REPORTING SYSTEM FOR ALLIED COMMAND EUROPE (ACE); SUPPLEMENTARY REPORT

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[redacted]

REPORTING SYSTEM FOR ALLIED COMMAND EUROPE; SUPPLEMENTARY REPORT

A HERO Report

20 April 1973

Introduction

This Supplemental Report to HERO's original report, "Reporting System for Allied Command Europe, Phase One," dated January, 1973, is submitted in response to comments received in a letter dated 26 March 1973, from Dr. H.M. Wilson, Director, SHAPE Technical Centre.

SECTION I

Relationship of Historical Report Data to Quantified Judgment Model

The basic material used in developing the QJM was taken from historical records, US, British, and German. The primary sources for the data base are unit reports, command diaries, and journals written at the time of, or immediately after, the engagments under examination. To a considerable extent the reports actually used by HERO are a matter of chance, since the retention of records has by no means been complete or consistent. The fact that some reports are not now available does not mean that they never existed, or necessarily that they were not available to the unit commanders, but rather that they were not retained.

US Statistical Inputs

In general, for US forces, the general staff files of divisions and higher units (Corps, Army, and Group), available at the Military Records Branch of the US National Archives, are the primary sources for statistical and qualitative data for the QJM. G-1 records yield daily personnel and casualty figures. G-2 documents tend to give way to German material on the same subjects, but sometimes help to fill gaps. G-3 documents available and used include daily situation reports, the G-3 Journal, and After Action Reports (AAR). From these were extracted general situation information, terrain and weather data, and details on movement of the FEBA. A number of files include useful situation maps. The AAR are generally less useful than daily reports. G-4 reports and estimates provide general logistic information and forecasts, but much detailed information was more readily found in special staff section reports. This is particularly true of Ordnance documents, which provide information on the status of weapons, unit ammunition expenditures, equipment out of service, and repair status conditions. The FMs and TMs of the time provide data for weapons performance calculations. Operations orders and planning documents have also been consulted as appropriate.

Some secondary sources, particularly the official OCMH histories and memoirs of senior commanders, also provide valuable information.

Air Force records include daily mission reports, showing sorties, tonnage dropped, and targets.

Some data on British forces is available with US Army and Army Air Force records. Additional material is contained in published historical works available in the US. Still further specific detailed data was collected by a member of the HERO staff in London from the office of the Minister of Defence (MOD) Historian, the MOD Library, and the office of the RAF Historian.

The table on the following page shows the sources of statistical inputs to the QJM, for US forces, with remarks on how the data was reported at the time of the engagements. As is readily seen, the data is not available in a single report or series of reports and must frequently be calculated or assembled from a number of sources. It is assumed that the data on weapons strength and allocations was originally available to unit commanders and much of it has not been retained.

German Statistical Inputs

The National Archives of the United States possess a wealth of German information from World War II, stored on microfilm. Many of the original records were lost or destroyed, but sufficient material remains to provide adequate information on most World War II operations. Division records are not so plentiful as those of Corps, Army, and Army Groups. At these and at the OKW (Supreme Command) and OKH (German Army) levels the Germans kept Daily Diaries, which proved to be extremely useful. These include substantial statistical data. In addition to this primary source material, a number of unpublished comments and reports were written after the war by German officers, under the direction of the Office of the Chief of Military History. These vary widely in quality and reliability and are regarded as a supplementary source.

The Germans were obviously meticulous in their reporting, with many reports required on a periodic basis, some daily, some covering ten days, others monthly, or related to the beginning of a campaign. Many of these from smaller units were appended to the Daily War Diary of the area commanders. The daily reports of quartermasters are very detailed, providing significant information on supply levels. Periodic reports of army commanders show artillery and tank strengths and losses. Others show personnel strengths and casualties. There is no doubt that the German army commanders and higher commanders had available to them all the statistical data used in the QJM, in clear and concise form. Since it has not all survived, for QJM purposes it has been necessary to augment existing records by interpolation from records of earlier or later date, longer time periods, or larger units, or to calculate strengths from normal Tables of Organization and Evaluation (T/O&E), modified according to historical operational records.

