

**RAND**

*The Readiness  
Enhancement Model*

*A Personnel Inventory Projection  
Model of the Army's Reserve  
Components*

*Herbert J. Shukiar*

**Arroyo Center**

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## PREFACE

This report describes the Readiness Enhancement Model, a personnel inventory projection model for the Army's Reserve Components developed at RAND. It was used to support research carried out under the Arroyo Center's Reserve Component personnel readiness project. Project findings are described fully in Bruce Orvis et al., *Ensuring Personnel Readiness in the Army Reserve Components*, MR-659-A, 1996. The reader who intends to employ the model should find this report useful. Readers who do not plan to employ the model should also find portions of the report useful as a vehicle for understanding the inventory projection environment within which the model operates.

The project was designed to examine the true extent of cross-leveling during Operation Desert Shield/Storm, the reasons for it, the likelihood of serious personnel shortfalls in future deployments, and, based on these findings, the types of policies that could enhance the Reserve Components' readiness to deal with future contingencies. The model described in this report supported research designed to estimate how increased use of prior service experience and reduced Reserve Component attrition and job turbulence would affect job qualification rates and annual requirements for recruiting and training. The work was carried out within the Manpower and Training Program of RAND's Arroyo Center, a federally funded research and development center sponsored by the United States Army.

The reader who intends to employ the model should find this report useful. Readers who do not plan to employ the model should also find portions of the report useful as a vehicle for understanding the inventory projection environment within which the model operates.



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## **SUMMARY**

The Readiness Enhancement Model is a spreadsheet-based personnel inventory projection model of the Reserve Component enlisted inventory. It allows the analyst to estimate the effect on Reserve Component duty MOS qualification rates, job experience and annual recruiting and training requirements of changes in the use of prior active duty personnel and in the rate of personnel turnover, i.e., attrition and job turbulence.

The Reserve Component enlisted inventory is projected into the future on an annual basis until the inventory reaches a steady state. The inventory is characterized in terms of grade, duty MOS qualification status, nonprior and prior active service status, and accession status (newly accessed soldiers are distinguished from those in the force at least one year). Transition probabilities govern the inventory projection, reflecting how soldiers change duty MOS qualification status, jobs, and grade. The transition probabilities also govern attrition from the enlisted force.

The analyst can impose changes in attrition, job turbulence, and promotions by using transition probability adjustment factors. The initial inventory, active duty experience and the duty MOS qualification status of accessions can also be altered through the use of other adjustment factors.

Auxiliary spreadsheets enable the analyst to estimate several measures of merit, including accession and training requirements and their related costs, job experience levels (measured in full-time equivalent years), and the effects of reduced attrition on accessions. The analyst can also direct the use of several alternative base cases as the basis of comparison for a specific inventory projection.

This report describes the model. It describes all model inputs. It conceptually describes the computational algorithms used and how those algorithms are reflected in the spreadsheet itself. The report also describes some of the more sophisticated spreadsheet features utilized by the model, such as spreadsheet linking and analytic/recursive model specification.



## **ACKNOWLEDGMENTS**

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## ABBREVIATIONS

ARNG	Army National Guard, one of the Army's two Reserve Components
DMOSQ	Duty-MOS-qualified, i.e., a soldier is DMOSQ if he is qualified in the MOS associated with his assignment
E1-3 E4 E5 E6 E7-9	The enlisted pay grades tracked by the Readiness Enhancement Model; E1-3 and E7-9 are aggregate grades
MOS	Military occupation specialty: a numerical code indicating a skill possessed by a soldier or required by a specific position
NPS	Nonprior active service
NQ	Not qualified in the MOS associated with the soldier's assignment
ODS	Operation Desert Shield/Storm
PS	Prior active service
Q	Qualified in the MOS associated with the soldier's assignment
RC	Reserve Components, consisting of the Army National Guard and the United States Army Reserve
USAR	United States Army Reserve, one of the Army's two Reserve Components



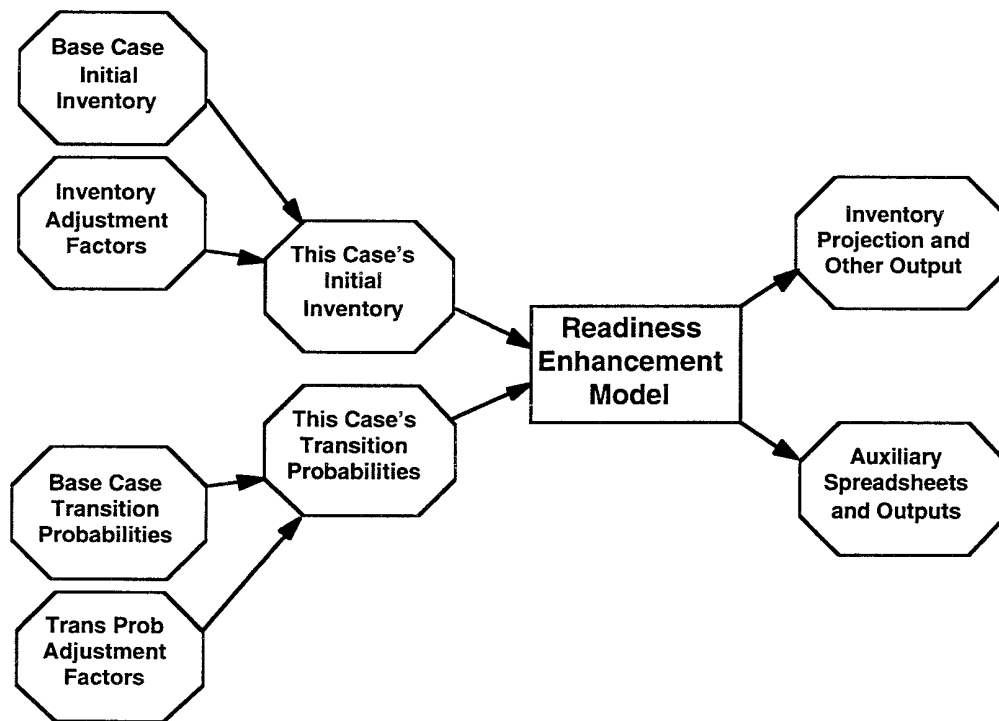


## 1. INTRODUCTION

During Operation Desert Shield/Storm (ODS), the United States Army mobilized about 145 thousand of its reserve forces. This required significant cross-leveling of reservists among units to bring the duty MOS qualification rates (DMOSQ rates) of those units up to the minimum required for deployment. On the whole, these cross-leveling actions took place very rapidly, usually during the one- to two-day intervals before and after a unit's official notification to report to its mobilization station.

The extent of this practice during ODS raised concern about the Army's ability to sustain the same degree of cross-leveling during future mobilizations, given the drawdown in military end strength since ODS. The Active Component is smaller. The Reserve Components are smaller. As a result, the Army does not now have the level of cross-leveling capability enjoyed during ODS. The Readiness Enhancement Model documented in this report examines how Reserve Component enlisted DMOSQ rates might be increased, thereby reducing the need to cross-level during future mobilizations. It allows the analyst to examine how improvements in the use of prior active duty personnel and in personnel turnover affect DMOSQ rates and other measures of effectiveness.

Figure 1.1 illustrates the relationships among the model's inputs and outputs. Conceptually, the model projects the Reserve Component inventory on an annual basis. The inventory is specified in terms of grade, prior active and nonprior active service, DMOSQ status, and whether or not the specific grade category represents recent accessions. Prior-service and nonprior-service cohorts are treated separately, i.e., a reservist cannot move from nonprior service to prior service. However, during the first several years of the inventory projection, the model holds the overall size of each grade constant by accessing only the new reservists needed to replace vacancies in the grade. After this initial interval, during which the analyst's policy inputs have had time to take hold, the accessions during the initial interval's final simulation year are used repeatedly for the remaining annual cycles until the force reaches a steady state.



**Fig. 1.1-Readiness Enhancement Model Schematic**

Transition probabilities govern how reservists move through the grade categories. During an annual cycle, several things can happen to a reservist: he can separate, change jobs, change DMOSQ status, and/or receive a promotion. Two or more of the latter three can happen simultaneously, e.g., an individual can change jobs, become duty MOS qualified, and receive a promotion during the same annual cycle.

As Figure 1.1 illustrates, the analyst can apply specific policy alternatives by adjusting appropriate base case transition probabilities, and the model provides a convenient mechanism to do so. For example, to estimate the effect of a 20 percent attrition reduction, the analyst can use an *attrition reduction factor* to reduce the base case attrition transition probabilities by 20 percent. This reduction is automatically distributed over the other transition probabilities, to ensure that they continue to sum to 100 percent. Similarly, the analyst can adjust turbulence- and promotion-related transition probabilities.

The analyst can apply other policy alternatives by adjusting the base case initial inventory. For example, to improve the DMOSQ rate of incoming accessions, a simple adjustment factor can be employed. Or if the analyst wishes to make excursions from more than one base case, several mechanisms are available to so specify.

Once the inventory is projected into the steady-state future, the model produces several measures of merit, including the projected DMOSQ rates and sizes of various inventory components. Additional measures of merit are produced by auxiliary spreadsheets. These include full-time equivalent years in the most recent job, training loads, and changes from the base case in various cost categories.

The remainder of this report describes the model's inputs, outputs, and computational logic. Section 2 presents a overview of the model. It describes the inventory's dimensions, the computations associated with an annual cycle, the distinction between the inventory projection in the first several years of the simulation and that in the remaining, *steady-state* years, and the annual accession *hierarchy* employed during the early inventory projection to ensure that the grade sizes remain constant.

Section 3 presents the model inputs and outputs. It describes how the initial inventory is specified, how adjustments are made to base case transition probabilities, how the job qualification levels of accessions can be adjusted, and how steady-state accessions can be adjusted during the steady-state segment of the inventory projection. This section also describes numerous output displays generated by the model.

Section 4 instructs how to employ the model. It guides the reader through the various spreadsheet displays used to determine the effects of specific input adjustments, and it helps the user to understand the issues associated with balancing promotion adjustments with attrition adjustments during an inventory projection. This section also describes the built-in error and warning messages that alert the analyst to undesirable inventory projection outcomes.

Section 5 describes the auxiliary spreadsheets that are used to generate additional model outputs. It describes how to estimate the impact on accession supply of reductions in attrition--a percentage of accessions arise from reservists who have had previous Reserve Component service, and reducing attrition reduces the supply of such accessions. The section also describes the *scorecard* or *trade-off summary* spreadsheet, which among other things shows the training load associated with the base case and excursions therefrom. The section also describes the cost spreadsheet in detail. It concludes with a discussion of how to keep track of the many excursions that might emerge from a single base case and the auxiliary spreadsheets that arise therefrom.

Finally, for model users familiar with spreadsheets but not necessarily adept at some of the spreadsheet capabilities employed in the model, an appendix treats selected spreadsheet system capabilities.

A companion document presents research findings: See Bruce Orvis et al., *Ensuring Personnel Readiness in the Army Reserve Components*, MR-659-A, 1996.

## **2. MODEL OVERVIEW**

The Readiness Enhancement Model is a spreadsheet-based model that projects the U.S. Army Reserve Components' (RC) enlisted inventory. In doing so the model annually calculates separations, lateral and promotion flows, job changes, and movements from duty-MOS-qualified to not-duty-MOS-qualified states and back. Transition probabilities govern these flows, and the analyst can examine the effects on the inventory of changes in attrition, turbulence, and promotions. The transition probabilities are specified over the full range of model dimensions.

In addition to the transition probabilities, independent variables include the starting inventory, annual accessions, and an array of adjustment factors that modify base case transition probabilities, accessions, and inventory to permit the analyst to easily specify excursions from base case inputs. For example, the analyst can alter the quantity of prior active service personnel accessed annually and the match rate of these soldiers' primary military occupational specialty (MOS) with their duty MOS.

### **MODEL DIMENSIONS**

The model identifies the RC inventory along the following dimensions:

Grade: E1-3, E4, E5, E6, E7-9

Prior active service/Nonprior active service

Duty-MOS-qualified/Not duty-MOS-qualified

Newly accessed/Not newly accessed

Grades E-1 through E-3 are combined, as are grades E-7 through E-9. A prior-service (PS) RC member is one with approximately two or more years of previous Active Component service. A nonprior-service (NPS) RC member has not had such previous Active Component service. An RC member cannot move from PS to NPS or from NPS to PS; e.g., an NPS enlisted who has had previous NPS service in the RC is still considered NPS, since he has had no prior Active Component service.

Enlistededs are considered to be newly accessed for one simulation year only, the year during which they are accessed. We make this distinction because the transition probabilities for newly accessed enlistededs in their first year of RC service differ substantially from those associated with enlistededs having more tenure.

Figure 2.1, which contains the base case starting inventory for the model, shows how these dimensions are captured in the spreadsheet. Note that there are two separate groupings: NPS and PS. Within each of these are four categorizations for each grade, called grade categories. Focusing on E1-3, we find the following:

E1-3 NEW NQ non-DMOSQ E1-3 accessions--  
NEW denotes accessions, and NQ denotes nonqualified

E1-3 NEW Q DMOSQ E1-3 accessions--Q denotes qualified

E1-3 OLD NQ non-DMOSQ E1-3 "old" enlistededs--OLD denotes enlistededs in the second or subsequent consecutive year of RC service

E1-3 OLD Q DMOSQ E1-3 "old" enlistededs.

The annual accessions are tracked in the first two categories, the *NEW* categories, shown in boldface type in the figure. We distinguish between those who come to the RC already duty-MOS-qualified and those who do not. Those already in the RC are tracked in the last two categories, the *OLD* categories, also distinguishing those who are duty-MOS-qualified and those who are not. Annual accessions can appear in all the grades. Further, it is possible for some RC enlistededs within a qualified (Q) category to move

STARTING INVENTORY			
NPS	E1-3 NEW NQ	<b>50939</b>	
	E1-3 NEW Q	<b>5305</b>	
	E1-3 OLD NQ	18718	
	E1-3 OLD Q	41580	
	E4 NEW NQ		
	E4 NEW Q	<b>2615</b>	
	E4 OLD NQ	14375	
	E4 OLD Q	65946	
	E5 NEW NQ	<b>1084</b>	
	E5 NEW Q	<b>1563</b>	
	E5 OLD NQ	8581	
	E5 OLD Q	35365	
	E6 NEW NQ	<b>286</b>	
	E6 NEW Q	<b>314</b>	
	E6 OLD NQ	4723	
	E6 OLD Q	19380	
	E7-9 NEW NQ		
	E7-9 NEW Q	<b>54</b>	
	E7-9 OLD NQ	3500	
	E7-9 OLD Q	11287	285614
PS	E1-3 NEW NQ	<b>1018</b>	
	E1-3 NEW Q	<b>1578</b>	
	E1-3 OLD NQ	556	
	E1-3 OLD Q	567	
	E4 NEW NQ	<b>4676</b>	
	E4 NEW Q	<b>14354</b>	
	E4 OLD NQ	8045	
	E4 OLD Q	23168	
	E5 NEW NQ	<b>2927</b>	
	E5 NEW Q	<b>5005</b>	
	E5 OLD NQ	10520	
	E5 OLD Q	35319	
	E6 NEW NQ	<b>580</b>	
	E6 NEW Q	<b>962</b>	
	E6 OLD NQ	7240	
	E6 OLD Q	27443	460000
	E7-9 NEW NQ		
	E7-9 NEW Q	<b>397</b>	460000
	E7-9 OLD NQ	7766	
	E7-9 OLD Q	22264	174386

Fig. 2.1-Model Dimensions

to nonqualified (NQ) during the course of a simulated year, as dictated by the transition probabilities associated with that category. The same is also true for those who begin the year as NQ; they can move to Q during the year, also dictated by the appropriate transition probabilities. In all, the model identifies 40 grade categories, 20 for NPS and 20 for PS.

The figure (and spreadsheet) also indicates the total number of NPS and PS enlisteds in the inventory (285,614 and 174,386, respectively), as well as the total enlisted RC force size (460,000). The italicized total force number is computed differently than the nonitalicized number as an automatic model consistency check feature.

#### **A WALK THROUGH AN ANNUAL MODEL CYCLE**

For each grade category (four per grade in the NPS force, and four per grade in the PS force), there are nine transition probabilities that govern the inventory flows during a simulation year. Figure 2.2 contains base case transition probabilities. The first transition probability is the fraction of RC enlisteds in the grade category who leave the RC during the year. Following that are two sets of four transition probabilities each, one set for those RC enlisteds who do not get promoted during the year and one set for those who receive a one-grade promotion during the year; because it is a rarity, promotions of more than one grade during a year are not treated. Each set of four includes the following four transition probabilities:

STABLE NQ	Those who remain in the same duty MOS during the year and end up not-DMOSQ at the end of the year
STABLE Q	Those who remain in the same duty MOS during the year and end up DMOSQ at the end of the year
MOVE NQ	Those who change duty MOS during the year and end up not-DMOSQ at the end of the year
MOVE Q	Those who change duty MOS during the year and end up DMOSQ at the end of the year

The transition probabilities associated with the E1-3 grade categories apply to the aggregated grade, i.e., the model does not try to capture internal movements among grades E1, E2, and E3. This means that the promotion transition probabilities reflect only promotions to E4 from E3. Similarly, for the E7-9 grade no attempt is made to capture internal movements among the E7, E8, and E9 grades. This is why we see no promotion transition probabilities for the E7-9 grade in Figure 2.2--there can be no

promotions out of this aggregate grade because there is no higher grade into which a reservist can be promoted.

BASE CASE TRANSITION PROBABILITIES											
		STAY WITHIN GRADE				ONE GRADE PROMOTION				checksum	
		STABLE		MOVE		STABLE		MOVE			
		LEAVE	NQ	Q	NQ	Q	NQ	Q	NQ		Q
NPS	E1-3 NEW NQ	0.2331	0.1443	0.4284	0.0878	0.0400	0.0046	0.0494	0.0061	0.0062	1.0000
	E1-3 NEW Q	0.3920	0.0092	0.1742	0.0586	0.0136	0.0021	0.2654	0.0551	0.0297	1.0000
	E1-3 OLD NQ	0.3406	0.1543	0.1633	0.0792	0.0464	0.0363	0.1239	0.0240	0.0320	1.0000
	E1-3 OLD Q	0.2822	0.0023	0.2957	0.0497	0.0120	0.0014	0.3008	0.0351	0.0206	1.0000
	E4 NEW NQ	0.3079	0.1614	0.2652	0.1211	0.0692	0.0074	0.0461	0.0074	0.0144	1.0000
	E4 NEW Q	0.3407	0.0082	0.4232	0.1021	0.0395	0.0010	0.0666	0.0068	0.0121	1.0000
	E4 OLD NQ	0.2558	0.2538	0.1751	0.1225	0.1148	0.0134	0.0361	0.0102	0.0183	1.0000
	E4 OLD Q	0.2156	0.0026	0.5722	0.0759	0.0327	0.0010	0.0841	0.0086	0.0074	1.0000
	E5 NEW NQ	0.2220	0.2038	0.2652	0.1654	0.0874	0.0070	0.0304	0.0070	0.0117	1.0000
	E5 NEW Q	0.2765	0.0090	0.4681	0.1138	0.0469	0.0023	0.0587	0.0124	0.0124	1.0000
	E5 OLD NQ	0.1587	0.3176	0.1877	0.1372	0.1299	0.0117	0.0299	0.0113	0.0160	1.0000
	E5 OLD Q	0.1507	0.0036	0.6582	0.0840	0.0327	0.0007	0.0591	0.0059	0.0051	1.0000
	E6 NEW NQ	0.1961	0.3009	0.2563	0.1393	0.0836	0.0060	0.0060	0.0060	0.0060	1.0000
	E6 NEW Q	0.2236	0.0041	0.5245	0.1301	0.0610		0.0393	0.0131	0.0044	1.0000
	E6 OLD NQ	0.1258	0.3515	0.1823	0.1425	0.1368	0.0085	0.0260	0.0101	0.0165	1.0000
	E6 OLD Q	0.1007	0.0036	0.7238	0.0870	0.0384	0.0009	0.0365	0.0042	0.0048	1.0000
	E7-9 NEW NQ	0.2595	0.2645	0.2380	0.1058	0.1322					1.0000
	E7-9 NEW Q	0.2492	0.0215	0.5685	0.1180	0.0429					1.0000
	E7-9 OLD NQ	0.1002	0.4049	0.1448	0.2170	0.1331					1.0000
	E7-9 OLD Q	0.0801	0.0026	0.7871	0.0967	0.0334					1.0000
PS	E1-3 NEW NQ	0.2931	0.1695	0.0809	0.1063	0.0231	0.0706	0.1516	0.0477	0.0572	1.0000
	E1-3 NEW Q	0.3677	0.0013	0.1486	0.0584	0.0152	0.0018	0.3138	0.0652	0.0281	1.0000
	E1-3 OLD NQ	0.3972	0.1811	0.0660	0.1008	0.0366	0.0595	0.0949	0.0310	0.0329	1.0000
	E1-3 OLD Q	0.4582	0.0007	0.2473	0.0422	0.0089	0.0015	0.2024	0.0249	0.0139	1.0000
	E4 NEW NQ	0.3254	0.2103	0.1838	0.1299	0.0749	0.0085	0.0433	0.0077	0.0161	1.0000
	E4 NEW Q	0.3344	0.0036	0.4433	0.0867	0.0348	0.0009	0.0790	0.0079	0.0093	1.0000
	E4 OLD NQ	0.3039	0.2508	0.1500	0.1232	0.0791	0.0145	0.0475	0.0116	0.0193	1.0000
	E4 OLD Q	0.2428	0.0034	0.4965	0.0767	0.0347	0.0012	0.1195	0.0134	0.0118	1.0000
	E5 NEW NQ	0.2534	0.2420	0.1914	0.1588	0.0875	0.0075	0.0346	0.0084	0.0164	1.0000
	E5 NEW Q	0.2639	0.0039	0.4755	0.0990	0.0427	0.0007	0.0942	0.0105	0.0096	1.0000
	E5 OLD NQ	0.1718	0.3071	0.1615	0.1517	0.1161	0.0148	0.0425	0.0139	0.0205	1.0000
	E5 OLD Q	0.1388	0.0037	0.6360	0.0884	0.0398	0.0007	0.0752	0.0083	0.0091	1.0000
	E6 NEW NQ	0.2516	0.2573	0.1988	0.1476	0.0976	0.0078	0.0183	0.0092	0.0118	1.0000
	E6 NEW Q	0.2581	0.0080	0.4702	0.1048	0.0609	0.0032	0.0721	0.0140	0.0086	1.0000
	E6 OLD NQ	0.1317	0.3466	0.1591	0.1591	0.1315	0.0114	0.0235	0.0143	0.0228	1.0000
	E6 OLD Q	0.1020	0.0034	0.6854	0.0880	0.0561	0.0006	0.0513	0.0057	0.0074	1.0000
	E7-9 NEW NQ	0.2099	0.2584	0.1640	0.2336	0.1342					1.0000
	E7-9 NEW Q	0.1517	0.0088	0.6919	0.0749	0.0727					1.0000
	E7-9 OLD NQ	0.1066	0.4009	0.1160	0.2383	0.1382					1.0000
	E7-9 OLD Q	0.0870	0.0054	0.7628	0.1017	0.0432					1.0000

**Fig. 2.2-Base Case Transition Probability Illustration**

The nine transition probabilities dictate all movement of RC enlisteds in the grade category during a simulation year and must therefore add to 1.0--the check sum in Figure 2.2 verifies that this is the case. The movements are illustrated in Figure 2.3, which we use to demonstrate how soldiers can flow into the NPS E4 OLD Q state. Similar flows apply to other grades as well. This figure represents the annual cycle from the beginning of a simulation year to the end of that year.



		BEGINNING STATE	LEAVE	STAY WITHIN GRADE				ONE GRADE PROMOTION				ENDING STATE	CHECK SUMS
				STABLE		MOVE		STABLE		MOVE			
				NQ	Q	NQ	Q	NQ	Q	NQ	Q		
NPS	E1-3 NEW NQ	50939	11875	7352	21822	4472	2039	235	2516	310	317		
	E1-3 NEW Q	5305	2080	49	924	311	72	11	1408	293	158		
	E1-3 OLD NQ	18718	6375	2888	3056	1483	869	680	2319	449	599	18718	18718
	E1-3 OLD Q	41580	11735	97	12296	2065	501	59	12508	1459	858	41580	41580
	E4 NEW NQ	0	0	0	0	0	0	0	0	0	0		
	E4 NEW Q	2615	891	21	1106	267	103	3	174	18	32		
	E4 OLD NQ	14375	3677	3649	2517	1761	1650	192	519	146	264	14375	14375
	E4 OLD Q	65946	14221	173	37731	5007	2154	64	5544	564	487	65946	65946
End year NPS E4 OLD Q													

**Fig. 2.3-Moving into the NPS E4 Old Qualified State**

We begin with the inventory at the beginning of the year. That is illustrated in the BEGINNING STATE column. The model applies the appropriate transition probabilities to determine what happens to the inventory during the year. For example, the NPS E1-3 NEW NQ beginning inventory (50939) is multiplied by the row of transition probabilities associated with NPS E1-3 NEW NQ, which results in the rest of the values in the row. Each of the 40 beginning-year grade category values is similarly expanded--we show eight such expansions in Figure 2.3, i.e., the eight grade categories that can flow into NPS E4 OLD Q.

