Le nuove frontiere della safety e della security: eventi chimici, biologici, radiologici, nucleari ed esplosivi

La crisi mondiale legata alla riduzione di risorse energetiche fossili, la riduzione di fonti di acqua potabile e la Guerra per il controllo delle fonti di energia rappresentano una parte delle cause che possono condurre ad un evento CBRNe (Chemical, Biological, Radiological, Nuclear, and explosive) di matrice intenzionale. Questo tipo di eventi potrebbe anche essere conseguenza del rilascio accidentale di sostanze (ad esempio, l'incidente di un camion contenente una sostanza chimica industriale tossica) o di eventi naturali, quali uno tsunami o un terremoto. Pertanto, l'elevata percentuale di rischio connesso a un tale accadimento è evidente. Il modo più opportuno di affrontare questo tipo di emergenze è di creare una squadra di Advisors e First Responders CBRNe altamente preparati a supporto dei vertici decisionali, che siano in grado non solo di gestire il rilascio delle sostanze, ma soprattutto di far fronte tempestivamente, e nel medio e lungo termine, alle conseguenze sul territorio colpito dall'evento. Attualmente, gli esperti in materia sono pochissimi e tipicamente concentrati in enti amministrativi centrali. Con il presente articolo, gli autori hanno inteso illustrare le criticità di questo tipo di eventi e le principali conseguenze sociali degli stessi.

New frontiers of safety and security: Chemical, Biological, Radiological, Nuclear, explosive events

The global crisis related to the reduction of energy fossil resources, the reduction of potable water resources and the war for the control of energy sources are part of the causes which can lead to an intentional CBRNe (Chemical, Biological, Radiological, Nuclear, and explosive) event. These kind of events could also be the consequence of an unintentional release of substances (i.e., an accident of a truck containing a Toxic Industrial Chemical), or of natural events like a tsunami or an earthquake. Thus the high percentage of risk connected to their occurrence is clear. The proper way to face these emergencies is to build a team of highly prepared Tech Advisors and First Responders to support Top Decision Makers, not only to deal with the agents released, but mainly to manage the consequences on the territory of occurrence, immediately and in the medium and long term. At the present moment, experts of the kind are really few and usually concentrated in the central administrative bodies. The authors in this work present the criticalities of these kinds of events and their principal societal implications.

DOI: 10.12910/EAI2014-99

■ *A. Malizia, V. Cusmai, V. Rossi, T. Labriola, E. Farrugia, F. Campopiano, F. Salerno, V. Trombadore, L. Cadoni, G. Rezza, R. Fantoni, S. Sandri, M. Chiappini, A. Gucciardino, F. D'Amico, C. Russo, D. Rothbacher, M. Carestia, D. Di Giovanni, O. Cenciarelli, C. Perrimezzi, I. Palombi, C. Bellecci, P. Gaudio*

■ **Contact person: Andrea Malizia**
malizia@ing.uniroma2.it

Sp

Introduction

The evolution and proliferation of safety and security issues in the National and International framework made it necessary to respond in a competent and professional way to any crisis scenarios resulting from non-conventional events (i.e., CBRNe events). In all industrialized countries there are Institutions and Facilities with highly specialized groups facing up to emergencies (first responders), but only a few persons are sufficiently trained to manage these incidents. The complexity of these events requires experts not only with a vertical but also with a horizontal knowledge. It is important to understand how extensive is the range of events that can be considered as a CBRNe event, and how different are the answers and implications in the countries all around the world.

The threat today: From toxic industrial chemicals and materials to CBRNe

A CBRNe emergency has not to be intended exclusively as a war or terroristic event, but also as deriving from an unintentional or natural one.
In this section the authors describe some events that can be classified as Chemical or Biological or Radiological or Nuclear or explosive. It is important to point out that the events described below have no connection to one another in terms of emergency planning or intrinsic threat or experts (and actors) involved or rescue methodologies to help the population. Purpose of this section is to give an important message to the readers: many events can be classified as CBRNe and many causes can provoke a CBRNe event. The dispersion of CBRNe materials can be a consequence of:

