The Enlisted Steady State-Simulation (ESS-SIM) Tool

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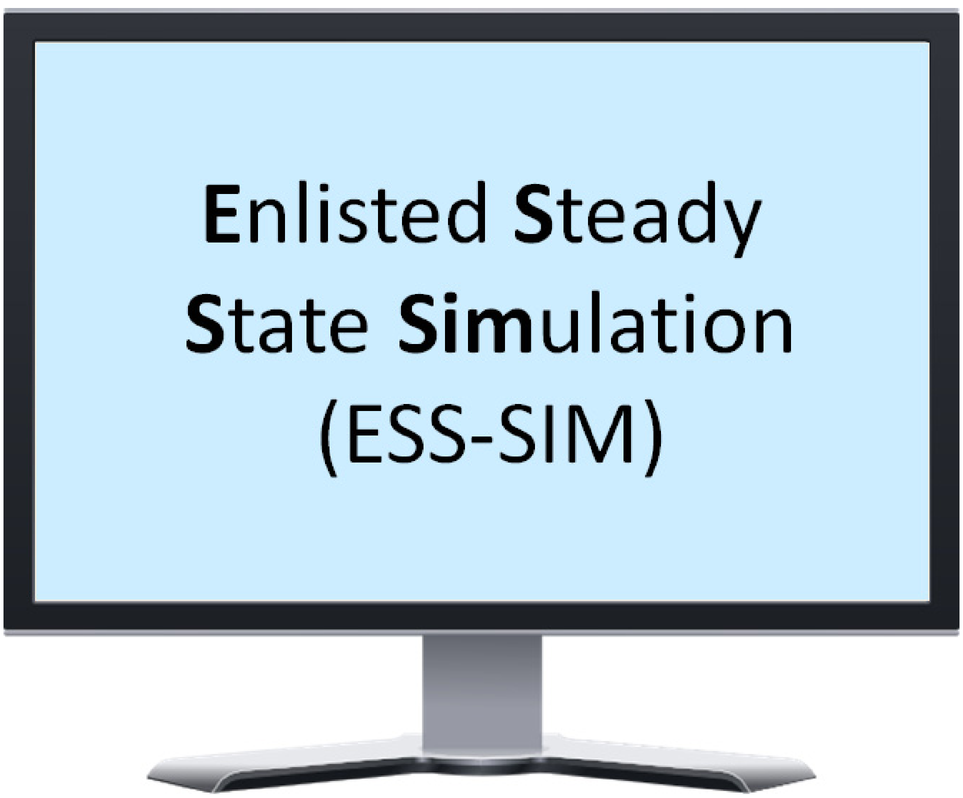

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Introduction

N81 asked CNA to examine the issues affecting fleet manning and provide recommendations for changes to the Manpower, Personnel, Training and Education (MPT&E) policies, processes, procedures, and funding that will lead to improved manning levels. We examined how a wide variety of Navy MPT&E policies and procedures combine to affect fleet manning. Many complicated interactions between these policies and procedures make it difficult to intuit their net effect on fleet manning. Simulation is a valuable tool in such a situation. We built and made use of a simulation model, *ESS-Sim* (**E**nlisted **S**teady-**S**tate **Sim**ulation), to obtain insights into attainable levels of fleet manning and estimate the impact of policy changes on fleet manning. This information memorandum describes this model.

Model overview

We built *ESS-Sim* to obtain insights into enlisted fleet manning, which is affected by many policies, procedures, and personnel behavior. MPT&E actions can be viewed in two distinct pieces:

1. The actions that attain and sustain overall inventories of personnel and their macro division between sea and shore duty
2. The actions that distribute personnel among individual units

The former set of actions is within the purview of OPNAV (N1 for MPT&E policies, N9 for sponsoring resources (manpower), and so on). The latter set of actions is within the purview of PERS-4 (the detailers) and United States Fleet Forces Command (USFFC) (for cross-decks, diverts, and so on). We developed a model to address the first set of activities; it provides a macro-level understanding of the impact of policies on the supply of personnel for sea duty.

Fleet manning is addressed and managed one community at a time; overmanning in one rating does not offset undermanning in another. Consequently, we developed a model that simulates one enlisted management community (EMC) at a time.

Navy personnel inventories are dynamic; they change substantially from one time period to another. When analyzing trends in Navy manning, it is difficult to discern between long-term trends and seemingly random fluctuations from one time period to the next. It is also difficult to discern limits in what is attainable due to policy and behavioral constraints (i.e., the fluctuations mask underlying structural dynamics of personnel inventories). We built *ESS-Sim* to address these concerns. It works in two phases:

- A simulation of long-term, *steady-state*, behavior that shows how inventories will evolve over time in response to a set of policies and procedures and obtain a stable *steady-state* inventory
- A simulation of the transition from a current inventory towards the steady state.

