LinkExchange

On nukes - the short form.

The important formula is:

$$(D/D1) = (w/W1)^{1/3}$$

where D is the slant range of the theoretical weapon, D1, the referent distance, and W is the theoretical weapons's yield in kt, and W1 is the referent weapon in kt. If the referent W1 = 1kt, then the formula is D = D1 times the cube root of the Weapon's Yield. D= D1*W^(1/3). In short - if an over pressure of 15psi is measured at a distance of D1 feet from the hypocenter (that spot directly under the detonation) for yield W1, you can computethe D for a larger or smaller yield to cause the same over pressure to occur. In theory. Remember - the real world is analog, not digital.

There are a number of fudge factors to account for variations in altitude, temp and such, but ... who cares, this is good enough for government work.

Ufda - lots of numbers, but ... Oh yes, something I didn't address in the program: Underground damage from a surface burst is going to extend two more crater width in all directions (in other words, for a 500 kt weapon if your shelter is within a mile of ground zero - you are going to be in serious trouble, just from the ground shock wave.) But it is also dependent on the soil type: hard rock, "soft" rock, dirt; wet or dry, smoking or non-smoking, etc, etc.

I've shortened the output to include just a 1 kt, 20 kt (nominal Hiroshima size), 335 & 500 kt (as those are (were) the two popular sizes in the US and USSR inventories,) 1, 10, 20 and 24 megatons TNT equivalent, just for comparison. My own feelings on the matter is that the Chinese might have 1 meg devices, but those are realistically city busters. More efficient to use the equivalent yield in a number of smaller weapons - cover's much more area.

I. NUKE DET - OR "HOW BIG A HOLE DOES THAT FIRE CRACKER MAKE"

Nuclear devices (jargon for A-bombs, H-bombs and other bombs using nuclear physics as the source of the bang) are simple applications of Boyles law: a thing heated expands, things heated a lot expand a lot, and gases expand to equalize pressure. For a good description of the sequence, read Clancy's "Sum of All Fears", chapter 35 has a very good description of what's going on. Nukes are a nerd engineering toy. Lots of time and effort goes into creating conditions lasting a fraction of a second (technically "three shakes of a lamb's tail - about 3 nanoseconds). In those three shakes the energy released heats the 'device' beyond merely hot, and then it is Mechanics 101: X kilos of metal heated to Y degrees forms Z plasma at what internal pressures? How much time elapses until the plasma expands and equalize pressure with the surrounding environment? (assume STP) What will the initial speed of a shock wave propagating through the fireball? Show all work.

I dunno - I'm a history major. The technical stuff is based on Gladstone, et. al., work: _Effects of Nuclear Weapons_ published by the Dept of Defense in several editions. They have enough mathematics to satisfy most nerds. Information about the yields, ranges, effectiveness, etc. are drawn from Dunnigan's _How to Wage War_. Keep in mind that most of the published information (and this program) is based on tests done under restricted conditions: a desert in Nevada and Pacific Atolls, under optimal weather conditions. Nobody (that I know of) has conducted a realistic test since August 1945, e.g. in the rain, at night, in the winter, or on a target not on level terrain. Nor was there been any real ballistic tests of the intercontinental ballistic missiles over the courses they would have been taking in time of war. On the other hand - if the US ever declares war on Kwajalien Atoll - it's toast.

As far as war fighting capabilities, all ballistic missiles have two targeting errors that accumulate. One error is generally similar for all of a model or production run. In rifle terms - one model will 'shoot low and left', another 'high and right'. The end result of this is that a model of rocket may have its aiming point off by as much as ten miles. At the final end of the mission is the "CEP" [Circle of error probability]: half the warheads will arrive inside the CEP, which will be centered on that mythical aiming point, which will be somewhere in the vicinity of the actual target. Note that cumulative error might put a warhead directly on the target desired. Don't bet on it. :)

II. JARGON:

Breakaway That time when the expansion of the fireball slows below the speed of sound, and the shockwave 'breaks away' from the expanding fireball. Remember, speed of sound is a relative constant. And note well that the fireball follows the laws of physics and is rising on the thermal it is creating. Rather rapidly too, I gather.

