CIVIL DEFENSE STATISTICAL PROGRAMS

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The civil defense function has been in the Federal establishment in one form or another since shortly after the start of World War II. Rather than attempt to provide a broad review of many studies over the past two decades, I will cover two active programs: first, the National Fallout Shelter Survey begun shortly after the civil defense functions were transferred to the Department of Defense in August 1961, and second, the damage assessment and vulnerability analysis program started by our predecessor agencies and now carried on by the Office of Emergency Planning and the Office of Civil Defense.

NATIONAL FALLOUT SHELTER SURVEY

The National Fallout Shelter Survey was established as a result of a determination that within feasible expenditure levels, a system of fallout shelters would provide a greater saving of lives than any other system. The first step, designed to make use of existing assets, was a survey to: (1) Locate suitable fallout shelter facilities; (2) mark them with distinctive signs; and (3) stock them with food and water, medical and sanitation kits, and radiation measuring instruments. The location of suitable fallout shelter facilities involved a large scale survey with all its inherent problems, plus additional administration problems arising from the use of trained architects and engineers to perform the survey, the use of the military engineer organizations as contract administrators for the survey, and the fact that civil defense responsibilities are divided between the Federal government and State and local governments.

The survey consisted of two distinct phases:

Phase I recorded structural and geographic data on all buildings other than single family housing units in the continental United States, Alaska, Hawaii and the possessions, that were estimated to have a protection factor of at least 20 and potential shelter space for 50 or more persons. This means that the shelter had to be capable of reducing the radiation intensity of the fallout outside the shelter by a factor of 20, and have 10 square feet per person in adequately ventilated spaces or 500 cubic feet per person in unventilated space. Further, the requirement includes 1 cubic foot of secure storage space per person.

Phase I operated as follows:

1. Data were gathered and recorded by architectural and engineering firms under contracts negotiated, administered and supervised by the Army Corps of Engineers and Navy Bureau of Yards and Docks field offices.
2. Field information was transmitted to the Bureau of Census Office in Jeffersonville, Indiana where it was microfilmed and sent to Suitland, Maryland for conversion into computer tape.
3. The computer tapes were transferred to the National Bureau of Standards for processing on its 7090 computer. Printouts were returned to the field offices and the contractors and summary reports were furnished to the various levels of local, county and state governments.

Information was recorded in Phase I on forms using the FOSDIC process "Film Optical Sensing Device For Input To Computer." This process, developed for the Bureau of Census, was used in recording data in the 1960 census. The procedure eliminates the card punching operation. The FOSDIC form is microfilmed, read on a FOSDIC head and converted into a computer tape.

COVERAGE

To make sure that every area of the United States was covered, we used a system of geographic identification that has been in existence for some time. This system divides the country into about 43,000 "Standard Locations" that have an average population of around 4,000. The standard location number designates the OCD region, state, county and sub-division of that county where appropriate. The areas are comparable to the Census Tracts and Minor Civil Divisions. This information, coupled with the name and address, adequately locates a structure for local needs and computer requirements.

The survey covered about 5 million buildings. About 3.7 million of these were rejected as patently unsuitable. Another million buildings were eliminated by closer examination and the data for 381,902 buildings were completely processed.

TRAINING

In order to develop competent enumerators, it was necessary to train some 2,700 architects and engineers in shielding analysis courses given at nine universities and two military schools.

PROCESSING

More than 500,000 FOSDICS forms were prepared, as some buildings required more than one form. A form was required for each wing or major section of a building.

The 7090 computer calculated the protection factor and capacity on a floor by floor basis, building by building. It required about 1/20 of a second to compute and check the results as compared with about two hours needed by a professional engineer to do these same calculations. The results were as follows:

Protection Factor	Buildings	Spaces (Millions)
PF 100 or better	112,899	55.8
40-99	103,467	68.1

Now for Phase II:

Based on the results of Phase I, those buildings which provided better than 40 protection factor were revisited by the architect and engineer firm to make detailed studies. Phase II also included the survey of selected special facilities, such as caves, mines, and tunnels, for shelter suitability. Phase II included the identification of:

1. The specific areas which provided the required shelter, and
2. The improvements required to increase the amount of protection and ventilation, to improve habitability and to increase shelter capacity.

