THE ROTTERDAM BLAST

The immediate humanitarian consequences of a 12 kiloton nuclear explosion

Wilbert van der Zeijden and Susi Snyder

PAX

THE ROTTERDAM BLAST

The immediate humanitarian consequences of a 12 kiloton nuclear explosion

Authors
Wilbert van der Zeijden and Susi Snyder

Graphics and design
Sigmon Visser - *www.sigmonvisser.com*

ISBN Number
9789070443290

About the authors
Wilbert van der Zeijden is a political scientist with an MA in International Relations from the Vrije University in Amsterdam, the Netherlands. Since early 2010, he's worked as a senior researcher for Pax (formerly called IKV Pax Christi). Previously, Wilbert worked for the Dutch think-tank Transnational Institute as Peace & Security program coordinator. He specialises on and frequently publishes about disarmament and arms control, European security, international military infrastructure and NATO reform.

Susi Snyder is the Nuclear Disarmament Programme Manager for Pax. Previously, Susi served as the Secretary General of the Women's International League for Peace and Freedom, based at their International Secretariat in Geneva, Switzerland where she monitored various issues under the aegis of the United Nations, including sustainable development, human rights, and disarmament.

About Pax
PAX stands for peace. Together with people in conflict areas and critical citizens in the Netherlands, we work on a dignified, democratic and peaceful society, everywhere in the world.

Peace requires courage. The courage to believe that peace is possible, to row against the tide, to speak out and to carry on no matter what. Everyone in the world can contribute to peace, but that takes courage. The courage to praise peace, to shout it from the rooftops and to write it on the walls. The courage to call politicians to accountability and to look beyond your own boundaries. The courage to address people and to invite them to take part, regardless of their background.

PAX brings people together who have the courage to stand for peace. We work together with people in conflict areas, visit politicians and combine efforts with committed citizens.
www.PAXforpeace.nl

About the No Nukes Project
No Nukes is Pax' campaign for a world free of nuclear weapons. No Nukes is on the steering group of the International Campaign to Abolish Nuclear weapons – ICAN. The No Nukes project seeks opportunities to strengthen the global non-proliferation regime and to accelerate global nuclear disarmament by stigmatizing, outlawing and eliminating nuclear weapons.
www.NoNukes.nl

Acknowledgements
We would like to thank the following people for their advice and input: Maarten van Bijnen, Selma van Oostwaard, Miriam Struyk, Daan Kayser, Suzanne van den Eynden and Krista van Velzen. ♦

Dulce Bellum İnexpertis

Sweet is
the **war**
to those
who **don't**
know it.

Erasmus of Rotterdam (1466 – 1536)

Contents

Introduction

The chances of a nuclear weapon detonating in the port of Rotterdam are said to be very small. Nuclear stockpiles are well protected and so is the biggest harbour in Europe. Containers and ships are scanned, intelligence services are diligent and keep track of suspicious activities. The Rotterdam Port Authority is one of the most advanced in the world.

That said, the terrifying events described in this report are realistic. There are over 17,000 nuclear warheads around the globe today and each is designed to do exactly this: to explode with enough force to take out entire neighbourhoods, or even whole cities. The 12 kiloton bomb 'used' in this report is not even a particularly big one. It is roughly the size of the bomb used in Hiroshima. Today, the nuclear arsenals of the nine nuclear armed countries contain weapons with an estimated explosive range of about 0.3 kt to 1,200 kt. The American B61 nuclear bombs stored in the Netherlands, for example, can be set for a 12 kiloton detonation, but can also be 'dialled up' to detonate with the force of 170 kilotons.

Rotterdam is a realistic target for someone mad enough to use a nuclear weapon. It is by far the biggest harbour in Europe, with access to the hinterland that includes the industrial and economic powerhouse regions of Germany and the Netherlands. The port was counted by the Soviets among the top priority targets during the Cold War. Since 9/11, the port has often topped the list of vital European strategic and logistical areas sensitive to disruption from terrorist attacks.

The use of weapons of mass destruction always seems like an impossibility, until it happens. The use of chemical weapons in Syria in 2013 is a reminder of how unpredictable the future behaviour of states and non-state actors can be. There is no magic formula to predict the future and today's responsible actor can become tomorrow's terrorist or terrorising state. And accidents happen.

The renewed focus of governments, experts and civil society on the humanitarian consequences of nuclear weapons is necessary to refocus the discussion on the essential quality of nuclear weapons: They are inhumane weapons that cause indiscriminate, disproportional humanitarian harm by their very nature. Pax believes that government participation in conferences on these matters, such as the conferences in Oslo (2013) and Nayarit (2014) are crucial to build the understanding that any possibility of the use of nuclear weapons, no matter how remote, is unacceptable.

This report hopes to contribute to the already existing body of evidence that no country can adequately prepare for or respond to a nuclear warhead detonation in or near a populated area. This report outlines such a scenario and examines the initial consequences. It poses some open ended questions on longer-term impacts for further consideration.

Disclaimer

The scenario in this report is the result of desktop research only. Telemetric data are taken from a number of reports in which similar scenarios have been studied. Special mention must be given to the 2006 RAND Corporation Center for Terrorism Risk Management report by Charles Meade and Roger C. Molander, called *"Considering the Effects of a Catastrophic Terrorist Attack"*. In the RAND report, a 10 kiloton bomb explodes in the Los Angeles harbour. The similarity with the scenario we decided to portray has meant that the RAND report has been especially useful. Additional data are taken from a number of reports, including the authoritative US Department

of Defense study *"The Effects of Nuclear Weapons"* by Samual Glasstone and Philip J. Dolan (3rd Edition, 1977) and more recent studies such as the Scottish CND 2013 report *"If Britain fired Trident"* and the 2011 Buddemeier et al report *"Key Responses Planning Factors for the Aftermath of Nuclear Terrorism"*. To increase readability of this report, we have decided not to footnote the telemetric data instead noting the source material here. When presented with options of scalable effects, the minimum possible impact was always chosen.

Facts and figures on the Netherlands, Rotterdam and the Port area are from public sources and publicly available Dutch documentation on national crisis response. It is noteworthy that government officials were extremely hesitant to provide detailed information and assistance in the process of writing this report and that even most non-governmental organisations in the Netherlands were shy to answer questions about emergency response, terrorist risk management and Rotterdam harbour security operations. All assessments are our own estimates and calculations. ♦

