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FALLOUT PREDICTION AS OF 1957

by

Orin W. Stopinski*

ABSTRACT

The development of models by which to predict fallout from tests of nuclear devices in the atmosphere has evolved from better understanding of the processes and from evaluation of data from previous explosions. The development of the models as of Operation Plumbbob (1957) is discussed in the report, as well as a brief description of the models in use at that time.

The draft report written in 1957 is being published as part of an effort to document atmospheric nuclear test data.

I. INTRODUCTION

Following an atomic explosion a cloud is formed, consisting, in part, of radioactive particles which adhere to other particles such as dust, tower material, debris from experimental equipment, or any other source which may have been near the explosion. It is the problem of the fallout predictor to describe the initial distribution of radioactive particles and to follow these particles in their trajectories to the surface as they are acted upon by the wind field.

In theory, if one knew the exact distribution of particles throughout the cloud at some given time and the wind field, throughout the region of interest and period of fall, it would be possible to state rather precisely the surface distribution of the radioactive particles.

*Los Alamos consultant. This document was written in 1957 in draft form while the author was at Los Alamos; only minor editing has been made. Organization names of that time have been retained for historical reasons.

There are two major reasons why it is not possible to do this. First, the particle distribution is not known, and secondly, the wind field cannot be known. The processes of particle formation are somewhat obscure, and because of varying conditions from shot to shot, the particle distribution doubtless varies over a wide range when individual shots are compared, one with another. Since there is no sound theoretical technique of describing the initial particle distribution, it is the practice to describe the particle distribution as deduced from a number of different shots. Sparsity of data has led to a single model (excluding air and balloon shots) with data derived from shots fired under a wide variety of conditions. Such a model might well depart radically from true particle distributions.

The wind problem has been considered, by some workers at least, as being more serious than the model problem. Even under the best of conditions, it is impossible to state precisely the structure of the wind field over a large area through a considerable depth of the atmosphere because of the sampling techniques which are necessarily used. Since it is virtually impossible to describe a wind field exactly by direct observation, then it is obviously even more difficult to predict that wind field continuously for periods of up to 24 hours or more. Such a prediction would be necessary for precise fallout predictions.

While these are the primary reasons for the inability of the fallout prediction to produce a precise prediction, there are other reasons why different techniques will lead to slightly different results. Differences in methodology employed by various techniques result from differences in desired results or different assessments of how best to reduce the problem to the point where it can be solved in a minimum of time.

A complete discussion of fallout prediction would then include

1. models,
2. differences in methodology and their consequences, and
3. winds.

II. MODELS

Model parameters of prime importance include (1) activity distribution versus fall rates at the various levels, (2) vertical distribution of activity, and (3) fallout fraction. One parameter which seems to have little significance within a wide range is the horizontal activity distribution.

The derivation of the model currently used was accomplished primarily by two groups. The group from LASL,[1*] especially T. N. White, approached the problem theoretically by assuming a number of model parameters and varying them separately and collectively to obtain the best fit with observed data. It is well to note here that the region of 30 to 40 miles out to 200 miles from ground zero was selected for fitting. This was done since this was the region of vital concern for the Nevada operations. The fact that the model which best fit in these regions might not be the best fit for lesser or greater distances was of no consequence operationally, yet application of the models applied outside these regions could lead to erroneous results.

The other group contributing a major part to the question of modeling was from the US Weather Bureau.[2] The approach of this group was empirical, working backward from observed data to an initial distribution which would have given such fallout patterns. This group made very careful analyses of wind fields, both in space and time, and with these wind fields worked back to distributions for each shot for which sufficient data were available. An average of these distributions was taken and a model so derived.

The work done by White led to the assumption that the activity distribution versus fall rates within each layer was log-normal. The model as derived by the Weather Bureau was very close to a log-normal distribution and the comparison led to a general acceptance of the log-normal distribution. Work has continued following each operation for which data are obtained, and the mean fall rates and standard deviations (in log units) are revised with the continual inclusion of these data.

The vertical distributions derived by the two groups showed greater differences than the layer distributions. A compromise was made between the two initially. Here, too, continual check was made when new data were available.

When the question of the amount of the activity falling out was examined, many problems arose. The UCRL[3**] group contributed considerably to this phase of the work. This one point is probably the weakest point, excluding meteorology, in the whole problem of fallout prediction. For example, the question of measuring the amount of activity on the ground proved exceedingly difficult.

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Differences of as much as 30-50% could arise between different measurements of this fallout fraction. In one case, one group arrived at a fraction of 12%, while another group, studying the same data, found a fraction of 18%.

The question of fallout fraction is normally answered individually for each shot by examining all existing techniques for computing fallout fractions and close examination of previous shots fired under similar conditions. This is especially true if a shot of the same general yield was closely monitored. It might be noted that during the last operation (Teapot) rather large errors in predicting fallout fractions were made--largely because the role of close-in material is simply not understood.