The steady-state inventory identifies what is attainable and sustainable. It is possible, for example, to have 100 personnel with 10 years of service and 150 personnel with 11 years of service, but it is not possible to sustain this inventory because—in this example—the number of personnel with 11 years of service is no greater than the number of personnel that had 10 years of service 1 year ago. Steady-state inventories describe the underlying structure/form of the personnel inventory derived from policies, procedures, and personnel retention. Steady-state inventories do not address the situations that may arise today or in the near future due to the idiosyncrasies of current inventories. A simulation of the transition from a current inventory toward the steady state is required for such an understanding.

Model design

We developed the model in Excel, which provides these advantages:

- Accessible by everyone
- Allows for incremental development (i.e., just add a worksheet)
- Transparent (i.e., easy to understand).

It is possible to write extensive visual-basic macros for Excel programs, adding much potential complexity and efficiency to spreadsheets. We chose not to do this, mostly due to time constraints. So, we need to show all intermediate calculations. This makes the spreadsheet voluminous, but it adds some transparency to the calculations.

As noted, we developed the model to consider one EMC at a time. We are trying to obtain insights into how personnel inventories behave, evolve, and match requirements. We consider three dimensions to personnel inventories in the model because these dimensions are routinely used to manage and assess the health of communities:

- **Paygrade**: Requirements are described by paygrade (e.g., the Navy needs 100 E-5 OS personnel).
- **Longevity (length of service):** Many personnel policies address longevity (e.g., Zone A, Zone B reenlistments; length of first and subsequent sea tours; retirement after 20 years of service).
- **Sea duty vs. shore duty**; Sea-shore flow policies are directed at attaining and maintaining the required distribution of personnel between sea and shore duty.

There are also numerous interactions between these inventory dimensions, which are not well understood. **A major benefit of this model is that it demonstrates the structural interrelationships between the paygrade, longevity, and sea-shore inventory dimensions.**

Model worksheets

The model contains four primary worksheets:

- **PG x YOS** computes the steady-state length of service by paygrade distribution that applies to the community under consideration, given a particular set of inputs.
- **Tour Flows** computes the percentage of personnel for each year of service that will be on sea duty, in the long term, for a given set of sea-shore flow policies.
- **Transition** computes the transition from today's inventory towards the steady-state inventory.
- **PG x YOS x Type Duty** provides summary output.

The worksheets allow the user to vary input parameters (continuation rates, tour lengths, etc.) and observe the impact on inventories. There are other worksheets for storing data and displaying results.

PG X YOS (paygrade and length of service)

Background and *Spread EPA*

The first worksheet in the model, PG x YOS, addresses how inventories evolve over time when current authorizations and continuation behavior are assumed to continue indefinitely. The interest and use of such a construct is that it enables users to answer such questions as, "Do we have sufficient accessions to provide the required number of experienced personnel 10 years in the future?" There is imprecision in such a question; notably, it's unclear what we precisely mean by "experienced personnel," but it's intuitively understandable. We are trying to address whether we have sufficient junior personnel today to meet future requirements for experienced personnel.

There is a considerable background to this issue. In recent years, enlisted community managers have relied on a concept known as *Spread EPA* to manage their communities. *Spread EPA* is an attempt to translate requirements, as specified by paygrade in Enlisted Programmed Authorizations (EPA), into a length-of-service distribution (*x* personnel with 1 year of service, *y* personnel with 2 years of service, and so on). Community managers have used *Spread EPA* to assess whether the number of personnel with a given amount of longevity is correct; that assessment has been used to guide community management. It is laudable to consider longevity profiles in community management, although the extent and nature of its use are subject to substantial debate, which we do not address here. However, one shortcoming of *Spread EPA* is the lack of a rigorous method to translate paygrade requirements into longevity profiles. The methods used in this model address this issue and provide a transparent and defensible approach to translating paygrade requirements into length-of-service profiles.

Theoretical underpinning

This worksheet is based on the following statement:

> Consider a community where we have an inventory, authorizations, and annual continuation rates. Suppose we age the inventory subject to the annual continuation rates; advance personnel to fill vacancies, subject to Navy advancement rules; and access sufficient personnel to meet end-strength goals. Further suppose we iterate this process of

continuation, advancement, and accessions for many years. Then the inventory will converge to a steady-state length of service by pay-grade distribution, which will maintain itself from one year to the next, i.e., after sufficient time, we derive an inventory that will have the same length of service by pay-grade distribution from one year to the next.

This steady-state distribution provides a crosswalk between paygrade and length-of-service considerations, allowing Navy personnel managers to understand how actions regarding paygrade structure will affect longevity and vice versa.

