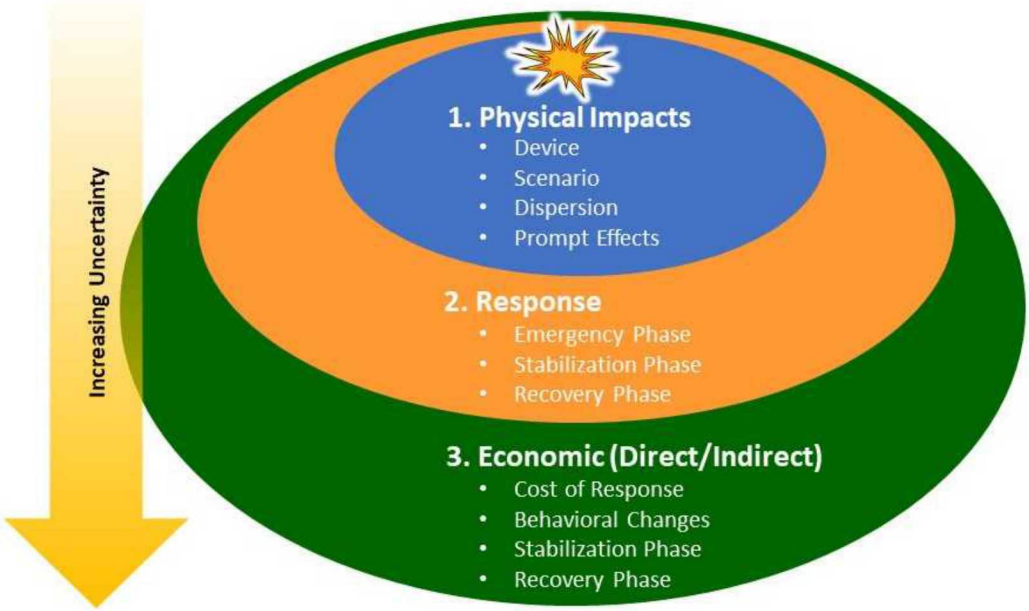

Figure 1. *Order of Proceeding for the Economic Impact Analysis.*

3. PHYSICAL IMPACTS

To model the physical effects of the RDD incident, an accident scenario had to be described. For this study, the scenario involved the release of a large amount of a radioactive isotope in lower Manhattan. The radioactive cloud was carried by prevailing winds across lower Manhattan, across the East River, and into Brooklyn. Figure 2 shows the venue of release and the general path of the cloud.

Figure 2. *Location of Release, with Wind Direction.*

The results of the incident are shown in Figure 3 and Figure 4. The diagram in Figure 3 shows the different Remedial Action Zones, which differ according to the contamination level. In Figure 3, Manhattan is shown to have 2 zones, the Central Financial District, which was extensively contaminated, and a peripheral zone, where there was lesser action required. The red area indicates contamination high enough to require population relocation.

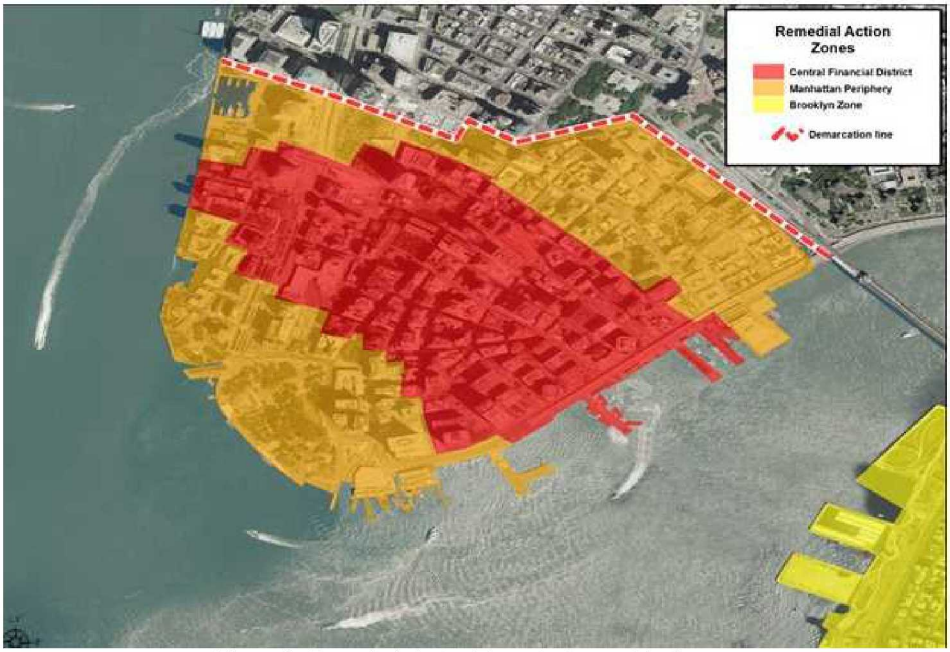

Figure 3. *Remedial Action Zones in Lower Manhattan.*

The contamination spreads across the river into Brooklyn. The resulting remedial action map is shown in Figure 4. The yellow zone shows the rest of the contamination from the plume across New York (Brooklyn) and out to the ocean. However, the level of contamination was below any level that would trigger a remedial action.

