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Application of Management Techniques For Improving of Rescue and Relief Operations in Flood Disaster Management Operations

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ABSTRACT - Flood disasters in specific areas are usually of repetitive nature. Maintaining of data viz a viz previous similar calamities and taking precautions such as proper weather / flood forecasting can give required reaction time for the analysis and application of management techniques to flood disaster management. Rescue and relief operations are important component of flood disaster management. By applying program evaluation and review technique (PERT) with inbuilt statistical methods, the optimization of resource utilization during the rescue and relief operation can be achieved. Slack periods can be identified and for optimization of resource management ideal resources can be put on other activities during the slack periods. Time duration for completing of flood disaster management operation with a higher confidence level can also be assessed with the PERT and by applying the statistical techniques using the 'Standard Normal Distribution'. Rescue and relief operations can be expedited by the PERT application by identifying critical activities and then analyzing them for reducing their execution times. An example of application of the PERT to rescue & relief operation during the flood disaster management has been taken for bringing out above mentioned points.

Key words: Critical, Dummy, PERT, Predecessor, Slack.

I. INTRODUCTION

Involving of Armed forces by the civil authorities in disaster management is very common [4], [5]. Although, as per the Government of India (GOI) instruction on the subject Armed forces are required to be called when all civil resources are committed and situations are beyond their control [7], [10], [11]. But in reality, Armed forces are the first respondents in most of the situations due to their quick reaction, discipline and readily available infrastructure [9]. Study of large volume of literature reveals that whenever called Armed forces have done an excellent job in such situations. They can be even more affective if the coordination by civil authorities improves [1].

Management or optimization techniques are not generally applied in disaster management operation. This is due to the fact that most of the tasks in such situation are carried out on emergency basis without any time for analysis. This is true in case of disasters like earthquake which strucks without notice and not of repetitive nature in specific areas. But in case of floods, the reaction time can be available if actions like weather and flood forecast, identifying low lying localities are taken and past data and experience due to repetitive nature of flood disaster in specific areas are made use of. Due to this, during the flood disasters, management and optimization techniques can be applied to rescue and relief operations. This paper deals with application of the program evaluation and review technique (PERT) to flood disaster management. An example of rescue and relief operation which is common in Flood Disaster Management is taken for analysis and optimization of resources use and reducing of operation time and finding time required with desired confidence level for the completion of operation using the PERT.

APPLICATION OF PROGRAM EVALUATION TECHNIQUE (PERT) FOR FLOOD DISASTER MANAGEMENT

1. The management techniques can be applied for optimization of flood disaster management operations. The application of program evaluation and review technique (PERT) for the optimization of these operations is explained here.
2. For this purpose, each operation should be defined in detail. Following example is being taken for detailed study.
   a) Name of the operation:- Rescue & relief operation by the Army.
   b) Job description :-

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i. Rescue a group of humans with their minimum essential belongings from the flood affected locality.
ii. Provide first aid to affected persons.
iii. Forward serious cases to hospitals.
iv. Transport other person to a place for temporary stay.
v. Provide accommodation, essential commodities at place of temporary stay.

c) Start of operation:- On receipt of information regarding rescue from the civil authorities to Army unit.

d) End of operation: - After settling of affected person at a temporary stay site and admission of serious medical cases into hospital.

3. Operation is required to be divided into various activities for the application of PERT. All the activities are given identification codes [6]. The responsibility with respect to each activity is also assigned. These details with respect to operation under consideration are given below in Table -1.

Table: - 1 Activities Description and Responsibilities

Sl. No	Activity Identification Code	Activity Description	Responsibility
1	a	Information from civil authorities to Army unit.	Civil authority
2	b	Informing to Army detachment earmarked for rescue operation.	Army unit
3	c	Informing medical department for first aid / hospital admissions.	Army unit
4	d	Informing relief team for providing the essential commodities during temporary stay.	Army unit
5	e	Forming and briefing a rescue team.	Incharge rescue team
6	f	Moving of the rescue team to a rescue site.	Incharge rescue team
7	g	Rescue operation.	Incharge rescue team
8	h	Forming of a medical team and briefing.	Incharge medical team
9	j	Moving of the medical team to a rescue site.	Incharge medical team
10	k	Segregating medical cases & first aid.	Incharge medical team
11	l	Moving serious medical cases to a hospital.	Incharge medical team
12	n	Moving relief material to a temporary stay destination.	Relief team
13	m	Moving rescued personnel to the temporary stay destination.	Rescue team
14	o	Providing temporary accommodation, essential commodities to the rescued personnel.	Relief team
15	p	Completion report to the Army unit by the rescue team.	Rescue team
16	q	Completion report to the Army unit by the medical team.	Medical team
17	r	Completion report to the Army unit by the relief team.	Relief team
18	s	Completion report by the Army unit to the civil authority.	Army unit

