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RESEARCH PAPER  
CAA-RP-89-9

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# GROUND, AIR, AND AIR DEFENSE FORCE CONCENTRATION MODEL

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PREPARED BY  
JEROME BRACKEN

US ARMY CONCEPTS ANALYSIS AGENCY  
8120 WOODMONT AVENUE  
BETHESDA, MARYLAND 20814-2797

CAA

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**Director  
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ATTN: CSCA-MV  
8120 Woodmont Avenue  
Bethesda, MD 20814-2797**

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| <p>A model for concentrating initial and subsequent ground and air forces in main-thrust sectors is developed. Timing of subsequent ground force reinforcements is then modeled. Finally, air defenses are included. These factors significantly influence force concentration outcomes. A FORTRAN program and sample results are presented.</p> |       |                                                          |                                                                                   |                                                        |                                      |
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## GROUND, AIR, AND AIR DEFENSE FORCE CONCENTRATION MODEL



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STATEMENT "A" per Howard Whitley  
US Army Concepts Analysis Agency/CSCA-MV  
8120 Woodmont Ave., Bethesda, MD 20814-  
2797 TELECON 9/28/90 VG

Prepared by

Jerome Bracken

US Army Concepts Analysis Agency  
8120 Woodmont Avenue  
Bethesda, Maryland 20814-2797

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## **GROUND, AIR, AND AIR DEFENSE FORCE CONCENTRATION MODEL**

**STUDY  
SUMMARY  
CAA-RP-89-9**

**THE REASON FOR PERFORMING THE STUDY** was to investigate the effect of air forces, time-phased commitment of ground forces and air defense forces on initial and subsequent force ratios in the main-thrust sectors.

**THE STUDY SPONSOR** was the Director, US Army Concepts Analysis Agency.

**THE STUDY OBJECTIVES** were to produce a mathematical model of the process and to obtain sample results.

**THE SCOPE OF THE STUDY** was a highly-aggregated mathematical model of forces and tactics.

**THE MAIN ASSUMPTIONS** of this work are:

- (1) Ground forces, air forces, and air defense forces can be concentrated initially and subsequently on main-thrust sectors.
- (2) A highly-aggregated mathematical model is useful in understanding this process.

**THE BASIC APPROACHES** used in this study were to:

- (1) Develop mathematical models.
- (2) Write computer programs.
- (3) Explore sample problems.

**THE PRINCIPAL FINDINGS** of the work reported herein are as follows:

- (1) Air force concentration makes a significant impact on main-thrust sector force ratios.
- (2) Timing of commitment of ground forces is influential.
- (3) Air defenses against air forces are influential.

**THE STUDY EFFORT** was directed by Jerome Bracken as an independent researcher.

**COMMENTS AND QUESTIONS** may be sent to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-MV, 8120 Woodmont Avenue, Bethesda, Maryland 20814-2797.

*Tear-out copies of this synopsis are at back cover.*

## CONTENTS

| PARAGRAPH |                                                                                   | Page |
|-----------|-----------------------------------------------------------------------------------|------|
| A         | INTRODUCTION . . . . .                                                            | 1    |
| B         | GROUND-AIR MODEL . . . . .                                                        | 3    |
| C         | EXTENSION TO INCLUDE TIME-PHASED COMMITMENT OF GROUND<br>FORCE RESERVES . . . . . | 7    |
| D         | EXTENSION TO INCLUDE AIR DEFENSES . . . . .                                       | 9    |
| E         | REFERENCES . . . . .                                                              | 14   |

## APPENDIX

|   |                            |     |
|---|----------------------------|-----|
| A | FORTTRAN Program . . . . . | A-1 |
| B | Sample Output . . . . .    | B-1 |
| C | Distribution . . . . .     | C-1 |

## GROUND, AIR, AND AIR DEFENSE FORCE CONCENTRATION MODEL

### A. INTRODUCTION

There are several highly-aggregated algebraic models of force concentration which have as their principal goal the analysis of the dynamics of ground, air, and air defense force ratios on main-thrust sectors. The models typically incorporate some dynamic behavior, but do not account for two-sided attrition over time.

The first model of note was that developed and applied by Research Study Group 1 of the NATO systems Science Panel VII (Reference 1). It explored ground force concentration assumptions for the attacker and defender in sectors of main attack and over the remainder of the front. To complement the representation of the indirect ground fire in Reference 1, air support and air defense were stressed in Reference 2. To highlight the importance of the dynamics of ground force reinforcement, timing issues were addressed in a series of models called FRONT, of which two recent discussions are in Reference 3 and 4. References 2, 3, and 4 build upon the work of Reference 1.

An independent derivation and evaluation of ground force concentration issues is presented in Reference 5. The model of Reference 5 determines the force ratio on the main-thrust sectors before and after reserves are committed. Reference 5 illustrates the sensitivities of main-thrust-sector force ratios to a variety of theater-wide assumptions.

More detail on the fine structure of attacker and defender position and dynamics is represented in the models of Reference 6. The issue of main concern is the identification of defense forces which possess both mobility and firepower, but do not contribute substantially to attack capability. It should be noted that a computer program, in BASIC, has been written by Wilbur B. Payne for the model of Reference 6.

The present paper focuses on the contribution of air firepower to initial and subsequent force ratios on the main-thrust sectors. This question is

quite important, for the results are changed substantially when air forces are included. Because of the sensitivity of force ratios to air firepower, the present paper also develops several models which include fixed and mobile air defenses. These forces, depending on the effectiveness parameters, may significantly affect the force ratios on the sectors of main attack.

As the modeling detail is increased by adding dynamic ground force concentration, several assumptions about air force employment, and finally, several assumptions about air defenses, the equations of the model become more complicated.

The paper includes examples for the same parameters as Reference 5, plus the variations made possible by the additional forces represented in the present model. In Appendix A the FORTRAN program is presented; it matches the mathematical formulas of the main body of the paper. In Appendix B sample force ratios are given for a spectrum of assumptions on ground and air forces.

## B. GROUND-AIR MODEL

### 1. Definition

The notation is an extension of that of Reference 5.

#### a. Inputs

$A$  = attacker ground forces

$\bar{A}$  = attacker air forces

$D$  = defender ground forces

$\bar{D}$  = defender air forces

$R$  = defender fraction ground forces in reserve

$\bar{R}$  = defender fraction air forces in reserve

$R'$  = attacker fraction ground forces in reserve

$\bar{R}'$  = attacker fraction air forces in reserve

$s$  = number of sectors

$t$  = number of main-thrust sectors

$h$  = force ratio to be tolerated by attacker in non-main-thrust sectors

#### b. Outputs

$C$  = force ratio in main-thrust sectors before reserves committed.

$C'$  = force ratio in main-thrust sectors after reserves committed.

### 2. Description of Process

The attacker has ground forces  $A$  of which he initially commits fraction  $(1-R')$ . The defender has ground forces  $D$  of which he initially commits

fraction  $(1-R)$ . The attacker, in the non-main-thrust sectors, matches fraction  $h$  of the defender's forces (for instance, the attacker may set  $h = \frac{2}{3}$ ). The defender's forces are assumed to be uniformly committed. The attacker, in the main-thrust sectors, concentrates the rest. This results in the initial force ratio  $C$ .

Then both sides commit their reserves to the main-thrust sectors. This results in force ratio  $C'$ .