Our objective is to determine how many E1-3s and E4s end up in the NPS E4 OLD Q grade category at the end of the year. The number ending up in NPS E4 OLD Q is the sum of all the flows into this state, i.e., the unshaded italicized values. A soldier can get to E4 OLD Q from the grade of E1-3 by receiving a promotion and ending up in a qualified state: the eight unshaded E1-3 values, all of which reflect soldiers who receive promotions and end up qualified. Soldiers already in the grade of E4 can end up in E4 OLD Q by staying within the E4 grade and ending up in a qualified state: the eight unshaded E4 values. The ending state value of 65,946 is the sum of all sixteen values.<sup>1</sup>

<sup>1</sup>The careful reader may note that the sixteen numbers actually sum to 65944. This is due to round-off in the figure, which does not include the fractional values. The careful reader may also note that the OLD beginning state and ending state values are identical. This is because the illustrative example we are using for this report is the base case, which begins in a steady-state, implying that the flows into and out of the model states do not vary from year to year.

For model debugging purposes, the check sum column performs the computations in a different manner, starting with the NPS E4 OLD Q beginning state, subtracting the seven flows out of the grade category, and adding the 14 flows into the grade category. The seven flows out of the grade category include those who leave the force (one flow), those who stay within the same grade but end up nonqualified (two flows), and those who are promoted to the grade of E5 (four flows). The 14 flows into the grade category include all promotions from E1-3 who end up qualified (eight flows) and all same-grade flows within E4 who end up qualified (six flows--we do not include the two E4 OLD Q qualified flows, since they are already counted in the beginning state).

The two computations are performed as an automatic check on model arithmetic. If the two computations do not produce the same value, then the model arithmetic is in error. This has proved to be a valuable debugging mechanism.

Similar computations are performed for NPS E4 OLD NQ, except that the NQ values are employed instead. Additionally, for the E1-3 grade, only E1-3 values are employed for each old category, since there are no promotions into this grade.

Finally, there are no flows into the NEW grade categories except via annual accessions. This is why the ENDING STATE values are zero for the NEW grade categories--accessions appear at the beginning of each model year.

#### **Determining Annual Accessions During the First Nine Simulation Years**

To conclude the annual cycle we must now determine the needed number of annual accessions. During the inventory projection's first nine years, annual accessions are not fully independent variables--accession processing during the tenth and subsequent inventory projection years are described below in the subsection entitled "Dynamic and Analytic Inventory Projection". The analyst specifies the accessions he wishes to impose annually as a maximum accession supply. They are specified by PS/NPS, grade, and DMOSQ vs. not-DMOSQ. Referring back to Figure 2.1, accession values can be specified for each of the NEW categories listed in that figure.

While the analyst can specify the accession supply, the model determines the actual accessions needed during a year based on inventory needs. For example, suppose the analyst-specified accession supply totals

80,000, but the model determines that only 50,000 are needed to meet a specific year's inventory constraint. The model will access only 50,000. However, the model will use the analyst-specified accession supply (the *NEW* categories in Figure 2.1) as a guide to determine how to distribute the 50,000 accessions over the grade categories. In making this determination the model imposes an accession hierarchy *within each grade* that favors qualified accessions over nonqualified accessions and favors prior service accessions over nonprior service accessions, as shown below:

ACCESSION HIERARCHY WITHIN A GRADE

PS qualified  
NPS qualified  
PS not qualified  
NPS not qualified

The model determines accessions separately within each grade, the objective being to keep the total grade size constant during the first nine years. Within each grade the model first takes accessions from PS qualified grade categories. The number taken from a specific category (say PS E5 NEW Q) is determined by the total number of RC enlistededs needed to meet the grade's total size requirement, including both NPS and PS forces. If fewer are needed than the supply specified for the category, then the model takes only the number permitted, and no more accessions into that grade are taken. If more are needed in the grade, then the NPS qualified category is examined next. The model moves in this fashion through the accession hierarchy until all accessions needed for the grade are taken or until the analyst-specified accession supply is exhausted.

If the hierarchy does not provide for the exact number needed within the grade, then the surplus (or deficit) is made up by adjusting the number of accessions taken for the NPS E1-3 NEW NQ grade category. In this manner the total force size is preserved even though the sizes within each of the grades may not be. The model may exceed the maximum specified accessions for NPS E1-3 NEW NQ.

The accession hierarchy is biased first towards taking qualified accessions, with PS favored over NPS. Once a grade's qualified accession supply has been exhausted, the hierarchy then moves to unqualified accessions, again favoring PS over NPS. In one analysis excursion from the base case, where the objective was to achieve a PS force size of 230,000 (50 percent of the RC enlisted force), it was necessary to alter the

accession hierarchy to favor PS accessions over NPS accessions. In this excursion, the hierarchy was PS Q, PS NQ, NPS Q, NPS NQ.

#### **Meeting Grade or PS/NPS Force Size Requirements**

Although the model attempts to meet specific grade size requirements, it is possible that they cannot be met. For example, there may be insufficient separations from and promotions out of a grade during a given year, and this, coupled with promotions into the grade, could lead to an excess of enlisted in the grade. All of these actions are governed by transition probabilities, and the analyst can apply adjustment factors to specific transition probabilities to increase separations, reduce promotions, and otherwise affect model actions.

It is also possible and quite likely that the size of the NPS and PS forces will change during the course of the inventory projection. The model attempts to preserve only the overall grade sizes and does not attempt to keep the PS and NPS sizes constant. Again, with appropriate adjustment factors, the analyst can adjust transition probabilities in an attempt to bring the PS and NPS force sizes back to their original values. We will revisit these issues when we discuss the adjustment factors and how they affect transition probabilities.

#### **Dynamic and Analytic Inventory Projection**

The accession hierarchy is employed during the first nine years of the simulation. Accessions are determined, in accord with the hierarchy, to meet overall grade size requirements. After the ninth year the model suspends the hierarchy and projects the force to steady state. It does so by using the ninth-year accessions continuously until the force converges.

Under normal circumstances, i.e., where the specific case's inputs do not deviate too much from those of the base case, the model does not have difficulty meeting force size requirements *during the first nine years*. The accession hierarchy assures that this is the case. PS and NPS force sizes may not be preserved, but the grade and total force sizes remain constant.

After the ninth year, however, when the model uses ninth-year accessions to project the inventory to steady state, the model's goal is not to preserve grade and total force size but to converge. The transition probabilities and accessions are held constant over the remaining years of the inventory projection, and the model will converge to a steady-state solution. This is akin to asking, "What happens when we introduce the same

accessions year after year assuming no change in soldier behavior, i.e., assuming no change in transition probabilities?" The answer is the steady-state force structure.<sup>2</sup>

Why do we not seek a steady-state solution beginning in the simulation's first year? Why wait until year nine? We want to give the analyst's directives, as reflected in model inputs, a chance to influence the force, and only after that point do we want to seek a steady-state, converged force structure. Generally, the analyst's directives, coupled with the accession hierarchy during the first nine years, causes the actual accessions to fall below the maximum permitted accessions, and experience running the model has indicated that nine years is sufficient time for these accessions to stabilize.

We have chosen to call the inventory projection during the first nine years the dynamic projection. We call the steady-state inventory projection after the ninth year the analytic projection. Indeed, the spreadsheet contains nine identically configured sections for the first nine years, and one additional section for the steady-state years. Model logic applies the accession hierarchy to the first nine years. The steady-state segment is defined in a circular, or analytic, manner, in terms of itself. This is possible because the spreadsheet system we use<sup>3</sup> allows for the circular definition of specific cells and for the iteration of the computations until convergence is reached.

In the case of the Readiness Enhancement Model, the cells that are defined circularly are the OLD beginning and ending states, as shown in Figure 2.3. The OLD Nth year beginning state is defined to equal the OLD ending state. The NEW states are defined to be equal to ninth-year

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<sup>2</sup>It is mathematically possible, although highly unlikely, to generate transition probabilities that do not lead to a converged force structure. Such transition probabilities would be highly contrived and not realistic, and we don't expect such transition probabilities to emerge during normal model use and reasonable transition probability adjustments. For example, consider transition probabilities for a grade that only change soldiers from qualified to not qualified, or from not qualified to qualified, i.e., no attrition, no promotion, but just a 100 percent movement from qualified to not qualified and back. In this situation convergence is not possible no matter how many years into the future the force is projected, because during any annual cycle all not-qualified soldiers will become qualified, and all qualified soldiers will become not-qualified. Such oscillation, while mathematically possible, is not realistic in our opinion and very unlikely to emerge from analyst adjustment of realistic transition probabilities.

<sup>3</sup>During the analysis we used Microsoft EXCEL version 4.0 for the Macintosh, and all spreadsheet illustrations are based on this version.

accessions. In this manner the model infuses the force with ninth-year accessions annually. By defining each OLD beginning state as equal to its associated OLD ending state, and by employing the spreadsheet system's iteration feature, the model can converge to the steady-state solution. This convergence, depending on the convergence tolerance the analyst specifies, occurs after about 30 to 40 iterations.

### 3. INPUTS AND OUTPUTS

This section discusses the more general model inputs and outputs. In the process it also describes some of the operating characteristics of the spreadsheet model.

Model inputs appear in the first few pages of the spreadsheet.<sup>4</sup> They come in three parts. The first part, found on the first two spreadsheet pages, comprises the base case inputs, i.e., the initial inventory, accession supply and transition probabilities associated with the base case. Subsequent pages contain the inputs associated with the specific analysis case, reflecting how the base case inputs have been altered to reflect analyst directives.

MODEL IDENTIFIER: R22-940614									
BASE CASE STARTING INVENTORY									
				(from data)		Proportionally increased to 460K			
NPS	E1-3 NEW NQ	50859						50939	
	E1-3 NEW Q	5297						5305	
	E1-3 OLD NQ	18689						18718	
	E1-3 OLD Q	41515						41580	
	E4 NEW NQ								
	E4 NEW Q	2610						2615	
	E4 OLD NQ	14353						14375	
	E4 OLD Q	65843						65946	
	E5 NEW NQ	1082						1084	
	E5 NEW Q	1560						1563	
	E5 OLD NQ	8568						8581	
	E5 OLD Q	35310						35365	
	E6 NEW NQ	286						286	
	E6 NEW Q	313						314	
	E6 OLD NQ	4716						4723	
	E6 OLD Q	19350						19380	
	E7-9 NEW NQ								
	E7-9 NEW Q	54						54	
	E7-9 OLD NQ	3495						3500	
	E7-9 OLD Q	11269	285169					11287	285614
PS	E1-3 NEW NQ	1016						1018	
	E1-3 NEW Q	1576						1578	
	E1-3 OLD NQ	555						556	
	E1-3 OLD Q	566						567	
	E4 NEW NQ	4669						4676	
	E4 NEW Q	14332						14354	
	E4 OLD NQ	8033						8045	
	E4 OLD Q	23132						23168	
	E5 NEW NQ	2922						2927	
	E5 NEW Q	4997						5005	
	E5 OLD NQ	10504						10520	
	E5 OLD Q	35264						35319	
	E6 NEW NQ	579						580	
	E6 NEW Q	961						962	
	E6 OLD NQ	7228						7240	
	E6 OLD Q	27401						27443	460000
	E7-9 NEW NQ								
	E7-9 NEW Q	397			459283			397	460000
	E7-9 OLD NQ	7754						7766	
	E7-9 OLD Q	22230	174114	459283				22264	174386

Fig. 3.1-Base Case Starting Inventory

<sup>4</sup>Adjustment factors are actually specified on the last spreadsheet page, but all the model input values appear in the first five pages for easy reference.

## **BASE CASE STARTING INVENTORY**

Figure 3.1 shows the base case starting inventory and annual accession supply, shown in bold for each of the new categories. The model is currently designed to work with an enlisted force size of 460,000. The starting inventory "from data", the figure's first numerical column, is the inventory that emerged from transition probability and other adjustments required to create a steady-state force, i.e., one whose grade, PS, NPS, and total force sizes remain invariant from year to year. In creating this force we employed what we call the *one percent rule*, which deems a force to be acceptable if its grade, PS, NPS, and total force sizes fall within one percent of target. The "from data" column is this force. The right-most column is the same force, adjusted proportionally to 460,000.

The annual accession supply numbers are also shown in Figure 3.1. They are the force sizes, shown in boldface type, associated with each of the NEW grade categories.<sup>5</sup> Only through direct analyst intervention can this supply be altered. Further, they are maximum accessions; the actual accessions during a given annual cycle are determined based on the accession hierarchy discussed in Section 2.

Finally, the spreadsheet also allows the analyst to specify a model identifier. We have found it necessary to modify the model from time to time to reflect special operational needs. The model identifier permits the analyst to determine which model version was employed in creating a specific inventory projection.

## **BASE CASE TRANSITION PROBABILITIES**

Figure 2.2 shows base case transition probabilities. Those are the transition probabilities that produced the base case inventory reflected in Figure 3.1. These probabilities were derived from actual 1992-93 data. The 1992-93 data, which are based on an RC force in the midst of the drawdown, are not in steady state. We developed the base case transition probabilities by making modest adjustments to the 1992-93 transition probabilities, the goal being to create a post-drawdown steady-state force. Table C-3 of the companion document presents those adjustment factors.

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<sup>5</sup>The analysis assumes that the accession supply and its distribution over the PS/NPS, grades and qualified/not qualified characteristics are reflected in the base case steady-state starting inventory, especially as related to the qualified/not qualified characteristic. Were more qualified accessions available in the base case, then they would have been accessed before the nonqualified accessions. The analyst can alter the accession supply in several ways, as discussed elsewhere in this section.



### **Force Projection Summary**

These transition probabilities, coupled with the base case force of Figure 3.1, lead to the force projection shown in Figure 3.2. Note that all grade category sizes are preserved from year to year, including during the steady-state years beyond year nine, where use of the accession hierarchy is suspended. This is because of the adjustments made to the 1992-93 transition probabilities to ensure that the base case force begins in a steady state. Excursions from the base case lead to new force structures, most of which preserve total grade size and total force size to the extent dictated by the *one percent* rule, but which differ from the base case force in the distribution of enlisteds among OLD and NEW, DMOSQ and not-DMOSQ, and PS and NPS categories.

FORCE PROJECTION SUMMARY											
		1	2	3	4	5	6	7	8	9	STEADY
		START	START	START	START	START	START	START	START	START	STATE
NPS	E1-3 NEW NQ	50939	50939	50939	50939	50939	50939	50939	50939	50939	50939
	E1-3 NEW Q	5305	5305	5305	5305	5305	5305	5305	5305	5305	5305
	E1-3 OLD NQ	18718	18718	18718	18718	18718	18718	18718	18718	18718	18718
	E1-3 OLD Q	41580	41580	41580	41580	41580	41580	41580	41580	41580	41580
	E4 NEW NQ										
	E4 NEW Q	2615	2615	2615	2615	2615	2615	2615	2615	2615	2615
	E4 OLD NQ	14375	14375	14375	14375	14375	14375	14375	14375	14375	14375
	E4 OLD Q	65946	65946	65946	65946	65946	65946	65946	65946	65946	65946
	E5 NEW NQ	1084	1084	1084	1084	1084	1084	1084	1084	1084	1084
	E5 NEW Q	1563	1563	1563	1563	1563	1563	1563	1563	1563	1563
	E5 OLD NQ	8581	8581	8581	8581	8581	8581	8581	8581	8581	8581
	E5 OLD Q	35365	35365	35365	35365	35365	35365	35365	35365	35365	35365
	E6 NEW NQ	286	286	286	286	286	286	286	286	286	286
	E6 NEW Q	314	314	314	314	314	314	314	314	314	314
	E6 OLD NQ	4723	4723	4723	4723	4723	4723	4723	4723	4723	4723
	E6 OLD Q	19380	19380	19380	19380	19380	19380	19380	19380	19380	19380
	E7-9 NEW NQ										
	E7-9 NEW Q	54	54	54	54	54	54	54	54	54	54
	E7-9 OLD NQ	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
	E7-9 OLD Q	11287	11287	11287	11287	11287	11287	11287	11287	11287	11287
PS	E1-3 NEW NQ	1018	1018	1018	1018	1018	1018	1018	1018	1018	1018
	E1-3 NEW Q	1578	1578	1578	1578	1578	1578	1578	1578	1578	1578
	E1-3 OLD NQ	556	556	556	556	556	556	556	556	556	556
	E1-3 OLD Q	567	567	567	567	567	567	567	567	567	567
	E4 NEW NQ	4676	4676	4676	4676	4676	4676	4676	4676	4676	4676
	E4 NEW Q	14354	14354	14354	14354	14354	14354	14354	14354	14354	14354
	E4 OLD NQ	8045	8045	8045	8045	8045	8045	8045	8045	8045	8045
	E4 OLD Q	23168	23168	23168	23168	23168	23168	23168	23168	23168	23168
	E5 NEW NQ	2927	2927	2927	2927	2927	2927	2927	2927	2927	2927
	E5 NEW Q	5005	5005	5005	5005	5005	5005	5005	5005	5005	5005
	E5 OLD NQ	10520	10520	10520	10520	10520	10520	10520	10520	10520	10520
	E5 OLD Q	35319	35319	35319	35319	35319	35319	35319	35319	35319	35319
	E6 NEW NQ	580	580	580	580	580	580	580	580	580	580
	E6 NEW Q	962	962	962	962	962	962	962	962	962	962
	E6 OLD NQ	7240	7240	7240	7240	7240	7240	7240	7240	7240	7240
	E6 OLD Q	27443	27443	27443	27443	27443	27443	27443	27443	27443	27443
	E7-9 NEW NQ										
	E7-9 NEW Q	397	397	397	397	397	397	397	397	397	397
	E7-9 OLD NQ	7766	7766	7766	7766	7766	7766	7766	7766	7766	7766
	E7-9 OLD Q	22264	22264	22264	22264	22264	22264	22264	22264	22264	22264

**Fig. 3.2-Base Case Force Projection**

#### **PROMOTION, TURBULENCE, ATTRITION AND ACCESSION ADJUSTMENTS**

Figure 3.3 illustrates a number of adjustment factors. The most notable are those governing promotion, attrition, and turbulence transition probabilities. Other adjustment factors are included that govern the level of accessions, the size of the force, and any promotion penalty to levy against the E1-3 grade. Further, the analyst can impose adjustments on all NPS and PS adjustment factors by simply employing the spreadsheet cells provided for this.

	ADJUSTMENT FACTORS			
	PROMOTION	ATTRITION	TURBULENCE	ACCESSIONS
NPS E1-3	1.00000	1.00000	1.00000	1.00000
E4	1.00000	1.00000	1.00000	1.00000
E5	1.00000	1.00000	1.00000	1.00000
E6	1.00000	1.00000	1.00000	1.00000
E7-9	1.00000	1.00000	1.00000	1.00000
PS E1-3	1.00000	1.00000	1.00000	1.00000
E4	1.00000	1.00000	1.00000	1.00000
E5	1.00000	1.00000	1.00000	1.00000
E6	1.00000	1.00000	1.00000	1.00000
E7-9	1.00000	1.00000	1.00000	1.00000
NPS adjustments	1.00000	1.00000	1.00000	1.00000
PS adjustments	1.00000	1.00000	1.00000	1.00000
100.00%	END STRENGTH ADJUSTMENT FACTOR			
		E1-3 Promotion Penalty		

**Fig. 3.3-Promotion, Attrition, Turbulence, and Accession Adjustments**

The values in the figure indicate that no adjustments are being made. Base case promotion, attrition, and turbulence transition probabilities are effectively being multiplied by 1.00000, as are annual accessions. The end strength is being kept at 100 percent of the base case, and we are imposing no promotion penalty on the grade of E1-3.

#### **Promotion, Attrition, and Turbulence Adjustments**

We employ these adjustment factors to create excursions from the base case of interest to the analyst. For example, if the analyst wishes to examine the implications of reducing attrition by 10 percent across the board, he can impose this by setting the associated NPS and PS attrition adjustment to 0.9, which effectively multiplies all attrition transition probabilities by 0.9. Reducing attrition in this manner means that fewer soldiers will leave the RC, and grade creep will likely result.<sup>6</sup> To compensate for grade creep we can also reduce promotions in a manner that keeps the grade sizes constant over time. We frequently have also found it necessary to reduce E1-3 promotions more severely through use of the E1-3

<sup>6</sup>Grade creep in this context is the growth in the E4-9 grades that results from lower attrition accompanied by the decline in the E1-3 grade. The E1-3 grade declines during the first nine years of the inventory projection because the model sets NPS E1-3 NEW NQ accessions to a level needed to meet the total force size requirement. The decline is likely to continue during the remaining years because these reduced accessions are applied annually until convergence occurs.

promotion penalty. We explore these issues in Section 4, where we describe methodologies we have developed to balance promotion, turbulence, and attrition adjustment factors.

### Redistributing Transition Probability Adjustments

Transition probabilities for a grade category must add to 1.0. Any change to a transition probability must be accompanied by an opposite change in some or all of the others. For example, a 10 percent reduction in one of a grade category's transition probabilities must be countered by increases in other transition probabilities that exactly balance the reduction. Figure 3.4 illustrates the rules governing this balancing process.

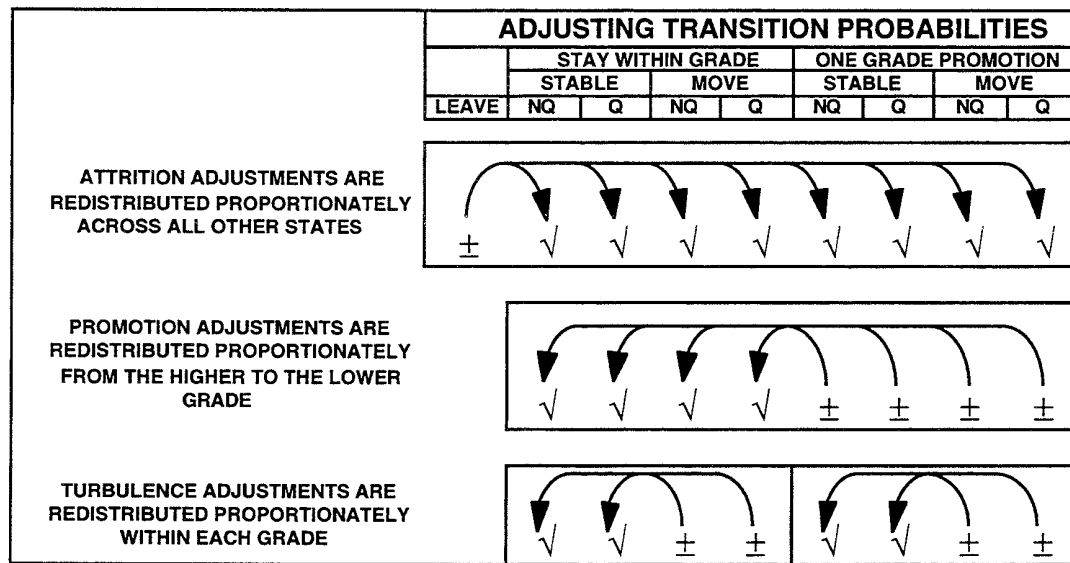


Fig. 3.4-Transition Probability Adjustment Balancing

In the figure, the  $\pm$  entries indicate the transition probabilities that the analyst is adjusting through the adjustment factors in Figure 3.3. The  $\checkmark$  entries indicate the transition probabilities that are being balanced to compensate for the  $\pm$  adjustment. For attrition, all adjustments are redistributed proportionately across the remaining eight transition probabilities. A promotion adjustment causes all of a grade category's promotion transition probabilities to be altered as dictated by the promotion adjustment factor, with the sum of the alterations distributed proportionately over the four lower grade transition probabilities. A turbulence adjustment causes all turbulence transition probabilities to be altered, but the redistribution does not cross grade boundaries. The sum of the two same-grade alterations is distributed proportionately over the

two same-grade stable transition probabilities, and the sum of the one-grade-promotion alterations is distributed over the one-grade-promotion stable transition probabilities.

The attrition transition probability does not participate in the balancing of either promotion or turbulence transition probability adjustments. One might argue that a reduction in promotions might cause an increased attrition response, i.e., reduced promotions might result in increased attrition. However, to more appropriately estimate the attrition response requires econometric modeling, which is beyond the scope of this analysis. We have chosen therefore to keep attrition independent of the promotion and turbulence balancing process.

