Natural Hazards

# Observer

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## On the Cover

On April 17, 2013, an explosion roared through the West Fertilizer Company in the small town of West, Texas. The cause was unknown for several years, and speculation ranged from terrorism to accident to arson, until federal officials finally concluded, three years after the event, that is was in fact arson.
*Continue reading on page 11.*

Aerial photo of the West explosion site taken several days after blast. © Shane Togerson, 2013

WELCOME TO the October issue of the *Natural Hazards Observer*, dedicated to National Security and Public Safety.

In March, three coordinated terrorist attacks in Belgium killed 35 people. While the country was reeling from these devastating attacks, evidence surfaced that indicated ISIS was possibly planning to infiltrate or sabotage a nuclear facility to obtain nuclear or radioactive material.

In response, security measures and military presence at the country's Tihange and Doel plants were increased immediately. These efforts were swift and necessary—Doel, in eastern Flanders, is surrounded by more residences than any other power station in Europe of any power station in Europe. More than nine million Belgians live in a 50-mile radius of the Doel plant.

The incident was an eye opener for the international nuclear industry, as well as for the chemical and explosives industries. Among the concerns it raised were the proximity of facilities that produce or store chemical, toxic, or flammable materials to densely populated areas and the safety measures in place to prevent attacks.

Attacks on such facilities are nothing new. In 1916, while Europe was embroiled in World War I, a massive explosion with the force of a 5.5 magnitude earthquake occurred on Black Tom Island, a peninsula near the Statue of Liberty. The blast, which decimated nearby neighborhoods in New Jersey and New York, was caused by a fire at the island's munition depot. After initially thinking it was an accident, investigators eventually pieced together evidence that pointed at German sabotage.

The explosion—by some historians considered the first major terrorist attack on U.S soil—informed the much-needed creation of a national security framework and ignited a public safety debate. This event is the focus of one of several articles in this issue that look at how public safety and terrorism risks often go hand-in-hand.

While the United States has gotten better at managing these types of threats in the past 100 years, risks remain. In an article about the 2013 West Fertilizer Company explosion in Texas, authors Michelle Meyer and Marccus Hendricks show how fragmented regulatory practices put people in harm's way. The facility, like so many other fertilizer plants throughout the country, was located near a populated area. While many communities agree that allowing a plant that handles dangerous substances to exist close to population centers isn't wise, there is no federal rule forbidding it. So—in many states, including Texas—those decisions are left up to local zoning authorities, some of which take a minimal approach to regulation.

The explosion in West destroyed a nearby high school, nursing home, and an apartment building. Fifteen people—including 14 first responders—died and more than 200 people were injured. The three-year investigation into the incident concluded that the blast was the result of arson.

Although much of the damage could have been prevented by stricter zoning laws, the explosion itself couldn't. As with the Black Tom incident, the threat to the West plant came from within—and inside jobs are notoriously difficult to guard against.

Doel, nuclear reactor © Torsade de Pointes 2013

That's what authors Steve Sin, Brecht Volders, and Sylvain Fanielle observed in their article about the illicit trafficking of radioactive and nuclear (RN) materials by sea. Using a case study of the Port of Antwerp, they examined the strengths and weaknesses of current international maritime security initiatives and found that a terrorist's best opportunity to traffic RN materials or physically attack a port would be to corrupt or recruit an insider. They also acknowledged that, like West and Black Tom, the Port of Antwerp's location in a heavily populated area presents a significant security challenge, not only in preventing illicit trafficking but also in protecting port facilities and infrastructure from becoming the physical target of a terrorist attack.

For more than 100 years we've known that dangers like chemicals and explosives are not only naturally hazardous, they're also a threat to those living near facilities where they're stored. As we've added radiological and nuclear materials to the mix, we've created even greater opportunities for not only accidents, but also for those who would attempt to leverage such dangers to achieve their own ends. It is now clear—even as it was clear 100 years ago—that issues of terrorism and public safety often coincide.

I hope you'll enjoy this *Observer*.

Elke Weesjes
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# Maritime Security Initiatives

## A Paper Tiger or a Concrete Solution?

By Steve Sin, Brecht Volders, and Sylvain Fanielle


Port of Antwerp © August Brill 2013

FOR MORE THAN A DECADE, the threat of terrorism from weapons of mass destruction (WMS) has been on the forefront of the international security agenda. In an increasingly globalized society, it is of utmost priority to detect and interdict illicit trafficking of radioactive and nuclear materials (RN) in order to prevent individuals and organizations—those who are willing to perpetrate acts of WMD terrorism—from acquiring such materials. Recently revealed terrorists' surveillance of a nuclear official in Belgium only confirms this importance. In this context it is also worth noting that "traditional" transnational criminal organizations (TCOs) are increasingly collaborating with terrorist organizations to traffic commodities, such as arms, narcotics, antiquities, humans, as well as wildlife and wildlife body parts. Another emerging trend is the hybridization of terrorist organizations that are engaging in criminal activities such as illicit trafficking of narcotics to fund their terrorist activities (Picarelli 2006, Picarelli 2012a, Picarelli 2012b, Picarelli and Shelley 2007, Sanderson 2004). In response to the potential threat of WMD terrorism, the international community has launched various political and legal initiatives to prevent illicit trafficking of RN materials via maritime means. Indeed, more than 58 million 20-foot equivalent units of containers are shipped around the world annually via 490 maritime trade routes, and international deep-sea container ports are still being used by TCOs and terrorist organizations alike to transship and transload illicit goods. These alarming statistics make commercial maritime shipping industry uniquely vulnerable to exploitation by nefarious actors seeking to traffic RN materials.

Through a case study of the Port of Antwerp, Belgium, we examine ways the international maritime security initiatives (i.e. Proliferation Security Initiative, Megaports Initiative, etc.) are implemented at one of the largest and fastest growing deep-sea container ports in Europe with services to and from the Americas, Africa, the Middle East, and the Indian subcontinent. We also seek to identify strengths and potential weaknesses of the current legal and political framework designed to curb illicit RN materials-trafficking. Additionally, we try to determine whether the existing initiatives are implemented with efficiency and respected by those connected to the maritime industry, or if the reality is far from ideal.

### Case selection and methodology

Three major characteristics led us to select the Port of Antwerp as the subject of our case study, beyond the fact that it is one of the largest and fastest growing deep-sea container ports in Europe. First, geospatial analyses have identified the Port of Antwerp as the potential European maritime chokepoint where multiple licit and illicit pathways converge (Boyd and Sin 2014, Sin and Boyd 2016). Second, the Port of Antwerp represents an excellent example of the latest security measures implemented at a large European international maritime cargo handling facility. Finally, the port reflects the convergence of national Belgian, European Union and international policies, which provide a unique opportunity to observe the operation of multiple types of security policies in a single location.

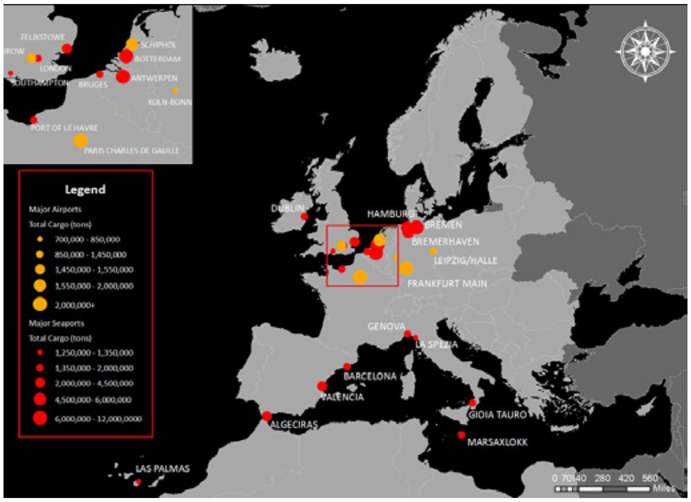


Figure 1: Major European Airports and Seaport (Source: Eurostat 2016)

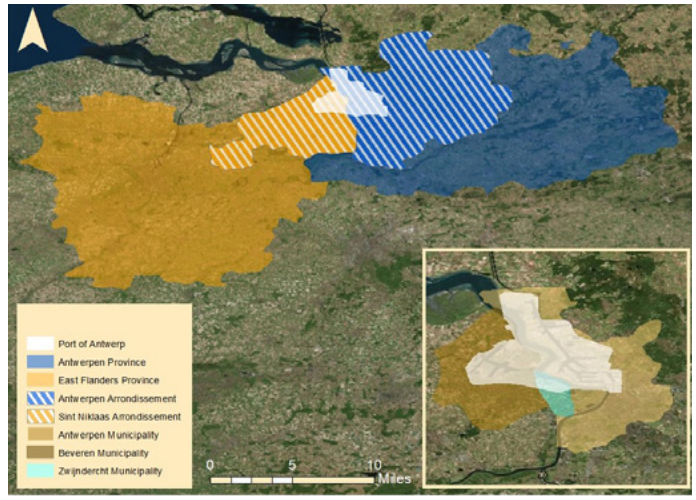


Figure 2: Port of Antwerp Jurisdictionsal Boundaries

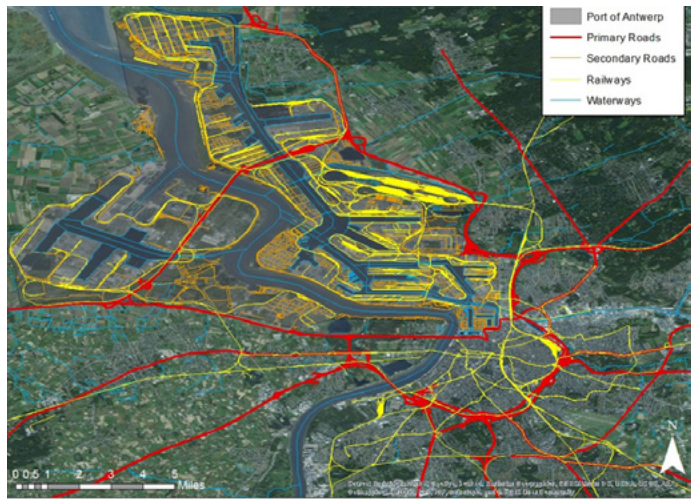


Figure 3: Port of Antwerp Infrastructure

Although we chose to conduct our case study at the Port of Antwerp, it is worth noting that there is no intentional illicit RN material trafficking case reported at the Port of Antwerp.

Several key officials involved in the operations and security of the Port of Antwerp were interviewed to provide insights to our case study. We also researched all available open-source media and academic literature pertaining to the Port of Antwerp's operations and security measures, as well as reports produced by governmental and non-governmental organizations. Additionally, we conducted an analysis of all relevant international and European security regimes, legislations, and regulations that Belgium (and therefore the Port of Antwerp) is obligated and/or has agreed to follow.

## Background: physical and jurisdictional complexity

The Port of Antwerp is the largest container port in Belgium and the second busiest container port in Europe (Port of Hamburg 2016). The port accounted for roughly 80 percent of all containers shipped to the United States and Canada from Europe in 2014 (Port of Antwerp 2014a). Its proximity to European consumer markets (located roughly 80 kilometers (129 miles) inland from the North Sea on the River Scheldt) gives it a competitive advantage over other European ports (World Port Source 2016).

Although the Port of Antwerp may appear to be a singular entity falling under one jurisdictional authority, in reality, several jurisdictional lines are present within the area. The port is located in two Belgian provinces (Antwerp and East Flanders), three municipalities (Antwerp, Beveren, and Zwijndrecht), and two judicial districts (Antwerp and Dendermonde). It also straddles multiple administrative and judicial boundaries. Within the Port of Antwerp area, nine government agencies[1] have a role in some aspect of the port security. There are also eight law enforcement agencies – three local[2] and five federal[3] – operational at the Port of Antwerp. Additionally, there are two prosecutor's offices (Antwerp and Dendermonde) that lay claims to the jurisdiction over the port; the Belgian intelligence and security services, and the Federal Agency for Nuclear Control also play a large role in port security. Other agencies in the port's security team include the Customs, the Environmental Inspection, and various local fire departments. (DeBoeck, et al. 2014) While all of these stakeholders are responsible for certain aspects of the port security, they all have divergent operational requirements and priorities; therefore, developing and implementing a comprehensive port security policies and procedures that can have each stakeholder's buy-in and leverage the unique capabilities each stakeholder possesses is a monumentally challenging task.

1 The nine government agencies with responsibility for port security include the Belgian Ministry of Home Affairs; the Belgian Ministry of Justice, the Flemish regional government, the Governor's Offices of the Provinces of Antwerp and East Flanders, the Mayor's Offices of the City of Antwerp and the municipalities of Beveren and Zwijndrecht, and the Antwerp Port Authority.

2 The local law enforcement agencies are Antwerp, Beveren, and Zwijndrecht.

3 The federal law enforcement agencies are the Federal Judicial Police for Antwerp and Dendermonde; the Federal Administrative Police for Antwerp and Dendermonde; and the Federal Maritime Police.

| International and Regional Initiative | Year Launched | Year Signed |
|---|---|---|
| Container Security Initiative (CSI) | 2002 | 2003 |
| G8 Global Partnership Against the Spread of Weapons of Mass Destruction and their Delivery Means (GP) | 2002 | 2004 |
| Global Initiative to Combat Nuclear Terrorism (GICNT) | 2006 | 2006 |
| Megaport Initiative | 2003 | 2004 |
| Nuclear Security Summit (NSS) | 2010 | 2010 |
| Proliferation Security Initiative (PSI) | 2003 | 2005 |

Table 1: International and Regional Initiatives to Prevent Nuclear and WMD Proliferation Signed by Belgium

| Code/Legislation/Directive/Resolution | Year Adopted | Year Signed |
|---|---|---|
| European Union Directive 2005/65/EC | 2005 | 2005 |
| European Union Regulation EC/324/2008 | 2008 | 2008 |
| European Union Regulation EC/725/2004 | 2004 | 2004 |
| International Ship and Port Facility Security Code (ISPS) | 2002 | 2002 |
| United Nations Security Council Resolution 1540 | 2004 | N/A |

Table 2: International and Regional Codes/Legislation?Directives/Resolutions to Prevent Nuclear and WMD Proliferation Signed by Belgium

## International initiatives, regulations, and resolutions signed by Belgium

Recognizing the threat of WMD terrorism and its implications, Belgium participates in various international and regional initiatives, codes, regulations and directives[4] in order to prevent WMD terrorist incidents and to curb illicit trafficking of RN materials.