Immediate Predecessor Activities:

In any operation execution of each activity will begin immediately on completion of certain specified activities. These specified activities are known as Immediate Predecessor Activities [3]. These are to be mentioned against each activity as shown below in Table – 2

Table:- 2 Activities Description, Immediate Predecessors & Responsibilities

Sl. No	Activity Identification	Activity Description	Immediate Predecessor Activities	Responsibility
1	a	Information from civil authorities to Army unit.	-	Civil authority
2	b	Informing to Army detachment earmarked for rescue.	a	Army unit
3	c	Informing medical department for first aid / hospital admission.	a	Army unit
4	d	Informing a relief team for providing essential commodities during a temporary stay.	a	Army unit
5	e	Forming and briefing a rescue team.	b	I/C Rescue team
6	f	Moving of the rescue team to a rescue site.	e	I/C Rescue team
7	g	Rescue operation.	f	I/C Rescue team
8	h	Forming of a medical team and briefing.	c	I/C Medical team

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Sl. No	Activity Identification	Activity Description	Immediate Predecessor Activities	Responsibility
9	j	Moving of the medical team to a rescue site.	h	I/C Medical team
10	k	Segregating medical cases & first aid.	g, j	I/C Medical team
11	l	Moving serious medical cases to hospital.	k	I/C Medical team
12	m	Moving relief material to a temporary stay destination.	d	Relief team
13	n	Moving rescued personnel to the temporary stay destination.	g, k	Rescue team
14	o	Providing temporary accommodation , essential commodities to the rescued personals.	m, n	Relief team
15	p	Completion report to the Army unit by the rescue team.	n	Rescue team
16	q	Completion report to the Army unit by the medical team.	l	Medical team
17	r	Completion report to the Army Unit by the relief team.	o	Relief team
18	s	Completion report by the Army unit to the civil authority.	p, q, r	Army unit

*I/C : Incharge

Estimated Time for Execution of Activities

For calculation of expected time duration for executing of activities as per the PERT assumption, three time estimates are made:

a) **Optimistic Time Estimate (t_o):**
If everything goes right, how much minimum time the activity is expected to take.

b) **Most Probable Time Estimate (t_m):**
It is the most probable time, assessment for an activity under normal circumstances with few expected hurdles.

c) **Pessimistic Time Estimate (t_p):**
How much maximum expected time the activity will take if many hurdle to be encountered during the activity.

Expected Time for Execution of Activities (t_e)

Assessed time for execution of the activities taking into consideration earlier mentioned three time estimates is known as expected time estimate (t_e) for execution of activities [13].

As per the PERT assumption time estimate 't_o' and 't_p' are equally likely to occur whereas time estimate 't_m' is four times likely to occur. Therefore the expected time estimate t_e is to be calculated as:

$$t_e = \frac{t_o + 4t_m + t_p}{6} \quad (1)$$

Where,

t_o, t_m & t_p are the random variables having expected values.

't_e' is itself a random variable being weighted average of three random variables.

t_e is the expected time estimate for the activity. This time estimate t_e is used for further calculations.

The expected time estimate (t_e) information is added to above table - 2 as shown below in table - 3.

Table :- 3 Activities Description, Immediate Predecessors, Responsibilities & Estimated Activity Times

Sl. No	Activity identification code	Activity description	Immediate predecessor activity	Responsibility	Time required (In Hours) – Estimate			Expected time (t_e) in hours
					Optimistic *to*	Most Probable *tm*	Pessimistic *tp*	$t_e = \frac{t_o + 4t_m + t_p}{6}$
1	a	Information from civil authorities to the Army unit	-	Civil authority	$\frac{1}{4}$	$\frac{1}{2}$	1	0.54