Figure 4. *Remedial Action Zones in Brooklyn.*

The published response thresholds within the US are guidance and not legally binding. Local authorities working with federal agencies will have to decide at what level to trigger remedial action, following an RDD

event. For this study, it was assumed the clean-up level would be the same as the relocation threshold. This assumption is meant to err on the higher side of the threshold. If a lower threshold for action is used, then the costs and time horizon will likely increase.

4. RESPONSE PHASES

The event and recovery is divided into four analysis phases. These phases are shown in Figure 5. The first phase (The Event), begins with the explosion of the device, the passing of the plume and detection of radiation and lasts approximately 40 minutes. This is not a worst-case scenario and was designed to be as representative as possible. The plume missed critical infrastructure and avoided cascading effects. A change in timing might have directed the plume over a major airport or seaport, or driven the plume up the spine of the island, increasing the impact.

The second phase (Emergency Phase) takes place in accordance with the NYC Office of Emergency Management plans for this type of event. The primary goal is preservation of human life. We assumed that the populace would comply with NYC guidance and shelter as directed. This could last up to 4 days and includes closing subway stations and surface access to the affected area. All economic activity in the affected area ceases during this time. Follow-on meetings with NYC indicated that the local area airports would be closed as well, but this was not accounted for in these results.

The next phase (Stabilization) involved surveying of the contamination, repaving evacuation routes, evacuating people from the affected area and providing initial medical screenings. This is driven by established policy and human decision making in the immediate aftermath of the release. This phase is assumed to last approximately 10 days. Based on Fukushima evacuations, we estimated significant deaths would be possible. The NYC emergency plan, if followed strictly, would require 195,000 evacuations. Medical screening would be very significant. As documented in the Goiania, Brazil incident, over 100,000 people required screening, far more than those exposed. The NYC agencies recognize that the psychosocial effect of having to be screened will be significant, and have made significant efforts to prepare for them

And finally, the recovery phase occurs. This final phase is the long-term recovery and clean-up of the urban area. It involves the remediation of the radiation hazard, including clean up and sometimes demolition and reconstruction of affected buildings. It was found that remediation is a not one size fits all affair. Interior modelling indicated the inside of the buildings with newer HVAC systems would have very limited contamination and not exceed thresholds of concern established in emergency guidance.

The overall goal of the economic analysis is to estimate the economic impact of the activities that occur in each phase. These activities are both negative and positive on the economy. In the end we are reporting a net change in the economy over the course of the years following the RDD release. For the purposes of this study we assume a time horizon of 10 years.