Chapter 1: The Scenario

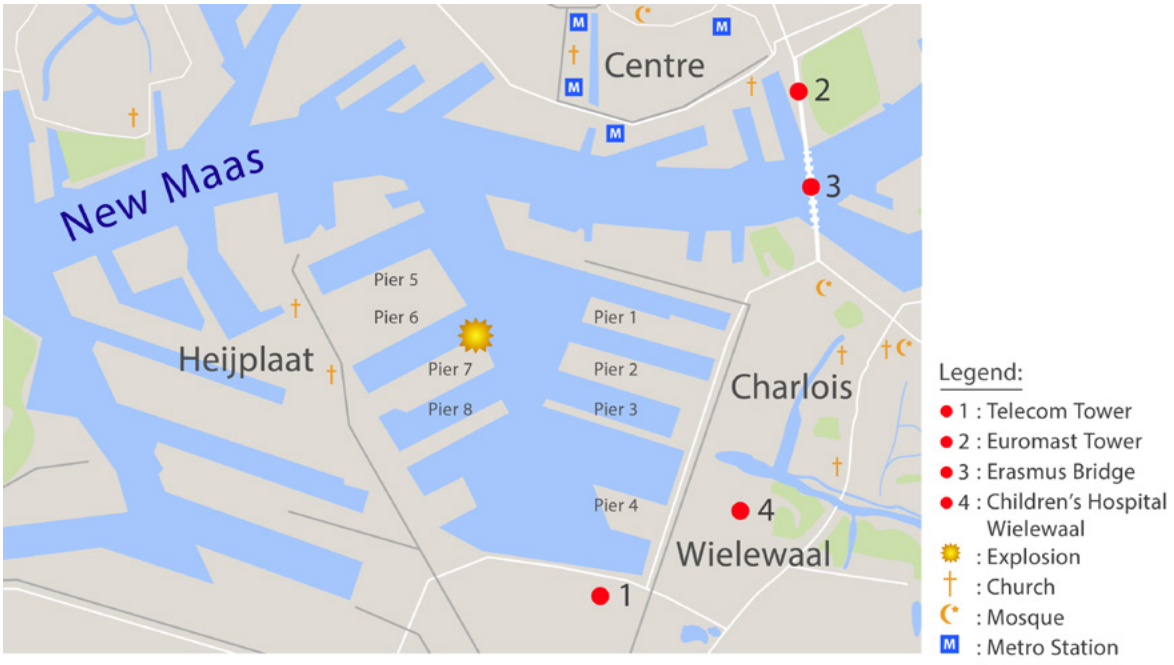
On February 14 2014, like any other day the Port of Rotterdam has hundreds of cargo vessels from all over the world in her docks. On this partly cloudy, somewhat windy morning, a container ship enters the harbour from the North Sea. The ship is fully loaded with containers filled with resources used in the production of specialized concrete products. The paperwork checks out, the scans reveal nothing out of the ordinary. The ship has visited Rotterdam harbour before and is directed to Pier 7 of the Waalhaven harbour area.

An hour later, while offloading the containers, one of the containers on the ship explodes.

The first seconds

12:00
The flash caused by the explosion can be seen throughout the provinces of South-Holland and Zeeland. Anyone outside and unshielded up to 4 km from the blast suffers flash burns on the parts of their bodies facing the detonation. The retinas of anyone looking directly at the blast are damaged. People looking in the direction of Rotterdam up to 16 kilometres away are temporarily blinded. This temporary blindness causes dozens of severe traffic accidents, especially on the E25, E19, A15 and A29 highways approaching Rotterdam. Traffic comes to a standstill. The sound of a thousand thunderstorms is heard in much of the Netherlands and parts of Belgium.

The blast damage in the harbour is instant and devastating. The piers and docks are gone, the neighbourhood Heijplaat, located approximately 1 km from ground zero, is flattened. Most inhabitants are crushed in the blast front or instantly burnt. All others receive lethal doses of radiation. This is also true for people working on the piers in the Waalhaven and those living in the parts of Rotterdam South closest to the Waalhaven. Thousands of people are instantly crushed, incinerated or lethally irradiated, never knowing what has hit them.



Waalhaven harbour - Rotterdam.

Structures on the other Waalhaven piers are flattened by the blast front. The scenery is one of total devastation and chaos, as cargo containers and parts of Piers 5, 6 and 7 as well as parts of the cargo ships are scattered at high speed throughout the Waalhaven and adjacent neighbourhoods. Up to 2 km from the detonation, people are seriously injured by flying glass and debris. Those who are unshielded suffer 3rd degree burns.

An electromagnetic pulse (EMP) knocks out all electric batteries up to 2 km away. Devices including power stations, wifi routers, mobile phones, computers and more are wiped out due to the EMP power surge. A major telecommunications tower just south of the Waalhaven is irreparably damaged.

The dams separating the Waalhaven port and the south-east lying residential neighbourhoods Charlois, Wielewaal and Rhoon are damaged by the blast. Radioactive water starts to flow into the below sea-level neighbourhoods.

Several bridges and tunnels that connect the north and south parts of Rotterdam are damaged. The lanes leading to and from the Maastunnel (2 km from the detonation) are obstructed by debris and stranded cars. The Erasmus Bridge 4 km east of ground zero, is only lightly damaged but blocked by traffic accidents. Two kilometres south of the detonation, the A15 highway, the main harbour train lines and the metro-line are destroyed by debris and massive accidents. Numerous cars and trucks, as well as a derailed cargo train are set ablaze.

Most of the buildings in the other parts of Rotterdam and Schiedam are relatively unaffected by the blast front, except for broken glass and dislocated roof tiles. High-rise buildings are more exposed to the blast effects. The 185m tall Euromast tower, at roughly 2500m from the detonation, sways but remains standing. Glass in the top-level restaurant shatters. People suffer 2nd degree burns in those parts of the restaurant facing the explosion. First degree burns, similar to sunburn, are experienced by people who are unshielded in a 3.5 km radius, including those at the Erasmus hospital.

Spontaneous combustion of dry materials – such as paper or wood – occurs up to 3.5 km away and results in uncontrollable fires in Rotterdam, Schiedam, Pernis, Poortugaal and Rhoon. One of the petroleum refineries in the Pernis 2nd Petroleum Harbour is set ablaze.

The detonation blows out water, dust and debris at high velocity in the first instance. Within seconds, the resulting pressure drop at the heart of the detonation sucks in thousands of tons of water vapour, pulverised materials and hot air. This highly radioactive mixture starts to rise in a mushroom cloud shape.

The first minutes

12.03
The power grid is damaged in Waalhaven and the surrounding areas. Together with the damage from the EMP this creates an eerie silence after the shock wave of the blast. No cars are moving. People are often blinded, deafened, in a lot of pain, unconscious, confused, or dying.

In the tall government buildings in The Hague, 23 kilometres northwest of Waalhaven, people see the mushroom cloud rising. Within minutes the Dutch government receives the first

acknowledgement of an explosion from NATO Command. GPS satellites place the exact coordinates at Pier 7, Zaltbommel Street, Waalhaven, Port of Rotterdam. The first estimate is a ground burst detonation of between 12 and 16 kilotons. The magnitude and signature of the detonation implies a nuclear detonation. NATO and Dutch military command are notified.

12.04
In The Hague, crisis response is immediately scaled up to the highest level. The Minister of Justice, the Minister of the Interior, the Prime Minister and several other ministers are moved to the 'Government Emergency Seat' (RNZ) bunker below the Ministry of the Interior.

12.06
NATO confirms that there have not been any incoming missiles reported. This raises the idea that the explosion is from a bomb hidden in a cargo container. This is supported by the GPS findings suggesting a ground burst detonation on Pier 7 or on a ship docked there.