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2	b	Informing to Army detachment earmarked for rescue operation	a	Army unit	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{2}$	0.28
3	c	Informing medical department for first aid / hospital admission	a	Army unit	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{2}$	0.28
4	d	Informing a relief team for providing essential commodities during a temporary stay	a	Army unit	$\frac{1}{2}$	1	$1\frac{1}{2}$	1
5	e	Forming and briefing a rescue team	b	I/C Rescue team	$\frac{1}{2}$	1	$1\frac{1}{2}$	1
6	f	Moving of the rescue team to rescue site	e	I/C Rescue team	$1\frac{1}{5}$	2	$2\frac{1}{2}$	2
7	g	Rescue operation	f	I/C Rescue team	2	$2\frac{1}{2}$	3	2.5
8	h	Forming of a medical team and briefing	c	Medical unit	$\frac{1}{2}$	$\frac{3}{4}$	1	0.75
9	j	Moving of the medical team to a rescue site	h	I/C medical team	$1\frac{1}{5}$	2	$2\frac{1}{2}$	2
10	k	Segregating medical cases & first aid	g, j	I/C medical team	1	$1\frac{1}{2}$	2	1.5
11	l	Moving serious medical cases to hospital	k	I/C medical team	1	$1\frac{1}{2}$	2	1.5
12	n	Moving relief material to a temporary stay destination	d	Relief team	2	3	4	1.5
13	m	Moving the rescued personals to the temporary stay destination	g, k	Rescue team	1	$1\frac{1}{2}$	2	1.5
14	o	Providing temporary accommodation, essential commodities to the rescued personals	a, n	Relief team	2	$2\frac{1}{2}$	3	2.5
15	p	Completion report to the Army unit by the rescue team	m	Rescue team	1/6	$\frac{1}{4}$	$\frac{1}{2}$	0.28
16	q	Completion report to the Army unit by the medical team	l	Medical team	1/6	$\frac{1}{4}$	$\frac{1}{2}$	0.28
17	r	Completion report to the Army unit by the relief team	o	Relief team	1/6	$\frac{1}{4}$	$\frac{1}{2}$	0.28
18	s	Completion report by the Army unit to the civil authority	p, q, r	Army unit	1/6	$\frac{1}{4}$	$\frac{1}{2}$	0.28

*I/C : Incharge

II. OPERATION EXECUTION NETWORK

The network depicting activities required to be done to complete a operation (Project) is known as operation execution network (Graph). The Operation Execution Network (Graph) is constructed as follows.

a) Each activity has certain starting and ending points depicted by serially numbered circles. The arrows connecting these circles represent activity with duration and code written there on. The end point of an activity is the start point of its immediate succeeding activity.

b) The network can have more than one branches representing sets of activity which can be performed in parallel.

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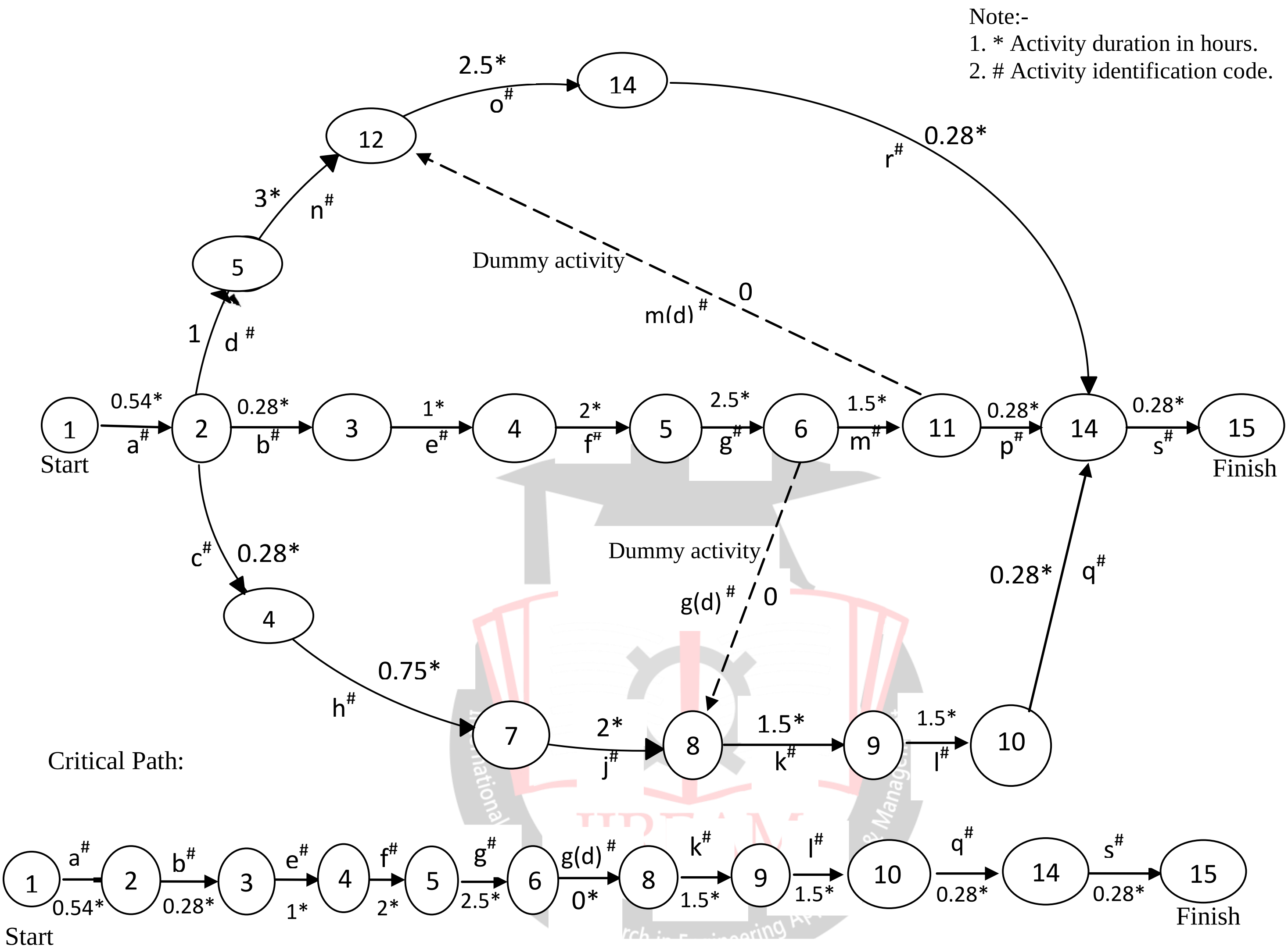
c) If there is any activity on the branch, one which is immediate predecessor to an activity on branch two, then ending node of respective activity on branch one is connected to the starting node of respective activity on branch two by a dotted line as dummy activity of zero time duration.

