ABSTRACT

COMBAT CALCULATOR USING QUANTIFIED JUDGEMENT MODEL (QJM)

By

Capt Imran Zaheer
NC Abdul Haseeb

This report focuses on development of software called combat calculator basing on Quantified Judgment Model (QJM). The **Combat Calculator** is a computer program that calculates the results of a combat situation between pairs of units, even though a battle may take place between several units at the same time.

The **quantified judgment analysis model** is "A method of comparing the relative combat effectiveness of two opposing forces in historical combat, by determining the influence of environmental and operational variables upon the force strengths of the two opponents".

Although the focus of the model is historical but the model can be predictive with the help of which, commanders will be able to quantify their chances of battlefield success and systematically identify the areas of weakness.

DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institute or elsewhere.

DEDICATION

This document is dedicated to our beloved parents and teachers who have been a source of constant encouragement for us.

ACKNOWLEDGEMENTS

All acclamation to Almighty Allah Who has empowered and enabled us to accomplish this task successfully

We are extremely thankful to our project supervisor Maj Ather Mohsin, for his guidance and instructive supervision even with his highly busy schedule.

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ACRONYMS

QJM – Quantified Judgment Model

OLI –Operational Lethality Index

TLI – Theoretical Lethality Index

DI – Dispersion Index

CEV – Combat Effectiveness Value

WEI **-** Weapons Effectiveness Index

Rf **-** Rate of Fire.

Rn – Range.

S – Force Strength.

MF – Mission Factor

Esp – Spatial Effectiveness

Ecas – Casualty Effectiveness

P – Power

Pb – Power of Friendly Force

Pr - Power of Enemy Force

CR – Casualty Rate.

Chapter 1

1. Introduction

The **Combat Calculator** is a computer program that calculates the results of a combat situation between pairs of units, even though a battle may take place between several units at the same time.

The **quantified judgment analysis model** is "A method of comparing the relative combat effectiveness of two opposing forces in historical combat, by determining the influence of environmental and operational variables upon the force strengths of the two opponents".

1.1 Aim

The aim of this project is to develop a Combat Calculator using Quantified Judgment Model (QJM).

1.2 Language and Platform

The development of this software has been done in Microsoft C sharp .NET and Database has been created and maintained in MS Access.

1.3 Software Model

The complexity of the project and the unavailability of the complete data required that we adopt the incremental model so as to iteratively develop on the functioning of the software.

1.4 Definition of the Theory of Combat

Theory of combat is defined as: the embodiment of a set of fundamental principles governing or explaining military combat, whose purpose is to provide a basis for the formulation of doctrine, and to assist military commanders and planners to engage successfully in combat at any level.

1.5 The QJM Model

The QJM or Quantified Judgment Model is a combat model developed by Col. Trevor N Dupuy. The model compares two opposing forces (called friendly and enemy) to each other. It does this by calculating for each force its total Operational Lethality Index (OLI).After applying the effects of other operational and environmental factors on the OLI, the model predicts the expected outcome of the battle based on the information available from the historical data.

Chapter 2

2. Operational Lethality Index (OLI)

2.1 Introduction

The measure of weapon effectiveness used in the QJM is the Operational Lethality Index (OLI). However, the QJM, properly calibrated, could be based on any logical and reasonable measure of weapon effectiveness.

The OLI was developed originally to represent the comparative lethality of all weapons over the course of history.' A methodology was derived that could consistently calculate OLIs in terms of weapons' characteristics. It was used [1] to compare the relative lethal effects of, for instance, spears, bows and arrows, rifled muskets, quick-firing artillery pieces, machine guns, and atomic weapons. It has been applied to most existing modern weapons, including tanks, aircraft, and missiles, and it can be applied to hypothetical future weapons.

The OLI represent the combat capability of a weapon system. It's a collection of a large variety of variables. The OLI provides a logical, reasonable, and consistent methodology for weapons' effects quantification. It is the number of casualties that a weapon can inflict upon the infinite targets in one hour.

2.2 Calculating OLI

The OLI is first based on the *Theoretical Lethality Index* (TLI) which is then divided by the DI or Dispersion Index.

$$OLI = TLI / DI$$

2.2.1 Calculating Theoretical Lethality Index (TLI)

Theoretical Lethality Index (TLI), is calculated from the variables listed below:

1. Rate of fire (RF): the number of times the weapon reasonably can strike at the target array in an hour.

2. Reliability (R): the probability that the weapon will function as designed when an attempt is made to strike the target array.

3. Accuracy (A): the probability that a specific intended target will be struck when the weapon functions properly.

4. Number of targets per strike (C): for most weapons this is related to the area of burst of a high-explosive shell. The method permits conversion of this effect to the damage that can be inflicted by a weapon employed against a point target, such as an individual soldier or a tank.

5. Range (Rn): based on effective range and muzzle velocity.

The product of the values for these five weapon characteristics is the Theoretical Lethality Index (TLI), expressed in casualties per hour. The formula is as follows:

$$\mathbf{TLI} = \mathbf{RF} \times \mathbf{R} \times \mathbf{A} \times \mathbf{C} \times \mathbf{Rn}.$$

2.2.2 Dispersion Index (DI)

This is the relative density of troops per square kilometer. The TLI is converted to an OLI by adjusting its value by appropriate weapon performance factors and by dividing the resulting product by a dispersion factor (DI). The increasing lethality of weapons over the past several centuries has had an effect upon combat formations that has made them less and less comparable to the assumed infinite array of targets in a density of 1 square meter per man. The effect has been increased dispersion. The actual average density of troops in combat formations has increased from an average of about 10 square meters per man in ancient armies, to about 27,500 square meters per man in World War II, and to about 35,000 square meters per man in the 1973 Arab-Israeli War. These are average density figures, since troops in units are not distributed over ground space uniformly, but in patterns of varying concentration. Based on the current doctrines of modern military forces, the average density in a conflict between modern forces in the 1980s and 1990s is likely to be about 50,000 square meters per man. If a French 75mm gun has a TLI of about 360,000 the dispersion factor would bring this down to about 120.

The effect of dispersion requires the conversion of the TLI scores of weapons to OLIs, to represent the actual operational effect of weapons against contemporary average troop densities. The dispersion factors that account for increased dispersion over history are shown in Table.

Table 2-1 Dispersion Index

Dispersion Factor (DI)	
Ancient Armies	1
Napoleonic Era	20
American Civil War	25
World War I	250
World War II	3,000
1970s	4,000
1980s	5,000

So the OLI is obtained by dividing TLI with DI

OLI = TLI / DI

Chapter 3

3. Applying QJM

3.1 Dividing Weapons into Categories

Once an OLI has been calculated for each weapon, it is possible to add the individual weapons values to provide aggregate scores for units and forces. This is complicated by the fact that each type of weapon is affected somewhat differently by environmental and operational factors, such as terrain and posture.