CEP Circle of Error Probability. A circle around the aim-point in which fifty percent of projectiles will land within. Compares to the strike-zone in baseball, only there is no bat. Early rockets had CEP measured in miles, the most recent ICBMs claim CEPs in the tens of meters. Tomahawks have CEPs measured in fractions of a meter.

EMP Electo-Magnetic Pulse. As a 'side effect' of releasing all this energy is what is called the EMP. Think of it as a lightening strike - and the effects are similar. Things most affected by EMP are electronics - chips, and least affected are tubes and standard AC equipment. It also screws up radio and radar reception.

HOB Height of Burst. In feet, it affects fallout, destructive area. For for a 24 megaton warhead, 'ground' zero is 27 feet in the air.) For 'soft targets, HOB can be higher, to maximize the extent of the damage.

There are six representative HOBs: a surface burst, a low altitude airburst for minimum fallout, two middle altitudes for maximum damage to ordinary buildings, and a high altitude burst to break the most glass.

Overpressures of 200 psi effectively clears an area down to ground level. Nothing remains. 15 psi will seriously damage even the most earthquake resistant structure, making it uninhabitable even if standing. 4 psi will render a standard American house uninhabitable (shift it off the foundation, and similar structural damage). 1 psi will cause 'light damage' - watch for flying glass, poodles and stuff. Window glass is vulnerable to a 0.1 psi overpressure - I couldn't deterimine this distance.c

K Kill factor. Targets have a K factor (how hard are they to destroy) and Weapons have a K factor (how well they destroy). K for nukes is computed as Yield to the two-third power divided by CEP to the second power. Y^.66/[CEP*CEP]. Obviously, the more accurate, the lower the required yield to reach a given K.

Serviceability Not all systems are ready at all times. Routine maintenance, inspections, upgrades, transit to patrol station makes some weapons unready.

Reliability: Ability of a delivery system to continue functioning from its launch until it delivers the payload. For Aircraft, this includes a SWAG on getting shot down along the way. A combination of known factors and SWAG.

SWAG Scientific Wild Ass Guess. Guesswork ennobled by having been run through a computer. Just because it's printed on greenbar only changes a Wild Guess into a SWAG, no better than the assumptions.

Targets: Hard Usually military targets that have been reinforced to withstand blast damage, e.g. missile silos, command bunkers, armored vehicles. Other hard targets are those which are naturally less vulnerable to blast damage: bridges, highways and railroads.

Targets: Soft Things that will not withstand a great deal of dynamic overpressure: most buildings, airplanes, people, shipping, trains, forests.

Yield: explosive equivalent, usually expressed in Tons of TNT.

Damage Measurements: There really isn't a 'Richter Scale' for damage assessment. But the rule of thumb for Strategic Air Command for military targets: Light is rubble, Moderate is gravel, Severe is sand or dust.

III. Table layout

The table reads across as Yield, Weapon Name, Owner, a two character code

[Tactical|Strategic][Gun|Bomber|Missile] for Type, the CEP and K for Strategic Missiles, number of Delivery Systems, their Serviceability and Reliability, Number of Warheads per delivery system, the Range in miles and the Year first deployed.

The entry for A Bomb has the last date the information was checked by me: 27 March 1987. This does not reflect START, STOP, or the break up of the Soviet Union.

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     1  A Bomb;             Other  TG    -      -    27   3  87   0      1 45
    40  Poseidon C3;        USA    SM  463     1.9  480  60  80  10   4600 71
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The second line 'reads': 40 kiloton yield, Poseidon C3 (a sub launched ICBM); it is American made, a Strategic Missle, CEP in yards is 463, it has a K of 1.9, 60% are ready at anyone time, and 80% of those ready are expected to arrive on target, delivering 10 warheads 4600 milies, and was first deployed in 1971.