### Accession Adjustments

The accession adjustment factor differs from the promotion, attrition, and turbulence adjustment factors in that it affects the number of accessions in each NPS/PS-grade pair. The analyst can reduce or increase the accession supply individually or across the board.

### ACCESSION DMOSQ ADJUSTMENTS

When making DMOSQ adjustments to accessions, the analyst can directly alter the distribution of an NPS/PS-grade pair's qualified and unqualified accessions. The total number of accessions associated with the NPS/PS-grade pair is not altered, only how those accessions are allocated between Q and NQ.

Figure 3.5 illustrates how the analyst can specify these adjustments. In the example no adjustment is being made, the multiplier being 1.0000.

However, if the analyst wishes to increase E5 PS Q accessions by 25 percent at the expense of PS NQ accessions, he would

place 1.25 in the E5 PS slot. The model would appropriately alter the base case accession supply for the E5 PS Q and E5 PS NQ grade categories. Were there not enough E5 PS NQ accessions to support a 25 percent increase in E5 PS Q accessions, the adjusted accession supply would be modified only to the level that the E5 PS NQ accessions could support, zeroing the

DUTY MOS QUALIFICATION ACCESSION ADJUSTMENT FACTORS		
	NPS	PS
E1-3	1.0000	1.0000
E4	1.0000	1.0000
E5	1.0000	1.0000
E6	1.0000	1.0000
E7-9	1.0000	1.0000

**Fig. 3.5-Adjusting Accession  
"Quality"**

accessions supply for the NQ grade category and increasing the Q by the previous NQ amount.

#### **"ADDITIONAL" ACCESSION MULTIPLIERS**

On rare occasions the analyst may wish to direct the model to create additional accessions, but based on model needs rather than specific analyst-specified factors. These accessions would be created only when the accession hierarchy for a grade exhausts the maximum accession supply specified

<b>"ADDITIONAL" ACCESSION MULTIPLIERS</b>		
	<b>NPS</b>	<b>PS</b>
<b>E1-3</b>	0.0000	0.0000
<b>E4</b>	0.0000	0.0000
<b>E5</b>	0.0000	0.0000
<b>E6</b>	0.0000	0.0000
<b>E7-9</b>	0.0000	0.0000

**Fig. 3.6-"Additional" Accession  
Multipliers**

in the inputs without meeting a grade's force size requirement. Figure 3.6 illustrates how these accessions can be specified. *We caution that this model feature is being documented for completeness only and recommend its use only with great care. We further note that other, more direct ways of adjusting accessions are provided for the steady-state years.*

The zeroes in the figure indicate that, for this case, the analyst does not wish to create additional accessions. The needed additional accessions for an NPS/PS-grade pair would be multiplied by 0.0000. If the analyst wished to create additional NPS accessions for any needed grade, he could replace the NPS column with 1.0 values. Were he to want to bias the additional accession creation to specific grades, he could place the 1.0 only in the desired cells. While nonnegative numbers other than 0.0 and 1.0 are permitted, the analyst should exercise great care in utilizing this feature. Other adjustment factors, imposed on accessions during the steady-state year, are more effective at balancing accessions.

## STEADY-STATE ACCESSION ADJUSTMENT

During the steady-state inventory projection phase, the accession hierarchy is suspended and ninth-year accessions are employed annually until the force converges. Because the accession hierarchy is suspended during this part of the inventory projection, grade sizes and total force sizes will likely deviate from the base case target sizes. We employ the one percent rule to judge whether the converged force is sufficiently close to grade and force size requirements. If the converged force falls outside the one percent guidelines, we sometimes adjust steady-state accessions to bring the force to within them.<sup>7</sup>

Figure 3.7 illustrates how we adjust these accessions. We have created what we call an accession safety valve, which allows the analyst to adjust the ninth-year accessions when they are applied to the steady-state years. The middle column of the figure, headed "YR 9/ DESIRED", is the ratio of ninth-year accessions to the accession supply. In the case shown, the ratio is 1 for all but three accession grade categories. The ratio of 1 means that the model is using all of the accession supply for those grade categories. The remaining three grade categories display the spreadsheet's mechanism for indicating that a division by zero has taken place, which in this case means that the accession supply for these grade categories is zero.

For those grade categories that have nonzero accession supply, i.e., that do not show the zero-divide indicator, the analyst can alter the steady-state accessions. Two actions are necessary. First, place the desired ratio in the appropriate grade category's "SAFETY VALVE" column. Second, place 1.0 in the associated "SAFETY FLAG" column.<sup>8</sup> The analyst can

ACCESSION SAFETY VALVE				
		SAFETY VALVE	YR 9/ DESIRED	SAFETY FLAG
NPS	E1-3 NEW NQ		1	
	E1-3 NEW Q		1	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ		#DIV/0!	
	E4 NEW Q		1	
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ		1	
	E5 NEW Q		1	
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ		1	
	E6 NEW Q		1	
PS	E6 OLD NQ			
	E6 OLD Q			
	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q		1	
	E7-9 OLD NQ			
	E7-9 OLD Q			
	E1-3 NEW NQ		1	
	E1-3 NEW Q		1	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ		1	
	E4 NEW Q		1	
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ		1	
	E5 NEW Q		1	
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ		1	
	E6 NEW Q		1	
	E6 OLD NQ			
	E6 OLD Q			
	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q		1	
	E7-9 OLD NQ			
	E7-9 OLD Q			

Fig. 3.7-The Accession Safety Valve

<sup>7</sup>The one percent rule, not built into the model, is applied by the analyst to determine if a particular force structure is acceptable.

<sup>8</sup>Two actions are required in the event that the analyst wishes to set a grade category's accessions to zero. Were the model to apply the safety

use any nonnegative ratio, including zero and numbers greater than 1.0. He can also violate the accession hierarchy. We urge caution when using numbers greater than 1.0, which effectively means that the steady-state inventory projection will annually access more than the accession supply for the associated grade category. We also urge caution when violating the accession hierarchy.<sup>9</sup>

#### **SOME ADDITIONAL MODEL DISPLAYS**

Figures 3.8 and 3.9 present other useful model displays. In Figure 3.8 we see the actual accessions used during the dynamic and analytic segments of the inventory projection. Although this figure does not reflect safety valve changes, such changes would be apparent in two distinct ways when looking at the model spreadsheet on the personal computer screen. First, the steady-state accession numbers would be different from the ninth-year accessions. Second, the safety valve adjustments are displayed on the same spreadsheet page, the one we suggest using to "fly" the model (discussed in Section 4).

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valve only in the presence of nonzero safety valve values, this possibility would be precluded.

<sup>9</sup>While the accession hierarchy is suspended during the analytic inventory projection segment, the hierarchy is implicit in the ninth-year accessions. We suggest preserving this hierarchy when adjusting steady-state accessions.



		ACTUAL ACCESSIONS								Stdy St Force
		2	3	4	5	6	7	8	9	
NPS	E1-3 NEW NQ	50939	50939	50939	50939	50939	50939	50939	50939	50939
	E1-3 NEW Q	5305	5305	5305	5305	5305	5305	5305	5305	5305
	E1-3 OLD NQ									18718
	E1-3 OLD Q									41580
	E4 NEW NQ									
	E4 NEW Q	2615	2615	2615	2615	2615	2615	2615	2615	2615
	E4 OLD NQ									14375
	E4 OLD Q									65946
	E5 NEW NQ	1084	1084	1084	1084	1084	1084	1084	1084	1084
	E5 NEW Q	1563	1563	1563	1563	1563	1563	1563	1563	1563
	E5 OLD NQ									8581
	E5 OLD Q									35365
	E6 NEW NQ	286	286	286	286	286	286	286	286	286
	E6 NEW Q	314	314	314	314	314	314	314	314	314
	E6 OLD NQ									4723
	E6 OLD Q									19380
	E7-9 NEW NQ									
	E7-9 NEW Q	54	54	54	54	54	54	54	54	54
	E7-9 OLD NQ									3500
	E7-9 OLD Q									11287
PS	E1-3 NEW NQ	1018	1018	1018	1018	1018	1018	1018	1018	1018
	E1-3 NEW Q	1578	1578	1578	1578	1578	1578	1578	1578	1578
	E1-3 OLD NQ									556
	E1-3 OLD Q									567
	E4 NEW NQ	4676	4676	4676	4676	4676	4676	4676	4676	4676
	E4 NEW Q	14354	14354	14354	14354	14354	14354	14354	14354	14354
	E4 OLD NQ									8045
	E4 OLD Q									23168
	E5 NEW NQ	2927	2927	2927	2927	2927	2927	2927	2927	2927
	E5 NEW Q	5005	5005	5005	5005	5005	5005	5005	5005	5005
	E5 OLD NQ									10520
	E5 OLD Q									35319
	E6 NEW NQ	580	580	580	580	580	580	580	580	580
	E6 NEW Q	962	962	962	962	962	962	962	962	962
	E6 OLD NQ									7240
	E6 OLD Q									27443
	E7-9 NEW NQ									
	E7-9 NEW Q	397	397	397	397	397	397	397	397	397
	E7-9 OLD NQ									7766
	E7-9 OLD Q									22264

**Fig. 3.8-Actual Accessions**

In addition to the accessions, the figure shows the OLD steady-state grade categories as well, allowing the user to see how the force converges to steady-state. We ask the reader to visualize the personal computer screen as the force converges, focusing specifically on the "Stdy St Force" column. The NEW grade categories will remain fixed during the analytic inventory projection, but the OLD categories will change values at a high rate, reflecting the convergence process. As the force gets closer to steady state, the changes will become smaller and smaller, stabilizing in

the early grades first, stabilizing in the higher grades later, until no grade category changes are detected.

Figure 3.9 presents total force aggregate summaries, both in terms of actual force sizes and in percentage terms. The "PERCENT OF TOTAL FORCE" and "DMOSQ RATES" derive directly from the "TOTAL FORCE AGGREGATE SUMMARIES" segment of the figure. The DMOSQ rates are simply the ratios of the appropriate Q force sizes and the corresponding total force sizes.

Other model displays have also proved useful in utilizing the model. We introduce those displays in the next section, where we describe the methodologies developed in trying to apply the model to specific analyses.

TOTAL FORCE AGGREGATE SUMMARIES										
	1 START	2 START	3 START	4 START	5 START	6 START	7 START	8 START	9 START	STEADY STATE
TOTAL NPS	285614	285614	285614	285614	285614	285614	285614	285614	285614	285614
TOTAL PS	174386	174386	174386	174386	174386	174386	174386	174386	174386	174386
NPS										
TOTAL NQ	102206	102206	102206	102206	102206	102206	102206	102206	102206	102206
TOTAL Q	183408	183408	183408	183408	183408	183408	183408	183408	183408	183408
PS										
TOTAL NQ	43328	43328	43328	43328	43328	43328	43328	43328	43328	43328
TOTAL Q	131058	131058	131058	131058	131058	131058	131058	131058	131058	131058
TOTAL Q	145534	145534	145534	145534	145534	145534	145534	145534	145534	145534
	314466	314466	314466	314466	314466	314466	314466	314466	314466	314466
checksum	460000	460000	460000	460000	460000	460000	460000	460000	460000	460000
TOTAL	460000	460000	460000	460000	460000	460000	460000	460000	460000	460000
PERCENT OF TOTAL FORCE										
	1 START	2 START	3 START	4 START	5 START	6 START	7 START	8 START	9 START	STEADY STATE
TOTAL NPS	62.1%	62.1%	62.1%	62.1%	62.1%	62.1%	62.1%	62.1%	62.1%	62.1%
TOTAL PS	37.9%	37.9%	37.9%	37.9%	37.9%	37.9%	37.9%	37.9%	37.9%	37.9%
NPS										
TOTAL NQ	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%
TOTAL Q	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%
PS										
TOTAL NQ	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%
TOTAL Q	28.5%	28.5%	28.5%	28.5%	28.5%	28.5%	28.5%	28.5%	28.5%	28.5%
TOTAL NQ	31.6%	31.6%	31.6%	31.6%	31.6%	31.6%	31.6%	31.6%	31.6%	31.6%
TOTAL Q	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%
checksum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
DMOSQ RATES										
	1 START	2 START	3 START	4 START	5 START	6 START	7 START	8 START	9 START	STEADY STATE
NPS	64.2%	64.2%	64.2%	64.2%	64.2%	64.2%	64.2%	64.2%	64.2%	64.2%
PS	75.2%	75.2%	75.2%	75.2%	75.2%	75.2%	75.2%	75.2%	75.2%	75.2%
TOTAL	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%	68.4%

Fig. 3.9-Aggregate Force Summaries

#### 4. "FLYING" THE MODEL

In this section we describe some model usage methodologies developed while conducting analyses. This section assumes that the reader is familiar with the Microsoft EXCEL spreadsheet software. For those unfamiliar with EXCEL, the appendix describes EXCEL software features needed to exploit the model.

##### BALANCING ATTRITION AND PROMOTIONS

Figure 4.1 illustrates the model display used to verify that the force size satisfies the one percent rule. For the base case (starting inventory) and final steady-state force, it shows various aggregated force sizes: the NPS and PS force sizes, the numbers in each grade, and the total force. The display also presents the absolute and percentage differences between the base case and steady-state force.

In Figure 4.1 the base case and steady-state inventories are the same; we have made no adjustments to transition probabilities. In Figure 4.2, we reduce attrition by 10 percent--the figure also shows the associated transition probability adjustment factors. The figure indicates that a 10

	STDY ST	BASE CASE	DELTA	% DIFF
TOTAL NPS	285614	285614		
TOTAL PS	174386	174386	0	0.0%
TOTAL	460000	460000		
E1-3	120260	120260	0	0.0%
E4	133179	133179		
E5	100363	100363	0	0.0%
E6	60928	60928		
E7-9	45269	45269		
TOTAL	460000	460000		

Fig. 4.1-Base Case Force

	ADJUSTMENT FACTORS			
	PROMOTION	ATTRITION	TURBULENCE	ACCESSIONS
NPS E1-3	1.00000	0.90000	1.00000	1.00000
E4	1.00000	0.90000	1.00000	1.00000
E5	1.00000	0.90000	1.00000	1.00000
E6	1.00000	0.90000	1.00000	1.00000
E7-9		0.90000	1.00000	1.00000
PS E1-3	1.00000	0.90000	1.00000	1.00000
E4	1.00000	0.90000	1.00000	1.00000
E5	1.00000	0.90000	1.00000	1.00000
E6	1.00000	0.90000	1.00000	1.00000
E7-9		0.90000	1.00000	1.00000
		BASE		
	STDY ST	CASE	DELTA	% DIFF
TOTAL NPS	302958	285614	17344	6.1%
TOTAL PS	157253	174386	-17133	-9.8%
TOTAL	460212	460000	212	0.0%
E1-3	119979	120260	-281	-0.2%
E4	133234	133179	54	0.0%
E5	100451	100363	88	0.1%
E6	60947	60928	19	0.0%
E7-9	45601	45269	332	0.7%
	460212	460000	212	0.0%

Fig. 4.2-Ten Percent Attrition Reduction

percent attrition reduction falls well within the total force and grade size constraints (applying the one percent rule), those constraints being established by the base case starting inventory.<sup>10</sup> However, the PS force has declined by over 17,000 soldiers, a condition deemed unacceptable for analysis purposes.<sup>11</sup> To bring the PS force under the one percent rule as well, we consider downward adjustments in promotions.

Figure 4.3 is a spreadsheet display that shows the implications of six potential promotion adjustments: from 0.90 to 0.85.<sup>12</sup> It shows the *deltas* associated with each alternative, both in absolute force number and percentage terms. The figure also shows, in the top four rows: the *independent variable* value, in this case the global promotion adjustment factor; the *NPS* and *PS promotion adjustment*, redundant in this discussion; and the *E1-3 promotion penalty*, which is zero in this case. The figure's bottom four rows show model consistency check displays, which we describe later in this section.

The bold numbers in the lower half of the figure show the percentage differences between the base case and steady-state force sizes, and these are the most relevant for this discussion. They indicate that across-the-board promotion adjustments of 0.88, 0.87, and 0.86 all satisfy the one percent rule for all the force aggregates, including the PS force size. Promotion adjustments above 0.88 lead to a PS force size that falls below the one percent tolerance. Adjustments below 0.86 lead to E7-9 force sizes that fall below the one percent tolerance. It would seem therefore that 0.88 is the desired promotion adjustment, the smallest adjustment needed to bring all force size aggregates within the one percent rule.

This alternative effectively applies equal promotion reductions to all the grades. There are other alternatives, however. We could choose to minimize promotion adjustments for the higher grades while reducing

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<sup>10</sup>In the spreadsheet itself the two segments of figure 4.2 do not sit one on top of the other. They are adjacent to each other, close enough to fit on the same computer screen. We have taken liberties in this document in making minor alterations to all the figures for reasons of compactness and clarity.

<sup>11</sup>We would permit increases in the prior-service force in excess of one percent, but not decreases unless there is no alternative.

<sup>12</sup>This display does not appear in the model spreadsheet but rather in a much smaller, auxiliary spreadsheet to which the model spreadsheet is linked. The analyst can employ the auxiliary spreadsheet in concert with the model spreadsheet to explore transition probability adjustment alternatives. The display shows an EXCEL table, and utilizing the EXCEL table feature has saved considerable analysis time. This feature and how we have employed it is described in the Appendix.

promotions more severely for the lowest grade.<sup>13</sup> This could be done by imposing a promotion penalty on the E1-3 grade. Figures 4.4 and 4.5 illustrate how we might explore this approach.

<b>EXCEL TABLE--global promotion adjustment factor</b>						
independent variable	0.90	0.89	0.88	0.87	0.86	0.85
NPS promotion adjustment	0.90	0.89	0.88	0.87	0.86	0.85
PS promotion adjustment	0.90	0.89	0.88	0.87	0.86	0.85
E1-3 promotion penalty	0.00	0.00	0.00	0.00	0.00	0.00
<b>NPS DELTA</b>	3941	2405	904	273	-284	-893
<b>PS DELTA</b>	-4036	-2487	-994	-340	138	604
<b>TOTAL DELTA</b>	-94	-82	-91	-67	-146	-289
<b>E1-3 DELTA</b>	0	0	0	35	271	523
<b>E4 DELTA</b>	117	111	105	100	132	172
<b>E5 DELTA</b>	27	18	9	1	5	14
<b>E6 DELTA</b>	-109	-116	-125	-117	-115	-107
<b>E7-9 DELTA</b>	-130	-95	-80	-87	-438	-890
<b>NPS PERCENT</b>	1.4%	0.8%	0.3%	0.1%	-0.1%	-0.3%
<b>PS PERCENT</b>	-2.3%	-1.4%	-0.6%	-0.2%	0.1%	0.3%
<b>TOTAL PERCENT</b>	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
<b>E1-3 PERCENT</b>	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%
<b>E4 PERCENT</b>	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
<b>E5 PERCENT</b>	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>E6 PERCENT</b>	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
<b>E7-9 PERCENT</b>	-0.3%	-0.2%	-0.2%	-0.2%	-1.0%	-2.0%
<b>tprob checksum</b>						
<b>tprob negative</b>						
<b>ipm checksums</b>	0.08	-0.03	-0.03	-0.06	-0.19	-0.20
<b>ipm negative</b>						

**Fig. 4.3-Promotion Adjustment Alternatives**

In Figure 4.4 we apply E1-3 promotion penalties ranging from 0.10 to 0.15, with no promotion adjustment to the higher grades--the 1.0 for *NPS* and *PS promotion adjustment* indicate this. The E1-3 promotion penalty of 0.1 means that E1-3 promotions are adjusted downward 0.1 more than the adjustments for the higher grades. Hence, for the six cases in Figure 4.4, the E1-3 promotion adjustment ranges from 0.9 to 0.85, with no adjustment of E4-9 promotions. The figure indicates that none of the alternatives fully satisfy the one percent rule. Note in particular that, as the E1-3 promotion penalty increases, so does the PS force size, while the NPS force size decreases. There is not much effect on the total force size and on

<sup>13</sup>This approach makes sense because, in a reduced attrition environment, we may wish to be more selective of those we promote into E-4.

E1-6 grade sizes. However, at no time does the E7-9 force size satisfy the one percent rule.

<b>EXCEL TABLE--E1-3 promotion penalty</b>						
independent variable	0.10	0.11	0.12	0.13	0.14	0.15
NPS promotion adjustment	1.00	1.00	1.00	1.00	1.00	1.00
PS promotion adjustment	1.00	1.00	1.00	1.00	1.00	1.00
E1-3 promotion penalty	0.10	0.11	0.12	0.13	0.14	0.15
NPS DELTA	5815	4534	3187	1827	465	-903
PS DELTA	-5575	-4286	-2933	-1571	-207	1163
TOTAL DELTA	240	249	253	256	258	260
E1-3 DELTA	-300	-302	-304	-306	-308	-310
E4 DELTA	3	-7	-18	-29	-40	-50
E5 DELTA	14	6	-3	-13	-22	-31
E6 DELTA	-23	-23	-26	-29	-31	-34
E7-9 DELTA	545	575	604	632	659	686
NPS PERCENT	2.0%	1.6%	1.1%	0.6%	0.2%	-0.3%
PS PERCENT	-3.2%	-2.5%	-1.7%	-0.9%	-0.1%	0.7%
TOTAL PERCENT	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
E1-3 PERCENT	-0.2%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%
E4 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E5 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E6 PERCENT	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
E7-9 PERCENT	1.2%	1.3%	1.3%	1.4%	1.5%	1.5%
tprob checksum						
tprob negative						
ipm checksums	0.02	0.01				
ipm negative						

**Fig. 4.4-E1-3 Promotion Penalty Alternatives**

Figure 4.5 reduces E4-9 promotions by one percent (the 0.99 adjustment factor), also applying an E1-3 promotion penalty that ranges from 0.1 to 0.15 (the E1-3 promotion adjustment ranges from 0.89 to 0.84). E1-3 promotion penalties of 0.13, 0.14, and 0.15 result in steady-state forces whose aggregates all satisfy the one percent rule. Choosing the minimum adjustment, we would select the 0.13 E1-3 promotion penalty.

We have now uncovered two ways to accommodate a 10 percent attrition reduction. We could apply an across-the-board promotion adjustment of 0.88, or we could minimally adjust E4-9 promotions by 0.99 accompanied by an E1-3 promotion adjustment of 0.86 (a 0.13 E1-3 promotion penalty). Because the slightly increased E1-3 promotion adjustment allows us to adjust E4-9 promotions only minimally, we've chosen this alternative rather than the across-the-board promotion adjustment.

<b>EXCEL TABLE--E1-3 promotion penalty</b>						
independent variable	0.10	0.11	0.12	0.13	0.14	0.15
NPS promotion adjustment	0.99	0.99	0.99	0.99	0.99	0.99
PS promotion adjustment	0.99	0.99	0.99	0.99	0.99	0.99
E1-3 promotion penalty	0.10	0.11	0.12	0.13	0.14	0.15
NPS DELTA	5170	3892	2536	1172	-194	-1566
PS DELTA	-5077	-3786	-2430	-1064	305	1678
TOTAL DELTA	92	105	106	108	110	112
E1-3 DELTA	-73	-74	-76	-78	-80	-82
E4 DELTA	44	32	21	10	-1	-12
E5 DELTA	25	16	7	-2	-11	-20
E6 DELTA	-15	-15	-17	-20	-23	-25
E7-9 DELTA	111	145	171	198	225	252
NPS PERCENT	1.8%	1.4%	0.9%	0.4%	-0.1%	-0.5%
PS PERCENT	-2.9%	-2.2%	-1.4%	-0.6%	0.2%	1.0%
TOTAL PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E1-3 PERCENT	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
E4 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E5 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E6 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E7-9 PERCENT	0.2%	0.3%	0.4%	0.4%	0.5%	0.6%
tprob checksum						
tprob negative						
ipm checksums	0.02	-0.01				
ipm negative						

**Fig. 4.5-E4-9 Promotions Modestly Adjusted**

#### **DIRECTLY ADJUSTING ACCESSIONS**

Some of the study's analysis cases call for reducing both attrition and turbulence by 50 percent. The promotion adjustments necessary to keep the force aggregates in balance are large, on the order of 0.46 with an additional 0.11 E1-3 promotion penalty, illustrated in Figure 4.6. Even with these major adjustments, it is not possible to keep two force size aggregates within the one percent rule; the PS force size falls about 11 percent below the base case PS force size, and the E7-9 size also falls a little short. Figure 4.6 illustrates this and further illustrates that more drastic reductions in promotion lead to infeasible force structures.