Pertinent information for each building or facility surveyed was sent to appropriate State and local civil defense officials for use in shelter planning. Similar information was sent to each of the military services relative to facilities under their jurisdiction. This information included the shelter capacity of existing buildings and special facilities suitable for shelter use, the computed fallout protection factors, estimated cost of upgrading substandard shelter space to a protection factor of 100, and estimated cost of increasing shelter space by improvements such as ventilation.

For program control and for further use in shelter planning, data compilations included the identification of shelter space available according to various types of structural categories; e.g., 33 classes of physical vulnerability, 5 types of ownership, 41 categories of current usage, and 9 kinds of special facilities. In addition, shelter space data were summarized by standard locations to show the findings for the entire Nation, OCD regions, states, counties, cities of 25,000 population or more, and standard metropolitan statistical areas.

The second step in the survey is the marking of the shelter facilities with distinctive signs. This is accomplished by the Corps of Engineers in cooperation with local civil defense directors. Obtaining of permission of the building owner to allow the facility to be used as a shelter is the function of the local civil defense director. This is done through a licensing agreement signed by the building owner, which includes permission to place shelter supplies in his building. This last step in the program, the stocking of the shelter with food and water, medical and sanitation kits, and radiation measuring instruments, is a joint task. The Federal government is responsible for procurement, warehousing and distribution of these supplies. The local civil defense director is responsible for getting these supplies into the shelter facility and for inspection to make certain that they are properly stored and maintained.

The initial program and its continued updating has now produced the following statistics as of October 25, 1964.

	Facilities	Spaces (000)
Located	146,332	124,671
Licensed	74,333	68,135
Marked	82,128	69,127
Stocked	50,552	26,852

Now for a related, but quite different program, - damage assessment and vulnerability analysis. Damage assessment is a postattack computation of the effects of an attack on population and other resources. It may be based upon actual damage reports, on aerial reconnaissance of attacked areas or on on-site survey reports. It can make use of manual or computer calculations of the effects of the attack using reports of the attack, our knowledge of weapons effects and physical vulnerability factors and precise locations of resources of interest. Vulnerability analyses, on the other hand, involve preattack estimates of the nature and effects of a wide range of possible attacks. Damage assessment models run the gamut from those which are designed to provide rapid national postattack situation estimates, to estimates designed to provide extensive detail at other levels of government. The model which we usually use for this latter type of assessment is known as JUMBO. Chart 1 provides the symbology for this model. I believe that the first line of the chart is self-explanatory so I shall limit my discussion to the squares identified as DUSTY and FLAME. DUSTY simulates the lifting of the radioactive particles by the mushroom cloud from each surface burst weapon, the transportation of the particles by the upper winds, and the depositing of these particles on the surface.

THE ATTACK

First, we must feed into the system the attack data; i.e., the ground zeros or coordinates of points of burst, the yields or sizes of the weapons, the heights of burst (or at least an indication of whether the burst is low enough for the fireball to touch the surface of the ground, because only such bursts cause serious fallout problems) and the time of burst.

Next, we must feed in the wind data; i.e., the directions and velocities of the upper winds, for all areas of the country. The computer then plots a path downwind from each surface burst weapon, the path curving in accordance with changes in wind directions, area by area.

The pattern by which the computer simulates the deposition of fallout along and on both sides of this path depends on the yield of the weapon and on basic assumptions concerning such things as the configuration of the fallout cloud and the rates of fall (which in turn depend on size and weight of the particles containing radioactive materials) -- so these inputs must be provided. Furthermore, computations of the densities of the radioactive fallout require information or assumptions about fission/fusion ratios -- the greater the percentage of fission, the greater the radioactive intensity. Radiation intensities decline rapidly with the decay of radioactivity, and in order to be additive, intensities must be computed as of some base time after detonation. The standard base used is H + 1, i.e., one hour after detonation.

The model estimates the intensity of radiation in a series of 2-minute trapezoids from each surface-burst weapon, and then sums the intensities of fallout in each trapezoid from all surface burst weapons.

The model also computes the radiation dose one might receive if standing, unprotected in the open, in each 2-minute trapezoid. It can do this on the basis of some stipulated period of accumulation, taking radiation decay rates into account. Usually, it follows a more complex procedure of taking into account both radiation decay rates and also rates of biological recovery from radiation damage. The dose thus computed is called Equivalent Residual Dose, usually referred to by the initials ERD.