These three problems, distribution with fall rate, vertical distribution, and fraction of fallout, as well as the uncertainties, are the reasons why the fallout predictors state there must be a factor of 2 uncertainty in prediction.

It may be noted that reference to Pacific data is made only rarely. This is due to the very sparse amount of usable data from those operations. The models then are based primarily on the Nevada data and may well differ radically from truth in the Pacific.

The question of lateral distribution of activity was examined rather closely during early work on the problem. Distributions examined most closely were (a) normal, (b) flat, (c) step approximation of the normal distribution, and (d) normal with a double peak. It was noted that change from one of these lateral distributions to another led to only minor changes in the results, so while different techniques employ slightly different distributions across the cloud, we feel that no significant variations in forecast can result from this difference.

III. DIFFERENCES IN METHODOLOGY

Many points led to individual differences in the approach to the problem of how to mechanically predict fallout. Here, one finds that one group will use slightly different vertical and horizontal dimensions of the cloud; some will use different fall-rate values than others; and many different layer dimensions will be used by the various groups. Some groups will argue that because of gross errors resulting from poor winds, different refinements of technique will not result in a more usable forecast. Some methods were built around use of only a small number of cloud layers--primarily because the Nevada problem of little directional shear in the wind was uppermost in thinking at some time.

The differences in methodology are probably best understood by examining a few of the areas where differences do occur and their consequences, followed by examination of the varied techniques.

Horizontal Dimensions. When the dimension of a fallout pattern is large with respect to the cloud dimension, changes in the cloud do not affect the final fallout pattern. This is due to the cumulative overlap in both dimensions of the fallout from various layers and over different fall rates. That is to say the large layers will overlap more than the small layers but will contain less activity, and the integrated effect will be the same. However, in the case of no directional shear, the intensity of the pattern will be inversely proportional to the cloud dimension chosen. This is well illustrated in the case of the Weather Bureau approach, which uses a standard cloud dimension but must make a special case for a hodograph with the winds all blowing from the same direction.

Fall Rates. Three methods of describing fall rates have been considered: (1) constant fall rates, (2) aerodynamic fall rates computed from theory for spherical particles of density 2.5, and (3) modified aerodynamic fall rates as proposed by the Weather Bureau. In this case the fall rates are computed for a standard particle, 120 μm. Then the assumption is made that f_1/f_2 is constant through all levels.

While the use of aerodynamic fall rates is advocated as being more exact, only one technique described in the literature employs them. This technique (E. A. Schuert of NRDL)[4*] has never been used operationally to predict fallout quantitatively.

The modified fall rates method proposed by the Weather Bureau is a truly simplifying assumption without much loss in reality. This assumption means that all hodographs are similar and only one need be drawn. Too, the departures from the true aerodynamic fall rates are not very great.

The constant fall rates were initially used in Nevada where the cloud heights are not very great, the differences in fall rates from top to bottom of the cloud do not differ greatly, and the differences in fallout predictions are normally not detectable. However, in the Pacific, with the much greater cloud heights, the assumption of constant fall rates does affect the forecast

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patterns appreciably. Of recent times the tendency is for most predictors to use the Weather Bureau fall rates, in particular for the Pacific operations.

Layer Dimensions. There is more variation in choice of the number of layers than any one other area where a choice is left to the individual. Obviously the greater the number of layers chosen, the greater the number of computations which must be made for prediction. So if a time restriction is placed on prediction, one of the first choices is to reduce the number of layers. A decrease in the number of layers gives rise to two major problems, proper representation of detail of wind structure (one mean wind per layer) and proper representation of vertical distribution of activity (one concentrated level of activity per layer used).

In cases of little directional shear, little is lost by choice of a small number of layers. This fact, coupled with the fact that normally Nevada shots are fired under these conditions, led White to select eight layers for his hand Gaussian method.[1]

The greater the number of layers chosen, the simpler the problem of overlap when it becomes necessary to add up the effects of different layers. If too few layers have been chosen, too much activity is assigned to some points, while too little activity is assigned to other points and subjective smoothing becomes necessary.

When problems are coded for IBM equipment, it is generally the practice to use a large number of layers, since the additional number of computations does not add much total time to the problem.

The variation in numbers of layers is as follows:

USWB 6-8,

Hand Gaussian 8,

Shelton Hand 10,

Cowan 1 (exact for each point),

Dropsey 8-12,

NBS 20,

IBM Computer Programs 30-150.