Content of worksheet—input

There are several arrays of input data for the worksheet:

- A starting inventory that is differentiated by years of service, paygrade, and time-in-grade. The time-in-grade dimension allows the model to calculate how many personnel are eligible for advancement.
- Continuation rates for each year-of-service and paygrade combination.
- Authorizations for each paygrade and duty type (sea duty, shore duty, and individuals account).
- Starting inventory, differentiated by paygrade and duty type.
- The distribution of accession gains to the community spread across the first few years of service and paygrades. (This facilitates the simulation of EMCs with varied training pipeline lengths and initial grades of personnel entering the community.) Note that the model computes accessions/community gains as personnel entering the community. Nonrated personnel are not included in the data, though the amount of time accessions spend in a nonrated status is considered.
- Percentage change to total authorizations for each projection year, which facilitates simulation of scenarios regarding how an inventory responds to changing authorization targets.

Tables 1 through 6 contain examples of input data, which were taken from a sample simulation of the OS community.

Table 1. Example of starting inventory

	End FY Inventory (YOS X PG X TIG)																							
	E1 to E3			E4		E5				E6				E7				E8				E9
YOS	0	1	2+	0	1+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	All
0	457	0	0	3						1												
1	417	33	0	267																		
2	97	19	9	466	118	52																
3	20	2	2	153	234	241	24	1														
4	2	0	2	37	68	219	94	16														
5	0	0	0	15	13	102	128	86	19	3												
6	0	0	0	6	6	25	48	87	138	20		1		1								
7	1	0	0	3	7	19	12	16	228	38	5			1								
8	1	0	0	1		8	11	5	189	45	8	4	1	2			1					
9	0	0	0			1	6	4	128	54	19	9	7	4	2							
10	0	0	0			1	1	3	50	50	22	12	16	5	4	2						
11	0	0	0					1	63	26	8	13	16	5	3	2						
12	0	0	0			1			62	47	17	25	46	10	7	6						
13	0	0	0			1	1	3	37	31	15	14	67	12	8	9	4	3				1
14	0	0	0						8	16	9	14	62	23	11	9	13	3			1	
15	0	0	0			1				2	7	15	76	9	6	11	18	3	1		1	1
16	0	0	0									2	74	12	11	13	15	4	2	4	1	
17	0	0	0							1		1	87	14	7	16	33	5	1	1	1	
18	0	0	0						12		1	1	74	4	7	10	36	5	3		2	
19	0	0	0				1	1	6	2	1	6	63	2	2	10	28	6	4	5	3	
20	0	0	0										1	6	2	5	30	5	3	5	7	2
21	0	0	0												2	1	27	7	3	2	4	1
22	0	0	0													1	30	2	2	2	11	1
23	0	0	0														23		1	3	7	2
24	0	0	0														1	3	1	4	11	5
25	0	0	0																	4	14	6
26	0	0	0																		1	3
27	0	0	0																			2
28	0	0	0																			3
29	0	0	0																			3

Table 2. Example of continuation rates

YOS	E1-E3	E4	E5	E6	E7	E8	E9
0	0.968	1.000					
1	0.930	0.976	1.000				
2	0.858	0.920	0.965				
3	0.858	0.920	0.965				
4	0.336	0.538	0.669				
5	0.517	0.776	0.848	1.000			
6	0.643	0.760	0.907	1.000	1.000		
7	0.250	0.878	0.941	1.000	1.000		
8	0.000	0.515	0.825	0.874	1.000		
9		0.500	0.826	0.898	1.000		
10		0.364	0.849	0.917	0.900		
11		0.375	0.807	0.868	0.955	1.000	
12		0.000	0.793	0.937	0.961	1.000	
13		0.000	0.787	0.933	0.940	1.000	
14		0.000	0.267	0.923	0.926	1.000	
15			0.364	0.950	0.975	1.000	
16			0.882	0.983	0.950	1.000	
17		0.000	0.933	0.985	0.965	0.917	
18			1.000	0.984	0.983	0.926	
19			1.000	0.991	0.970	0.975	1.000
20		0.000	0.053	0.060	0.766	0.863	1.000
21				0.000	0.864	0.796	1.000
22					0.825	0.821	1.000
23					0.829	0.892	1.000
24					0.151	0.875	1.000
25				0.000	0.000	0.825	0.800
26						0.048	1.000
27							1.000
28							0.889
29							0.000

Table 3. Example of authorizations

Authorizations x Type Duty								
	E1-E3	E4	E5	E6	E7	E8	E9	Total
Sea	730	1001	1855	640	229	73	15	4543
Shore	12	127	800	456	316	75	16	1802
IA	275	44	101	46	21	7	1	495
Total	1017	1172	2756	1142	566	155	32	6840

Table 4. Example of starting inventory (PG X Type Duty)

Starting Inventory PG x Type Duty								
	E1-E3	E4	E5	E6	E7	E8	E9	Total
Sea	772	1256	1213	632	270	75	11	4229
Shore	69	112	797	456	233	81	18	1766
IA	221	29	150	67	33	5	1	506
Total	1062	1397	2160	1155	536	161	30	6501