<b>EXCEL TABLE--E1-3 promotion penalty</b>						
independent variable	0.11	0.12	0.13	0.14	0.15	0.16
NPS promotion adjustment	0.46	0.46	0.46	0.46	0.46	0.46
PS promotion adjustment	0.46	0.46	0.46	0.46	0.46	0.46
E1-3 promotion penalty	0.11	0.12	0.13	0.14	0.15	0.16
NPS DELTA	19185	16350	13247	10132	7004	3863
PS DELTA	-19464	-16601	-13475	-10335	-7182	-4016
TOTAL DELTA	-280	-252	-228	-203	-178	-153
E1-3 DELTA	-15	-16	-17	-19	-20	-22
E4 DELTA	997	907	816	725	634	542
E5 DELTA	-76	-79	-83	-87	-92	-96
E6 DELTA	-513	-467	-432	-398	-363	-328
E7-9 DELTA	-672	-596	-511	-425	-338	-250
NPS PERCENT	6.7%	5.7%	4.6%	3.5%	2.5%	1.4%
PS PERCENT	-11.2%	-9.5%	-7.7%	-5.9%	-4.1%	-2.3%
TOTAL PERCENT	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%
E1-3 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E4 PERCENT	0.7%	0.7%	0.6%	0.5%	0.5%	0.4%
E5 PERCENT	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
E6 PERCENT	-0.8%	-0.8%	-0.7%	-0.7%	-0.6%	-0.5%
E7-9 PERCENT	-1.5%	-1.3%	-1.1%	-0.9%	-0.7%	-0.6%
tprob checksum						
tprob negative		t < 0	t < 0	t < 0	t < 0	t < 0
ipm checksums	-0.02	0.03	0.03	0.03	0.03	0.03
ipm negative		ipm < 0	ipm < 0	ipm < 0	ipm < 0	ipm < 0

**Fig. 4.6-50 Percent Turbulence and Attrition Reductions**

The figure, which anchors E4-9 promotion adjustments at 0.46, considers E1-3 promotion penalties ranging from 0.11 to 0.16 (E1-3 promotion adjustments range from 0.35 to 0.30). Note the figure's bottom four rows, which are used to indicate when computational inconsistencies arise. When confronted with combined attrition and turbulence adjustments of 0.5, attempting to adjust promotions too drastically leads to some negative transition probabilities, which are indicated by the  $t < 0$  messages. These in turn lead to negative states, which are indicated by the  $ipm < 0$  messages. We address this phenomenon later in this section. For now suffice to say that the most drastic feasible promotion adjustments are those that lead to an E1-3 promotion adjustment of 0.35; if the E1-3 promotion adjustment falls below 0.35, some transition probabilities become negative.<sup>14</sup>

<sup>14</sup>Other combinations of E4-9 promotion adjustment and E1-3 promotion penalty include 0.47/0.12, 0.48/0.13, and 0.49/0.14.

Without taking additional steps to bring the PS and E7-9 force sizes into balance, the force structure illustrated in Figure 4.6's first column is the closest we can get. What additional steps might we take? Figure 4.7 summarizes the steady-state accession ratios associated with this case. Focusing on the middle column, which shows the ratio of ninth-year accessions to the accession supply, we see that all of the E4-9 accessions are PS Q, and that the ninth-year accessions fall below the accession supply. The figure also indicates that the E1-3 PS accessions are at their maximum, since the PS NQ and PS Q ninth-year ratios are 1.0. We can also see from Figure 4.6 that the E4-6 grades are within the one percent rule. In order to increase the number of E7-9s so that they too can meet the one percent rule requirement, we can try to increase E4-9 PS Q accessions. This would not violate the accession hierarchy, since we have a surplus of E4-9 PS Q accessions, as indicated by the 0.29824 accession ratio.

The model permits us to override the accession ratio in the steady-state years. Figures 4.8, 4.9, and 4.10 illustrate how we can do this. They also help illustrate how we can use the *interpolation scratch pad* to help in this process. In Figure 4.8 we see a more precise version of the differences in the base case and steady-state force aggregates. The figure also includes the interpolation scratch pad, a device developed to help determine the adjustments needed to meet specific numerical objectives. In this case we are trying to increase the size of the E4 grade to just reach the upper one percent bound. It currently is at 0.75 percent, based on an accession ratio of 0.44051--this value comes from Figure 4.7. We have configured the interpolation scratch pad to reflect that 0.75 is associated with 0.44051. The scratch pad also shows that the target is 1.0--the "1" in the first column. It further contains the number 0.45000, which is the value we will use to override the model-determined ratio. There is a blank to the left of the 0.45000 entry because we do not know what percent difference the 0.45000 will yield. We will use the model to

determine this, and then place that number to the left of the 0.45000 entry. Finally, also note that one of the scratch pad cells is shaded. This is done for display purposes only, because the number currently in that cell is meaningless. This cell will contain the ratio to use based on linear interpolation.

		SAFETY	YR 9/	SAFETY
		VALVE	DESIRED	
NPS	E1-3 NEW NQ		0.54283	
	E1-3 NEW Q		1.00000	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ		#DIV/0!	
	E4 NEW Q			
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ			
	E5 NEW Q			
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ			
	E6 NEW Q			
	E6 OLD NQ			
	E6 OLD Q			
	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q			
	E7-9 OLD NQ			
	E7-9 OLD Q			
PS	E1-3 NEW NQ		1.00000	
	E1-3 NEW Q		1.00000	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ			
	E4 NEW Q		0.44051	
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ			
	E5 NEW Q		0.67589	
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ			
	E6 NEW Q		0.53104	
	E6 OLD NQ			
	E6 OLD Q			
	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q		0.29824	
	E7-9 OLD NQ			
	E7-9 OLD Q			

**Fig. 4.7-The Accession Safety Valve**

Figure 4.9 indicates how to modify the accession safety valve to reflect that we wish to superimpose 0.45000 as the E4 accession ratio. Note the two entries, in italics, on the PS E4 NEW Q row. The first entry is the ratio we wish to superimpose, 0.45. The second entry, a 1, is the flag that tells the model to superimpose this ratio in place of the default value--we require the second entry because we may occasionally wish to set the ratio to zero.

The model will use this ratio to determine the number of PS E4 Q accessions to impose in the steady-state years. This leads to the force aggregates shown in Figure 4.10, and we can see that the superimposed ratio causes us to overshoot the E4 grade size--the E4 percent difference is 1.22 percent.

Figure 4.10 also includes the completed interpolation scratch pad, which now includes the 1.22 entry. The scratch pad linearly interpolates between 0.75 and 1.22, with the target percent difference being 1. The linearly interpolated value is 0.44556, which we can now use as the new PS E4 Q accession ratio.

Figure 4.11 contains the accession summary and force aggregate summary after adjusting all E4-9 accessions to bring their grade sizes to the top of the one percent range. The PS force size, which is over nine percent below the base case, still fails to satisfy the one percent rule. However, the E7-9 force size does.

	STEADY STATE	BASE CASE	DELTA	% DIFF
TOTAL NPS	304793	285614	19179	6.72%
TOTAL PS	154928	174386	-19458	-11.16%
TOTAL	459721	460000	-279	-0.06%
E1-3	120245	120260	-15	-0.01%
E4	134176	133179	997	0.75%
E5	100287	100363	-76	-0.08%
E6	60415	60928	-513	-0.84%
E7-9	44598	45269	-671	-1.48%
	<i>padj</i>	<i>psdelta</i>	<i>3delta</i>	
	0.75	0.44051		
		0.45000		
	1	0.57163		
	INTERPOLATION			
	SCRATCH PAD			

Fig. 4.8-Force Aggregates and the Interpolation Scratch Pad

Second, our objective in presenting this example was to illustrate how to adjust steady-state accessions. We caution the reader to consider the accession hierarchy when taking this path. As discussed in Section 2, the accession hierarchy is imposed during the first nine years of the inventory projection, the *dynamic* years. This hierarchy favors prior service accessions over those with no prior service, and it favors qualified accessions over those who are nonqualified. The current example, for the inventory projection's steady-state years, illustrates how the user can directly affect accessions in any of the grade categories, independent of the accession hierarchy. If the user chooses to employ this feature, we simply caution that there is no model mechanism to impose the accession hierarchy. The user must

**Fig. 4.9-Overriding the Default Accession Ratio**

Fig. 4.10-Grade E4 Size is Too Large

Third, we used this example as an illustrative vehicle only. We encourage the model user, when confronted with situations that require such intervention, to be creative.

Fourth, we used this example to illustrate how the interpolation scratch pad can help the user. It provides the user with an arithmetic aid, and it can be applied to more than accession ratio determination. The user may wish to employ other such aids, and we encourage this. Further, linear interpolation has limitations, especially when the target point is relatively far from the starting point. Don't be surprised if the linear assumption doesn't work as well in such circumstances, thereby requiring several adjustment cycles before the target is reached.

Finally, while we have employed fifth place precision in the example, such precision is probably not necessary in most applications.

#### CHANGING BASE CASE FORCES

Three mechanisms exist whereby the user can change the base case force. First, there is an adjustment factor to proportionally alter the force size, illustrated in Figure 4.3. The second mechanism allows the user to use the unnormalized (to 460,000)

		SAFETY	YR 9/	SAFETY
		VALVE	DESIRED	
NPS	E1-3 NEW NQ		0.54283	
	E1-3 NEW Q		1.00000	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ		#DIV/0!	
	E4 NEW Q			
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ			
	E5 NEW Q			
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ			
	E6 NEW Q			
	E6 OLD NQ			
	E6 OLD Q			
PS	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q			
	E7-9 OLD NQ			
	E7-9 OLD Q			
	E1-3 NEW NQ		1.00000	
	E1-3 NEW Q		1.00000	
	E1-3 OLD NQ			
	E1-3 OLD Q			
	E4 NEW NQ			
	E4 NEW Q	0.44556	0.44051	1
	E4 OLD NQ			
	E4 OLD Q			
	E5 NEW NQ			
	E5 NEW Q	0.69878	0.67589	1
	E5 OLD NQ			
	E5 OLD Q			
	E6 NEW NQ			
	E6 NEW Q	0.57780	0.53104	1
	E6 OLD NQ			
	E6 OLD Q			
	E7-9 NEW NQ		#DIV/0!	
	E7-9 NEW Q	0.32764	0.29824	1
	E7-9 OLD NQ			
	E7-9 OLD Q			
	STDY ST	BASE CASE	DELTA	% DIFF
TOTAL NPS	304929	285614	19316	6.76%
TOTAL PS	158458	174386	-15928	-9.13%
TOTAL	463388	460000	3388	0.74%
E1-3	120245	120260	-15	-0.01%
E4	134509	133179	1330	1.00%
E5	101370	100363	1007	1.00%
E6	61540	60928	612	1.00%
E7-9	45723	45269	454	1.00%

Fig. 4.11-Accession-Adjusted Force

starting inventory. This inventory is illustrated in Figure 3.1, referred to as the (*from data*) inventory in the figure.

The final mechanism allows the user to employ a completely different base case. The need for this mechanism arose because we wanted to apply some adjustment to the original base case, e.g., increase the DMOSQ status of PS accessions by 50 percent, and then make attrition and turbulence reduction excursions from this new force. We called the force structure that emerged from the accession adjustment the *affected* base case.

CURRENT FORCE MULTIPLIER	
ACSN DCRMNT MLTPLR	
AFFECTED BASE CASE MULTIPLIER	

**Fig. 4.12-Selecting Other Base Cases**

Figure 4.12 indicates how to select either of the two latter mechanisms. To select the (*from data*) force, the user must set the CURRENT FORCE MULTIPLIER cell to 1.0. To select the affected base case, the user must set the AFFECTED BASE CASE MULTIPLIER to 1.0. Clearly the user should not select both at the same time.

Both the current force and the affected base case sit in auxiliary spreadsheets, and the user must employ the EXCEL linking mechanism to access them. The next subsection discusses these files in some detail. The appendix discusses spreadsheet linking and other useful EXCEL features.

#### **REDUCED-ATTRITION ACCESSION EFFECTS**

Many of the analysis cases included reductions in attrition. Because roughly one-third of the annual separations from the RC will rejoin later, if attrition is reduced then so too must the supply of annual accessions. The next section, which discusses auxiliary files, describes how these accession *decrements* are determined. Figure 4.12 illustrates how to direct the model to apply the accession decrements. To select this feature, the user must set the ACSN DCRMNT MLTPLR to 1.0.

#### **MODEL WARNING, ERROR DETECTION, AND CONSISTENCY CHECK DISPLAYS**

The model incorporates many warning, error detection and consistency check mechanisms. We have briefly discussed two already: negative transition probabilities and negative inventory projection flows. This subsection describes all the mechanisms.

### Warning Messages

The model has seven warning messages, designed to detect unusual conditions and make the user aware of them. Figure 4.13 illustrates all of these messages.

The first two warnings indicate that the user has selected either the affected base case or the current force. The third warning indicates that the accession safety valve has been activated, signaling that the user is changing one or more steady-

state accession ratios. The fourth through sixth warning messages indicate that the user has chosen to make nonuniform adjustments to promotion, attrition, and turbulence respectively. If the user chooses to employ an E1-3 promotion penalty, the promotion-related message will be displayed. The final warning message is displayed when the steady-state PS force falls below the base case PS force by at least one soldier. It does not take the one percent rule into consideration.

*** USES AFFECTED BASE CASE ***
*** USES CURRENT FORCE ***
*** SAFETY VALVE ON ***
PROMOTION ADJUSTMENTS NOT UNIFORM
ATTRITION ADJUSTMENTS NOT UNIFORM
TURBULENCE ADJUSTMENTS NOT UNIFORM
PS FORCE BELOW FLOOR

Fig. 4.13-Model Warning Messages

### Transition Probability Messages

The model checks for two kinds of transition probability conditions: whether a grade category's transition probabilities sum to 1.0, and whether there are negative transition probabilities. Figure 4.14 illustrates how these are reported. This figure also illustrates the two inventory projection problem messages, discussed in the next subsection.

Because the transition probabilities associated with a grade category (a row in the transition probability matrix) indicate all the possible paths a soldier in that category can take during an annual cycle, they must sum to 1.0. If they don't, then the model will inappropriately lose soldiers or create soldiers,

depending on whether the sum falls below or exceeds unity. To warn the user about this, the model displays the difference between all the transition probabilities in a grade category and 1.0. That difference must be zero for the model to work properly. The difference is displayed in the display illustrated in Figure 4.14--0.0000 in the figure. A nonzero value

checksum sums	
tprobs	ipm
0.0000	0.0156
t < 0	ipm < 0

Fig. 4.14-Transition Probability and Inventory Projection Problems



alerts the user to a transition probability problem. He can then go to the section of the spreadsheet that displays the transition probabilities to determine which probabilities are in error.

As discussed above when we examined the implications of large reductions in attrition, turbulence, and promotions, it is possible for severely adjusted transition probabilities to become negative. This happens because, for a grade category, each type of adjustment is made independent of the other types. For example, suppose the analyst wishes to substantially reduce turbulence, possibly as part of a turnover reduction excursion that includes both attrition and turbulence reduction. When this reduction is coupled with the promotion adjustment required to keep the grade aggregates within the one percent rule, it is possible to subtract more from the promotion-and-move transition probability cells than they have in them.<sup>15</sup>

### **Inventory Projection Problems**

The model checks for two inventory projection problems: are there any negative flows during the course of the simulation, and do the two end-state computation schemes agree? The discussion associated with Figure 2.3 addressed the latter consistency check.

Negative flows can arise from two causes. First, if one or more transition probabilities are negative, then the model arithmetic will generate negative states during the course of an annual cycle. Second, if the model equations are in error in some other respects, then negative flows may also arise. The model looks for such errors by testing each inventory projection cell and reporting if negative cells are found.

The discussion associated with Figure 2.3 indicates how the model verifies the arithmetic associated with computing each year's ending state. Briefly, the model computes the end state in two ways. It computes the end

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<sup>15</sup>Consider, for example, the extreme case where we reduce both turbulence and promotions to zero--this case would probably never arise in a policy context, but it demonstrates arithmetically how negative transition probabilities can arise. The two transition probability cells in a grade category associated with promotion-and-move will be zeroed twice, once to reduce promotions to zero, and once to reduce turbulence to zero. Hence, when the model does the arithmetic to redistribute those probabilities, the result will be that those two cells will become negative and equal to the negative of the original unadjusted transition probabilities. Attrition adjustments tend to mitigate against this, because attrition adjustments are redistributed proportionally to the other eight transition probability states.

state by adding together all the flows into that state. It also computes the end state by starting from the annual cycle's beginning state, subtracting all the flows out and adding all the flows in. In the first nine, dynamic years of the inventory projection, the two end-state computations must agree exactly. If they do not, the model's equations contain errors. In the analytic, steady-state segment of the inventory projection, these two computations must converge. Due to the cyclic nature of the steady-state year's mathematical specification, the two end states will not start out as equal. However, during the iterative process they must converge. If they do not, then the model's equations contain errors.

Figure 4.14 displays the difference between the end-state computations. In the figure, the difference is 0.0156--it is not exactly zero because the convergence tolerance was set at a relatively high value, sufficient for percentage difference convergence but not for absolute, fifth decimal place convergence. Considering that the total force size is about 460,000, this is a very small fraction of that force.

#### **THE ADJUSTMENT PAGE**

All of the displays presented in this section appear in the same segment of the spreadsheet, called the adjustment page. We have found it useful to run the model from this page. The page contains all the cells associated with adjustment factors, and it contains all the cells associated with warning and error condition messages. The page also contains the interpolation scratch pad. The analyst can tell at a glance if the run has problems, and he can make appropriate adjustments as needed.

## 5. AUXILIARY SPREADSHEETS

Several auxiliary spreadsheets are employed in conjunction with the model spreadsheet. They allow specification of the base case, the affected base case, reduced-attrition accession adjustments, and systematic independent variable specification. Several additional spreadsheets are employed to support postprocessing computations that generate case comparison reports. This section describes these auxiliary spreadsheets.

### SPECIFYING THE BASE CASE AND AFFECTED BASE CASE

#### The Base Case Spreadsheet

Before conducting an analysis the analyst must create a base case. In conducting our analysis we created a base case based on 1992-93 Reserve Component data, whose force structure remains invariant from one year to the next, i.e., is in a steady state. This base case was created by adjusting the transition probabilities that emerged from the 1992-93 data, as discussed in Section 3. We refer to this spreadsheet model run as the *base case spreadsheet*.

Other spreadsheet model runs *link*<sup>16</sup> to two specific arrays of the base case spreadsheet to obtain the base case inventory and transition probabilities. These serve as the starting point for other model runs. The first array, placed in the current model run's *from data* base case starting inventory (see Figure 3.1), comes from the steady-state inventory in the base case spreadsheet. Figure 3.2, the force projection summary, contains the base case steady-state inventory array to which we link. The second array, placed in the current model run's base case transition probabilities, comes from the base case spreadsheet's adjusted transition probability array.

Because the base case spreadsheet employed the one percent rule in creating the base case, we cannot be sure that the base case force structure is exactly 460,000 in size. Therefore, the current model run's *from data* base case inventory is normalized to an enlisted RC size of 460,000, and the annual accession supply is dictated by the normalized

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<sup>16</sup>EXCEL provides a mechanism whereby certain cells (or arrays of cells) in one spreadsheet can actually come from another spreadsheet. The EXCEL link mechanism is a convenient way to establish and alter these interspreadsheet connections.

starting inventory. Were we to run the current spreadsheet with no adjustments, we would duplicate the base case spreadsheet model with a 460,000 force size.

#### **The Affected Base Case Spreadsheet**

Recall that the affected base case is the result of an analysis excursion from which we wish to make additional excursions. For example, we may wish to improve PS accession duty MOS match rates by 50 percent and then apply attrition and/or turbulence reductions to the resultant force. Just as we link to the base case spreadsheet, we also link to the affected base case spreadsheet. In this case, however, we only use the affected base case force structure and not its transition probabilities.<sup>17</sup> This link should point to the same array of cells in the affected base case spreadsheet as is accessed from the base case spreadsheet. When the affected base case is selected, it too is normalized to an RC force size of 460,000.

#### **ACCESSION SUPPLY DECREMENT SPREADSHEETS**

Kirby and Grissmer have shown that between 25 and 50 percent of Army RC separations return to the Army RC at a later time.<sup>18</sup> We try to reflect this phenomenon by estimating the reduction in accession supply that would obtain when attrition is adjusted and then applying this reduction to the current run's accession supply. We do this only for those cases where attrition is adjusted.

This process involves making two distinct sets of model runs for each attrition reduction case. We first create the set of attrition reduction cases without attempting to decrease accession supply, which we call the *unreduced accession* cases. We then employ three auxiliary spreadsheets to determine each unreduced accession case's attrition reduction effect. This effect is then applied to a second set of reduced attrition spreadsheet

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<sup>17</sup>Our analysis approach does not call for adjusting transition probabilities when creating the affected base case. We simply apply base case transition probabilities. The resultant affected base case force structure is used as the base case from which additional excursions are made, and these excursions may require transition probability adjustments.

<sup>18</sup>See Section 3 in Sheila Nataraj Kirby and David Grissmer, *Reassessing Enlisted Reserve Attrition: A Total Force Perspective*, N-3521-RA, RAND, 1993. Quoting from the report's Conclusions section, "About one-quarter to one-half of all losses [from the Reserve Components] return to the same component or join another Selected Reserve component." For our analysis we assume that 33 percent of separations return to the RC.

model runs, this time with the analyst specifying that the supply of accessions is to be reduced. Figure 4.12 illustrates how the analyst can impose the reduced-attrition accession effect.

#### **The "... acsn diff" Spreadsheet**

Three auxiliary spreadsheets are needed to estimate the reduced-attrition accession effect. The first, which by convention we name "... acsn diff",<sup>19</sup> compares a specific unreduced accession case with the base case, taking the difference in steady-state separations between the two cases. An "... acsn diff" spreadsheet must be created for each attrition-adjusted unreduced accession case. It is created by linking to the appropriate model spreadsheet and to the base case spreadsheet.

This spreadsheet computes the difference in separations for each of the dynamic years and the steady-state year. It then organizes the computed results for the second spreadsheet.

#### **The "... diffs summary" Spreadsheet**

The second, "... diffs summary", spreadsheet must link to five "... acsn diff" spreadsheets, each associated with a different attrition-reduction excursion. If the analyst has fewer than five attrition-reduction excursions, the remaining links need not be used. The "... diffs summary" spreadsheet's function is to organize the differences computed in the five "... acsn diff" spreadsheets in a manner convenient for use by the third spreadsheet. It does no computations of its own.<sup>20</sup>

#### **The "... end year smry" Spreadsheet**

This spreadsheet performs the computations necessary to transform the separation differences in the "... diffs summary" spreadsheet into accession supply reductions for use by the model spreadsheet during the second cycle of attrition reduction runs. In addition to a link to the "... diffs summary" spreadsheet, it requires four parameters to perform its computations, as illustrated in Figure 5.1.

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<sup>19</sup>We use ellipses (...) to signify the prefix associated with the spreadsheet's name. The analyst is encouraged to define a run-identifying scheme to help keep track of spreadsheets. See the discussion on spreadsheet naming later in this section.

<sup>20</sup>We chose not to integrate the second and third spreadsheets for spreadsheet size reasons.

The first two parameters specify the percent of NPS and PS separations that return to the RC at some future time.

PERCENT OF SEPARATIONS THAT RETURN	
NPS	33.00%
PS	33.00%
PERCENT OF RETURNING SEPARATIONS THAT ARE DMOSQ	
NPS	50.00%
PS	0.00%

**Fig. 5.1-"... end year smry" Parameters<sup>21</sup>**

The second two parameters specify the percent of returning NPS and PS separations that are DMOSQ when they return. The "... end year smry" spreadsheet uses the first two parameters to determine the fractions of NPS and PS accessions that would have returned had attrition reduction not taken place. It uses the last two parameters to determine how many of those accessions would have been qualified and how many nonqualified.

The analyst must link to the appropriate "... diff summary" spreadsheet. When doing so he will notice that other links exist. The "... end year smry" spreadsheet contains computations based on results from the other spreadsheets, which the current methodology does not utilize. The computations remain in the "... end year smry" spreadsheet should the need arise to resurrect the computations in the future. In the "... end year smry" spreadsheet itself we have used the EXCEL pattern feature to shade the spreadsheet cells associated with these computations.

A spreadsheet array, shown in Figure 5.2, illustrates the accession supply decrements for several turnover reduction cases. The analyst must ensure that the model spreadsheet for a specific attrition case points to the correct accession supply decrements in the "... end year smry" spreadsheet. See the Sections CHANGING EXCEL ARRAYS and LINKS FROM ONE SPREADSHEET TO ANOTHER in the appendix for discussions of how to accomplish this.

<sup>21</sup>These parameters come from Kirby and Grissmer, referenced earlier in this section.