The network of operation under consideration is shown in Figure – 1.

OPERATION EXECUTION NETWORK



Project Length = 9.88 Hours.
Starting free slack for relief team = 4 Hrs.
Starting free slack for Medical team = 3 Hrs.

Fig - 1

Critical Path: The longest path in terms of time in the operation execution network is known as 'critical path'. In this case critical path is a + b + e + f + g + g(d) + k + l + q + s.

Critical Activities: All the activities on the critical path are known as 'critical activities'. In this case, critical activities are a, b, e, f, g, g(d), k, l, q, s.

The Expected Time Duration (Time Length of Critical Path) of Operation (T_e)

The expected time duration of operation (T_e) will be the sum of expected time durations *(t_e)* of activities on the critical path.

$$T_e = \sum_{i=1}^{n} A_i^c \quad \text{-----------------} \rightarrow \quad (2)$$

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Where A_i^c (i = 1 to n) are critical activities.

'T_e' will also be a random variable being sum of many random variables

Expected Time Duration of Operation in Hours: The length of a critical path in terms of time (Hours) is expected time duration of operation (T_e) in Hours.

T_e = a (0.54) + b (0.28) + e (1) + f (2) + g (2.5) + g (d) 0 + k (1.5) + ℓ (1.5) + q (0.28) + s (0.28)
= 9.88 Hours

Slack: The activities not on the critical path can be started late by a certain time (slack) without affecting the total time required for the completion of project.

In above Rescue and Relief Operation:

(a) Relief team has a slack of 4 hours; it can start moving the relief material four hours late without affecting the total project time. This team can be used for some other work for these four hours (slack), hence optimizing the utilization of manpower.

(b) Similarly medical team has a slack of three hours; it can move three hours late without affecting the project. This team can carry out some other job during this time (slack) for the optimization of resources utilization.

Probability Distribution of Activity Duration Time (t_e)

The expected time duration of activities (t_e) are not having exact but expected values having probability distributions as per details in succeeding paragraphs hence expected time duration of activity (t_e) is a random variable having probability distribution as shown in Fig – 2 below.