Belgium also has joined a number of international initiatives focused on preventing nuclear and WMD proliferation and terrorism (see Tables 1 and 2). As the largest deep-sea container port in Belgium, the Port of Antwerp is subject to all of the conditions and terms of the international and regional initiatives, legislations, codes, directives, and resolutions that Belgium must adhere to. Tables 1 and 2 (above) provide a list of agreements related to preventing nuclear and WMD proliferation and to terrorism that Belgium has signed.

## Current security measures, procedures, and protocols

The Port of Antwerp unites multiple security actors at several levels due to the multi-faceted nature of the concept 'security' and the administrative and judicial complexity of the port area.[5] There are more than 20 governmental bodies, justice and policing bodies, and inspection and rescue actors (DeBoeck, et al. 2014). Although no single security actor or agency specifically focuses on the detection of illicit trafficking of RN materials, this issue falls within the broad scope of four key operational agencies charged with the daily operational mission of securing the port: Customs and Excises, the Harbor Master's Office, the Federal Agency for Nuclear Control (FANC), and the Federal Maritime Police.

Port of Antwerp © August Brill 2013

The primary RN materials inspection tool for container traffic in the port is the Megaports portal monitors. In 2004 Belgium joined the Megaports Initiative and has contributed approximately $17 million to the initiative between its two ports, Antwerp and Zeebrugge (NNSA 2013). As a port participating in the Megaports Initiative, all of its major terminals are equipped with Megaports Initiative scanners, and the majority of the containers processed at the port go through these scanners. The port is also equipped with secondary fixed scanners and tertiary mobile scanners that can be used to conduct a more detailed inspection of containers. (Pellens, et al. 2010)

In 2012 the Port of Antwerp developed a new security protocol, which was implemented and exercised under the observation of the European Commission representatives. The "Exercitium, Drill and Exercise Handbook," drafted by the Port Authority after the completion of the exercise at the request of the European Commission, has been adopted throughout the European Union as a model (Port of Antwerp 2012). In 2013 the Port Authority introduced a game called "Serious Game," which port users and the public can download and play on their computers or mobile devices to learn how to contribute to the safety and security of the port (Port of Antwerp 2013a).

In an effort to allow for earlier intervention of police in the investigation of suspicious or possible criminal/terrorist activities at and around the port area, the Port Authority established a Local Information Network (LIN) at the end of 2013. The network brings private companies, various port agencies, and local authorities together in an information- sharing environment. The LIN not only allows the private companies and the port agencies to report suspicious activities to the local authorities, but it also allows the local authorities to share information with the companies and port agencies about possible threats at and around the port area. As of February 2014, the mayors of Antwerp, Beveren, and Zwijndrecht, as well as the Ant-

4 Belgium has joined and implemented the following international and regional initiatives, legal codes, and legislations that are most relevant the prevention of WMD proliferation through increased security measures, policies, and procedures at seaports: Proliferation Security Initiative (PSI); Megaports Initiative; Container Security Initiative (CSI); International Ship and Port Facility Security Code (ISPS); European Union (EU) Regulation EC/725/2004, "Enhancing Ship and Port Facility Security"; EU Directive 2006/65/EC, "Enhancing Port Security", and EU Regulation EC/324/2008, "Procedures for Conducting Inspections in the Field of Maritime Security."

5 On one hand, security consists of port-related crimes such as illicit trafficking of goods, human smuggling, and scams with vehicles and waste. The port is a 'logistical gateway' to carry out other types of crime. On the other hand, security is related to the protection of the port itself from, primarily, a physical attack by terrorists.

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werp port alderman, the Belgian Federal Policy, the Shipping Police, senior police officers of the local jurisdictions, and the Port Authority had all signed the LIN protocol.

Since the development of LIN, the Port Authority has approached 650 companies to join the network, and currently more than 450 companies participate in the LIN protocol. (Port of Antwerp 2014b, 2013b)

To counter the constantly increasing cyber threat faced by the Port, and as a response to the hacking incident that was uncovered in 2013[6], the Port Authority, in concert with the Antwerp Port Community System (APCS) and the Belgian Federal Cyber Emergency Response Team (CERT), set up a special cyber security taskforce at the end of 2013 (Port of Antwerp 2013b). Moreover, the port implemented additional container-security measures. One of the new measures includes the Container Release System–originally developed by MSC–in which the users have to log onto a secure portal that is hosted on an independent network from the Port's network in order to gain access to the container release data (Port of Antwerp 2013c). Other security measures at the container terminals include integrated electronic data management (EDI), International Ship and Port Security (ISPS) certification, and the Secured Alfpass card management system (Port of Antwerp 2016d).

## Security challenges and potential issues

Although more than 90 percent of the containers processed at the port go through the Megaports Initiative scanners when entering and leaving the port, a number of the containers still do not get scanned. There are two primary reasons for this: 1) those containers that are directly transloaded from one ship to another (both international and domestic shipping transfers) do not have to be scanned, and they can then be offloaded at another port that is not a part of the Megaports Initiative; and 2) of all the containers that do go through the portal RN detector, a very small percentage of them are selected for secondary and tertiary scans due to the extremely high volume of the containers flowing through the port.

Additionally, primarily because of this high volume of containers, when a container is selected for further scanning it takes a long time for the transporter to submit the container to further scanning. As a result, the material of interest could be dumped or transferred to other means of transportation prior to the container being submitted for scanning (Fanielle and Volders 2014).

The primary function of the customs office, the agency that receives the monitor alarm information from the Megaports portal scanners, is to detect and curb illicit trafficking of goods (i.e. narcotics and counterfeit goods) and not necessarily to look for RN materials. Likewise, the Federal Maritime Police's main task is to actively control the port area to prevent and investigate "conventional" crimes. In cases when alarms are deemed credible[7] the Federal Agency for Nuclear Control (FANC)'s Security & Transport Department will be notified for assistance. Although this department is the central point of contact for the port authorities in an event of credible RN alarm, its mission is to protect the people in the potentially affected area from radiation and/or contamination, in accordance with the IAEA's guidance document. Again, like the customs office and the maritime police, though FANC must respond to a potential RN event, its focus is not in preventing illicit trafficking of RN materials. Finally, although the Harbor Master Office's Port Security & Safety Department is responsible for monitoring all port terminal operators' and port tenant companies' correct implementation of the ISPS-guidelines, the department is still not charged with proactively monitoring attempts of illicit RN materials trafficking (Fanielle and Volders 2014).

The Maritime Security Law (2007) and the Royal Decree

6 In June 2013, the Belgian authorities seized approximately a ton of heroin and cocaine after one of the shipping companies notified the Antwerp Port Authority that its container tracking system had been hacked. In October 2013, the Belgian authorities discovered the full extent of the security system breach at the port. The investigation found that narco-traffickers had hired hackers to break into the port's computer systems as early as 2011 to facilitate the trafficking of narcotics through the port. According to the reports, the narco-traffickers hired hackers through the dark web. The narco-traffickers would hide their "commodities" in the banana and timber containers from South America. The hackers would facilitate the recovery of the "commodities" from the port by breaching into the port's container location system and identifying the precise location of the relevant containers. The hackers will then change the pickup time and destinations of the containers, after which the narco-traffickers would send their own drivers to pick up the containers as "scheduled" with the "correct" documentation for pickup and delivery.

7 It is worth noting that false alarms are common occurrences. Some products such as bananas, broccoli, and toilets often trips the monitor's alarm because they give out a weak radioactivity signal. The Customs and Excises currently has the authority to arbitrarily decide whether or not to conduct a secondary and/or tertiary scanning of a particular container.

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on Maritime Security (2007), pursuant to the EU Regulation EC/725/2004 and the EU Directive 2005/65/EC, establish two overarching bodies responsible for proactively securing the port and creating preventive measures against terrorist threats. These are the National Authority for Maritime Security, and the Local Committee for Maritime Security (in the Port of Antwerp's case, the Port of Antwerp Local Committee for Maritime Security). Although these two organizations are designed to integrate intelligence and interdiction capabilities to prevent terrorism, there is no clear guidance on which agency is in charge of orchestrating the operations on the ground.

Another challenging issue is that the Port of Antwerp is considered an open port, meaning most of the port area is not controlled or has very limited control. In fact, there are some parts of the port in which private residences are situated. Although the immediate terminal areas and other sensitive areas are secured and controlled, the openness of the port does present a significant security challenge—not only for preventing illicit trafficking, but also because the port's facilities and infrastructure could be the physical target of a terrorist attack. It is also worth noting that all commercial ports have an economic finality, meaning that economic interests of the ports will almost always supersede all other concerns, including security. Security of the ports, at the most fundamental level, is vital only because it ensures the economic viability and the interests of the ports as well as those private entities operating within and around them (Fanielle and Volders 2014).

Finally, the port faces two emerging security challenges: cyber security, including the potential danger a cyberattack could pose on the port's security; and insider threat, whereby someone affiliated with the port could be corrupted or recruited to facilitate illicit trafficking. According to several Belgian federal and local officials working at the port, cyberspace could be the weakest link in the port's security posture.

Cyberspace, together with a corrupted or recruited insider, could represent the best chance of success for any potential adversary attempting to illicitly traffic RN material through the port (Fanielle and Volders 2014).

## Conclusion

Through our examination of the security measures and procedures at the Port of Antwerp, we were able to gain valuable insights into the strengths and potential weaknesses of the current international maritime security initiatives intended to curb illicit RN material trafficking.

The current international and regional maritime security initiatives appear to provide for an appropriate level of security requirements and recommended implementation measures to curtail illicit trafficking of RN materials via maritime means. Critical pressure points common to all initiatives were found to be a) active engagement of officials and private partners; b) specific mandate; and c) sustainability. Irrespective of the initiatives' design, if one of the previously identified criteria is not met, the collective power of the initiatives' measures will not be as strong.

The authorities and private partners at the Port of Antwerp were very enthusiastic about implementing security measures to address the threat of WMD terrorism and illicit trafficking of RN materials. To that end, the Port of Antwerp has implemented various security measures, procedures, and protocols as required and recommended by the international and regional initiatives, regulations, and resolutions to which Belgium is party. For example, the Port of Antwerp has a well implemented ISPS certification program and Megaports Initiative scanning procedures. The authorities and civilian partners of the port are also actively engaged in countering the cyber security threat posed by individual hackers and organized criminal groups. Additionally, the Port Authority is constantly raising the awareness of the operators and tenant companies about the security measures as well as the potential threats.

Despite all of its successes, the large physical size, extremely voluminous commercial throughput, and jurisdictional complexities of the port pose unique challenges to the authorities who are charged with implementing the security measures and procedures to mitigate the vulnerabilities and secure the port's facilities and infrastructure.

One of the most unique challenges stems from the jurisdictional complexities of the port. A variety of measures and procedures have been implemented at the Port of Antwerp in response to the threat of WMD terrorism and illicit trafficking of RN materials. Still, no one agency at the port has a specific mandate to focus on or is designated as the lead agency to monitor and coordinate the responses to a potential illicit RN materials trafficking or WMD terrorism incidents. While it seems the Port of Antwerp Port

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Port of Antwerp © August Brill 2013

Authority is responsible for coordinating all of the relevant agencies' response to any terrorist activities in and around the port once an incident occurs, it is still unclear which agency has the specific mandate to monitor and respond to illicit RN materials trafficking.

Balancing the scale between security and operational efficiency is one of the most difficult tasks that managers of facilities, companies, and organizations face. The Port of Antwerp is no different. The managers and security officials toil with these difficult decisions every day. The security of the port infrastructure and facilities is important. And stopping illicit trafficking of RN materials is paramount. But the security measures and procedures cannot degrade the operational efficiency of the port to the point where it becomes economically unsustainable. This harsh reality of the seemingly inversely correlated relationship between security and operational efficiency not only presents a challenge for the authorities as they attempt to find the "right" balance, but it also presents openings that can potentially be exploited by adversaries.

Constant communication and information-sharing among the different agencies, offices, and private partners operating in and round the port, as well as the continuous outreach programs designed to increase the awareness of all parties about the potential and consequences of illicit RN materials trafficking, are extremely valuable in mitigating potential weaknesses of the initiatives derived from jurisdictional complexity and economic sustainability. One can compare this to the direct correlation that DeCanio (1993) observed about the implementation of the U.S. Environmental Protection Agency's (EPA) Energy Star program[8] and the level of outreach activity conducted by EPA field offices located throughout the country. DeCanio found that the level of consumer and business awareness of the Energy Star program's benefits and the level of participation in the program is directly correlated with the level of outreach activity conducted by the EPA field office responsible for overseeing that particular area/region. Similarly, developing and implementing effective security measures, policies, and procedures that are sustainable is only the first half of the equation in securing our ports against the threat of illicit RN material trafficking, or any other threat.

*Balancing the scale between security and operational efficiency is one of the most difficult tasks that managers of facilities, companies, and organizations face*

The second half of the equation that must not be overlooked if we are to achieve a truly comprehensive security posture is the outreach and partnership programs that involve all stakeholders within and around the ports. The more active the port authorities are in reaching out to the public and private partners in and around the ports about the threats they face as well as the countermeasures already in place to counter those threats, the more aware the people will become and more buy-in there will be, which will lead to increased effectiveness of the security measures, policies, and procedures overall.


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8 Energy Star is a joint Environmental Protection Agency (EPA) and Department of Energy (DOE) program. The goal of the program is to protect the environment by encouraging consumers, businesses, and industry to adopt the use of energy efficient products and practices. The incentive to adopt such products and practices is that the adopters will see the return in the form of money saved on their energy costs.