IV. TECHNIQUES

There are three general classes of techniques in current or recent usage proposed for the very near future:

a. Hand Techniques
   1. USWB[2]
   2. Hand Gaussian (White)[1]
   3. Shelton[3]
   4. Cowan[5]

b. Analogue Computers
   1. Dropsey (Sandia)[6]
   2. NBS[7]

c. Digital Computers Programs*
   1. IBM 701, 704 computer programs
   2. Peaslee - Schuert technique

A. Hand Techniques

1. USWB. The US Weather Bureau hand technique[2] is the oldest quantitative technique currently in use. The solution was adapted primarily for Nevada testing at the same time that group was working out data for modeling the initial cloud. The technique resembles quite closely the type of work which was done to produce the models and was undoubtedly influenced by the fact that so much ground work was done in the modeling work.

The primary aim of the Weather Bureau group was to present a general fallout pattern with the computation to be completed in approximately one-half hour.

The technique is quite straightforward, using the hodograph as a point of departure. (See Fig. 1 for reference.)

A hodograph is drawn for a given particle size (usually 120 μm is used), and the hodographs for other particle sizes are drawn. Radial lines through the tops and bottoms of the levels are then drawn, forming a grid of height and particle-size lines. The model of the cloud is set in tabular form, so the

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* Despite considerable effort the fallout digital computer programs were not useful operationally. The main problems were getting the wind data from the observer stations into the machine and interpreting the output. The input problem was mostly radio communication problems, the data generally arriving garbled and requiring many rechecks.

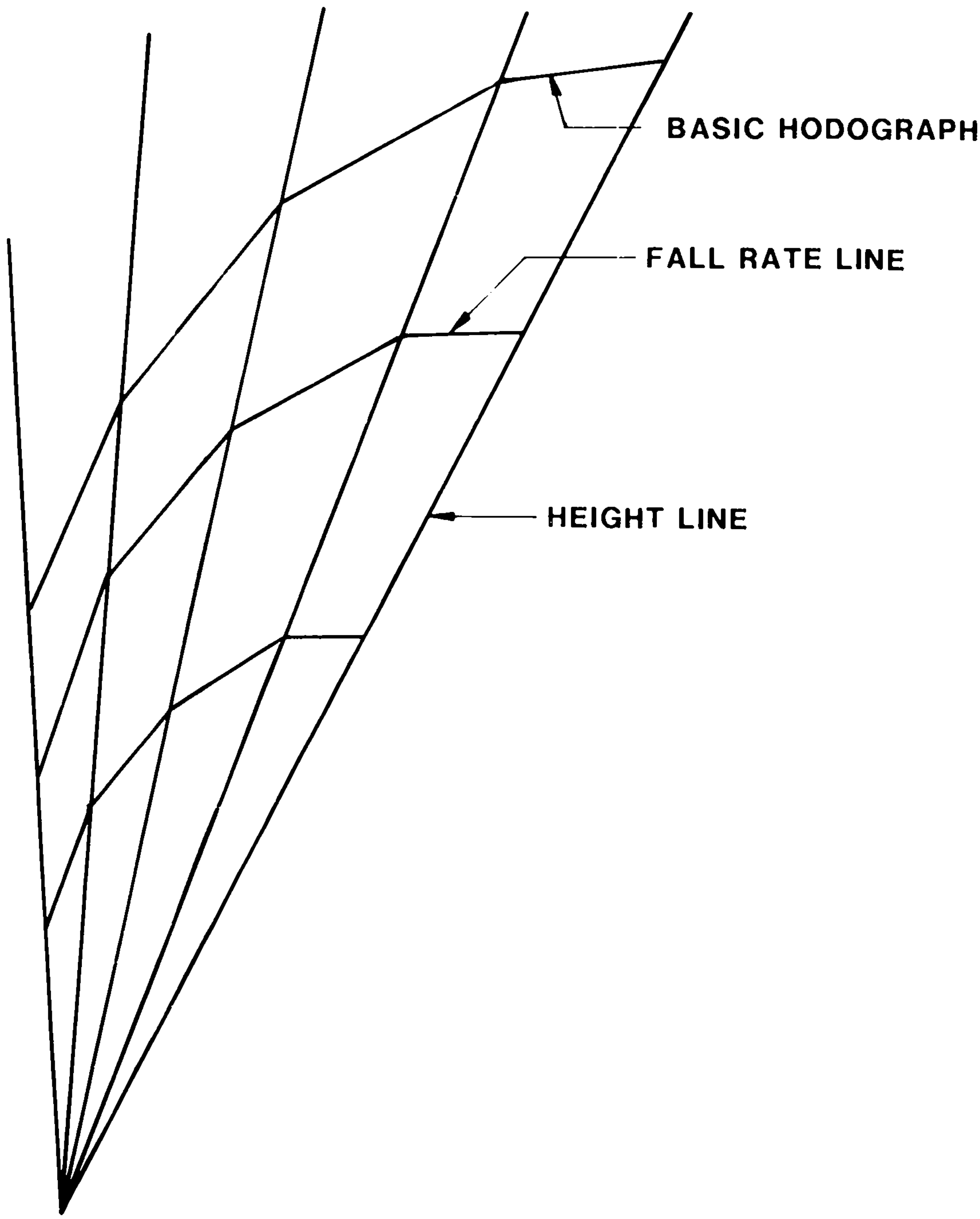

Fig. 1. Basis of USWB fallout prediction method.

amount of activity contained in a grid square--between two height and two fall-rate lines--can be selected and spread uniformly over the area bounded by these lines. A standard cloud diameter of 5 miles is always used. This diameter is used to determine whether the different levels will overlap on a particular point on the ground.