To facilitate the consistent application of factors to different weapons, weapons are divided into six major classes:

1. Infantry Weapons, which include not only the small arms of individual riflemen, but also machine guns, mortars, and armored personnel carriers.

2. Artillery Weapons, some of which are towed, some self- propelled; some are traditional ballistic cannon; others are some form of rocket or missile.

3. Armor Weapons, mobile fighting machines that combine firepower, armored protection, and automotive mobility, and intended primarily for direct fire employment.

4. Air Support Weapons, mobile fighting machines based behind the ground-fighting troops, which fly over the battle to apply gunfire, rockets, and bombs to the combat.

5. Air Defense Weapons, guns and missiles designed primarily to protect ground-based troops from hostile air support weapons.

6. Anti-Armor Weapons, guns and missiles designed to protect forces from hostile armored weapons.

3.2 Calculating Force Strength

For every battle the OLI values of all weapons in each class are modified by the variable factors representing the effects of the circumstances of that particular battle upon that class of weapon. A value for Force Strength (S) is calculated by the following procedure:

$$\mathbf{S} = (Wn \times Vn) + (Wg \times Vg) + (Wi \times Vi) + (Wy \times Vy) + (Wgi \times Vgi) + (Wgv \times Vgy).$$

The symbols represent:

S = Force strength

W = The aggregate OLIs of the weapons in a category.

V = Weapon effect factors

n = Infantry Weapons Identifier

g =Artillery weapons identifier

i = Armor weapons identifier

y = Air support weapons identifier

gi =Anti-armor weapons identifier

gy = Air defense weapons identifier

3.3 Defining Force Effects Variables

There are many such variables, and their effects can differ greatly from one variable to another. Some of them are more or less physical in nature (like weather and terrain) and lend themselves relatively easily to quantification, at least conceptually. Other variables are behavioral in nature (like leadership, training, and morale) and are intangible. In between are some other variables that are in themselves intangible, and perhaps unquantifiable, but produce effects that can be measured. The latter category of quantifiable variables includes such things as surprise and relative combat effectiveness.

3.3.1 Dividing Force Effects Variables into Categories

In the QJM, the circumstantial variables are divided into three major groups according to kind. The three kinds of variables are environmental, operational, and human behavioral. Environmental variables are those that occur because of nature.

3.3.2 Environmental Variables

Environmental variables include weather, terrain, and season. Commanders have no influence over this kind of variable, and they affect both sides, although not necessarily equally.

3.3.3 Operational Variables

Operational variables are those that occur because of the actions of the combat forces. Operational variables include posture, mobility, air superiority, surprise, fatigue, and vulnerability. Commanders have great influence over these. And behavioral variables are those that exist because of the nature of the human participants in the combat.

3.3.4 Behavioral Variables

Behavioral variables include leadership, morale, training, and experience. Commanders have influence over these variables, but that influence must be applied at least in part before the battle. Factors representing behavioral variables are applied only to forces.

Factors representing both the environmental and operational variables are applied to weapons to calculate Force Strength (S). Factors representing both of these kinds of variables are also applied to forces to represent the effects of battle circumstances on the forces. Historical analysis of combat has permitted factor values to be established for the environmental and operational force effects variables shown in Table

Table 3-1 Force Effects Variables

Forces Effects Variables		
ENVIRONMENTAL	OPERATIONAL	BEHAVIORAL
Terrain	Posture	Leadership
Weather	Mobility	Training
Season	Vulnerability	Experience
	Fatigue	Morale
	Surprise	Manpower Quality
	Air Superiority	

3.4 Calculating Combat Power

The environmental and operational force effects variable factors are denoted by the symbol Vf. By multiplying Vf to combat strength S, we get the combat power P.

$$P = s \times vf$$

3.5 Substituting Relative Combat Effectiveness for Troop Quality

In order to determine how troop quality (which is based upon the behavioral variables) affects the outcome of a battle, it is necessary to be able to compare the theoretical outcome of a combat event (in which troop quality is not considered) to the actual outcome of the same combat event (in which the relative troop quality has influenced the outcome). The theoretical outcome is described by the relative force strengths and force variables. The actual outcome of a historical battle or engagement is represented in the QJM by a results factor, which combines three measures of effectiveness as follows:

1. **Mission Factor (MF)**, an "expert" judgment of the extent to which a force accomplished its assigned or perceived mission.
2. **Spatial Effectiveness (Esp),** a value representing the extent to which a force was able to gain or hold ground.
3. **Casualty Effectiveness (Ecas)**, a value representing the efficiency of the force in terms of casualties, taking into consideration the strengths of the two sides, and the casualties incurred by both sides.

The three factor values are summed to obtain a measure of results (R) as shown below:

$$\mathbf{R = MF + Esp + Ecas}$$

Having calculated results for both sides, then the outcome of a battle or engagement is described as follows:

$$\mathbf{Actual\ Outcome = Rr/Rb.}$$

The theoretical outcome of a battle is represented by the combat power ratio: **Pr/Pb** (in which quality of troops has not been considered). The actual outcome of the battle is represented by the ratio **Rr/Rb**. It might seem reasonable to expect that **Pr/Pb** should be the same as **R1/Rb** for any battle. But this is rarely the case.

Clausewitz has indicated the two principal reasons why the values of these two ratios will rarely be identical, even under the best of circumstances. First, the "fighting value of the troops," as he called it, is rarely identical. Second, there is always some element of chance or luck, particularly in the interactions of hundreds or thousands of troops on each side of the battle. In addition, it is impossible to achieve absolute accuracy in developing factors to represent the variables affecting the circumstances of the battle, particularly those relating to behavior.

The intangible behavioral considerations are combined into a single factor representing a relative combat effectiveness value (CEV). The CEV is the factor explaining the difference between the **P/P** (theoretical outcome) and **R/R** (actual outcome) ratios.

This relationship is expressed as follows:

$$\mathbf{CEVr = (Rr/Rb)/\ (Pr/Pb)}$$

The **CEV** is a ratio, and **CEVb** is the reciprocal of **CEVr**. To the extent data is available; it is possible by means of above equation to calculate the CEV for any historical battle.

The CEV is used in this theory to represent relative combat effectiveness, and the final QJM combat power formula is to include CEV in the combat power formula.

$$\mathbf{P = S \times Vf \times CEV.}$$

Alpha testing controls whether pixels are written to the render-target surface that is, it verifies whether the pixels are accepted or rejected.