DUSTY

The DUSTY model provides two forms of output. One consists of fallout maps, including both fallout intensity maps showing intensities at one hour after detonation, and "outside" dose maps showing, for example, 36-hour dose or equivalent residual dose.

The other output is a magnetic tape record of radiation intensities and "outside" doses for each 2-minute trapezoid. This record is used as an input to the attack environment model.

FLAME

Now for the FLAME model. As the name implies, this model simulates the spread of fires from points of ignition by direct thermal radiation. The basis inputs are the attack data and weapons data on thermal radiation. The computer then identifies the 2-minute trapezoids in which 2-minute trapezoids in which ignitions might start. Then it considers in turn: firespread barriers (both absolute and probable barriers), fuel densities (i.e., densities of combustible materials), and weather and moisture conditions, area by area. It estimates the potential spread of fire through contiguous 2-minute trapezoids beyond the area in which fires might be ignited by direct thermal radiation from the fireball.

The burned-out areas are delineated on an electronically-printed map, and also a list of burned 2-minute trapezoids is recorded on magnetic tape as another input to the attack environment computation.

VULNERABILITY ANALYSIS

Calculations based on a single set of attack inputs are fairly straight forward. However in vulnerability analysis we apply a range of similar inputs; and I should like to cover briefly the analytical model which we use most commonly in our vulnerability studies.

Analytical models are used to simulate almost any conceivable activity or operation, e.g., an air battle, the effects of a nuclear attack, or even the operation of a national economy. Repeated trials or operations of the analytical model, with stipulated changes in assumptions or parameters, enable us to determine the sensitivity of the results to changes in any of the variables in a problem or operation. Using the results of many trials in such controlled "experiments", we can perform our analyses, understanding the consequences of alternate courses of action.

What we aim for in vulnerability studies is to obtain estimates of the probability that certain effects may take place in areas of interest to us given a specified set of attack parameters.

The model which we use for these studies is known as RISK. This model computes the distribution of effects that a specific point will be exposed to, in terms of ranges of blast and radioactive fallout intensities as well as ranges of losses and availability of specified resources.

In developing input parameters for the RISK system, major uncertainties such as the following must be considered:

a. A hypothetical attack may include military, population and industrial targets, or any combination thereof.
b. The specific targets within each of these categories may vary, as may the number of weapons assigned to each.
c. Delivery vehicles may be missiles or aircraft; they may also vary as to type and number and may have varying reliability. Additionally, our defense capability against enemy vehicles will vary.
d. Variations will occur in weapons yield, fission yield, height of burst and aiming error.
e. Our assumptions on the damage resulting to various resources from blast, radiation and thermal effects are approximations.
f. Meteorological considerations have infinite variations. To meet these uncertainties, we require the following:

Input Data for Each Target

a. The coordinates of the designated ground zeros (DGZ). (The DGZ represents the aiming point. The actual ground zero (AGZ), or actual point of detonation, may differ because of weapon inaccuracy.)
b. Numbers of weapons, yield, height of burst, and time of detonation.
c. Abort rate - (weapon does not arrive over U. S.)
d. Attrition rate - (Weapon arrives over U. S., but is destroyed prior to reaching target.)
e. Circular error probable (CEP). The CEP represents the weapon aiming error. It is construed as the radius of a circle around a target in which it would be expected that 50% of the weapons would land.

f. Mean wind speed and direction, and the corresponding standard deviation. These data are furnished for each season of the year. Now let us examine the RISK model (CHART 3).

In the attack selection process, we start with statements of the various alternative combinations of the objectives and capabilities of the potential enemy along with pertinent data on the U. S. resources against which these capabilities might be applied. The output of this process is a number of enemy attack options, each related to one of the alternative sets of objectives and capabilities.

The attack options lead to the next process, attack gaming, which takes into account military operational factors such as abort rates, attrition rates, and aiming errors.

A Monte Carlo Program generates random numbers and applies them to wind and weapons data for each target. The result is an attack 'trial' which contains AGZ's, weapons delivered, wind speed and direction. All the variables in the problem, including the operational factors and the weather, are taken into account in many separate 'trials' for each of the attack options. The output consists of one hundred or more separate attack 'trials' which then become inputs to the RISK analysis. The results of these attack trials applies to resource points are shown as a distribution table of attack effects.