Several simplifying assumptions are made by this group:

1. Differences of less than 2500 ft in height can be neglected.
2. All clouds are 5 miles in diameter.

The first of these assumptions allows the precomputation of a considerable amount of the work and speeds up the prediction by a factor of 4-5 in time. It becomes obvious that if all clouds are of the same height, the fall times for material from the same layer are always the same. Consequently, a time correction can be built into the tables of activity between two fall rates. Comparison with other techniques under extreme conditions indicates that a maximum error of 20% can be caused by this assumption. In most cases this error is approximately 5%. The assumption does allow choice of only two or three representative heights (for Nevada clouds) and reduces the time for computation.

The second of these assumptions as discussed earlier has no effect on the predicted pattern except in those cases when little or no directional shear is present in the wind pattern. With no directional shear, the areas degenerate to zero, and the result is infinite doses. This leads to the necessity of special handling in the case of no shear, which the Weather Bureau accomplishes by a faster solution. It does, however, lead to a problem in the case of little shear when neither technique is strictly applicable; here the judgment of the predictor is used and interpretation becomes subjective.

At one time an attempt was made by Leon Sherman[8] to eliminate the need for this special case. However, this adaptation (augmenting the area by the initial cross-sectional area of the cloud) led to a cumbersome measurement, and the results were not as consistent as those by the Bureau method. No further attempt has been made to eliminate the awkwardness of the necessity for two solutions.

2. Hand Gaussian Method. The hand Gaussian method[1] is T. White's simplification for Nevada of the basic work which was done for the IBM 701 fallout code at Los Alamos. The name is derived from the fact that White used log-normal and normal distributions wherever possible.

The technique is simple and was strictly devised for work in Nevada with the simple low-shear hodographs, which were basically the only kind considered acceptable at that time. In the hands of a skilled predictor, it can be used for more complicated hodographs as the Pacific type.

In this technique since all parameters of the model are described mathematically, it becomes possible to compute rather simply the contribution from any of the eight layers for a specified distance from ground zero. Overlap is handled by comparing the standard deviation of the directions for the various layers with the standard deviations of the activity (laterally) of the layers. Time dependence is handled as a mean speed for the entire hodograph. (This could be made more precise by considering the layers individually, but for the case which White considered, there was no significant change.)

Two main lines of thought went into developing the techniques. Nevada patterns can be described rather well by taking traverses at various distances out from ground zero and using smooth-line interpolation for doses at intervening distances. Agreement with other solutions which give a more general picture is quite good. Consequently, the method was set up to compute for four basic distances, with interpolation used for the others.

Secondly, in Nevada, no matter in which direction one looks, there are certain distances which are of interest because of the location of population centers. A mean of these distances was selected as the basic distance from ground zero. In this way a detailed look at the fallout pattern could be made at distances where it was likely of importance.

3. Shelton Hand Technique. The Vay Shelton[3] (UCRL) hand technique is probably more comparable to the USWB technique than any other but is a more flexible method of looking at fallout. Rather than doing the precomputation that is done by the Bureau, we made all calculations for the specific wind and forecast height conditions, with the layer thicknesses adjusted accordingly. Further, the technique uses the basic cloud dimension, as forecast, and augments this area as a function of distance out and directional shear, so that the area covered by a specific cloud layer is better represented than by most other techniques.

The technique has one of the advantages of the White approach, in that any distance out may be selected and a detailed look may be taken at distances of prime interest.

Tables of fractional amounts of activity are computed for layers and units of fall rate. The amount selected from this table is multiplied by a function of cloud diameter and mean wind speed for that layer. This activity is then multiplied by a time factor, a fallout fraction factor, and divided by an area factor (derivation described above) giving the resultant activity from that layer. Overlap is handled subjectively. Actually the method purports to do this objectively, but results so obtained are not smooth.

Initial work of hodograph construction and selection of heights and mean winds consumes some 15-20 min. From that point it is possible to examine one distance in about 10 min. So while this method gives great detail at selected distances, it is slower than the first two described.

4. Cowan. The Maynard Cowan[5] hand technique (Sandia)* method is designed also to give detailed examination at a particular distance or more precisely at a definite point. Since wind information is never this accurate, it, in practice, is used as the Shelton or White method.