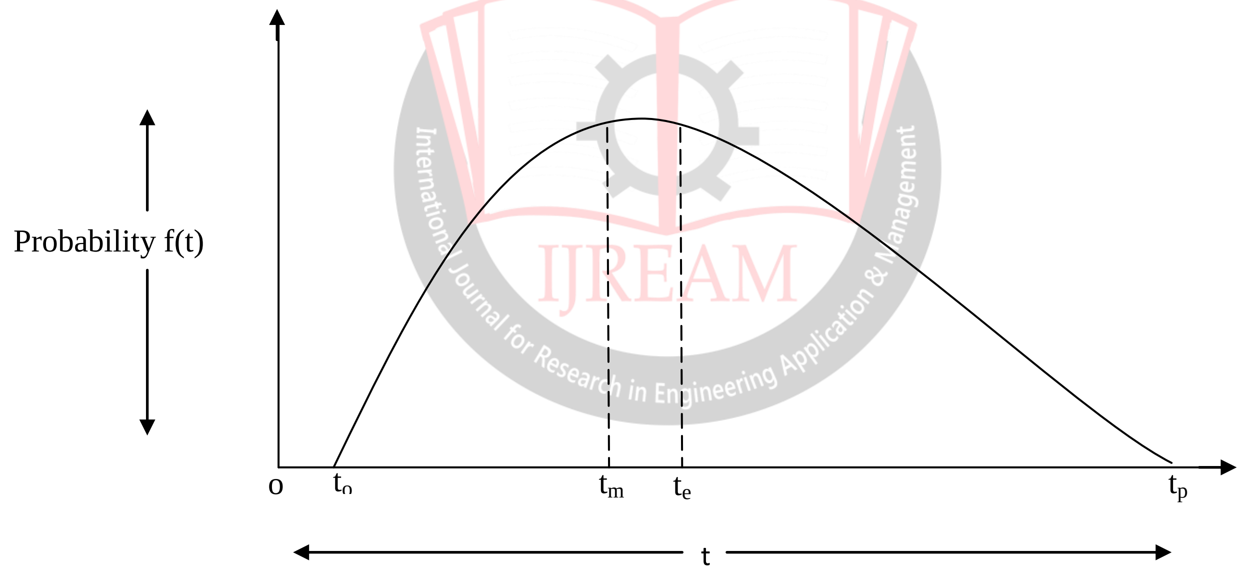

Fig – 2 Probability Distribution of Activity Duration Time (t_e)

The probability of 't' being at 't_o' is very less and then increase till 't' at 't_m' and then again decrease, up to 't' at 't_p'. The probability of ($t = t_m$) is maximum.

As discussed earlier ($t=t_e$) is expected time duration of activity. Probability distribution of expected time duration of activity (t_e) follows β distribution [2] with the following properties:

(a) Unimodal (single peak value)

(b) Finite non – negative end points

(c) Not Necessarily be Symmetrical

These properties are desirable for the distribution of activity times as per the PERT assumption.

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now,

$$\int_{t_o}^{t_e} f(t)dt = \int_{t_e}^{t_p} f(t)dt \quad \text{-----------------}\rightarrow \quad (3)$$

Areas on both sides of 't_e' ordinate are same.

Variability of Activity Times

Since activity times are expected values, therefore they are bond to have variability. In statistical analysis, the popular measures of variability are variance and standard deviation.

Let the expected activity time (t_e) be represented by random variable 'X' having values as x_1, x_2, x_3…..xn and having corresponding probabilities as $f(x_1)$, $f(x_2)$, $f(x_3)$…..$f(x_n)$

$$\text{Mean of } t_e = \bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \quad \text{------------}\rightarrow (4)$$

$$\text{Variance of } t_e = \sigma^2 = \frac{\sum_{i=1}^{n} (\bar{X} - x_i)^2}{n} \quad \text{-----------}\rightarrow (5)$$

$$\text{Standard Deviation of } t_e\ (\sigma) = \sqrt{\frac{\sum_{i=1}^{n} (\bar{X} - x_i)^2}{n}} \quad \text{------------}\rightarrow (6)$$

The PERT follows simplified expression for the calculation of standard deviation (s_t) of expected activity duration (t_e)

$$s_t = \frac{t_p - t_o}{6} \quad \text{------------------------}\rightarrow \quad (7)$$

The standard derivation (S_T) of expected time duration of operation (T_e) is given by

$$S_T = \sum_{i=1}^{n} s_{ti} \quad \text{------------------------}\rightarrow \quad (8)$$

(i=1 to n) are standard deviations of expected time duration of critical activities (t_e).

Probability of Completing an Operation In Given Time (Duration)

T_e is the sum of large number of independent random variables (critical activities time duration) so as per centre limit theorem it will be approximately 'Normal Distributed' regardless of probability distribution of individual activities as shown in Fig – 3 below.