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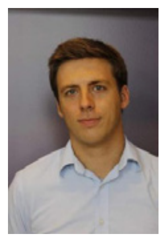

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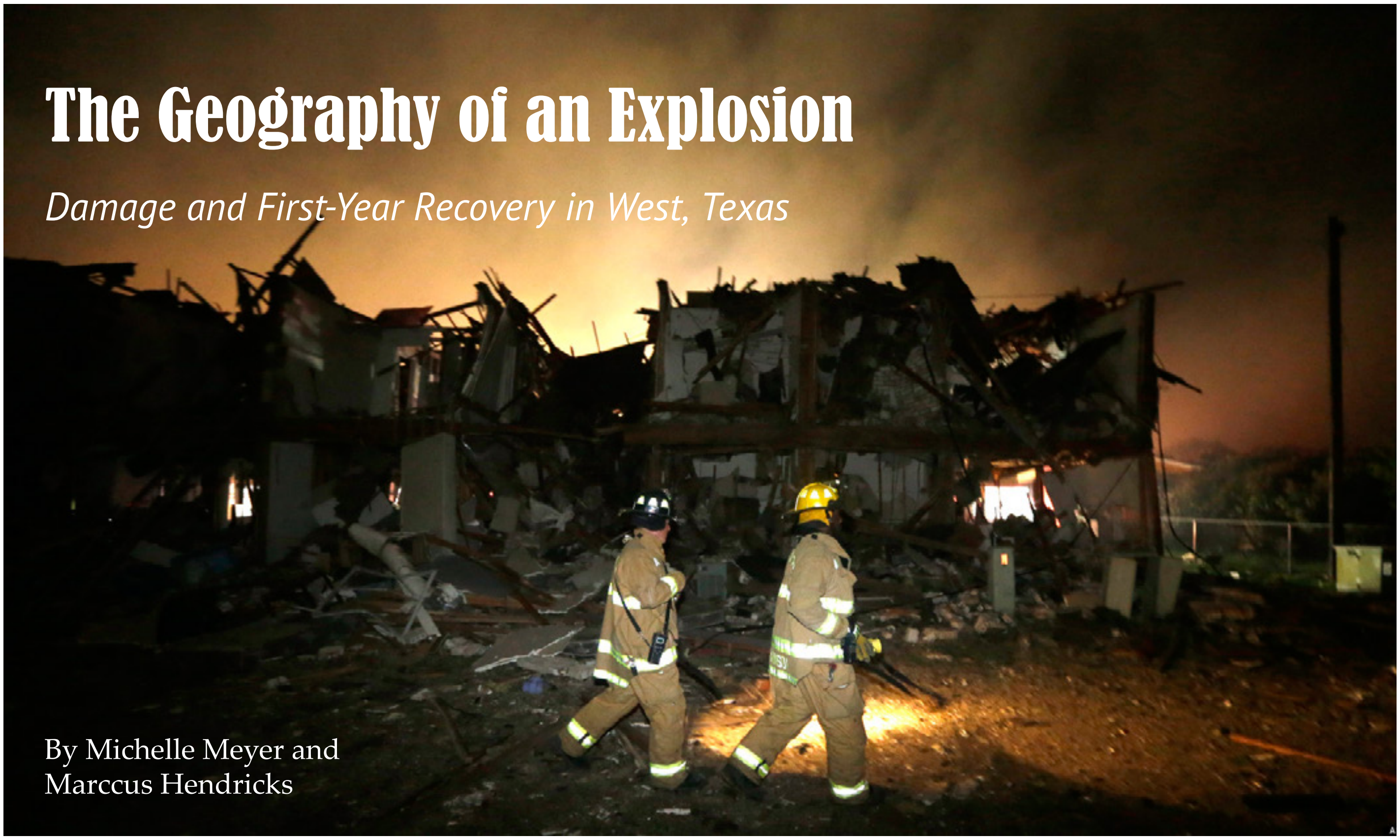
# The Geography of an Explosion

*Damage and First-Year Recovery in West, Texas*

By Michelle Meyer and
Marccus Hendricks



West Fertilizer Explosion


ON APRIL 17, 2013, only a few days after the Boston Marathon Bombing, an explosion roared through the West Fertilizer Company in the small town of West, Texas. The cause was unknown for several years, and speculation ranged from terrorism to accident to arson, until federal officials finally concluded, three years after the event, that is was arson. Fifteen people lost their lives in the explosion, all but one of whom were first responders working to stop the fire that led to the explosion. The explosion was felt miles away and nearby structures were decimated, while damage to buildings extended over half the town. West Rest Haven, a nursing home situated about 200 yards from the fertilizer plant, started evacuating when the fire began, but the blast that followed knocked the ceilings, windows, and walls of the building before residents and staff had finished evacuating. The high school and the only apartment building on that side of town took such heavy tolls that they were unsalvageable. Fortunately, the explosion happened in the evening when the school was empty. After the explosion, all the town's residents were evacuated, some for days and others for weeks. As many residents described in our research interviews, it was a miracle more people didn't lose their lives that day.

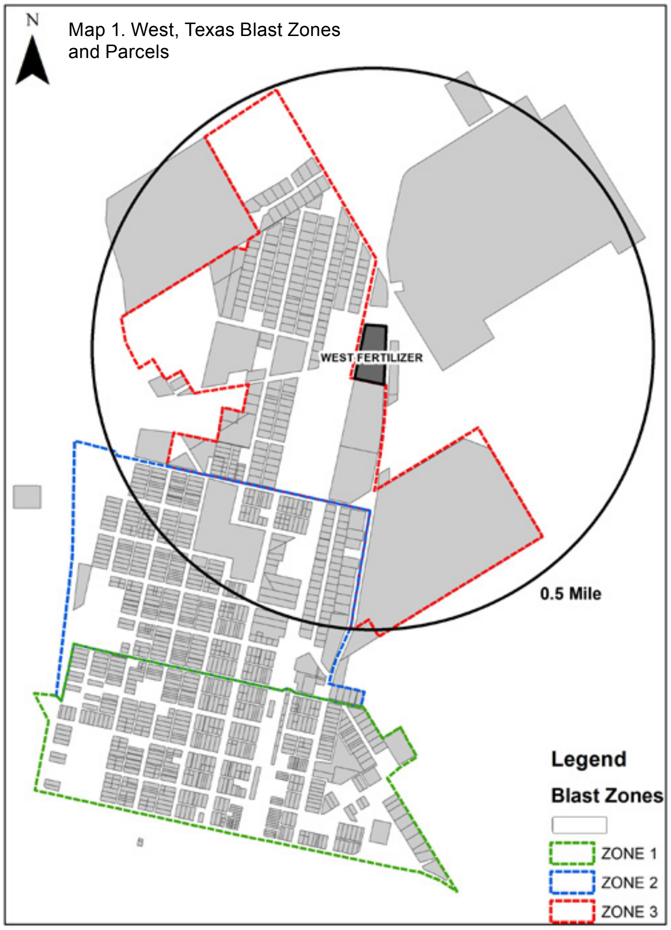
The explosion in West happened 66 years and one day after the deadliest industrial accident in U.S. history. In 1947, two ships carrying fertilizer similar to those stored in West exploded in the Texas City harbor and killed 581 people. According to Hugh Stephens (1997), officials at the time noted that Texas City was ripe for an explosion. Some wondered why the city had allowed development of many industrial facilities around the harbor in such as way as to concentrate the danger. Similar questions hung in the air in the numerous meetings and official reports following the explosion in West.

Despite these disasters, fertilizer is still big business. Today, more than 1,300 facilities nationwide store the same type of chemical that exploded in West (Fernandez 2016). In just the 22 years between 1984 and 2006, 224 accidents occurred at ammonia-based fertilizer facilities alone, killing 50 people across the U.S. (LeCompte 2013). For all these facilities and especially for the many other fertilizer facilities located near schools, nursing homes, or hospitals, understanding the potential damage and recovery outcomes of such events is crucial to developing response and recovery plans as well as informed future land-use decisions.

To address this need, we, together with colleagues from the Hazard Reduction and Recovery Center at Texas A&M University, developed an ongoing visual and geographic assessment of damage and rebuilding of West. This dataset offers a visual and spatial understanding of how the explosion affected homes in West, and how the explosion, along with other indicators, such as housing value and structure age, predict rebuilding at year 1. This research provides detailed information about the potential consequences of fertilizer facilities. The data can be used to support community planning and provide information to local residents about what risks exist in their backyards.

## Visual imagery in disaster research

As with most other disasters today, a quick internet search




for the West explosion yields hundreds of visuals. Both journalists and charities use images of suffering and damage to convey need as well as to increase pledges of donations following a disaster. Yet such images have been underutilized by researchers studying disaster impacts and recovery.

Observation through the use of systematic photographs or video has grown in popularity across sociology, criminology, and public health, among other disciplines, as a method to assess neighborhood-level effects on various individual and group outcomes. For example, video recordings have been used to assess disorder and crime in urban environments (Sampson and Raudenbush 1999) and Google Street View™ has been used to assess neighborhood features that affect children's health outcomes (Odgers et al. 2012) and gentrification (Hwang and Sampson 2014).

Only a few disaster scholars have employed visual imagery to conduct damage or recovery assessments, and they have focused on natural disasters, not technological events (Curtis & Mills 2012; Curtis & Fagan 2013; Mills et al. 2010). Curtis and Fagan (2013), for example, conducted an analysis of the 2011 Joplin, Missouri, tornado to compare mortality risk to structure damage. Curtis, Duval-Diop, and Novak (2010) used multiple video cameras equipped with GPS systems to collect visual images of the Holy Cross neighborhood of New Orleans following Hurricane Katrina. They found clear neighborhood-level patterns of recovery and abandonment, but spatial heterogeneity was apparent at the parcel-level within every neighborhood. In other words, abandonment and rebuilding existed in neighboring homes that had experienced similar physical affects from the disaster.

Using the same dataset, Curtis and Mills (2011) linked recovery to crime, finding that streets with more recovery activity had lower crime in 2007 and 2009 than other streets. Burton et al. (2011) used repeat photography rather than video to document recovery from Hurricane Katrina. They took four photos every six months over a three-year period at 131 sites. They scored each site on rebuilding using a four-point scale, and then aggregated the scores to the community level. They found patterns of recovery across communities over the three years, but also variation within each community. Higher levels of damage were correlated with lower levels of recovery, especially in the earliest time periods following the storm. This correlation became weaker three years after the hurricane, implying that other factors, such as pre-event household resources and vulnerabilities, affected long-term recovery above and beyond the disaster damage.

For technological events, disaster scholars have not used images. Instead, they have focused on changes in community cohesion, mental health, and social capital that occur while litigation and blame pull the community apart (Ritchie et al. 2013; Ritchie & Gill 2007). There has been no use of visual imagery for technological disasters, such as explosions, and few studies include analysis of rebuilding rates at all, let alone at the house level.

For small, rural communities, aggregate analyses, like those following Hurricane Katrina, are often not useful because data on economic and social characteristics are not available at a small enough scale to capture variation within small communities. West, for example, has only two Census block groups, which is the smallest publically available unit of analysis for basic demographic data, such as race and income. The explosion occurred in only one of those block groups, so aggregate analyses would be futile. Parcel-level analyses are the only way to understand variation in damage and recovery in this small town.

## West, Texas

West, Texas is located just north of Waco along Interstate 35. Though relatively close to a metro area, West has the feel of a small town. In fact, many people we spoke with rarely made the 15-minute drive into Waco. West has a population of roughly 2,900, is nearly 90 percent white, and boasts a Czech heritage. Expressions of such pride include the "Czech Stop" gas station on the interstate, which sells fresh and frozen kolaches, a Texas-Czech breakfast bakery treat. West's median household income was $36,000 in 2010, much lower than the Texas median household income of $51,900. The West Fertilizer Company facility was located at the northeastern corner of the town and separated from the nearest houses by a railroad track. Because it had been there for several decades, before the subdivisions and high school were built next to it, residents said they never worried about the potential danger.

Following the explosion, local emergency management officials divided the city into three zones based on extent of damage to delineate who could safely reenter their properties. Zone 1 was the farthest from the plant and had little damage. Zone 2 suffered more damage and residents were evacuated for more than a week. Zone 3 suffered the most extensive damage; residents were prevented from reenter-

Damage Level 3, below

Damage Level 4, below

Damage Level 7, below

Image 1. Selected Levels of Damage

ing for several weeks. Map 1 (page 12) shows the town, the location of the fertilizer facility, and the zones.

These zones became important determinants of not only reentry but also tax revenue. County appraisers used the blast zones as markers for setting reassessment values for the remainder of 2013. Any property within Zone 3 was reassessed for $0 for the reminder of the 2013 tax year. Buildings in Zone 2 were reassessed at 90 percent of their previous improved value. Zone 1 properties retained their previous 2013 values. This allowed for very quick reassessment, but is unusual, as most communities have full, visual reassessments of each property following disasters. This reassessment process eliminated our ability to use just tax value as indicators of damage or rebuilding, because the tax value was not indicative of actual damage sustained.

A resident of West reported to us that in the first few days following the explosion, and on the heels of the terrorist attack in Boston, the federal government requested Google to conduct a new Street View™ for the city to collect any potential evidence in case this, too, was an act of terrorism (Personal Interview 2014). Google uses a camera on top of a car to collect Street View images. The company has amassed images of buildings as viewed from the street on all seven continents.[1] Google did the new imagery of West within two to three days of the explosion. We used this opportunity to download three images of 389 structures located in zones 2 and 3, the most heavily damaged zones. These images included a left view, center view, and right view of the structure. We removed public buildings from our sample to focus on housing and also removed the one apartment building, which was totally destroyed and has not been rebuilt. We also encountered some issues related to data collection via Google Street View. First, there were several time hops, in which the image on Google "hops" from one time period to another with a slight movement of the mouse (Curtis et al. 2013). Some houses were only viewable for June 2013, and had already been demolished by then; others were only viewable for 2008 before the ex-

1 See: https://www.google.com/maps/streetview/understand/.


Image 2. Recovery Score Examples, 1 top left, 2 top right, 3 bottom left, 4, bottom right.

plosion. Other homes were blocked by trees or trucks. We ended up with useable images from 351 houses in West. In June 2014, we used a Digital SLR camera and took the same photos again to document how much rebuilding had reoccurred. We have images from 2015 and 2016 as well, and we are undertaking a longitudinal analysis.

To assess the damage to the parcels, we adapted methods used by Curtis and Fagan (2013) for assessing tornado damage. The Tornado Injury Scale (TIS) is used to understand the risk of injury or death for a person in structures of various damage levels, ranging from 0 (no damage) to 9 (complete structural collapse). We scored the images separately and then conducted inter-rater reliability tests that showed very high correlation between our ratings. Image 1 (see page 13) shows selected levels of damage.

For the photos from 2014 (above), we used the recovery scale from Curtis, Duval-Diop, and Novak (2010), which is similar to that used by Burton and colleagues (2011) to assess rebuilding rates at Year 1: 1) Damaged structure remains, 2) Cleared lot, 3) Emerging structure/ construction underway, 4) Completed structure.

## Distance Matters for Damage

The majority of structures within our sample received damage scores of less than 4, as shown in Figure 1. In fact, 21 percent of the structures showed no visible damage in the Street View images. Reviewing Map 2 (page 15) of the location of structures by damage score shows the expected pattern of greater damage closer to the fertilizer facility. The most extensive damage seems to have occurred within 0.2 miles of the facility.