- natural events (volcanos/earthquakes; storms/inundations; hydrogeological disasters; floods/lack of water; epidemic/pestilences, etc.), or
- accidental events (fires, incidents, etc.)
- events like migration flux or man-made events (i.e., war or terrorism). [13]

The real challenge is getting not only a better knowledge on risks, agents, protection-decontamination and investigation techniques, but also the establishment of a doctrine on prevention capabilities (referred to new NON-Proliferation methodologies), and learning to face non-conventional events and to manage their very consequences.
From a chemical point of view, one of the most well-known unintentional events was the one occurred in 1976 in Seveso, Italy, where a dense vapor cloud was released from a chemical plant manufacturing pesticides and herbicides. In Europe, the Seveso accident prompted the adoption of legislation aimed at the prevention and control of such accidents. The toxic cloud contained tetrachlorodibenzoparadioxin

FIGURE 1 Seveso Disaster
Source: http://unitaecarismi.cittanuova.it/contenuto.php?TipoContenuto=web&idContenuto=35315

FIGURE 2 Viareggio Accident
Source: http://it.wikipedia.org/wiki/Incidente_ferroviario_di_Viareggio#mediaviewer/File:2009_Viareggio_train_explosion_fire.jpg

(TCDD), a by-product of the trichlorophenol synthesis, also known as Seveso dioxin. TCDD has poisonous and carcinogenic properties with an LD50 of 0.02 mg/kg. Although no fatalities were reported, soon after its release a large amount of different toxic chemicals were dispersed in the environment and spread on a large area. This resulted in the immediate contamination of some ten square miles of land and vegetation. More than 600 people had to be evacuated from their housings and as many as 2000 were treated for dioxin poisoning [1] (Fig. 1).

Moving to recent years, another chemical, accident-related event is the one occurred in Viareggio, Italy, in 2009 (Fig. 2).

The Viareggio derailment of a freight train and subsequent fire occurred on June 29, 2009, in a railway station in Viareggio, (province of Lucca), a city in Central Italy's Tuscany region.

Some of the wagons were reported to have been carrying Liquefied Petroleum Gas (LPG). Two of these exploded and caught fire. Seven people were reported to have died in a building collapse.

Among the unintentional biological events, the 2009 swine flu A-H1N1 pandemic can be considered as a blatant example of biological threat. The disease originated from a mutation occurred in a swine flu virus, that acquired the ability to infect humans and, subsequently, to be contagious from human to human (Fig. 3). In 2009, the A-H1N1 flu pandemic spread fast worldwide, causing several hundreds of deaths and thousands of contagions, especially in America. The World Health Organization and the Centers for Disease Control and Prevention considered it as pandemic due to its global diffusion. Since then, people continued to get sick from swine flu, but not so frequently as before [2]. On October 24, 2009, the US President signed a statement declaring the 2009 A-H1N1 pandemic flu as a national emergency. It enabled to respond to the pandemic by allowing – if warranted – the waiver of certain statutory Federal requirements for medical treatment facilities. [3]

The last (but not least) accidental event, in this case from a radiological point of view, is the one that perhaps impressed us the most, but negatively: the Fukushima Daiichi nuclear disaster, a catastrophic failure at the Fukushima I Nuclear Power Plant on March 11, 2011. The failure occurred after the tsunami triggered by the Tōhoku earthquake hit the nuclear plant (Fig. 4) and substantial amounts of radioactive materials were released starting on March 12. This has become the largest nuclear incident since the 1986 Chernobyl disaster, and the second (with Chernobyl) to measure Level 7 on the International Nuclear Event Scale