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     1  A Bomb;             Other  TG    -      -    27   3  87   0      1 45
     2  155mm Howitzer;     Nato   TG    -      -  1800  90  90   2     16 64
     5  203mm Howitzer;     Warsaw TG    -      -   300  90  90   4     16 62
    10  Lance;              Nato   TM    0     0.0  108  90  90   6    110 72
    20  Pluton;             Frog   TM    0     0.0   42  75  90   3    120 74
    40  Poseidon C3;        USA    SM  463     1.9  480  60  80  10   4600 71
    50  FROG-7;             Warsaw TM    0     0.0  480  65  90   3     70 67
   100  SS-22;              Soviet SM    0     0.0  200  65  90   2   2000 79
   125  Trident C4;         USA    SM  200    18.5   48  60  80  10   7400 79
   150  SSBS S-3 (Fr);      Frog   SM  359     7.5   18  90  85   1   3000 80
   175  Minuteman III;      USA    SM  315    10.8  250  90  85   3  12800 70
   200  ACLM;               USA    SC   30  1302.7 2300  60  40   1   2400 85
   335  Minuteman III;      USA    SM  220    34.2  300  90  85   3  12800 70
   500  SS-N-20;            Soviet SM 1000     2.2   10  65  70   6   9000 83
   550  SS-19 mod 1;        Soviet SM  400    14.4  280  75  75   6   8000 74
   600  Polaris A3;         Brit   SM  463    11.4   64  60  80  10   4600 64
   750  SS-17 mod 1;        Soviet TM  400    17.7  160  75  75   4    880 75
   800  B-52 G/H;           USA    SB    -      -   240  75  70  12  12000 59
   900  SS-18 mod 2;        Soviet SM  400    20.0  107  75  75   8   8800 76
   950  SS-11 mod 3;        Soviet SM 1400     1.7  470  75  80   1   9700 66
  1000  MSBS M-20;          Frog   SM  926     4.0   80  60  75   1   3100 77
  1500  SS-N-6;             Soviet SM 1300     2.7  468  35  65   1   2500 68
  3000  SS-8;               Soviet SM 1900     2.0    0  75  75   1  11000 67
  4000  SS-7;               Soviet SM 1900     2.4    0  75  75   1  10000 62
  5000  CSS-4;              PRC    SM 1500     4.5   18  70  65   1  12000 70
  6000  SS-17 mod 2;        Soviet SM  400    70.7   20  80  85   1   9000 77
  9000  Titan II;           Other  SM 1482     6.8    0  75  75   1  11665 63
 10000  SS-19 mod 2;        Soviet SM  250   254.5  100  85  85   1   8800 78
 20000  SS-18 mod 3;        Soviet SM  350   206.1   26  85  85   1  12000 77
 24000  SS-18 mod 1;        Soviet SM  400   178.2    0  80  85   1   9600 74
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The results format is straight forward.   The times mentioned in each column are arrival times for the shock wave. You haven't got much time to do more than "duck and cover". Two notes: the "Safe" level of radiation in the fallout table is based upon the estimated dosage received and survived by members of a Mexican family when the Co-60 gamma source for an X-ray machine was left in a pickup truck outside their home for several months. Secondly the area contaminated is a SWAG, and has no credibility with me and I computed it. If you want to print this out - set your character size to 20 cpi, and it should line up nicely. The dashed line is one page width.

Theoretically the detonation Of a 1 kt device has the following results.

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for an airburst with negligible FallOut:0.0045 secs after detonation the FireBall reaches Breakaway and 220 Feet in diameter.
0.6000 secs after detonation the FireBall reaches Maximum Size 440 Feet in diameter.
for a Ground burst0.0060 secs after detonation the FireBall reaches Breakaway and 293 Feet in diameter.
0.8000 secs after detonation the FireBall reaches Maximum Size 587 Feet in diameter.
Crater dimensions are:Width 260 Feet, the lip extending another 70 Feet.
Apparent Crater Depth is 30 Feet. Buildup Of ejecta over original surface is 8 Feet.
volume Of Crater is 597289.1 cubic Feet.(About 1.371 AcreFeet,or 0.00000406 cubic Miles.) Nice Lake.