To assess this visual result, we used ordinal regression to predict damage score based on distance from the facility (in 0.1 mile increments) along with structure age and value. Ordinal regression is a statistical technique designed specifically for variables that are ordered scales, such as the damage scale that ranges from 0 to 9. It allowed us to determine what independent variables explain variation in damage score. Because socioeconomic data is not avail-

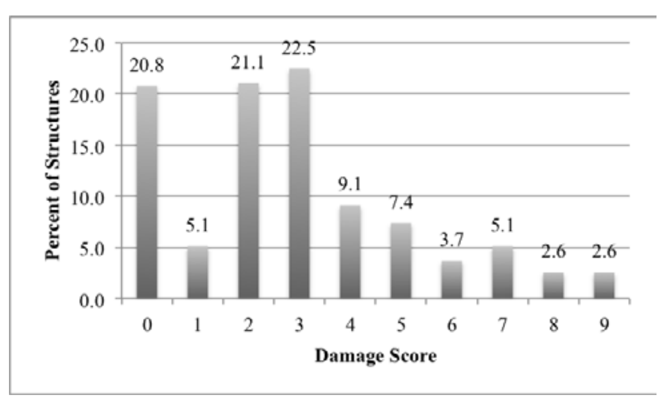



Figure 1. Percent of structures damaged (n = 351)


Map 2. Map of Parcels with Damage Scores and Distance from Explosion


Map 3. Map of Parcels with Recovery Scores and Distance from Explosion

able for individual households, we use housing value as a proxy for economic assets. Although this is an imperfect indicator of resources that households may have, houses are primary components of wealth in the U.S. and housing value does correlate with income. Distance from the facility had a statistically significant effect on damage score, while neither structure age nor value did. Specifically, for each 0.1 mile farther from the facility, the odds of increasing one point on the damage scale were reduced by more than 60 percent.

## Price matters for recovery

We completed the same analyses for the photos taken at Year 1. In our sample 66 percent of the houses were fully rebuilt within one year of the explosion. Only 4 percent still had visible damage in 2014. Nearly one-fifth of all houses assessed had been demolished but no rebuilding had begun. Looking at Map 3 of recovery scores, no clear pattern has emerged showing where rebuilding is happening and where it is not.

Again, we used ordinal regression to predict recovery scores based on damage level, structure value, and structure age. Comparing damage score to recovery score alone, we did find that structures with more damage were less likely to have higher recovery scores, as we predicted. But, this model of damage alone did not explain much variance in recovery scores, meaning that damage was a poor predictor of recovery scores.

Instead, structure value before the explosion was the best predictor of recovery score. Each $10,000 increase in assessed value increased the odds of a 1-point higher recovery score by nearly 50 percent. Age of the structure, on the other hand, had little effect on recovery score. These results confirm our hypotheses that characteristics of the house (and potentially household) are better predictors of recovery than damage alone.

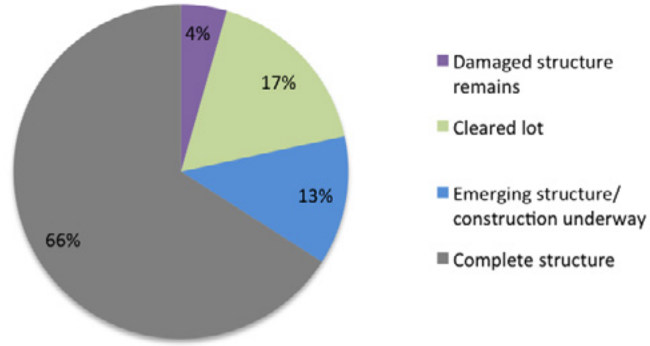



Figure 2. Rebuilding Year 1.

## Will we learn from West?

Our results suggest that land-use controls limiting development near hazardous facilities are crucial to reduce damage, and that even small buffer zones can reduce damage from an explosion. In this case, each one-tenth of a mile from the explosion dramatically reduced the damage to houses. Thus, tighter limitations on development that provide a buffer of at least a half mile around the facility could have eliminated a large proportion of the damage in this disaster. For other communities, determining the contents and potential explosion area will aid in setting buffer zones around hazardous facilities to reduce impacts from future technological disasters, as well as to develop evacuation plans and better insurance coverage for houses near these facilities.

We expected this conclusion. Land-use controls and zoning are notably absent in many Texas communities, and numerous urban planning experts have placed blame on the zoning inadequacies for this explosion, just as they did with the Texas City explosion 66 years earlier.

**Buffers may be even more important in low-income areas where homeowners will have a tougher time rebuilding on their own following an incident**

Understanding the layers of regulations (city versus county versus state) is important for better future coordination of buffer zones and development decisions. The West Fertilizer Company facility was built prior to development in the area and was outside of city limits. That meant it reported to and was under land-use regulation from the county rather than the city. Because of this issue, the City of West could not regulate the facility itself and lacked control over emergency management protocols that involved the facility. This lack of coordination was problematic in that people living and working near a facility could not fully grasp the risk and then demand accountability.

Although distance from the plant was the most significant predictor of damage, housing value in 2013 was the strongest predictor of rebuilding at year 1. More expensive houses were more likely to have higher recovery scores, and some houses farther away from the explosion with limited damage remained damaged one year later. A buffer would reduce major damage, but distance is less important in predicting rebuilding following an event. One conclusion we have reached is that buffers may be even more important in low-income areas where homeowners will have a tougher time rebuilding on their own following an incident. Our results show how economic status affects homeowner disaster recovery and confirms results from research in large disasters, such as Hurricanes Andrew, Katrina, and Ike that show disparities in recovery based on pre-existing social and economic characteristics. But our analyses add the layer of socioeconomic status to rebuilding from technological disasters and in rural communities, both of which are understudied. Without the ability to use Census data to determine variation of recovery by neighborhood, the use of parcel characteristics and visual damage and recovery assessment provide a way for future research and for community planners to understand social vulnerability consequences for disaster recovery in small or rural areas and more accurately describe the individual impacts and losses from disasters.

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Please send items of interest to
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L: Black Tom Island, lying off a Jersey City pier, Public Domain.
R. Black Tom explosion Jersey City © National Archives, 1916

# 100 Years of Terror

## The Black Tom Explosion and the Birth of U.S. Intelligence Services

By Elke Weesjes, with Phil Nerges

JULY 30, 2016, marked the 100th anniversary of the Black Tom explosion in Jersey City, New Jersey. The violent blast, one of the largest explosions on U.S. soil, occurred on Black Tom Island, a peninsula jutting out into Upper New York Bay situated across from the Statue of Liberty. The explosion, which decimated nearby neighborhoods within a five-mile radius, was caused by a number of fires at the island's munition depot, where barges and railroad freight cars were storing significant amounts of ammunition and dynamite to be sent to Entente powers in Europe. The explosion was at first believed to be an accident. Local officials quickly blamed the Lehigh Valley Railroad, which owned the facility where the incident occurred. However, three years later, after piecing together evidence that pointed at German sabotage, investigators concluded that that the explosion was not accidental after all (King 2011; Roberts 2016).

Some historians consider the explosion—measuring up to 5.5 on the Richter scale and, as such, 30 times more powerful than the collapse of the World Trade Center 85 years later—as the most destructive terrorist attack on U.S. soil until that fateful day in 2001 (King 2011; Roberts, 2016). Nevertheless, not many people have heard of the Black Tom explosion. Fewer events, however, have had a greater impact on the creation of federal agencies charged with national security.

At the time of the Black Tom blast, the United States was still officially neutral in World War I. There were no federal statutes that addressed peacetime spying or sabotage by foreign nations, nor were there any agencies that possessed the structure or resources to protect the country from attacks of that type. All of this changed after Black Tom. Laws related to spying and espionage were introduced; the most prominent being the Espionage Act of 1917. Furthermore, intelligence agencies, such as the Bureau of Investigation (later renamed Federal Bureau of In-

Wrecked munition barge and other ruins caused by explosion of munitions on Black Tom Island, New Jersey © National Archives, 1916


Shop on Warren Street guarded by two police men. This is one of hundred of shops in Lower New York City which had its windows shattered by the explosion of a carload of dynamite and 100 carloads of ammuniction and shrapnel for the entente Allies. Policemen were placed on guard to prevent looting. © National Archives, 1916

vestigation) and the Secret Service, were restructured to combat the enemy within.

Today Americans—who live under the near-constant threat of terrorism—rely on these agencies and the laws implemented to stop foreign conspiracies.

## War profiteering and German retaliation

The British Royal Navy blockaded German ports soon after World War I erupted in August 1914, shutting off not only war supplies, but also much needed food supplies for Germany and Austria. Exports from the United States to Great Britain, France, and Russia continued in spite of Germany's objections. The commerce swiftly transformed the United States from debtor nation status to creditor nation. The transport sector and the steel and chemical industries prospered creating an economic boom that lasted through the war's end (Witcover 1989).

On February 4, 1915, locked in a fight-to-the-death battle with the Entente powers, Germany launched unrestricted submarine warfare against all allied-bound vessels to stem the flow of munitions. It also started sabotage efforts[1] on American soil. German agents placed small cigar-shaped firebombs on Europe bound vessels, intended to ignite after the ship departed port. A series of accidents at sea occurred, damaging munitions and other cargoes. However, without a national intelligence service, these acts were investigated separately by federal, state, and local authorities. Initially, none of these authorities had the power or the resources to make connections between these sabotage efforts and the perpetrators got away unscathed. As such, the United States' neutrality was maintained and the public refrained from taking sides in the conflict (Warner 2007).

Public opinion in the United States on the war changed almost overnight in May 1915, when a German U-Boat off the coast of Ireland torpedoed the British passenger liner *Lusitania*.[2] Of the 1,962 passengers, 1,198, including 128 American citizens, lost their lives. The brutal attack turned the American public against Germany and angered President Woodrow Wilson. Still, he refused to declare war on Germany.[3] Instead, Wilson immediately contacted Secretary of State Robert Lansing to have the Secret Service—which until then was only concerned with combatting counterfeiting and protecting the president—investigate espionage in the United States. A few months later, in 1916, Lansing founded the Bureau of Secret Intelligence. The aforementioned secret service agents, who were tasked with the surveillance of German diplomatic personnel at the Germany Embassy and the German consulate office in New York City, were transferred to this new bureau (United States Department of State, 2011).

Furthermore, the New York Police Department Bomb Squad[4], under leadership of New York City Police Department inspector Thomas J. Tunney, was also instructed to turn its focus on foreign agents. Not much later, in early 1916, the Squad rounded up a number of German saboteurs in New York and New Jersey who were subsequently indicted in August of that year. The arrest briefly halted the cigar bomb campaigns on ships, but the men in question were quickly replaced and the campaign restarted with vigor. In addition, a small team of German agents shifted their targets from ships carrying war materiel to munitions factories and storage depots.

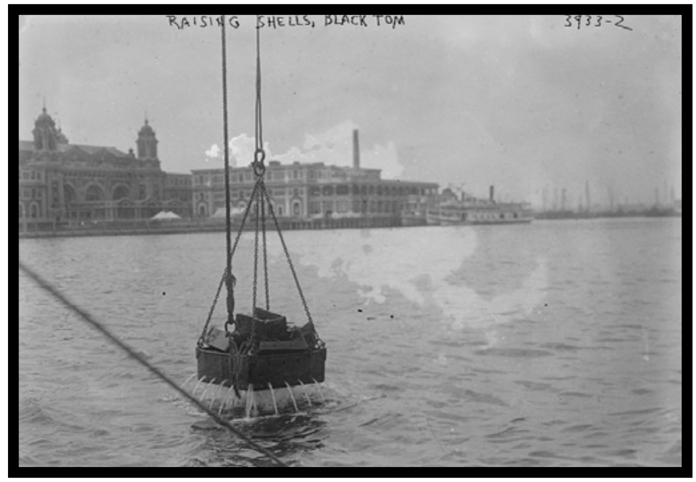
1 In 1914, the German government gave Count von Bernstorff, the German ambassador in Washington, $150 million to limit the shipment of munitions to the British and the French. Since munitions couldn't be transported safely to German ports, this money was largely invested in sabotage operations. Hiding behind his diplomatic role, Von Bernstorff became Germany's chief of espionage and sabotage in the Western Hemisphere (Witcover 1989).

2 In 1915, the British (much to the United States' discontent) put foodstuffs on its contraband list and subsequently seized the cargo of the *S.S. Wilhelmina*, an American ship carrying a cargo of foodstuffs to Hamburg. In retaliation, the German admiralty declared a "war zone" around the British Isles in which "any enemy merchant vessel found would be sunk by the new and terrible weapon, the armed submarine" (Witcover 1989). The *Lusitania*, on her way from New York to Liverpool, was torpedoed on the day she was scheduled to arrive.

3 President Wilson was adamant to maintain neutrality. Even when the public opinion turned against Germany after the attack on the *Lusitania*, Wilson continued to see nonintervention and nonbelligerency as essential to his role as the world's peacemaker. This stance is underlined by the slogan he used during the 1916 elections, "He Kept Us Out of the War."(Witcover 1989).

4 The New York City Bomb Squad was created in 1905 to deal with anarchist and immigrant crime groups that operated in New York (Witcover 1989).

Bomb suspects indicted August 1916 © National Archives, 1916



Raising shells after the Black Tom explosion © National Archives, 1916

Their attention focused on one of the largest ammunition stockpile outside of Europe, the National Dock and Storage facility on Black Tom Island. Surprisingly the site, a rail-to-ship terminal, was unfenced, easily accessible from land or water and virtually unguarded (Witcover 1989, Milman 2006).

The German agents tasked with infiltrating Black Tom recruited Michael Kristoff, a 23-year-old Austrian immigrant who worked for the Tidewater Oil Company in Bayonne, New Jersey, not far from Black Tom. Kristoff—a familiar face around Black Tom who would not have a problem walking past the guards—was described as slow-witted, gullible, and eager to stop the war. Because he could be easily controlled, along with his belief in the cause, Kristoff was exactly the person the agents needed for the job (Witcover 1989).

The night of the Black Tom explosion, nearly 70 railroad freight cars loaded with two million pounds of munitions were awaiting shipment to Europe. Nearby, a barge, the Johnson No. 17 contained 100,000 pounds of dynamite. Shortly after midnight, Kristoff, accompanied by two other more seasoned saboteurs named Kurt Jahnke and Lothar Witzke, placed explosives on the barge and freight cars. They then left the way they had arrived: Kristoff left by foot and the two other men by boat. It took about 20 minutes before the explosives went off and created a fire. By the time the Jersey City Fire Department pulled up at 1:20 a.m., the fire had developed into an inferno and the fire fighters were unable to get close enough to do anything. They stood by helplessly as more cars and vessels caught fire. At 2:08 a.m., the entire barge load of dynamite exploded and shook the surrounding area.