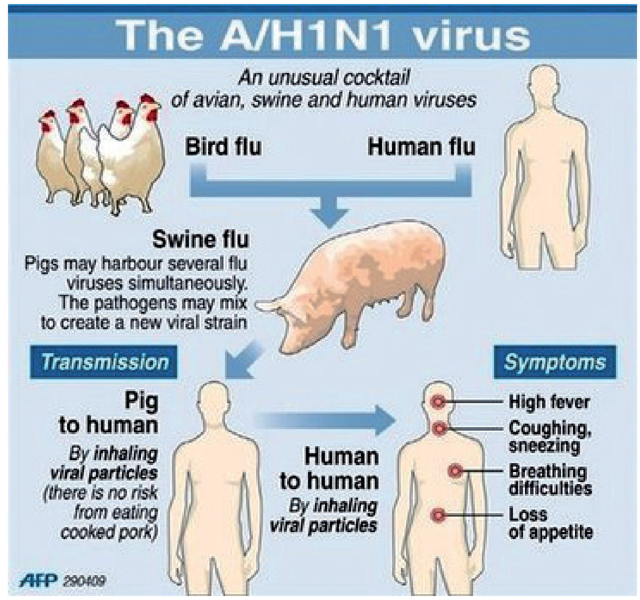

FIGURE 3 H1N1 a contemporary pandemic
Source: http://dxline.info/diseases/h1n1-influenza

FIGURE 4 Tsunami at Fukushima
Source: http://www.corriere.it/gallery/esteri/05-2011/tepco/1/tsunami-investe-fukushima_52bd44c4-81ec-11e0-817d-481efd73d610.shtml#

(INES). 300,000 people had to be evacuated from the area, approximately 18,500 died in the earthquake and tsunami events, and, as in August 2013, approximately 1,600 deaths were attributed to the evacuation conditions, such as living in temporary housing and hospital closures. [4]

These are just four of the most well-known examples of disasters that can be listed as CBRNe events of unintentional or natural origin. Thousands of natural events involve dispersion of chemical, biological or radiological materials (i.e., earthquakes, hurricanes, tsunami, and natural epidemics). It is clear that the victims are related to the fact the radioactive contamination levels for humans are too high.

Frequently people link CBRNe threats to war or terrorism scenarios. Below few examples of CBRNe events in the contexts of war or terrorism are reported.

One of the most famous intentional events linked to Chemical Weapons (CW) is the first use of Mustard Gas during the First World War when, in 1917, the German army fired artillery shells against British and Canadian soldiers near Ypres, Belgium. The place where the chemical agent was used for the first time gave the name to the aggressive chemical today still known as Yperite. Delivered by artillery shells, Mustard Gas caused more than 20,000 casualties and remained active for weeks because of its persistency in the environment. This represented a problem since the contaminated areas remained unusable for long periods. The protection devices available against Mustard Gas were relatively ineffective: although the mask filters partially protected the lungs from the inhalation contamination, no shield was offered to the blister effects due to the contact between the chemical warfare agent and the skin [5] (Fig. 5).

FIGURE 5 Soldiers at Ypres during the WWI
Source: http://www.thehistorypostblog.co.uk/tag/mustard-gas/

FIGURE 6 Nuclear explosion
Source: http://www.planetdeadly.com/human/incredible-nuclear-explosion-photos

Biological Weapons (BW) were never extensively used in war even if, especially during the two World Wars, some countries started a program of biological weapons. One of the most notorious research program focused on the weaponization of biological agents and the development of biological weapons was conducted during World War II by the secret Imperial Japanese Army Unit 731, based at Pingfan (Manchuria) and commanded by Lieutenant General Shirō Ishii. In this unit fatal experiments on prisoners were conducted: microorganisms were inoculated in order to study the pathogenesis and the virulence of the inducted diseases, and dissections were done without anesthesia. Although the Japanese effort lacked of the technological sophistication of the American or British programs, it far outstripped them in its widespread application and indiscriminate brutality. Biological weapons were used against both Chinese soldiers and civilians in several military campaigns. In 1940, the Imperial Japanese Army Air Force bombed Ningbo with ceramic bombs full of fleas carrying the plague.