QJM TYPE INPUTS IN THE ACE REPORTING SYSTEM

QJM Inputs	Location in Reporting System[1] (or other available sources)	Page Numbers
Category I Inputs		
Weapons Data (friendly)	Current National and NATO Ordnance Publication, Test and Evaluation Data;	
	NUCLEAR OPERATIONS STATUS;	46-49
	for air, COMMANDER'S EVALUATION REPORT	25-29
Weapons Data (enemy)	Standard Intelligence Publications;	
	TECHNICAL INTELLIGENCE REPORTS;	22-23
	for air, INTELLIGENCE SUMMARY	14-16
Category II Inputs		
Environmental Variables (terrain, weather, season, air situation)	Meteorological Reports; Routine and Special Map Resources (including special air and ground reconnaissance);	
	INTELLIGENCE SUMMARY	14-16
Category III Inputs		
Posture (friendly)	COMMANDER'S EVALUATION REPORT	25-29
Posture (enemy)	INTELLIGENCE REPORT (OB chges);	12-13
	INTELLIGENCE SUMMARY (identification);	14-16
	SUPPLEMENTARY INTELLIGENCE REPORT;	17-18
	Reconnaissance by involved units	
Environmental Operational Variables	Same as Category II	
Category IV Inputs		
Trucks and Armored Vehicles, other than tanks (friendly)	LOGISTICS SITUATION REPORT;	74-75(8pp)
	AVAILABLE AIRLIFT REPORT[2]	76-78
Trucks and Armored Vehicles, other than tanks (enemy)	INTELLIGENCE REPORTS	12-13
Strength (friendly)	COMMANDER'S EVALUATION REPORT	25-29
Strength (enemy)	INTELLIGENCE REPORT (OB);	12-13
	INTELLIGENCE SUMMARY (current situation)	14-16
Logistics (friendly)	COMMANDER'S EVALUATION REPORT;	25-29
	LOGISTICS INSTALLATION DAMAGE REPORT;	84-85
	LOGISTICS SITUATION REPORT;	74-75(8pp)
	WEEKLY/DAILY POL STOCK STATUS REPORTS	82-83, 89
Logistics (enemy)	INTELLIGENCE SUMMARY or	14-16
	SUPPLEMENTARY INTELLIGENCE REPORT	17-18
Category V Inputs		
Intangibles, training, morale, leadership (friendly)	These elements are subjective in nature and impossible to evaluate except in the mind of the higher commander.	
[illegible]ibles, [illegible]ining, morale, [illegible]ership (enemy)	INTELLIGENCE SUMMARY (estimate of enemy strength and weaknesses);	14-16
	Information from continuing intelligence collection--units, personal data on enemy leaders, unit performance and reputation	
Logistics (friendly & enemy)	Same as Category IV	
Category VI Inputs		
Air Factors (friendly)	COMMANDER'S EVALUATION REPORT	25-29
Air Factors (enemy)	INTELLIGENCE SUMMARY or	14-16
	SUPPLEMENTARY INTELLIGENCE REPORTS	17-18

[1]Direct derivation from ACE system shown in caps.

[2]A significant omission from the variables used in the QJM because of its development for analysis of historical combat is air transport for troops, including STOL aircraft and helicopters. These would have to be included in any calculation of mobility in current or future warfare, under Category IV. Appropriate data on airlift availability is available in the ACE reporting system on pages 76-78 of the Available Airlift Report.

Since German records are available, HERO researchers make relatively little use of Allied intelligence material covering the same subjects. Such material does exist in usable form and has been used effectively under some circumstances, despite some errors made clear in retrospect in identifications and assessments of strength. A series of Allied technical intelligence publications on German weapons provide timely, detailed, and accurate information on weapons characteristics.

Non-statistical Inputs

The non-statistical information required for the QJM--terrain, degree of air superiority, logistical status, leadership, training and experience, morale--was not reported in World War II on a regular basis, or as in the case of daily weather reports, was not preserved. Although some units made a daily report of the condition of the troops (almost without exception "excellent"), accompanying the daily report of operations by G-3, it is not of much value. Extracting the necessary information then becomes a task for the historical researcher, who must examine the whole record of the operation and apply to it knowledge from other sources in order to determine which of the values on the appropriate tables should be used in the QJM calculation. The fact that these things were not reported does not mean that they might not have been reported--had the contemporary commanders been aware of the future needs of HERO researchers. In each case appropriate values for these qualitative factors could have been reported in the daily operational report of G-3 with little additional effort.