12.10
The mushroom cloud reaches its highest altitude at roughly 6.1 km. Fallout begins to pour down just outside the 2.5 km radius and is carried downwind to the east-northeast.[1]

Rotterdam Harbour and metropolitan authorities activate standard response plans for large catastrophes. Police start to close on-ramps at inbound traffic lanes to clear routes for emergency response. Emergency sirens sound throughout the city.

12.12
The first media begin to report what is happening in Rotterdam. Amateur images of the mushroom cloud are shown as well as images of fires in Rotterdam, interspersed with historical footage of the destroyed city in 1940 during WWII. The imagery causes panic. The first comments on TV are misinformed and confused about location, magnitude and prediction of possible fall-out zones. Many people get their information from Twitter and other social media outlets where the basis is speculation, rather than information, adding to the confusion.

Some commentators call for full and immediate evacuation of the whole of South-Holland province. Others, including a politician at the parliament in The Hague, tell people to "stay sheltered and indoors".

12.15
At the EURONEXT financial market, stock prices have started to plummet. Trade is automatically suspended.

The first radioactive fallout is measured by emergency medical teams operating from Erasmus Medical centre, Rotterdam's main hospital, 3 kilometres northeast of the detonation. Fire fighters in that area report rising levels of radioactivity.

The National Crisis Centre (NCC) issues orders to establish a 3 km perimeter from the suspected ground zero. Emergency responders are instructed by the National Operational Coordination Centre (LOCC) to operate outside the perimeter only. Based on the first measurements by the National Measurement Network for Radioactivity (NMR), a rough estimate of fallout effects raises

[1] The prevailing wind at 100 meters altitude in February for Rotterdam is 7m/s (14 knots; 4 Beaufort) in an east-northeast direction. See http://www.klimaatatlas.nl/klimaatatlas.php?wel=wind&ws=kaart&wom=Gemiddelde windsnelheid 100 m

concerns that wind will carry highly radioactive contaminants directly over the centre of Rotterdam, a metropolis of roughly 1.2 million inhabitants.

The first reports come in about severed transportation infrastructure. The A15 Southern Ring-road, the main highway connecting Rotterdam city and the harbour, is destroyed. In the same traffic corridor, tram and metro lines as well as harbour railway connections are no longer functional. Several bridges and tunnels connecting the northern and southern parts of the city are blocked and unable to be used. The on and off ramps of the Maas Tunnel and the Erasmus Bridge are blocked. North – south connections are now only possible via the A4 (Ring West) Benelux Tunnel and the A16 (Ring East) Brienenoord Bridge located much farther away.

On the orders of the LOCC, regional police forces start allowing outbound traffic on inbound lanes in the south of Rotterdam. Tens of thousands of people begin to flee, especially where people have a clear view of the mushroom cloud. Outbound traffic is severely hampered. People in cars get trapped trying to get from south to north and vice versa. Conflicting assessments of the fastest route out of the city lead to further traffic jams and most traffic in Rotterdam centre comes to a standstill.

Reports come in that the Waalhaven dams have been breached and that harbour water continues to flow into the streets in the south of Rotterdam. It is immediately understood that this water is contaminated.

Black smoke hinders evacuation and emergency operations closer to the detonation as well as directly downwind. Phone systems that are not damaged by the explosion, now start to falter because of overloading. The C2000 national emergency communication systems however, continues to function without problem.

The Dutch defence forces go on high alert, fearing that this may be the first of a series of attacks on critical infrastructure in Holland or even in the whole of Western Europe. Orders are given by the Ministerial Commission Crisis Management (MCCB) to close all harbours in the Netherlands. The Minister of the Interior alerts the European Commission that a nuclear explosion has taken place with potential cross-border effects.

12.18
The Minister of the Interior is on the phone with the International Atomic Energy Agency (IAEA) to clarify that a release of nuclear material appears to be ongoing, not related to nuclear power plants. The Minister then notifies the European Community Urgent Radiological Information Exchange (ECURIE) about the incident. To mitigate possible damage from additional undetected nuclear weapons, throughout the EU Ministries of the Interior order the closure of container harbours and the movement of all cargo containers to ‘safe locations’. Ships are directed to international waters and all commercial air traffic is brought to an immediate halt.

12.20
The first real time weather reports from the Dutch meteorological institute (KNMI) confirm concerns that a radioactive cloud is hovering directly over the centre of Rotterdam. First predictions from the Dutch Institute for Public Health and the Environment (RIVM) indicate that at current wind speeds, the people in Rotterdam centre are already receiving radiation dosages that will lead to sickness and possibly death, unless they are sheltered in isolated, shielded spaces such as underground

tunnels or basements. For much of Rotterdam South and other parts of the city, longer term sheltering or evacuation before the fall-out starts to rain down is necessary to prevent radiation sickness.

All oil and chemical refineries and processing facilities in the larger Rotterdam harbour area have initiated emergency shutdown procedures after noticing the explosion and experiencing power surges. The shut downs involve burning off large amounts of fuel and venting pollutants into the air. This causes smoke and soot to fill the air. The process is slowed, especially in refineries close to Pernis because many workers have fled the scene.

12.25
Confusion in the media grows. One commentator on Dutch state television suggests that everyone in the Western half of the Netherlands, an area of up to 8 million inhabitants should evacuate. Panic is fuelled by images of the flooding in South Rotterdam, collision fires on highways to the east and photos of people leaving their cars and walking along clogged highways to get away.

The LOCC orders the sounding of emergency sirens throughout the Netherlands to encourage people to listen to the radio or watch TV announcements.

12.30
Emergency services from outside Rotterdam are getting stranded trying to get to the city because people are using inbound lanes for outgoing traffic.

The media starts offering escape route suggestions and one of the commercial channels has footage of taken from the Euromast and from a TV-crew south of the harbour area, showing enormous devastation, what looks like a crater and a continuing rise of black smoke from the area.

The media reports that people are beginning to flee other harbour cities in Western Europe, including Amsterdam, Antwerp and Hamburg.

A regional radio station in the urban area of Utrecht, 50 kilometres from Rotterdam claims it has received information from someone working at the meteorological institute KNMI warning that the fall-out plume is rapidly moving in the direction of Utrecht. The station urges residents to flee the Utrecht province while they still can.

12.35
The first SMS alerts are sent using the national Alert-NL system. Phones in the centre of Rotterdam receive a Dutch SMS urging people to stay away from the harbour and find shelter, preferably underground, including in metro stations. A similar SMS is sent to phones in Rotterdam South urging people to leave as soon as possible if flooding has occurred or seek shelter in non-flooded areas. People are told to evacuate in a south and southeast direction. Many mobile phone networks are overloaded however and phones and mobile networks within the 2.5 km EMP zone are no longer functioning.

The Dutch Prime minister appears on TV and radio announcing the apparent release of a large amount of radioactivity. He declares a national state of emergency and explains that he has called on NATO and EU partners to prepare for emergency humanitarian aid as well as stand by for possible military manoeuvres.