Many of these operations were ineffective due to inefficient delivery systems, although up to 400,000 people may have died [6]. Attacking animals is another area of biological warfare intended to eliminate animal resources for transportation and food. During the First World War, German agents were arrested while attempting to inoculate draught animals with anthrax, and they were believed to be responsible for outbreaks of glanders in horses and mules.
It is easy to associate a nuclear event to war: Hiroshima and Nagasaki are two unforgettable shocking moments of our contemporary history. The atomic bombings of the cities of Hiroshima and Nagasaki in Japan were conducted by the United States during the final stages of World War II in 1945. The two events are the only use of nuclear weapons in war to date. The Little Boy atomic bomb was dropped on the city of Hiroshima on August 6, 1945, followed by the Fat Man bomb on the city of Nagasaki on August 9. Within the first two to four months of the bombings, the acute effects killed 90,000–166,000 people in Hiroshima and 60,000–80,000 in Nagasaki, with roughly half of the deaths in each city occurring on the first day. During the following months, large numbers died from the effect of burns, radiation sickness and other injuries, compounded by illness. In both cities, most of the dead were civilians, although Hiroshima had a sizeable garrison [7] (Fig. 6).
Finally, to give a more general description of the international scenario, it is necessary to describe some CBRNe events related to terrorism.
Starting from chemical events, the most famous event is the Sarin gas release in Tokyo's subway on March 20, 1995. Five members of the Aum Shinrikyo cult launched a chemical attack in Tokyo's subway, one of the world's busiest commuter transport systems, at the peak of the morning rush hour. Sarin, the chemical agent which was released, was contained in plastic bags wrapped in newspaper. Each perpetrator carried two packets totalling approximately 900 milliliters of sarin, except Yasuo Hayashi, who carried three bags. Aum originally planned to spread the Sarin as an aerosol but did not follow through with it. Carrying their packets of Sarin and umbrellas with sharpened tips, the perpetrators boarded their appointed trains. At prearranged stations, the Sarin packets were dropped and punctured several times with the sharpened tips of the umbrella. Each perpetrator then got off the train and exited the station to meet his accomplice with a car. By leaving the punctured packets on the floor, Sarin, which is a very volatile substance, was allowed to leak out into the train and stations. This chemical agent affected passengers, subway workers, and those who came into contact with them [8] (Fig. 7).

FIGURE 7 Sarin attack in Tokyo
Source: http://matome.naver.jp/odai/2136380668192730201

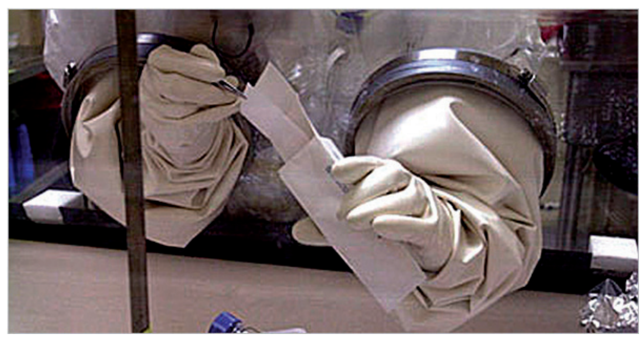

FIGURE 8 Letters with B contamination
Source: http://qn.quotidiano.net/cronaca/2012/12/04/812127-pacco-sospetto-antrace-ricoverati-ospedale.shtml

A terrorist use of biological agents is represented by the well-known 2001 anthrax attacks in the United States, also called Amerithrax by the Federal Bureau of Investigation (FBI). The attacks occurred over the course of several weeks, beginning one week after the September 11 attacks. The first set of anthrax letters had a Trenton, New Jersey postmark dated September 18, 2001. Five letters are believed to have been sent at that time to: ABC News, CBS News, NBC News and the New York Post, all located in New York City, and to the National Enquirer at American Media, Inc. (AMI) in Boca Raton, Florida. A series of conflicting news reports appeared, some of them claiming that the powders had been weaponized with silica. Bioweapons experts, who later viewed images of the anthrax attacks, saw no indication of weaponization and tests by Sandia National Laboratories in early 2002 confirmed that the attack powders were not weaponized. At least 22 people developed anthrax infections, 11 of these with the especially life-threatening inhalational variety [9] (Fig. 8).

Speaking about R-N terrorist attack, one of the most known was the Alexander Litvinenko (Fig. 9) murder. In UK, Litvinenko became a journalist for a Chechen separatist site. On November 1, 2006, Litvinenko suddenly fell ill and was hospitalized. For several days he suffered of severe diarrhea and vomiting. At one point, he could not walk without assistance.