HOB	200 psi	15 psi	10 psi	8 psi	6 psi	4 psi	2 psi	1 psi
1 Feet	200 Feet	820 Feet	1020 Feet	1150 Feet	1350 Feet	1650 Feet	2500 Feet	3800 Feet
	0.0400 secs	0.3000 secs	0.4300 secs	0.5000 secs	0.6000 secs	0.9000 secs	1.600 secs	2.900 secs
200 Feet	250 Feet	880 Feet	1111 Feet	1200 Feet	1500 Feet	1800 Feet	3000 Feet	4500 Feet
	0.0700 secs	0.3500 secs	0.5000 secs	0.5800 secs	0.8000 secs	1.100 secs	2.000 secs	3.400 secs
500 Feet		1100 Feet	1310 Feet	1350 Feet	1700 Feet	2200 Feet	3500 Feet	4900 Feet
		0.5500 secs	0.8000 secs	0.8000 secs	1.000 secs	1.500 secs	2.500 secs	3.400 secs
1000 Feet		300 Feet	760 Feet	1500 Feet	2000 Feet	2700 Feet	4200 Feet	1.2 Mile
		0.5000 secs	0.7000 secs	1.100 secs	1.500 secs	2.200 secs	3.300 secs	5.000 secs
1500 Feet					750 Feet	1500 Feet	3200 Feet	1.4 Mile
					1.000 secs	1.400 secs	2.600 secs	6.500 secs
2000 Feet						500 Feet	2600 Feet	1.5 Mile
						1.300 secs	2.400 secs	6.500 secs

Distances for Thermal and Gamma/Xray Radiation

HOB	500 Rads	1000 Rads	12 Cal/cm)	8 Cal/cm	5 cal/cm	
1 Feet	A: 640 Feet	B: 100 Feet	C: 600 Feet	D: 900 Feet	E: 500 Feet	A:Distance To 500 rads prompt radiation
200 Feet	A: 630 Feet	B: 90 Feet	C: 580 Feet	D: 880 Feet	E: 490 Feet	B:Distance To 1000 rads prompt radiation
500 Feet	A: 590 Feet	B: 40 Feet	C: 520 Feet	D: 830 Feet	E: 440 Feet	C:Distance To ignition Of Fires (12 cal/sq cm).
1000 Feet	A: 440 Feet	B: 840 Feet	C: 240 Feet	D: 610 Feet	E: 290 Feet	D:Distance To 3rd degree burns (8 cal/sq cm).
1500 Feet	A: 170 Feet	B: 470 Feet	C: 57 Feet	D: 160 Feet	-	E:Distance To 2nd degree burns (5 cal/sq cm).
2000 Feet	A: 720 Feet	B: 40 Feet	-	-	E: 500 Feet	

Assuming average winds Of 15 mph in One direction, ideal fallout patterns are ellipses Of these dimensions:

Initial dosage Rate (rad/hr)	Distance from GZ downwind	Ground Zero (GZ)radius	Maximum Width (Crosswind)	Contaminated Area (Sq Miles)	Wait To decay To "Safe" Level Of 0.25 rad/hr
3000	0.9500 Mi.	0.0260 Mi.	0.0076 Mi.	0.0233 Mi.	2500 Hr (3 months,2 Weeks).
1000	0.8000 Mi.	0.0600 Mi.	0.0360 Mi.	0.0205 Mi.	1000 Hr (6 Weeks.)
300	4.4990 Mi.	0.2000 Mi.	0.1300 Mi.	0.1122 Mi.	370 Hr (15 days.)
100	8.9000 Mi.	0.3900 Mi.	0.3600 Mi.	0.2218 Mi.	150 Hr (6 days,6 hours).
30	16.0000 Mi.	0.5299 Mi.	0.7600 Mi.	0.3945 Mi.	54 Hr (two days)
10	24.0000 Mi.	0.6800 Mi.	1.4000 Mi.	0.5892 Mi.	22 Hr
3	30.0000 Mi.	0.8900 Mi.	2.1990 Mi.	0.7374 Mi.	8 Hr
1	40.0000 Mi.	1.5000 Mi.	3.3000 Mi.	0.9908 Mi.	3 Hr

Theoretically the detonation Of a 20 kt device has the following results.