The first estimates provided by the NCC are that 5,000 people have died instantly, that there will be a similar amount of burn victims beyond help and an additional 10,000 burn victims that will need medical attention to survive. Experts from the Unit Planning and Advice nuclear (EPAn) point out that at the time of detonation, many children may have been outside on a lunch break, heightening the chance that they will have been exposed to the direct blast, heat, flash and radiation effects. A fear is that among the burn victims 2,500 may be children. The EPAn estimates that over 500,000 people are at risk of being impacted by fall-out or contaminated water. It is clear that the Erasmus Medical Centre, as well as the Rotterdam Harbour Hospital and several secondary hospitals are in the fall-out zone. None will be able to aid the enormous number of people expected to need medical attention.

12.45
The National Calamity Hospital in Utrecht, with capacity for 300 victims, opens.

Still worried that the nuclear attack may be one in a series, the Ministers re-emphasize the decision to move all containers and vessels in the Netherlands to secure locations. The LOCC orders regional authorities to move all container ships out to sea at least 30 kilometres from the coast. Floating debris in the New Maas makes this more difficult. Regional police forces are ordering trucks, trains and river vessels with cargo containers to move to secure locations assigned by regional coordination centres (RCC).

Intelligence reports confirm that the explosion was likely 12 kiloton. At NATO HQ, in Brussels, the Netherlands Ambassador to NATO invokes Article 5 of the Washington Treaty. NATO allies accept. This means that all NATO countries now consider themselves under attack and are mobilising for immediate military responses to further attacks or threats of an attack. The Dutch Ambassador in New York begins contacting Security Council members, who start preparations for an emergency session and the drafting of a text for a Chapter VII resolution.

12.50
Faced with reports of emergency response workers feeling sick, and taking into account the first estimates of the fall-out zone, government decides to give up attempts to rescue or aid people in areas directly downwind. This however, includes most of the centre of Rotterdam.

12.55
A reporter, broadcasting live from the Erasmus Medical Centre in Rotterdam calls for everyone to flee and is visibly, on air, getting very ill.

The first hours

13:00
The Dutch minister of the Interior appears on national TV and radio. He confirms that a massive explosion has taken place in the Rotterdam Waalhaven harbour that appears to include the release of nuclear radiation. He urges people to stay calm and listen to emergency services. He also urges people to stay close to their radio, TV or other communication device to be able to receive updated information as the government is still trying to figure out how many people will need to evacuate. He urges people in the Rotterdam central area to seek shelter underground and all others to vacate the Rotterdam region.

The Flemish government, worrying that a similar attack may happen in the Antwerp harbour, orders the closing of the A4 and E19 highway border crossings connecting Rotterdam and Antwerp, arguing that evacuees from Rotterdam are better advised to go east, away from Antwerp. 15 minutes later, after discussions with the Dutch government, the order is cancelled. The harbour authorities of Antwerp and Hamburg and Bremen in Germany, decide to follow the example of the Dutch authorities and order all container ships to go out to sea and all container trucks, trains and river boats to be moved to secure locations.

13.15
The National Measurement Network for Radioactivity (NMR) provides the NCC with a more precise prediction of the fallout pattern. It is estimated that fall-out will continue to be deposited for at least 24 hours. In a narrow band running directly between Rotterdam and Utrecht, radiation dosages will be harmful for humans. Wind directions appear steady and roughly the same at lower and higher altitudes. This may limit the total area affected but likely increases the concentration in the fall-out zone. Based on the predictions, the NCC suggests to the Ministers to evacuate the area that is likely to receive more than 50 REM in the first 24 hours, a strip of land of about 10 kilometres wide and 60 kilometres long.

Meanwhile, traffic control authorities report that many people are leaving Amsterdam. It is speculated that this is caused by people deciding to evacuate the city as a precaution – Amsterdam too is a major port city – but also that many people are trying to leave the city to go home or to pick up kids from school.

13.30
A national radiological decontamination plan is activated and the first two central locations are appointed for refugees. One is near The Hague, one is closer to Rotterdam, southeast of the city.

The LOCC informs local and regional authorities in the provinces of South Holland and Utrecht of updated protocols for evacuation, decontamination and sheltering.

13.35
The first reports are broadcast of overwhelmed hospitals throughout the country. Many people need help, and many are seeking advice, uncertain about the level of radiation they may have been exposed to. Confirming that people are ‘not affected’ is difficult, especially because it is clear to many citizens that the government is not fully in control of the situation. People are demanding to be given “radiation pills” or potassium iodide as a precautionary measure. Medical staff are unable to assess whether people have been exposed, and limited supplies are quickly exhausted.

13.45
The order is broadcast to evacuate according to the NMR prediction of fall-out. This includes most of the Rotterdam area, some smaller towns including Gouda and the entire Utrecht/Amersfoort area. The previous decision to open the National Calamity Hospital in Utrecht is cancelled because of the updated fall-out predictions. Burn victims are now directed to the specialized hospital in Beverwijk, near Amsterdam.

14.00
National TV and radio broadcasts are interrupted to give repeated orders for evacuation. People in Gouda and the northwest of Rotterdam are urged to evacuate in the direction of Delft and The Hague. People in the city of Utrecht are advised to find shelter in or close to their homes, in cellars

if possible and to prepare for evacuation after the fall-out cloud has passed. Evacuees are asked to go to the southeast, to the cities of Nijmegen, Oss and Eindhoven. People residing northeast of Utrecht are told to stay indoors and await further instructions.

New footage taken with mobile phones shows a disheartening scenery of devastation and despair in Rotterdam. The first imagery of burn victims arriving at hospitals outside the Rotterdam strengthens the idea for many that they need to move farther away from Rotterdam.

Even without the Flemish temporary blockade of important escape routes, the traffic jams and highway obstructions around Rotterdam are massive. The excessive numbers of vehicles trying to leave, accidents and abandoned cars have all but stopped any movement except by foot. Some trains have taken people out of Rotterdam, but by 2 PM, the train system has stopped working due to refusals of train drivers to go close to Rotterdam. The train connections between Rotterdam and Antwerp are lost.

14.30
Evacuation of Utrecht is now in progress. In the centre of the city, most roads are clogged. Radioactivity is measured just south of the city centre. On highways leaving the city, there are jams, but all in all, evacuation seems to go in a relatively orderly fashion.

15.00
The LOCC adopts a new set of estimates. It is estimated that 6,000 people have died in the initial blast and that up to 65,000 will be unable to escape lethal fall-out dosages. 130,000 are expected to have received doses of radiation that will make them sick, but from which they will recover, even without medical attention.

15.30
On television and radio the Prime Minister calls on all citizens to do whatever necessary to help victims, help prevent more injuries and to remain calm. He explains that the number of victims is still unknown but will be in the thousands and that people sheltering in the centre of Rotterdam will need to stay there until help arrives. He asks people to follow orders from emergency agencies and army personnel. Finally, he asks people living in areas that are not directly affected to set up places to sleep and shelter for the night for the evacuees from Rotterdam, Utrecht and other places.
The announcements are followed by repeated TV and radio spots on how to identify and mitigate radiation exposure.

In The Hague, the LOCC is coordinating evacuation operations for over 2 million people. For the first time, someone remarks that Rotterdam will be lost as a city, perhaps indefinitely.

16.00
News reports show footage of people stocking up in stores and the first reports are coming in of shortages of gas and petrol at gas stations.