3.6 Summarizing QJM

The essence of the QJM as a theory of combat is as follows:

1. A military force goes into combat with an organization consisting of men and weapons, with the men employing the weapons to impose their collective will upon the enemy by means of firepower. The firepower of the force is quantified in terms of Operational Lethality Indexes (OLIs).

2. The aggregate OLIs for the weapons inventory of a force (W) is converted to Force Strength (S) by application of weapon effects variables (to each of six classes of weapons) as follows:

$$\mathbf{S=W} \times \mathbf{V}$$

3. Force Strength is converted to Combat Power (P) as follows:

$$\mathbf{P=S} \times \mathbf{Vf} \times \mathbf{CEV}$$

4. Illustration Of QJM On Flanders Campaign Of 1940

4.1 Introduction

That campaign is a good vehicle to illustrate the application of the QJM. The Germans won an overwhelming victory over the French and British in this campaign, which led to the fall of France.

If the simplified version of the QJM formula is applied on the campaign of Flanders, the following results can be obtained.

4.2 Allied Force Strength

The numerical strength and composition of the forces actually available to the Allies in May of 1940 are summarized in a much aggregated way in Table 4-1.

To compute troop strengths into force strength it is assumed that each combat aircraft was the equivalent of 100 soldiers, each with his share of supporting weapons (such as mortars, machine guns, and artillery). Thus, 1700 aircraft would have been the equivalent of 170,000 men. Comparisons of the firepower values of the weapons involved (using the OLI methodology) reveal that this assumption, while arbitrary, is neither unreasonable nor capricious.

Table 4-1 Allied Force composition

Allied Force Composition, May 1940

Strength:	Anglo-French	2,000,000	
	Dutch	400,000	
	Belgian	600,000	
	Total	3,000,000	
Combat aircraft		1,700	
Tanks		3,600	
Anglo-French field armies:		9	
Anglo-French divisions:			
	Infantry	87	(c. 1,740,000 men)
	Armored	3	(c. 60,000 men)
	Fortress	13	(c. 200,000 men)
	Total	103	divisions (plus about 40 Dutch and Belgian division-equivalents)

Similarly, it is assumed that each Allied tank was worth 50 men and their share of supporting weapons. This means that the 3600 tanks were the equivalent of 180,000 troops. With the exception of the three armored divisions, the Allies allocated their tanks and planes more or less equally among their divisions and armies. The three armored divisions were also parceled out to the army groups.

On the basis of these assumptions about the manpower values of planes and tanks, the force strength of the Allies in thousands of manpower equivalents is shown in Table 4-2

Table 4-2 Allied Force Strength

Allied Force Strength (000s): May 1940	
Dutch	400
Belgian	600
Anglo-French Forces	
· French fortress troops	200
Field Forces	
Manpower	1,800
Aircraft	170
Tanks	180
Subtotal Field Forces	2,150
Allied Total	3,350

Since the field forces were divided among nine field armies, the force strength of each army was about 240,000 manpower equivalents.

4.3 German Force Strength

An aggregated summary of the numerical strength of the German forces is shown in Table 9-3.

It is assumed that each German combat aircraft was roughly the equivalent of the Allied planes, or worth about one hundred men and their share of supporting weapons. Thus, the Luftwaffe force was the equivalent of 350,000 troops.

The German tanks were, on the average, inferior to those of the Allies. So it is assumed that each German tank was worth about forty men, plus their share of supporting weapons. Thus, the German tanks had a manpower equivalent of 103,040.

Table 4-3 German Force Strength

German Force Composition: May 1940	
Manpower	2,460,000
Combat aircraft	3,500
Tanks	2,576
Field armies:	8, plus a panzer group (or panzer army)
Divisions:	
Infantry	104 (c. 2,080,000 men)
Panzer	10 (c. 200,000 men)
Mechanized	9 (c. 180,000 men)
Total	123 divisions

Germans allocated their tanks exclusively to panzer and mechanized divisions, and then combined these divisions into one panzer group (General von Kleist), and one panzer corps (General Hoth). The Germans did not allocate their airpower to armies, but kept it under centralized control.

4.4 Variable Factors

Next, in order to apply the QJM it was necessary to consider the variable factors that affected the outcome of the battle significantly. There were two factors of principal importance: defensive posture and terrain. Both of these affect the strength of the defender. It was assumed that other variable factors more or less cancelled each other out on the two sides.

The analyses show that (other things being equal) a force in a hasty defensive situation has its force strength multiplied by a factor of 1.3; prepared defense enhances the force strength of a defender by a factor of 1.5; fortified defense has a multiplying effect of 1.6. An average value for a mixture of these postures would be about 1.4.

The multiplying factor in favor of the defender of the fiat terrain of the Low Countries is about 1.1. The effect of the mixed terrain of the Ardennes and northeastern France is to increase the defender's force strength about 1.3 times. In the more rugged areas, like the Vosges Mountains, the terrain factor is about 1.5. Across the entire front, from North Sea to Switzerland, the average terrain factor would be about 1.2 for the defender

4.5 Quality of Troops

Quantification of the quality of the troops is also based on extensive analysis. The analyses show that in their previous conflict (World War I), the Germans were better in ground combat than the Allies by a factor of about 1.2. In QJM terms the German Combat Effectiveness Value (CEV) relative to the allies was 1.2. In other words, 100 Germans in combat units were roughly the equivalent of 120 Allies in combat units. The factor turned out to be almost identical in World War II.

4.6 Overall Comparison

The next step is a general comparison of the opponents, however, when the comparison is based on combat power, the result is changed considerably. The general equation is as follows:

$$\frac{P}{P} = \frac{\text{German S x Terrain Factor x Posture Factor x CEV}}{\text{Allied S x Terrain Factor x Posture Factor x CEV}}$$

The Germans were the attackers, and the Allies were the defenders. In this chapter the combat power ratios are all calculated with the Germans in the numerator and the Allies in the denominator. The Allied combat power ratios are the reciprocals of the calculated German combat power ratios. The average terrain factor for the defender is 1.2 and the average defense posture factor for the defender is 1.4. (The terrain and posture factors for the attackers are both 1.0.) Inserting these factor values and the German CEV of 1.2 gives the following equation:

$$\frac{P}{P} = \frac{\text{German: } (2913)\ (1.0)\ (1.0)\ (1.2)}{\text{Allies: } (3350)\ (1.2)\ (1.4)\ (1.0)} = \frac{3496}{5628} = 0.62.$$

The German attack would obviously be stopped, according to this analysis, which gives the Allies a combat power ratio preponderance of 1.61 (the reciprocal of 0.62).If both sides attack, the equation gives a slightly different result:

$$\frac{P}{P} = \frac{\text{German: } (2913)\ (1.0)\ (1.0)\ (1.2)}{\text{Allies: } (3350)\ (1.0)\ (1.0)\ (1.0)} = \frac{3496}{3350} = 1.04$$

There is a slight German preponderance (due to their greater CEV), but in the light of the crudeness and aggregation of the comparison any combat power ratio of less than about 1.10 must be considered inconclusive. This case is clearly a standoff, particularly because whichever side is forced on the defensive will immediately have combat power preponderance, for the variable factors will then favor the defense.