"The shock was so great that I was thrown off my chair into the hall and the broken glass fell in showers upon me as I lay on the floor," Owen Fitzpatrick, a telephone operator who was working on Ellis Island that night, told *The New York Times*. "Four shells of three-inch caliber fell on the gravel path in front of the main door and another shell passed through the roof of the coals bunker attached to the power house" (*The New York Times*, July 31, 1916).

The first blast shattered windows of buildings in a five-mile radius, including nearly all buildings in Jersey City, and much of Brooklyn, Manhattan, Hoboken, and Bayonne. Another massive explosion followed at 2:40 a.m., raining shrapnel on the fire fighters who were still present at the site (Millman 2006). The explosions caused mayhem and panic throughout the New York City and Jersey City area.

Considering the sheer force of the blasts, fatalities were miraculously low: The official death toll held at five. However, according to Millman (2006), "there had been hundreds of people living on barges just northwest of Black Tom—immigrants, vagrants, and the poor—and that dozens of them surely should be counted among the dead." Property damage was catastrophic, totaling an estimated $20 million (Millman 2006), the equivalent of nearly $460 million today.

On September 2, 1916, Tunny, one of the few who suspected foul play, arrested Kristoff. Unfortunately he was unable to make the charges stick and was forced to let his main suspect go (*The New York Times*, July 6, 1921).

## Accident or sabotage?

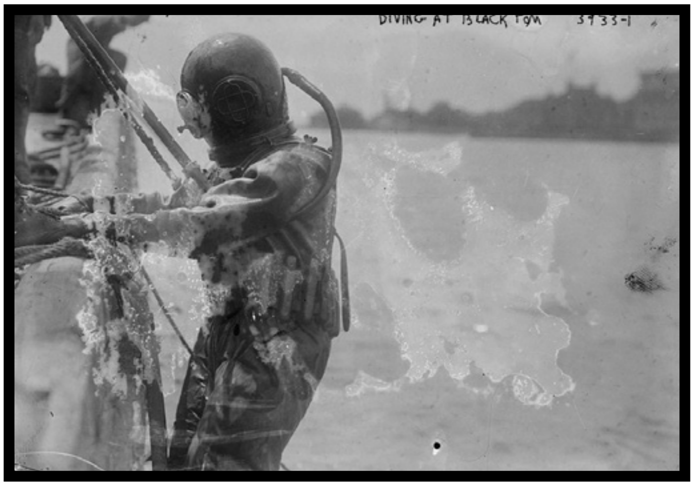
Just a few months before the Black Tom explosion, the NYC bomb squad arrested nine Germans who were charged with "conspiring to set on fire by means of incendiary bombs munitions ships playing between this port and Europe" (*The New York Times*, April 29, 1916). The subsequent trial made it clear that it was the group's ingenious cylinder-shaped cigar bombs that were responsible for what had been—up to that point—considered mysterious fires and explosions that had occurred on merchant ships.[5]

In light of these developments, it might come as a surprise that only a few people thought the Black Tom explosion was an act of sabotage. Most thought it was just another accident. After all, it wasn't the first time that human negligence caused a devastating blast.[6]

Assuming a similar act of carelessness led to the Black Tom explosion, local officials and the newspapers generally assigned responsibility to the Lehigh Valley Railroad,

5 The biggest breakthrough in the investigation of the mysterious fires on merchant vessels came when a British Captain of the *S.S. Kirk Oswald*, found the unexploded bombs on board after traveling from Brooklyn, NY to Marseille. Because the route of the ship was changed last minute, it had arrived at its destination before the devices could explode (Witcover 1989).

6 In 1911, not far from Black Tom Island, a carelessly tossed cigarette caused a massive explosion while dockworkers were unloading explosives and detonating caps from a steamer at the Communipaw dock no. 7 in Jersey City Harbor. Ten people were killed and damages were estimated to be $250,000 (Report on Explosion at Communipaw 1911).




Raising shells after the Black Tom explosion © National Archives, 1916


Recovered shells after the Black Tom explosion © National Archives, 1916

the National Dock and Storage Company, and the Interstate Commerce Commission, the governmental branch charged with the formulation of regulations for the safe transportation of explosives and other dangerous materials by land.

After the Black Tom explosion journalists and residents questioned if these regulations could actually protect the public from catastrophe. Only days after the incident, a concerned President Wilson sent commissioner Edgar E. Clark of the Interstate Commerce Commission to New Jersey to conduct further investigations. In the subsequent report to the president, Clark declared that no evidence had been found of violation of Federal laws (*The New York Times*, August 5, 2016).

In this context, it is important to recognize that the Interstate Commerce regulations only apply to the packing and safe transportation of explosives. Storage facilities, railroad yards and freight terminals had to follow state regulations[7] (*The New York Times*, August 1, 1916). In the case of Black Tom, storage facility owners violated several regulations. For example, on the night of the explosion, loaded freight cars were in the railroad yard when they weren't supposed to be. Witcover (1989) writes that the workload was so backed up that it took up to a week before cargo was loaded from cars onto barges that in turn transferred their loads onto ships waiting offshore in the harbor.[8] The parties in charge of the Johnson No. 17 barge also violated safety regulations. According to a 1922 report by the *Atlantic Reporter*[9], "the barge had been moored to the pier for the purpose of taking on a load of explosives." However, "before it was entirely loaded the workday had ended and the barge was left there until the following morning for the purpose of having the loading completed" (*Atlantic Reporter*, 1922). It was against the law to keep a loaded barge docked overnight (Witcover 1989).

7 During the safety debate that followed the Black Tom explosion *the New York Times* revealed that down to the shore line the regulations were "many and minute" designed to cover every phase of the movement of explosives. Yet once this dangerous freight is loaded from the pier on lighters, the authority of the Interstate Commission and the State comes to an end. (*The New York Times*, August 1, 1916).

8 The intensification of the German U-boat campaign had slowed down the actual transport, but the demand for munitions was greater than ever. As a result freight bottlenecks such as the one at Black Tom occurred.

9 The Atlantic Reporter is a regional case law reporter.

## Debating public safety

The Black Tom explosion ignited a short-lived public safety debate.[10] Jersey City made a particularly bold move and attempted to stop all shipments of explosives in or from Jersey City (The Commercial and Financial Chronicle, August 5, 1916). The embargo, which was enacted on August 3, 1916, was lifted only a week later. The judge ruled that there can't be two sources of power to regulate the same thing, according to *The New York Times*. He said that control of interstate commerce is vested exclusively in the Federal Government through its proper agent, the Interstate Commerce Commission.

In response, the Jersey City Public Safety department agreed to obey the injunction and would not interfere in the passage of explosives through the city. However, Jersey City would prevent the storage of explosives in the city and would make sure that any shipments hauled into Jersey City were immediately transferred to ships in the harbor or to points outside the city limits (*The New York Times*, August 11, 1916).

While efforts like Jersey City's are admirable, a fire at the Canadian Car and Foundry Company plant in Kingsland, a town located only a few miles northwest of Black Tom Island, showed that more systematic action was needed to keep the public safe.

After the outbreak of World War I, the Canadian Car and Foundry Company had secured major contracts with Russia and England for delivery of munitions, in particular artillery shells. To fulfill these contracts, the Montreal-based company built a large factory in New Jersey.

Following the Black Tom Island explosion (while most thought it was an accident, there were some rumors the incident was caused by arson), the plant owners tightened security and constructed large fences. Unfortunately, these measures did not protect the plant from an inside sabotage job. The same German agents that recruited Kristoff ensured that Theodore Wozniak—a Pole from Austria who sympathized with the German cause—got a job on the factory line. On January 11, 1917, Wozniak started a fire while at work. The impact of his actions was disastrous: An es-

10 Several initiatives addressed improving public safety, however, it is unclear which were successful. While newspaper articles discuss short-term embargoes, the introduction of tighter laws, and other efforts, long-term analysis is lacking and more research is required.

Kingsland, New Jersey, Explosion. Wretched kitchen of the Lackawanna Hotel, Kingsland, N.J. The havoc was caused by the great explosion which occured at the Canadian Car and Foundry plant at Kingsland. The photo shows a hole made by a shell in the wall of the kitchen.© National Archives, 1917

Kingsland, N.J. Munitions Plant Explosion. Photo shows the hill which is said to have been the only thing that saved the N.J. towns of Kinsland and Rutherford from probable destruction by exploding munitions from the ammunition factory which blew up. © National Archives, 1917

timated half-million artillery shells burst into the air as the fire swiftly spread through the plant. Fortunately the shells were not yet fitted with detonators, if they had, the shells would have exploded as soon as they hit the ground. Perhaps because of this, not one of the 1,400 workers was killed or seriously injured (Witcover 1989). The damage, however, was severe—estimated at $17 million (the equivalent of $320 million today). In addition, about 1,000 people in the town of Kingsland were forced to evacuate (*The New York Times*, January 12, 1917).

Similar to the Black Tom explosion, there was little speculation that the Kingsland fire might be the work of saboteurs. *The New York Times* reported it as an accident. Its headline read "No Hint of a Plot – Fire Believed to Have Started from a Spark." The investigation that followed quickly pointed at Wozniak, but he claimed it was an accident[11] and it was difficult to prove otherwise.

While the public didn't seem too concerned about the cause of the two incidents, the NYC Bomb Squad continued its own investigation. Wozniak was arrested in relation to Kingsland but like Kristoff subsequently released because of a lack of evidence. Tunney, who led the Squad, was convinced that Black Tom and Kingsland were more than just accidents, and he was determined to find more evidence to prove sabotage (Millman 2006).

Kingsland was not the only munition plant destroyed by a mysterious fire. According to Warner (2007), between early 1915 and spring 1917, 43 U.S. munition factories suffered explosions or fires of mysterious origins, including the Hercules Powder Plant in Eddystone Pennsylvania. The plant went up in flames just three months after the Kingsland fire, killing more than 100 workers, mostly women and children.

## Wilson gives in

The intensified U-boat campaign had already poised U.S. public opinion against Germany, but the final straw that even Wilson the champion of neutrality could not ignore came in the form of a telegram that was sent by Foreign Secretary of the German Empire Arthur Zimmermann on January 11, 1917. The so-called Zimmerman Telegram—in which the German Foreign Office promised Mexico its lost territory in Texas and the Southwest if it would attack America—was intercepted and decoded by British Intelligence (Witcover 1989).

Unable to maintain his neutral stance any longer, President Wilson instructed Congress to declare war on Germany on April 2, 1917. This decision accelerated the organization of the country's counterintelligence agencies. Immediately after the declaration of war, the Attorney General instructed the roughly 400 agents within the Bureau of Investigation[12] to focus on espionage and acts of sabotage. The U.S. army followed suit by increasing its small Military Intelligence Division; it hired detectives from the NYPD Bomb Squad (Warner 2006).

Only weeks later, on June 15, a major piece of legislation that remains the basis of modern espionage statutes was passed--the Espionage Act. This act made it a federal crime, punishable by death or life imprisonment, to "convey information with the intent to interfere with the operation or success of the armed forces of the United States or to promote the success." The Sedition Act, a set of amendments to the Espionage Act, was passed in May 1918. The latter act made it a federal crime to "willfully urge, incite, or advocate any curtailment of the production of materials necessary for the war effort" (Dixon 2016).

The passage of these two acts seems to have abruptly quelled the debate over public safety that followed the Black Tom explosion. A plausible explanation is that under these acts protests, such as obstructing freight trains containing munitions from running through a city, became a federal crime. Also, patriotism most likely trumped public safety. Rather than worrying about the safety of residents living in the vicinity of munition plants and storage facilities, Americans shifted their focus to their boys and brothers fighting in Europe.

11 German agents had paid two Italian factory workers to testify sparks came off the machine Wozniak was operating (Millman 2006).

12 The Bureau of Investigation was established in 1908. At the time there were few federal crimes and it focused primarily on violations of laws involving national banking, bankruptcy, naturalization, and land fraud.

## Justice served (eventually)

After the war, the investigation into Black Tom and Kings land continued. The NYPD and local New Jersey Police departments assisted by federal agents, focused primarily on Michael Kristoff, who had told two witnesses that he was involved in the Black Tom explosion. As mentioned before, Kristoff was arrested but released for lack of evidence. He disappeared and reappeared twice. In both cases he resurfaced because he was arrested for larceny. Police officers attempted to get more answers out of him about Black Tom, but Kristoff would not talk. He eventually died of tuberculosis and was buried in a local potter's field. Similarly, detectives were unsuccessful gathering other evidence that would attest Lothar Witzke and Kurt Jahnke's involvement. In fact, they had a hard time proving anything: All they had were testimonies by unreliable witnesses and circumstantial evidence (Witcover 1989).

In the aftermath of World War I, a peace treaty between the U.S. and German governments was signed in Berlin on August 25, 1921.[13] One of the treaty's provisions was the creation of a bilateral commission governing claims of the United States and its nationals against Germany arising out of the war. This so-called Mixed Claims Commission blew new life into the unsolved cases of Black Tom and Kingsland. Unfortunately, whereas most other claims were quickly resolved, the ones related to Black Tom and Kingsland remained open because they warranted evidence that could prove the allegations of sabotage and German complicity.

It would take another 18 years of exhaustive investigations by more than 40 insurance companies, countless detectives, and a small army of lawyers before the Mixed Claims Commission was finally convinced that the incidents on Black Tom Island and at Kingsland were indeed caused by acts of German sabotage. On October 30, 1939, the Commission decided that Germany had to pay up.

But that was not the end of it (Witcover 1989). As World War II raged through Europe, the court fight about the awards money dragged on. It wasn't until February 1953, after Kristoff, Jahnke, and Witzke were long dead, when, during a postwar conference in London, the United States and Germany reached an agreement that the German government would pay $97,500,00 in awards to the victims of acts of sabotage. This number included $50 million to plaintiffs in the Black Tom explosion. The final installment was completed in 1979 (*The New York Times*, February 27, 1953).

## Legacy

The attack on Black Tom Island and other acts of German sabotage, such as the Kingsland fire, were devastating. But they also left a positive legacy. Notably, they informed the much-needed creation of domestic intelligence agencies. By the time World War II started, the United States had a well-trained corps of agents to fight the enemy within, the Secret Service was a major intelligence force, and the Federal Bureau of Investigation was the lead agency for investigating and preventing acts of domestic and international terrorism.

13 The reason for this separate peace treaty was the fact that the U.S. Senate did not ratify the treaty of Versailles.

The impact of Black Tom on public safety legislation was less apparent, but still a factor. Without the public safety concerns raised by the incident, much of the work of untangling overlapping laws and jurisdictions—and determining exactly which governments are responsible for American's wellbeing—would have been delayed.