	B	C	D	E	F	G	H
1324			RC23-510 -10% turnover	RC23-520 -20% turnover	RC23-530 -30% turnover	RC23-540 -40% turnover	RC23-550 -50% turnover
1325	NPS	E1-3 NQ	964	1928	2802	3712	4568
1326	NPS	E1-3 Q	67	122	310	458	668
1327							
1328							
1329	NPS	E4 NQ	364	795	1119	1486	1656
1330	NPS	E4 Q	185	424	632	842	924
1331							
1332							
1333	NPS	E5 NQ	218	337	534	699	763
1334	NPS	E5 Q	55	122	254	363	396
1335							
1336							
1337	NPS	E6 NQ	79	148	214	267	300
1338	NPS	E6 Q	25	65	102	132	149
1339							
1340							
1341	NPS	E7-9 NQ	14	52	88	116	146
1342	NPS	E7-9 Q	4	22	39	52	68
1343							
1344							
1345							
1346	PS	E1-3 NQ	-3	-17	4	3	17
1347	PS	E1-3 Q	-3	-11	-2	-5	-1
1348							
1349							
1350	PS	E4 NQ	495	877	1356	1655	2157
1351	PS	E4 Q	126	213	451	680	1069
1352							
1353							
1354	PS	E5 NQ	268	577	743	910	1158
1355	PS	E5 Q	62	142	216	325	498
1356							
1357							
1358	PS	E6 NQ	136	219	303	395	502
1359	PS	E6 Q	31	72	119	173	239
1360							
1361							
1362	PS	E7-9 NQ	85	145	202	265	334
1363	PS	E7-9 Q	42	67	91	120	154
1364							
1365							

**Fig. 5.2-"... end year smry" Accession Decrement Table**

The array's first row (row 1324) shows the run identifiers associated with each attrition reduction run.<sup>22</sup> The illustration shows five turnover reduction cases (turnover reduction implies the parallel reduction of

<sup>22</sup>The analyst, when setting up an attrition reduction run that includes accession decrements, must ensure that the model points to rows 1324 through 1365. The run identifier row is included to permit its display in

attrition and turbulence). The reductions range from 10 through 50 percent. The first few characters, e.g., RC23-510, reflect the naming convention we have adopted for our analysis runs, i.e., for each turnover-adjusted model run.

Figure 5.3 illustrates how, in the model spreadsheet, the accession supply decrements are displayed. The rightmost column is the one that the analyst must ensure points to the correct accession supply decrement column in the "... end year smry" spreadsheet. In the example, this column should contain EXCEL text similar to the following:

```
{='... : ... end year
smry'!$D$1324:$D$1365}
```

Notice the *\$D\$1324:\$D\$1365* at the end of this line, indicating that the first column in the "... end year smry" array is being referenced.<sup>23</sup>

#### THE "SCORECARD"/TRADE-OFF SUMMARY SPREADSHEET

The scorecard spreadsheet compares the base case with as many as six excursions therefrom. It presents full-time equivalent job years, DMOSQ rates, annual accessions and training load for the NPS, PS, and total force aggregates. *Full-time equivalent job years (FEJY)* is the number of years a reservist has spent in his current duty MOS, where 228 days is counted as one year as it is for active duty personnel. For prior-service

ACCESSION DECREMENT		
		RC23-510 -10% turnover
NPS	E1-3 NQ	964
NPS	E1-3 Q	67
NPS	E4 NQ	364
NPS	E4 Q	185
NPS	E5 NQ	218
NPS	E5 Q	55
NPS	E6 NQ	79
NPS	E6 Q	25
NPS	E7-9 NQ	14
NPS	E7-9 Q	4
PS	E1-3 NQ	-3
PS	E1-3 Q	-3
PS	E4 NQ	495
PS	E4 Q	126
PS	E5 NQ	268
PS	E5 Q	62
PS	E6 NQ	136
PS	E6 Q	31
PS	E7-9 NQ	85
PS	E7-9 Q	42

Fig. 5.3-Accession Decrement Display

the model spreadsheet. This allows the analyst to verify that the appropriate attrition reduction case is being used.

<sup>23</sup>The ellipses would be replaced by appropriate directory/folder and run-identifying text. The surrounding braces {...} indicate that this is an EXCEL array. See the appendix for a discussion of EXCEL arrays.



reservists, active duty time is included, provided it was spent in a matching MOS.

*Training load* is presented in three parts: AIT (advanced individual training); RCTI<sup>24</sup> (Reserve Component Technical Institute); and OJT (on-the-job training). AIT is conducted at Active Component schools with the reservist attending full time. RCTI training is conducted primarily at schools run by the Reserve Component, and the reservist attends either during additional time or in lieu of his normal reserve commitment. OJT takes place during the reservist's normal reserve time with his unit.

The spreadsheet also presents *full-time equivalent training years (FETY)* which is the length of time the reservist has served in the military, including both Active Component and Reserve Component time, again assuming 228 days per year for a full-time soldier.

The spreadsheet is named "... trd smry", the *trd smry* standing for *trade-off summary*, a rather lengthy spreadsheet. It also requires links to the base case and six excursion model spreadsheets. For each model spreadsheet, two additional auxiliary spreadsheets must also be linked, called the *average times* and *time on job* spreadsheets. We describe them later in this subsection.

While the spreadsheet is lengthy, the relevant summary displays appear on its first two pages. Figure 5.4 shows the first spreadsheet page, whose purpose is to ensure that the appropriate model spreadsheets are included along with their associated *average times* and *time on job* spreadsheets. The three spreadsheets associated with each model run are listed together, the model spreadsheet being the first, the *average times* spreadsheet being the second, and the *time on job* spreadsheet being the third.<sup>25</sup>

As the warning indicates, the first set of three spreadsheets must be the base case spreadsheet. This is necessary because the full-time equivalent year computations take differences between excursion values and base case values.

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<sup>24</sup>The trade off summary spreadsheet shows RCTI/USARF. USARF stands for United States Army Reserve Forces schools.

<sup>25</sup>The first page also displays the force size differences from the base case by grade, total force size and PS force size. For compactness, we have chosen not to include them in the figure.

This figure compares the base case with six turnover reduction cases. This page is displayed to allow the analyst to ensure that the appropriate spreadsheets are linked in the proper order. Were they not, the page could possibly have an auxiliary spreadsheet for one turnover reduction case listed with the model spreadsheet for another turnover reduction case. We caution the analyst to scan this page carefully to ensure that such does not occur. We discuss how to guard against this happening in the appendix, where we address EXCEL spreadsheet linking in more detail.

Figure 5.5 shows a cut-down version of the second spreadsheet page, along with the appropriate column headings. We show a cut-down version because the page is rather wide, and all the information is not of great importance to this discussion. The figure contains several relevant segments, each of which will be described below.

OUT YEAR TRADEOFF SUMMARY	
<b>WARNING: FIRST CASE MUST BE BASE CASE</b>	
RC23-940729 base case stdy state	
RC23-940729 base case stdy state average times	
RC23-940729 base case stdy state time on job	
RC23a-510 -10% turnover -acsns	
RC23a-510 -10% turnover -acsns average times	
RC23a-510 -10% turnover -acsns time on job	
RC23a-520 -20% turnover -acsns	
RC23a-520 -20% turnover -acsns average times	
RC23a-520 -20% turnover -acsns time on job	
RC23a-525 -25% turnover -acsns	
RC23a-525 -25% turnover -acsns average times	
RC23a-525 -25% turnover -acsns time on job	
RC23a-530 -30% turnover -acsns	
RC23a-530 -30% turnover -acsns average times	
RC23a-530 -30% turnover -acsns time on job	
RC23a-540 -40% turnover -acsns	
RC23a-540 -40% turnover -acsns average times	
RC23a-540 -40% turnover -acsns time on job	
RC23a-550 -50% turnover -acsns	
RC23a-550 -50% turnover -acsns average times	
RC23a-550 -50% turnover -acsns time on job	

**Fig. 5.4-Trade-off Summary Header Page**



smaller than its PS counterpart, reflecting the Active Component experience of prior-service reservists.

FEJY is computed based on the time the reservist has spent in his current duty MOS. The computation is performed in the *time on job* auxiliary spreadsheet by projecting one year's worth of annual accessions thirty years into the future in a dynamic (not analytic) manner, keeping track of when job changes occur. For those individuals who have prior active service and who come into the Reserve Component as qualified reservists, we assume that their prior active service time was spent in the same MOS and include an estimate of that length of time--see Figure 5.12 below and the related discussion.

#### Duty MOS Qualification, Accession, and Training Summaries

Figure 5.6 shows the page segment that summarizes DMOSQ rates and accessions. The figure includes only the base case and the 10 percent turnover reduction excursion. Note how turnover reduction improves DMOSQ rates and reduces accessions.

A	B	C	D	E	F
		CASE		DMOSQ%	ACCESSIONS
		RC23-940729 base case std	TOTAL NPS	64.22%	62159
		RC23-940729 base case std	TOTAL PS	75.15%	31497
		RC23-940729 base case std	TOTAL	68.36%	93656
		RC23a-510 -10% turnover -a	TOTAL NPS	66.99%	56065
		RC23a-510 -10% turnover -a	TOTAL PS	78.14%	27852
		RC23a-510 -10% turnover -a	TOTAL	71.19%	83917

Fig. 5.6-DMosq Rate and Accessions

Figures 5.7 and 5.8 illustrate the training summaries. Note that spreadsheet columns E and F are not included in Figure 5.7, and that columns E-H are not included in Figure 5.8. The tables present summaries of three types of training that reservists can undergo: initial training, entry retraining, and job change retraining.

A	B	C	D	G	H
				INITIAL	ENTRY
		CASE		TRAINING	RETRAINING
		RC23-940729 base case std	TOTAL NPS	50939	1370
		RC23-940729 base case std	TOTAL PS		9200
		RC23-940729 base case std	TOTAL	50939	10570
		RC23a-510 -10% turnover -	TOTAL NPS	46615	
		RC23a-510 -10% turnover -	TOTAL PS		6168
		RC23a-510 -10% turnover -	TOTAL	46615	6168

Fig. 5.7-Initial Training and Entry Retraining

Figure 5.7 presents initial training and entry retraining summaries, both of which are related to accessions. Only unqualified E1-3 NPS accessions receive initial training. We assume that this is the accession's first tour, and he therefore must undergo initial training. This training is usually performed as part of the NPS accession's initial active duty tour, which includes basic training.<sup>26</sup>

PS accessions and unqualified E4-9 NPS accessions receive entry retraining. We assume that these accessions have served previously, either in the Active Component or the Reserve Component, and they are reentering the Reserve Component as nonqualified reservists. This retraining is required to make these accessions duty-MOS qualified. Qualified accessions receive no entry retraining.

In the figure the NPS *ENTRY RETRAINING* cell is empty for the 10 percent turnover reduction case, which means that only qualified E4-9 NPS soldiers were accessed. This is in contrast with the base case's 1370 unqualified E4-9 NPS accessions--we know that they are NPS E4-9 accessions because unqualified NPS E1-3 accessions receive initial training. This demonstrates the model's accession hierarchy at work. When attrition is reduced by 10 percent, as is the case with the 10 percent turnover reduction case shown in the figure, there is no longer a need to access unqualified NPS E4-9 soldiers, the last accession hierarchy category, in order to meet overall grade size requirements. For a fuller discussion of the accession hierarchy, see "Determining Annual Accessions During the First Nine Simulation Years" in Section 2.

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<sup>26</sup>All training, including initial training, entry retraining and job change retraining, could be performed through AIT, RCTI, or OJT. An input table, discussed below, determines how specific training is distributed over these three alternatives. Currently, that table directs that all initial training must take place via AIT, and all retraining via RCTI or AIT. The retraining distribution of RCTI vs. AIT is allowed to vary by pay grade.

A	B	C	D	I	J	K	L	M	N	O
				SUMMARY OF JOB CHANGERS						
				WITHOUT PROMOTION		WITH PROMOTION		TOTAL SANS	TOTAL WITH	
		CASE		TO NQ	TO Q	TO NQ	TO Q	PROMOTION	PROMOTION	TOTAL
		RC23-940729 base case stdy stat	TOTAL NPS	24169	12105	3706	3237	36274	6944	43218
		RC23-940729 base case stdy stat	TOTAL PS	18478	10130	1535	1781	28608	3317	31925
		RC23-940729 base case stdy stat	TOTAL	42647	22235	5242	5019	64882	10260	75143
		RC23a-510 -10% turnover -acsns	TOTAL NPS	22706	11087	3196	2769	33793	5964	39757
		RC23a-510 -10% turnover -acsns	TOTAL PS	16690	9023	1388	1584	25712	2971	28684
		RC23a-510 -10% turnover -acsns	TOTAL	39396	20110	4583	4352	59506	8935	68441

**Fig. 5.8-Job Change Training**

Figure 5.8 presents summaries of those who change jobs. A fraction of these reservists undergo job change retraining when they change jobs whether or not they move to a qualified state. That fraction appears at the bottom of Figure 5.5, in the field labeled PROPORTION OF JOB CHANGES NEEDING RETRAINING.

Two summary columns are also included, showing the total number of job changers not receiving a promotion (TOTAL SANS PROMOTION) and those who do receive a promotion (TOTAL WITH PROMOTION). A final summary column adds the SANS PROMOTION and WITH PROMOTION summaries. Note that these figures do not indicate the number of job changers requiring retraining. Those figures are presented later on this spreadsheet page--see Figure 5.9.

	TRAINING LOAD				
	DMOSQ	ACCESSIONS	AIT	RCTI/USARF	OJT
RC23-940729 base case stdy stat	68.36%	93656	59400	67483	
RC23a-510 -10% turnover -	71.19%	83917	53961	58366	
RC23a-520 -20% turnover -	73.97%	74479	47430	50622	
RC23a-525 -25% turnover -	75.06%	69459	45876	46545	
RC23a-530 -30% turnover -	75.98%	64669	43398	43997	
RC23a-540 -40% turnover -	77.88%	55290	37670	39411	
RC23a-550 -50% turnover -	79.70%	45848	32784	34711	

**Fig. 5.9-Dmosq, Accession and Training Load Summary**

Figure 5.9 presents a page-two display that further summarizes the DMOSQ, accession, and training implications of each case. For each case the display presents the overall DMOSQ rate, total accessions, and training load. However, this training load is broken down by the three training venues: AIT, RCTI and OJT. Note that the OJT training load is blank, indicating that OJT does not play prominently in USAR and ARNG duty MOS qualification training.

Figure 5.10 presents an input display that indicates how the training load should be distributed over the training venues. These figures were derived based on discussions with USAR and ARNG personnel and analysis of the SIDPERS and ATTRS databases for the 1992-93 time frame. Both entry retraining and job change training differ by grade as to which training venues provide that training. In no case does OJT figure prominently. Further, the higher the grade the more likely that entry retraining and job change training will take place at RCTI.

		AIT	RCTI/ USARF	OJT
INITIAL TRAINING DISTRIBUTION		97%	3%	
ENTRY RETRAINING DISTRIBUTION	E1-3	20%	80%	
	E4	14%	86%	
	E5	12%	88%	
	E6	9%	91%	
	E7-9	6%	94%	
JOB CHANGE TRAINING DISTRIBUTION	E1-3	20%	80%	
	E4	14%	86%	
	E5	12%	88%	
	E6	9%	91%	
	E7-9	6%	94%	

**Fig. 5.10-Training Venue Distribution**

#### **Full-Time Equivalent Training Years**

Figures 5.11 and 5.12 display full-time equivalent training years and the previous service durations associated therewith. In Figure 5.12, the previous experience inputs for both nonprior-service and prior-service reservists are displayed. These figures come from work done by Grissmer et al.<sup>27</sup> They reflect the amount of time a reservist had in previous Reserve Component tours and/or the amount of time a reservist spent on previous Active Component tours (for PS reservists).

<sup>27</sup>Full-time equivalent training years is explained on pages 41-42 of Grissmer et al., *Prior Service Personnel: A Potential Constraint on Increasing Reliance on Reserve Forces*, MR-362-OSD, 1994. The FETY numbers used in the spreadsheet model are integrated United States Army Reserve and Army National Guard numbers.

	FETY ADJUSTED			FETY UNADJUSTED		
	"10th PCTL"	MEDIAN	"90th PCTL"	"10th PCTL"	MEDIAN	"90th PCTL"
RC23-940729 base case std	0.37	2.70	1.16	0.37	2.70	1.16
RC23a-510 -10% turnover	0.44	2.82	1.36	0.37	2.70	1.17
RC23a-520 -20% turnover	0.56	3.04	1.72	0.37	2.69	1.18
RC23a-525 -25% turnover	0.63	3.16	1.90	0.37	2.69	1.17
RC23a-530 -30% turnover	0.68	3.26	2.04	0.37	2.70	1.17
RC23a-540 -40% turnover	0.75	3.39	2.23	0.37	2.71	1.16
RC23a-550 -50% turnover	0.87	3.43	2.57	0.40	2.59	1.25

Fig. 5.11-Full-time Equivalent Years

The *unadjusted* full-time equivalent training year values in Figure 5.11 assume that the previous AC/RC durations in Figure 5.12 hold, even if an excursion from the base case results in increased (or decreased) full-time equivalent training years. The *adjusted* values reflect the assumption that an excursion from the base case has affected Figure 5.12's previous AC/RC durations.

J	K	L	M	N	O	P
ASSUMED TO BE ASSOCIATED WITH BASE CASE						
FULL-TIME TRAINING EQUIVALENT YEARS BY GRADE (PART-TIME RESERVISTS ONLY)						
	NONPRIOR SERVICE			PRIOR SERVICE		
	"10th PCTL"	MEDIAN	"90th PCTL"	"10th PCTL"	MEDIAN	"90th PCTL"
E1-3	0.00	0.49	0.83	0.00	3.06	0.00
E4	0.66	1.00	1.84	0.00	3.38	0.00
E5	1.00	1.67	2.68	0.00	5.57	0.00
E6	1.33	2.52	3.70	0.00	6.44	0.00
E7-9	2.35	3.53	4.71	0.00	6.44	0.00

Fig. 5.12-Prior Duty MOS Experience by Grade

Indeed, for the FETY-adjusted values in Figure 5.11, the scorecard spreadsheet changes the Reserve Component contribution to the previous AC/RC durations in proportion to the excursion's changed average years in the Reserve Component. Specifically, the following transformations are applied for each excursion from the base case:

$$FTTNPS(g)_i = FTTNPS(g)_{bs} * \frac{AT(g)_i}{AT(g)_{bs}}$$

$$FTTPS(g)_i = FTTNPS(g)_i + (FTTPS(g)_{bs} - FTTNPS(g)_{bs})$$

where:

$AT(g)_{bs}$  Average time a reservist in grade  $g$  spends in his current Reserve Component tour for the base case

$AT(g)_i$  Average time a grade  $g$  reservist spends in his current Reserve Component tour for excursion  $i$ .



The above ten values ( $AT(g)_{bs}$  and  $AT(g)_i$ ) come from the *average time* spreadsheet associated with the base case and excursion  $i$ .

- $FTTNPS(g)_{bs}$  The *full-time equivalent training years* for an NPS grade  $g$  reservist in the base case--the unshaded NPS column in Figure 5.12.
- $FTTNPS(g)_i$  The *full-time equivalent training years* for an NPS grade  $g$  reservist in excursion  $i$ .
- $FTTPS(g)_{bs}$  The *full-time equivalent training years* for a PS grade  $g$  reservist in the base case--the unshaded PS column in Figure 5.12.
- $FTTPS(g)_i$  The *full-time equivalent training years* for a PS grade  $g$  reservist in excursion  $i$ .

The first transformation proportionally adjusts an excursion's NPS full-time equivalent training years based solely on the excursion's changed average years (these come from the *average time* auxiliary spreadsheet, described below). The second transformation reflects the assumption that the prior-service full-time equivalent training years has two parts: the Active Component part and the Reserve Component part. We assume that only the Reserve Component part undergoes the proportional change, the Active Component part remaining the same as in the base case. We further assume that the Reserve Component part is the same for both PS and NPS reservists in the base case and the excursion.

### **Auxiliary Spreadsheets**

Each model spreadsheet to which the trade-off summary spreadsheet links requires two additional spreadsheets: the *average times* spreadsheet (named "... avgtms") and the *times on job* spreadsheet (named "... toj").

The *average times* spreadsheet takes a model run's accessions and transition probabilities and projects the accessions into the future. It only tracks a single cohort of accessions, projecting them sufficiently far into the future to ensure that they undergo a complete *cradle-to-grave* process. The spreadsheet uses this projection to determine two average durations for each grade: (1) for those reservists in a grade who do not get promoted to the next higher grade, the average length of time the reservists remain in the grade; (2) for those reservists in a grade who do get promoted to the next higher grade, the average length of time they remain in the grade.

The trade-off summary spreadsheet uses these ten values (five for NPS grades and five for PS grades) for each model run to compute the average

length of time an individual who separates in grade g has spent in the Reserve Component during his current tour. These values then form the basis for adjusting the full-time equivalent training years, as discussed above.

The *times on job* spreadsheet also projects a cohort of accessions an appropriate number of years into the future. However, instead of determining the average time to separation and the average time to promotion for each grade, this spreadsheet determines the average time a reservist spends in his current duty MOS. As with the *average times* spreadsheet, this spreadsheet gives both prior-service and nonprior-service reservists credit for previous AC/RC tours, using the same durations as were used for the *average times* spreadsheet--see Figure 5.12.

The *times on job* spreadsheet tracks the cohort's job history as it unfolds during the inventory projection. The cohort begins the inventory projection with an initial amount of experience, dictated by the FETY values in Figure 5.12. As the cohort moves through the inventory projection, the length of time spent in a qualified state is accumulated and averaged, thereby allowing the spreadsheet to determine the average time members of the cohort spend in a qualified state. When cohort members move from qualified to nonqualified, i.e., change jobs, we reset the job clock to zero and begin accumulating again. The final result, after thirty years of inventory projection, is a determination of the average length of time members of the cohort have continuously spent in a qualified state, which we assume to mean the average length of time the cohort has spent in the current job, i.e., in the same MOS, specified for the NPS, PS and total force aggregates.

The trade-off summary spreadsheet links to three additional spreadsheets: the *FETY parameters* spreadsheet, the *costing data* spreadsheet, and the *ait/rcti distributions* spreadsheet. The *FETY parameters* spreadsheet is a small spreadsheet that performs no computations. It simply provides the FETY parameters shown in Figure 5.12. It also provides two additional parameters: the number of working days in the year (228), and the number of Reserve Component drilling days in a year (38). These values are used in both the trade-off summary spreadsheet and the *times on job* spreadsheet as part of the average duration computations.

The *costing data* spreadsheet contains data of importance to the cost spreadsheet, discussed below. It also contains one data item of use to the trade-off summary, the proportion of job changes needing retraining.

The *ait/rcti distributions* spreadsheet contains the distributions over the training venues and grades for initial entry training, entry retraining and job change training.

#### THE COST SPREADSHEET

Beginning with a scorecard/trade-off summary spreadsheet, i.e., linking to the scorecard, the cost spreadsheet (called "... cost smry") determines training and recruiting cost differences between the base case and the six excursions contained in the scorecard. The cost spreadsheet also estimates the additional compensation that would be required to achieve the attrition and/or turbulence reductions reflected in the excursions.<sup>28</sup>

The spreadsheet requires two types of input. The first type, which comes from a costing data spreadsheet, contains costing parameters and pay elasticities. The second type, which comes from the scorecard spreadsheet, contains the following scorecard arrays:

Training load	AIT, RCTI and OJT training, as illustrated in Figure 5.9
Entry retraining parameters	The distribution of entry retraining over AIT, RCTI and OJT
For each case, end-year inventory and transition probability expansions	The steady-state year's inventory and expansion into the nine transition probability states, as illustrated in Figure 2.3
For each case, promotion, attrition, turbulence and accession adjustment factors	The transition probability and accession adjustment factors, as illustrated in Figure 3.3
For each case, the final year accessions by grade category	The accessions applied annually in the steady-state, analytic segment of the inventory projection, as illustrated in the steady-state force column of Figure 3.8

With these inputs the cost spreadsheet determines:

The number of accessions in the steady-state year that receive basic training

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<sup>28</sup>This spreadsheet was designed primarily to compare attrition-, turbulence-, and turnover-reduction excursions, but it can be used to compare any excursions to the base case. Attrition- and turbulence-related bonuses are determined only when an excursion's associated adjustment factors are not unity.

For those cases that have attrition reductions, estimates of the compensation required to reduce attrition the indicated amount

For those cases that have promotion reductions, estimates of the compensation required to compensate reservists for the forgone promotions

For those cases that have turbulence reductions, estimates of the compensation required to reduce turbulence the indicated amount

The recruiting cost savings that accrue from reduced accessions

The basic training and AIT cost savings that accrue from reduced accessions

The AIT and RCTI cost savings that accrue from reduced turbulence

We now discuss the cost parameters and the above-listed items in detail.