4.7 The Historical Comparison

The Germans, of course, had no intention of making a general attack all along the line. They had amassed a powerful striking force in Army Group A, in the center of their line, and planned to make a penetration through the Ardennes. This situation is shown diagrammatically in Figure 9-2. The German plan and deployment requires an analysis of the battle in its three major sectors: (1) Low Countries, (2) Ardennes, and (3) the Maginot

Line.

Low Countries: Army Group B was to make a holding attack against the Dutch, Belgians, and any Allied forces advancing into Belgium and Holland. It was their intention to make the Allies believe this was their main effort, and that they were initiating a new Schlieffen Plan. The Allies took the bait. Three Allied armies actually moved into Belgium, but only two were in contact very briefly with Army Group B. The Allied posture was a combination of hasty and prepared defense. The QJM analysis is as follows:

$$\frac{P}{P} = \frac{G: (766)\ (1.0)\ (1.0)\ (1.2)}{A: (1480)\ (1.4)\ (1.1)\ (1.0)} = \frac{919}{2279} = 0.40$$

Obviously the German holding attack would be stopped under these circumstances by the Allied combat power preponderance of 2.48.

Ardennes: The Allied defensive posture was again a combination of hasty and prepared defense. The analysis:

$$\frac{P}{P} = \frac{G: (1712)\ (1.0)\ (1.0)\ (1.2)}{A: (720)\ (1.4)\ (1.3)\ (1.0)} = \frac{2054}{1310} = 1.57$$

The German preponderance of combat power is sufficient to assure a breakthrough, which in fact occurred.

Maginot Line: The Germans never had any intention of attempting a bloody, and essentially doomed, assault on the Maginot Line. All they wanted was to demonstrate with sufficient vigor so that they could hold the Allied forces in and behind the fortifications as long as possible. Had they really attempted an attack, the result would have been as follows:

$$\frac{P}{P} = \frac{G: (595)\ (1.0)\ (1.0)\ (1.2)}{A: (1400)\ (1.6)\ (1.3)\ (1.0)} = \frac{714}{2912} = 0.25$$

This comparison demonstrates most clearly the appalling waste of French forces deployed in the Maginot Line area, giving them a combat power preponderance of 4.0.

The analysis concludes that the overwhelming German attack in the Ardennes area would break through the Allied lines. This is what happened. As a result of the breakthrough, the Allied defensive effort collapsed.

5. Relative Combat Effectiveness

5.1 Relative Combat Effectiveness and Force Quality

An important and unique feature of the QJM is that it includes an explicit, aggregated factor to account for those factors of combat that are generally intangible, but very identifiable, such as leadership, morale, training, experience, initiative, momentum, and chance. The effects of those intangible variables have to be determined by historical analysis because they cannot be detected from engineering tests of weapons or from field exercises. The real human factors of combat appear only during actual combat, when the element of fear is present. No model or theory of combat can be complete unless it can and does deal with these human factors. In the QJM, these are all represented by the concept of relative combat effectiveness and the quantitative expression of that concept, the Relative Combat Effectiveness Value (CEV).

The CEV is a composite factor representing the total effect of all of the variables that have not been identified and quantified explicitly in the computation of combat power. The CEV includes the effects of all of the behavioral variables and the effects of those operational variables that have not yet been identified separately. In Table 5-1 a large set of variables included in the circumstances of combat are shown. This is not meant to be an exhaustive list, and additional variables could probably be added. However, the variables in Table 5-1 cover most of the important circumstances. As the list expands, the distinction between behavioral and operational variables tends to blur because some of the operational variables (surprise, for instance) include a large amount of the human element.

Table 5-1 Circumstantial Variables of Combat

Circumstantial Variables of Combat	
ENVIRONMENTAL	OPERATIONAL
*Terrain	*Posture and Fortifications
*Weather	*Mobility
*Season	*Vulnerability
	*Air Superiority
BEHAVIORAL	*Surprise
Leadership	*Fatigue
Training	*Weapons Sophistication
Experience	Logistical Capability
Morale	Intelligence
Manpower Quality	Initiative
	Command and Control
	Communications
	Momentum
	Time and Space
	Chance
*Factor values established	Friction

Those variables in Table 10-1 for which factor values have been established in the QJM are marked with an asterisk. The remaining variables constitute the present composition of the CEV. It may be possible to isolate and quantify the individual effects of additional variables, and as this is done the composition of the CEV will be adjusted accordingly.

The variables included in the CEV are those that are difficult if not impossible, to quantify on a consistent basis. The CEV includes all of the human behavioral variables often referred to as "intangibles of combat." The CEV also includes several operational or composite operational/behavioral variables that have thus far resisted quantification. CEV assures that the overall impact of all of the circumstances of combat is considered for each battle or engagement.

The CEV also includes the effects of chance and friction. There is an element of chance in all human activities, and friction is created by the interactions of hundreds of thousands of individuals on a battlefield. The calculated CEV for any one battle will include not only the influence of the quality of the troops and leadership on both sides, but also the influence of the ambient circumstances of chance and friction. The more battles for which the CEV for a unit is calculated, particularly against the same opponent, the more the ambient circumstances will tend to cancel out, and the closer the average CEV will approach the true quality of the force

5.1.1 Combat Outcome Diagram

The Combat Effectiveness Value (CEV) is defined as the ratio of the result ratio to the combat power ratio. This is shown in the equation below for the red side, CEVr. The value for the blue side, CEVb, is the reciprocal of CEVr.

$$CEVr = \frac{(Rr/Rb)}{(Pr/Pb)}$$

If the outcome predicted by the combat power ratio is matched by the outcome expressed in the result ratio, the combat effectiveness of the two sides is equal. If the result ratio for one side is larger than its combat power ratio, this means that that side performed better than was predicted by the combat power ratio and it’s CEV for that battle or engagement is greater than 1.0. If the result ratio is smaller than the combat power ratio, then the actual outcome was not as good as was predicted, and the CEV is less than 1.0

Relationships between results and combat power can be presented conveniently in graphic form using the combat outcome diagram shown in Figure 5-1, for two sides, red and blue.