Table 5. Example of PG and YOS distribution of accession gains

YOS x PG Distribution of Accessions				TIG for E1-E3 Accessions	
	E1-E3	E4	Total	TIG = 0	TIG = 1
YOS = 0	1	0	100%	60%	40%
YOS = 1	0%	0%	0%		
YOS = 2	0	0%	0%		

Table 6. Example of changes to total authorizations

Adjustments to Authorizations					
Proj. Year	Adjustment	Proj. Year	Adjustment	Proj. Year	Adjustment
1	1%	11	0%	21	0%
2	0%	12	0%	22	0%
3	-1%	13	0%	23	0%
4	0%	14	0%	24	0%
5	1%	15	0%	25	0%
6	0%	16	0%	26	0%
7	1%	17	0%	27	0%
8	0%	18	0%	28	0%
9	1%	19	0%	29	0%
10	0%	20	0%	30	0%

Content of worksheet—computations

The spreadsheet computes annual accessions for 30 years; inventories will converge to very close to an absolute steady state within this timeframe. (The transition worksheet addresses the timing of the transition and shows that inventories typically get "close" to a steady state within a much smaller number of years.)

Three arrays of data are displayed for each projection year:

- The inventory that continues (i.e., remains on active duty) until the end of the year when continuation rates are applied to the inventory at the start of the year.
- The advancements and accessions that occur each year. The model computes vacancies by comparing the inventory remaining at the end of the year to authorizations and also accounting for personnel who advance up to the next grade, creating additional vacancies. For example, vacancies for E-9 are the difference between the number of E-9 personnel who remain to the end of the year and E-9 authorizations; vacancies for E-8 are the difference between the number of E-8 personnel who remain to the end of the year and E-8 authorizations, plus the number of personnel who are advanced from E-8 to E-9, and so on. The

model also computes the number of personnel who are eligible to advance by considering time-in-grade policies. Vacancies are filled by taking the appropriate proportion of advancement-eligible personnel, selecting uniformly across length-of-service cells, to advance the appropriate number of personnel. Accessions are computed as the difference between the continuing inventory and total authorizations, and they are spread across the early years of service and paygrade cells according to the model input.

- The end-of-fiscal-year inventory that is the net effect of both of the prior arrays (i.e., continuation, and advancement and gains).

Tables 7 through 9 show examples of computations for one projection year.

The worksheet repeats these calculations for each of 30 years. Results may be observed by scrolling across the columns. The worksheet also contains some tables that summarize each year's projection.

Tour flows

In this worksheet, we simulate the percentage of personnel that, in the long term, will be at sea for each year of service. The percentage of personnel at sea depends on policies, procedures, and personnel behavior. The model parameterizes many of the policies, procedures, and personnel behavior, allows the user to vary the parameters, and projects the impact of these parameter values on the percentages of personnel on sea duty.

The methodology considers all the possible paths personnel may follow regarding their type of duty assignments (first tour at sea, second tour ashore, third tour at sea, OR first tour at sea, second tour ashore, third tour ashore, etc.), computes the probability of following any particular path, computes the type of duty for each month of service for a given path, and computes a weighted average over all possible paths to derive the percentage of personnel on sea duty for each year of service. The computations are intricate and laborious, but comparatively easy to follow once one has an idea of the methodology.