Cowan, by looking at the point in connection and drawing rays to tangency points on a circle around the point in question (circle of cloud diameter), determines the exact top and bottom of the total contributing layer. (See Fig. 2.)

Cowan assumes that the cloud volume is a direct and linear function of yield and that all clouds precipitate the same fraction of their activity

From this assumption a plot can be made of cloud height and contributing fall rates to a given point. If the fall-rate curves are separated by a distance proportional to the activity contained between these fall rates, then the area enclosed by such a curve is proportional to the amount of activity which will be deposited on a given point.

Cowan feels that volume (hence concentration) departures from this assumption are never greater than 20% for high-yield weapons and thus should fall within the factor of 2 fallout prediction error.

The technique is about as fast as Shelton's hand method but not as flexible for adaptation to varying cloud dimensions for the same yields.

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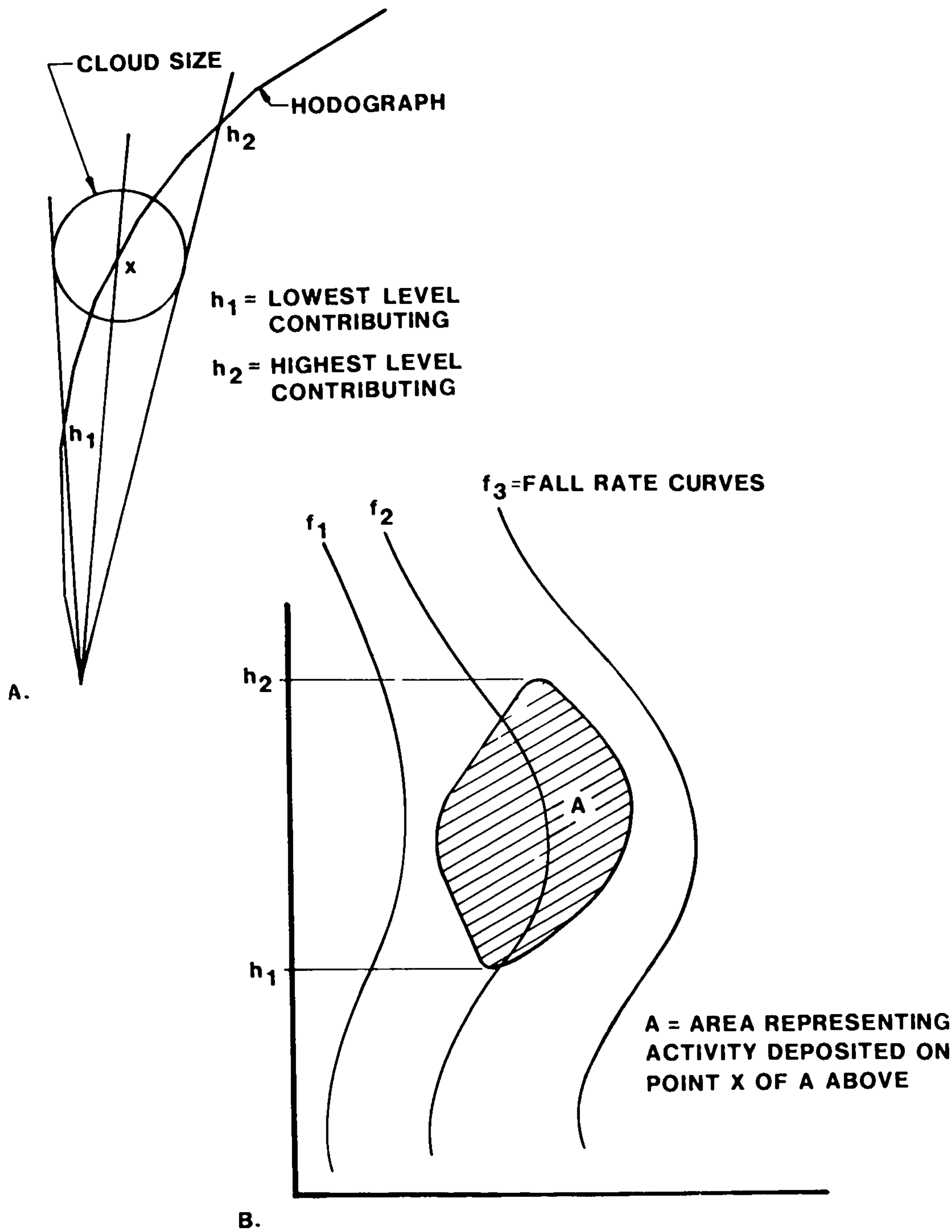

Fig. 2. Basis of Cowan's fallout prediction method.