17.00
In Belgium, estimates are that about 25% of the inhabitants of Antwerp have left the city and that a similar amount may be trying to get away.

Shortly before 6 PM, the sun sets on a smouldering Rotterdam harbour.♦

Chapter 2: The Effects

Flash

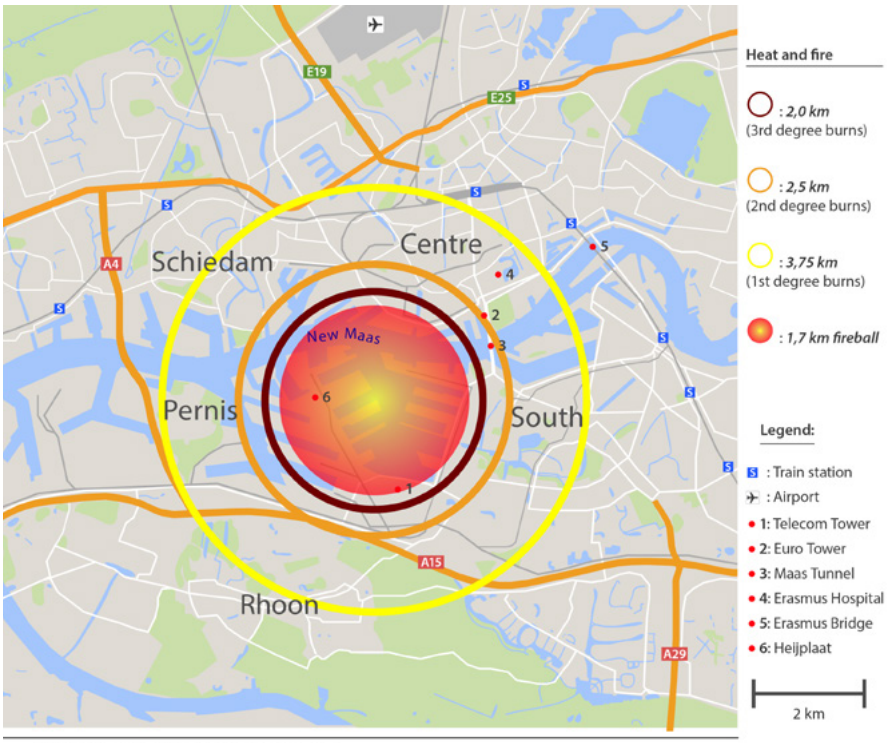
Light travels faster than sound or shock waves, so the first noticeable effect of a 12 kt nuclear detonation will be an incredible flash of light. Up to 2.5 km from the detonation, people will suffer retinal burns and longer term damage to their eyesight if they happened to look directly at the flash. Up to 4.5 km away, people may be temporarily blinded from looking into the flash and up to 16 kilometres away, accidents will occur because of temporary loss of eyesight among drivers, especially those on lanes approaching Rotterdam.

Heat and fire

The detonation will first take the visible form of a ball of fire with a radius of about 1.7 kilometres. At the core of the fireball, temperatures may rise as high as 50 million degrees Celsius. Those closest to the detonation may be vaporised or burnt beyond recognition. Up to 2 km from ground zero, people not sheltered by large concrete structures, will suffer 3rd degree burns. In Rotterdam, almost 8,000 people may die directly as a result of such injuries.

Second degree burns will be experienced by those exposed up to 2.5 km from ground zero, an area with over 44,000 inhabitants. Many factors will determine how many thousands will eventually die, but it is safe to assume that several thousand will suffer from burns that need medical attention. The suffering among those who survive the 2nd and 3rd degree burns will be severe. Hundreds will require long term medical treatment.

The flash will cause 1st degree burns, not unlike a sunburn, up to 3.5 km (an area of 38 square kilometres) from ground zero, for people that are directly exposed to the flash and to those parts of their bodies not shielded by clothing.



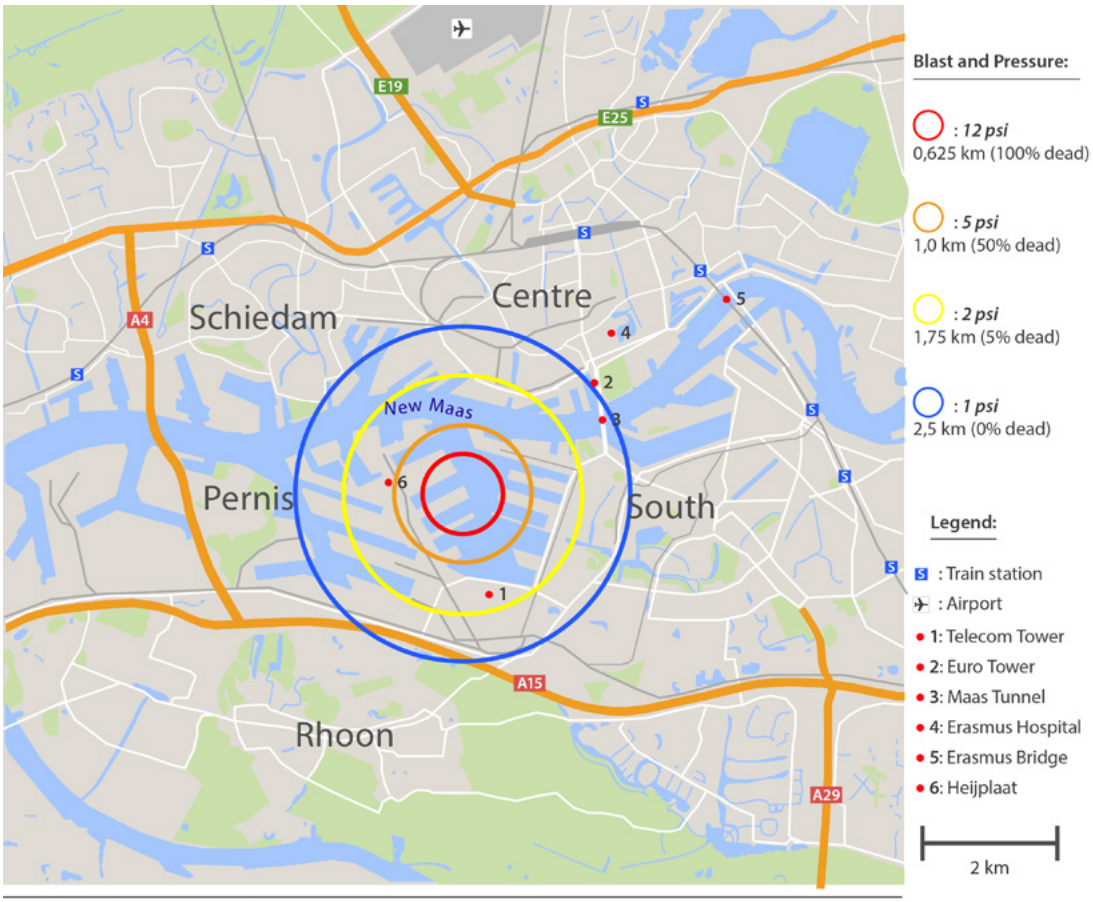
Burn injuries for people unshielded.