SECTION II

Sensitivity Analysis

Introduction

Any model that attempts to represent combat mathematically must necessarily be based on assumptions and hypotheses concerning the relationships among the variables, assumptions and hypotheses for which it is extremely difficult to provide complete mathematical proof and which limit the scope and significance of a sensitivity analysis of the model. Among the assumptions that limit the significance of such an analysis of the QJM are:

1. The assumption that there is a linear relationship among the discernible factors influencing combat effectiveness, and representing interaction of combat processes;

2. The assumption that relative combat effectiveness can be determined by a simple ratio;

3. The assumption that all of the variables are of the first power (although exponential functions are sometimes used in the process of deriving factors by formula).

While these assumptions cannot yet be proved mathematically, the consistency of the results attained in the application of the model formulae to 78 sets of circumstances in a wide variety of historical combat situations provides strong evidence that the simple linear relationships do in fact provide a remarkably valid representation of the results of the historical interactions of combat processes.

These results suggest the possibility that, with revised inputs for weapons constants and mobility and vulnerability factors, the QJMA has potential for use for predictive purposes, but this remains to be tested. For the present, and in this study, the QJMA, and its QJM model, are being used only as research tools for the analysis of historical combat. Any test or analysis performed at this time must relate to that use.

In view of the innate limitations on the scope and significance of a sensitivity analysis of any combat model, in the present "state of the art," it is doubtful that the analysis described below

contributes substantially to the evaluation of the QJM as a reasonable representation of the relative effectiveness of opposing combat forces in historical combat or a means of assessing the potential accuracy of its prediction of combat results. For this reason HERO believes that its ability to offer a larger, and more completely analyzed data base than had been available when it prepared its proposal for this study provided a better opportunity for assessment of the QJMA, and its QJM, than would be possible with a sensitivity analysis. This was explained in the original report. However, the sensitivity analysis has been performed, and the results are presented herewith.

Methodology

The purpose of a sensitivity analysis is to determine the extent that model results are dependent upon certain data or combinations of data, and thus the extent to which the output of any model (and particularly a computer model) will be influenced by changing the values of the various factors being considered. The standard procedure for such an analysis is to test variable effects in any given combination of data by successively determining rates of change for each variable in turn within that particular combination, by calculating derivatives of the function for each variable, while holding constant all other variables in that combination.

Since the QJM produces power potential values (P) for each of two opposing forces in historical combat by means of a linear equation, the results of this testing process for P values cannot reveal any changes in the variables that differ markedly from the variable input values. However, the performance of this process with a significant sample of the data can reveal patterns that are useful for analysis in relation to the qualitatively observed processes of combat. A comparable process, for instance, provided a hitherto unavailable quantitative assessment of the significance of close air support and of naval gunfire support in amphibious operations (see Monograph, p. 57). Furthermore, those patterns revealed when the process is performed for each of the P value functions separately can also provide a useful basis for comparison when the testing process is used with the combat power potential ratio as the function being tested.

For the purpose of consistency in this study the analysis was performed with respect to the relationship of attacker to defender (P_a/P_d, or P_d/P_a) rather than in terms of the mixed posture relationship of friendly force versus enemy (P_f/P_e, or P_e/P_f). The results suggest that the performance of this analysis for the entire data base, using the enemy-friendly relationship might reveal interesting differences in Allied and German operations and capabilities in World War II, but that is beyond the scope of this study.

Sample Selected for Analysis

The engagements selected as a sample for this sensitivity analysis include two "normal" engagements, two unpredictable engagements, two inconclusive engagements (one with an outcome differing substantially from the model prediction), and one engagement clearly inconsistent with the model prediction. The following are the seven engagements selected:

D-12, Triflisco, with prediction versus outcome results plotting on the "normal battle line" in the upper right-hand quadrant of Figure IX of the Monograph;

D-22, Monte Lungo, an unpredictable engagement plotting in the lower left-hand quadrant;

D-23, Pozzilli, plotting near the normal battle line in the lower left-hand quadrant;

D-33, Campoleone Counterattack, an unpredictable engagement plotting in the upper right-hand quadrant;

D-39, Moletta II, an inconclusive engagement with results differing substantially from the theoretical model prediction;