#### Cost Parameters<sup>29</sup>

Figures 5.13-5.15 present the cost parameters used by the cost spreadsheet. Figure 5.13 shows the low and high bounds on per-recruit recruiting costs

associated with NPS and PS reserve

accessions--even though the figure has

the low bounds equal to the high bounds, the spreadsheet is designed to provide a lower and higher bound should the data warrant. PS accessions have a lower cost because their recruiting can take place as part of their separation from the Active Component.

RECRUITING COSTS PER PERSON (\$)		
	LOW	HIGH
NPS	\$7,750	\$7,750
PS	\$2,200	\$2,200

Fig. 5.13-Recruiting Costs

<sup>29</sup>The cost parameters are described in Bruce Orvis et al., *Ensuring Personnel Readiness in the Army Reserve Component*, MR-659-A, 1996, the companion document to this user's manual.

	ANNUAL PAY PER PERSON (\$)	PAY ELASTICITY BOUNDS		ANNUAL PAY DIFFERENCES	
		LOW	HIGH	FOR TARGETED JOB CHANGERS (OPTION 1)	FOR "N%" OF GRADE'S INVENTORY (OPTION 2)
E1-3	\$2,217	0.45	0.95		
E4	\$2,659	0.45	0.95	\$143	\$143
E5	\$3,180	0.45	0.95	\$166	\$166
E6	\$3,786	0.45	0.95	\$315	\$315
E7-9	\$4,844	0.45	0.95	\$398	\$398

**Fig. 5.14-Annual Pay, Elasticities, and Pay Differences**

Figure 5.14 shows the estimated annual pay a reservist receives by grade. This is an estimate because the actual pay depends on both grade and year of service. The figure also includes low and high bounds on attrition-related pay elasticities.<sup>30</sup> These are used to estimate the compensation required to achieve specific attrition reductions.

Finally, the figure presents two types of turbulence reduction pay differentials: one targeted specifically for those who forgo job changes (when compared to the base case number of job changers) and the attendant promotion therewith associated (option 1), and one targeted for *N* percent of the grade's inventory, where *N* indicates the amount of turbulence reduction that takes place (option 2). For now these pay differentials are set equal to each other, but the distinction remains in the spreadsheet should data be developed.

	TRAINING COST SAVINGS (\$) (PER STUDENT-COURSE)			
	TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSET	FREED MANPOWER
BASIC TRAINING:	\$6,148	\$4,638	\$0	\$1,510
AIT from BASIC TRAINING:	\$7,729	\$5,749	\$0	\$1,980
AIT from RECLASSIFICATION:	\$10,198	\$5,992	\$2,254	\$1,952
RCTI/USARF:	\$4,903	\$734	\$2,273	\$1,896

**Fig. 5.15-Training Cost Savings**

Figure 5.15 displays the training cost savings per student. For each type of training the figure shows the direct savings associated with reducing enrollment by one student (*PER-STUDENT SAVINGS*), the unit savings (*UNIT TRAINING OFFSET*), and the training manpower savings (*FREED MANPOWER*).

<sup>30</sup>The attrition-related pay elasticity is the percent increase in pay caused by a one percent reduction in attrition.

We distinguish between AIT that immediately follows basic training and AIT that results from reclassification, i.e., an MOS change.

TRAINING LOAD (from trade-off summary)					ADJUSTED AIT TRAINING LOAD		
CASE	AIT (from trade-off summary)	RCTI/USARF	OJT	BASIC TRAINING (NPS E1-3 NEW NQ)	AIT from BT	OTHER AIT	TOTAL AIT
CASE 1: RC23-940729 base case	59400	67483	0	50939	50939	8461	59400
CASE 2: RC23a-510 -10% turn	53961	58366	0	46615	46615	7346	53961
CASE 3: RC23a-520 -20% turn	47430	50622	0	41003	41003	6427	47430
CASE 4: RC23a-525 -25% turn	45876	46545	0	40020	40020	5856	45876
CASE 5: RC23a-530 -30% turn	43398	43997	0	37826	37826	5573	43398
CASE 6: RC23a-540 -40% turn	37670	39411	0	32558	32558	5112	37670
CASE 7: RC23a-550 -50% turn	32784	34711	0	28170	28170	4614	32784

**Fig. 5.16-Training Load**

Figure 5.16 shows training load, all of which comes from links to the trade-off summary spreadsheet (the italicized numbers),<sup>31</sup> and the adjusted AIT training load. The number of soldiers receiving basic training is assumed to be the same as the number of NPS E1-3 NEW NQ accessions. Note that, while this spreadsheet allows for consideration of OJT for duty MOS qualification, we have precluded this from our analysis.

The adjusted AIT training load is derived from the left spreadsheet segment. Total AIT training load is broken into those that receive AIT from basic training, and those that receive AIT without having to go through basic training first. The *OTHER AIT* column is simply the difference between *TOTAL AIT* and the *BASIC TRAINING* column from the left spreadsheet segment.

#### Attrition-Reduction-Based Compensation

Figure 5.17 shows the spreadsheet segment that computes attrition reduction pay out bounds. The computation requires the appropriate adjustment factor, the end-year inventory and separations, and the annual pay and pay elasticities illustrated in Figure 5.14. The computation assumes constant elasticity, as indicated below:

$$compensation_a(g) = bonus(g) * \frac{(1 - adjust_a(g))}{elasticity(g)} * (inventory(g) - separations(g))$$

<sup>31</sup>In the cost spreadsheet, italicized items come from the scorecard/trade-off summary, and bold items come from the cost parameter spreadsheet. All other items are computed in the cost spreadsheet itself.

where:

$compensation_a(g)$	The additional compensation required to reduce attrition by the amount indicated in the adjustment factor
$inventory(g)$	The inventory, as indicated in Figure 5.17
$separations(g)$	The number of separations, also indicated in the figure
NOTE: $inventory - separations$ is simply the number of payees receiving the attrition-reduction bonus	
$bonus(g)$	The estimated pay (Figure 5.14)
$adjust_a(g)$	The attrition adjustment factor, found in Figure 5.17
$elasticity(g)$	The attrition-based pay elasticity (Figure 5.14)

	A	B	C	D	E	F	G	H	I	J
87	CASE 2	ADJUSTMENT FACTORS							ATTRITION REDUCTION PAY (\$M)	
88		PROMOTION	ATTRITION	TURBULENCE	ACCESSIONS		INVENTORY	SEPARATIONS	LOW ELASTICITY	HIGH ELASTICITY
89	NPS E1-3	0.8600	0.9000	0.9000	1.0000		116331	29001	\$43.0	\$20.4
90	E4	0.9900	0.9000	0.9000	1.0000		83755	17018	\$39.4	\$18.7
91	E5	0.9900	0.9000	0.9000	1.0000		46078	6476	\$28.0	\$13.3
92	E6	0.9900	0.9000	0.9000	1.0000		24609	2358	\$18.7	\$8.9
93	E7-9		0.9000	0.9000	1.0000		15925	1212	\$15.8	\$7.5
94	PS E1-3	0.8600	0.9000	0.9000	1.0000		4118	1379	\$1.3	\$0.6
95	E4	0.9900	0.9000	0.9000	1.0000		49153	12549	\$21.6	\$10.2
96	E5	0.9900	0.9000	0.9000	1.0000		54281	7839	\$32.8	\$15.5
97	E6	0.9900	0.9000	0.9000	1.0000		36298	3640	\$27.5	\$13.0
98	E7-9		0.9000	0.9000	1.0000		29586	2445	\$29.2	\$13.8

Fig. 5.17-Attrition Reduction Pay<sup>32</sup>

The figure indicates the adjustment factors that have been used for the specific case illustrated, namely the ten percent turnover reduction case. Note that this case adjusts E4-9 promotions downward by one percent (and promotion adjustment factor of 0.9900), and that the E1-3 promotion adjustment applies an additional 0.13 E1-3 promotion penalty.

#### Promotion-Reduction-Based Compensation

In determining the amount of compensation to pay those reservists who have forgone promotion (as a result of adjusting the promotion transition probabilities), we assume that providing a bonus equal to the forgone pay will be sufficient, i.e., we pay to each forgone promotee the difference in

<sup>32</sup>This figure illustrates the attrition reduction computation using the turnover reduction cases in order to be consistent with the rest of this document, which follows the turnover reduction cases used in the analysis.

pay between his current grade and the next grade. This payment is made only in the face of promotion adjustment. For those model excursions that do not adjust promotions, the computation is not performed.

#### **Turbulence-Reduction-Based Compensation**

A similar scheme is employed for those excursions that include turbulence reduction. We assume that providing a bonus equal to the forgone pay will be sufficient, assuming that the individual would have moved in order to get a promotion. This computation is performed only when there is a turbulence adjustment accompanied by *no* attrition adjustment. In those instances where both attrition and turbulence are being simultaneously adjusted, we assume the greater attrition-related compensation would be sufficient to also achieve the turbulence reduction.

#### **Recruiting, Basic Training, AIT and RCTI Cost Savings**

Recruiting cost savings are determined based on the reduction in accessions when compared to the base case. Basic training costs are determined in the same manner, as are AIT and RCTI costs.



## Cost Spreadsheet Summary Displays

BASIC TRAINING COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)					AIT from BASIC TRAINING COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)				
	TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER		TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER
CASE 1: RC23-940729	---	---	---	---		---	---	---	---
CASE 2: RC23a-510	\$26.6	\$20.1	\$0.0	\$6.5		\$33.4	\$24.9	\$0.0	\$8.6
CASE 3: RC23a-520	\$61.1	\$46.1	\$0.0	\$15.0		\$76.8	\$57.1	\$0.0	\$19.7
CASE 4: RC23a-525	\$67.1	\$50.6	\$0.0	\$16.5		\$84.4	\$62.8	\$0.0	\$21.6
CASE 5: RC23a-530	\$80.6	\$60.8	\$0.0	\$19.8		\$101.4	\$75.4	\$0.0	\$26.0
CASE 6: RC23a-540	\$113.0	\$85.3	\$0.0	\$27.8		\$142.1	\$105.7	\$0.0	\$36.4
CASE 7: RC23a-550	\$140.0	\$105.6	\$0.0	\$34.4		\$176.0	\$130.9	\$0.0	\$45.1

AIT TOTAL COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)					AIT from RECLASSIFICATION COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)				
	TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER		TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER
CASE 1: RC23-940729	---	---	---	---		---	---	---	---
CASE 2: RC23a-510	\$44.8	\$31.5	\$2.5	\$10.7		\$11.4	\$6.7	\$2.5	\$2.2
CASE 3: RC23a-520	\$97.5	\$69.3	\$4.6	\$23.6		\$20.8	\$12.2	\$4.6	\$4.0
CASE 4: RC23a-525	\$111.0	\$78.4	\$5.9	\$26.7		\$26.6	\$15.6	\$5.9	\$5.1
CASE 5: RC23a-530	\$130.8	\$92.7	\$6.5	\$31.6		\$29.5	\$17.3	\$6.5	\$5.6
CASE 6: RC23a-540	\$176.2	\$125.7	\$7.5	\$42.9		\$34.2	\$20.1	\$7.5	\$6.5
CASE 7: RC23a-550	\$215.2	\$154.0	\$8.7	\$52.6		\$39.2	\$23.1	\$8.7	\$7.5

RCTI/USARF COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)					TOTAL TRAINING COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)				
	TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER		TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER
CASE 1: RC23-940729	---	---	---	---		---	---	---	---
CASE 2: RC23a-510	\$44.7	\$6.7	\$20.7	\$17.3		\$116.1	\$58.3	\$23.2	\$34.6
CASE 3: RC23a-520	\$82.7	\$12.4	\$38.3	\$32.0		\$241.3	\$127.8	\$42.9	\$70.6
CASE 4: RC23a-525	\$102.7	\$15.4	\$47.6	\$39.7		\$280.7	\$144.4	\$53.5	\$82.9
CASE 5: RC23a-530	\$115.1	\$17.2	\$53.4	\$44.5		\$326.6	\$170.8	\$59.9	\$95.9
CASE 6: RC23a-540	\$137.6	\$20.6	\$63.8	\$53.2		\$426.9	\$231.6	\$71.4	\$123.9
CASE 7: RC23a-550	\$160.7	\$24.1	\$74.5	\$62.1		\$515.9	\$283.6	\$83.2	\$149.1

Fig. 5.18-Training Cost Reduction Summaries

Figure 5.18 shows the summary display for training costs, expressed as a difference between the indicated case and the base case.<sup>33</sup> The lower right spreadsheet segment is the sum of the three left-hand spreadsheet segments. (This segment, while not in this part of the spreadsheet, is included for completeness of description. The next figure shows this spreadsheet segment in its natural location.) The two upper right spreadsheet segments break AIT costs down into those that arise after basic training and those that arise from reclassification. They are based on the right-hand contents of Figure 5.16. The middle left-hand spreadsheet segment is the total of the two upper right AIT cost segments.

<sup>33</sup>As with the trade-off summary, the base case must always be case 1 in the cost spreadsheet. Because the cost spreadsheet links only to the trade-off summary spreadsheet, this happens automatically.

We have taken liberties with this and the next figure. The case-identifying text has been truncated for display economy purposes, but the turnover cases are clearly discernible from the spreadsheet run-identifying text. The next subsection contains further discussion of run identification text and spreadsheet naming conventions.

Figure 5.19 shows the spreadsheet's remaining cost summary displays. This spreadsheet display summarized all costs and all savings, expressed as a difference between the indicated case and the base case. It also includes net savings. The *TOTAL TRAINING COST SAVINGS* spreadsheet segment, which appeared in Figure 5.18, is repeated here in its natural place in the spreadsheet. Adjacent to this spreadsheet segment, recruiting cost savings appear.

Total, marginal, and average bonus summaries appear in the second vertical spreadsheet segment. Because the cases are turnover cases, which include both attrition and turbulence reductions, the turbulence reduction bonus is zero--we assume that attrition reduction bonuses, which are greater than turbulence reduction bonuses, will be sufficient to achieve both attrition and turbulence reduction. Similarly, the average turbulence reduction bonuses, computed in *OPTION 1*, *OPTION 2* and *MARGINAL* terms, are also zero. The attrition (turbulence) marginal cost computations are computed based on the difference in attrition (turbulence) between the indicated case and the base case. This would be the payment necessary were the bonuses paid only to those who chose to remain in the force (remain in the same job).

The final two vertical spreadsheet segments show total costs, total savings, and net savings, computed for both turbulence reduction options. Because the turnover cases do not pay turbulence reduction bonuses, the *OPTION 1* costs are the same as those for *OPTION 2*.

	TOTAL TRAINING COST SAVINGS (\$M) (COMPUTED AS DIFFERENCE FROM CASE 1)				RECRUITING COST SAVINGS COMPUTED AS DIFFERENCE FROM CASE 1 (\$M)					
	TOTAL	PER-STUDENT SAVINGS	UNIT TRAINING OFFSETS	FREED MANPOWER	TOTAL		NPS		PS	
					LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND
CASE 1: RC23-940729	---	---	---	---	---	---	---	---	---	---
CASE 2: RC23a-510	\$120.5	\$60.4	\$23.2	\$36.8	\$16.5	\$55.0	\$14.3	\$45.7	\$2.2	\$9.3
CASE 3: RC23a-520	\$250.7	\$132.0	\$42.9	\$75.8	\$32.9	\$109.5	\$28.8	\$91.8	\$4.2	\$17.7
CASE 4: RC23a-525	\$291.9	\$149.8	\$53.4	\$88.6	\$41.6	\$138.3	\$36.3	\$116.0	\$5.2	\$22.3
CASE 5: RC23a-530	\$339.9	\$177.2	\$59.9	\$102.8	\$49.9	\$166.0	\$43.7	\$139.5	\$6.2	\$26.5
CASE 6: RC23a-540	\$445.0	\$240.1	\$71.3	\$133.6	\$66.3	\$220.4	\$58.2	\$185.7	\$8.2	\$34.7
CASE 7: RC23a-550	\$538.3	\$294.1	\$83.1	\$161.1	\$80.1	\$267.2	\$69.0	\$220.1	\$11.1	\$47.1

	ATTRITION REDUCTION BONUS (\$M)		"MISSED PROMOTION" BONUS (\$M)	TURBULENCE REDUCTION BONUS (\$M)		MARGINAL ATTRITION REDUCTION PLUS MISSED PROMOTION BONUS (\$)		AVERAGE TURBULENCE REDUCTION BONUS (\$M)		
	LOW BOUND	HIGH BOUND		OPTION 1	OPTION 2	LOW BOUND	HIGH BOUND	AVERAGE 1	AVERAGE 2	MARGINAL
CASE 1: RC23-940729	\$0.0	\$0.0	\$0.0							
CASE 2: RC23a-510	\$122.0	\$257.5	\$2.7			\$12,627	\$26,355			
CASE 3: RC23a-520	\$249.3	\$526.4	\$3.7			\$13,179	\$27,608			
CASE 4: RC23a-525	\$315.3	\$665.6	\$4.2			\$13,201	\$27,678			
CASE 5: RC23a-530	\$382.7	\$808.0	\$4.3			\$13,313	\$27,939			
CASE 6: RC23a-540	\$521.4	\$1,100.8	\$5.3			\$13,674	\$28,716			
CASE 7: RC23a-550	\$663.7	\$1,401.1	\$6.5			\$14,099	\$29,613			

#### OPTION 1 (TARGETED JOB CHANGERS)

	TOTAL COSTS (\$M)		TOTAL SAVINGS (\$M)		NET SAVINGS (\$M)	
	LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND
CASE 1: RC23-940729	\$0.0	\$0.0			\$0.0	\$0.0
CASE 2: RC23a-510	\$124.6	\$260.2	\$132.6	\$171.3	(\$127.6)	\$46.7
CASE 3: RC23a-520	\$253.0	\$530.0	\$274.2	\$351.5	(\$255.8)	\$98.4
CASE 4: RC23a-525	\$319.5	\$669.8	\$322.3	\$419.8	(\$347.4)	\$100.3
CASE 5: RC23a-530	\$387.1	\$812.3	\$376.5	\$493.6	(\$435.8)	\$106.5
CASE 6: RC23a-540	\$526.7	\$1,106.1	\$493.2	\$648.7	(\$612.9)	\$121.9
CASE 7: RC23a-550	\$670.2	\$1,407.6	\$595.9	\$784.0	(\$811.7)	\$113.8

AVG ATTRIT REDUC PLUS MISSED PROM BONUS (\$)	
LOW BOUND	HIGH BOUND
\$331	\$692
\$656	\$1,375
\$818	\$1,715
\$979	\$2,054
\$1,301	\$2,732
\$1,619	\$3,401

#### OPTION 2 (FRACTION OF INVENTORY)

	TOTAL COSTS (\$M)		TOTAL SAVINGS (\$M)		NET SAVINGS (\$M)	
	LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND	LOW BOUND	HIGH BOUND
CASE 1: RC23-940729	\$0.0	\$0.0			\$0.0	\$0.0
CASE 2: RC23a-510	\$124.6	\$260.2	\$132.6	\$171.3	(\$127.6)	\$46.7
CASE 3: RC23a-520	\$253.0	\$530.0	\$274.2	\$351.5	(\$255.8)	\$98.4
CASE 4: RC23a-525	\$319.5	\$669.8	\$322.3	\$419.8	(\$347.4)	\$100.3
CASE 5: RC23a-530	\$387.1	\$812.3	\$376.5	\$493.6	(\$435.8)	\$106.5
CASE 6: RC23a-540	\$526.7	\$1,106.1	\$493.2	\$648.7	(\$612.9)	\$121.9
CASE 7: RC23a-550	\$670.2	\$1,407.6	\$595.9	\$784.0	(\$811.7)	\$113.8

**Fig. 5.19-Total Cost and Savings Summaries**

The third vertical segment includes a computation of the average attrition plus missed-promotion bonus costs. This corresponds with the second vertical segment's marginal attrition plus missed-promotion bonus costs. The total bonus remains the same in both sets of computations, which is simply the sum of the attrition reduction bonus and the missed-promotion bonus reported in the second spreadsheet segment. The marginal cost computation assumes the bonus is paid only to those whose behavior is affected by the policy change. The average cost computation assumes the bonus is paid to all soldiers who remain to the end of the year, i.e., to *inventory - separations*.

Because the spreadsheet permits both low and high bounds for the attrition reduction bonus, the net savings low bound is defined to be the difference between the low bound total savings and the high bound total costs. Similarly, the net savings high bound is defined to be the difference between the high bound net savings and the low bound total costs.

#### **SPREADSHEET NAMING CONVENTIONS**

During the course of the project's work, many different analyses were performed. These analyses came in cycles, and the results of one analysis cycle very often led to spreadsheet model modifications and another analysis cycle. We have found it very useful to adopt spreadsheet naming conventions to help keep track of analysis cycles and the various excursions performed during a cycle. This subsection describes how we chose to keep track of analysis cycles and cases.

The discussion is couched in terms of Macintosh *folders*, which are equivalent to PC *directories*. Figure 5.20 illustrates how we have structured the analysis cycles and folders. The figure shows a window into the folder:

##### **RC Readiness**

as it would appear on the Macintosh screen. The scroll bar at the right of the window allows the user to move up and down the window. Three cycles are listed:

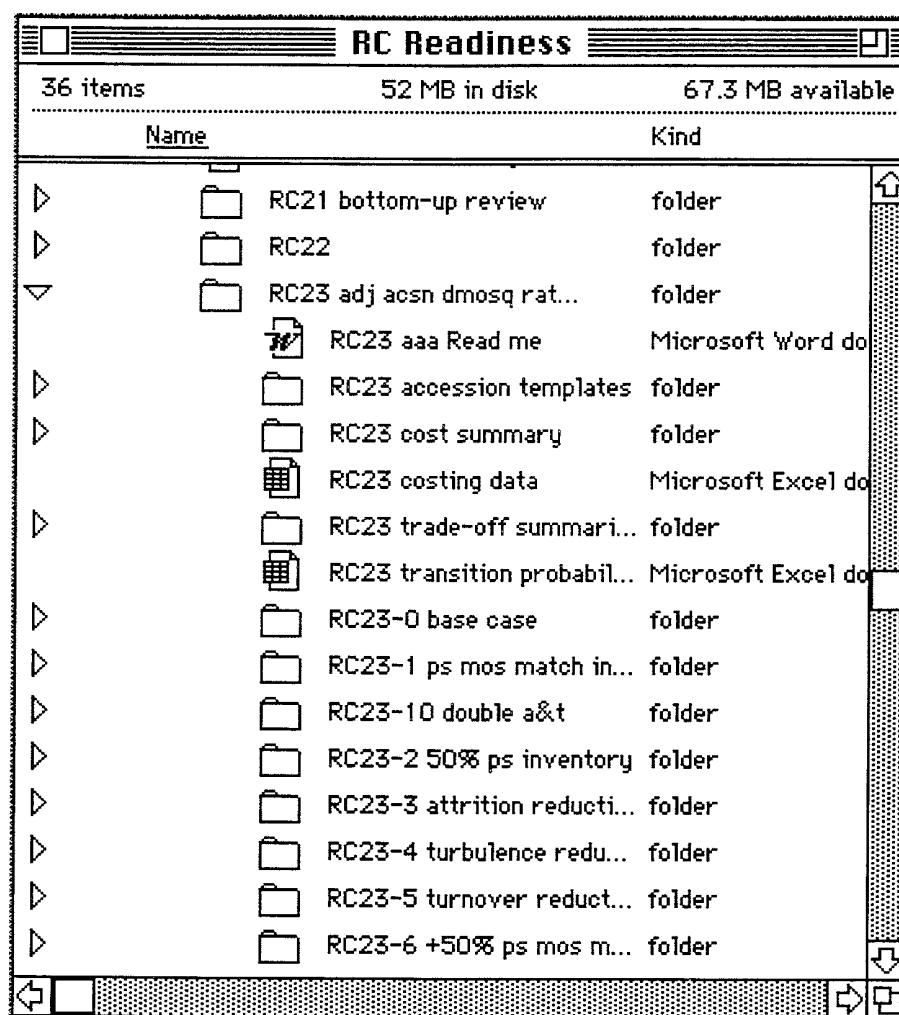
RC21 bottom-up review

RC22

RC23 adj acsn dmosq rat....

The RC23 folder is open, and its contents are also listed. First, notice that we have numbered analysis cycles sequentially, and that each cycle name begins with RC, e.g., RC21, RC22, and RC23. The "RC" is for convenience, but the numbering scheme has proved useful. We can tell at a glance where the files associated with a specific analysis cycle can be found.

Second, we have set things up so that the first file in the RC23 folder is a "read me" file. This file describes the objectives of the analysis cycle and any other information that would be important for understanding the cycle's assumptions and other characteristics.



**Fig. 5.20-Sample Folder/Directory Structure**

Third, all files in the RC23 folder begin with the characters RC23. This further helps in keeping track of cases and in ensuring that we're in the proper folder when looking for specific files.