B. Analogue Computers

1. Dropsey. Dropsey[6] is the Sandia Corporation analogue computer based on the simplified approach presented by Tom White's hand Gaussian technique.[1] In fact this particular solution is the same as that of the hand Gaussian with some minor variations:

1. Number of Layers: While the basic solution proposed by White only required the use of eight layers, Dropsey in its second model uses 12 layers. This represents an advantage over the hand method since the problem of adding the contributions from different portions of the cloud is simplified.
2. The effects of each layer are presented as a picture rather than a mathematical description of this effect. This also is an advantage in that it allows the operator to visually determine which layers will contribute fallout at a given point.
3. Effects of different layers are added graphically, rather than mathematically as in the original. However, Sandia personnel are contemplating adding an automatic summation attachment to Dropsey.

The same general criticisms can be made of the Dropsey solution as can be made of the comparable hand solution. The hand solution was designed to meet the problem as seen in Nevada, where many times the total effective directional shear is small. Under these conditions it is possible to use only a small number of layers. In principle, the Dropsey computer could be designed for any number of layers. However, the 12 now used allow the operator to obtain some five or six traverses within a half an hour. Addition of other layers would increase the time needed for machine operation. In the field increasing the number of layers has been by working the problem twice, which adds considerably to the time required.

Some judgment is required in assessing the cumulation of activity from different layers for the Pacific problem, since with the large amounts of directional shear, traverses some distance removed from ground zero show individual peaks from different layers that do not overlap.

The ability to take a detailed look at the pattern at selected distances by means of traverses is both an advantage and a disadvantage. It is a disadvantage in that between traverses it becomes necessary to interpolate for completion of the pattern. However, when a particular distance is selected (possibly the distance of a population center), the solution obtained by this technique is probably one of the best available at the present time.

2. NBS Computer. The National Bureau of Standards, at the request of the AEC* and coordinated through Lester Machta of the US Weather Bureau, undertook to design a high-speed electronic computer which would display a fallout pattern on a cathode ray tube.[7] Primarily the NBS computer was considered as a briefing aid, with a requirement placed that input parameters could easily be changed and only a short time elapse before a new fallout pattern would be displayed.

The Bureau of Standards did in fact deliver to the AEC two models of this computer. The computer solved the same problem many times and presented the solution on a cathode ray tube, and depending on persistence, the image (both eye and tube) allowed an individual to observe the form of the pattern.

To present a quantitative solution of the problem, it was necessary to integrate the light over some area. This was accomplished by use of a light meter with a very small aperture--hand held, read visually.

There were several drawbacks to the NBS computer. The equipment was complicated and required that an electronics technician maintain the prediction unit. While the qualitative presentation was excellent, the quantitative solution presented problems. To have the NBS computer agree with results obtained by other techniques (and/or observed patterns), it was necessary to calibrate the picture with a pattern quite similar. That is to say, quantitative solution was good if the equipment were properly calibrated; however, it was impossible to calibrate over a wide range of wind conditions. In fact the computer could not be used dependably unless the variations in the wind patterns were over only a very small range.

General reaction to the NBS computer was it was simply an experiment that was tried but was not as successful as others.

C. Digital Computers

1. IBM 701: White. Much of the preliminary or pioneer work was done on the IBM 701 at Los Alamos by T. N. White. This code represented the most complete solution to the fallout problem that has yet been attempted. By use of the high-speed computers, it was possible to integrate for a great number of points of the grid over a very large number of layers and a great number of fall

*Atomic Energy Commission now Department of Energy.

rates. In fact trials were made with as many as 90 layers and over something like 100 fall rates, so that it was possible to make as many as 9 000 computations for a particular point. The main advantage of so many layers and so many fall-rate ranges was a smoothing in the patterns before the final smoothing by the operators.

This technique, together with the USWB hand technique, was used exclusively throughout operation Teapot (1955) until the simplification into the hand Gaussian technique.

2. IBM 704 Computer Program: Peaslee, Schuert. One approach that has not been utilized operationally by the fallout prediction units is that of E. Schuert[4] (NRDL). The approach has been used by Schuert for placing NRDL ships in the fallout path (Redwing, 1956). There it was used only for the determination of the "hot line" and has never been used for quantitative forecasting.

The method differs primarily in the question of modeling in that the lateral distribution of activity across a layer is step function. In the Peaslee adapted model however, the lateral distribution reverts to the normal distribution.

The major difference in this technique from all others is that this approach uses the actual fall rates as computed from theory without making the Weather Bureau simplifying assumption. However, the "hodographs" are drawn for only four "particle sizes."

This method is being coded for the IBM 704, and provision is made for time and space variability by providing space for a wind at 5000-ft levels and in blocks which are two degrees square. Winds are entered (theoretically) for each of these squares and altitudes for three times (0-6, 6-12, 12 and greater). The assumption here being that once it is possible to deliver winds over a grid and for more than one forecast period, this technique will be ready to take advantage of time and space variability and will be the only technique that will be able to give quantitative effects of the changing wind fields.