Table 7. Example of continuing inventory

Continued t+1																					
	E1 to E3			E4		E5				E6				E7				E8			E9
YOS	0	1	2+	0	1+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	All
0																					
1		442.3	0.0		3.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
2		387.7	30.7		260.7		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
3		83.2	24.0		537.1		50.2	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
4		17.2	3.4		355.9		232.5	23.2	1.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
5		0.7	0.7		56.5		146.4	62.8	10.7		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
6			0.0		21.7		86.5	108.6	89.1		3.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
7			0.0		9.1		22.7	43.5	204.1		20.0	0.0	1.0		1.0	0.0	0.0		0.0	0.0	0.0	
8			0.0		8.8		17.9	11.3	229.6		38.0	5.0	0.0		1.0	0.0	0.0		0.0	0.0	0.0	
9			0.0		0.5		6.6	9.1	160.1		39.3	7.0	4.4		2.0	0.0	1.0		0.0	0.0	0.0	
10			0.0		0.0		0.8	5.0	109.0		48.5	17.1	14.4		4.0	2.0	0.0		0.0	0.0	0.0	
11			0.0		0.0		0.8	0.8	45.0		45.9	20.2	25.7		4.5	3.6	1.8		0.0	0.0	0.0	
12			0.0		0.0		0.0	0.0	51.7		22.6	6.9	25.2		4.8	2.9	1.9		0.0	0.0	0.0	
13			0.0		0.0		0.8	0.0	49.2		44.1	15.9	66.6		9.6	6.7	5.8		0.0	0.0	0.0	
14			0.0		0.0		0.8	0.8	31.5		28.9	14.0	75.5		11.3	7.5	12.2		3.0	0.0	0.0	
15			0.0		0.0		0.0	0.0	2.1		14.8	8.3	70.2		21.3	10.2	20.4		3.0	0.0	1.0	
16			0.0		0.0		0.4	0.0	0.0		1.9	6.6	86.4		8.8	5.9	28.3		3.0	1.0	1.0	0.0
17			0.0		0.0		0.0	0.0	0.0		0.0	0.0	74.7		11.4	10.4	26.6		4.0	2.0	5.0	0.0
18			0.0		0.0		0.0	0.0	0.0		1.0	0.0	86.7		13.5	6.8	47.3		4.6	0.9	1.8	0.0
19			0.0		0.0		0.0	0.0	12.0		0.0	1.0	73.8		3.9	6.9	45.2		4.6	2.8	1.9	0.0
20			0.0		0.0		0.0	1.0	7.0		2.0	1.0	68.4		1.9	1.9	36.9		5.9	3.9	7.8	0.0
21			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.1		4.6	1.5	26.8		4.3	2.6	10.4	2.0
22			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	1.7	24.2		5.6	2.4	4.8	1.0
23			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	25.6		1.6	1.6	10.7	1.0
24			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	19.1		0.0	0.9	8.9	2.0
25			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.2		2.6	0.9	13.1	5.0
26			0.0		0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	14.9	4.8
27			0.0				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	3.0
28			0.0				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	2.0
29			0.0				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	2.7
30+			0.0				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	0.0
PG Total			989.8		1253.4				1834.4				1085.9				494.8				142.4	23.5
Vacancies			1084.2		1046.9				1116.5				167.4				99.9				23.0	8.9

Table 8. Advances and accessions

Advancees & Accessions							
YOS	Accessions	E1-3	E-4	E-5	E-6	E-7	E-8
0	1084.2	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	2.7	0.0	0.0	0.0	0.0
2	0.0	30.7	232.2	0.0	0.0	0.0	0.0
3		24.0	478.5	0.0	0.0	0.0	0.0
4		3.4	317.1	0.2	0.0	0.0	0.0
5		0.7	50.3	1.8	0.0	0.0	0.0
6		0.0	19.4	14.9	0.0	0.0	0.0
7		0.0	8.1	34.1	0.1	0.0	0.0
8		0.0	7.8	38.4	0.0	0.0	0.0
9		0.0	0.5	26.8	0.6	0.1	0.0
10		0.0	0.0	18.2	2.1	0.0	0.0
11		0.0	0.0	7.5	3.8	0.1	0.0
12		0.0	0.0	8.6	3.7	0.1	0.0
13		0.0	0.0	8.2	9.9	0.4	0.0
14		0.0	0.0	5.3	11.2	0.9	0.0
15		0.0	0.0	0.4	10.4	1.4	0.1
16		0.0	0.0	0.0	12.8	2.0	0.1
17		0.0	0.0	0.0	11.1	1.9	0.5
18		0.0	0.0	0.0	12.9	3.4	0.2
19		0.0	0.0	2.0	11.0	3.2	0.2
20		0.0	0.0	1.2	10.1	2.6	0.9
21		0.0	0.0	0.0	0.0	1.9	1.1
22		0.0	0.0	0.0	0.0	1.7	0.5
23		0.0	0.0	0.0	0.0	1.8	1.2
24		0.0	0.0	0.0	0.0	1.4	1.0
25		0.0	0.0	0.0	0.0	0.0	1.4
26		0.0	0.0	0.0	0.0	0.0	1.6
27		0.0	0.0	0.0	0.0	0.0	0.0
28		0.0	0.0	0.0	0.0	0.0	0.0
29		0.0	0.0	0.0	0.0	0.0	0.0
30+		0.0	0.0	0.0	0.0	0.0	0.0
Total	1084.2	58.8	1116.5	167.4	99.9	23.0	8.9