Typically, the attacker fraction held in reserve is smaller than the defender's fraction held in reserve (for instance,  $R' = 1/6$  while  $R = 1/3$ ). Initial force ratio  $C$  is typically much greater than subsequent force ratio  $C'$ .

Air forces added to the ground forces are  $A$  and  $D$ , with reserve fractions  $R'$  and  $R$ , respectively.

In Model 1 it is assumed that initially committed air is uniformly spaced across the theater (except for the attacker's excess after meeting the  $h$  fraction). In Model 2, it is assumed that initially committed air is concentrated in the main-thrust sectors. In both Model 1 and Model 2, subsequent air is concentrated in the main-thrust sectors.

## 3. Models

## Model 1 - Air initially committed to all sectors

$$C = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right] - R'A - \bar{R}'\bar{A}}{\left(\frac{t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right]}$$

$$C' = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right]}{\left(\frac{t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right] + RD + \bar{R}\bar{D}}$$

## Model 2 - Air initially committed to main-thrust sectors only

$$C = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) (1-R)D - R'A - \bar{R}'\bar{A}}{\left(\frac{t}{s}\right) (1-R)D + (1-\bar{R})\bar{D}}$$

$$C' = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) (1-R)D}{\left(\frac{t}{s}\right) (1-R)D + (1-\bar{R})\bar{D} + RD + \bar{R}\bar{D}}$$

#### 4. Example Problem

##### a. Parameters - Model 1 and Model 2

$$R = 1/3$$

$$\overline{R} = 1/2$$

$$R' = 1/6$$

$$\overline{R'} = 1/2$$

$$s = 9$$

$$t = 2$$

$$h = 2/3$$

##### b. Sample Results

| Case | Models          | A | $\overline{A}$ | D | $\overline{D}$ | C    | C'   |
|------|-----------------|---|----------------|---|----------------|------|------|
| 1    | Models 1 and 2* | 1 | 0              | 1 | 0              | 3.29 | 1.36 |
| 2    | Model 1         | 2 | 1              | 2 | 1              | 2.98 | 1.30 |
| 3    | Model 2         | 2 | 1              | 2 | 1              | 1.85 | 1.18 |
| 4    | Models 1 and 2* | 3 | 0              | 2 | 0              | 6.10 | 2.40 |
| 5    | Model 1         | 3 | 1              | 2 | 1              | 5.03 | 1.94 |
| 6    | Model 2         | 3 | 1              | 2 | 1              | 2.90 | 1.69 |

\*Model 1 and Model 2 give the same results when there is no air.

### c. Dramatic Result

Compare Case 4 with Case 6.

Ground forces only in Case 4 result in initial force ratio 6.10 and subsequent force ratio 2.40 in the two main-thrust sectors. However, when air forces are added, and concentrated by the attacker and defender in the main-thrust sectors, the initial and subsequent force ratios are reduced to 2.90 and 1.69, respectively.

## C. EXTENSION TO INCLUDE TIME-PHASED COMMITMENT OF GROUND FORCE RESERVES

### 1. Assumptions

Assume that ground force reinforcement speeds differ for the attacker and defender. Define

$r_i$  = defender fraction of reserves available in main-thrust sectors by period  $i$

$r'_i$  = attacker fraction of reserves available in main-thrust sectors by period  $i$

Sample parameters are as follows:

$$r_1 = 0$$

$$r'_1 = 0$$

$$r_2 = .1$$

$$r'_2 = .3$$

$$r_3 = .4$$

$$r'_3 = .8$$

$$r_4 = 1$$

$$r'_4 = 1$$

Define

$C'_i$  = force ratio on main-thrust sectors at period  $i$  of reserve ground forces arrival.

## 2. Models

The revised models are as follows.  $C$  does not change;  $C'_i$  includes the index  $i$  and new terms in the numerator and denominator.

### Model 1 - Air initially committed to all sectors

$$C = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right] - R'A - \bar{R}'\bar{A}}{\left(\frac{t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right]}$$

$$C'_i = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right] - (1-r'_i)R'A}{\left(\frac{t}{s}\right) \left[ (1-R)D + (1-\bar{R})\bar{D} \right] + r_i RD + \bar{R}\bar{D}}$$

### Model 2 - Air initially committed to main-thrust sectors only

$$C = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) (1-R)D - R'A - \bar{R}'\bar{A}}{\left(\frac{t}{s}\right) (1-R)D + (1-\bar{R})\bar{D}}$$

$$C'_i = \frac{A + \bar{A} - h\left(\frac{s-t}{s}\right) (1-R)D - (1-r'_i)R'A}{\left(\frac{t}{s}\right) (1-R)D + (1-\bar{R})\bar{D} + r_i RD + \bar{R}\bar{D}}$$

## 3. Sample Results

Sample results for the previous example, expanded, are given at the top of the next page.

| Case | Models         | A | $\bar{A}$ | D | $\bar{D}$ | C    | $C_1$ | $C_2$ | $C_3$ | $C_4$ |
|------|----------------|---|-----------|---|-----------|------|-------|-------|-------|-------|
| 1    | Models 1 and 2 | 1 | 0         | 1 | 0         | 3.29 | 3.29  | 2.96  | 2.21  | 1.36  |
| 2    | Model 1        | 2 | 1         | 2 | 1         | 2.98 | 1.89  | 1.86  | 1.69  | 1.30  |
| 3    | Model 2        | 2 | 1         | 2 | 1         | 1.85 | 1.52  | 1.52  | 1.43  | 1.18  |
| 4    | Models 1 and 2 | 3 | 0         | 2 | 0         | 6.10 | 6.10  | 5.40  | 3.92  | 2.40  |
| 5    | Model 1        | 3 | 1         | 2 | 1         | 5.03 | 2.81  | 2.77  | 2.51  | 1.94  |
| 6    | Model 2        | 3 | 1         | 2 | 1         | 2.90 | 2.17  | 2.17  | 2.05  | 1.69  |

Note that, though not appearing in this example, it is possible for  $C_i$  to increase during the interim periods (for instance, from  $C_1$  to  $C_2$ ) if the attacker reserves are committed sufficiently faster than the defender reserves, even if the attacker reserves are smaller.

#### D. EXTENSION TO INCLUDE AIR DEFENSES

##### 1. Introduction

Definitions are presented, accompanied by assumptions. The revised model is given. Results are presented.

##### 2. Definitions and Assumptions

Define

$k_f, k_m$  = kill of attacker air firepower per unit of fixed and mobile defender ground forces

$l_f, l_m$  = kill of defender air firepower per unit of fixed and mobile attackers ground forces

Assume that defender initial ground forces with their air defenses are uniformly deployed. Assume that defender reserve ground forces with their air defenses arrive at main-thrust sectors.

Assume that attacker initial ground forces have their air defenses deployed in proportion  $p_{mt}$  in the main-thrust sectors and  $(1 - p_{mt})$  in the non-main-thrust sectors. Assume that attacker reserve ground forces with their air defenses arrive at the main-thrust sectors.

### 3. Models

These models are extensions of the previous models. They are given in a different format, however, to facilitate understanding.

The primary difficulty with adding air defense to the models is that firepower killed by air defenses cannot exceed firepower of the air forces being killed. Thus, many  $\max(\text{term}, 0)$  expressions appear.