V. PAST TREATMENT OF WIND PROBLEMS

For simplicity of computation of fallout patterns, the work is greatly reduced if the wind were the same throughout the horizontal region of interest and did not change with time throughout the period of active fallout. Since this statement is true, some effort has been spent at various times to justify making this simplifying assumption. Since past practice in test operations has been to attempt to fire only under stable meteorological conditions and since the major Nevada fallout is down within 6 hours, it has been the practice to assume that wind forecasting is poor and that gains made by including time and/or space changes were misleading and led simply to a false feeling of accuracy in the fallout forcast.

Examination of the question of changes in the wind following shot time indicated that in fact shots were fired under conditions when either space or time changes were important. However, for Nevada operations it has been noted that over 75% of the deviation from shot-point winds was due to space rather than time changes. Therefore, the step of including at least space changes in the wind structure should be attempted. The use of streamline analysis and presentation of the wind field in the Pacific and in Nevada during Plumbbob (1957) made it possible to make at least a qualitative correction to the fallout prediction based on space changes.

No prior requirement had been made for the type of streamline presentation required for Redwing (1956). However, one of the more interested forecasters proposed that such a presentation could be made whenever time permitted. On a few occasions this was done during Redwing, and sufficient feel for the technique was obtained that it was felt justified to request special wind field presentation for the Nevada operation Plumbbob.

Streamline analyses for layers of 10 000-foot thickness were prepared for the fallout prediction group, and trajectories of particles were made by that group for qualitative changes in the fallout prediction.

Note: Actually Machta, as early as 1954, recommended study of the use of layered wind for use by fallout personnel. Others have sporadically made recommendations on tailoring forecasting specifically for use by fallout prediction. Some good steps have been made.

VI. WIND FORECASTING

To understand why wind forecasts are made the way they are for test operations, it is well to look briefly at the supporting weather agency. For both the Pacific and Nevada operations, the weather support has been provided by the air weather service of the USAF. Forecasters from this organization are concerned primarily with forecasting for flight operations, and forecasting techniques for any operational forecasts stem from those used for operations forecasting.

Until recent operations, no attempt has really been made to provide forecasts in a form most useful to the fallout predictor. The underlying reasons are probably twofold: that mentioned above--forecaster background--and because normally the same group of forecasters has been responsible for forecasting for flight operations. A third reason, which is by no means the fault of the forecasters, is that until recent operations the fallout predictors have not critically examined their own requirements for forecasts and have not insisted that forecasts be delivered in the most usable form.

Weather forecasting for operations has differed for the two operational sites in the past. Beginning with operation Greenhouse, forecasters in the Pacific began to turn to streamline techniques of analysis and forecasting. During that operation dual work was done, in that the station was manned sufficiently to perform conventional forecasting by use of pressure charts while another group worked solely with streamline techniques working with winds directly rather than through the pressure fields.

Experience gained during that operation indicated that better wind forecasts were obtained by use of streamline techniques. On that operation the streamline charts were used for long-range tracking and trajectory work, but not until later were the results applied to fallout prediction. For all operations since that time, the primary technique employed for both analysis and forecast has been the standard streamline technique. However, throughout this entire period only the conventional type forecasting was delivered. Personnel concerned with fallout problems during this period took the winds forecast for specific levels and treated them as being effective for 5000-ft levels.

During operation Redwing, one of the air-weather-service forecasters voluntarily provided, on a sporadic basis, streamline charts for layers of 15 000-ft depth. Such a chart is ideally adapable for use in inclusion of time and space change effects on fallout patterns. Although not used routinely, both time and space changes were introduced into computation of fallout patterns by use of forecast layer-wind charts valid at different times.

In the Pacific the period of primary interest is some 24 hours, while in Nevada the longest time of interest is 12 hours, with virtually all of the important fallout down within the first 6 hours.

During Plumbbob the requirement for routine use of streamline charts for 10 000-foot thicknesses was placed on the supporting weather unit in time for the program to be planned in the training phase. In support of such a program, the US Weather Bureau at Las Vegas was requested to perform research in such techniques and to prepare to instruct the operational forecasters in use of the techniques.

Prior to this operation all forecasting had been done in Nevada using normal routines for high altitudes. However, forecasters during this operation were unanimous in feeling that their forecasts were improved, and certainly they were able to present forecasts in the form that were usable in introducing time and space changes into the calculations.

In reality only one set of charts was used by the fallout predictors, and in effect only space changes were taken into account. However, since the primary period of interest was only 6 hours, most of the changes which did occur in the patterns were space changes.

VII. FUTURE PLANS

During the next overseas operation, it is planned to attempt forecasting by machine techniques. Operationally, the concept is to try this technique as an experiment, completely independent of the routine forecasting to be done by the normal task force weather central.