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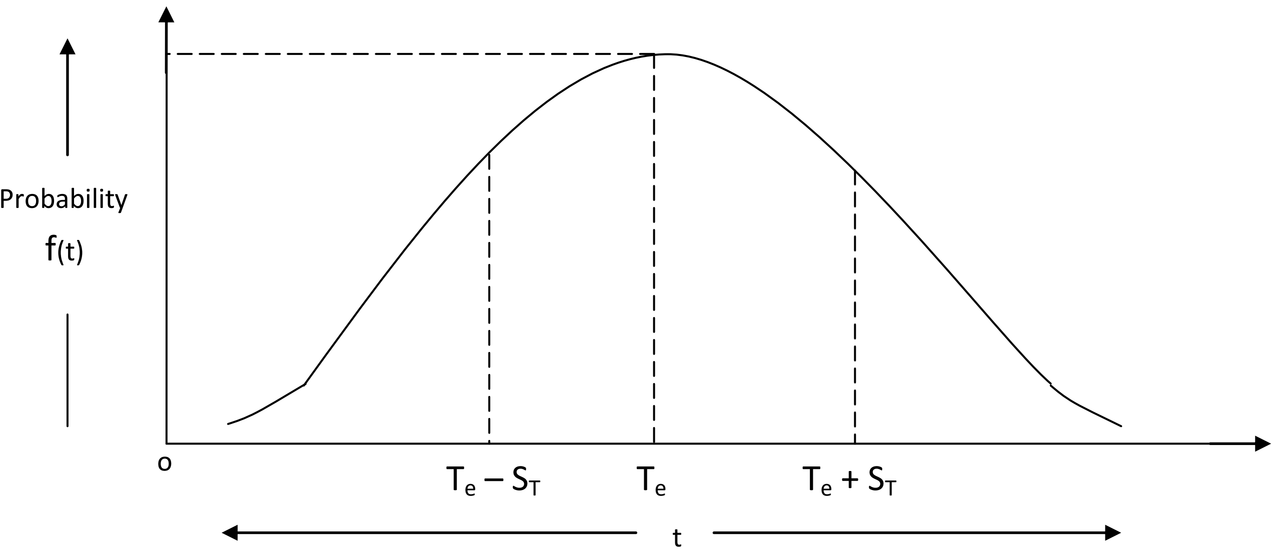

Fig – 3 Normal Distribution Curve – For Expected Time Duration of Operation (T_e)

This probability distribution has the mean as T_e and standard deviation as S_T. Now, normal probability distribution function f(t) is given by:

$$f(t) = \frac{1}{\sqrt{2\pi}S_T} e^{-\frac{1}{2}\left(\frac{t-T_e}{S_T}\right)^2} \dashrightarrow \quad (9)$$

Standard Normal Distribution

For simplifying equation (9) for making calculation easy, the T_e is assumed as '0' and S_T as '1'.

Let $$\frac{t-T_e}{S_T} = z$$

From (9)

$$f(z) = \frac{1}{2\pi} e^{-\frac{1}{2}z^2}$$

$$F(z) = \int_{-\infty}^{z} e^{-\frac{t^2}{2}} dt \dashrightarrow \quad (10)$$

The standard normal distribution table gives the value of F(z) for various values of z.

if 'z' is negative, F(-z) = 1- F(z) $\dashrightarrow$ (11)

Confidence Level

The area under probability distribution curve (Fig.3) is considered to be '1'. The ordinate of this normal distribution curve at the expected time duration of operation (T_e) divides the area under curve into two halves. Time duration of operation is a random variable, there are 50% chances that it will be less than or equals to T_e and 50% chances are that it will be equals to or more than T_e. Therefore, we can say with 50% confidence that the operation duration will be equals to or less than ($t=T_e$) or

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there are 50% chance that the operation will be completed within T_e time duration (c). If we want to increase the confidence level, we have to move towards right of T_e (giving more time than T_e).

Based on the properties of normal distribution, we can say with approximate 84% confidence level that the project will finished by $T_e + S_T$ time, with approximate 95% confidence level that it will finish by $T_e + 2S_T$ and with approximate 99% confidence level that it will be finished by $T_e + 3S_T$.

As brought out earlier, the expected operation duration (T_e) gives us 50% confidence level that operation will be completed in that time. This is the minimum confidence level which we should maintain. In certain situation, ensuring higher confidence level is necessary. The details are as under:

a) When a transportation cost of infrastructure employed on the operation is high as compared to rental values, we should go for higher confidence level.
b) When second time, availability of special equipment or trained manpower required for operation is doubtful. We should go for higher confidence level.
c) If after completion of present operation, the resources are going to be used for non – critical or low priority task. We should go for the higher confidence level.
d) If the operation under consideration is high daily cost process, we should plan for the less confidence level.