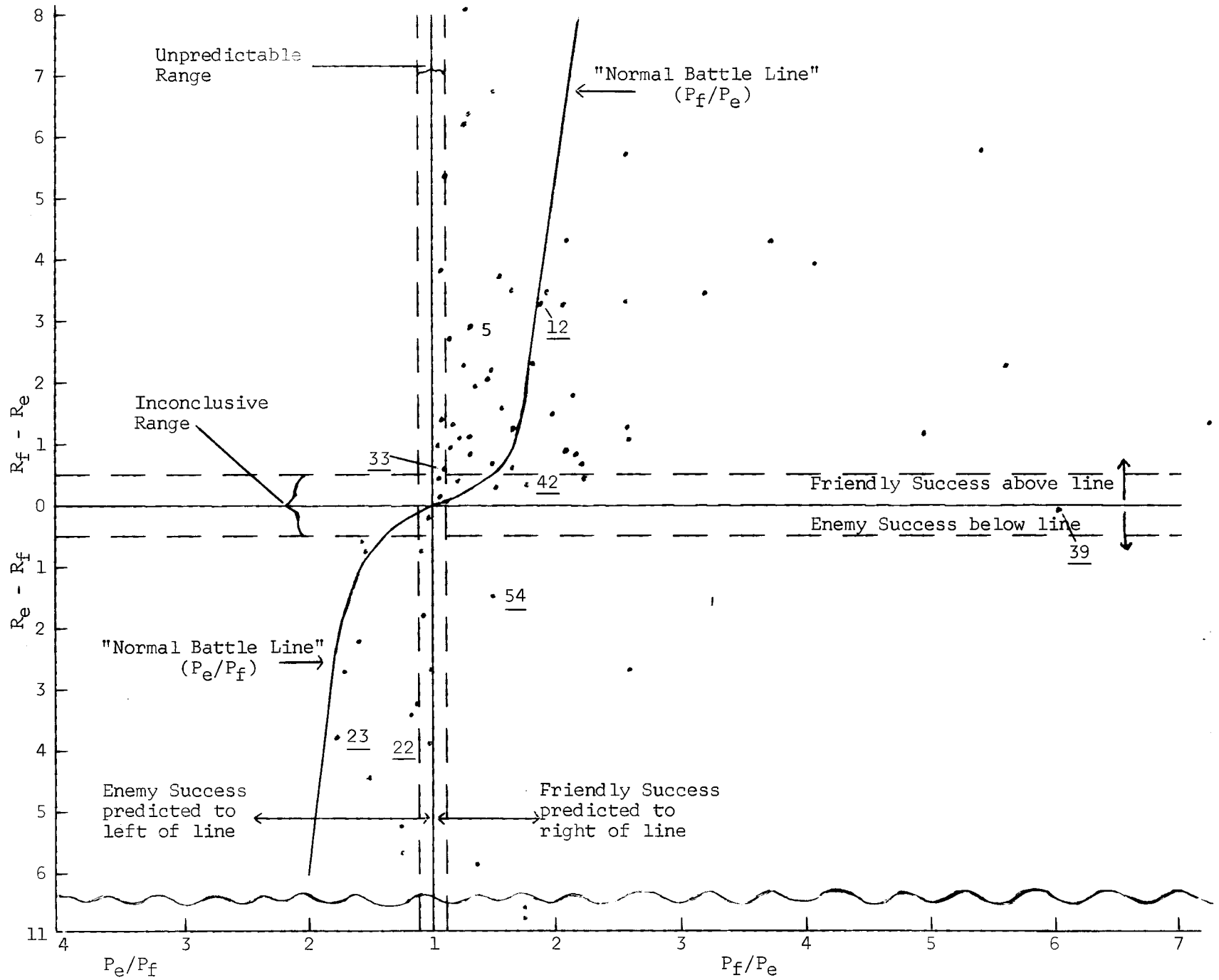
D-42, San Martino, an inconclusive engagement with results relatively consistent with the theoretical model prediction;

D-54, Velletri, an engagement plotting in the lower right-hand quadrant, with results inconsistent with the theoretical model prediction.

Thus two of the seven engagements selected (28.6%) yield results inconsistent with the model prediction; this is believed to provide adequate assurance that the results of the analysis are not weighted in favor of the high rate of consistency (about 92%) which the model has achieved in a comparison of theoretical predictions and results in the entire data base of 78 engagements. Since analysis has revealed that in both of these engagements the inconsistency was due primarily to surprise (a factor not reflected in the basic inputs) it was determined to test the variables of these two engagements with and without the tentative surprise factors which have been evolved in the development of the model (see page 58 of Monograph).