Basic philosophy behind the attempt to introduce machine techniques is twofold. First, machine computation is much faster than comparable work done by individuals, and it should prove possible to produce analyses and forecasts based on later data. If this is true, equal quality forecasts by the two methods would mean better forecasts from machine techniques because they are delivered from later data. Secondly, differences in forecast based on individual differences are eliminated. A third reason is that, should such techniques prove feasible, they would result in an ability to introduce detailed time and space considerations in fallout predictions, since with such forecasts already in the machine memory, it becomes a simple matter to append a code for fallout forecasting to the weather prediction code in a manner never before possible.

Field testing of the program provides the best method of checking the techniques against the type of forecasts that is routinely delivered to the task force. Further, should the system prove useful, it will be available immediately for operational use.

The principles involved differ somewhat from those employed by the USWB-AF-NAVY joint unit at Suitland, Maryland. At Suitland the primary approach is through pressure fields, while the attempt in the Pacific will be made with use of wind fields directly.

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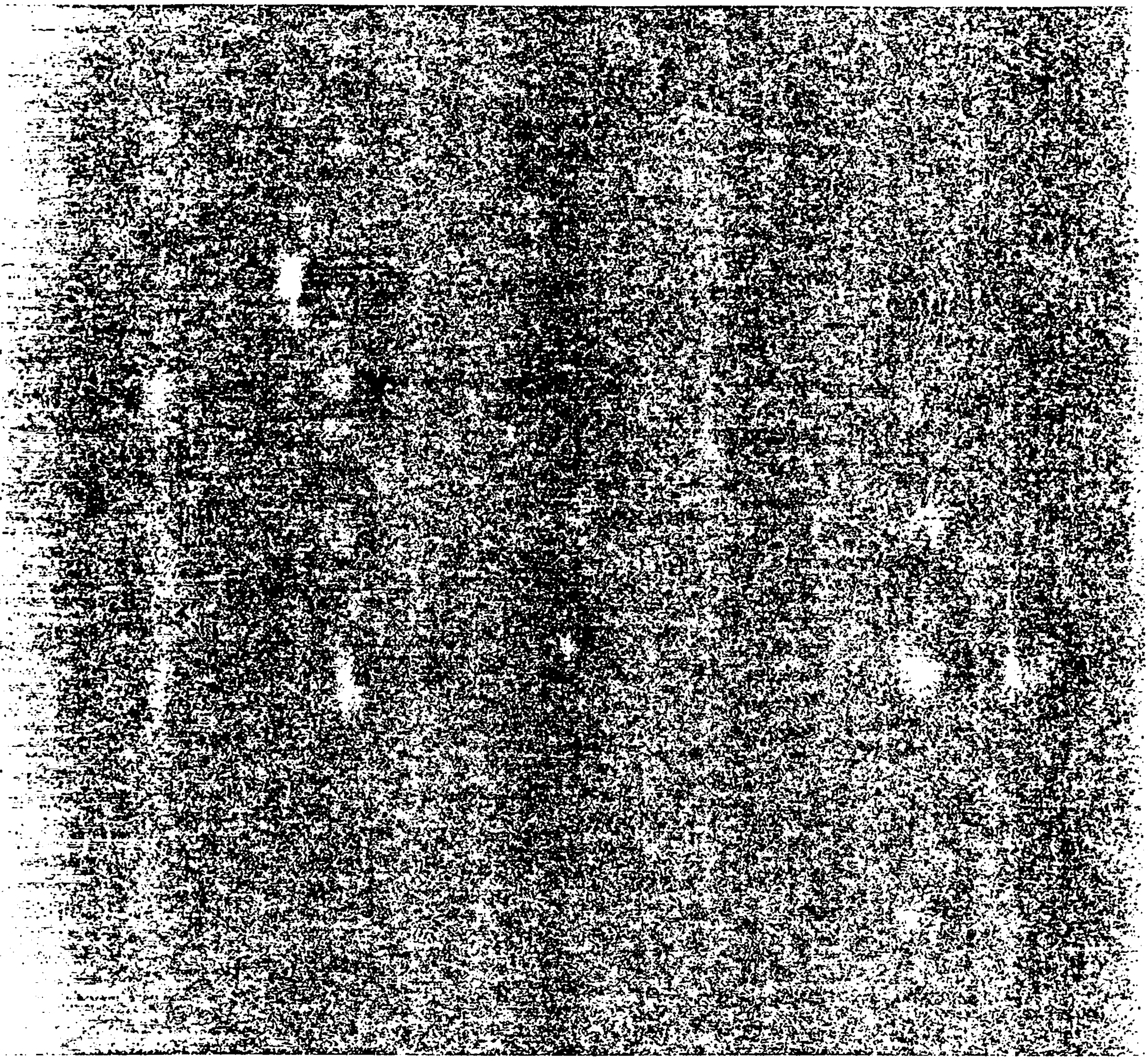
*Contact NTIS for a price quote.



Los Alamos