**Model 1 - Air initially committed to all sectors and subsequently committed to main-thrust sectors**

0. Defender ground and air firepower in non-main-thrust sectors

$$T_0 = \left( \frac{s-t}{s} \right) (D - RD) + \max \left\{ \left( \frac{s-t}{s} \right) (\bar{D} - \bar{R}\bar{D}) - (1 - p_{mt}) l_f (A - R'A), 0 \right\}$$

1. Attacker ground and air firepower in main-thrust sectors

$$T_1 = (A - R'A) + \max \left\{ \left( \bar{A} - \bar{R}'\bar{A} \right) - k_f \left( \frac{t}{s} \right) (D - RD), 0 \right\} - h T_0$$

2. Defender ground and air firepower in main-thrust sectors

$$T_2 = \left( \frac{t}{s} \right) (D - RD) + \max \left\{ \left( \frac{t}{s} \right) (\bar{D} - \bar{R}\bar{D}) - p_{mt} l_f (A - R'A), 0 \right\}$$

**Initial Force Ratio**

$$C = \frac{T_1}{T_2}$$

## 3. Attacker ground and air firepower in main-thrust sectors

$$T_{3_i} = (A - R'A) + r'_i R'A + \max \left\{ \left[ (\bar{A} - \bar{R}'\bar{A}) + \bar{R}'\bar{A} - k_f \left( \frac{t}{s} \right) (D - RD) - k_m r'_i RD \right], 0 \right\} - h T_0$$

## 4. Defender ground and air firepower in main-thrust sectors

$$T_{4_i} = \left( \frac{t}{s} \right) (D - RD) + r_i RD + \max \left\{ \left[ \left( \frac{t}{s} \right) (\bar{D} - \bar{R}\bar{D}) - p_{mt} l_f (A - R'A) - l_m r'_i R'A \right], 0 \right\}$$

## Subsequent Force Ratios

$$C_i = \frac{T_{3_i}}{T_{4_i}}$$

## Model 2 - Air initially committed to main-thrust sectors and subsequently committed to main-thrust sectors

1. Attacker ground and air firepower in main-thrust sectors. (Note: it is assumed here that attacker knows that defender does not commit air to non-main-thrust sectors; thus, attacker only needs to tie down h times ground force firepower.

$$T_1 = (A - R'A) + \max \left\{ \left[ (\bar{A} - \bar{R}'\bar{A}) - k_f \left( \frac{t}{s} \right) (D - RD) \right], 0 \right\} - h \left( \frac{s-t}{s} \right) (D - RD)$$

2. Defender ground and air firepower in main-thrust sectors

$$T_2 = \left( \frac{t}{s} \right) (D - RL) + \max \left\{ \left[ \left( \frac{t}{s} \right) (\bar{D} - \bar{R}\bar{D}) - p_{mt} l_f (A - R'A) \right], 0 \right\}$$

## Initial Force Ratio

$$C = \frac{T_1}{T_2}$$

## 3. Attacker ground and air firepower in main-thrust sectors

$$T_{3_i} = (A - R'A) + r'_i R'A + \max \left\{ \left[ \left( \bar{A} - \bar{R}'\bar{A} \right) + \bar{R}'\bar{A} - k_f \left( \frac{t}{s} \right) (D - RD) - k_m r'_i RD \right], 0 \right\} \\ - h \left( \frac{s-t}{s} \right) (1 - R)D$$

## 4. Defender ground and air firepower in main-thrust sectors

$$T_{4_i} = \left( \frac{t}{s} \right) (D - RD) + r_i RD + \max \left\{ \left[ \left( \frac{t}{s} \right) (\bar{D} - \bar{R}\bar{D}) + \bar{R}\bar{D} - p_{mt} l_f (A - R'A) - l_m r'_i R'A \right], 0 \right\}$$

## Subsequent Force Ratios

$$C'_i = \frac{T_{3_i}}{T_{4_i}}$$

## 4. Sample Results

The following results are for two force structures which have different amounts of defending ground and air forces. Variations in air defense parameters are made and initial and final main-thrust sector force ratios are displayed. Results are sensitive to air defense parameters.

| Force structures |           |   |           | Air defense parameters |       |       |       |          | Results |        |         |        |
|------------------|-----------|---|-----------|------------------------|-------|-------|-------|----------|---------|--------|---------|--------|
| A                | $\bar{A}$ | D | $\bar{D}$ | $k_f$                  | $k_m$ | $l_f$ | $l_m$ | $P_{mt}$ | Model 1 |        | Model 2 |        |
|                  |           |   |           |                        |       |       |       |          | C       | $C'_4$ | C       | $C'_4$ |
| 4                | 1         | 3 | 1         | 0                      | 0     | 0     | 0     | .5       | 4.57    | 1.80   | 2.96    | 1.62   |
| 4                | 1         | 2 | 2         | 0                      | 0     | 0     | 0     | .5       | 5.06    | 1.73   | 2.42    | 1.45   |
| 4                | 1         | 3 | 1         | .1                     | .1    | .1    | .1    | .5       | 5.86    | 2.01   | 3.54    | 1.73   |
| 4                | 1         | 2 | 2         | 1                      | .1    | .1    | .1    | .5       | 7.69    | 1.95   | 2.76    | 1.54   |
| 4                | 1         | 3 | 1         | 2                      | .2    | .2    | .2    | .5       | 6.01    | 2.29   | 4.43    | 1.86   |
| 4                | 1         | 2 | 2         | 2                      | .2    | .2    | .2    | .5       | 9.40    | 2.22   | 3.20    | 1.65   |
| 4                | 1         | 3 | 1         | .3                     | .3    | .3    | .3    | .5       | 5.99    | 2.44   | 5.99    | 2.02   |
| 4                | 1         | 2 | 2         | .3                     | .3    | .3    | .3    | .5       | 9.68    | 2.58   | 3.83    | 1.78   |
| 4                | 1         | 3 | 1         | .3                     | .1    | .3    | .1    | .5       | 5.99    | 2.50   | 5.99    | 1.99   |
| 4                | 1         | 2 | 2         | .3                     | .1    | .3    | .1    | .5       | 9.68    | 2.45   | 3.83    | 1.73   |