The origin is set so that the values of the two ratios are unity. The upper half of the diagram is the result ratio of side blue over side red; this is reversed for the lower half. Similarly, the combat power ratio in the right half is for side blue over side red, and is

Combat Outcome Diagram

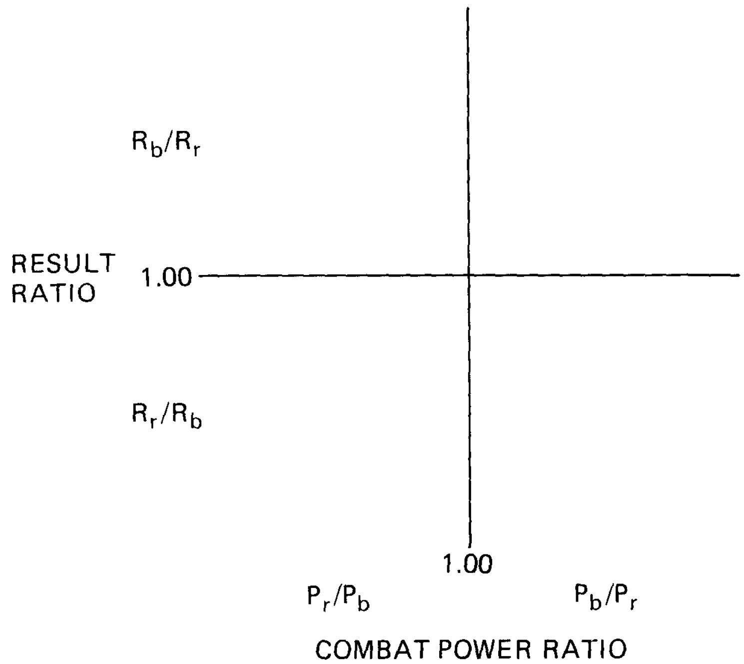


Figure 5-1 Combat Outcome Diagram

reversed in the left half. This permit plotting the ratios for individual engagements consistently as having values over 1.00.

The meaning of each quadrant of the combat outcome diagram is shown in Figure 5-2. It is evident that if the result ratio and combat power ratio are reasonably consistent with each other, all of the engagement plots would fall into either the upper-right or lower-left quadrants.

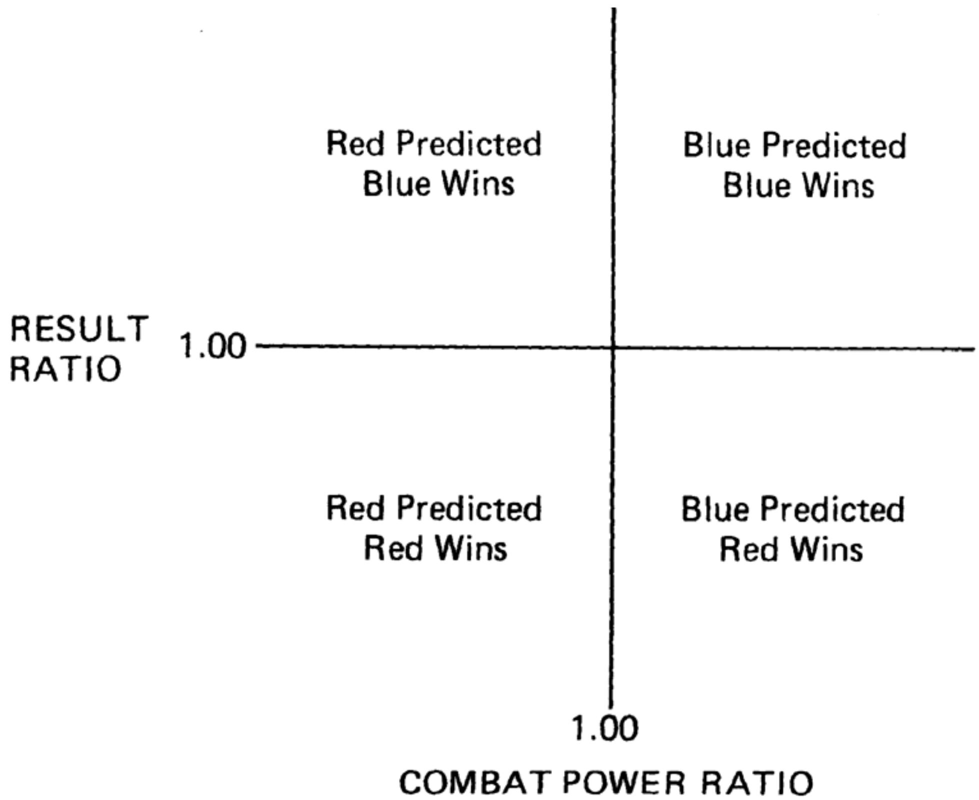


FIG 5-2 Combat Power Ratio

Chapter 6

6. Calculating Casualties in Combat

6.1 Calculating casualties

The QJM calculates losses in an engagement for personnel, tanks, artillery, other weapons and equipment. The basis for the QJM approach to attrition is the experience derived from the analysis of attrition in modern warfare mentioned in the preceding section and summarized qualitatively in the combat attrition verities.

The basic calculation is for personnel losses. Losses for tanks, artillery, and other materiel items are based on their historical relationship to personnel losses. The basic relationship to determine the personnel loss rate is as follows:

Personnel Loss Rate = **(standard casualty rate)** x **(variable factors).**

The standard casualty rate (SR) is the average casualty rate experienced for a particular war or historical era. This value may be determined by historical analysis, or assumed for future combat. For modern combat a standard casualty rate of 3% per day is assumed for an exposed force of division strength. Personnel casualties include killed, wounded, and missing in action. (It does not include men or units that surrender or are captured after the engagement or battle.)

The variable factors that influence personnel casualties include:

Terrain (rc). Casualties decrease as the terrain becomes more difficult,

Weather (he). Casualty rates go down in bad weather,

Season (zc). This factor recognizes the influence of the time of

year and the general climate on casualties,

Shoreline (Sh). Attacker casualties are higher and defender casualties are lower at or near the landing sites in major river crossings, or amphibious operations,

Day/Night (dn). Casualties are lower at night than in the day light,

Surprise (Su). The surpriser suffers fewer casualties and the force being surprised more casualties than the standard rate,

Posture (uc). The defender's posture affects the casualties of the defender,

Strength-Size (tz). The smaller the size of the forces, the greater the casualty rate,

Velocity (vl). After a certain point, faster advance rates cause lower casualty rates for both attacker and defender,

Fatigue (if). The longer a force is engaged in sustained combat, the lower the casualty rates of its opponent will tend to be,

Opposition (op). This factor is determined by the combat power ratio. The greater the combat power ratio, the greater the casualty rate of the other side.