For several weeks, Litvinenko's health conditions worsened and doctors began to investigate the causes of his illness. Litvinenko became physically weak, and spent periods unconscious. He died three weeks later, becoming the first confirmed victim of lethal Polonium-210-induced acute radiation syndrome. According to the doctors, "Litvinenko's murder represents an ominous landmark: the beginning of an era of nuclear terrorism" [10].

FIGURE 9 Litvinenko

Source: http://www.repubblica.it/2006/12/sezioni/esteri/spia-avvelenata-3/litvinenko-bersaglio/litvinenko-bersaglio.html

War, terrorism but also explosions, accidents and natural disasters can provoke CBRNe events, attempting the safety of people and operators and the security of environments and structures. CBRNe risk is a concrete threat and new scenarios are opening in this field.

It is difficult to place events like the dispersion of chemical substances in Iraq and in Syria in one specific category. Are these events War? Terrorism? The new frontiers of risks have unknown and unexpected characteristics.

Different mentality with a common enemy

The loss of national control and the global spread of knowledge related to chemical, biological, radiological and nuclear weapons and technologies have been a long-standing concern in the post-Cold War World. In recent years, the fear that terrorist groups might employ CBRNe agents has particularly increased as some of these sensitive technologies and under pinning scientific knowledge have become more easily available for use in crude weapons. The National Security Strategy places a strong emphasis on these concerns by including the risk of international terrorism activity with the possibility of using CBRNe agents at the highest priority level; the risk of CBRNe attacks from state actors ranks just one priority level below. Multidisciplinary research, focused on the long-term perspective, will play an important role in understanding the implications of constant rapid technological development in the CBRNe area. It will also allow enlightening how the global spread of scientific education might affect aspirations of different State and non-State actors to use these technologies and knowledge for malevolent actions. A clearer understanding of these developments and the direction they may take will aid the progress of more effective policies and tools to counter possible CBRNe threats [11].

Because of security budget reduction, the way in which different Countries prepare for CBRNe incidents deserves renewed attention; this involves the prioritization of capabilities against C, B, R, or N in the Analysis, Prevention and Response (APR) phases. It will also be necessary to acquire detailed information about the capability of the actor involved to use or produce CBRNe weapons, taking into account all the latest scientific developments in the field of chemistry, physics, biology and nanotechnology. An analysis of how actual CBRNe threats and hazards are perceived by policy makers from different Countries shows the following outcomes:

- there is a consensus on the importance of CBRNe threats. Some Countries list CBRNe-terrorism, or CBRNe-weapon use and proliferation among the most important security threats;
- the general perception is that State actors have the potential to acquire CBRNe expertise and experts, but are restrained to deploy them; the opposite holds to be true for non-State actors.

With respect to science and technology, experts expect: (a) an increasing interaction between chemistry and biology know-how development; (b) dramatic advances in understanding and manipulating genes, cells, and organisms, and (c) developments in the field of nanotechnology that may revolutionize dispersal methods. With respect to materials: (a) an increasing availability of CBRNe materials; (b) the potential to engineer (CB) materials from scratch and (c) a growth in the number of dual-use materials and technology that pose major challenges to non-proliferation regimes. With respect to intentions: (a) a persistent intention on the part of State actors to acquire new types of CBRNe capabilities and (b) a persistent intention on the part of non-State actors to acquire new types of CBRNe capabilities and in some cases an explicit desire to use these capabilities. Overall, experts agree that in the 21st century CBRNe agents may be used and deployed as weapons in novel ways, both in the military and civil domains. This reveals how countries formulate and execute their respective CBRNe policies. The conclusion is that some countries deal with CBRNe as a single policy issue in its own right; other countries approach CBRNe as part of a larger security policy approach; CBRNe crisis management has shifted from the military to the civil domain resulting in a duplication of efforts. While capabilities have been strategically identified along the APR phases, few countries have developed specific CBRNe strategies [12].