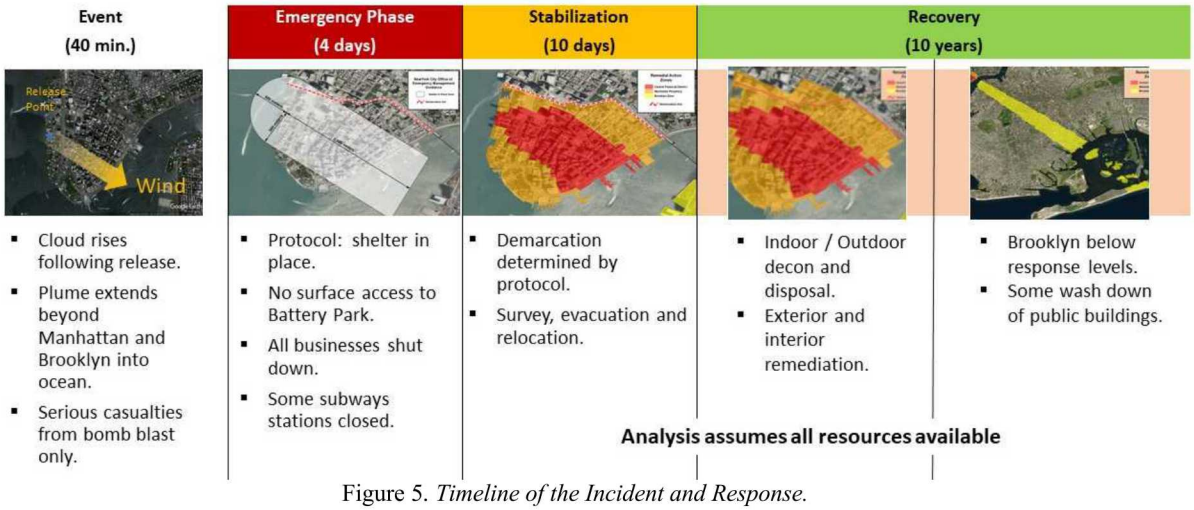

Figure 5. *Timeline of the Incident and Response.*

The detailed building data provided by NYC was used to conduct a building by building analysis of indoor radiation infiltration. The output of the PATH/AWARE models and the detailed information regarding building exteriors was used to determine individual building remediation actions. The process developed by the analysts is represented by Figure 6. It shows the remediation efforts carried out in the different remedial action zones. The indoor infiltration levels were low enough that it was reasonable to assume that decision-makers under this type of event would seek to eventually return the buildings to productive economic use. As such the most advanced decontamination technology are assumed to be used extensively throughout the Red and Orange remedial action zones. The analysts also assumed full availability of labor and capital to carry out the remediation activity. It should be noted that a shortage in either category could extend the recovery time horizon.

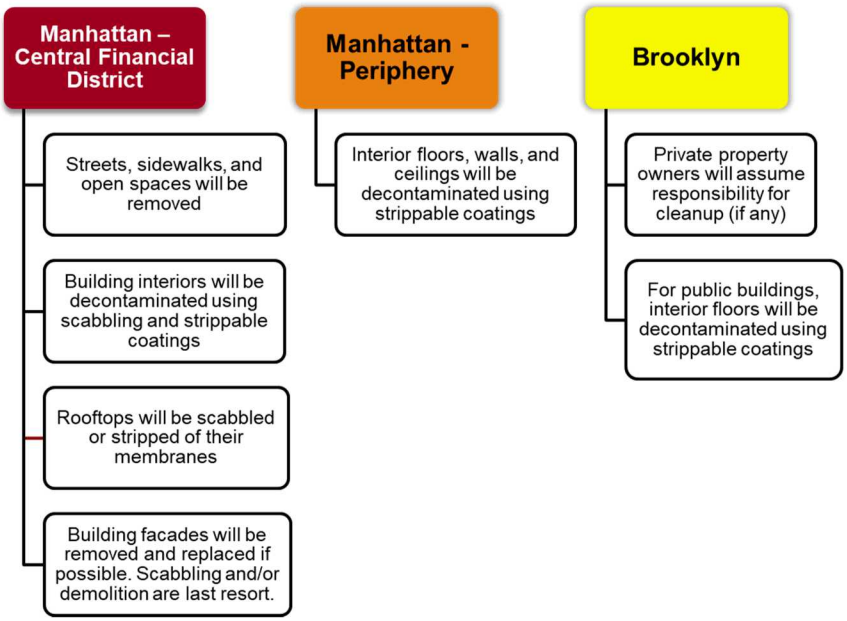

Figure 6. *Remediation Activities by Zone.*

Figure 7 shows the scale of the remediation efforts in terms of the number of buildings requiring remediation in Manhattan.

Figure 7. *Building Remediation in Lower Manhattan.*

5. ECONOMIC IMPACTS

The objective of the economic analysis was to estimate the cumulative economic impacts. Considering both the dollars subtracted from the economy and the dollars spent for remediation and healthcare. Figure 8 is a high-level representation of the economic modelling process. The economist works closely with all analysts to properly represent the costs and timeframes. This is an iterative process not a simple input to output process.