The QJM formula for the personnel casualty rate is:

$$CR=SR \times rc \times hc \times zc \times dn \times Su \times uc \times tz \times vl \times if \times op.$$

The casualties suffered in an engagement by a force of strength S are calculated as C = CR x S x Duration of Engagement (days).

For equipment and weapons, the QJM attrition calculation includes both losses and recovery. Recovery takes into account the repair and return to units of lost equipment. Losses of equipment are related to the calculated personnel casualty rate, and they are adjusted to take into account special factors relating to the particular kind of equipment.

Table 6 -1 Causality calculating Factors

S_NO	POSTURE	IKILL	ARKILL	Arty KILL
1	ATTK ON PREP DEF (SUCCESS)	0.2	0.01	0.03
2	ATTK ON PREP DEF (FAILURE)	0.25	0.01	0.02
3	ATTK ON LIGHTLY HELD POSN (SUCCESS)	0.14	0.02	0.03
4	ATTK ON LIGHTLY HELD POSN (FAILURE)	0.19	0.05	0.01
5	COUNTER ATTK (SUCCESS)	0.18	0.02	0.03
6	COUNTER ATTK (FAILURE)	0.23	0	0.02
7	DEFENCE (SUCCESS)	0.07	0.04	0.06
8	DEFENCE (FAILURE)	0.1	0.04	0.03
9	WITHDRAWL	0.12	0.04	0.04
10	ADVANCE	0.17	0.02	0.02

Chapter 7

7. Summarizing QJM As A Model

7.1 QJM as a Model

The QJM is both a model and a theory of combat. Let's examine its nature and function in each of these roles. First, I summarize the QJM as a model of combat.

The QJM provides a basis for comparing the relative combat power of two opposing forces in historical combat by determining the influence of variable factors upon the opponents. Two kinds of variables are considered in this process: those affecting weapons effectiveness, and those affecting the employment of the force as a whole. Data from more than 200 selected historical engagements between 1915 and 1973 has been analyzed to obtain factor values of many of these variables under a variety of different battlefield circumstances. For some intangible variable factors, such as leadership (or the more general Relative Combat Effectiveness Value (CEV), which includes leadership), it is necessary to estimate values or to assume equality if there is no basis for such an estimate. Once these variables have been applied to the numerical strengths of each of the opposing forces under the circumstances of the engagement, a combat power ratio is produced. This combat power ratio indicates which of the opponents should theoretically have been successful in the engagement, and by what margin.

Note that in arriving at this combat power ratio, the relative combat effectiveness of the troops is either estimated or assumed to be equal. In the analysis of historical combat, it is possible to test such estimates and assumptions.

The first step is to compare the combat power ratio to the result ratio, which is a quantification of the actual outcome of the battle. This outcome value, also derived from historical records, represents the comparative performance of the opposing forces in terms of their (1) accomplishment of their respective missions, (2) ability to gain or hold ground, and (3) efficiency in terms of casualties incurred. If the combat power ratio of force A with respect to force B is greater than 1.0, the result ratio of force A with respect to force B should also be greater than 1.0. In the event the value of the combat power ratio is not consistent with that of the result ratio, further exploration is necessary to explain the discrepancy. Such discrepancies are usually due to the effects of surprise, and/or to a difference in the relative combat effectiveness of the two sides. The effects of surprise are quantifiable and can be stripped out. Then the residual difference between the combat power ratio and the result ratio is a reflection of the relative combat effectiveness of the opponents.

QJM analyses have shown patterns of relative combat effectiveness values (CEVs) in different historical forces. In World Wars I and II the Germans—on the average—had a CEV of about 1.20 with respect to the Western Allies and about 2.50 with respect to the Russians. In other words, 100 Germans in combat units were the equivalent of about 120 British or American troops in combat units, and equivalent to about 250 Russians in combat units. In the recent Arab-Israeli Wars the Israeli CEV has been over 2.00; i.e. 100 Israelis in combat units were the equivalent of more than 200 Arabs in combat units.

Note my emphasis on "in combat units." I do not believe the qualitative differences represented quantitatively in the CEV reflect any greater strength, intelligence, motivation or individual skill on the part of the individual soldiers of opposing units or national forces. The CEV represents the quantitative differences in force quality resulting from a number of factors affecting unit performances, of which leadership, training, and experience—in other words, professionalism—are probably the most important. The basic operation of the QJM is a two-step mathematical process. In the first step, force strength (S), is the sum of the firepower of weapons (categorized as infantry, anti-tank, artillery, air defense, armor, and air support), after the effects of each of these weapons have been modified by all applicable variable factors affecting their effectiveness, such as weather, terrain, and season. The formula for this is expressed as follows:

$$S = (WnxVn) + (WgixVgi) + (WgxVg) + (WgyxVgy) + (WxV) + (WgxVg)$$

In the second step, force strength (S) is modified by force effectiveness variable factors to yield a value for combat power potential (P). The most important of these variable factors are as follows: surprise (su), mobility (m), posture (u), vulnerability (v), terrain (r), weather (h), and season (z); and such intangible, behavioral factors as leadership (le), training/experience (t), morale (0), and logistical capability(b). This is expressed in the basic QJM formula as follows:

$$P = S \times su \times m \times u \times v \times r \times h \times z \times (le \times t \times o \times b)$$

(CEV)

The basic QJM formula is further simplified by consolidating the intangible or behavioral variables as a relative combat effectiveness value (CEV), and aggregating all of the other operational variables together as Vfe, or more simply, V. The general model, then, is expressible as follows:

$$\text{Combat Power} = \text{Force Strength} \times \text{Variable factors} \times \text{CEV}$$

Chapter 8

8. Collection Of Data And Arranging The Database

8.1 Collection of Important Data

8.1.1 Collecting the Data of Pakistan Army

Collection of important data required to build the software was an important and difficult task. First of all we had to consult the TO&E s of the formations starting from the corps level to the section level of each arm i.e. infantry, armor, artillery, air defense etc. By consulting the TO&E we came to know the organizational hierarchy of every formation and unit and the total number of persons, vehicles and weapons they possess.

8.1.2 Collecting Data of Indian Army

Since Command and Staff College Quetta had previously made an effort to develop the similar kind of software few years back and they acquired the data of Indian Army. We got some data from them and rest of the data was arranged from the GHQ.