The recent terrorist attacks in the United States are a good opportunity to pause and remember the Black Tom explosion and its legacy. Today more than ever, terrorists are testing the national security framework that was created in the explosion's aftermath. The United States has gotten safer in the past 100 years, yet some issues—such as the tension between national security, public safety, freedom of speech, and the rights of citizens to question government and industry activities—remain relevant as ever. The United States continues to be trapped in a vicious cycle of terrorism and heavy handed counter terrorism.


### Acknowledgement

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# MONEY MATTERS

## Rapid Post-Earthquake Financial Decision-Making

By David Wald and Guillermo Franco

POST-EARTHQUAKE financial decision-making is a realm beyond that of many people. In the immediate aftermath of a damaging earthquake, billions of dollars of relief, recovery, and insurance funds are in the balance through new financial instruments that allow those with resources to hedge against disasters and those at risk to limit their earthquake losses and receive funds for response and recovery.

Many of these mechanisms, such as catastrophe bonds (also called CAT bonds), have come to rely on near-real-time (NRT; typically minutes to a few hours) earthquake information that allows those affected by the consequences of a disaster to quickly access financial capital.

NRT products had been routinely used for situational awareness, to support response and facilitate aid, but the evolution of these innovative post-earthquake financial decision-making tools is expanding the usage of NRT information. This is obviously important for those who generate NRT earthquake alerts and it should also be of interest to those in the earthquake hazard and risk community. Such financial strategies can have significant benefit for stakeholders: They facilitate risk transfer, foster sensible management of risk portfolios, and assist in disaster response and recovery. Making funds available for at-risk populations also provides opportunities for investors who benefit from financial diversification.

Today, three general categories of post-earthquake financial decision-making benefit from detailed NRT earthquake hazard input: (1) Rapid damage assessments that guide disaster response and aid deployment; (2) estimation of monetary loss to a portfolio of industrial, commercial, or residential exposures to guide the claims adjustment process; and (3) the triggering of so-called parametric transactions—insurance instruments that rely on the physical measurement of event characteristics to determine if the insured party receives compensation and how much. Here, we focus on these latter two categories.

### Earthquake Insurance Strategies

As new financial instruments in earthquake risk mitigation have become available in the last several years, the U.S. Geological Survey (USGS) received more inquiries regarding the accuracy and usage of NRT tools. These inquiries prompted questions about how these financial instruments work and how they interact with NRT earthquake information, and call for an attempt to further link the scientific and business communities operating in this field. As a first step, we set out to provide a brief overview of existing insurance and alternative risk-transfer strategies that make use of NRT earthquake information systems.[1]

Earthquake insurance and related instruments play an important role in risk transfer. These mechanisms complement more direct forms of risk mitigation such as stricter building codes or improved infrastructure. Such policies may cover damages to the built environment, injury, casualty, and business interruption. Both private individuals and companies purchase insurance products to protect their assets. In doing so, they cede their risk to an insurance company, which acts as a risk aggregator that diversifies risk across the population. Insurance companies, in turn, may choose to cede risk to global reinsurance companies, thus providing further diversification. Naturally, the most well-known providers of insurance services are insurance companies. However, the availability of insurance-linked products arising from the capital markets has been growing in the past few decades (Artemis, 2016).

Insurance-linked securities (ILS) serve as a vehicle for investors unfamiliar with the insurance sector to market and deploy de facto insurance services. They attract institutional and private investors because they often have

1 This article is a synopsis of a longer article by Wald and Franco (2016) aimed at the earthquake engineering community. Franco (2015) provides a comprehensive background of insurance-related earthquake mitigation strategies.

higher yields and provide diversification. Additionally, according to Artemis (2016): "Investors are looking to the ILS market as a new socially and societally responsible investment category, as an asset class that provides essential disaster risk capital after major impactful regional catastrophe or weather events, thus enabling a greater ability to recover from disasters."

In this context, CAT bonds (a form of ILS) allow capital markets instead of governments to take on the risk of disaster financing in exchange for a premium (or spread in the investment lingo). These transactions can also provide capital in the immediate post-event environment (see the 2016 Ecuador earthquake for example, in Fig 1 and 2), not only to maintain cash-flow liquidity and pay claims but also to provide financial stability. The social benefits from such financial pre-planning can also include increased confidence and stability of markets in the immediate aftermath of a shaking-induced financial scare.

CAT bonds account for eight percent of the total global catastrophe reinsurance market (Acton, 2015). As of 2016, the outstanding CAT bond market is more than $26 billion. While indemnity insurance (which provides compensation based on actual loss) is the most common form of insurance in both the traditional and so-called "alternative risk transfer" market (the ILS market), non-indemnity-based strategies including CAT bonds make up a significant fraction. These non-indemnity solutions rely not on assessing actual losses, but on proxies to these losses. For example, rapidly determined magnitude and location parameters or the level of population exposed to areas of strong shaking can serve as a trigger for predefined payouts. As you could image, understanding the potential difference between the payout they generate and the actual losses—referred to as basis risk—plays an important role in setting expectations for the utility of these products.

These new financial strategies were possible largely because of the availability of more rapidly and accurately determined earthquake parameters and more quantitative geospatial hazard information. In addition to providing accurate estimates of magnitude and hypocentral parameters, the USGS earthquake information products now include ShakeMap (Worden and Wald, 2016) and the PAGER global loss modeling system (Wald et al., 2008). These benefit the financial sector because they provide estimates of shaking over the region affected, as well as early estimates of loss.

## Types of parametric triggers

Non-indemnity mechanisms rely on a set of parameters to determine if an event triggers a payment. In the case of earthquake risk transactions, these are usually pre-agreed upon seismic hazard parameters determined by an independent reporting agency (typically the USGS). These parameters are strongly linked to NRT earthquake information systems both in their creation (trigger design) and in obtaining the actual parameters after an event. The immediacy of the parametric triggers and thus their allowance for a quick payout is one major advantage over indemnity-based instruments, which can take months or even years to pay out.

First-Generation (or "CAT-in-a-Box") parametric tools appeared in the early 1990s. These instruments base payments on independently measurable parameters of the physical event—that is, the magnitude of the event and the location of its focus. Their mechanism is extremely simple and that is their main strength: If an earthquake occurs in a pre-determined geographic area and is of a magnitude greater than a set threshold (according to the reporting agency), the instrument generates an immediate payout. They are very simple to set up and for investors and sponsors to understand. Their rapid payout provides financial liquidity and reduces financial uncertainty. Their main limitation is their high-basis risk—the potential gap between payment and the actual losses, since the fundamental parameters of an earthquake might only loosely correlate to the losses that follow. This can be perceived as an advantage since it allows the sponsor (the party who issues the bond) to get financial coverage for losses that are hard to predict and quantify, such as business interruption, and demand surge.

### Example 1:

The recent $200 million Acorn Re 2015-1 CAT bond is a western United States parametric trigger-based earthquake bond that provides coverage for Kaiser-Permanente (Artemis, 2016) for three years. Parts of British Columbia, northern Mexico, and seven western states are in the coverage area, but most of the exposure is in California. The geographic area is divided into one-degree (~110 km2) boxes to distinguish events according to their location and magnitude; it has four severity levels triggering variable event-loss percentages. For example, for the Cascadia subduction zone, magnitudes of 8.2, 8.5, 8.7, and 8.9 trigger 25 percent, 50 percent, 75 percent, and 100 percent coverage, respectively.

Second-Generation Parametric triggers allay some of these high-basis risk concerns by considering hazard intensities distributed among a series of locations near exposed assets, rather than the overall characteristics of the event. Parameters frequently used for these transactions consist of recorded or inferred ground motions. Cases in which there is high uncertainty in the exposure distribution could favor first-generation approaches, where areas that have reliable seismometer networks and well-known exposure could benefit more from second-generation approaches (Franco, 2015).

Second-generation parametric CAT bonds typically use shaking values from ShakeMap, or from proximal observed ground motions to establish the value of the index after an event. Modeling losses with ShakeMap input for parametric triggers is now standard operating procedure. For earthquakes, other parametric index-based triggers can, for example, be based on the ratio of the population exposed to a predefined shaking intensity level compared to the total population of the country (Fig. 2). Such an arrangement would ensure financial coverage for any earthquake for which significant pre-agreed upon measures of shaking levels affect some fraction of the country's population. The main benefit of such triggers is that—being direct proxies for shaking, and thus damage—they potentially provide a better correlation between parametric losses and

### Example 2:

The Turkish Catastrophe Insurance Pool (TCIP) combines exposure into a CAT bond that provides three-year reinsurance coverage for Istanbul. The parametric trigger uses recorded peak ground motions from the Kandilli Observatory and Earthquake Research Institute (KOERI) at Bogazici University, the reporting agency. KOERI will provide shaking values for input into a pre-arranged earthquake model, based on strong-motion sensor observations in the Istanbul region. For an event to qualify, its shaking must be greater than 0.1g for at least 10 percent of the calculation locations (Artemis, 2016). As a contingency, if KOERI data are not available after an event, it will source alternative data from the USGS ShakeMap.

### Example 3:

The Inter-American Development Bank (IDB) structures sovereign liquidity guarantees (e.g., contingency loans) for natural disasters in seven Latin American countries. A 72-hour turnaround for indexed coverage calculations allows rapid dissemination of funds without the need for ground-truth assessments. The indexed payout of up to $300 million per country avoids the moral hazard associated with reported losses, but the basis risk may be high: ShakeMap shaking estimates are uncertain, and population exposure per intensity level (Figure 2) may not adequately characterize actual losses. IDB Contingent Credit Facility Loan triggering (up to $300 million per country) is based on USGS ShakeMap and uses PAGER population exposure per intensity level published 72 hours after a significant event (J. Martinez, IDB, oral communication, 2015). Loans are initiated for an earthquake with an intensity MMI-VI or greater that affects at least two percent of the population within the coverage area (Figure 2). On April 20, 2016, IDB activated a US$300M credit line to support the Ecuadorian government with losses and emergency expenses (ReliefWeb, 2016).

actual losses than first-generation triggers that are based on magnitude and hypocenter alone.

Although the parametric triggers described portray the strongest link to NRT information systems, there are other types of triggers that also leverage NRT data in less direct ways.

Modeled-Loss triggers, for instance, are derived from calibrated catastrophe models. Payouts are based on modeled losses simulated using these models and NRT earthquake information. All inputs (e.g., earthquake parameters, shaking prediction equations, causative faults, and observed shaking constraints) are carefully vetted and agreed upon in advance, and then NRT information is used to identify the modeled event that most resembles the actual event (or, in some cases, a new synthetic event may be built within the model to represent the actual event). To model potential loss values and set coverage rates, exposure estimates are required. Like parametric triggers, modeled-loss triggers can be settled relatively quickly (in weeks) since the input parameters are rapidly available.

## Summary

While it is difficult to quantify precisely (because not all transactions are public), billions of dollars of relief and recovery funds already rely on NRT earthquake parameters.

Figure 1. In Manta, Ecuador, one of the worst affected cities, the entire neighbourhood of Tarqui was destroyed. © European Union/ECHO,2016

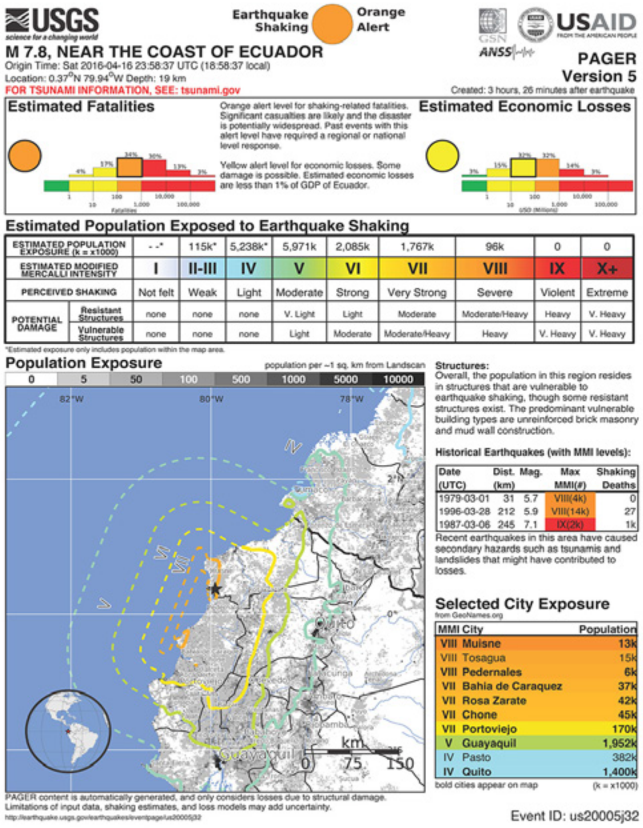


Fig. 2 – April 2016 magnitude 7.8 Ecuador earthquake "onePAGER" loss estimates. Population per intensity level can be used as a trigger for a second-generation CAT bond or as a contingency loan trigger.

Monetary resources available for response and recovery depend in part on these preexisting financial arrangements. A better understanding of the tools of the trade and specific needs of the financial sector could further advance NRT earthquake information systems, which in turn could enhance the development of creative financial instruments and result in additional beneficial risk management alternatives for at-risk communities.

Discussion and debate of the role of the financial component of earthquake resilience will continue within the community. Healthy insurance mechanisms for disaster financing, arising from the capital markets as well as from the traditional insurance markets—and linked to a strong provision of scientific information—can contribute critical resources for a more holistic community-wide risk-mitigation strategy.

## Example 4.

The California Earthquake Authority (CEA) uses ShakeMap for post-earthquake evaluation of liquidity (solvency) for insured losses to California residential proprieties as well as for situational awareness. CEA guidelines require industry-standard (proprietary) insured loss estimates to report to the governor within seven days of any significant earthquake that affects California (B. Patton, oral comm., 2015). CEA also employs ShakeMap for post-earthquake situational awareness via GIS-layer GeoJSON feeds in the aftermath of earthquakes.

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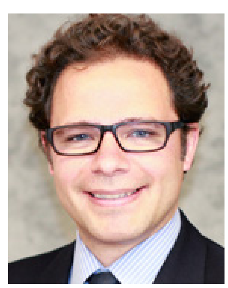
Wald's scientific interests include the characterization of rupture processes from complex recent and historic earthquakes; seismic waveform modeling and inversion; analysis of ground motion hazards and site effects; earthquake source physics; and modeling earthquake-induced landslides, liquefaction, and losses.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# Our Shop

## *Readers explain their Organizations and Projects*


The Havana Pond Dam, City of Denver, Colorado breached and failed on Thursday, Sept. 12, 2013 © USFWS Mountain-Prairie 2013

INFRASTRUCTURE IS, by design, largely unnoticed until it breaks down and services fail. This includes water supplies, gas pipelines, bridges and dams, phone lines and cell towers, roads and culverts, railways, and the electric grid—all of the complex systems that keep our societies and economies running. Climate change, population growth, increased urbanization, system aging, and outdated design standards stress existing infrastructure and its ability to satisfy the rapidly changing demands from users. The resilience of both physical and cyber infrastructure systems, however, is critical to a community as it prepares for, responds to, and recovers from a disaster, whether natural or man-made.