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for an airburst with negligible FallOut:0.0149 secs after detonation the FireBall reaches Breakaway and 319 Feet in diameter.
1.980 secs after detonation the FireBall reaches Maximum Size 458 Feet in diameter.
for a Ground burst0.0199 secs after detonation the FireBall reaches Breakaway and 425 Feet in diameter.
2.640 secs after detonation the FireBall reaches Maximum Size 611 Feet in diameter.
Crater dimensions are:Width 706 Feet, the lip extending another 190 Feet.
Apparent Crater Depth is 81 Feet. Buildup Of ejecta over original surface is 22 Feet.
volume Of Crater is 11890799.5 cubic Feet.(About 27.296 AcreFeet,or 0.00008089 cubic Miles.) Nice Lake.

HOB	200 psi	15 psi	10 psi	8 psi	6 psi	4 psi	2 psi	1 psi
3 Feet	543 Feet	2226 Feet	2769 Feet	3122 Feet	3664 Feet	4479 Feet	1.3 Mile	2.0 Mile
	0.1086 secs	0.8143 secs	1.167 secs	1.357 secs	1.629 secs	2.443 secs	4.343 secs	7.872 secs
543 Feet	679 Feet	2389 Feet	3016 Feet	3257 Feet	4072 Feet	4886 Feet	1.5 Mile	2.3 Mile

0.1900 secs 0.9500 secs 1.357 secs 1.574 secs 2.171 secs 2.986 secs 5.429 secs
9.229 secs
1357 Feet 2986 Feet 3556 Feet 3664 Feet 4615 Feet 1.1 Mile 1.8 Mile
2.5 Mile
1.493 secs 2.171 secs 2.171 secs 2.714 secs 4.072 secs 6.786 secs
9.229 secs
2714 Feet 814 Feet 2063 Feet 4072 Feet 5429 Feet 1.4 Mile 2.2 Mile
3.3 Mile
1.357 secs 1.900 secs 2.986 secs 4.072 secs 5.972 secs 8.958 secs
13.572 secs
4072 Feet 2036 Feet 4072 Feet 1.6 Mile
3.9 Mile
2.714 secs 3.800 secs 7.057 secs
17.643 secs
5429 Feet 1357 Feet 1.3 Mile
4.1 Mile
3.529 secs 6.515 secs
17.643 secs

Distances for Thermal and Gamma/Xray Radiation

HOB	500 Rads	1000 Rads	12 Cal/cm)	8 Cal/cm	5 cal/cm	
3 Feet	A: 800 Feet	B: 820 Feet	C: 540 Feet	D: 760 Feet	E: 210 Feet	A:Distance To 500 rads prompt radiation
543 Feet	A: 770 Feet	B: 780 Feet	C: 510 Feet	D: 740 Feet	E: 200 Feet	B:Distance To 1000 rads prompt radiation
1357 Feet	A: 610 Feet	B: 570 Feet	C: 390 Feet	D: 640 Feet	E: 120 Feet	C:Distance To ignition Of Fires (12 cal/sq cm).
2714 Feet	A: 960 Feet	B: 690 Feet	C: 950 Feet	D: 270 Feet	E: 850 Feet	D:Distance To 3rd degree burns (8 cal/sq cm).
4072 Feet	A: 550 Feet	-	C: 110 Feet	D: 610 Feet	E: 370 Feet	E:Distance To 2nd degree burns (5 cal/sq cm).
5429 Feet	-	-	C: 640 Feet	D: 550 Feet	E: 650 Feet	

Assuming average winds Of 15 mph in One direction, ideal fallout patterns are ellipses Of these dimensions:

Initial dosage Rate (rad/hr)	Distance from GZ downwind	Ground Zero (GZ)radius	Maximum Width (Crosswind)	Contaminated Area (Sq Miles)	Wait To decay To "Safe" Level Of 0.25 rad/hr
3000	3.6570 Mi.	0.1477 Mi.	0.0999 Mi.	1.1940 Mi.	2500 Hr (3 months,2 Weeks).
1000	3.0800 Mi.	0.3309 Mi.	0.3508 Mi.	1.0700 Mi.	1000 Hr (6 Weeks.)
300	17.3200 Mi.	0.8424 Mi.	0.9389 Mi.	5.7010 Mi.	370 Hr (15 days.)
100	34.2600 Mi.	1.3720 Mi.	2.1720 Mi.	11.1800 Mi.	150 Hr (6 days,6 hours).
30	61.6000 Mi.	1.8100 Mi.	4.0680 Mi.	19.9000 Mi.	54 Hr (two days)
10	92.4000 Mi.	2.3220 Mi.	6.8490 Mi.	29.7300 Mi.	22 Hr
3	115.5000 Mi.	3.0390 Mi.	9.8370 Mi.	37.2100 Mi.	8 Hr
1	154.0000 Mi.	5.1220 Mi.	13.8900 Mi.	49.9400 Mi.	3 Hr