<u>Calculating Standard Deviation of Expected Operation Duration:</u> Standard deviation of expected time duration of operation (T_e) can be calculated by adding standard deviation of all Critical activities. For example for under consideration operation the calculations are as shown in Table – 4 below:

Table:- 4 Critical Activity, Expected Time Required and Standard Deviation

S. No.	Activity Identification	Critical Activity	Expected Time Required (t_e)	Standard Deviation $S_t = \frac{t_p - t_o}{6}$
1	a	Information from civil authorities to the Army unit.	0.54	$\frac{1-\frac{1}{4}}{6}=\frac{1}{8}$
2	b	Informing to the Army detachment earmarked for rescue.	0.28	$\frac{\frac{1}{2}-\frac{1}{6}}{6}=\frac{1}{18}$
5	e	Forming and briefing a rescue team.	1	$\frac{\frac{3}{2}-\frac{1}{2}}{6}=\frac{1}{6}$
6	f	Moving of the rescue team to rescue site.	1.5	$\frac{2-1}{6}=\frac{1}{6}$
7	g	Rescue operation.	2.5	$\frac{3-2}{6}=\frac{1}{6}$
10	k	Segregating medical cases & first aid.	1.5	$\frac{2-1}{6}=\frac{1}{6}$
11	l	Moving serious medical cases to hospital	1.5	$\frac{2-1}{6}=\frac{1}{6}$
16	q	Completion report to the Army unit by the medical team	0.28	$\frac{\frac{1}{2}-\frac{1}{6}}{6}=\frac{1}{18}$
18	s	Completion report by the Army unit to the civil authority	0.28	$\frac{\frac{1}{2}-\frac{1}{6}}{6}=\frac{1}{18}$

Standard deviation of expected time duration of operation (T_e) = $\sum_{i=1}^{n} S_{ti}$ = S_T from equation 8

$$S_T = \frac{1}{8}+\frac{1}{18}+\frac{1}{6}+\frac{1}{6}+\frac{1}{6}+\frac{1}{6}+\frac{1}{6}+\frac{1}{18}+\frac{1}{18}$$
$$=1\frac{1}{8}$$

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$= 1.125$ hours

Calculation of Time Duration of Operation for Desired Confidence Level

The following procedure to be followed:

- Let the desired confidence level be 0.8 (80%).
- Expected time duration of operation at 50% confidence level = T_e = 9.88 Hours with the standard deviation of 1.125 Hours.
- In the 'Standard Normal Distribution Table F (z) = $\int_{-\infty}^{z} e^{-\frac{t^2}{2}} dt$ ', identify figure '0.8' or a figure, nearest to that say (0.7995).
- With respect to 0.7995 find the value of z which is = 0.84.
- Let T_c = Time duration of operation with respect to the desired confidence level of 0.8 (80%). Then,

$$Z = \frac{T_c - T_e}{S_T} \quad \dashrightarrow \quad (12)$$

$$0.84 = \frac{T_c - T_e}{S_T}$$

$$0.84 \times S_T = T_C - T_e$$

$$0.84 \times 1.125 = T_C - 9.88 \text{ Hours}$$

$$T_C = (0.84 \times 1.125 + 9.88) \text{ Hours}$$

$$= 10.825 \text{ Hours}$$

We can say with 80% confidence level that the operation will be completed by 10.825 Hours.

Reducing Expected Time Duration of Operation (T_e)

Expected time duration of operation (T_e) depends on the expected time duration of only critical activities (t_e). Therefore, T_e can be reduced by reducing t_e with respect to few or all critical activities.

For this, we have to analyze all the critical activities with a view to decrease its duration by:

a) Improving the process.
b) Employing more versatile equipment.
c) Employing additional manpower.

After analysis, one can employ one or more of above methods to those critical activities where reduction in t_e is maximum with minimum additional resources.

In the process of reducing T_e by reducing one or more than one t_e on the critical path, a near critical path may become critical. Then, we have to reassess expected time duration of operation for the desired confidence level for the new critical path following the same procedure.

Effect of Near Critical Path on Confidence Level:

If standard deviation (S_{Tn}) of expected time duration in respect of near critical path is more than the standard deviation (S_T) of critical path, it is desirable to calculate required time duration T_c for both the critical and near critical paths for the desired confidence level and higher figure is to be taken into consideration.

Futuristic Scope

If time permits we can improve the time estimates in PERT by formulating stochastic PERT network as Bayesian network. Inference in PERT Bayesian networks will be more relevant as algorithms exist for solving mixtures of Gaussians hybrid Bayesian networks exactly [12].