OUTPUTS

There are two general types of output derived from the RISK analysis:

1. Estimates of hazards at particular places in terms of probabilities for -
   a. Various ranges of blast overpressure intensities, and
   b. Various ranges of radioactive fallout, including variations in arrival time as well as intensity.

2. Estimates of hazard to population and resources expressed in terms of probabilities for -
   a. Various ranges of casualties
   b. Various ranges of resource losses, and
   c. Various ranges of resource availabilities during specified postattack time periods.

Tables 1, 2, and 3 illustrate some RISK outputs.

USES

There are many applications of these 'probability' data with varied levels of sophistication. One relatively simple use is to provide vulnerability advice to all levels of government, the military and industry, for dispersion planning to provide protection in existing and new structures. At the other end of the scale, these data are used in government-wide studies of the magnitude of postattack problems and these studies provide a tool for developing preattack plans to meet such postattack problems.

As I mentioned previously, models can be developed to simulate almost any conceivable activity or operations; e.g., an air battle, the effects of a nuclear attack, or even the operation of a national economy. Development work on many models has been carried out by the National Resources Evaluation Center. I shall now turn the discussion over to my friend, Dr. Joseph D. Coker, the Director of the NREC, who will discuss models for resources management.

THE JUMBO DAMAGE ASSESSMENT MODEL (Part I)