Figure 1 is an adaptation of Figure IX of the Monograph, and shows the location of these seven selected engagements on the graphical plot of predictions against outcomes.

Figure 1. COMPARISON OF PREDICTIONS AND OUTCOMES QUANTIFIED JUDGMENT METHOD



Analysis Results

The standard sensitivity analysis procedure described above was employed separately for the P_a (attacker's power potential) function and the P_d (defender's power potential) function. Combat power ratios for these separate variable results were then calculated. The comparisons within the functions, and in the ratios, are shown in terms of percentage change for each variable. Figure 2 shows the results of these tests and comparisons. Figure 3 lists the variables in the order of significance of change for P_a, P_d, and for the P_a/P_d comparison.

It was determined, as expected, that the inclusion of the surprise factor had little or no effect on the relative changes among the other variables.

The variables were then tested for the ratio P_a/P_d as the model function, and then for the ratio P_d/P_a. Since this process involved calculation of derivatives of fractions, the results of the tests for the two different ratios were substantially different, although the relative significance of the variables did not change to a marked degree. A typical derivative formula, testing the rate of change of the mobility variable in the P_d/P_a function, is as follows:

$$\frac{dP_d/P_a}{dm} = - \frac{S_d \times t_d \times o_d \times g_d \times u_{sd} \times r_{ud} \times v_d}{S_a \times le_a \times t_a \times g_a \times h_{ua} \times z_{ua} \times v_a \times m^2}$$

Figure 4 shows the results of these tests, and also shows the average of the change values for each variable as calculated for the two different ratio functions. (Again it was determined that inclusion of the surprise factor did not have any significant effect upon the relationships among the other variables.) Figure 5 lists the variables in the order of significance of change for P_a/P_d, for P_d/P_a, and for the average changes. It will be noted that the results of the comparison of the average variable changes are similar to those for the ratio comparisons in Figure 3.

Since some of the factors are based primarily upon the development and refinement of judgmental factors through the iterative process discussed in the Monograph, while some are based essentially on mathematical relationships of input data combined with judgmental factors, it is useful to compare the percentage of change exhibited by judgmentally-derived variables with that of those that are primarily mathematically derived. The results are as follows:

Figure 2

PERCENTAGE OF CHANGE FOR FUNCTIONS P_a AND P_d

Eng. No.	Unit	Attack							Defense						Unit
		m	le	t	g	h_u	z_u	v_a	t_d	o	g	u_s	r_u	v	
12	US 3ID	12.2	. .	21.0	. .	0.0	9.1	19.1	11.5	. .	. .	33.3	31.0	41.2	G HGPzD
22	US 3ID	6.3	. .	21.0	. .	25.0	9.1	15.6	5.5	. .	. .	37.5	35.5	24.4	G 3PzGD
23	US 45ID	11.5	. .	37.6	. .	25.0	9.1	27.7	5.5	. .	. .	37.5	35.5	18.8	G 3PzGD
33	G CCG	1.0	. .	8.2	11.1	11.1	0.0	29.4	30.0	. .	. .	28.6	16.7	21.8	B 1ID
39[a]	G 65ID	32.5	. .	8.9	4.7	0.0	0.0	145.0	54.2	. .	. .	28.6	16.7	8.1	B 56ID
42	US 85ID	5.8	. .	31.6	. .	0.0	9.1	17.5	17.3	5.3	19.0	37.5	31.0	28.8	G 94ID
54[a]	US 1AD	31.2	25.0	22.0	. .	0.0	9.1	9.9	0.0	11.2	23.6	37.5	31.0	17.6	G 362ID
	Total	100.5	25.0	150.3	15.8	61.0	45.5	264.2	124.0	16.5	42.6	240.5	197.4	160.7	
	Average	14.4	25.0	21.5	7.9	8.7	6.5	37.7	17.7	8.3	21.3	34.4	28.2	23.0	