Theoretically the detonation Of a 335 kt device has the following results.

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for an airburst with negligible FallOut:0.0460 secs after detonation the FireBall reaches Breakaway and 251 Feet in diameter.
6.140 secs after detonation the FireBall reaches Maximum Size 503 Feet in diameter.
for a Ground burst0.0613 secs after detonation the FireBall reaches Breakaway and 335 Feet in diameter.
8.187 secs after detonation the FireBall reaches Maximum Size 671 Feet in diameter.
Crater dimensions are:Width 1806 Feet, the lip extending another 486 Feet.
Apparent Crater Depth is 208 Feet. Buildup Of ejecta over original surface is 56 Feet.
volume Of Crater is 199809191.2 cubic Feet.(About 458.680 AcreFeet,or 0.00135925 cubic Miles.) Nice Lake.

HOB	200 psi	15 psi	10 psi	8 psi	6 psi	4 psi	2 psi	1 psi
7 Feet	1389 Feet	5695 Feet	1.3 Mile	1.5 Mile	1.8 Mile	2.2 Mile	3.3 Mile	5.0 Mile
	0.2778 secs	2.084 secs	2.986 secs	3.472 secs	4.167 secs	6.251 secs	11.112 secs	20.140 secs
1389 Feet	1736 Feet	1.2 Mile	1.5 Mile	1.6 Mile	2.0 Mile	2.4 Mile	3.9 Mile	5.9 Mile
	0.4862 secs	2.431 secs	3.472 secs	4.028 secs	5.556 secs	7.640 secs	13.890 secs	23.613 secs
3473 Feet		1.4 Mile	1.7 Mile	1.8 Mile	2.2 Mile	2.9 Mile	4.6 Mile	6.4 Mile
		3.820 secs	5.556 secs	5.556 secs	6.945 secs	10.417 secs	17.362 secs	23.613 secs
1.3 Mile		2084 Feet	5278 Feet	2.0 Mile	2.6 Mile	3.6 Mile	5.5 Mile	8.5 Mile
		3.472 secs	4.862 secs	7.640 secs	10.417 secs	15.279 secs	22.918 secs	34.725 secs
2.0 Mile					5209 Feet	2.0 Mile	4.2 Mile	10.0 Mile
					6.945 secs	9.723 secs	18.057 secs	45.143 secs
2.6 Mile						3473 Feet	3.4 Mile	10.5 Mile
						9.029 secs	16.668 secs	45.143 secs

Distances for Thermal and Gamma/Xray Radiation

HOB	500 Rads	1000 Rads	12 Cal/cm)	8 Cal/cm	5 cal/cm	
7 Feet	A: 440 Feet	B: 710 Feet	C: 4500 Feet	D: 1.7 Mile	E: 1.6 Mile	A:Distance To 500 rads prompt radiation
1389 Feet	A: 330 Feet	B: 570 Feet	C: 4500 Feet	D: 1.7 Mile	E: 1.6 Mile	B:Distance To 1000 rads prompt radiation
3473 Feet	A: 690 Feet	B: 750 Feet	C: 4300 Feet	D: 1.7 Mile	E: 1.6 Mile	C:Distance To ignition Of Fires (12 cal/sq cm).
1.3 Mile	A: 800 Feet	-	C: 3500 Feet	D: 1.6 Mile	E: 1.5 Mile	D:Distance To 3rd degree burns (8 cal/sq cm).
2.0 Mile	-	-	C: 2200 Feet	D: 1.4 Mile	E: 1.3 Mile	E:Distance To 2nd degree burns (5 cal/sq cm).