Fourth, folders associated with a specific analysis case are named with the cycle identifier followed by a hyphen and number plus some descriptive text, as in:

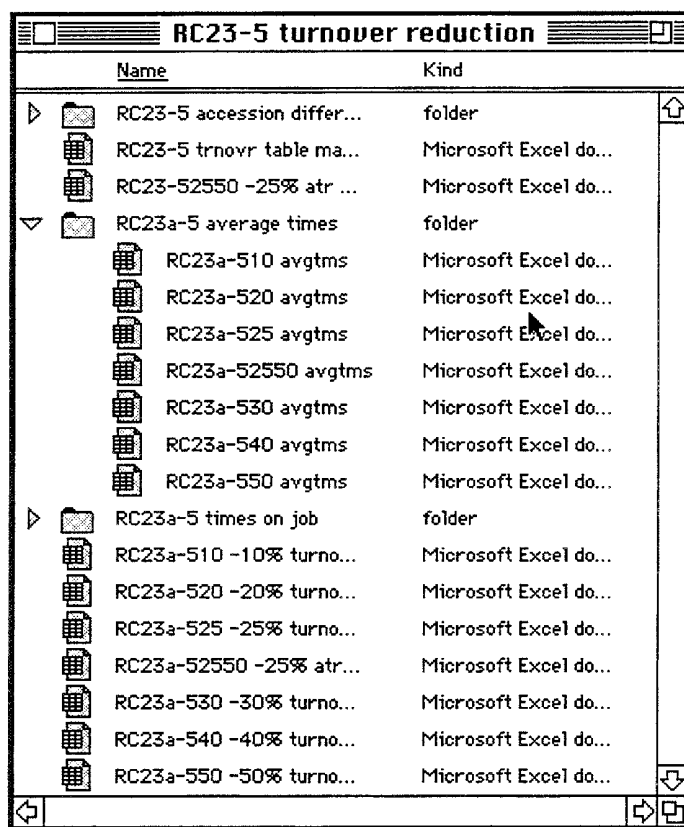
#### **RC23-5 turnover reduction**

which is displayed in the figure as "RC23-5 turnover reduct...". This makes it easy to find a specific case of interest. Note the other cases as well. For example, the files associated with the base case are contained in "RC23-0 base case". We suggest that this case-identifying scheme be the same in all analysis cycles.

Finally, at the beginning of the RC23 folder, several files appear that are applicable to all the cases, and their names begin with RC23

followed by descriptive information. For example, all the cost summaries are held in "RC23 cost summary", and all the trade-off summaries are in "RC23 trade-off summaries".

Figure 5.21 shows the contents of the turnover reduction folder, "RC23-5 turnover reduction". Note that all the files in this folder begin with RC23-5. In the same way that the RC23 label has proved useful in navigating through the RC23 folder, the RC23-5 label has proved useful as well. Further, specific model runs are labeled by adding the percentage reduction to the RC23-5 label, e.g., RC23-510 refers to the 10 percent turnover



**Fig. 5.21-The Turnover Reduction Folder**

reduction case. Further, to distinguish between model spreadsheets that include accession decrements from those that do not, we add the character "a", as in RC23a-510 to the accession reduction cases. Finally, we have chosen to have a separate table manager for each case, and the RC23-5 table manager is found in the case's folder ("RC23-5 trnovr table ma..." in Figure 5.21).

We have also found it useful to group all average time spreadsheets into a single folder, in this example labeled "RC23a-5 average times". We have used the same labeling scheme for the time on job spreadsheets (RC23a-5 times on job) and the spreadsheets that are used to determine accession decrements (RC23-5 accession differences).

We don't necessarily advocate adopting the specific nomenclature described in this subsection, but we do strongly recommend adopting a well

thought out nomenclature *before* beginning to use the model for analysis.  
We hope the preceding discussion helps this process.





## A. SPREADSHEET SOFTWARE DISCUSSION

This appendix, intended for model users who are not familiar with the details of EXCEL spreadsheet features, discusses the features employed in the Readiness Enhancement Model. Topics covered include:

- Navigating within the spreadsheet using the EXCEL *Goto* feature
- EXCEL *Calculation* and setting convergence tolerance levels
- EXCEL Arrays and how to modify them
- Spreadsheet linking, including linking spreadsheets in the trade-off summary spreadsheet, and using the table manager spreadsheet in conjunction with the model spreadsheet

Most of the EXCEL features are accessible from the EXCEL menu bar pictured below.

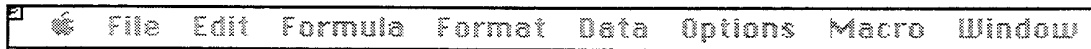


FIG. A.1--EXCEL MENU BAR<sup>34</sup>

When discussing an option, we will indicate under which item in the menu bar the option falls, e.g., the *Goto* option falls under the *Formula* menu item.

### SPREADSHEET NAVIGATION

The EXCEL *Goto* feature allows the model user to go to specific spreadsheet locations, defined either via absolute cell reference or via a mnemonic identifier--see Figure A.2. This feature can be found under the *Formula* menu item. The scroll bar provides a window on all mnemonically defined locations (and variables) in the model spreadsheet. The most useful one for model users is the *adjustment-page* entry, which the figure shows as having been selected. By selecting this entry and "clicking" OK, we go directly to the spreadsheet page from which most model usage is controlled.

---

<sup>34</sup>This menu bar and all illustrations in this appendix come from displays generated with Microsoft EXCEL version 4.0.

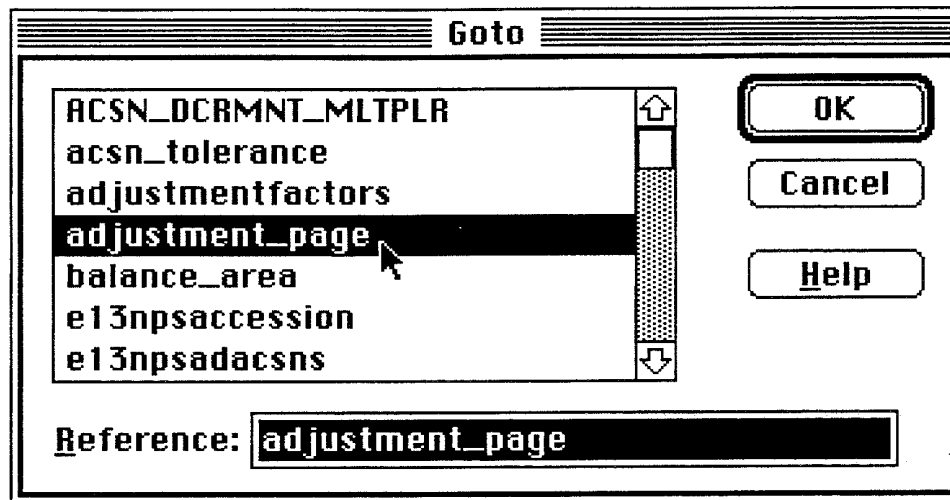


Fig. A.2--Goto Dialogue Box

#### THE CALCULATION OPTIONS

The Readiness Enhancement Model uses noniterative computations during the first nine years of the inventory projection. During the tenth year, the model employs iterative techniques in that the beginning-of-year states for the OLD grade categories are set equal to the end-of-year states for these categories--see the discussion associated with Figure 2.3 for a description of how the end-of-year OLD states are computed, and see the subsection "Dynamic and Analytic Inventory Projection" at the end of Section 2 for a discussion of analytic inventory projection in the tenth year.

By setting the beginning-of-year OLD states equal to the end-of-year OLD states, the model indicates to EXCEL that it wishes to perform the tenth-year computations iteratively until the beginning-of-year and end-of-year values converge. Under the normal set of calculation options, EXCEL will not support such iterative computations--those options are seen in Figure A.3's *Iteration* section, which depicts the *Calculation Options* dialogue box. This option can be found under the *Options* menu item. The key point of the figure is that the iteration box has not been selected because the field to the left of *Iteration* is not marked.

Calculation Options		
<b>Calculation</b> <input checked="" type="radio"/> Automatic <input type="radio"/> Automatic Except Tables <input type="radio"/> Manual <input checked="" type="checkbox"/> Recalculate Before Save	Calc Now (%+=) Calc Document	OK Cancel Help
<input type="checkbox"/> Iteration Maximum Iterations: 100 Maximum Change: 0.001	<b>Sheet Options</b> <input checked="" type="checkbox"/> Update Remote References <input type="checkbox"/> Precision as Displayed <input checked="" type="checkbox"/> 1904 Date System <input checked="" type="checkbox"/> Save External Link Values <input type="checkbox"/> Alternate Expression Evaluation	

Fig. A.3--Calculation Options Dialogue Box

In Figure A.4 the iteration box has been selected, and two other changes have been made. First, within the *Calculation* box calculation has been changed from automatic to manual, which means that the model user must signal EXCEL when he wishes computations to be carried out; this is done by pressing the *Calc Now* button in the dialogue box or by hitting

Calculation Options		
<b>Calculation</b> <input type="radio"/> Automatic <input type="radio"/> Automatic Except Tables <input checked="" type="radio"/> Manual <input checked="" type="checkbox"/> Recalculate Before Save	Calc Now (%+=) Calc Document	OK Cancel Help
<input checked="" type="checkbox"/> Iteration Maximum Iterations: 100 Maximum Change: 3	<b>Sheet Options</b> <input checked="" type="checkbox"/> Update Remote References <input type="checkbox"/> Precision as Displayed <input checked="" type="checkbox"/> 1904 Date System <input checked="" type="checkbox"/> Save External Link Values <input type="checkbox"/> Alternate Expression Evaluation	

Fig. A.4--Suggested Calculation Options

<COMMAND><=> on the keyboard. Setting calculation to manual is a useful convenience when making changes to model inputs. We can make all the changes and then call for the calculations to occur. Otherwise, as we make each input change the model will try to carry out the calculations, only to stop when we interrupt with the next model input change.

The second change falls within the *Iteration* box, where we have changed the *Maximum Change* from 0.001 to 3. This means that the model will think it has converged when each beginning-of-year value falls within three of the associated end-of-year value. At first this may seem to be an excessively large convergence tolerance. However, we have found that stability, as measured by the one percent rule, is achieved with this tolerance, and narrower tolerance does not bring any change in the percentage variations displayed in Figures 4.2, 4.3, 4.4, and 4.5.

A final point is worthwhile about the number of iterations. We have kept these at 100, and experience has shown that convergence usually occurs with fewer than 100 iterations, depending on the extent of the input changes. However, the maximum iteration count is occasionally reached. The user has three options. First, he can ignore this fact since at 100 iterations we are relatively close to convergence. Second, the user can execute another <COMMAND><=> to call for continued calculation--this has the effect of continuing iteration from where we left off for a maximum of 100 more iterations. Finally, the user can choose a higher maximum iteration level.

#### **CHANGING EXCEL ARRAYS**

EXCEL provides a space- and time-saving feature called array computation. Contiguous spreadsheet cells that have identical or parallel computation structures or cell references can all use the same unique specification. This saves space because one specification applies to all the cells of the array. For computations it also saves time, since the computation formula is *interpreted* (prepared for computation) only once for the array rather than once for each cell in the array.

This is relevant for model usage because several arrays are used in the model spreadsheet that the model user may have cause to change. In particular, the accession decrement specification is one such array, and the discussion in this subsection will describe how to make changes to that array. For normal, i.e., nonarray, cells, changes are easy. You simply

make them and hit <RETURN>. For arrays, changes are modestly more complicated.

A line similar to the one below can be found in the model spreadsheet's accession decrement array:

```
{='RC23 ... end year smry'!$D$1324:$D$1365}
```

This line is an edited version of the contents of model spreadsheet cells V951 through V992, denoted in EXCEL parlance as \$V\$951:\$V\$992, and contains the necessary link to the accession decrement table in the "RC23 ... end year smry" spreadsheet--see the subsection "Accession Decrement Spreadsheets" in Section 5 and in particular Figures 5.2 and 5.3. This line simply says that the accession decrements can be found in cells \$D\$1324:\$D\$1365 of the "RC23 ... end year smry" spreadsheet.

Figure 5.2 shows this cell range, clearly indicating that this is a 10 percent turnover reduction case. If the model user wishes to alter the model spreadsheet to represent another turnover reduction case, say 20 percent turnover reduction, he must change the accession decrement array in the following way:

```
{='RC23 ... end year smry'!$E$1324:$E$1365}
```

The underlined letters indicate the change that must be made, which simply changes the reference from the *end year smry*'s D column to its E column--see Figure 5.2. However, because the accession decrement section of the model spreadsheet is an array, indicated by the braces {} surrounding the array contents, the model user cannot just make the change and hit the carriage return. EXCEL will not permit the model user to casually change an array's contents by simply making the changes and then following with a carriage return--EXCEL will print an error message indicating that the model user cannot change a part of an array. Rather, because arrays are treated in a special manner, EXCEL requires the user to take special action to make array changes. The user must make the changes and then follow with a <COMMAND><RETURN>. After the changes are made, the user can verify that the correct accession decrements were selected by looking at the run identifier displayed at the top of the accession decrement array--see Figure 5.3.

This discussion has been lengthy because we believe the model user must understand the context of the accession decrement change he is making. To summarize, the key points are as follows:

1. In the model spreadsheet, go to the accession decrement array, found in cells \$V\$951:\$V\$992. Note that braces {} surround the cell contents for these cells, indicating that this is an array.
2. Carefully change the column pointers to the "... end year smry" spreadsheet. The correct column pointers can be D, E, F, G, or H. Note that you have to make two changes, as illustrated in the boldfaced line above.
3. After the column pointer changes have been made, hit <COMMAND><RETURN> to cause the accession decrement array to be changed.
4. Check the run identifier at the head of the accession decrement array to verify that the appropriate case has been selected.

Before leaving this discussion, we should note that the model spreadsheet must link to the "... end year smry" spreadsheet. We discuss spreadsheet linking in the next subsection.

#### **LINKS FROM ONE SPREADSHEET TO ANOTHER**

The model spreadsheet has links to several other spreadsheets. In addition, the auxiliary spreadsheets contain similar links. This subsection describes how to change spreadsheet links. In particular, it discusses the problems to avoid when making such changes.

The *Links* option can be found under the *File* menu item. If the open spreadsheet has no links to other spreadsheets, this option will be inaccessible. However, when the open spreadsheet does have such links, this option is accessible and very useful.

#### **Links to the Model Spreadsheet**

The model spreadsheet has links to three files (four if the table manager is also employed.) Figure A.5 illustrates the *Links* dialogue box when the user selects the *Links* option for the model spreadsheet.

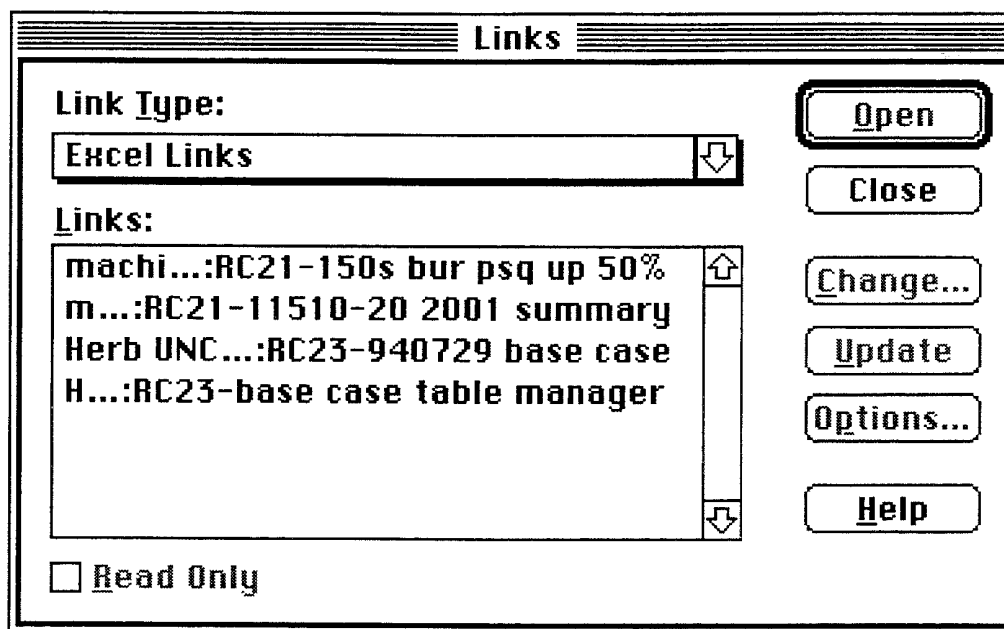


Fig. A.5--Model Spreadsheet Links

The spreadsheet links are:

- \* The base case model spreadsheet, from which we obtain the base case inventory (called the current inventory) and the base case transition probabilities. In the figure this is the third spreadsheet in the dialogue box, named "...:RC23-940729 base case".<sup>35</sup>
- The "... end year smry" spreadsheet, from which we obtain the accession decrement arrays. This is the second spreadsheet in this dialogue box, named "...:RC21-11510-20 2001 summary".
- The *affected* base case model spreadsheet, from which we obtain the affected base case's inventory. This is the first spreadsheet in the dialogue box, named "...RC21-150s bur psq up 50%". (Recall that the affected base case is an excursion from the base case from which we wish to make additional excursions. See "Changing Base Case Forces" in Section 3 and "Specifying the Base Case and Affected Base Case" in Section 5.)
- The table manager spreadsheet, from which we obtain independent variable values. This is the fourth spreadsheet in the dialogue box, named "...:RC23-base case table manager". The table manager

<sup>35</sup>It need not be the third spreadsheet in the list, since that order depends on the order in which the user changes links. See the trade-off summary spreadsheet discussion below.

spreadsheet also links to the model spreadsheet to obtain computation results, and we discuss the table manager in detail later in this subsection. Also see "Balancing Attrition and Promotion" in Section 3.

#### Links to the "... acsn diff" Spreadsheet

Figure A.6 illustrates the *Links* dialogue box when the user selects the *Links* option for an "... acsn diff" spreadsheet. As the dialogue box indicates, this spreadsheet links to two spreadsheets, the base case spreadsheet and the appropriate attrition reduction model spreadsheet (the ten percent turnover reduction case).

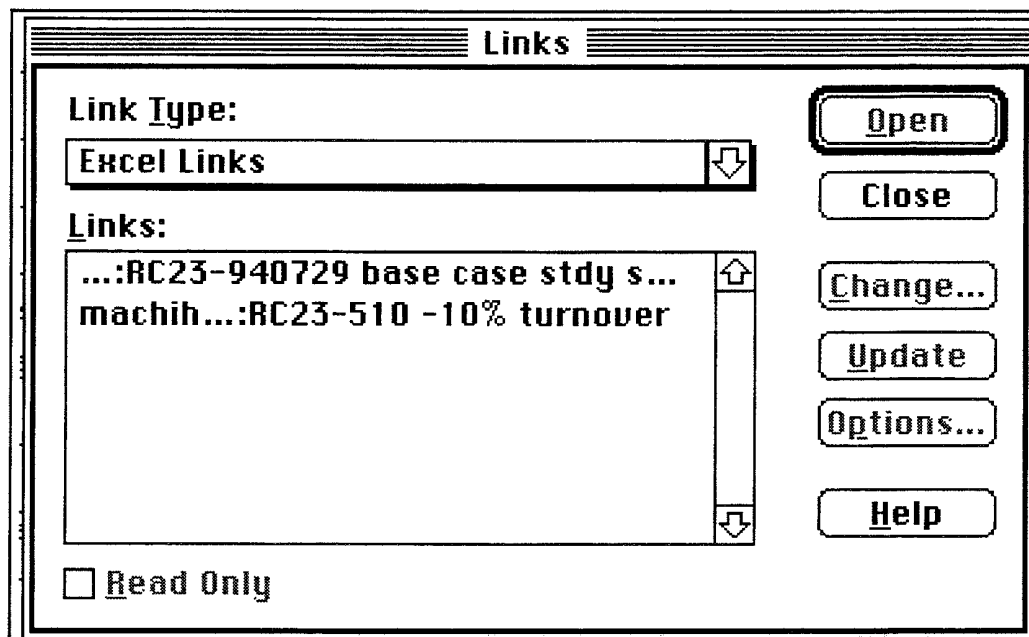
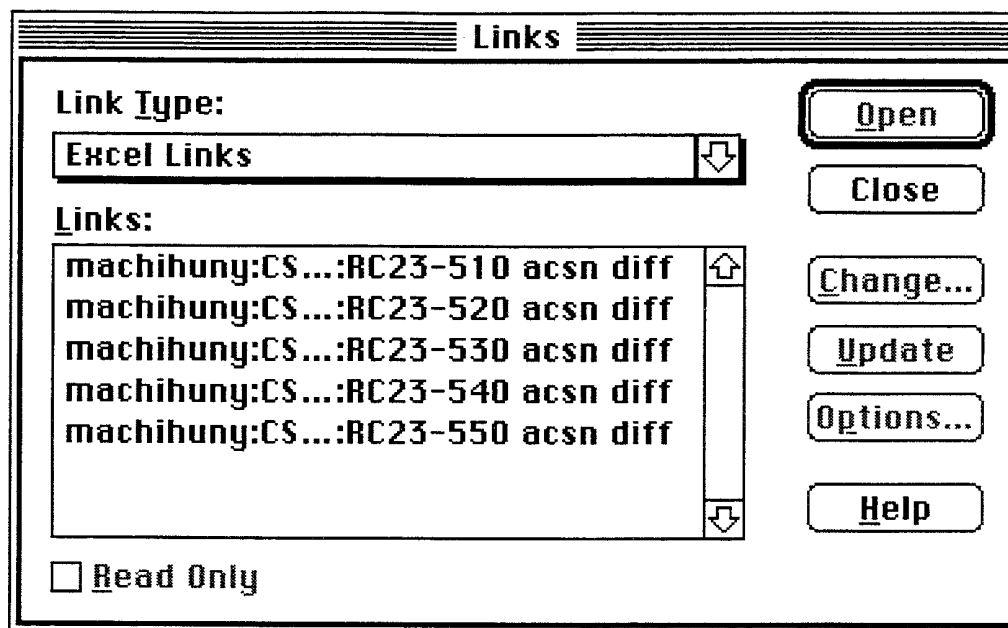


Fig. A.6--"... acsn diff" Spreadsheet Links

#### Links to the "... diffs summary" spreadsheet

Figure A.7 illustrates the *Links* dialogue box when the user selects the *Links* option for a "... diffs summary" spreadsheet. The dialogue box indicates that as many as five individual "... acsn diff" spreadsheets can be linked to the "... diffs summary" spreadsheet.





**Fig. A.7--"... diffs summary" Spreadsheet Links**

The dialogue box shows the linked spreadsheets in turnover reduction order, beginning with 10 percent turnover reduction and ending with 50 percent turnover reduction--this is indicated by the 510, 520, 530, 540, and 550 numbering scheme. This ordering scheme is not accidental. Indeed, were the model user to decide to link to the "... acsn diff" spreadsheets by beginning first with 530, followed by 520, and then 510, 550, and finally 540, this is the order that would be displayed in the dialogue box--the order of the links in the dialogue box is based on the order in which the user changes the links. We have found it useful to change spreadsheet links in a systematic fashion, e.g., 510, 520, 530, 540, 550, and we encourage the model user to make all link changes in a consistent manner across all spreadsheets. We address this issue again when discussing the trade-off summary spreadsheet below.

#### **Links to the "... end year smry" Spreadsheet**

Figure A.8 illustrates the *Links* dialogue box when the user selects the *Links* option for an "... end year smry" spreadsheet. The dialogue box shows links to a number of spreadsheets. However, only the last link is relevant, the one pointing to the "RC23-5 diffs summary" spreadsheet. The other spreadsheets are related to an affected base case of an earlier analysis cycle, and they are needed for computations that today are obsolete but still included in the "... end year smry" spreadsheet. They

do not affect the relevant accession decrement computations that result in the accession decrement table to which model spreadsheets link.