8.1.3 Collecting OLIs of Weapons

Since every weapon system issued to army starting from pistol to a tank or air craft, has an OLI value which is provided by the manufacturer along with other technical specifications. We acquired these OLIs from the GHQ Ordnance Directorate for each and every weapon Pakistan army is currently having. Similarly OLIs of the Indian weapons was also collected from internet and GHQ directorates of respective arms.

8.2 Arranging the Database

All the data was arranged in tables using MS Access. The Variable factor values established by the author of the model were also arranged in the tables so that the values can be picked up from the tables according to the given queries. For example the values for the variable factor morale are depicted in the table 7-1

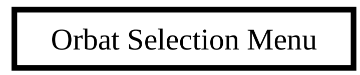
Table 8-1: Calculating Morale

SNO	FACTOR	MORL
a	Excellent morale	1
b	Good morale	0.9
c	Fair morale	0.8
d	Poor morale	0.7
e	Panic	0.2

Chapter 9

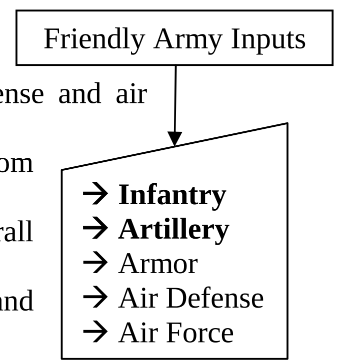
9. Design of the Software

9.1 Orbat Selection Menu



This is the main form where we select the friendly and enemy army inputs.

9.2 Friendly/Enemy Army Inputs



Here we get inputs for infantry, artillery, armor, air defense and air force. The forms are connected with a central database from where lethality values of each input are selected and overall lethality is calculated. Other values like Persons, Vehicles and No. of selected formation are input and displayed.

9.3 Environment Selection Menu

Environment and Behavior inputs like;

→ Terrain

→ Weather

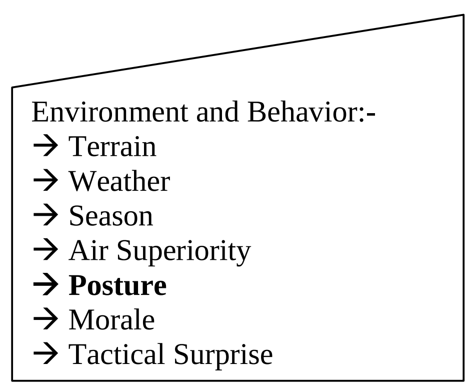
→ Season

→ Air Superiority

→ Posture

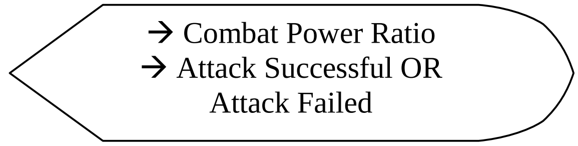
→ Morale

→ Tactical Surprise



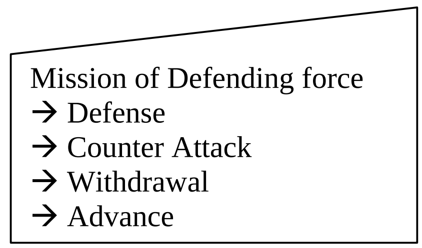
are selected in this form, then database is consulted form extraction of corresponding values and based on these values “Combat Power Potential” is calculated.

9.4 Results of combat



Combat power ratios calculated and based on it decision is made whether Attack Successful OR Attack Failed.