## E. REFERENCES

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# APPENDIX A

## FORTRAN PROGRAM

```

1  C
2  C --- FORCE CONCENTRATION MODEL
3  C
4      PROGRAM FCM
5  C
6      5  FORMAT(1X,'A,AB,D,DB,C,CP(1),CP(2),CP(3),CP(4)')
7      6  FORMAT(4F5.0,3X,F8.2,3X,4F8.2)
8      7  FORMAT(4F5.1,3X,F8.2,3X,4F8.2)
9  C
10     11  FORMAT(1X,'MODEL 1')
11     12  FORMAT(1X,'MODEL 2')
12  C
13     DIMENSION RS(4),RPS(4),CP(4)
14  C
15     OPEN (6,FILE='6.OUT',STATUS='NEW')
16     OPEN (7,FILE='7.OUT',STATUS='NEW')
17  C
18  C --- FIRST SET OF PARAMETERS (SECTION B OF DOCUMENT)
19  C
20  C     R = DEFENDER FRACTION GROUND FORCES IN RESERVE
21  C     RB = DEFENDER FRACTION AIR FORCES IN RESERVE
22  C     RP = ATTACKER FRACTION GROUND FORCES IN RESERVE
23  C     RPB = ATTACKER FRACTION AIR FORCES IN RESERVE
24  C     S = NUMBER OF SECTORS
25  C     T = NUMBER OF MAIN THRUST SECTORS
26  C     H = FORCE RATIO TO BE TOLERATED BY ATTACKER ON NON-MAIN-THRUST
27  C         SECTORS
28  C
29     R=1./3.
30     RB=1./2.
31     RP=1./6.
32     RPB=1./2.
33     S=9.
34     T=2.
35     H=2./3.
36  C
37  C --- SECOND SET OF PARAMETERS (SECTION C OF DOCUMENT)
38  C
39  C     RS(I) = DEFENDER FRACTION OF RESERVES AVAILABLE IN MAIN-THRUST
40  C             SECTORS BY PERIOD I (I=1 TO 4)
41  C     RPS(I) = ATTACKER FRACTION OF RESERVES AVAILABLE IN MAIN-THRUST
42  C             SECTORS BY PERIOD I (I=1 TO 4)
43  C
44     RS(1)=0.
45     RS(2)=.1
46     RS(3)=.4
47     RS(4)=1.
48     RPS(1)=0.
49     RPS(2)=.3
50     RPS(3)=.8
51     RPS(4)=1.
52  C
53  C --- THIRD SET OF PARAMETERS (SECTION D OF DOCUMENT)
54  C
55  C     FKF = KILL OF ATTACKER AIR FIREPOWER PER UNIT OF FIXED
56  C             DEFENDER GROUND FORCES
57  C     FKM = KILL OF ATTACKER AIR FIREPOWER PER UNIT OF MOBILE
58  C             DEFENDER GROUND FORCES

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59 C      FLF = KILL OF DEFENDER AIR FIREPOWER PER UNIT OF FIXED
60 C      ATTACKER GROUND FORCES
61 C      FLM = KILL OF DEFENDER AIR FIREPOWER PER UNIT OF MOBILE
62 C      ATTACKER GROUND FORCES
63 C      PMT = FRACTION OF ATTACKER AIR DEFENSES INITIALLY DEPLOYED TO
64 C      MAIN-THRUST SECTORS
65 C
66 C      FKF=.1
67 C      FKM=.1
68 C      FLF=.1
69 C      FLM=.1
70 C      PMT=.5
71 C
72 C --- MODEL 1 (AIR INITIALLY COMMITTED TO ALL SECTORS)
73 C
74 C      WRITE(6,11)
75 C      WRITE(6,5)
76 C
77 C --- LOOP ON GROUND AND AIR PARAMETERS
78 C
79 C      DO 100 IA=1,4
80 C      IABM=IA+1
81 C      DO 100 IAB=1,IABM
82 C      DO 100 ID=1,IA
83 C      IDBM=ID+1
84 C      DO 100 IDB=1,IDBM
85 C
86 C      A=IA
87 C      AB=IAB-1
88 C      D=ID
89 C      DB=IDB-1
90 C
91 C --- TERM ZERO
92 C
93 C      TZ= ((S-T)/S) * (D-R*D)
94 C      X   + MAX ( ( (S-T)/S) * (DB-RB*DB)
95 C      X   - (1.-PMT) * FLF * (A-RP*A) ) , 0. )
96 C
97 C --- TERM ONE
98 C
99 C      T1 = (A-RP*A)
100 C      X   + MAX ( ( (AB-RBP*AB)
101 C      X   - FKF * (T/S) * (D-R*D) ) , 0. )
102 C      X   - H* TZ
103 C
104 C --- TERM TWO
105 C
106 C      T2 = (T/S) * (D-R*D)
107 C      X   + MAX ( ( (T/S) * (DB-RB*DB)
108 C      X   - PMT * FLF * (A-RP*A) ) , 0. )
109 C
110 C --- INITIAL FORCE RATIO
111 C
112 C      C=T1/T2
113 C
114 C      DO 90 I=1,4
115 C
116 C --- TERM THREE

```

```

117 C
118     T3 = ( A-RP*A) + RPS(I)*RP*A
119     X   + MAX ( ( (AB-RBP*AB) + RBP*AB
120     X   - FKF * (T/S)*(D-R*D)
121     X   - FKM * RS(I)*R*D ), 0. )
122     X   - H * TZ
123 C
124 C --- TERM FOUR
125 C
126     T4 = (T/S) * (D-R*D) + RS(I)*R*D
127     X   + MAX ( ( (T/S)*(DB-RB*DB) + RB*DB
128     X   - PMT * FLF * (A-RP*A)
129     X   - FLM * RPS(I)*RP*A ), 0. )
130 C
131 C --- SUBSEQUENT FORCE RATIO I
132 C
133     CP(I)=T3/T4
134 C
135 90  CONTINUE
136 C
137     WRITE(6,6) A,AB,D,DB,C,CP(1),CP(2),CP(3),CP(4)
138 C
139 100 CONTINUE
140 C
141 C --- MODEL 2 (AIR INITIALLY COMMITTED TO MAIN-THRUST SECTORS ONLY)
142 C
143     WRITE(7,12)
144     WRITE(7,5)
145 C
146 C --- LOOP ON GROUND AND AIR FORCES
147 C
148     DO 200 IA=1,4
149     IABM=IA+1
150     DO 200 IAB=1,IABM
151     DO 200 ID=1,IA
152     IDBM=ID+1
153     DO 200 IDB=1,IDBM
154 C
155     A=IA
156     AB=IAB-1
157     D=ID
158     DB=IDB-1
159 C
160 C --- TERM ONE
161 C
162     T1 = (A-RP*A)
163     X   + MAX ( ( (AB-RBP*AB)
164     X   - FKF * (T/S) * (D-R*D) ), 0. )
165     X   - H * ((S-T)/S) * (D-R*D)
166 C
167 C --- TERM TWO
168 C
169     T2 = (T/S) * (D-R*D)
170     X   + MAX ( ( (DB-RB*DB)
171     X   - PMT * FLF * (A-RP*A) ), 0. )
172 C
173 C --- INITIAL FORCE RATIO
174 C

```

```

175      C=T1/T2
176 C
177      DO 190 I=1,4
178 C
179 C --- TERM THREE
180 C
181      T3 = ( A-RP*A) + RPS(I)*RP*A
182      X      + MAX ( ( (AB-RBP*AB) + RBP*AB
183      X              - FKF * (T/S)*(D-R*D)
184      X              - FKM * RS(I)*R*D ), 0. )
185      X      - H * ( (S-T)/S) * (D-R*D)
186 C
187 C --- TERM FOUR
188 C
189      T4 = (T/S) * (D-R*D) + RS(I)*R*D
190      X      + MAX ( ( (DB-RB*DB) + RB*DB
191      X              - PMT * FLF * (A-RP*A)
192      X              - FLM * RPS(I)*RP*A ), 0. )
193 C
194 C --- SUBSEQUENT FORCE RATIO I
195 C
196      CP(I)=T3/T4
197 C
198 190 CONTINUE
199 C
200      WRITE(7,6) A,AB,D,DB,C,CP(1),CP(2),CP(3),CP(4)
201 C
202 200 CONTINUE
203 C
204      STOP
205      END

```

APPENDIX B  
SAMPLE OUTPUT

Results are given for Model 1 and Model 2. They are produced by the FORTRAN program of Appendix A.