Table 9. End of year forecast inventory

End FY +1 Inventory

	E1 to E3			E4		E5				E6				E7				E8				E9	YOS
YOS	0	1	2+	0	1+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	All	Total
0	650.5	433.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1084.2
1	0.0	442.3	0.0	0.0	0.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	445.3
2	0.0	387.7	0.0	30.7	28.5	232.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	679.1
3		83.2	0.0	24.0	58.6	478.5	50.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	694.5
4		17.2	0.0	3.4	38.9	317.1	232.5	23.2	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	633.1
5		0.7	0.0	0.7	6.2	50.3	146.4	62.8	8.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	277.8
6		0.0	0.0	0.0	2.4	19.4	86.5	108.6	74.2	14.9	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	308.9
7		0.0	0.0	0.0	1.0	8.1	22.7	43.5	170.0	34.1	20.0	0.0	0.9	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	301.5
8		0.0	0.0	0.0	1.0	7.8	17.9	11.3	191.2	38.4	38.0	5.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	311.5
9		0.0	0.0	0.0	0.1	0.5	6.6	9.1	133.4	26.8	39.3	7.0	3.7	0.6	2.0	0.0	0.9	0.1	0.0	0.0	0.0	0.0	230.0
10		0.0	0.0	0.0	0.0	0.0	0.8	5.0	90.8	18.2	48.5	17.1	12.2	2.1	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	200.7
11		0.0	0.0	0.0	0.0	0.0	0.8	0.8	37.5	7.5	45.9	20.2	21.9	3.8	4.5	3.6	1.7	0.1	0.0	0.0	0.0	0.0	148.3
12		0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.0	8.6	22.6	6.9	21.4	3.7	4.8	2.9	1.8	0.1	0.0	0.0	0.0	0.0	115.9
13		0.0	0.0	0.0	0.0	0.0	0.8	0.0	41.0	8.2	44.1	15.9	56.7	9.9	9.6	6.7	5.4	0.4	0.0	0.0	0.0	0.0	198.6
14		0.0	0.0	0.0	0.0	0.0	0.8	0.8	26.2	5.3	28.9	14.0	64.3	11.2	11.3	7.5	11.4	0.9	3.0	0.0	0.0	0.0	185.5
15		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.4	14.8	8.3	59.7	10.4	21.3	10.2	18.9	1.4	3.0	0.0	0.9	0.1	151.2
16		0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.9	6.6	73.6	12.8	8.8	5.9	26.3	2.0	3.0	1.0	0.9	0.1	143.2
17		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.7	11.1	11.4	10.4	24.7	1.9	4.0	2.0	4.5	0.5	134.2
18		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	73.9	12.9	13.5	6.8	43.9	3.4	4.6	0.9	1.6	0.2	162.6
19		0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	2.0	0.0	1.0	62.9	11.0	3.9	6.9	42.0	3.2	4.6	2.8	1.7	0.2	152.1
20		0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.8	1.2	2.0	1.0	58.2	10.1	1.9	1.9	34.2	2.6	5.9	3.9	6.9	0.9	137.7
21		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.6	1.5	24.9	1.9	4.3	2.6	9.2	3.1	52.3
22		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	22.5	1.7	5.6	2.4	4.3	1.5	39.7
23		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.7	1.8	1.6	1.6	9.5	2.2	40.5
24		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.7	1.4	0.0	0.9	8.0	3.0	30.9
25		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.6	0.9	11.7	6.4	21.8
26		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	6.4	19.7
27		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0
28		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
29		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.7
30+		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total			2015.2		195.6				2783.6				1153.4				571.7				156.6	32.3	6908.4

Content of worksheet—input

There are several arrays of input for the worksheet:

- Tour lengths in months for the first through fifth sea tours and shore tours. The model assumes that the sixth and subsequent sea and shore tours have the same length as the fifth tour.
- Length of the initial training time in months, i.e., the time it takes accessions to reach the fleet.
- Time to be rated—the number of months in the initial training pipeline before personnel transition from nonrated to a community asset.
- First tour billets—the percentage of initial assignments that are for sea duty.
- At the end of each tour, sailors rotate from their current type duty (sea or shore) to either sea or shore duty. There is an input array that specifies the probability of each transition (e.g., 80 percent of personnel rotate ashore after their second sea tour and 20 percent have back-to-back sea tours).
- In practice, many personnel do not have a tour length that precisely matches prescribed tour lengths. The model allows input regarding the distribution of tour lengths around prescribed tour lengths. The user may specify the percentage of tours that are completed for each month within 6 months of the prescribed tour length. For example, the user may input that 40 percent of personnel serve the prescribed tour length, 10 percent have tours 1 month shorter, 15 percent have tours 1 month longer, and so on. (The percentages need to add to 100 percent to be sure of accounting for all personnel.)

Tables 10 through 14 show sample input for the OS community.

Table 10. Tour lengths (months)

Tour lengths		Sea	Shore
1st tour in type duty		60	39
2nd tour in type duty		48	39
3rd tour in type duty		42	48
4th tour in type duty		36	36
5th tour in type duty		36	36

Table 11. Length of initial training & time to be rated (months)

Training time		7
Time to get rated		6

Table 12. Type duty for first tour

		Sea	Shore
First tour billets		95%	5%

Table 13. Tour path flows

Flows		Sea-Sea	Sea-Shore	Shore-Sea	Shore-Shore
After 1st tour		5%	95%	95%	5%
After 2nd tour		5%	95%	95%	5%
After 3rd tour		5%	95%	95%	5%
After 4th tour		5%	95%	95%	5%
After 5th tour		5%	95%	95%	5%
After 6th tour		5%	95%	95%	5%
After 7th tour		5%	95%	95%	5%

