PRELIMINARY NUCLEAR TERRORIST EFFECTS STUDY

by

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INTRODUCTION

Earlier studies[1] have looked at the overall problem of nuclear terrorism. It is assumed that the adversary can obtain the necessary people, special nuclear materials, precision machining capability and high explosives materials to accomplish the task of constructing a nuclear device. The nuclear device is assumed to be a small-yield (less than a few tens of kilotons) fission device. Larger yields are also possible.

A nuclear device could be placed in a myriad of urban locations in order to accomplish the goals of the terrorist organization. The simplest location from a technical analysis point of view may be an open street in a simple transporting mechanism such as a trailer or van. Most other locations will add complexity to the problem. For purposes of discussion, we will use the open street location.

For evacuation planning, the device type and expected yield will be very important. Although information about the device type is expected to be relatively easy to obtain, the expected yield will be very difficult to assess. Assuming the device can neither be rendered safe nor disassembled and that a large amount of time is not available for detailed diagnosis, the device must be assumed to have a yield range from just the high explosive yield to the maximum credible yield of nuclear material contained in the device. Even estimating the maximum credible yield requires that a tremendous number of assumptions be made about the nuclear material in the device.

TECHNICAL PROBLEMS ASSOCIATED WITH THE URBAN ENVIRONMENT

In an urban environment, such as Manhattan, with the device on the surface of a street, several mechanisms will come into play that do not exist in the free-field environment. First, the thermal and ionizing radiation output of the device will heat the close surroundings of the device, and some of these surroundings (e.g., buildings on two sides) will emit this energy back into the fireball in an asymmetrical fashion. The shockwave will also build up on the sides of the non-rigid, and possibly collapsing, buildings and be reflected non-symmetrically back into the fireball. The competition of these effects along with the restricted ability of the fireball to "breathe" (i.e., the inrush of cool air is heated causing the fireball to rise) may bring about a strong ballistic component to the rise as opposed to a buoyant rise normally assumed for a small yield fission device. This would have a major effect on the radioactive fallout and dispersal.

The shockwave in the direction of the street (as opposed to the direction of the building) would be channeled and directed down the street. The surrounding buildings and structures would cause drag on this shock front, and depending on the building surfaces, large scale roughness factors may rapidly remove energy from the wave by turbulence build-up. Breakage of glass walls with blast filling of buildings would also remove energy. At street intersections, a pressure relief will occur down side streets and an associated eddy fluid flow and turbulence pattern will build up to remove energy from the shock front. Another problem to be considered might be the collision of shock fronts channeled in different routes in the grid of streets. When this phenomenon occurs, the result will be a loss of shockwave energy that will heat the fluid. Although the problems mentioned above have been studied individually for various fluids, the ability to comprehensively study these effects for a nuclear explosion in an urban environment does not currently exist. If one removes all of the problems above with simplifying assumptions, models are available to coarsely treat the problem. The uncertainty in the results from these models is so large when coupled with the uncertainty in the device yield that it makes the result nearly useless to the emergency planner.

The thermal problem is somewhat easier to analyze. The major considerations are the objects and people in the streets, since this wavelength of radiation energy does not penetrate opaque objects but rather heats them. The temperature of the fireball constrained by the structures of the urban environment when viewed at a distance from the burst probably will not change significantly from the normal 6000K to 7000K and only the cross-sectional area of the radiating surface will have to be considered. The majority of the thermal energy (approximately one-third of the total energy from the device in a free-field environment) will be emitted in a few tenths of a second. At street level, the thermal pulse will come from a volume of luminous gas that will approximate a cylinder filling the area between the buildings and be of a height approximating the radius of the normal free field fireball hemisphere. At times after the thermal pulse, the fireball should exhibit some jetting and movement down the street. This is the result of the pressure created by partial early-time containment on two sides by the buildings, but the buildings will not play a major role in the very early time fireball that gives rise to the thermal pulse. This assumes the yield is 10 kT or less, so the thermal pulse is short.

The fallout problem associated with the urban environment may be the most difficult and overriding in terms of evacuation planning. The problem is to understand the dominant factors in order to determine what fraction of the nuclear debris cloud will rise above the surrounding buildings. As mentioned earlier, the partial blast containment, the radiation and thermal heating of structures, the full involvement of building material in the condensation chemistry, and the "breathing" ability of the cloud will all have an effect on cloud rise. Although recent new fallout models have brought this effect to a level of predictability associated with other nuclear effects in a free-field environment, the effort has never been seriously attempted for an urban environment[2].

A second major problem is to estimate a meteorological surface roughness to be used for an urban environment over large areas that will receive fallout. The surface roughness is used to estimate the turbulence and eddy fluid flow conditions and consequently the air mixing near the ground surface. It should be noted that although fallout a long way downwind does arrive in time lengths of hours, the moderately close fallout (less than one kilometer) can start arriving within a few minutes. Thus, the portion of the population close-in that takes cover during the explosion should not try to outrun the fallout. The rescue effort will have to be well planned and executed to save them. Protection factors of building shielding from fallout may be good enough to protect them for the time needed to plan the area re-entry. In particular, the center areas of midlevel floors in a high-rise building should be reasonably safe.

REFERENCES

1. Northrup, J.A., "The Role of Civil Preparedness in Nuclear Terrorism Mitigation Planning", SSS-R-80-4185, Systems, Science and Software, La Jolla, CA, September 1979.

2. Office of Technical Assessment, U.S. Congress, The Effects of Nuclear War, p. 45 (1979).