The following are tabulated:

A = attacker ground forces (A)

$\bar{A}$  = attacker air forces (AB)

D = defender ground forces (D)

$\bar{D}$  = defender air forces (DB)

C = initial force ratio in main-thrust  
sectors before reserve committed (C)

$C'_i$  = subsequent force ratios main-threat sectors at periods  
i = 1, 2, 3, 4 of ground forces arrival  
(CP(1), CP(2), CP(3), CP(4))

A is varied from 1 to 4. D is varied from 1 to A.  $\bar{A}$  and  $\bar{D}$  are varied from 0 to A.

## MODEL 1

A, AB, D, DB, C, CP(1), CP(2), CP(3), CP(4)

|    |    |    |    |       |       |       |       |       |
|----|----|----|----|-------|-------|-------|-------|-------|
| 1. | 0. | 1. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 1. | 0. | 1. | 1. | 1.18  | .36   | .41   | .47   | .41   |
| 1. | 1. | 1. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 1. | 1. | 1. | 1. | 3.41  | 1.73  | 1.73  | 1.63  | 1.33  |
| 2. | 0. | 1. | 0. | 8.92  | 8.92  | 7.83  | 5.64  | 3.44  |
| 2. | 0. | 1. | 1. | 6.35  | 1.65  | 1.74  | 1.77  | 1.49  |
| 2. | 0. | 2. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 2. | 0. | 2. | 1. | 2.38  | .94   | .99   | .98   | .76   |
| 2. | 0. | 2. | 2. | 1.18  | .36   | .41   | .47   | .41   |
| 2. | 1. | 1. | 0. | 12.19 | 15.57 | 13.24 | 9.09  | 5.41  |
| 2. | 1. | 1. | 1. | 9.11  | 3.11  | 3.14  | 3.01  | 2.46  |
| 2. | 1. | 2. | 0. | 4.88  | 6.57  | 5.62  | 3.88  | 2.30  |
| 2. | 1. | 2. | 1. | 3.83  | 2.11  | 2.08  | 1.86  | 1.38  |
| 2. | 1. | 2. | 2. | 2.26  | 1.03  | 1.06  | 1.03  | .85   |
| 2. | 2. | 1. | 0. | 15.57 | 22.32 | 18.75 | 12.65 | 7.49  |
| 2. | 2. | 1. | 1. | 11.95 | 4.59  | 4.58  | 4.29  | 3.49  |
| 2. | 2. | 2. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 2. | 2. | 2. | 1. | 5.38  | 3.33  | 3.22  | 2.80  | 2.06  |
| 2. | 2. | 2. | 2. | 3.41  | 1.73  | 1.73  | 1.63  | 1.33  |
| 3. | 0. | 1. | 0. | 14.54 | 14.54 | 12.70 | 9.07  | 5.51  |
| 3. | 0. | 1. | 1. | 13.35 | 3.12  | 3.26  | 3.27  | 2.70  |
| 3. | 0. | 2. | 0. | 6.10  | 6.10  | 5.40  | 3.92  | 2.40  |
| 3. | 0. | 2. | 1. | 5.51  | 2.09  | 2.14  | 2.01  | 1.52  |
| 3. | 0. | 2. | 2. | 3.49  | .99   | 1.05  | 1.09  | .93   |
| 3. | 0. | 3. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 3. | 0. | 3. | 1. | 2.90  | 1.38  | 1.42  | 1.31  | .95   |
| 3. | 0. | 3. | 2. | 1.90  | .67   | .72   | .75   | .61   |
| 3. | 0. | 3. | 3. | 1.18  | .36   | .41   | .47   | .41   |
| 3. | 1. | 1. | 0. | 17.82 | 21.19 | 18.11 | 12.53 | 7.49  |
| 3. | 1. | 1. | 1. | 16.63 | 4.67  | 4.77  | 4.60  | 3.74  |
| 3. | 1. | 2. | 0. | 7.69  | 9.38  | 8.05  | 5.60  | 3.34  |
| 3. | 1. | 2. | 1. | 7.10  | 3.33  | 3.29  | 2.95  | 2.17  |
| 3. | 1. | 2. | 2. | 4.69  | 1.68  | 1.72  | 1.68  | 1.38  |
| 3. | 1. | 3. | 0. | 4.32  | 5.44  | 4.70  | 3.29  | 1.95  |
| 3. | 1. | 3. | 1. | 3.92  | 2.41  | 2.35  | 2.02  | 1.41  |
| 3. | 1. | 3. | 2. | 2.74  | 1.29  | 1.31  | 1.23  | .96   |
| 3. | 1. | 3. | 3. | 1.88  | .80   | .83   | .83   | .68   |
| 3. | 2. | 1. | 0. | 21.19 | 27.94 | 23.62 | 16.08 | 9.57  |
| 3. | 2. | 1. | 1. | 20.00 | 6.25  | 6.30  | 5.98  | 4.83  |
| 3. | 2. | 2. | 0. | 9.38  | 12.75 | 10.81 | 7.38  | 4.37  |
| 3. | 2. | 2. | 1. | 8.79  | 4.61  | 4.49  | 3.94  | 2.89  |
| 3. | 2. | 2. | 2. | 5.96  | 2.40  | 2.41  | 2.29  | 1.88  |
| 3. | 2. | 3. | 0. | 5.44  | 7.69  | 6.54  | 4.47  | 2.64  |
| 3. | 2. | 3. | 1. | 5.05  | 3.48  | 3.33  | 2.79  | 1.94  |
| 3. | 2. | 3. | 2. | 3.66  | 1.94  | 1.92  | 1.76  | 1.36  |
| 3. | 2. | 3. | 3. | 2.64  | 1.27  | 1.28  | 1.23  | 1.01  |
| 3. | 3. | 1. | 0. | 24.57 | 34.69 | 29.13 | 19.63 | 11.64 |
| 3. | 3. | 1. | 1. | 23.38 | 7.83  | 7.83  | 7.35  | 5.92  |
| 3. | 3. | 2. | 0. | 11.07 | 16.13 | 13.56 | 9.15  | 5.41  |
| 3. | 3. | 2. | 1. | 10.47 | 5.88  | 5.69  | 4.93  | 3.60  |
| 3. | 3. | 2. | 2. | 7.23  | 3.12  | 3.10  | 2.91  | 2.38  |
| 3. | 3. | 3. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 3. | 3. | 3. | 1. | 6.17  | 4.56  | 4.32  | 3.57  | 2.47  |
| 3. | 3. | 3. | 2. | 4.58  | 2.58  | 2.53  | 2.28  | 1.76  |
| 3. | 3. | 3. | 3. | 3.41  | 1.73  | 1.73  | 1.63  | 1.33  |
| 4. | 0. | 1. | 0. | 20.17 | 20.17 | 17.56 | 12.51 | 7.59  |
| 4. | 0. | 1. | 1. | 19.17 | 4.79  | 5.02  | 5.01  | 4.08  |
| 4. | 0. | 2. | 0. | 8.92  | 8.92  | 7.83  | 5.64  | 3.44  |
| 4. | 0. | 2. | 1. | 8.42  | 3.37  | 3.42  | 3.17  | 2.36  |
| 4. | 0. | 2. | 2. | 6.35  | 1.65  | 1.74  | 1.77  | 1.49  |
| 4. | 0. | 3. | 0. | 5.17  | 5.17  | 4.59  | 3.35  | 2.05  |
| 4. | 0. | 3. | 1. | 4.83  | 2.42  | 2.42  | 2.17  | 1.54  |
| 4. | 0. | 3. | 2. | 3.78  | 1.26  | 1.32  | 1.31  | 1.05  |