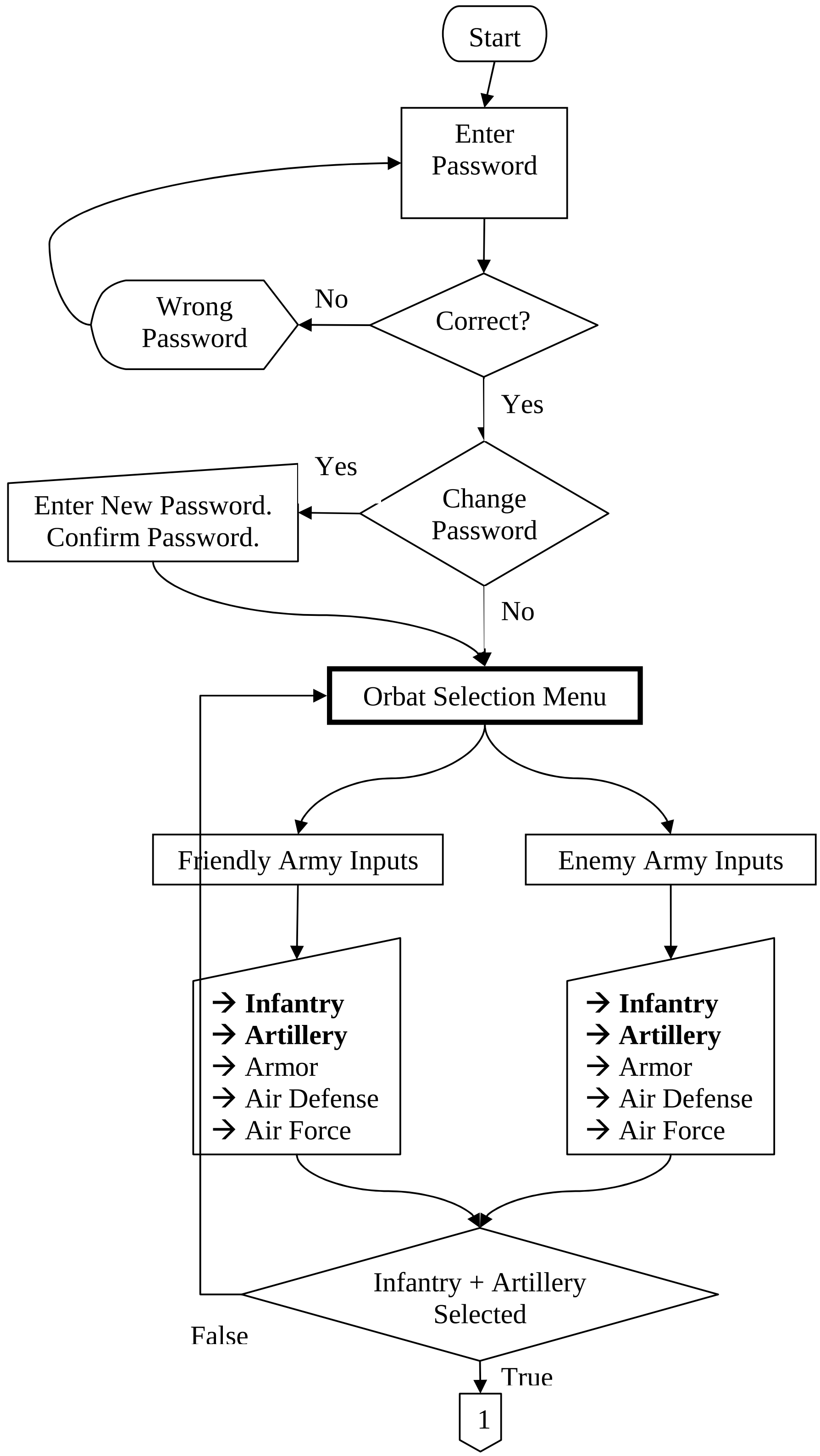
9.5 Casualties

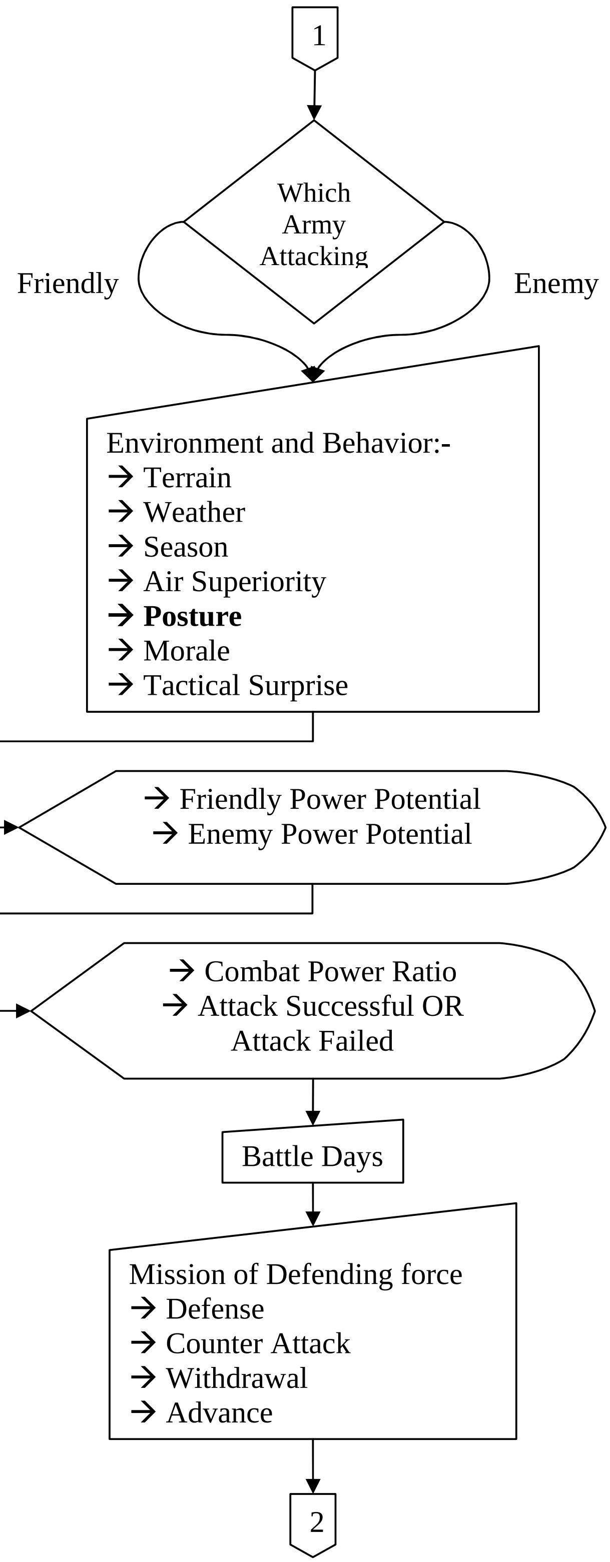


Friendly and Enemy Army Casualties are separately calculated and displayed on proceeding forms. They are based on “Posture of Defending Force” and “Attack Success/Failure” results of the combat.

9.1 Flow Diagram

Flow diagram of the software design can be depicted as follow


Start
Enter Password
Correct?
No
Wrong Password
Yes
Change Password
Yes
Enter New Password. Confirm Password.
No
Orbat Selection Menu
Friendly Army Inputs
Enemy Army Inputs
Infantry
Artillery
Armor
Air Defense
Air Force
Infantry
Artillery
Armor
Air Defense
Air Force
Infantry + Artillery Selected
False
True
1


1
Which Army Attacking
Friendly
Enemy
Environment and Behavior:-
→ Terrain
→ Weather
→ Season
→ Air Superiority
→ **Posture**
→ Morale
→ Tactical Surprise
→ Friendly Power Potential
→ Enemy Power Potential
→ Combat Power Ratio
→ Attack Successful OR Attack Failed
Battle Days
Mission of Defending force
→ Defense
→ Counter Attack
→ Withdrawal
→ Advance
2

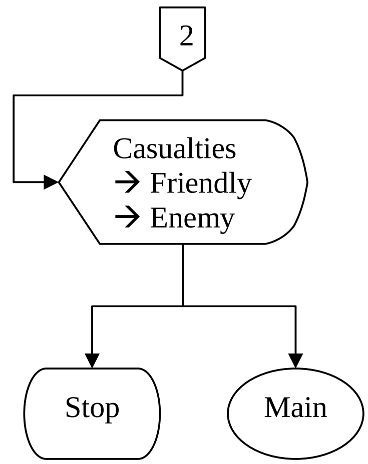


Figure 9-1: Flow Diagram

Chapter 10

10. Deficiencies and Further Improvement

10.1 Deficiencies in the Model

The QJM model has not established values for many operational and behavioral variables and is deficient in following aspects

1. Map data
2. Int
3. Avn
4. Electronic Warfare
5. Engrs
6. Logistics
7. Ldrship, trg and relative

10.2 Lack of Available Data

Since the QJM model is totally historical based and presently it is establishing values of the operational and other variables on the bases of historical data available from the II world war and Arab Israel war. Therefore in order to implement the model in the combat scenario of Pakistan and India, we have to establish the values of operational and behavioral factors on the bases of past wars fought between India and Pakistan so that we can get the accurate results of the battle. Due to lack of the available data from the previous wars this could not be implemented.

10.3 Conclusion

The QJM model is no doubt a step forward in a quest for scientific research of combat. There has to be a lot of further research to be done in this regard to implement this model in the scenario of Pakistan and its adversaries. If we want to get maximum results out of this model so as to predict the future outcome of expected battle, then we have to establish all the operational and circumstantial variables in context of Pakistan and Indian scenario.

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