Table 14. Example of continuing inventory

Distribution of Tour Lengths around Sea Tour Lengths												
n-6	n-5	n-4	n-3	n-2	n-1	n = PST	n+1	n++2	n+3	n+4	n+5	n+6
2%	4%	6%	8%	10%	12%	16%	12%	10%	8%	6%	4%	2%
-2%	-6%	-12%	-20%	-30%	-42%	-42%	42%	30%	20%	12%	6%	2%
Distribution of Tour Lengths around Shore Tour Lengths												
n-6	n-5	n-4	n-3	n-2	n-1	n = NST	n+1	n++2	n+3	n+4	n+5	n+6
2%	4%	6%	8%	10%	12%	16%	12%	10%	8%	6%	4%	2%
2%	6%	12%	20%	30%	42%	42%	-42%	-30%	-20%	-12%	-6%	-2%

Content of worksheet—computations

As noted earlier, the worksheet considers all the possible paths personnel may follow regarding their type of duty assignments (first tour at sea, second tour ashore, third tour at sea, OR first tour at sea, second tour ashore, third tour ashore, etc.), computes the probability of following any particular path, computes the type of duty for each month of service for a given path, and computes a weighted average over all possible paths to derive the percentage of personnel on sea duty for each year of service. The computations take place in several stages.

Initially, there is an array that considers all 256 possible combinations of tours for the first eight tours (e.g., sea-shore-sea-shore-sea-shore-sea-shore, OR sea-sea-shore-shore-sea-shore-sea-shore). This array computes the probabilities of each combination, based on the probabilities regarding tour path flows that are entered in tables 12 and 13.

Next there is a series of arrays, displayed horizontally on the worksheet, that determine the type duty (sea duty = 1; shore duty = 0) for each month of service for each of the 256 possible tour paths. These arrays build on the above array and account for the time taken to get rates and reach the fleet for initial accessions, as displayed in table 11. These arrays lead to a computation of the percentage of personnel that would be on sea duty for each month of service if all personnel precisely followed prescribed tour lengths. We then roll up these data into percentages on sea duty for each year of service

Next, there is a sequence of computations that adjust the above computations due to divergences in tour lengths, as specified in table 14. These computations consider each of the 256 paths, note when tours are supposed to end, and make fractional adjustments to the type duty assignment based on the data in table 14. The computations are made separately for both sea-duty and shore-duty tours.

Transition

The previous two worksheets provide a long-term, steady-state projection of the paygrade and length-of-service distribution, and the percentage of personnel at sea for each year of service. This information is important and valuable to policy-makers and informs leadership whether policies are heading in the right direction and whether targets are attainable.

It is also important to understand the transition from today's inventory toward the steady state because Navy leadership is concerned first and foremost with current personnel inventories and inventories during the next few years. This worksheet simulates how inventories would evolve as it moves toward a steady state, providing insights into how long it takes before current problems/issues are largely addressed.

Worksheet design, theoretical underpinnings, and limitations

The transition toward a steady-state distribution is based on accessions being anchored at (or around) the level required to sustain the target authorization total. The worksheet reproduces the computations of the PG x YOS worksheet, except that accessions are constrained to be at the sustaining levels that were derived in the PG x YOS worksheet. The resulting projections show how the inventory would evolve and how quickly it approaches a steady state. The results are encouraging in that inventories typically move close to the target steady state in a few years (no more than five years).

The user may also simulate the impact of trying to speed up the transition by varying accession levels. The user may specify percentage deviations from sustaining accession levels for each forecast year, and the worksheet computes the impact on future inventories. This provides a useful capability to simulate speeding up the transition and observing the impact over time on successive cohort sizes. The downside of trying to address inventory problems in one year is that one may access overly large or small cohorts, and these unevenly sized cohorts "echo" by leading to unevenly sized losses in the future, whence unevenly sized accession cohorts. Comparatively small deviations from sustaining accession levels (roughly less than a 15-percent deviation), if not sustained over successive years, will cause a minor, maybe negligible, disturbance to future accession levels.

The worksheet also provides a capability to simulate the effect of authorizations changing from one year to the next, causing accession level and advancements to vary as they chase moving targets. This is an important and realistic capability.

The worksheet also simulates the disposition of personnel between sea and shore duty for each forecast year. It makes these projections by applying the output of the Tour Flows worksheet to the above inventory projections. This is a heroic and somewhat unrealistic assumption that the steady-state disposition of personnel between sea and shore duty will apply in the first projection year and thereafter. In reality, it will take several years before the long-term effects of sea-shore flow policy are fully observed. However, to accurately simulate the transition of personnel as sea-shore flow policies are applied would require a lot more complexity than exists in this model. The worksheet has an added and comparatively simple capability to simulate sea-shore flow transition. The user may specify deviations from the long-term disposition of personnel between sea and shore duty for each of the first five projection years.