In the same 38 square kilometre area, dry materials such as wood and paper may spontaneously combust. Many of these fires will spiral out of control, adding to the destruction. In particular cases, the raging fires radiate heat upwards and suck in new air on the ground level. This can cause large firestorms that incinerate everything in their path. But even without those, the fires from spontaneous combustion are the cause of much of the devastation in the ring between 2 and 3.5 kilometres from the detonation. Examples in the scenario are the burning refinery to the west, the burning cars and cargo train to the south and damage to the Erasmus Medical Centre to the northeast.

Blast

Up to 625 metres from ground zero, individuals not shielded by solid concrete structures receive and overpressure of 12 pounds per square inch (PSI). This is enough pressure to crush a person's internal organs, killing them on impact. Buildings, ships, cargo and piers, everything within this zone is destroyed. Within a 1 km radius concrete structures are likely to collapse. This is within the zone that is consumed by fire.

Most of the blast effects will be indirect: People will be hit by debris, parts of concrete from the docks or metal shards of the hundreds of containers that are thrown about the harbour at high speeds. Up to 1.75 km from ground zero, people are at risk of being killed by the debris. The outer circle, at 2.5 kilometres away marks the boundary within which infrastructural damage caused by debris will likely occur as a direct consequence of the blast wave. Minor injuries from glass shards may occur beyond that point.



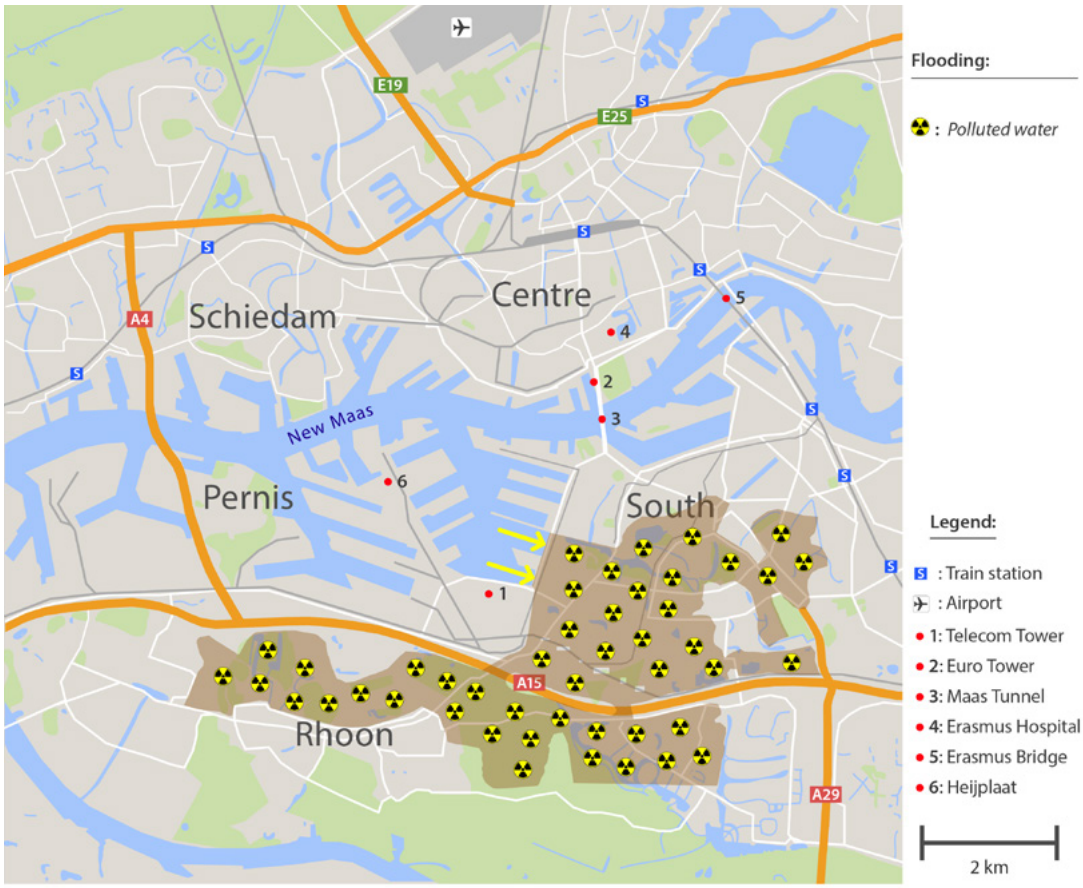
Pounds per Square Inch (PSI) overpressure.

Electro Magnetic Pulse (EMP)

The large, sudden release of energy will also result in an electromagnetic pulse (EMP). The EMP caused by a 12 kt nuclear bomb will fuse electronic devices and batteries up to about 1.75 km from the detonation. In this area, car batteries, mobile phones and televisions will not work anymore. In all likelihood the EMP will interfere with electricity, shutting off batteries and causing disruptions in computers, radar installations, telephone networks and electricity grids throughout the Waalhaven and surrounding neighbourhoods. The telecommunications tower just south of the Waalhaven is very likely out of order. The EMP could cause trouble for airplanes leaving or approaching Rotterdam Airport, although it is not likely that planes will crash as a result.

Flooding

The blast damages the south and southeast lying dams of the Waalhaven, allowing radioactive water to flow into the below sea-level areas of the residential neighbourhoods Wielewaal, Charlois and the town of Rhoon. The area is home to roughly 43,000 people. Most ground floors are between 1 and 2 metres below the harbour water line, with the lowest points over 2.5 metres below sea level. In most streets, the water levels may not rise more than knee deep, but the danger for humans in this case is not the depth of the flood. The highly radioactive water will contaminate a part of the area beyond immediate remediation and inhabitants of all flooded areas will need relocation until the area is decontaminated. It is questionable if it is economically feasible to remediate much of this area, as parts of it will be contaminated by fall-out as well.