PERCENTAGE OF CHANGE IN P_a/P_d RATIO OF SEPARATELY TESTED FUNCTIONS

12	US 3ID	12.6	. .	20.0	. .	0.0	8.8	19.2	9.9	. .	. .	50.0	45.1	29.1	G HGPzD
22	US 3ID	6.4	. .	21.3	. .	25.5	9.6	16.0	5.3	. .	. .	59.6	55.3	19.1	G 3PzGD
23	US 45ID	10.7	. .	35.7	. .	25.0	8.9	26.8	5.4	. .	. .	58.9	53.6	16.1	G 3PzGD
33	G CCG	1.1	. .	8.8	12.1	12.1	0.0	29.7	23.1	. .	. .	40.7	20.9	17.6	B 1ID
39[b]	G 65ID	29.4	. .	7.6	3.5	0.0	0.0	141.2	35.3	. .	. .	41.2	17.6	5.9	B 56ID
42	US 85ID	5.8	. .	31.8	. .	0.0	9.2	17.3	14.5	5.2	16.2	60.1	45.1	22.5	G 94ID
54[b]	US 1AD	30.8	25.3	21.9	. .	0.0	9.6	10.3	0.0	9.6	19.2	60.3	45.2	15.8	G 362ID
	Total	96.8	25.3	148.0	15.6	62.6	46.1	260.5	93.5	14.8	35.4	370.8	282.8	126.1	
	Average	13.8	25.3	21.1	7.8	8.9	6.6	37.2	13.4	7.4	18.7	53.0	40.4	18.0	

[a]Unchanged by surprise.

[b]Minor changes by surprise.

Figure 3

POWER POTENTIAL FUNCTION VARIABLES IN ORDER OF SIGNIFICANCE OF CHANGE
(in percentages)

Attack Changes	Defense Changes	Combined Attack & Defense	Composite Combined Changes	Ratio of Separate Changes	Composite Ratio Changes	
v 37.7	u 34.4	v_d 37.7	u 34.4	u 53.0	u 53.0	Most sensitive
le 25.0	r 28.2	u 34.4	v 30.35	r 40.4	r 40.4	
t 21.5	v 23.0	r 28.2	r 28.2	v_a 37.2	v 27.6	Moderately sensitive
m 14.4	g 21.3	le 25.0	le 25.0	le 25.3	le 25.3	
h 8.7	t 17.7	v_d 23.0	t 19.6	t_a 21.1	t 17.3	
g 7.9	o 8.3	t_a 21.5	g 14.6	g_d 18.7	m 13.8	
z 6.5		g_d 21.3	m 14.4	v_d 18.0	g 13.3	
		t_d 17.7	n 8.7	m 13.8	h 8.9	Least sensitive
		m 14.4	o 8.3	t_d 13.4	o 7.4	
		h 8.7	z 6.6	h 8.9	z 6.6	
		o_a 8.3		g_a 7.8		
		g_a 7.9		o 7.4		
		z 6.5		z 6.6		

Figure 4

PERCENTAGE OF CHANGE FOR FUNCTION P_a/P_d

Eng No	Unit	Attack							Defense						Unit
		m	le	t	g	h	z	v	t	o	g	u	r	v	
12	US 3ID	12.6	. .	20.9	. .	0.0	8.8	19.2	28.6	. .	. .	237.9	204.9	64.3	G HGPzD
22	US 3ID	6.4	. .	21.3	. .	25.5	9.6	16.0	14.9	. .	. .	309.6	272.3	47.9	G 3PzGD
23	US 45ID	10.7	. .	35.7	. .	25.0	8.9	26.8	16.1	. .	. .	307.1	269.6	41.1	G 3PzGD
33	G CCG	1.1	. .	8.8	12.1	12.1	0.0	29.7	53.8	. .	. .	175.8	73.6	44.0	B 1ID
39	G 65ID	29.4	. .	7.6	3.5	0.0	0.0	141.2	70.6	. .	. .	170.6	76.5	23.5	B 56ID
42	US 85ID	5.8	. .	31.8	. .	0.0	9.2	17.3	38.2	14.5	40.5	213.9	108.7	53.2	G 94ID
54	US 1AD	30.8	25.3	21.9	. .	0.0	9.6	10.3	0.0	26.7	46.6	310.2	205.5	38.4	G 362ID
	Total	96.8	25.3	148.0	15.6	62.6	46.1	260.5	222.2	41.2	87.1	1,725.1	1,211.1	312.4	
	Average	13.8	25.3	21.1	7.8	8.9	6.6	37.2	31.7	20.6	43.6	246.4	173.0	44.6	

