Calculating the Effects of a Nuclear Explosion at a European Military Base

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NRDC: Natural Resources Defense Council, Washington, DC
What are the effects of a nuclear explosion?

- Crater
- Blast Overpressure
- Blast Dynamic Pressure
- Thermal Radiation
- Initial Nuclear Radiation
- Local Fallout
- Global Fallout
- Electromagnetic Pulse

Energy partition of a nuclear explosion:

- 50%
- 35%
- 5%
- 10%

Important effects in military planning:

- Initial Nuclear Radiation
- Global Fallout

Important widespread humanitarian effects:

- Thermal Radiation
- Blast Dynamic Pressure
- Blast Overpressure
- Crater
A Hypothetical Scenario
A Standard Military Target

46.031278 N, 12.596778 E
Choosing a Nuclear Yield

Choosing a Height of Burst

- Nuclear Explosion Height of Burst (meters)
- Overpressure near Ground Zero (psi)
- Percent of Activity in Local Fallout
- Overpressure at 100 meters from ground zero

200 kt Nuclear Explosion

Red: Overpressure
Blue: Activity

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Crater
Initial Radiation

- > 10,000 rad
- 1,000 rad
- 400 rad
- 200 rad

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HPAC Local Fallout Dose Calculation: 4 hours after detonation (historical November winds)
HPAC Local Fallout Dose Calculation: 8 hours after detonation (historical November winds)
HPAC Local Fallout Dose Calculation: 12 hours after detonation (historical November winds)
HPAC Local Fallout Dose Calculation:
16 hours after detonation
(historical November winds)
HPAC Local Fallout Dose Calculation:
20 hours after detonation
(historical November winds)
HPAC Local Fallout Dose Calculation:
24 hours after detonation (historical November winds)
HPAC Local Fallout Dose Calculation: 36 hours after detonation (historical November winds)
HPAC Local Fallout Dose Calculation: 48 hours after detonation (historical November winds)
U.S. DoD HPAC Model (Hazard Predication and Assessment Capability)
U.S DoD HPAC: Casualty Tables

For an Unsheltered Population

<table>
<thead>
<tr>
<th></th>
<th>Best Estimate</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Prompt</td>
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<tr>
<td>Fatalities</td>
<td>16,901</td>
</tr>
<tr>
<td>Injuries</td>
<td>6,304</td>
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<tr>
<td>Total Casualties</td>
<td>23,205</td>
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</tbody>
</table>

For a Sheltered Population

<table>
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<tbody>
<tr>
<td></td>
<td>Prompt</td>
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<tr>
<td>Fatalities</td>
<td>10,169</td>
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<tr>
<td>Injuries</td>
<td>16,737</td>
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<tr>
<td>Total Casualties</td>
<td>26,906</td>
</tr>
</tbody>
</table>
Examples for ZAMG emergency activities using the FLEXPART model

**Nuclear emergencies**

- TAMOS Model
  - Plume transport and nuclear fallout computation
  - Accumulated deposition
  - Time-integrated concentrations
  - Weather bulletins

**Volcano eruptions**

- Calculation of fine ash at flight levels
- Calculation of SO2 pollution
- Integration of satellite information, source term estimates

**Atmospheric backtracking**

- Investigation of interesting measurements
- CTBT Verification
- WMO designation (RSMC)
View of Fallout Cloud Model
40 km from Ground Zero

Developing a Source Term for FLEXPART:
Fallout Cloud Geometry
Developing a Source Term for FLEXPART: Fallout Cloud Geometry
Developing a Source Term for FLEXPART: Radionuclides

Total activity from a nuclear explosion: 450 megacuries per kiloton of fission yield at 1 hour after detonation.

Our Scenario: 200 kt x 450 megacuries/kt x 75% fission x 50% in local fallout = 33,750 megacuries initial source term.
October 09, 2014

Cesium-137 Deposition

Location of Hypothetical Scenario

Cs-137 Deposition

- 0 - 10 Bq/m²
- 10 - 100
- 100 - 200
- 200 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 10,000
- 10,000 - 20,000
- 20,000 - 50,000
- 50,000 - 175,000

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8-9 DEC. 2014
October 10, 2014

Cesium-137 Deposition

Location of Hypothetical Scenario

Cs-137 Deposition
- 0 - 10 Bq/m²
- 10 - 100
- 100 - 200
- 200 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 10,000
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- 20,000 - 50,000
- 50,000 - 175,000

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8-9 DEC. 2014
October 11, 2014

Cesium-137 Deposition

Location of Hypothetical Scenario

Cs-137 Deposition

- 0 - 10 Bq/m²
- 10 - 100
- 100 - 200
- 200 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 10,000
- 10,000 - 20,000
- 20,000 - 50,000
- 50,000 - 175,000

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8-9 DEC. 2014
November 13, 2014

Precipitation

Location of Hypothetical Scenario

Precipitation

Precipitation

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November 12, 2014

Cesium-137 Deposition

Location of Hypothetical Scenario

Cesium-137 Deposition

0 - 10 Bq/m²
10 - 100
100 - 200
200 - 500
500 - 1,000
1,000 - 2,000
2,000 - 10,000
10,000 - 20,000
20,000 - 50,000
50,000 - 175,000

0 250 500 1,000 Kilometers

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8–9 DEC. 2014
Concluding Thoughts:

• Open-source information can be used to calculate the effects of a nuclear explosion in terms of crater, blast, thermal, initial radiation and fallout effects.

• Military targeting requirements for destruction of hardened objects involves surface or near-surface bursts, maximizing fallout.

• For a 200kt nuclear explosion, the prompt nuclear weapons effects are far more localized than the fallout effect, which were shown to extend across international boundaries for this hypothetical scenario.

• Variations on fallout patterns with weather conditions are a motivation for non-nuclear weapon states to develop a capability to model nuclear explosive effects to mitigate humanitarian impacts of nuclear conflict.

• Humanitarian impacts of nuclear war continue to be relevant to our societies, given the large nuclear arsenals retained decades after the end of the Cold War, and new nuclear weapons development in many states.
Nuclear emergencies – standard protocol used

- Unknown source term: usage of 1 Bq release (3 hours)
- Known source term: usage of source term
- Weather bulletin: discussion of weather situation and development with regard to accident
- Standard computations include $^{137}\text{Cs}$ accumulated deposition (24/48 hrs), $^{137}\text{Cs}$ time-integrated concentration (24/48 hrs)
Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

- Weather Forecasts, warnings and advisories
- National seismological Service, CTBT Verification
- Meteorological, climatological and seismic monitoring
- Environmental emergencies – nuclear accidents, chemical accidents, volcano eruptions
FLEXPART model

- Lagrangian particle dispersion model
- Source code and documentation can be downloaded from internet: [http://flexpart.eu](http://flexpart.eu)
- Users include research institutions, private companies, weather services (ZAMG) and operational organisations (CTBTO)
- Many different meteorological input data can be used:
  - ECMWF
  - NCEP
  - Aladin/Alaro
  - Mesoscale Model WRF
Electromagnetic Pulse