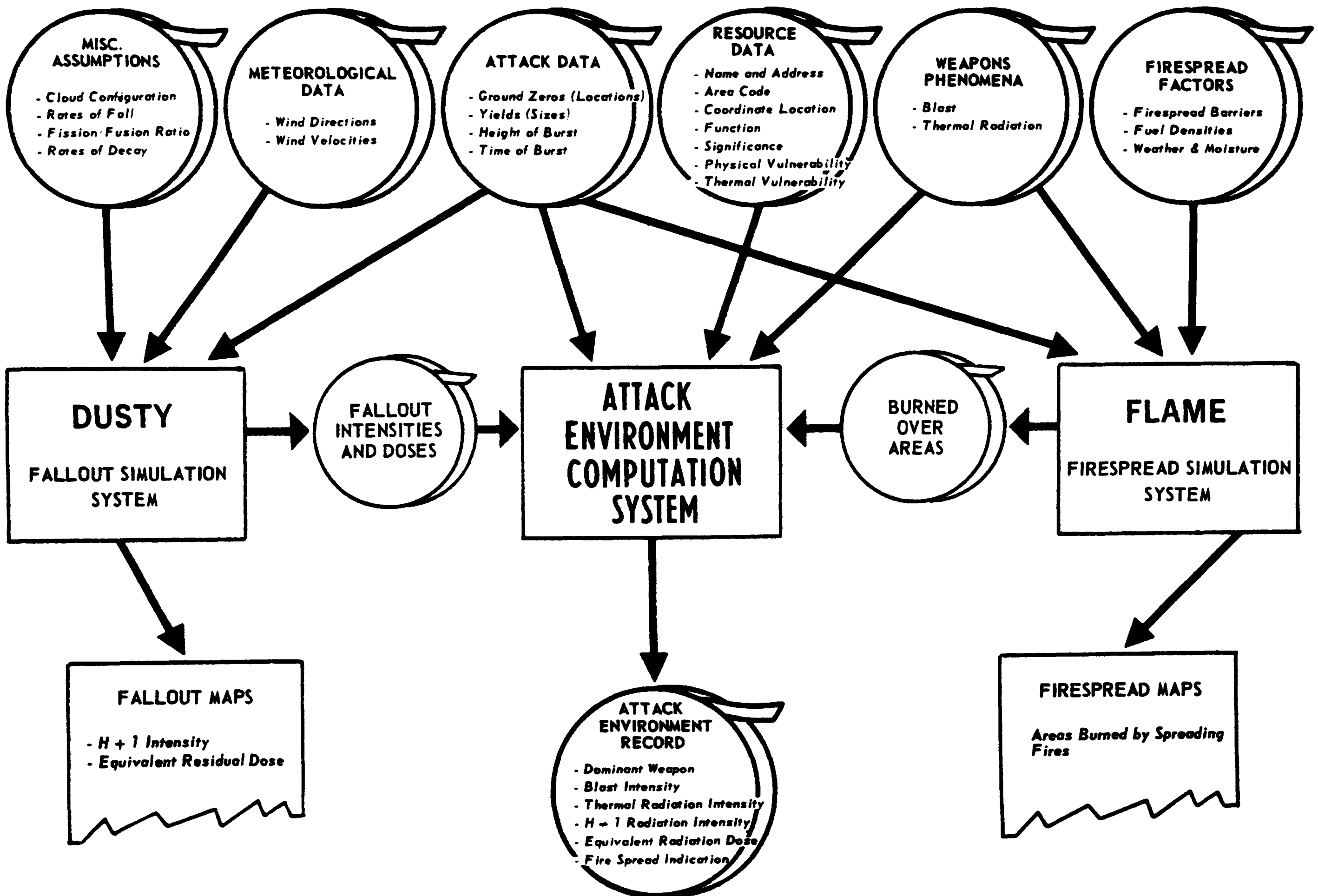

CHART 1

THE JUMBO DAMAGE ASSESSMENT MODEL (Part II)