We have provided a rough estimate of the disposition of personnel between sea and shore duty and would welcome the opportunity to add more complexity, fidelity, and accuracy to these simulations.

Content of worksheet—input

The worksheet takes input from the LOS x PG and Tour Flows worksheets and augments the input with three additional arrays of data:

- Adjustments to steady-state accessions for each projection year
- Adjustments to total authorizations for each projection year
- Adjustments to percentages of personnel at sea for each of the first five projection years.

Table 15. Adjustments to steady-state accessions

Steady State Accession Requirement			756		
Adjustments to steady state accessions					
Proj. Year	Adjustment	Proj. Year	Adjustment	Proj. Year	Adjustment
1	15%	11	0%	21	0%
2	15%	12	0%	22	0%
3	15%	13	0%	23	0%
4	0%	14	0%	24	0%
5	0%	15	0%	25	0%
6	0%	16	0%	26	0%
7	0%	17	0%	27	0%
8	0%	18	0%	28	0%
9	0%	19	0%	29	0%
10	0%	20	0%	30	0%

Table 16. Adjustments to total authorizations

Adjustments to authorizations					
Proj. Year	Adjustment	Proj. Year	Adjustment	Proj. Year	Adjustment
1	0%	11	0%	21	0%
2	0%	12	0%	22	0%
3	0%	13	0%	23	0%
4	0%	14	0%	24	0%
5	0%	15	0%	25	0%
6	0%	16	0%	26	0%
7	0%	17	0%	27	0%
8	0%	18	0%	28	0%
9	0%	19	0%	29	0%
10	0%	20	0%	30	0%

Table 17. Adjustments to percentages of personnel at sea

Model	Adjust	Projected Inventory t+1								
% Sea	% Sea	YOS	E1-3	E4	E5	E6	E7	E8	E9	Total
96.1%	0.0%	0	869	0	0	0	0	0	0	869
99.6%	0.0%	1	442	0	3	0	0	0	0	445
58.8%	0.0%	2	388	69	223	0	0	0	0	679
9.7%	0.0%	3	83	103	509	0	0	0	0	694
9.7%	0.0%	4	17	55	560	0	0	0	0	633
28.8%	0.0%	5	1	9	267	2	0	0	0	278
88.3%	0.0%	6	0	3	290	16	0	0	0	309
88.9%	0.0%	7	0	1	248	51	1	0	0	301
87.1%	0.0%	8	0	1	232	77	1	0	0	312
74.4%	0.0%	9	0	0	153	74	4	0	0	230
16.9%	0.0%	10	0	0	99	94	8	0	0	201
17.3%	0.0%	11	0	0	40	95	13	0	0	148
24.2%	0.0%	12	0	0	44	59	13	0	0	116
76.5%	0.0%	13	0	0	43	125	31	0	0	199
82.5%	0.0%	14	0	0	28	113	41	4	0	186
79.4%	0.0%	15	0	0	2	84	60	5	0	151
46.5%	0.0%	16	0	0	0	83	53	7	0	143
15.6%	0.0%	17	0	0	0	64	57	12	1	134
20.5%	0.0%	18	0	0	0	76	76	10	0	163
23.2%	0.0%	19	0	0	10	66	63	12	0	152
47.6%	0.0%	20	0	0	7	63	48	19	1	138
77.6%	0.0%	21	0	0	0	0	31	18	3	52
74.9%	0.0%	22	0	0	0	0	24	14	2	40
52.1%	0.0%	23	0	0	0	0	24	15	2	41
25.1%	0.0%	24	0	0	0	0	18	10	3	31
27.7%	0.0%	25	0	0	0	0	0	15	6	22
28.5%	0.0%	26	0	0	0	0	0	13	6	20
0.0%	0.0%	27	0	0	0	0	0	0	3	3
0.0%	0.0%	28	0	0	0	0	0	0	2	2
0.0%	0.0%	29	0	0	0	0	0	0	3	3
		30+	0	0	0	0	0	0	0	0
		Total	1800	242	2756	1142	566	155	32	6694

Worksheet computations and output

The computations in the worksheet mostly duplicate the computations in the LOS x PG worksheet. There are some additional computations where the worksheet splits the PG x LOS inventories between sea and shore duty using the output of the Tour Flows worksheet.

PG x YOS x Type Duty worksheet

This worksheet is mostly a summary output worksheet. It provides the most important output of the computations:

- The steady-state LOS x PG distribution for the entire community
- The steady-state LOS x PG distribution for personnel on sea duty
- The steady-state LOS x PG distribution for personnel on shore duty or in the individuals account

All data are taken from the appropriate worksheets.

The worksheet also allows the user to vary the percentages of personnel on sea duty and observe the changes to the steady-state distributions.

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List of tables

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