Overcoming these challenges requires communities to strengthen existing infrastructure and build new infrastructure using modern design, next-generation materials, and engineering methods that account for interdependencies.

This is where Argonne National Laboratory comes in. Argonne has established the *Resilient Infrastructure Initiative* to promote strategies for reducing risk to critical infrastructure and designing future infrastructure systems to minimize the consequences of service disruptions. These strategies are highlighted below.

**1. Build infrastructure interdependency computer simulations to design resilient infrastructure systems that minimize the impacts of disasters**

Major hazards, whether natural or man-made directly impact infrastructure and erode the ability to function normally. These effects are exacerbated when the functionality of one infrastructure system depends on other, damaged infrastructure systems. Argonne is developing next-generation models to understand the interdependencies across the four lifeline infrastructure sectors: energy, water and wastewater, transportation, and communications. The creation of a science-based, integrated modeling framework in which two-way interdependencies are explicitly modeled will significantly advance the systems-level understanding of connected systems in communities. It will also identify unknown risks that emerge from such complex systems.

The first *Resilient Infrastructure Initiative* research and development project focused on fully automating and integrating existing energy system modeling tools (i.e., EPfast for electric power (Portante et al. 2007) and NGfast for natural gas (Portante et al. 2011) to anticipate cascading failures and support the analysis of infrastructure interdependencies. Argonne conducted a failure analysis to define how a natural hazard or a human threat would affect energy infrastructure. This failure analysis characterized the initial state of energy infrastructure, which served as an input to the integrated model.

Argonne integrated EPfast and NGfast model capabilities using a data-centric modeling and simulation framework. The two models ran in an iterative process until the results converged. This approach was necessary because of the inherent interdependencies between the electric power and natural gas infrastructures: outages in electric power assets can trigger outages in natural gas assets and vice versa until there are no further failures. Dynamic visualizations of this integrated model depicted the interactions between the electric power and natural gas infrastructures, showed cascading failures, and identified geographic areas, populations, and businesses affected by the degradation of energy infrastructures. In a case study, Argonne's model results illustrated the detailed impacts of an electrical power outage in one state that led to a reduction in natural gas supply in multiple states far from the initial site of the disruption.

The general concept behind the project was to test the possibility of integrating existing infrastructure modeling tools and developing a flexible computational architecture that can integrate new modules with minimal effort. Ultimately, the concepts and computing framework developed in this project will serve as the foundation for future efforts. With a flexible computing architecture, additional datasets (e.g. asset data, hazard data) and modules can be incorporated in a straightforward way with the goal of uncovering unknown, systemic risks.

**2. Create a virtual user facility focused on modeling and data-exchange to improve disaster planning, emergency response, and community recovery**

State, local, tribal, and territorial governments, as well as the private sector (e.g., investor-owned, federal, municipal, and cooperative utilities) could benefit from advanced modeling, computational tools, and technical research and development that advance infrastructure resilience. Argonne's goal is to lead the creation of a virtual user facility focused on infrastructure resilience, available for external use by public and private sector partners to advance scientific and technical knowledge. This virtual user facility will provide a centralized platform with data, models, and tools to help governments, industry, and non-governmental organizations better understand risks to infrastructure across a range of scenarios, as well as the implications of infrastructure system changes. This improved understanding will help infrastructure owners and operators, planners, and communities more effectively allocate limited resources to manage risk.

**3. Develop new materials and technologies to strengthen infrastructure and reduce risk**

In addition to advanced modeling, communities need the technological and physical engineering capabilities to design infrastructure that addresses future threats and the risks they pose. Argonne's goal is to drive development of new materials and technologies through experimentation and simulation. These developments will be a basis for new standards that communities can adopt when they need to rebuild stronger and safer. Argonne's unique facilities and tools, such as the Advanced Photon Source, Argonne Leadership Computing Facility, and Materials Design Laboratory, will propel this research. Examples include, testing the properties of materials under extreme conditions that lead to more robust grid components; designing materials to address failing transportation systems (e.g. bridges and roads); building and deploying sensing technologies to enable real-time situational awareness; and developing and downscaling global climate models to predict the climate change impact by region and gauge climate implications on infrastructure services.

## Benefits

Argonne's work in achieving these strategic goals can provide numerous benefits to a variety of stakeholders.

- Building innovative capabilities to increase community resilience. A challenge of this scale and complexity requires the research and development community to use science to create practical solutions. Argonne's advancements in interdependency modeling allow us to provide decision-makers with user-friendly and technically sound tools to help them effectively allocate resources to infrastructure resilience.
- Making science accessible to local communities and owners/operators to manage risk. State, local, tribal and territorial governments and infrastructure owners and operators need the technical capabilities and assistance for their planning processes (e.g., mitigation, land use, and response) and disaster response and recovery operations. The Resilient Infrastructure Virtual User Facility will streamline delivery of research, models, tools, and technologies to communities, industry, and research partners.
- Advancing materials and technology for resilient design. In addition to modeling capabilities, communities need scientific, technological, and engineering capabilities to help design infrastructure systems based on future risk. Resilient infrastructure design will become increasingly critical as communities experience more intense disasters more frequently and are consequently faced with building and re-building critical infrastructure for near-term needs and long-term resilience.

## Now is the time

Our nation's infrastructure and the public it serves is facing increasing risk from natural and man-made disasters, climate change, deterioration from age, and growing and shifting populations. We can no longer afford to be just reactive. Nor can we design and build infrastructure to withstand future worst-case conditions based on outdated historical records. If we do, infrastructure will be obsolete before it is up and running. We must proactively research, model, redesign, and build the infrastructure of our country for long-term sustainability using the best that science, engineering, and technology has to offer. At Argonne, we aim to do just that—advance the science and technology needed to revolutionize the design of future infrastructure systems. In doing so, science and technology will play a vital role in helping to protect lives and property when disaster strikes.

**Acknowledgement**

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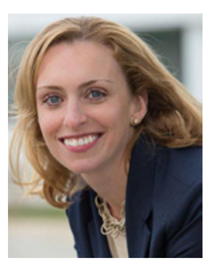

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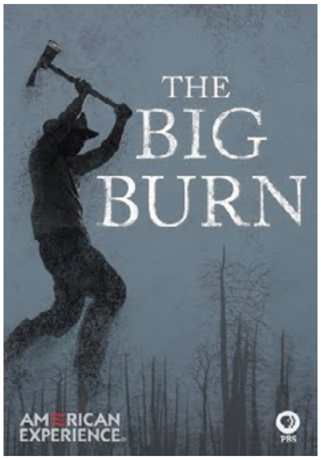


**The Big Burn (2015)**
Length: 60 min
Producer: Amanda Pollack

**By: Elke Weesjes**

This fascinating 2015 documentary is loosely based on American author and journalist Timothy Egan's acclaimed 2009 book *The Big Burn – Teddy Roosevelt and the Fire that Saved America*, which explores the history of the U.S. Forest Service and its response to the Great Fire of 1910, the largest forest fire in U.S. history.

The Great Fire, commonly referred to as the Big Burn, was a firestorm that burned more than three million acres of land in northeast Washington, northern Idaho, and western Montana. It took the lives of 87 people, including 78 firefighters, incinerated seven towns in Idaho and Montana, and destroyed parts of ten National Forests.

Whether the Great Fire has sparked policies that benefit or further damage forest health has been the subject of intense debate. According to Egan, the fire did both. He argues, in his book and in the documentary, that the inferno strengthened the Forest Service (created in 1905) and served as an impetus for the forest protection movement, which President Theodore Roosevelt started. In the long run, however, the policies introduced following the Great Fire of 1910 proved to be detrimental for forest ecology and caused bigger and more powerful fires. *The Big Burn* examines both the short-term as well as the long-term impacts of these policies.

## The birth of the U.S. Forest Service

When President Theodore Roosevelt came into power in 1901 he was especially concerned with the conservation of the nation's forests, a passion shared by his close friend Gifford Pinchot, a dedicated forester and politician. Until that moment the United States government had encouraged the development of open spaces, harvesting timber, industrial mining, and the creation of railroads. Unfortunately, all of this industrial progress had detrimental effects on the country's forests. So much so that Roosevelt and Pinchot were worried that several species of trees would become extinct if they did not act quickly, according to environmental historian Steven Pyne.

"Timber was really a critical industrial product, and we were going to run out, much like an oil crisis in present times," says Pyne in the PBS documentary. "So the solution was to regulate this unsettled land as a public domain that would then be governed by scientific informed bureaus, and this would allow us to conserve it. Not lock it up, but use it in some kind of rational regulated way."

To this effect, the United States Forest Service was created in 1905 much to the discontent of timber and mining magnates, many of whom had seats in Congress and made it their personal mission to slash the agency's budget and staff whenever possible.


A Forest Service fire patrol in 1914 © Library of Congress

Pinchot was named the Forest Service's first Chief and was in charge of an astonishing 200 million acres of forestland divided between ten regions.[1] He subsequently hired rangers for each of these regions. His first hire was William Greeley, who was asked to oversee the Northern Region; nearly 30 million acres, covering Montana, Northern Idaho, North Dakota, Northwestern South Dakota, Northeast Washington, and Northwest Wyoming. In turn, Greeley oversaw 160 rangers who would each be responsible for almost 300 square miles of National Forest.

Their duties were apparently more than just a job. "[These rangers] called what they were doing 'The Great Crusade.' In some ways, it was a religious crusade to them. They were doing God's work to preserve the earth," Egan notes in the documentary.

## The Great Fire

These passionate and energetic rangers soon found out that the mission they felt so strongly about wasn't very popular with the locals they encountered in their regions. After all, "forest rangers were standing in between the frontier mentality and the resource, standing in between what the frontier wants for the moment, and what Gifford Pinchot believes the country needs for the future," says environmental historian Alfred Runte.

While the two camps did not agree on much, there was one common foe—fire.

Fire was particularly feared in those Western mining and ranching towns dotted along the transcontinental railroad. Steam locomotives passing through these wooden towns and surrounding timbered areas caused a significant num-

1 Today there are only 9 regions. Region 7 was eliminated in 1965 when the current Eastern Region was created from the former Eastern and North Central regions.

Seven companies of Buffalo Soldiers, the first African-Americans to serve as peacetime soldiers, heroically tackled and helped contain the Big Burn. © The Museum of North Idaho

ber of fires each year.[2]

Considering the sheer size of the area they were responsible for, Forest Service rangers were not equipped to cope with these fires. Sometimes it would take days before they came across a wildfire and even then they would not know what to do.

The art of firefighting was only in its infancy, says Pyne. "[In case of a fire] you were building what we would call a fire line now. You're cutting a path clearing it of all debris. Some parts say three or four feet would be completely down to mineral soil so no fire could cross. This is just brutal grunt labor."

When a violent electrical storm ignited hundreds of fires in a drought-stricken northern region in July 1910, desperate rangers under Greeley's leadership applied this laborious method to control the inferno. Ed Pulaski, one of *The Big Burn*'s heroes, had joined the Forest Service in 1908. Together with another 159 rangers he was in charge of the disaster stricken region. Aware of their limited workforce, the Service quickly hired an army of mostly immigrants to help rangers fight the fire. Untrained, underpaid, and only equipped with some basic hand tools, many of these newcomers suffered terrible injuries. Others quit or mutinied, leaving the Service desperate for more manpower.

By early August the fire was still spreading. President Taft who succeeded Roosevelt in 1908, sent 4,000 troops to the Rockies, including the 25th Infantry Regiment, also known as the Buffalo Soldiers—the first peacetime all-black regiments in the regular U.S. Army. Although there to help, these black soldiers were initially met with hostility in Idaho, according to Egan. "This is the first time they were ever sent to fight a fire. And they are sent to a very white area, almost doubling the black population of the state of Idaho. And so when this all black platoon comes and sets up camp, people scoff at 'em, people say racist things about them. The newspapers say they play cards and drink all night. They say, 'What can a black man know about possibly fighting a fire?'"

As it turned out, they knew a lot. While sudden hurricane-force winds of 70 miles an hour merged the flames of thousands of fires into one Big Burn, the Buffalo Soldiers evacuated Wallace, Idaho, a town that was encircled by fire.[3] Some 30 miles up the road, in Avery, these brave soldiers started a number of backfires that saved the town from being burned.

While the Buffalo soldiers were evacuating Wallace, Pulaski, accompanied by 44 men, found himself face to face with a firestorm in the hills surrounding Wallace. He kept his cool and led his men to an old mining shaft where they sat out storm. Horribly disfigured but still alive Pulaski was able to bring 39 of his men to safety.

Other firefighters weren't as lucky. In total, 79 firefighters lost their lives.

## From fire suppression to fire management

The inferno was finally extinguished late August by an early season snowstorm. Once the atmosphere cleared, the scope of the devastation became apparent. Three million acres were burned and an estimated one billion dollars

Ranger Ed Pulaski, whose actions saved many lives © U.S. Forest Service

2 Sparks, released by the engines, caused fires. To address this fire hazard legislation requiring spark arresters (mechanical device that traps or destroys hot exhaust particles expelled from an internal combustion engine) was passed in 1905 and applied to engines and boilers operated in, through, or near forest-, brush-, or grass-covered lands (Gonzales 2003).

3 A third of Wallace was burned to the ground with an estimated $1 million (about $25 million today) in damage.


worth of timber had been lost.

The stories of *The Big Burn*'s heroes, the firefighters, the forest rangers, and the Buffalo Soldiers, were published in all the national newspapers, galvanizing support for the Forest Service and National Forests. Even a previously reluctant Congress changed its tune and gave the Forest Service the resources it needed. It doubled its budget and eventually created National Forests in the East.

Thoroughly shocked by the destruction of the fire, Pinchot and his successor, William Greeley (1911), after him became obsessed with putting out fires. They made it the Forest Service's number one priority. This focus on fire suppression was further cemented when the so-called 10 AM Policy. Introduced in 1935, the policy t stipulated that fires must be contained and controlled by 10 o'clock the next morning.