Advantages of Using PERT in Flood Disaster Management

The use of program evaluation and review technology (PERT) in flood disaster management has following advantages:

1. The slacks available in execution of various activities in parallel branches can be identified and branch resource during slack time can be utilized somewhere else resulting into optimization of resources utilization.
2. The time required for completing the operation with various confidence levels can be calculated.
3. Operation time can be reduced by analyzing and optimizing the critical activities.
4. Operation execution can be further improved for successive operation by the analysis of previous operations.

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III. Conclusion

In case of flood disasters, with proper forecasting of weather and floods, taking precautionary measures, linking low lying localities with water level in major rivers and tributaries, the availability of reaction time will increase. Flood disasters are of repetitive nature in specific areas, the data and experience of previous calamity can be used for improving the present rescue and relief operations. Due to this, most of the situations in flood disaster will turn from emergent to predictable. Therefore, management techniques like program evaluation and review technique (PERT) can be deployed for the optimization of resource utilization and expediting rescue and relief operations.

REFERENCES

[1] Major General (Retd) Amar Krishna, Dr Pramod Damle, "Armed Forces in Disaster Management in India: Need for Improving Civil – Military Coordination", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 7, July 2017

[2] Enobong Francis Udoumoh, Daniel W. Ebong, A Review of Activity Time Distributions in Risk Analysis, American Journal of Operations Research, Vol.7, pp. 356-371, 2017.

[3] R.O. Aja and W.I.E. Chukwu, "Application of Program Evaluation, Review Technique and Critical Path Method (PERT-CPM) Model in Monitoring Building Construction", World Applied Sciences Journal Vol. 35 (11), pp. 2401-2413, 2017.

[4] Satendra Dr. K. J. Anandha Kumar Maj. Gen. Dr. V. K. Naik, KC, "AVSM, Uttarakhand Disaster 2013", National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, 2015.

[5] Sanjeev Singh & Kaveri Tandon, "Armed Forces in Disaster Management: Challenges in Indian Perspective", Scholarly Research Journal for Interdisciplinary Studies, Vol. III/XVII, pp. 2902-2908, MAR – APR, 2015.

[6] Hahn, E.D. and Martín, M.M.L. Program Evaluation And Review Technique (PERT), available at

[7] http://www.improhealth.org/fileadmin/Documents/Improvement_Tools/PERT.pdf

[8] ANI J-K floods: 'Operation Megh Rahat'. Udhampur: Ani News. Ani. 2014

[9] Available at http://aninews.in/newsdetail2/story182423/j-k-floods-indian-army-in-aid-to-civil-administration-under-039-operation-megh-rahat-039-.html.

[10] Siamak Haji Yakhchali, Program Evaluation and Review Techniques II (PERT II), Engineering Letters, Vol.19 , pp. 1-7 November 2011.

[11] Lt. Gen. Vijay Oberoi, 'Disaster Management: Why the Army Continues to take the Lead', Indian Defense Review, Vol. 28.3, 2013.

[12] http://www.indiandefencereview.com/news/disaster-management-why-the -army-contineus-to-take-the-lead/

[13] Memon. M. D. (2013), "We Must Define The Role of Armed Forces in Disaster Management", Indian Express, June 30, 2013. www.indianexpress.com

[14] Disaster Management in India - Government of India Ministry of Home Affairs -Manual (2012)

[15] Esma Nur Cinicioglu and Prakash P. Shenoy, "Solving Stochastic Pert Networks Exactly Using Hybrid Bayesian Networks", Conference Paper ·September 2006.

[16] Dimitri Golenko, On the Distribution of Activity Time in PERT, J. Opl Res. Soc. Vol. 39, pp. 767-771, 1988.

BIOGRAPHY

Lt Gen Ranbir Singh is an alumnus of the National Defence Academy, Khadakwasala. He has done his M. Sc. in Defence and Strategic Studies from University of Madras and MA in International Security & Strategy from King's College, London. M. Phil. in Defence & Management Studies from School of Defense and Management Studies, Devi Ahilya Vishwavidyalaya, Indore. He has held varied command, staff and instructional appointments in the Army in all types of terrain & conflict scenarios and has served in the prestigious appointment of Director General of Military Operations in Army Headquarters. He is currently posted as the Army Commander Northern Command at Udhampur. He has also attended the Anti-Terrorist Course in Royal College of Defence Studies in United Kingdom and has served on two important United Nations missions in Rwanda and Sudan. He has also been involved in coordinating Disaster Relief operations at the directional and functional levels in several disaster situations. For his distinguished and exceptional service in the Army, he has been awarded Ati Vishisht Seva Medal on two occasions, Yudh Seva Medal and Sena Medal. The General Officer is presently pursuing Ph D in Management.

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