PERCENTAGE OF CHANGE FOR FUNCTION P_d/P_a

12	US 3ID	29.1	. .	43.6	. .	0.0	37.7	41.8	10.9	. .	. .	34.5	30.9	41.8	G HGPzD
22	US 3ID	16.0	. .	43.4	. .	50.9	34.0	65.1	5.7	. .	. .	37.7	34.9	24.5	G 3PzGD
23	US 45ID	27.8	. .	61.7	. .	48.9	32.8	47.8	5.0	. .	. .	37.8	35.6	18.9	G 3PzGD
33	G CCG	3.7	. .	21.1	26.6	26.6	0.0	54.1	30.3	. .	. .	28.4	16.5	22.0	B 1ID
39	G 65ID	57.0	. .	22.7	12.9	0.0	0.0	93.3	54.1	. .	. .	28.6	16.8	8.1	B 56ID
42	US 85ID	19.0	. .	56.9	. .	0.0	32.8	37.9	17.2	5.2	19.0	37.9	31.0	27.6	G 94ID
54	US 1AD	208.8	48.5	44.1	. .	0.0	33.8	25.0	0.0	11.8	23.5	36.8	30.9	17.6	G 362ID
	Total	361.4	48.5	293.5	39.5	126.4	171.1	365.0	123.2	17.0	42.5	241.7	196.6	160.5	
	Average	51.6	48.5	41.9	19.8	18.1	24.4	52.1	17.6	8.5	21.3	34.5	28.1	22.9	
Combined Av. Total		65.4	73.8	63.0	27.6	27.0	31.0	89.3	49.3	29.1	64.9	280.9	201.1	67.5	
Combined Av. Average		32.7	36.9	31.5	13.8	13.5	15.5	44.7	24.7	14.6	32.5	140.5	100.6	33.7	

Figure 5

POWER RATIO FUNCTION VARIABLES IN ORDER OF SIGNIFICANCE OF CHANGE (in percentages)

P_a/P_d Changes		P_d/P_a Changes		Average Ratio Changes		Composite Changes		
u	246.4	v_a	52.1	u	140.5	u	140.5	Most sensitive
r	173.0	m	51.6	r	100.6	r	100.6	
v_d	44.6	le	48.5	v_a	44.7	v	39.2	Moderately sensitive
g_d	43.6	t_a	41.9	le	36.9	le	36.9	
v_a	37.2	u	34.5	v_d	33.7	m	32.7	
t_d	31.7	r	28.1	m	32.7	t	28.1	
le	25.3	z	24.4	g_d	32.5	g	23.2	
t_a	21.1	v_d	22.9	t_a	31.5	z	15.5	Least sensitive
o	20.6	g_d	21.3	t_d	24.7	o	14.6	
m	13.8	g_a	19.8	z	15.5	h	13.5	
h	8.9	h	18.1	o	14.6			
g	7.8	t_d	17.6	g_d	13.8			
z	6.6	o	8.5	h	13.5			

Mathematically-derived average (m, v, t) = 33.3%

Judgmentally-derived average (u, r, z, h) = 67.5%

(The number of examples does not warrant consideration of the values for le, g, or o, which it will be recalled are "intangible" factors.)

This same comparison of the variable change values found in the ratio results in Figure 3, establishes these values at 19.6% and 27.2%, respectively.

Assessment

The results presented above reveal, not surprisingly, that the model is most sensitive to changes in the judgmental factors of posture and terrain. Since these are the combat variables that are qualitatively most susceptible to manipulation by leadership in order to enhance combat power, this result is entirely consistent with what is known of the processes of combat. For want of any other historically and mathematically-derived value for the significance of the change of these variables, those indicated in Figure 5 seem reasonable and realistic.

It is interesting to note that the other major judgmental variables for which conclusions are warranted (weather and season) are less sensitive in the model than are the variables for vulnerability, mobility, and combat effectiveness.

The averages suggest that, on balance, the model is almost twice as sensitive to changes in judgmentally-derived variables as it is to those which are essentially derived through mathematical processes. It is doubtful if this has much significance.

The consistency between the results of calculating a ratio of the changes to be found in the linear equations for the two power potential values (Figure 3), and the calculation of changes for the more complex ratio function (Figure 5), suggests that the varying sensitivity of the model to changes in the different variables is reasonable and consistent with the results of actual combat processes. Thus this sensitivity analysis provides grounds for increased confidence in the validity of the QJM as a representation of the results of the combat processes based on historical combat data, enhancing the consistency in results of the analysis of combat data with the QJM summarized in Figure X, page 45 of the Monograph.