Conclusions

The CBRNe world offers several starting points for national and international collaborations in a wide range of public, private, research, and industrial contexts. It is important to create the conditions to connect the best experts, allowing a reverse brain-drain process. Why pursuing this challenge? To create a new way of working together and, above all, to have a new vision of work. It is essential to identify the needs in the CBRNe safety and security framework and then deploy existing skills and develop new theoretical and practical knowledge to answer those needs. The problems presented in this paper give just an overview of a more complex scenario. It is necessary have well-prepared experts to face these particular events. The Department of Industrial Engineering and the School of Medicine and Surgery of Rome's University of Tor Vergata decided to face these problems with the "International Master Courses in Protection Against CBRNe events" presented in the paper: "Building a CBRNe Tech Advisor and First Responders Team to support Top Decision Makers during the emergencies" printed in this issue of EAI-ENEA.

Acknowledgements

Special Acknowledgments to the International Master Courses in Protection Against CBRNe events. Further information available at: www.mastercbrn.com. Enrollment for A.Y. 2014/2015 OPEN.

Andrea Malizia, Fabrizio D'Amico, Dieter Rothbacher, Mariachiara Carestia, Daniele Di Giovanni, Orlando Cenciarelli, Carlo Bellecci, Pasqualino Gaudio
University of Rome Tor Vergata, Industrial Engineering Department

Vittorio Cusmai
Italian Defence Staff, Division I

Vincenzo Rossi
Italian Ministry of the Interior

Tiziano Labriola
Italian Presidency of the Council of Ministers

Emanuele Farrugia
Italian Ministry for Foreign Affairs

Francesco Campopiano
Italian Presidency of the Council of Ministers, Civil Protection Dept.

Franco Salerno
Joint NBC Defence School

Vincenzo Trombadore
Italian Ministry of the Interior, Public Security Dept.

Luciano Cadoni
Italian Ministry of the Interior, Firefighters Dept.

Giovanni Rezza
ISS - Istituto Superiore di Sanità (Italian National Institute of Health)

Roberta Fantoni
ENEA, Technical Unit for the Development of Applications of Radiation

Sandro Sandri
ENEA, Radiation Protection Institute - Radiation Protection for Nuclear Fusion Plants and Large Accelerators Laboratory

Massimo Chiappini
Istituto Nazionale di Geofisica e Vulcanologia (INGV)

Antonio Gucciardino
University of Tor Vergata, Scientific Board of International Master Courses in Protection Against CBRNe events, Department of Industrial Engineering and School of Medicine and Surgery

Colomba Russo, Carlo Perrimezzi
Crati Scrl - Consorzio per la ricerca e le applicazioni di tecnologie innovative

Leonardo Palombi
University of Rome Tor Vergata, School of Medicine and Surgery - Department of Biomedicine and Prevention

references & notes

[1] http://ec.europa.eu/environment/seveso/
[2] http://www.webmd.com/cold-and-flu/flu-guide/h1n1-flu-virus-swine-flu
[3] http://www.flu.gov/planningpreparedness/federal/h1n1emergency10242009.html
[4] http://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster
[5] http://en.wikipedia.org/wiki/Sulfur_mustard#History
[6] http://en.wikipedia.org/wiki/Biological_warfare#Interwar_period_and_WWII
[7] http://en.wikipedia.org/wiki/Atomic_bombings_of_Hiroshima_and_Nagasaki
[8] http://en.wikipedia.org/wiki/Sarin_gas_attack_on_the_Tokyo_subway
[9] http://en.wikipedia.org/wiki/2001_anthrax_attacks
[10] http://en.wikipedia.org/wiki/Poisoning_of_Alexander_Litvinenko
[11] http://www.globaluncertainties.org.uk/research/weapons-proliferation/
[12] http://www.hcss.nl/reports/navigating-the-cbrn-landscape-of-2010-and-beyond-towards-a-new-policy-paradigm/15/
[13] R. Fiorito, C. Bellecci, A. Gucciardino, A. Malizia, F. D'Amico, C. Fontana, C. Russo, C. Perrimezzi, P. Gaudio, 2013, "Training internazionale: eventi accidentali, naturali, dolosi = EVENTI CBRNe", in AIRP - Atti del XXXVI Convegno Nazionale di Radioprotezione, Palermo, 18-20 settembre 2013, V sessione, BOLLETTINO AIRP, p. 61-69, ISBN 978-88-88648-38-5, ISSN 1591-3481.