|    |    |    |    |       |       |       |       |       |
|----|----|----|----|-------|-------|-------|-------|-------|
| 4. | 0. | 3. | 3. | 2.67  | .77   | .84   | .88   | .75   |
| 4. | 0. | 4. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 4. | 0. | 4. | 1. | 3.04  | 1.74  | 1.74  | 1.54  | 1.07  |
| 4. | 0. | 4. | 2. | 2.38  | .94   | .99   | .98   | .76   |
| 4. | 0. | 4. | 3. | 1.69  | .57   | .63   | .66   | .55   |
| 4. | 0. | 4. | 4. | 1.18  | .36   | .41   | .47   | .41   |
| 4. | 1. | 1. | 0. | 23.44 | 26.82 | 22.97 | 15.96 | 9.57  |
| 4. | 1. | 1. | 1. | 22.44 | 6.45  | 6.64  | 6.46  | 5.19  |
| 4. | 1. | 2. | 0. | 10.50 | 12.19 | 10.49 | 7.32  | 4.37  |
| 4. | 1. | 2. | 1. | 10.00 | 4.68  | 4.65  | 4.16  | 3.03  |
| 4. | 1. | 2. | 2. | 7.69  | 2.37  | 2.43  | 2.37  | 1.95  |
| 4. | 1. | 3. | 0. | 6.19  | 7.32  | 6.32  | 4.44  | 2.64  |
| 4. | 1. | 3. | 1. | 5.86  | 3.49  | 3.40  | 2.91  | 2.01  |
| 4. | 1. | 3. | 2. | 4.69  | 1.90  | 1.92  | 1.81  | 1.40  |
| 4. | 1. | 3. | 3. | 3.41  | 1.22  | 1.27  | 1.25  | 1.04  |
| 4. | 1. | 4. | 0. | 4.04  | 4.88  | 4.24  | 2.99  | 1.78  |
| 4. | 1. | 4. | 1. | 3.79  | 2.65  | 2.55  | 2.12  | 1.42  |
| 4. | 1. | 4. | 2. | 3.06  | 1.51  | 1.52  | 1.39  | 1.04  |
| 4. | 1. | 4. | 3. | 2.27  | .98   | 1.02  | .99   | .78   |
| 4. | 1. | 4. | 4. | 1.68  | .68   | .72   | .73   | .60   |
| 4. | 2. | 1. | 0. | 26.82 | 33.57 | 28.49 | 19.51 | 11.64 |
| 4. | 2. | 1. | 1. | 25.82 | 8.14  | 8.29  | 7.95  | 6.35  |
| 4. | 2. | 2. | 0. | 12.19 | 15.57 | 13.24 | 9.09  | 5.41  |
| 4. | 2. | 2. | 1. | 11.69 | 6.03  | 5.92  | 5.21  | 3.78  |
| 4. | 2. | 2. | 2. | 9.11  | 3.11  | 3.14  | 3.01  | 2.46  |
| 4. | 2. | 3. | 0. | 7.32  | 9.57  | 8.16  | 5.62  | 3.34  |
| 4. | 2. | 3. | 1. | 6.98  | 4.62  | 4.43  | 3.72  | 2.56  |
| 4. | 2. | 3. | 2. | 5.69  | 2.56  | 2.55  | 2.35  | 1.81  |
| 4. | 2. | 3. | 3. | 4.23  | 1.70  | 1.72  | 1.66  | 1.36  |
| 4. | 2. | 4. | 0. | 4.88  | 6.57  | 5.62  | 3.88  | 2.30  |
| 4. | 2. | 4. | 1. | 4.63  | 3.61  | 3.42  | 2.78  | 1.86  |
| 4. | 2. | 4. | 2. | 3.83  | 2.11  | 2.08  | 1.86  | 1.38  |
| 4. | 2. | 4. | 3. | 2.93  | 1.43  | 1.44  | 1.35  | 1.07  |
| 4. | 2. | 4. | 4. | 2.26  | 1.03  | 1.06  | 1.03  | .85   |
| 4. | 3. | 1. | 0. | 30.19 | 40.32 | 34.00 | 23.07 | 13.72 |
| 4. | 3. | 1. | 1. | 29.19 | 9.83  | 9.94  | 9.43  | 7.52  |
| 4. | 3. | 2. | 0. | 13.88 | 18.94 | 16.00 | 10.87 | 6.45  |
| 4. | 3. | 2. | 1. | 13.38 | 7.38  | 7.19  | 6.26  | 4.52  |
| 4. | 3. | 2. | 2. | 10.53 | 3.85  | 3.86  | 3.65  | 2.97  |
| 4. | 3. | 3. | 0. | 8.44  | 11.82 | 10.00 | 6.80  | 4.03  |
| 4. | 3. | 3. | 1. | 8.11  | 5.74  | 5.46  | 4.53  | 3.11  |
| 4. | 3. | 3. | 2. | 6.69  | 3.23  | 3.19  | 2.89  | 2.22  |
| 4. | 3. | 3. | 3. | 5.05  | 2.17  | 2.18  | 2.07  | 1.69  |
| 4. | 3. | 4. | 0. | 5.72  | 8.25  | 7.00  | 4.77  | 2.82  |
| 4. | 3. | 4. | 1. | 5.47  | 4.57  | 4.29  | 3.44  | 2.29  |
| 4. | 3. | 4. | 2. | 4.60  | 2.72  | 2.65  | 2.33  | 1.72  |
| 4. | 3. | 4. | 3. | 3.59  | 1.87  | 1.86  | 1.72  | 1.35  |
| 4. | 3. | 4. | 4. | 2.83  | 1.38  | 1.39  | 1.33  | 1.09  |
| 4. | 4. | 1. | 0. | 33.57 | 47.07 | 39.51 | 26.62 | 15.80 |
| 4. | 4. | 1. | 1. | 32.57 | 11.52 | 11.59 | 10.92 | 8.68  |
| 4. | 4. | 2. | 0. | 15.57 | 22.32 | 18.75 | 12.65 | 7.49  |
| 4. | 4. | 2. | 1. | 15.07 | 8.73  | 8.46  | 7.31  | 5.27  |
| 4. | 4. | 2. | 2. | 11.95 | 4.59  | 4.58  | 4.29  | 3.49  |
| 4. | 4. | 3. | 0. | 9.57  | 14.07 | 11.83 | 7.99  | 4.72  |
| 4. | 4. | 3. | 1. | 9.23  | 6.87  | 6.50  | 5.34  | 3.66  |
| 4. | 4. | 3. | 2. | 7.69  | 3.90  | 3.82  | 3.43  | 2.63  |
| 4. | 4. | 3. | 3. | 5.87  | 2.65  | 2.64  | 2.47  | 2.02  |
| 4. | 4. | 4. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 4. | 4. | 4. | 1. | 6.32  | 5.54  | 5.15  | 4.10  | 2.72  |
| 4. | 4. | 4. | 2. | 5.38  | 3.33  | 3.22  | 2.80  | 2.06  |
| 4. | 4. | 4. | 3. | 4.25  | 2.31  | 2.28  | 2.08  | 1.63  |
| 4. | 4. | 4. | 4. | 3.41  | 1.73  | 1.73  | 1.63  | 1.33  |