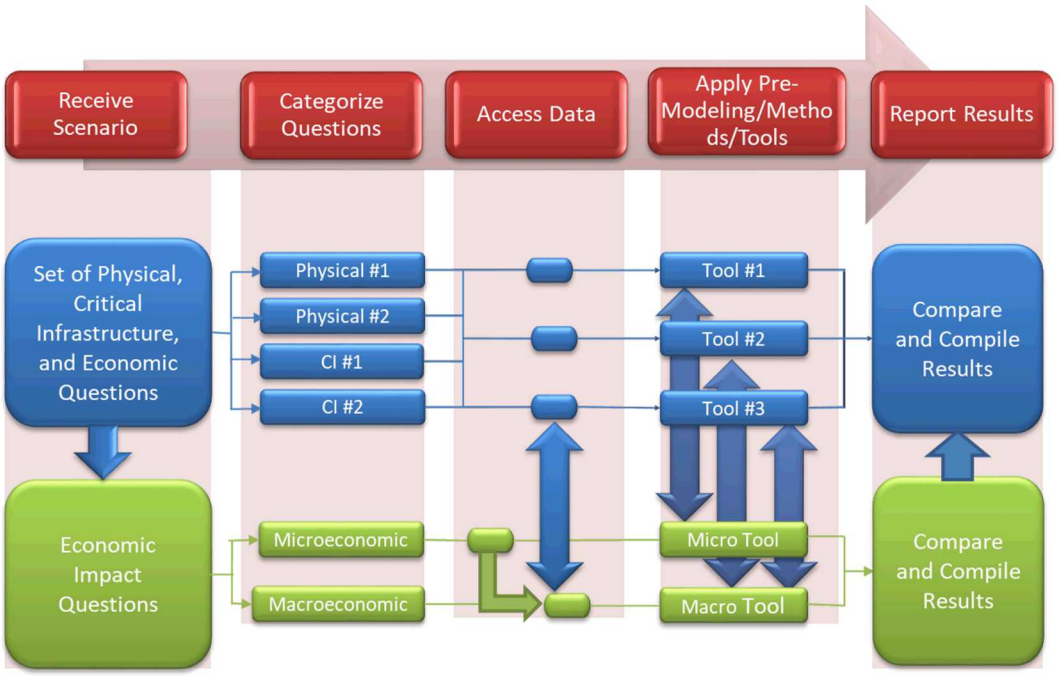

Figure 8. *A Complex, Iterative Process for Economic Analysis.*

Much of the disruption to business, physical consequences, and rehabilitation of physical assets from an RDD event would span weeks to years. These consequences are best understood using the multi-year scenarios made possible by newly developed economic modelling capabilities. The new analysis employs two models that combine input-output, econometric, and computable general equilibrium techniques at local, regional, and national levels. The first, the Regional Economic Accounting Tool (REAcct) developed by Sandia, is an economic consequence methodology implemented through GIS software that provides short- to medium-term (less than 1 year) disruptions at the zip code and county levels. A second economic model, Regional Economic Models, Inc.'s Policy Insight Plus (REMI PI+), is a dynamic economic model of the United States that can be used to simulate a wide variety of economic and demographic effects and provides results on an annual basis.

Business disruptions are characterized by the relocation of businesses and residents within the New York City Metropolitan Statistical Area. Perception effects manifest as worried-well populations seeking unnecessary medical treatment and reduced tourism. Regional impacts vary with some positive offsets (dollars spent on remediation). First-year, there is significant economic downturn driven by business disruption and perception effects, but multi-year analysis showed some recovery with limited national impacts over 10 years. Investment in resilience and preparedness effort could significantly drive down recovery costs in a real event, while lack of prior attention could increase resulting economic costs. In the end, there was an estimated 10s of $billions loss in Gross Domestic Product (GDP) over ten years.

The human cost is substantial. We estimated that evacuation deaths can be significant, even greater than the prompt deaths from the release. Perception and avoidance behaviours had the largest negative impact on the economy. The dollars spent on clean- up did not completely offset the lost tourism dollars associated with the perceptual avoidance of Manhattan. The economic impacts and other information gathered during this study will provide valuable insights that can be used to establish radiological material protection and RDD risk mitigation measures, and to direct resource optimization for post-event efforts.

6. INSIGHTS

Upon reviewing the results of study effort, we believe that the insights are as important as the numerical data. The insights seemed to fall in two major categories: the factors that drove the costs, and the balance between regional and national impact.

The biggest driver of human costs was the large-scale evacuation and the accompanying deaths. Care will have to be exercised to avoid making the precautionary measures a greater danger than the release. For example, elderly and physically impaired evacuees will require special treatment.

As far as economic effects go, it was found that perception and avoidance had the largest negative economic impact, not clean-up costs. The loss in tourism and real-estate value was greater than remediation spending.

When the geographic distribution of impacts was examined, it was found that regional impacts vary tremendously with some positively affected. For example, while Manhattan was seriously damaged financially, some surrounding boroughs benefitted from the influx of spending for the remediation of Manhattan.

Analysing the economic effects in time, it was seen that first-year cost categories had a significant down turn, but multi-year analysis showed some recovery. Manhattan would recover in time, if the large-scale remediation efforts described earlier were carried out promptly and consistently.

7. SUMMARY

In summary, an RDD event is disruptive and has significant economic impact.

A representative scenario led to the Lower Manhattan Central Financial District (CFD) being disrupted for over 10 years with significant deaths possible from the evacuation. There was significant economic impact: well outside of Manhattan, and the national GDP was reduced by 10s of $billion.

The impact of an RDD incident is not solely determined by the physical factors of the radioactive release. Response protocols, readiness, resource availability, and response threshold determine cost and human impact: resilience and preparedness will make a difference.

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