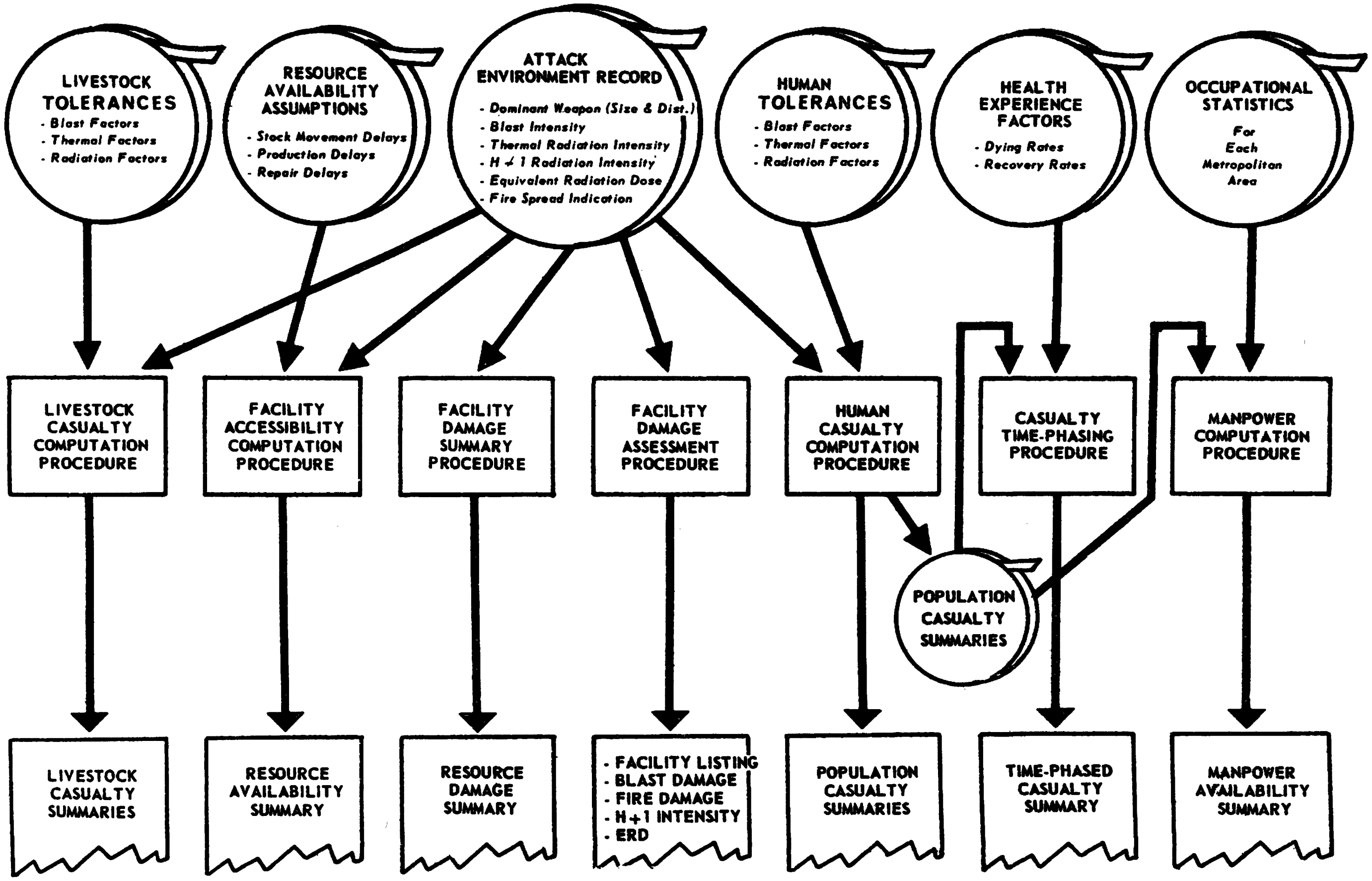

CHART 2

THE RISK MODEL

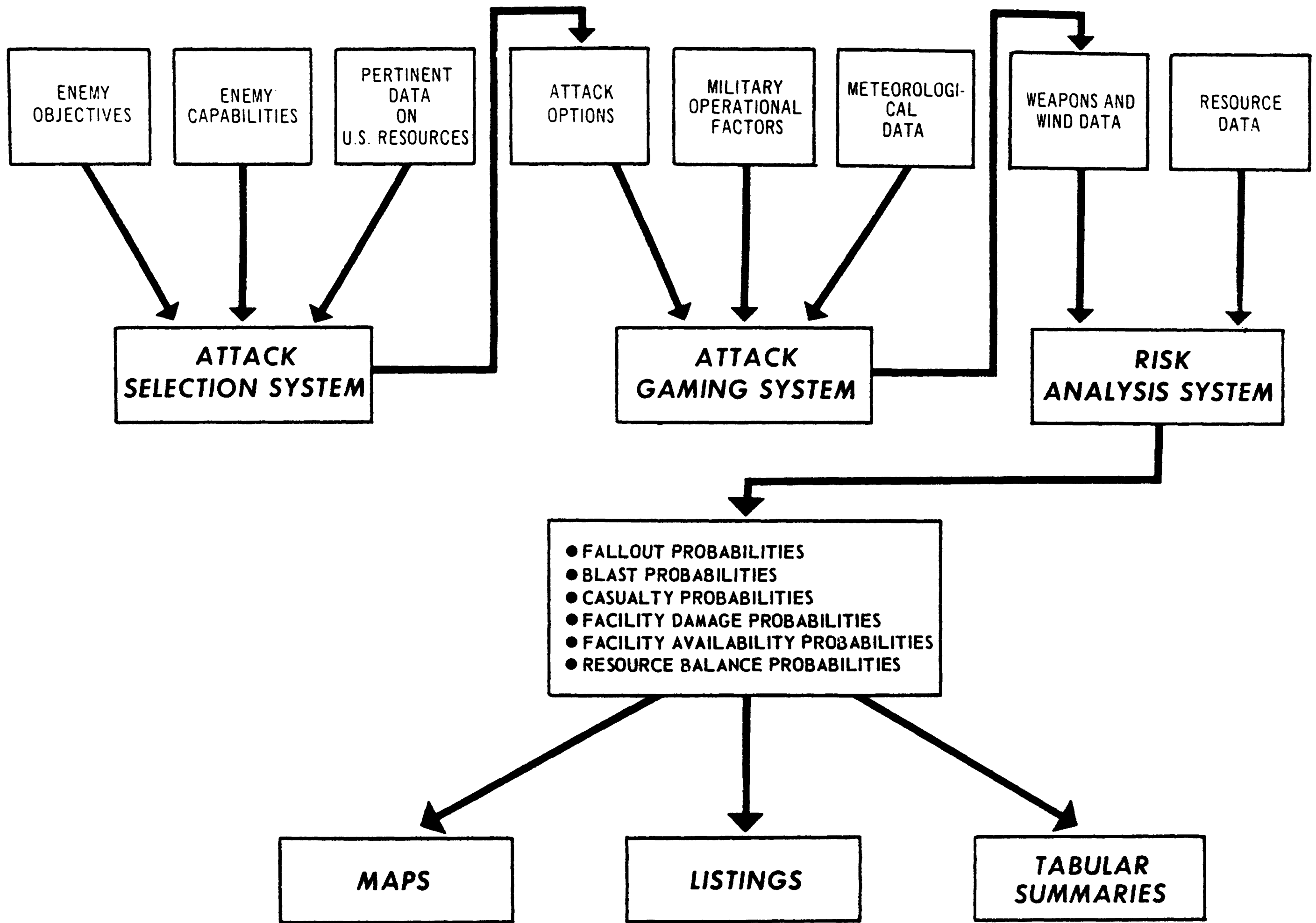

CHART 3

Probabilities of Weapon Effects   Based on Attack   AR2 Run 1   100 Trials Season Winter Computed 12 Apr 62

Probabilities of Experience in Percent

Northwest Washington   Washington DC Class TR 2211000000 VN 2201 2 UTM 18 43127 3198

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Blast and Radiation Dose Probabilities

Peak Overpressure (P.S.I.)