## MODEL 2

A, AB, D, DB, C, CP(1), CP(2), CP(3), CP(4)

|    |    |    |    |       |       |       |       |       |
|----|----|----|----|-------|-------|-------|-------|-------|
| 1. | 0. | 1. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 1. | 0. | 1. | 1. | .80   | .44   | .47   | .51   | .46   |
| 1. | 1. | 1. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 1. | 1. | 1. | 1. | 1.60  | 1.33  | 1.34  | 1.30  | 1.13  |
| 1. | 1. | 1. | 1. | 8.92  | 8.92  | 7.83  | 5.64  | 3.44  |
| 2. | 0. | 1. | 0. | 2.34  | 1.24  | 1.31  | 1.36  | 1.21  |
| 2. | 0. | 1. | 1. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 2. | 0. | 2. | 0. | 1.37  | .80   | .85   | .85   | .71   |
| 2. | 0. | 2. | 1. | .80   | .44   | .47   | .51   | .46   |
| 2. | 0. | 2. | 2. | 12.19 | 15.57 | 13.24 | 9.09  | 5.41  |
| 2. | 1. | 1. | 0. | 3.20  | 2.17  | 2.21  | 2.18  | 1.91  |
| 2. | 1. | 1. | 1. | 4.88  | 6.57  | 5.62  | 3.88  | 2.30  |
| 2. | 1. | 2. | 0. | 2.03  | 1.60  | 1.61  | 1.50  | 1.20  |
| 2. | 1. | 2. | 1. | 1.19  | .88   | .90   | .89   | .78   |
| 2. | 1. | 2. | 2. | 15.57 | 22.32 | 18.75 | 12.65 | 7.49  |
| 2. | 2. | 1. | 0. | 4.08  | 3.10  | 3.13  | 3.04  | 2.64  |
| 2. | 2. | 1. | 1. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 2. | 2. | 2. | 0. | 2.73  | 2.43  | 2.39  | 2.19  | 1.74  |
| 2. | 2. | 2. | 1. | 1.60  | 1.33  | 1.34  | 1.30  | 1.13  |
| 2. | 2. | 2. | 2. | 14.54 | 14.54 | 12.70 | 9.07  | 5.51  |
| 3. | 0. | 1. | 0. | 4.12  | 2.11  | 2.21  | 2.29  | 2.03  |
| 3. | 0. | 1. | 1. | 6.10  | 6.10  | 5.40  | 3.92  | 2.40  |
| 3. | 0. | 2. | 0. | 2.69  | 1.54  | 1.60  | 1.58  | 1.29  |
| 3. | 0. | 2. | 1. | 1.54  | .83   | .88   | .92   | .83   |
| 3. | 0. | 2. | 2. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 3. | 0. | 3. | 0. | 1.79  | 1.11  | 1.15  | 1.11  | .86   |
| 3. | 0. | 3. | 1. | 1.11  | .63   | .67   | .70   | .60   |
| 3. | 0. | 3. | 2. | .80   | .44   | .47   | .51   | .46   |
| 3. | 0. | 3. | 3. | 17.82 | 21.19 | 18.11 | 12.53 | 7.49  |
| 3. | 1. | 1. | 0. | 5.05  | 3.07  | 3.16  | 3.16  | 2.76  |
| 3. | 1. | 1. | 1. | 7.69  | 9.38  | 8.05  | 5.60  | 3.34  |
| 3. | 1. | 2. | 0. | 3.39  | 2.37  | 2.39  | 2.25  | 1.80  |
| 3. | 1. | 2. | 1. | 1.95  | 1.28  | 1.31  | 1.31  | 1.15  |
| 3. | 1. | 2. | 2. | 4.32  | 5.44  | 4.70  | 3.29  | 1.95  |
| 3. | 1. | 3. | 0. | 2.34  | 1.83  | 1.82  | 1.65  | 1.24  |
| 3. | 1. | 3. | 1. | 1.45  | 1.04  | 1.06  | 1.04  | .86   |
| 3. | 1. | 3. | 2. | 1.05  | .73   | .75   | .76   | .66   |
| 3. | 1. | 3. | 3. | 21.19 | 27.94 | 23.62 | 16.08 | 9.57  |
| 3. | 2. | 1. | 0. | 6.00  | 4.05  | 4.12  | 4.05  | 3.53  |
| 3. | 2. | 1. | 1. | 9.38  | 12.75 | 10.81 | 7.38  | 4.37  |
| 3. | 2. | 2. | 0. | 4.14  | 3.23  | 3.21  | 2.97  | 2.36  |
| 3. | 2. | 2. | 1. | 2.37  | 1.74  | 1.76  | 1.73  | 1.51  |
| 3. | 2. | 2. | 2. | 5.44  | 7.69  | 6.54  | 4.47  | 2.64  |
| 3. | 2. | 3. | 0. | 2.95  | 2.59  | 2.53  | 2.25  | 1.68  |
| 3. | 2. | 3. | 1. | 1.83  | 1.47  | 1.48  | 1.41  | 1.17  |
| 3. | 2. | 3. | 2. | 1.33  | 1.03  | 1.05  | 1.03  | .89   |
| 3. | 2. | 3. | 3. | 24.57 | 34.69 | 29.13 | 19.63 | 11.64 |
| 3. | 3. | 1. | 0. | 6.96  | 5.02  | 5.08  | 4.95  | 4.29  |
| 3. | 3. | 1. | 1. | 11.07 | 16.13 | 13.56 | 9.15  | 5.41  |
| 3. | 3. | 2. | 0. | 4.88  | 4.08  | 4.02  | 3.69  | 2.92  |
| 3. | 3. | 2. | 1. | 2.80  | 2.20  | 2.21  | 2.15  | 1.87  |
| 3. | 3. | 2. | 2. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 3. | 3. | 3. | 0. | 3.56  | 3.35  | 3.25  | 2.85  | 2.12  |
| 3. | 3. | 3. | 1. | 2.21  | 1.90  | 1.90  | 1.78  | 1.47  |
| 3. | 3. | 3. | 2. | 1.60  | 1.33  | 1.34  | 1.30  | 1.13  |
| 3. | 3. | 3. | 3. | 20.17 | 20.17 | 17.56 | 12.51 | 7.59  |
| 4. | 0. | 1. | 0. | 6.21  | 3.04  | 3.20  | 3.32  | 2.93  |
| 4. | 0. | 1. | 1. | 8.92  | 8.92  | 7.83  | 5.64  | 3.44  |
| 4. | 0. | 2. | 0. | 4.20  | 2.34  | 2.42  | 2.36  | 1.91  |
| 4. | 0. | 2. | 1. | 2.34  | 1.24  | 1.31  | 1.36  | 1.21  |
| 4. | 0. | 2. | 2. | 5.17  | 5.17  | 4.59  | 3.35  | 2.05  |
| 4. | 0. | 3. | 0. | 2.95  | 1.80  | 1.84  | 1.74  | 1.34  |
| 4. | 0. | 3. | 1. | 1.80  | 1.01  | 1.06  | 1.08  | .92   |
| 4. | 0. | 3. | 2. |       |       |       |       |       |