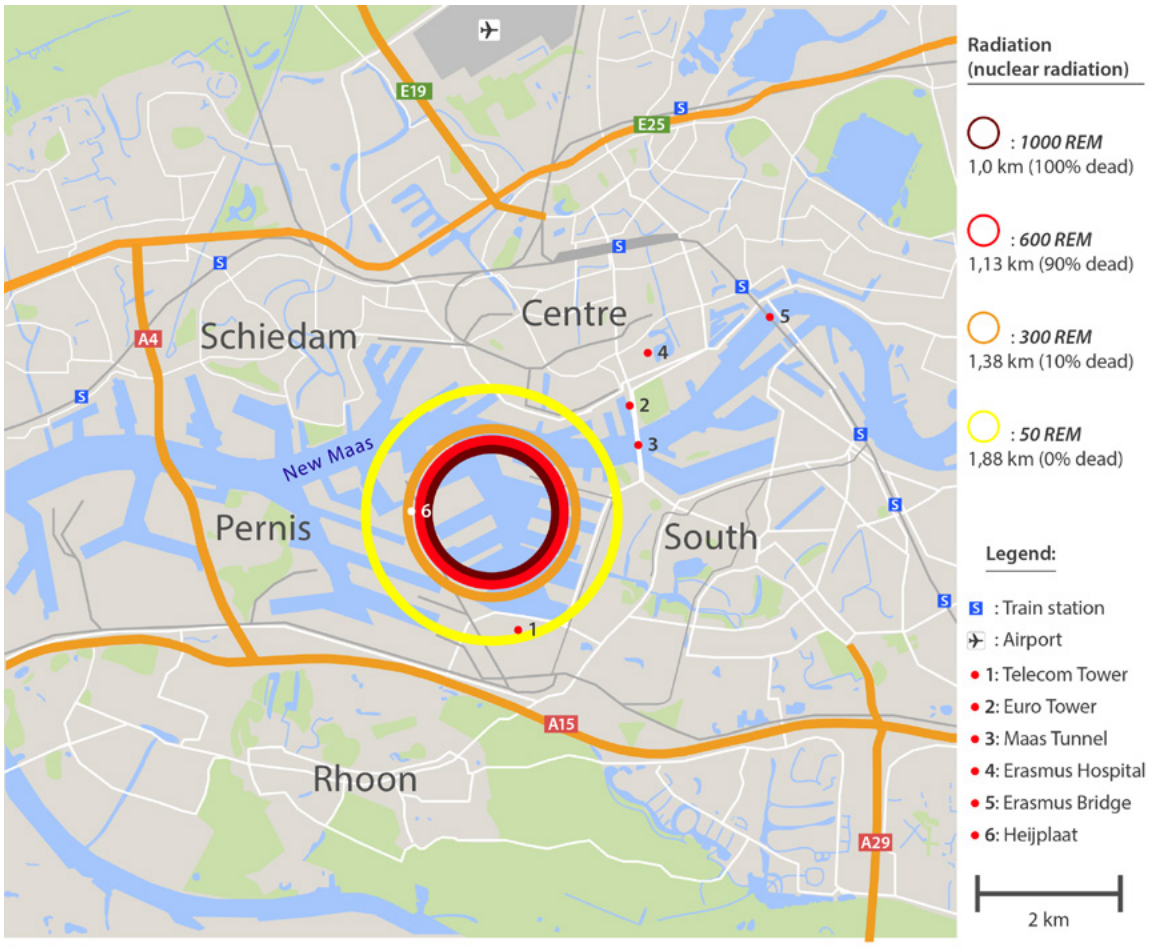


Estimated area flooded with contaminated water.

Radioactivity

Ionising radiation is the unseen and unheard killer of a nuclear bomb. It will ionize atoms it hits. Ionized atoms will lose their electrical bonds with neighbouring atoms thereby changing their molecular composition. In the human body, ionising radiation affects the proteins of cell walls. The cells start to leak fluid and eventually stop functioning. People receiving over 1000 REM may die within minutes of internal bleeding or suffocate after their lungs fill with blood and other bodily fluids.

Up to one kilometre from ground zero, people will receive a dose of radiation upwards of 1000 REM (10,000 mSv). The radiation levels drop quickly beyond that circle. At 1.13 km, it is 600 REM, enough to kill most people, though this may take hours or even days. At 1.38 km, exposure drops to 300 REM. This will make a person violently ill for days but there is a 90% chance of survival. At 1.88 km, the dosage drops to 50 REM, which is considered the maximum dosage that one can receive without considerable direct effects to the health.



1 REM is 10 Millisievert (mSv).

Fall-out

Fall-out is the main killer in a scenario such as this. The mushroom cloud, the typical image of a nuclear detonation, consists of thousands of kilos of highly radioactive water and dust particles that are sucked in, and pushed upwards over 6 kilometres above ground. The size of the cloud is much bigger for a bomb detonating on the ground (as in this scenario) than for one detonating in the air (as in Hiroshima). The contamination caused by the falling, or raining down of these particles, the 'fall-out', is highly dependent on weather conditions. In the presented scenario, the wind blows the particles to the east-northeast at 7 meters per second (25 km per hour), which is the prevailing wind speed and direction in February for Rotterdam. In the scenario, the wind direction is the same at all layers of the atmosphere at all altitudes. This means that fall-out is deposited in one direction only, limiting the area that will need cleaning up or long term abandonment. On the other hand, because of the singular wind direction, radioactive levels are more concentrated in a limited area, a straight narrow band that runs between the major cities of Rotterdam and Utrecht.

Fall-out will start to come down on the central parts of Rotterdam city within 15 minutes after the detonation, leaving people very little time to find refuge. Leaving the area before the fall-out will be almost impossible but it is unlikely that most people will realise this. The effect is that over 300,000 people will receive a doses of more than 50 REM radiation while they are trying to evacuate Rotterdam or out on the street trying to figure out what has happened. Of those, 60,000 are likely to die the slow and painful death of radiation sickness in the hours and days after the detonation. About 120,000 people will survive but with lasting effects to their health, including a higher risk for cancerous diseases for the rest of their lives. This is also the segment of survivors that have the highest risk of transferring genetic mutations to their children in the decades after the detonation.

Logically, the closer one is to ground zero, the higher the potential exposure will be. Likewise, the closer one is to the central line of the fall-out cloud, the higher the potential dosage will be. The area depicted on the map, receiving 50 REM or more, will be the area where long term relocation is needed after the dust has – literally – settled. Of the 300 square kilometre of affected land, roughly one third is densely populated urban area.

The centre of Rotterdam and about half of the entire Rotterdam urban area will require abandonment for at least one year. Closer to ground zero, areas may have to be abandoned for more than 5 years. Although remediation can limit some of the longer term effects of fall-out, it is hard to see how Rotterdam as a city can survive this scenario, especially because the centre of the city and the waterways between the city and the harbour are so severely damaged.

The wind will blow the cloud of fall-out towards Utrecht, the 4th largest city in the Netherlands. The central line of the deposit area runs over the south of the city and the 50 REM zone ends just east of the city, where Utrecht University and the National Calamity Hospital are located. The whole of the Utrecht area will be evacuated until precise measurements can provide a credible overview of areas that need longer term relocation. All in all, the fall-out will affect an area with roughly 2 million inhabitants, of which 400,000 will need long term relocation.

Two thirds of the affected area is farm land, part of the area known in the Netherlands as the "Green Heart" and the area from which Gouda cheese originates. The fall-out will stop all trade of dairy and meat products for at least half a year, a significant blow to the Dutch economy and identity.

Radioactive fallout will also have indirect effects. Surface and ground water will be contaminated.

Large parts of the affected area are below sea level and water will need to be continuously pumped out of these areas and into the North Sea. This can help to speed up the removal of radioactive particles from the surface and disperse radioactive contamination into the North Sea. On the other hand, it also means that it will be difficult to seal off affected areas and prevent further spreading of contamination through waterways and ground water.

Contamination will jeopardise the availability of clean drinking water in the short term, in areas where filtered river water is used, such as in the city of Rotterdam. In Utrecht, the drinking water problems may occur much later, if fall-out contaminates the ground-water reservoirs that are the main source of tap water in the region.