It wasn't until the 1970s that scientists began to realize that fires are needed to maintain a healthy forest ecology. Fires are a natural way for a forest to rid itself of dead or dying plant matter. It replenishes the soil and opens up space for new plants and trees to grow. In addition, there are many plant species in fire-affected environments that need fire in order to germinate or reproduce. Fire suppression eliminates these species and the animals that depend on them. These findings encouraged the Forest Service to abandon its 10 AM policy in 1978 and shift its focus from fire suppression to fire management. Rangers began to use fire to thin out potential fuel sources to prevent another Great Fire.

However, the ecological effects of the policies implemented after the Great Fire of 1910 couldn't be undone. More than half a century of fire obstruction has left the country's national forests more vulnerable to wildfire. Indeed, the Forest Service's fire-suppression policies allowed a fuel buildup that renders today's fires more powerful and difficult to control.

**A firefighter's or U.S. Forest Ranger's perspective could have enriched this documentary**

Yet without the Service there might not have been a forest at all, Egan argues.

"By putting out every fire . . . , they created indirectly, what are now some of the greatest wildfires. But imagine now, if this fire had not happened. They might have killed the Forest Service. And with it would've gone the idea that's so embraced by a majority of Americans today, that we have more than 500 million acres that is all of ours, that belongs to each of us. By saving the fledgling idea of conservation, then only a few years old, this fire did save a larger part of America."

The documentary, part of the PBS series *American Experience*, makes great use of archival images and footage. Like the book, the documentary focuses primarily on heroes: the dedicated rangers who risked their own lives to protect others. It also shines a light on the crucial role Buffalo Soldiers played in fighting the fire. The result is an exciting, educational, yet somewhat one-sided account of the Great Fire of 1910. The story is told by environmental historians, authors and journalists. While these are knowledgeable experts, a practitioner's point of view is sorely missed. A firefighter's or U.S. Forest Ranger's perspective could have enriched this documentary.

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**November 7-9, 2016**
**Annual Hazus Users Conference**
**South Carolina Emergency Management Division and College of Charleston**
**Charleston, South Carolina**
**Cost and Registration: Free, register before November 1**

This conference will focus on achieving disaster resilience through innovation using the Federal Emergency Management Agency's Hazus model for estimating potential loss. Topics include success stories, best practices, lessons learned, recent research, and other issues of interest to Hazus users.

**November 10, 2016**
**Disaster Preparedness Forum 2016**
**CSR Asia**
**Bangkok, Thailand**
**Cost and Registration: $50 before September 30, open until filled**

This forum will examine the need to build disaster resilient homes and schools in vulnerable communities in Asia, with a focus developing improved strategies for better funding. Topics include policy approaches for affordable and resilient housing, innovations in financing disaster resilient homes, advances in home and school design, and challenges and solutions for creating large-scale affordable housing policies.

**November 14-17, 2016**
**International Smoke Symposium**
**International Association of Wildland Fire**
**Long Beach, California**
**Cost and Registration: $620, open until filled**

This conference will address smoke-related issues including social implications, climate impacts, modeling and field management. Topic include remote sensing data for smoke monitoring, fuel management and fire planning, U.S. Forest Service smoke management tools, wildfire smoke and health, and bushfires and planned burns in Australia.

**November 16-17, 2016**
**Measuring Personal Environmental Exposure Workshop**
**National Academy of Sciences**
**Washington, D.C.**
**Cost and Registration: No Information available**

This workshop will examine advances and challenges in personal environmental exposure measurement, which attempts to assess individual health impacts of contact with environmental toxins. Topics will include trends in measurement, emerging capabilities, communication practices, and online mapping. The meeting will also be webcast.

**November 17-18, 2016**
**Humanitarian Evidence**
**Evidence Aid**
**Washington, D.C.**
**Cost and Registration: $225, open until filled**

This conference addresses access to evidence-based disaster information and how it can be used to inform decisions when responding to or preparing for disasters and humanitarian emergencies. Topics include identifying gaps in the disaster response evidence base, evidence and improved return on public health investments, changing emergency responder behavior, infectious diseases in the areas of conflict, and preventing under-nutrition during emergencies.

**November 23-25, 2016**
**CRHNet Annual Symposium 2016**
**CRHNet**
**Montreal, Canada**
**Cost and Registration: $650, open until filled**

This conference explores paths toward empowering Canadian civil society into disaster resilience. Symposium tracks include current achievements and challenges in Canada, understanding risks and vulnerabilities, inspiring resilience, risk and emergency communication, risks, diversity and equity, and legislation, policy, and implementation.

**January 22-26, 2017**
**AMS Annual Meeting**
**American Meteorological Society**
**Seattle, Washington**
**Cost and Registration: $625 before December 1, register by January 20**

This annual meeting will focus on obtaining necessary science-driven observations to support weather prediction, situational awareness, societal impacts, and the many other factors informed by meteorology. Topics include advances in numerical weather prediction, big data in the coastal environment, meteotsunami detection, remote sensing of airborne particulates, space weather predictions, connecting weather to human health, and wind resource assessments.

**March 1-3, 2017**
**Climate Leadership Conference**
**Center for Climate and Energy Solutions**
**Chicago, Illinois**
**Cost and Registration: $995 before December 18, open until filled**

This conference examines climate change in the context of policy and business to gain insights that lead to greater resilience, best practices, and innovative funding of climate solutions. Topics include leveraging environmental markets, transforming the energy grid, driving subnational climate action, managing energy and carbon risk, and cultivating a climate culture.

## Jobs

*A Farewell to David Mendonça*

Time flies and David Mendonça is coming to the end of his tenure as director of the National Science Foundation's program in Infrastructure Management and Extreme Events. We're sorry to see David go, but looking forward to seeing who our next program director is. NSF has issued a colleague letter to fill the space.

**IMEE Program Director**
**National Science Foundation**
**Salary: Not Listed**
**Deadline: Open until filled**
**Intended start date: Summer of 2017**

This postion is responsible for service to Foundation-wide activities and initiatives that together accomplish NSF's strategic goals to: 1) Transform the Frontiers of Science and Engineering, 2) Stimulate Innovation and Address Societal Needs through Research and Education, and 3) Excel as a Federal Science Agency. This position will solicit, receive and review research and education proposals, make funding recommendations, administer awards, and undertake interaction with research communities in these fields.  are also responsible for service to Foundation-wide activities. Requirements include: a commitment to high standards of intellectualism and ethical conduct, a considerable breadth of interest, receptivity to new ideas, a strong sense of fairness, good judgment, and a high degree of personal integrity.

Qualifications for the IMEE Program Director position include a PhD degree in an appropriate field, along with demonstrated success in appropriate areas of research, research administration, and/or management for a period of six or more years beyond the PhD.

Those interested can E-mail a single PDF document that includes (I) a cover letter outlining qualifications for the position and (II) a curriculum vitae to the search committee chair, George Hazelrigg, at ghazelri@nsf.gov.

**Professor, Disaster and Emergency Management**
**Royal Roads University**
**Victoria, Canada**
**Salary: Not Listed**
**Deadline: November 15, 2016**

This limited, full-time faculty position will support the university's master's program in disaster and emergency management. Duties including teaching three to four master's courses, academic administration, and thesis supervision. A PhD in emergency management or a related field, graduate-level teaching experience, and knowledge of interdisciplinary and outcome-based curriculums are required.

**Resource Mobilization Officer**
**World Health Organization**
**Geneva, Switzerland**
**Salary: Not Listed**
**Deadline: November 18, 2016**

This position will work with WHO external partners to assure the mobilization of resources in health emergencies. Duties include developing strategies for resource mobilization for the Health Emergencies program, monitor donor trends and funding, seek out new donors and funding opportunities, and support WHO resource teams during emergencies. A degree in public relations, communications, or social science; training in resource mobilization; knowledge of the United Nations system; and at least seven years of experience are required.

## Calls

**Call for Applications**
**Assistance to Firefighters Grants**
**Federal Emergency Management Agency**
**Deadline: November 18, 2016**

The Federal Emergency Management Agency is accepting applications for its Assistance to Firefighters Grant program. AFG grants are available to help firefighters and other first responders purchase equipment, vehicles, training, and other needed resources. For full grant information, application guidance, and a list of items eligible to be purchased using grant funds, visit the FEMA grant Web site.

**Call for Comments**
**Gender-Related Dimensions of Disaster Risk Reduction in a Changing Climate**
**United Nations**
**Deadline: December 13, 2016**

The Committee on the Elimination of Discrimination against Women is accepting comments on its draft Recommendation on Gender-Related Dimensions of Disaster Risk Reduction in a Changing Climate. The objective of the recommendation is to highlight the steps needed to achieve gender equality and increase resilience to climate-related disasters. For more information on how to submit comments and to read the full text of the report, visit the Committee Web site.

**Call for Comments**
**Community Resilience Indicators and National-Level Measures**
**Federal Emergency Management Agency and NOAA**
**Deadline: December 15, 2016**

The Mitigation Framework Leadership Group—a joint team led by the Federal Emergency Management Agency and the National Oceanic and Atmospheric Agency—is accepting comments on a conceptual framework to help communities describe resilience and develop metrics to measure it. For more information on the group and framework, and to contribute feedback, visit the project page on the FEMA Web Site.

*Below are descriptions of some recently awarded contracts and grants related to hazards and disasters. Please see http://www.nsf.gov/awardsearch/*

Collaborative Research: Landslides related to the 2015 Mw7.8 Gorkha earthquake, from ground motion and hazard to geomorphic response
Award Number:1640797. Principal Investigator: Marin Clark. Co-Principal Investigator: Dimitrios Zekkos. Organization: University of Michigan Ann Arbor. NSF Organization: EAR.
Start Date: 08/01/2016.
Award Amount:$285,660.00.

NRI: Enabling Unmanned Aerial Systems (UAS) Fire Ignitions in Complex Firefighting Contexts
Award Number: 1638099.Principal Investigator: Sebastian Elbaum. Co-Principal Investigator: Dirac Twidwell, Brittany Duncan, Carrick Detweiler, Justin Bradley. Organization: University of Nebraska-Lincoln. NSF Organization: IIS.
Start Date:08/01/2016.
Award Amount:$995,470.00.

Collaborative Research: Can Low-Angle Normal Faults Produce Earthquakes? Reading a Pseudotachylyte 'Rosetta Stone'
Award Number: 1630130. Principal Investigator: Laurel Goodwin. Co-Principal Investigator: Bradley Singer. Organization: University of Wisconsin-Madison.NSF Organization: EAR.
Start Date: 08/01/2016.
Award Amount: $290,400.00.

Collaborative Research: Preparing engineers to address climate change and its implications on sustainability: modeling impact of college experiences on students
Award Number: 1635534. Principal Investigator:Tripp Shealy. Organization: Virginia Polytechnic Institute and State University. NSF Organization: EEC.
Start Date: 09/01/2016.
Award Amount:$239,678.00.

Coastal SEES: Coastal fog-mediated interactions between climate change, upwelling, and coast redwood resilience: Projecting vulnerabilities and the human response
Award Number: 1600109. Principal Investigator: John Campbell. Co-Principal Investigator: Nicole Ardoin, Ulrike Seibt, Joseph Berry, Roger Samelson; Organization:University of California - Merced. NSF Organization: OCE.
Start Date: 09/15/2016.
Award Amount: $1,749,658.00.

Magnitude, Extent, and Impact of a Pre-Historical Multi-Century Drought in the Western US
Award Number:1636519. Principal Investigator: Scott Mensing. Co-Principal Investigator: Douglas Kennett, David Rhode, Adam Csank. Organization: Board of Regents, NSHE, University of Nevada, Reno. NSF Organization:BCS.
Start Date:09/15/2016
Award Amount:$350,000.00.

Collaborative Research: Flood volcanism and environmental impacts--multidisciplinary investigation of the Deccan Traps and events at the Cretaceous-Paleogene boundary
Award Number:1615021. Principal Investigator: Paul Renne. Organization: Berkeley Geochronology Center; NSF Organization: EAR.
Start Date: 09/01/2016.
Award Amount:$140,956.00.

Enhancing Community Resilience to Floods: A Theoretical Framework of Community Participation in Federal Voluntary Programs
Award Number: 1635381. Principal Investigator: Abdul-Akeem Sadiq. Co-Principal Investigator: Doug Noonan. Organization: Indiana University. NSF Organization: CMMI.
Start Date: 09/01/2016.
Award Amount:$201,772.00.

NRT: Coastal Climate Risk and Resilience (C2R2)
Award Number: 1633557. Principal Investigator: Robert Kopp III. Co-Principal Investigator: Clinton Andrews, Jie Gong, Rebecca Jordan, Lisa Auermuller; Organization: Rutgers University New Brunswick. NSF Organization: DGE.
Start Date:09/15/2016.
Award Amount:$2,999,055.00.

RAPID: Collaborative Research: Carbon and nutrient responses in an estuarine-coastal complex impacted by floodwaters from Hurricane Matthew
AwardNumber: 1706009. Principal Investigator: Christopher Osburn. Organization: North Carolina State University. NSF Organization: OCE
Start Date:11/01/2016.
Award Amount: $84,257.00.

Rapid proposal: Fires and floods: Acquisition and analysis of perishable data on the sustainability of reservoirs following wildfires
Award Number:1600016. Principal Investigator: Desiree Tullos. Co-Principal Investigator: Kevin Bladon. Organization: Oregon State University. NSF Organization: CBET
Start Date: 11/01/2015.
Award Amount: $83,117.00.

Dimensions - Predicting Biodiversity Vulnerability to Climate Change: Integrating Phylogenetic, Genomic, and Functional Diversity in River Floodplains
Award Number:1639014. Principal Investigator: Gordon Luikart. Co-Principal Investigator: Brian Hand, Jack Stanford. Organization: University of Montana. NSF Organization:DEB.
Start Date:11/01/2016;
Award Amount:$1,998,804.00.

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The success of the Natural Hazards Center relies on the ongoing support and engagement of the entire hazards and disasters community. The Center welcomes and greatly appreciates all financial contributions. There are several ways you can help:

Support Center Operations—Provide support for core Center activities such as the DR e-newsletter, Annual Workshop, library, and the Natural Hazards Observer.

Build the Center Endowment—Leave a charitable legacy for future generations.

Help the Gilbert F. White Endowed Graduate Research Fellowship in Hazards Mitigation—Ensure that mitigation remains a central concern of academic scholarship.

Boost the Mary Fran Myers Scholarship Fund—Enable representatives from all sectors of the hazards community to attend the Center's Annual Workshop.

To find out more about these and other opportunities for giving, visit:

https://hazards.colorado.edu/about/contribute

Or call (303) 492-2149 to discuss making a gift.

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