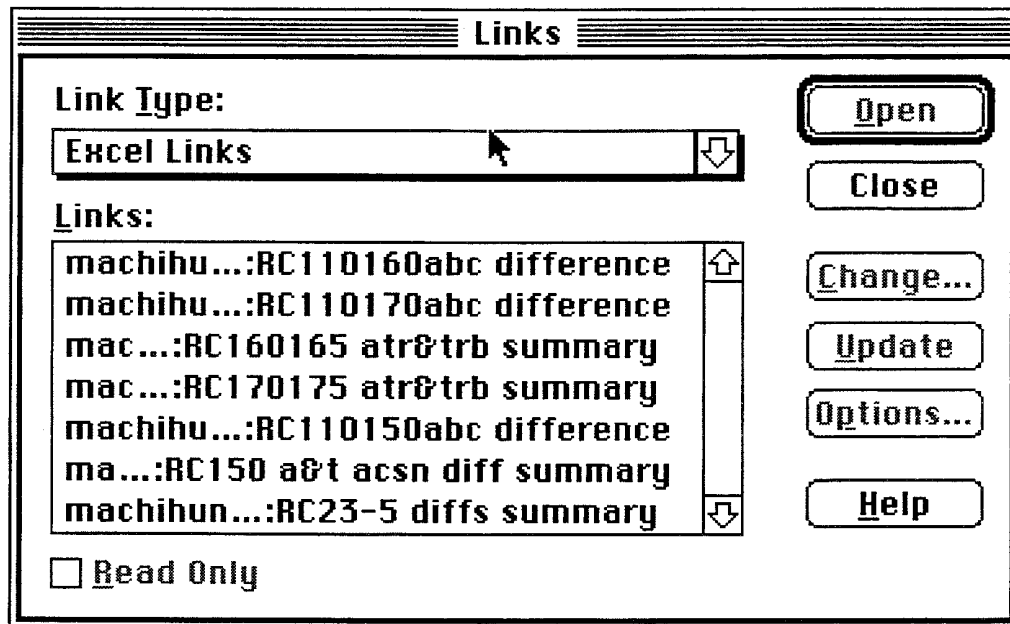


Fig. A.8--"... end year smry" Spreadsheet Links

#### The Trade-off Summary Spreadsheet

Figures A.9, A.10, A.11, and A.12 illustrate the *Links* dialogue box when the user selects the *Links* option for a trade-off summary spreadsheet. Four figures are used to illustrate this because the trade-off summary spreadsheet has links to 22 other spreadsheets, and we want to discuss all of these spreadsheets. Note that the four figures show the scroll bar in different locations.

We discuss the first four spreadsheets from Figure A.9. The first three of these are the base case model spreadsheet (which has been selected and is therefore shown with a black background), the base case model's "... avgtms" spreadsheet, and the base case model's "... toj" spreadsheet. The fourth spreadsheet contains full-time equivalent year input data used by the trade-off summary as part of its experience computations.

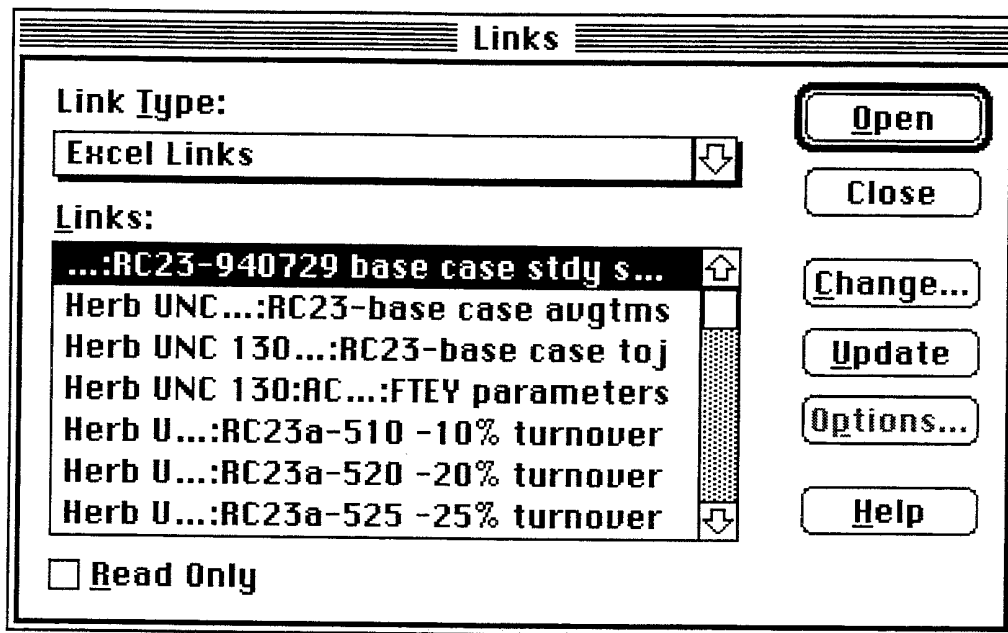


Fig. A.9--Trade-off Summary's Base Case Model Links

Figure A.10 shows the links to all six turnover reduction model spreadsheets. Note that the turnover reduction spreadsheets are listed in numerical order, a convention we have adopted to ensure that the proper spreadsheets are linked appropriately. Figure A.11 shows the links to all six "... avg tms" spreadsheets, also displayed in numerical order. Figure A.12 shows the links to all six "... toj" spreadsheets, again in numerical order.

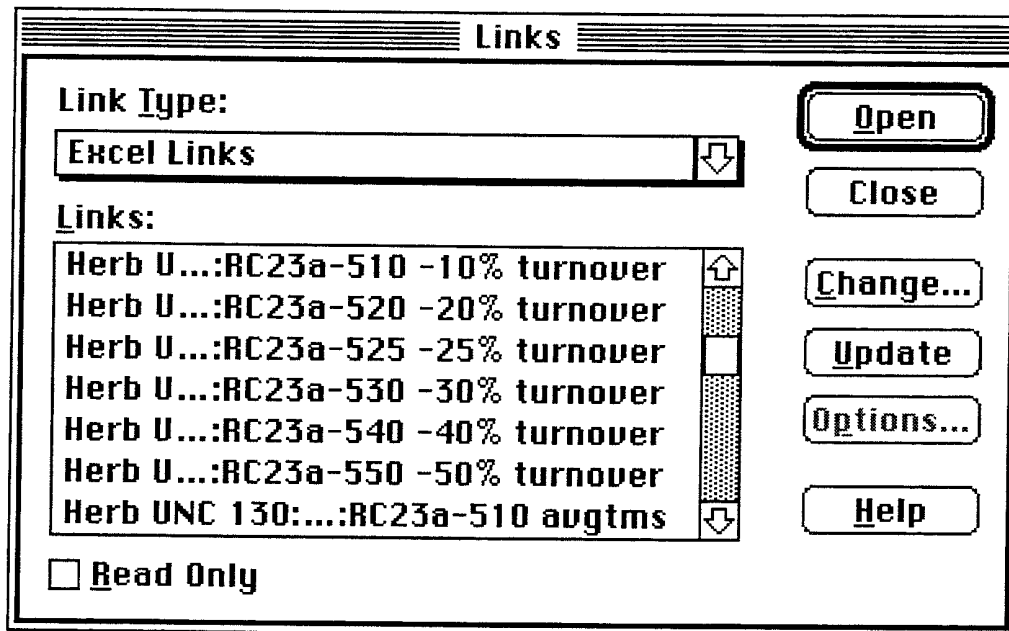


Fig. A.10--The Trade-off Summary's Turnover Model Spreadsheet Links

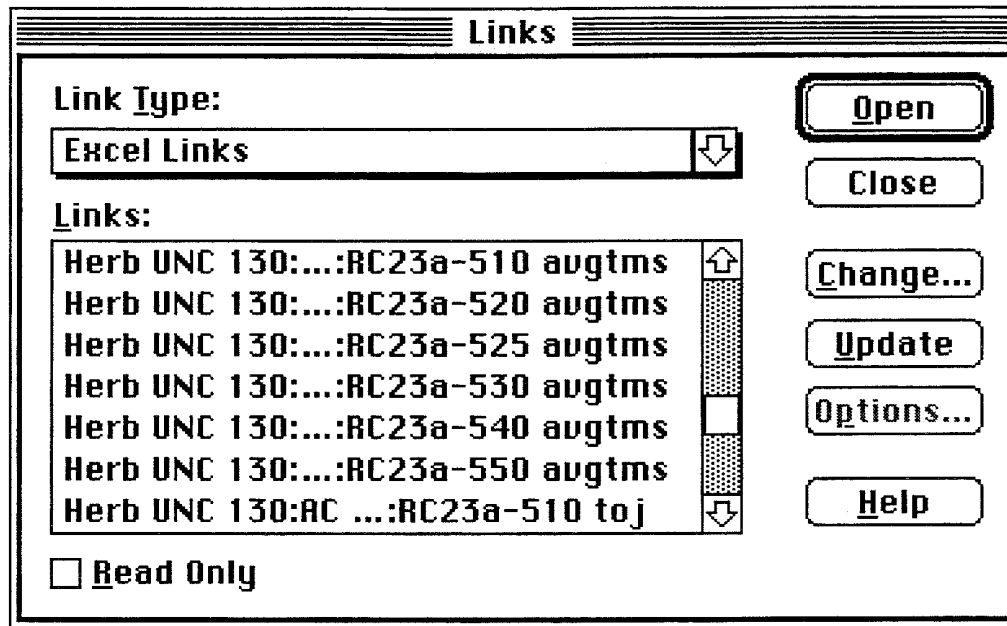


Fig. A.11--The Trade-off Summary's "... avgtps" Links

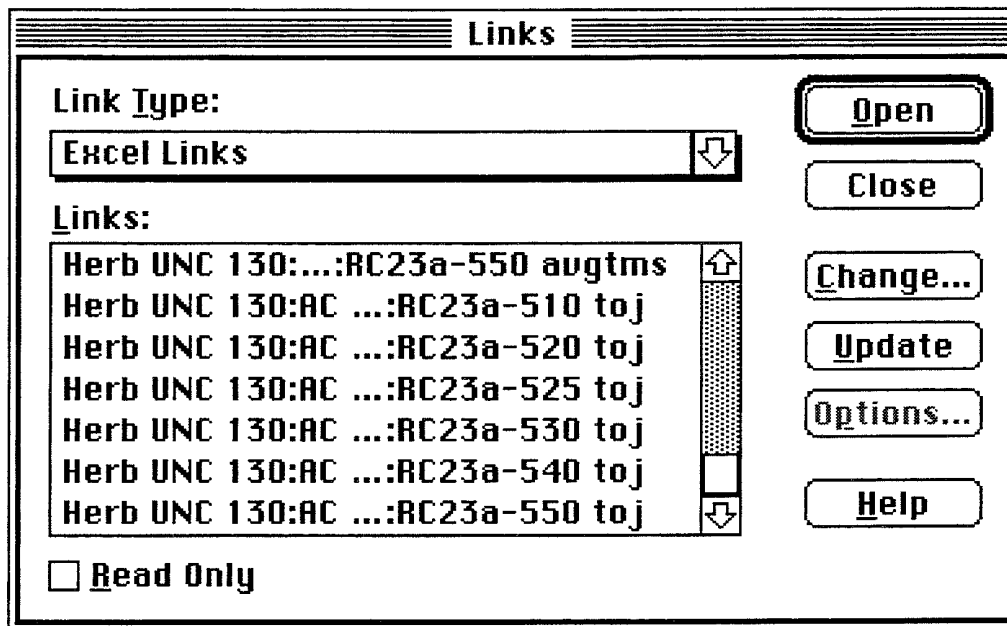


Fig. A.12--The Trade-off Summary's "... toj" Links

We wish to stress the importance of changing the links associated with a spreadsheet in a systematic manner. Specific cells in the open spreadsheet (the linked spreadsheets do not need to be open alongside the spreadsheet to which they are linked) refer to cells in a specific linked

spreadsheet. In changing links the user must ensure that spreadsheets do not get mixed up, with, for example, the "... avgtms" spreadsheet for the 10 percent turnover reduction case inadvertently getting associated with the 20 percent turnover reduction case. This is why we created the header page of the trade-off summary spreadsheet, which shows the specific spreadsheet associations--see Figure 5.4. It is also why we have rigorously adhered to a set of spreadsheet naming conventions.

Getting spreadsheets mixed up would not be a problem except for the way EXCEL alters the list of linked spreadsheets in the *Links* dialogue box. The most recently changed linked spreadsheet appears at the end of the list, no matter where it appeared in the list before it was changed. This helps the user remember the spreadsheet links that have not been changed because the unchanged ones always appear at the beginning of the list. Unfortunately, when trying to keep associated spreadsheets together, as we must do with the model, "... avgtms" and "... toj" spreadsheets, this EXCEL feature can actually cause confusion. To overcome this we have chosen to systematically change spreadsheet links by first changing the model spreadsheet links, thereby keeping them together in the dialogue box list, then changing the "... avgtms" links, keeping them together and after the model spreadsheet links, and finally changing the "... toj" spreadsheet links, also keeping them together and following the "... avgtms" links in the dialogue box.

After the user finishes the link-changing process, he should verify that the linked model, "... avgtms" and "... toj" spreadsheets properly correspond, as illustrated in Figure 5.4. That figure lists seven blocks of three spreadsheets. The first block of three spreadsheets *must* be the base case spreadsheet and its associated "... avgtms" and "... toj" spreadsheets. The remaining six spreadsheet blocks can be ordered at the user's discretion, based on the order in which he changes spreadsheet links. However, within each block the first spreadsheet must be the model spreadsheet, the second must be the corresponding "... avgtms" spreadsheet, and the third must be the corresponding "... toj" spreadsheet. We stress the usefulness of making these linkage changes in a systematic manner, e.g., low turnover to high turnover, to promote a reasonable order in the *Links* dialogue box.

### The "... avgtms", "... toj", and "... cost smry" Spreadsheets

Figures A.13 and A.14 show the *Links* dialogue boxes for the "... avgtms" and "... toj" spreadsheets. The "... avgtms" spreadsheet simply links to the appropriate model spreadsheet, in this case the 10 percent turnover reduction model spreadsheet. The "... toj" spreadsheet links to two spreadsheets. Like the "... avgtms" spreadsheet, the "... toj" spreadsheet links to the model spreadsheet. It also links to the spreadsheet that contains the full-time equivalent year inputs--the "...:FTEY parameters" spreadsheet.

Figure A.15 shows the *Links* dialogue box for the "... cost smry" spreadsheet. It shows links to the related trade-off summary spreadsheet and to a spreadsheet that contains costing data--the "...:RC23 costing data" spreadsheet.

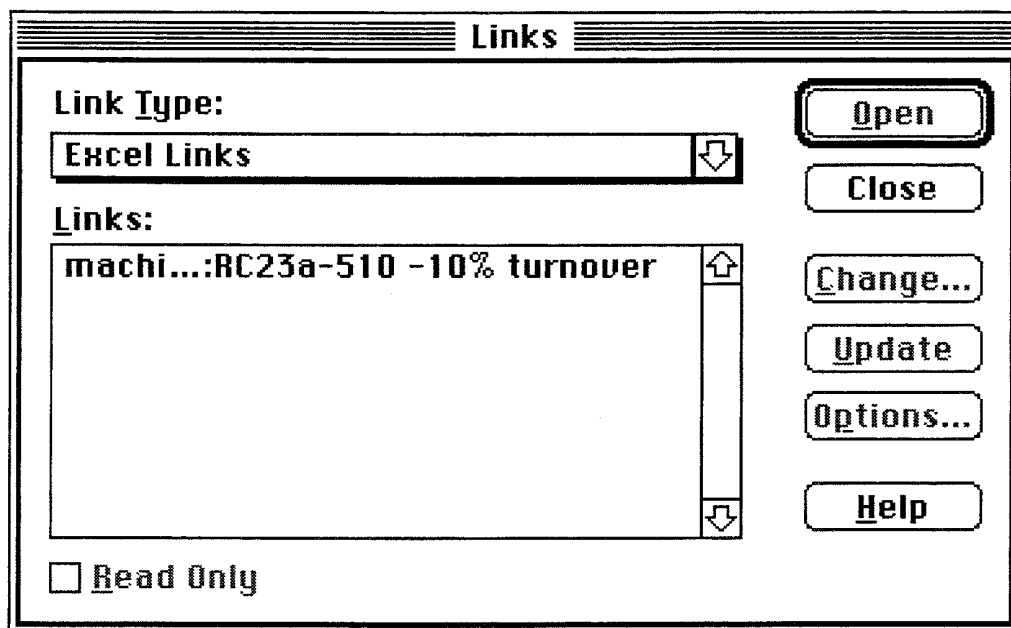


Fig. A.13--Links to the "... avgtms" Spreadsheet

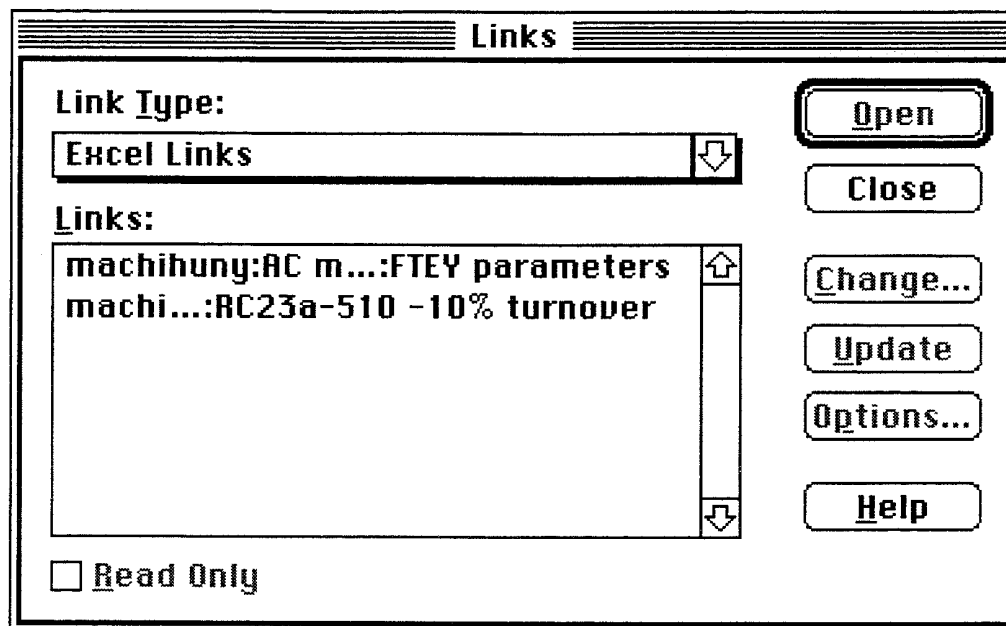


Fig. A.14--Links to the "... toj" Spreadsheet

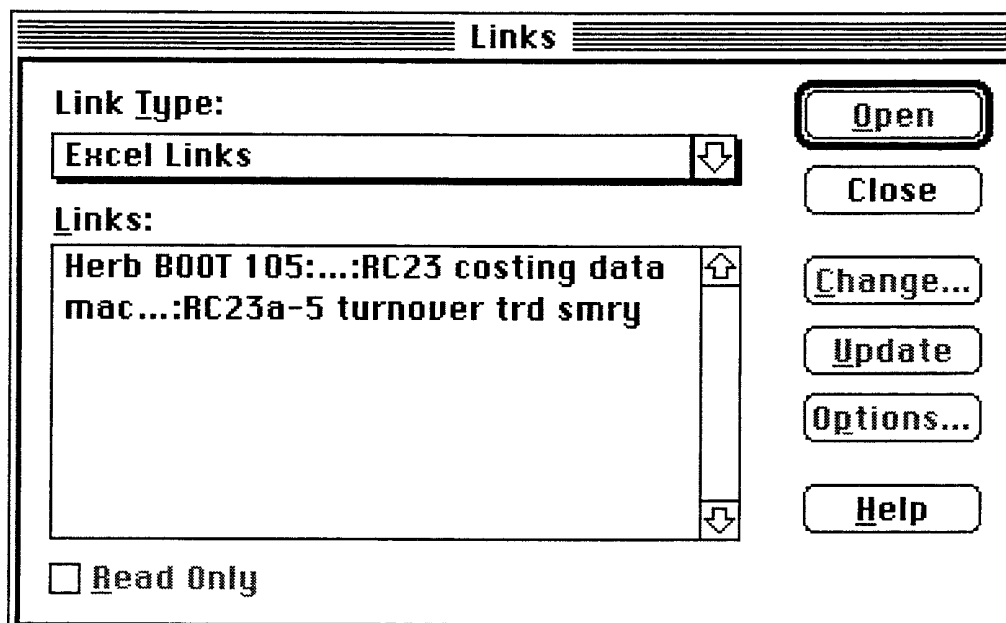


Fig. A.15--Links to the "... cost smry" Spreadsheet

#### Using the Table Manager in Conjunction with the Model Spreadsheet

The Section 3 discussion, "Balancing Attrition and Promotions", discussed at great length the use of the table manager. It did not, however, address how to ensure that the model spreadsheet and table manager

are appropriately linked to each other. This subsection addresses this issue.

Figure A.16 contains excerpts from the model spreadsheet and the table manager spreadsheet. Both must be open simultaneously, and both must be linked to each other. Further, in the model spreadsheet, the adjustment factor we wish to use as the independent variable must be defined in terms of the first independent variable cell in the table manager. In our example we use promotion, and both PS and NPS promotion adjustment factors are defined as the value contained in the table manager's first independent variable row--the two arrows are meant to signify this. Additionally, the dependent variables of interest in the table manager must refer to the associated cells in the model spreadsheet. We identify these in the figure below as those cells displayed in larger type, beginning with *NPS DELTA* and ending with *ipm negative*. We don't show arrow linkages for these because the table manager is already set up to access these variables. The only pointer the user needs to worry about is the independent variable pointer.



### MODEL SPREADSHEET

	ADJUSTMENT FACTORS			
	PROMOTION	ATTRITION	TURBULENCE	ACCESSIONS
NPS E1-3	0.90000	0.90000	1.00000	1.00000
E4	0.90000	0.90000	1.00000	1.00000
E5	0.90000	0.90000	1.00000	1.00000
E6	0.90000	0.90000	1.00000	1.00000
E7-9		0.90000	1.00000	1.00000
PS E1-3	0.90000	0.90000	1.00000	1.00000
E4	0.90000	0.90000	1.00000	1.00000
E5	0.90000	0.90000	1.00000	1.00000
E6	0.90000	0.90000	1.00000	1.00000
E7-9		0.90000	1.00000	1.00000
nps adjustments	0.90000	0.90000	1.00000	1.00000
	100.00%			
	E1-3 Promotion Penalty			
ps adjustments	0.90000	0.90000	1.00000	1.00000

### TABLE MANAGER SPREADSHEET

EXCEL TABLE--global promotion adjustment factor						
independent variable	0.90	0.89	0.88	0.87	0.86	0.85
nps promotion adjustment	0.90	0.89	0.88	0.87	0.86	0.85
ps promotion adjustment	0.90	0.89	0.88	0.87	0.86	0.85
e1-3 promotion penalty	0.00	0.00	0.00	0.00	0.00	0.00
NPS DELTA	3941	2405	904	273	-284	-893
PS DELTA	-4036	-2487	-994	-340	138	604
TOTAL DELTA	-94	-82	-91	-67	-146	-289
E13 DELTA	0	0	0	35	271	523
E4 DELTA	117	111	105	100	132	172
E5 DELTA	27	18	9	1	5	14
E6 DELTA	-109	-116	-125	-117	-115	-107
E7-9 DELTA	-130	-95	-80	-87	-438	-890
NPS PERCENT	1.4%	0.8%	0.3%	0.1%	-0.1%	-0.3%
PS PERCENT	-2.3%	-1.4%	-0.6%	-0.2%	0.1%	0.3%
TOTAL PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
E13 PERCENT	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%
E4 PERCENT	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
E5 PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E6 PERCENT	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
E7-9 PERCENT	-0.3%	-0.2%	-0.2%	-0.2%	-1.0%	-2.0%
tprob checksum						
tprob negative						
ipm checksums	0.08	-0.03	-0.03	-0.06	-0.19	-0.20
ipm negative						

Fig. A.16--Model and Table Manager Spreadsheet Linkages

Figure A.16 uses the promotion adjustment factor as the independent variable, and we have described how to ensure that the model spreadsheet is

linked to the table manager so that this will be the case. The next thing to worry about is how to specify other values for the independent variable. The five cells to the right of the first independent variable cell are used to specify these additional values. The user must ensure that these cells are also appropriately valued. We have found the *Series* option under the EXCEL *Data* menu item to be useful for this purpose in that it allows the user to specify that a range of cells are to vary arithmetically using an appropriate increment or decrement.

The table manager segment illustrated in Figure A.16 is defined as an EXCEL *table*. This allows us to ask EXCEL to run six related model cases at a time, displaying the results as each case's calculations are completed. The table definition treats the first column--the one displayed in larger type in the figure--as a guide to indicate which model parameters are of interest. It then fills in those model parameters for each successive case. To start the calculation the user need simply key in <COMMAND><=>.

When calculations are begun the user will note that the first column of numbers begins to change as the iteration process unfolds. Once the iteration process concludes for the first case, the user will note that the model seems to be doing nothing. This is not the case. The model is conducting calculations for the second case, but it does not cause the display to change until after the calculations for that case are completed. The model then turns to the third, fourth, fifth, and sixth cases sequentially. It then must repeat the first case calculations in order to restore the model to the first case's conditions.



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