|    |    |    |    |       |       |       |       |       |
|----|----|----|----|-------|-------|-------|-------|-------|
| 4. | 0. | 3. | 3. | 1.29  | .70   | .74   | .78   | .70   |
| 4. | 0. | 4. | 0. | 3.29  | 3.29  | 2.96  | 2.21  | 1.36  |
| 4. | 0. | 4. | 1. | 2.11  | 1.37  | 1.40  | 1.30  | .97   |
| 4. | 0. | 4. | 2. | 1.37  | .80   | .85   | .85   | .71   |
| 4. | 0. | 4. | 3. | 1.01  | .57   | .61   | .64   | .56   |
| 4. | 0. | 4. | 4. | .80   | .44   | .47   | .51   | .46   |
| 4. | 1. | 1. | 0. | 23.44 | 26.82 | 22.97 | 15.96 | 9.57  |
| 4. | 1. | 1. | 1. | 7.21  | 4.05  | 4.19  | 4.23  | 3.69  |
| 4. | 1. | 2. | 0. | 10.50 | 12.19 | 10.49 | 7.32  | 4.37  |
| 4. | 1. | 2. | 1. | 4.94  | 3.20  | 3.24  | 3.07  | 2.44  |
| 4. | 1. | 2. | 2. | 2.76  | 1.70  | 1.75  | 1.76  | 1.54  |
| 4. | 1. | 3. | 0. | 6.19  | 7.32  | 6.32  | 4.44  | 2.64  |
| 4. | 1. | 3. | 1. | 3.54  | 2.54  | 2.53  | 2.31  | 1.73  |
| 4. | 1. | 3. | 2. | 2.15  | 1.43  | 1.46  | 1.43  | 1.19  |
| 4. | 1. | 3. | 3. | 1.55  | .99   | 1.03  | 1.03  | .91   |
| 4. | 1. | 4. | 0. | 4.04  | 4.88  | 4.24  | 2.99  | 1.78  |
| 4. | 1. | 4. | 1. | 2.58  | 2.03  | 2.00  | 1.77  | 1.27  |
| 4. | 1. | 4. | 2. | 1.68  | 1.19  | 1.21  | 1.16  | .93   |
| 4. | 1. | 4. | 3. | 1.24  | .84   | .87   | .86   | .73   |
| 4. | 1. | 4. | 4. | .99   | .65   | .68   | .69   | .60   |
| 4. | 2. | 1. | 0. | 26.82 | 33.57 | 28.49 | 19.51 | 11.64 |
| 4. | 2. | 1. | 1. | 8.25  | 5.07  | 5.20  | 5.17  | 4.49  |
| 4. | 2. | 2. | 0. | 12.19 | 15.57 | 13.24 | 9.09  | 5.41  |
| 4. | 2. | 2. | 1. | 5.74  | 4.08  | 4.09  | 3.81  | 3.01  |
| 4. | 2. | 2. | 2. | 3.20  | 2.17  | 2.21  | 2.18  | 1.91  |
| 4. | 2. | 3. | 0. | 7.32  | 9.57  | 8.16  | 5.62  | 3.34  |
| 4. | 2. | 3. | 1. | 4.18  | 3.33  | 3.27  | 2.92  | 2.18  |
| 4. | 2. | 3. | 2. | 2.54  | 1.87  | 1.88  | 1.81  | 1.50  |
| 4. | 2. | 3. | 3. | 1.83  | 1.30  | 1.32  | 1.31  | 1.14  |
| 4. | 2. | 4. | 0. | 4.88  | 6.57  | 5.62  | 3.88  | 2.30  |
| 4. | 2. | 4. | 1. | 3.12  | 2.73  | 2.65  | 2.29  | 1.64  |
| 4. | 2. | 4. | 2. | 2.03  | 1.60  | 1.61  | 1.50  | 1.20  |
| 4. | 2. | 4. | 3. | 1.50  | 1.14  | 1.15  | 1.12  | .94   |
| 4. | 2. | 4. | 4. | 1.19  | .88   | .90   | .89   | .78   |
| 4. | 3. | 1. | 0. | 30.19 | 40.32 | 34.00 | 23.07 | 13.72 |
| 4. | 3. | 1. | 1. | 9.29  | 6.09  | 6.20  | 6.12  | 5.29  |
| 4. | 3. | 2. | 0. | 13.88 | 18.94 | 16.00 | 10.87 | 6.45  |
| 4. | 3. | 2. | 1. | 6.53  | 4.97  | 4.94  | 4.56  | 3.59  |
| 4. | 3. | 2. | 2. | 3.64  | 2.64  | 2.67  | 2.61  | 2.28  |
| 4. | 3. | 3. | 0. | 8.44  | 11.82 | 10.00 | 6.80  | 4.03  |
| 4. | 3. | 3. | 1. | 4.82  | 4.11  | 4.01  | 3.54  | 2.63  |
| 4. | 3. | 3. | 2. | 2.94  | 2.31  | 2.31  | 2.19  | 1.81  |
| 4. | 3. | 3. | 3. | 2.11  | 1.60  | 1.62  | 1.59  | 1.38  |
| 4. | 3. | 4. | 0. | 5.72  | 8.25  | 7.00  | 4.77  | 2.82  |
| 4. | 3. | 4. | 1. | 3.66  | 3.43  | 3.30  | 2.82  | 2.01  |
| 4. | 3. | 4. | 2. | 2.38  | 2.02  | 2.00  | 1.85  | 1.47  |
| 4. | 3. | 4. | 3. | 1.76  | 1.43  | 1.43  | 1.38  | 1.16  |
| 4. | 3. | 4. | 4. | 1.40  | 1.11  | 1.12  | 1.09  | .95   |
| 4. | 4. | 1. | 0. | 33.57 | 47.07 | 39.51 | 26.62 | 15.80 |
| 4. | 4. | 1. | 1. | 10.33 | 7.10  | 7.21  | 7.06  | 6.09  |
| 4. | 4. | 2. | 0. | 15.57 | 22.32 | 18.75 | 12.65 | 7.49  |
| 4. | 4. | 2. | 1. | 7.33  | 5.85  | 5.79  | 5.30  | 4.17  |
| 4. | 4. | 2. | 2. | 4.08  | 3.10  | 3.13  | 3.04  | 2.64  |
| 4. | 4. | 3. | 0. | 9.57  | 14.07 | 11.83 | 7.99  | 4.72  |
| 4. | 4. | 3. | 1. | 5.47  | 4.89  | 4.74  | 4.15  | 3.08  |
| 4. | 4. | 3. | 2. | 3.33  | 2.74  | 2.73  | 2.57  | 2.12  |
| 4. | 4. | 3. | 3. | 2.39  | 1.91  | 1.92  | 1.86  | 1.62  |
| 4. | 4. | 4. | 0. | 6.57  | 9.94  | 8.37  | 5.66  | 3.34  |
| 4. | 4. | 4. | 1. | 4.20  | 4.13  | 3.95  | 3.34  | 2.39  |
| 4. | 4. | 4. | 2. | 2.73  | 2.43  | 2.39  | 2.19  | 1.74  |
| 4. | 4. | 4. | 3. | 2.02  | 1.72  | 1.72  | 1.63  | 1.37  |
| 4. | 4. | 4. | 4. | 1.60  | 1.33  | 1.34  | 1.30  | 1.13  |

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