Traffic

Existing transportation infrastructure- roads and railways- is a specific consideration to examine in this type of scenario. Even if people have the time to get away from the fall-out, the infrastructure is not sufficient to handle so many people trying to flee a city at short notice. Traffic accidents caused by the blinding flash or - closer to the detonation – by the blast wave will hinder or obstruct traffic from the outset. Furthermore it must be assumed that people will not be able to guess what the best escape routes will be. For example, if you live just south of the river, in Charlois, it is not unlikely that you would see the mushroom cloud rising to the southwest and reason that you need to cross the river to go northeast, which would lead you into a massive traffic jam at the obstructed bridges and tunnels and into the centre of the fall-out zone. Just north of the river, people who realise immediately that they are downwind of a nuclear explosion may have the wits to try and flee the area within minutes, moving at right angles with the wind direction. To the northwest would be the escape direction with the highest chance of success, while escape to the southeast – across the river – would almost certainly lead to being stuck in a massive traffic jam in the midst of heavy fall-out. We cannot assume that people on the ground in the scenario will be able to figure this all out, lacking information on what has just happened and what the direct consequences could be.

Chemical contamination

Apart from radiological contamination, the explosion will have additional toxic effects caused by damages and emergency measures at oil refineries and chemical plants in the region. The 2nd Petroleum Harbour is only 3.5 km to the west, just within the zone in which flammable materials will spontaneously combust. In the scenario, one of the petrol storage tanks will be damaged and set ablaze, leading to an uncontrollable chemical fire. Even without this eventuality, the emergency shutdown of refineries in the entire harbour area will lead to considerable additional contamination in the region, complicating cleanup and remediation efforts.

Chemical and petroleum contamination is likely to occur from the destruction and damaging of containers and vessels in the harbour as well. There are 100,000 containers present in the Rotterdam harbour at any given time. The cargo of roughly 25% of these containers is considered environmentally hazardous. Many of the most toxic chemicals are processed far away from the city and the Waalhaven, but many of the river boats and many of the cargo trains and trucks bound for the hinterland pass through the destruction zones in this report.

Accumulated effects

Fatalities
Close enough to the explosion, people may die because they are hit by the blast front, by peak dosages of ionising radiation or by heat and fire. The zone of 100% fatalities is the largest for the heat and fire effects, killing approximately 7,800 people in the Waalhaven, the Heijplaat community or in the residential parts of Rotterdam South closest to the explosion. There will always be exceptions to the rule – people who happen to be underground or just happen to be shielded by large amounts of concrete – but the combination of heat, radiation and overpressure is hard to hide from.

The majority of fatalities is less direct. In a 300 square kilometre area downwind from the detonation, people are in danger of receiving fatal doses of radiation. Rotterdam centre is directly downwind. 180,000 people will not be able to avoid harmful dosages of radiation. All will be very ill. 60,000 will die in the hours and days after the detonation.

This brings the total amount of people dying as a direct consequence of the nuclear detonation to between 60 and 70 thousand. In this figure, people dying young due to cancerous diseases are not included.

Wounded

Just outside the 100% death zone, 7,800 people will be injured and need medical attention. About half of those will have 2nd or 3rd degree burns. Required medical attention is difficult to obtain, as emergency response units will not be able to enter the contaminated area. Survival for people in these zones depends on their ability to move out of the area and seek help. For those that would make it outside the zone, with less than 100 burn beds in the Netherlands, it is hard to imagine how the country would be able to provide the necessary medical care.

A much larger category of people will suffer from radiation sickness in various grades. Although it is often impossible to ascribe individual cases of cancer to exposure to radiation, it can be assumed that an additional 6,000 or more cancer cases, outside of statistical expectations, will be measured in the decades after the detonation.

The number of thyroid cancer cases is partly dependent on the ability of the Dutch government to provide people in affected areas with iodine prophylaxis pills in time. It is almost certainly impossible to distribute potassium iodide to people living in the centre of Rotterdam in time in this scenario, as the fall-out cloud would reach this area within 20 minutes after the detonation.

Evacuees and displaced people

Roughly half the population of the Province South-Holland will be urged to evacuate as well as the entire population of the Utrecht province, almost 3,000,000 people. Estimating that 75% will chose to and be able to evacuate, this results in 2,250,000 evacuees most of whom will be moving out of their respective areas within the first hours after the detonation.

Once the extent of the fall-out has become clear, many of the evacuees can return home. All in all, roughly 400,000 people will need longer term relocation. Their return depends on the question when – and if – the Dutch government will be able to remediate the areas from which they originate. Most of these people used to live in Rotterdam. Of the 1,850,000 people allowed to return home, it is to be expected that many will be reluctant to go back. The areas where they live will be stigmatised and perceived as contaminated – regardless of whether this is true or not. Businesses are likely to move out of these areas as well as the inhabitants that have the financial means to relocate.

Rotterdam

It is hard to see a future for the city of Rotterdam as we know it. The entire centre will be abandoned for a longer period of time. Neighbourhoods around the centre will be stigmatised. The outermost neighbourhoods may be largely unaffected, but would over time become more connected to the municipal services and infrastructural connections of other cities like Delft, Vlaardingen and Dordrecht. By the time Rotterdam city centre is clean enough to rebuild, the adjustments and temporary measures may have become permanent and the city as it once was will have ceased to exist. ♦

Concluding Remarks

What this report shows is that no society can adequately prepare for any use of a nuclear weapon. Not even a country as wealthy and as well-organised as The Netherlands has the infrastructure or capacity to address such an event. There are not enough ambulances, hospital beds, burn beds, potassium iodide pills, medical personnel. There is not enough stored oil and gas, food and equipment to contain the contamination or to quickly recover from the use of a weapon such as this. Rescue operations will not be able to reach the wounded and the dying in highly irradiated areas. Tents and blankets sent by neighbouring countries will not be enough to shelter the refugees in the first, uncertain night. With a nuclear explosion as described in this report, Rotterdam as we know it today will cease to exist.

If you know you cannot remedy or even mitigate the consequences of an event, there are two other strategies left: One is to choose to accept that there is just nothing you can do. During the Cold War, acceptance of the possibility of nuclear destruction was the prevalent attitude – the idea that there is nothing to do but hope that the threat of destruction is enough to prevent others from destroying us. This attitude has shaped the treaties and negotiation mechanisms that we have today. The NPT for example, still allows five states to drag their feet in fulfilling their pledge to negotiate nuclear disarmament. The Conference on Disarmament has remained deadlocked for 17 years, unable to provide the necessary impetus for meaningful steps towards a world without nuclear weapons.

The world has changed, and there is no reason to continue accepting the status quo of complacency. We do not have to live with the continued threat of 17,000 nuclear nightmares. Instead, there is another strategy: Prevention. Twenty years after the end of the Cold War, it is time to fully embrace a new attitude and a new approach. We can choose to prevent this type of destruction from ever happening. It is time to go for the most obvious way to prevent a nuclear disaster: An international treaty that prohibits the use, deployment, stockpiling, possession and development of all nuclear weapons, for everyone, always, anywhere.

We have banned landmines, cluster munitions, chemical weapons and biological weapons. Let's ban the bomb. ♦

Sweet is
the **war**
to those
who **don't**
know it.

Erasmus of Rotterdam (1466 – 1536)

PAX