Radiation Dose Roentgens	0-1	1-2	2-3	3-5	5-7	7-10	10-15	15-20	20-25	25-50	50-100	100-200	200-300	300-500	Over 500	Maximum ERD Prob.	Cumulative Maximum ERD Prob.
Over 100,000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100
25,000- 100,000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100
10,000- 25,000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100
7000- 10,000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100
4000- 7000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	100
2000- 4000	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	4	100
1000- 2000	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	4	96
300- 1000	3	1	.	.	.	.	1	1	.	.	.	.	.	.	.	6	92
100- 300	3	3	2	.	.	.	.	.	.	.	.	.	.	.	.	8	86
Under 100	70	6	.	2	.	.	.	.	.	.	.	.	.	.	.	78	78
Overpressure Prob.	80	12	2	4	.	.	1	1	.	.	.	.	.	.	.	100	
Cumulative Overpressure Prob.	80	92	94	98	98	98	99	100	100	100	100	100	100	100	100		100

FORMAT NO. 6: Point Experience. <u>Overpressure and Dose</u>

Table 1

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Probabilities of Weapon Effects   Based on Attack   AR2 Run 1   100 Trials Season Winter   Computed 12 Apr 62

Independent Probabilities of Experience in Percent

Location	Blast Overpressure (PSI) Does Not Exceed 1	2	3	5	7	10	15	20	25	50	100	200	300	500	Radiation Dose Rate (R/Hr Normalized to H+1 Hour) Does Not Exceed 100	300	1000	3000	10000	30000
Northwest Washington — Washington DC Class TR 2211000000 VN 2201 2 UTM 18 43127 3198	80	92	94	98	98	98	99	100	100	100	100	100	100	100	86	91	100	100	100	100
Washington Monument — Washington DC Class TR 2211000000 VN 6500 2 UTM 18 43063 3234	85	94	96	97	98	99	99	99	100	100	100	100	100	100	83	91	100	100	100	100
Southeast Washington — Washington DC Class TR 2211000000 VN 2201 2 UTM 18 43028 3291	91	97	98	99	100	100	100	100	100	100	100	100	100	100	80	86	100	100	100	100

UNCLASSIFIED

FORMAT NO. 2: Condensed Point Experience

Example 2. <u>Overpressure and Dose Rate</u>

Table 2

Summary Analysis of Vulnerability Based on Attack AR2 Run C2 Season Spring 100 Trials Computed 20 Mar 62

Percent of Pre-Attack Population	Probability Percentile											Population
In Each Casualty Class	1%	5%	10%	15%	25%	50%	75%	85%	90%	95%	99%	
Category UPl Test Population Category												
National Total												389825
Blast Killed	0	0	0	0	0	0	0	0	1	8	41	
Blast Casualties	0	0	0	0	0	0	0	1	8	23	41	
Total Killed	0	0	0	0	0	0	0	0	1	8	41	
Total Casualties	0	0	0	0	0	0	11	22	23	41	44	
Total Non-Casualties	56	58	77	78	86	100	100	100	100	100	100	
400 Maryland												88280
Blast Killed	0	0	0	0	0	0	0	0	0	0	48	
Blast Casualties	0	0	0	0	0	0	0	0	0	34	82	
Total Killed	0	0	0	0	0	0	0	0	0	0	48	
Total Casualties	0	0	0	0	0	0	0	0	62	96	96	
Total Non-Casualties	4	4	18	100	100	100	100	100	100	100	100	
410 Montgomery County												72100
Blast Killed	0	0	0	0	0	0	0	0	0	0	59	
Blast Casualties	0	0	0	0	0	0	0	0	0	41	100	
Total Killed	0	0	0	0	0	0	0	0	0	0	59	
Total Casualties	0	0	0	0	0	0	0	0	59	100	100	
Total Non-Casualties	0	0	0	100	100	100	100	100	100	100	100	

FORMAT NO. 19: Casualty Summary Formats

Percent of Population - Probability Percentiles

Table 3